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Extending bioenergy towards smart biomass use Issues of social acceptance at Park Cuijk, The Netherlands

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Abstract

Background: While the share of bioenergy in the overall energy supply has increased over the last decade, its social acceptance is fragile, mainly due to concerns about negative sustainability impacts. In this paper, we will investigate to what extent the extension of bioenergy towards 'smart' or 'cascaded' biomass use enhances a project's social acceptance. Smart use involves the prioritised use of biomass for food and materials.

Methods: We adopt an explorative single case study approach to investigate issues of social acceptance. Our case is the Biobased Economy Park at Cuijk, in The Netherlands. The central element in this project is the revival of an existing but off-line biopower plant. For the power company involved, the integration of biopower into a broader smart use scheme, involving several new business partners, is a strategy to make the exploitation of the plant profitable again. For the data collection, we used interviews, as well as information provided by members of our expert panel, in addition to information collected from websites and provided at a bioeconomy event. The data was analysed by taking existing conceptual work on the social acceptance of renewable energy innovation as a guide.

Results: We found that issues of social acceptance changed rather than diminished when entrepreneurs extended a project's focus from biopower to smart biomass use. This change can be observed in relation to all three conceptual categories: market acceptance, sociopolitical acceptance and community acceptance.

Conclusions: We conclude that the extension from bioenergy towards smart biomass use does not necessarily enhance a project's social acceptance. Compared to the social acceptance of renewable energy innovation, the social acceptance of smart biomass use is fuzzier, more open to recursive patterns and more dependent upon inter-firm trust. Importantly, embracing the principle of smart biomass use instigates the question of how biomass use can be optimised—either with or without purposes related to energy. We suggest further comparative case study research into the social acceptance dynamics of smart biomass use, for which we identify the following variables as relevant: the type of bioenergy, the sector that takes the initiative, the greenfield character of the project and the complexity of the smart use scheme.

Keywords: Bioenergy; Smart biomass use; Social acceptance; Cascading; Resource efficiency

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Background

The use of biomass for bioenergy is increasingly discussed within a broader bioeconomy context, where utilisation of biomass is seen as a way to replace a range of petroleum-based products with renewable alternatives. According to The Organisation for Economic Co-operation and Development (OECD), '[t]he bioeconomy in 2030 is likely to involve three elements: advanced knowledge of genes and complex cell processes, renewable biomass, and the integration of biotechnology applications across sectors' [30]. Crops, residues of food crops, wood (and residues) and vegetable oil, as well as (to a much lesser extent) waste products from meat production, can serve as a feedstock. The overarching, beckoning prospect, strongly embraced by the European Commission, is one of sustainable economic growth [14].

The principle of 'smart' or 'cascaded biomass use' is taken up in certain policy circles as a stylised blueprint of how such a bioeconomy should be organised (see Fig. 1; cf. [9, 16] and [15]). 'A smart use of biomass should be based on sustainability, affordability and added value. Under this principle, biomass should be first used for food, then for high value added products (including re-use and recycling) and afterwards as a source for bioenergy and biofuels.' [16]. Several European Parliament committees have stated that they support this approach. Such an 'integrated valorisation' (cf. [3]) of biomass gives priority to produce products with the highest economic value, which coincides with a small biomass demand, which, in turn, is expected to cause only limited negative impacts on the environment and society.

The principle of smart biomass use is, however, at odds with the current biomass demand of energy companies in Europe. Bioenergy competes with other biomass uses: energy companies do not patiently and voluntarily await any theoretical cascaded merit order. Their behaviour is mainly an effect of the European policy framework for stimulating renewable energy in transportation and power production (cf. [12] and [13]).

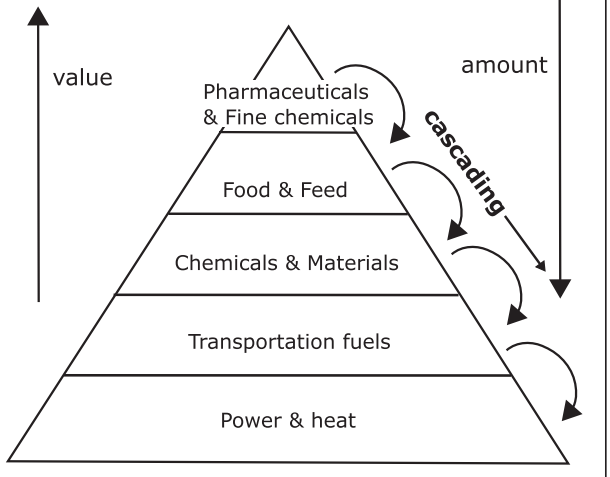

Fig. 1 Principle of smart or cascaded use of biomass [15]

While the share of bioenergy in the overall energy supply has increased over the last decade, its social acceptance is fragile, mainly due to concerns about negative sustainability impacts. In 2008 in The Netherlands, for example, one of the environmental organisations [32] produced a list of 'good', 'bad' and 'doubtful' biomass utilisation. In addition, the oil industry complained that there was insufficient sustainably produced biomass available (cf. [40]). In reaction to these concerns, the Dutch Ministry of the Environment decided to lower the agreed blending percentages [6] from 5.75 to 4 % in 2010. Internationally, debates about to what extent bioenergy production can be carried out sustainably are ongoing. One important controversy relates to the modelling data on the effect of indirect land use changes (iLUC) on environmental sustainability, which was particularly highlighted by Searchinger et al. in 2009 [38]. Although this was later refuted by several other authors (cf. [41]), it remains a large factor in the debate.

The problematic social acceptance of bioenergy falls within the broader theme of the social acceptance of renewable energy innovation, as addressed by Wüstenhagen et al. [44]—a work regularly quoted by other scholars who study the interaction between society and (renewable) energy technology (see, for example, [19, 36] and [37]). Wüstenhagen et al. conceptualise social acceptance by distinguishing three dimensions which are sometimes interdependent: sociopolitical acceptance, market acceptance and community acceptance. They define sociopolitical acceptance as 'social acceptance on the broadest, most general level. Both policies (…) and technologies can be subject to societal acceptance' ([44], p. 2684). To understand market acceptance, they point to Rogers [33] for inspiration, who has discussed processes of diffusion and the market adoption of innovations. In relation to community acceptance, they refer to 'the specific acceptance of siting decisions and renewable energy projects by local stakeholders, particularly residents and local authorities. This is the arena where the debate around NIMBYism [not in my back yard] unfolds.' Table 1 gives an overview

Table 1 Three dimensions of social acceptance of renewable energy technologies and policies, according to Wüstenhagen et al. [44]

Market acceptance	Community acceptance	Sociopolitical acceptance
• By consumers	• Procedural justice	• By the public
• By investors	• Distributional justice	• By key stakeholders
• Intra-firm	• Trust	• By policymakers

of the three dimensions that make up what Wüstenhagen et al. call the 'triangle of social acceptance'.

In this paper, we will investigate to what extent the extension of bioenergy towards smart biomass use enhances a project's social acceptance, based on a concrete case study. By doing this, we contribute to the existing literature in two ways. Our first contribution relates to the growing list of often policy-oriented reports and articles about smart or cascaded biomass use (cf. [3, 29] and [23]). Though often based on consultation with industrial experts, we consider such reporting theoretical, rather than practical, for the following reason. Overviews are given of potential smart use options and barriers, but these remain on a generic level, relying heavily on a top–down greenfield ideal of how smart use should be organised. Our focus provides information on the actual practice from a bottom–up perspective. We zoom in on the dynamics of social acceptance on the project level, shedding light on the barriers and opportunities entrepreneurs face when trying to implement smart use in practice. Our second contribution to the existing literature is a broadening of existing conceptualisations of social acceptance of renewable energy innovation. We show the dynamics when the object of social acceptance becomes broadened from renewable energy to an integrated concept: one that connects renewable energy production to renewable material production and recycling.

Methods

Single case study approach

We adopt a case study approach, as comprehensively described by Yin [46], to investigate the issues of social acceptance. Yin defines a case study as 'an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the

> [a] boundaries between phenomenon and context are not clearly evident. (…) The case study inquiry copes with the technically distinctive situation in which there will be
> [b] many more variables of interest than data points, and as one result relies on
> [c] multiple sources of evidence, with data needing to converge in a triangulating fashion and as another result benefits from
> [d] the prior development of theoretical propositions to guide data collection and analysis.' [p. 13]

Aspects a and b match the emerging phenomenon of smart biomass use well. To date, proponents have embraced smart biomass use as a rather unbounded, open-ended concept. It is the contextual conditions (for enhancing social acceptance) in which we are especially interested (aspect a). The cross-sectorial, multi-use character of smart biomass use, compared to sole bioenergy use, is likely to increase complexity, probably leading to there being more variables of interest than, from a practical viewpoint, can be covered by the data (aspect b).

Aspects c and d relate to the sound foundation of the case study. For the data collection, we used interviews, as well as information provided by members of our expert panel, in addition to information collected from websites and provided at a bioeconomy event.[1] To guide the analysis, we used the conceptual work of Wüstenhagen et al., as discussed in the Background section.

We chose a single case approach, rather than a multiple one, which we were able to carry out in the framework of a dedicated project, ensuring good data access. We chose the single case of Park Cuijk, which can be justified by the fact that our study has several elements of what Yin calls a 'revelatory case' ([46], p. 40), meaning that the phenomenon investigated was previously inaccessible to scientific investigation.[2] An extensive literature review to justify a claim that our case is unique was beyond the scope of our study, but we know that the envisioned scheme for smart use of biomass in our case study is unprecedented in The Netherlands, as it probably also is in the European context, in terms of the number and the rich diversity of steps involved in cascaded biomass uses that are envisaged. No publications on similar case studies have been identified. In addition, we consider our research as an 'exploratory device' ([46], p. 40): a prelude to other studies about the social acceptance of smart biomass use; we fully underline that our work is only a first step on this path.

The social research performed was part of a Dutch Responsible Innovation project, for which a panel made up of industry, civil society and policymaking representatives was established. Dutch power company Essent (which belongs to the German-based RWE Company) was the initiator of efforts to develop practices of smart biomass use at Cuijk, and was a member of this panel. This ensured good access to information and experts relevant to Park Cuijk. Semi-structured interviews with four of the professionals involved were conducted.[3] They provided us with additional materials, such as slides they use(d) for internal and external presentations.

Introduction to the case

We use Park Cuijk as shorthand to refer to our case study. This name is derived from the name of a consortium that was established, called Biobased Economy Park Cuijk, and the notion of a 'park' underlines the collective willingness and physical proximity of partners involved in creating one of the first small, modern facilities for the bioeconomy. The founders of the consortium are the power company Essent/RWE, life sciences and materials

sciences multinational DSM, waste-processing company Van Gansewinkel, farmers' cooperative Mestac and entrepreneurs' association ZLTO (Southern Agri- and Horticulture Organisation). In a broader network, several other firms and public organisations are involved, either as a knowledge partner, a sponsor, or both.

Figure 2 shows the envisioned smart biomass use scheme for Park Cuijk. The central element is an existing biopower plant of 25 MWe. For reasons which we will discuss later, the plant is, at the time of writing, off-line (Phase 0). For the power company, the integration of biopower into a broader scheme of smart biomass use is a strategy to make the exploitation of the power plant profitable again. It is envisaged that all the biomass or residuals used at the park will be collected regionally, within a radius of about 200 km, including paper sludge from the local paper industry (Phase 1). Heat will be decoupled from the power plant and delivered to local industries, including the paper industry and a manure dryer that is to be established (Phase 2). The manure dryer will receive digestate from a manure digester (also Phase 2). It is envisioned that a biorefinery plant, which provides the paper industry with paper fibres and the power plant with lignin/cellulose, will be built at a later stage (Phase 3).

Results

We applied the existing conceptual framework of social acceptance of renewable energy innovations to the case of Park Cuijk, in The Netherlands. We will subsequently discuss the results for market acceptance, sociopolitical acceptance and community acceptance.

Market acceptance

Market acceptance relates to processes of diffusion and the market adoption of innovations. Three conceptual categories of market acceptance have been identified: intra-firm acceptance; acceptance by investors; and acceptance by consumers. We applied each category to the case of Park Cuijk. For each category, we first discuss the acceptance of biopower, followed by a discussion of the issues relating to and the dynamics of acceptance that will become relevant when the envisioned smart biomass use scheme becomes reality.

Intra-firm acceptance

Within the power company Essent, the acceptance of biopower is high. The company has built up a good track record in green (renewable) power production, for which biomass is an important ingredient. The Cuijk biopower

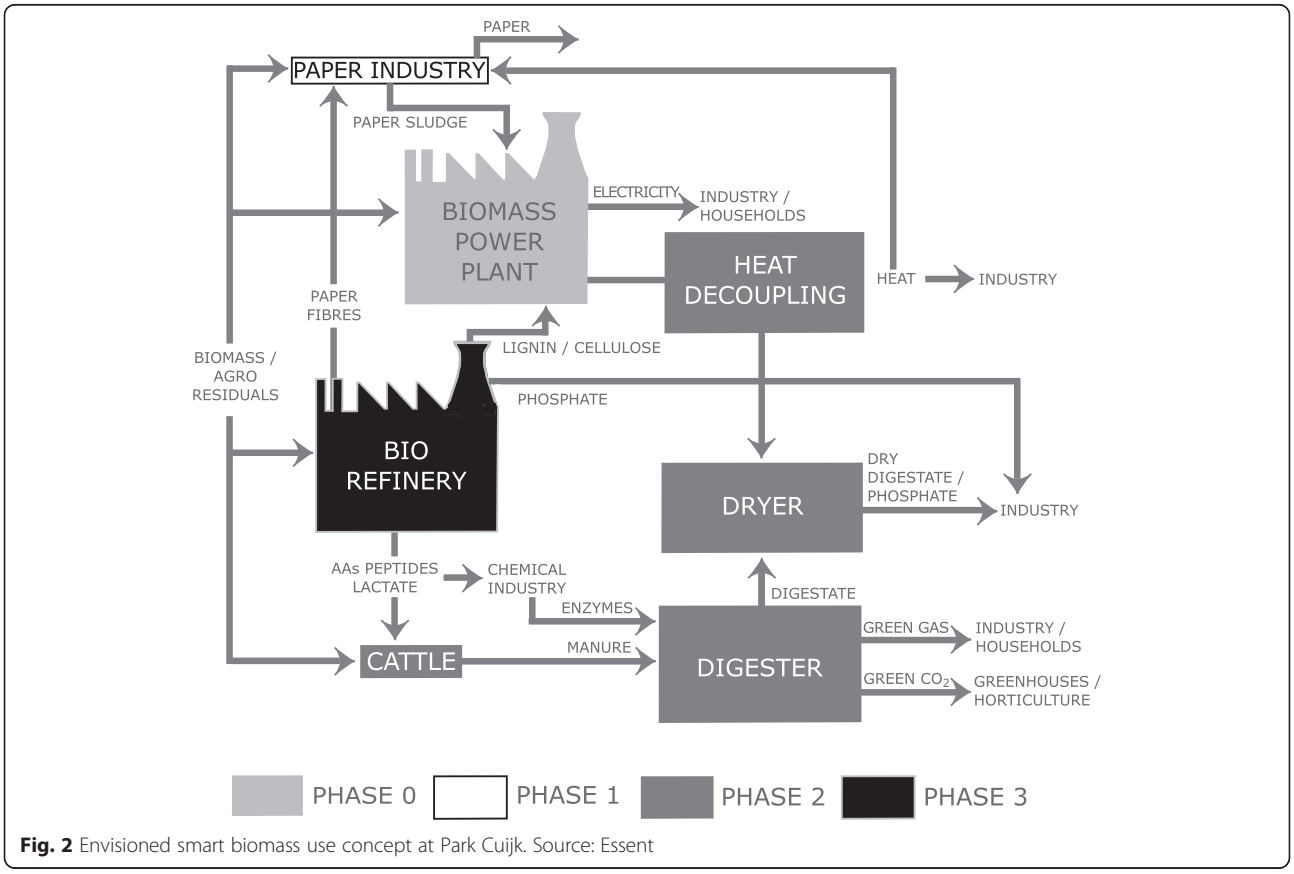

Fig. 2 Envisioned smart biomass use concept at Park Cuijk. Source: Essent

plant successfully contributed to this portfolio of green power for 10 years. The company embraces biomass as 'the most efficient way to reduce CO_2 and the most affordable form of sustainable energy' [10] (our translation).

The acceptance of smart biomass use within the power company is more fragile, not so much because it is a new concept, but because it increases its dependence upon other business partners outside the traditional business chain. In the case of Cuijk, it is the agricultural sector and the life sciences sector which are to become such new partners.

For both the power company and the new business partners, the process of creating a shared vision of the new venture works as a way of enhancing acceptance within each company. It clarifies the position of each of the (proposed) business partners in the broader scheme, physically (how 'biobased' flows should become connected) and in terms of timing, proposing a sequence of phases in which processes of biomass valorisation should be expanded. Though the vision has been reified in the establishment of a consortium, it is not a contractual agreement, but rather a flexible, largely rhetoric entity, serving as a mediator for further refinements and negotiations, which require further support in the organisation of the parties involved.

In the subsequent process, consortium meetings are regularly held, enabling smooth communication. Non-disclosure agreements (NDAs) are installed, which provide some legal status without imposing too much restriction. Business partners feel connected to the same goal and are aware that at times, and to a certain extent, they should help each other out. However, everybody is fully aware of the possibility that partners will drop out along the way.

Acceptance by investors

Who should pay for the costs of reviving an old biopower plant? Technically speaking, the plant is still in good shape; the typical redemption period for such plants is several decades. In 1999, it was profitable for the power company to invest in a biopower plant, because of favourable subsidising schemes. Ten years later, the ending of this support made the Cuijk plant a matter of lost investments in capital expenditures (CAPEX) with unsustainable operational expenditures (OPEX), because producing power with biomass could not compete with fossil-based production without a subsidy.

Co-delivery of steam as a by-product opens up possibilities for reviving the plant. Centralised steam delivery at the park can replace local, non-renewable and less efficient production of steam to, for instance, the paper industry, which normally uses natural gas to produce the steam that is utilised in industrial processing. In cooperation with the province of Brabant, the power company successfully lobbied for the creation of an additional category in the 2011 national subsidy scheme for stimulating renewable energy production (SDE+), enabling these opportunities for by-product use with a subsidy at Cuijk. Politicians were willing to support the lifetime extension of an existing biopower plant such as the one at Cuijk, but only if such a plant would increase its environmental performance, either by switching to renewable gas production or by co-delivery of heat [35].

The new category in exploitation subsidy does not, however, provide an answer to the question of who should pay for the investments to adjust the power plant, which is needed upfront. The infrastructure is especially relevant here. Steam delivery needs piping and adjustments to the existing process control, for instance. Such investments would also be needed to use waste heat of a lower temperature—about 80 °C—that becomes available during the power production process. For all types of heat use, natural gas is the direct competitor, for which the infrastructure is already there. Investments are needed to overcome this difference.

While all the involved parties and also the government already invest specifically in knowledge development, the challenge is paying for the adaptation of the use of novel forms of biomass utilisation which are a result of the cascading chain. The power company has invested in 'mixed fuel' biomass combustion, which provides flexibility and redundancy in terms of supply chains. The downside is that the inclusion of highly moist biomass in the fuel mix (as envisioned in the new cooperation) leads to severe technical challenges in relation to combustion techniques, such as fouling (ash particles that become attached to the boiler). Overcoming such combustion challenges is the aim in Phase 1 for Park Cuijk. In particular, the fact that the boiler already exists, meaning that it cannot be redesigned from scratch, requires innovative solutions. The power company stresses that Park Cuijk is to be seen as an early icon in the broader context of an emerging bioeconomy, implying that not all investments will pay off at the small scale of the park.

Acceptance by consumers

In relation to the biopower that the power company sells, acceptance by consumers is high. In the north-west European power market, renewable power is an established sub-market, to which biomass contributed with a share of 4.1 % in 2012, which is a doubling compared to the 2002 situation [17]. Consumers may have several reasons for buying green instead of fossil-based power, taking into account that from a user point of view, no behaviour changes and no investments are needed: the wall outlet is always the same. With the step from biopower to smart biomass use, a more diverse set of

customers and use practices become relevant. We distinguish between local, regional and economy-wide customers of integrated valorisation products.

Many of the customers of smart biomass use processes are other businesses. The category of local customers can be divided in companies already established at Park Cuijk and companies willing to settle at the park, for reasons relating to favourable establishment conditions. For existing neighbouring firms, the acceptance of products depends on the option for direct cost reduction in their existing production processes. Examples at Cuijk are established factories for paper production and potato processing. Organisations still to arrive at the park, such as companies involved in manure processing, are probably more flexible in redesigning their industrial processes to fit the overall valorisation scheme.

The acceptance of products by regional customers can be stimulated by an agent that acts as a regional broker, bringing supply and demand together. The regional farmers' cooperative acts as such a mediator. Park Cuijk can offer the processing of livestock manure surplus, which is of importance to the livestock farmers. From 2014, the issue of manure handling has become more problematic because of a substantial reinforcement of environmental legislation in The Netherlands [8]. The anticipated dryer and digester turn manure surplus into useful products. The envisioned delivery of emitted CO_2 to greenhouses in the region, where it can be used as a carbon source to help grow crops, may also benefit from a similar kind of brokerage function.

The acceptance of smart biomass use products by consumers in the wider economy is no different from the acceptance of any innovative product on the European and global market. The potential for high diffusion rates increase when the product is highly transportable, bringing distances way beyond local and regional boundaries within reach—something that depends on the product characteristics, transportation costs and the availability of the infrastructures needed. For the Park Cuijk concept, economy-wide trading options include the markets of (green) energy, fertiliser, enzymes and products of the biorefinery plant.

Sociopolitical acceptance

Sociopolitical acceptance is acceptance of policies and technologies on the broadest, most general level. After presenting some of the overarching issues for Park Cuijk, we subsequently discuss the acceptance of biopower and its extension to smart use by the public, by stakeholders and by policymakers.

Acceptance of technologies and policies in general

We found three general issues regarding the acceptance of technologies and policies. The first issue is that to proponents of renewable energy, the acceptance of biopower is a dilemma. Stimulating the uptake of biomass in fossil-based industries boosts the renewable portfolio. At the same time, this further fortifies these incumbents' market positions, thereby lowering the chances for other renewables, such as solar and wind energy, to further increase their market share. The biopower plant at Park Cuijk is a compromise that does not overcome this dilemma. The design needed for the plant to run on biorenewables is completely at the cost of staying very small, compared to fossil-fired power plants, as biomass supplies from the region are not enough for a full-sized, more profitable plant.

The second issue is that for the sociopolitical acceptance of biopower, credible sustainability schemes are relevant, but these are problematic for Park Cuijk. The power company developed the Green Gold Label for international supply chains. This label is, however, not suited for the kind of regional biomass exchanges that are envisaged. Such markets have not matured yet, making it hard to get a certification system up and running. Another issue is that the low-value, moisture-rich biomass flows that are being used are less homogeneous than the standardised, dry wood pellets that are being traded internationally, and therefore difficult to certify.

The third issue is that the power company cannot claim fully fledged smart use, since it is dependent on the SDE subsidies for economic viability. At present, alignment with biomaterial production can only be realised when such utilisation is also awarded SDE-type subsidies. From the perspective of worldwide energy demand, energy experts often portray great quantities of modern biomass applications to be indispensable (cf. [11]) for reaching the climate change mitigation goals, which can indeed be realised through energy production, as these replace large amounts of fossil by (renewable) biomass, and therefore such practices are being put forward as a ground for subsidising bioenergy. Proponents of biomaterials and biorefinery demand support schemes that are similar to the SDE [1, 25]. This is in line with the smart use concept, which stresses that biomaterials should have priority over energy. The Park Cuijk vision does not yet provide a clear option for bridging the world of energy and materials as it is dependent on the present policy incentives, which means there is not a level playing field. It does encompass biorefinery practices, but these are planned no earlier than after all developments are complete, making it the least certain step and dependent upon more generous policies in the future. The mutual dependencies are also not equal: the chemical industry does not have to be present in the park as the expected biorefinery products are highly transportable. This implies that the availability of local customers at the park is not essential for the biomaterials

industry: the biorefinery plant could just as well be located elsewhere. The benefits for each partner need to be enough to make the consortium worthwhile, which creates a large challenge to the overall process design chain.

Acceptance by the public

Since regional biomass resources are used, biopower production at Cuijk is not in direct competition with international food supply chains. This makes biopower at Cuijk less vulnerable to public protests, as happened during what is called the tortilla crisis [24], which in turn was probably the most prominent exponent of the underlying 'food or fuel' discussion. Mexican citizens protested fiercely against a rise in food prices, presumed to be caused by American farmers who preferred to deliver their corn to the international biofuel market rather than to the Mexican food market.

Nevertheless, the inclusion of Cuijk's power plant in a broader valorisation scheme means that the public acceptance of the park becomes dependent upon a range of factors, which is wider than before. Biopower becomes more firmly associated with the agricultural sector, which is a supplier of an important resource for the park: livestock manure. Public perceptions of (intensive) farming probably have an influence on the public acceptance of the park and its portfolio of activities.

Acceptance by key stakeholders

Non-governmental organisations (NGOs) are important stakeholders regarding the sociopolitical acceptance of biopower. Several NGOs are very active in the public debate, scrutinising international biomass supply chains. Sensitive issues, besides the food or fuel debate, are indirect land use change (iLUC), monopolies of multinationals and the use of genetically modified organisms (cf. [11]).

The overarching dilemma that biomass used for energy purposes stimulates the use of renewable resources but fortifies the fossil industry at the same time typically makes NGOs support biomass but only under certain conditions. It is likely that biopower from available regional resources, as aimed for at Park Cuijk, falls within these conditions, being preferred over biopower that is based on long international supply chains. To both environmental and human rights organisations, it is important that negative impacts elsewhere are absent. This includes the avoidance of importing genetically modified energy crops, as such crops are not currently allowed to be cultivated in Europe. Though potentially obtainable from farther away—the mother company (RWE) incinerates dry wood pellets that are imported from production woods in the state of Georgia (US)[4]—the power company aims to limit biomass transport distances to Park Cuijk to about 150 km, accepting that this regional biomass will be of a lower quality, containing more moisture and being more diverse.

The cross-sectorial aspect of smart biomass use makes additional types of NGOs relevant for Park Cuijk. One example is the 'kink the sausage' campaign [25] (in Dutch: 'Knak de Worst'). From the perspective this movement takes, manure processing, as anticipated at Park Cuijk, should not be seen as environmental care, but rather as a permit for letting the overall number of our livestock increase.

NGOs do not take part in the Park Cuijk consortium. Within the broader context of bioeconomy developments in The Netherlands, however, the power company has significant interaction with different NGOs, which facilitates the company in its efforts to increase the social acceptance of smart biomass use at Park Cuijk. Bioeconomy professionals from industry, consultancy, science and policy circles and NGOs meet regularly, in different kinds of settings, often enabled by or as part of public–private bioeconomy development programmes. One outcome of this collaboration is the establishment of a bioeconomy manifesto, in which smart biomass use (cascading) is embraced as a common goal, subscribed to by all parties, including participating NGOs [1].

Acceptance by policymakers

Biopower would be firmly embraced by policymakers if it contributed to three goals at the same time: reaching renewable energy targets, meeting the interests of existing industries and stimulating innovation—all at low cost, something which has become even more important since the financial crisis. The reality of Dutch biopower policymaking is that it shows a continuous search for compromises. With increasing shares of national renewable energy production in sight (following European guidelines) and a drastic reduction in available subsidies for renewable energy production in 2009, the government stopped subsidising the exploitation of the Cuijk biopower plant. Biopower is still embraced by policymakers, but only when it offers something extra, such as the co-use of steam, which improves overall energy efficiencies. Whether or not biopower supply chains are sustainable is only a secondary consideration. Sustainability criteria, such as those developed for liquid biofuels, are, at the time of writing, still lacking regarding the use of solid biomass in Dutch power plants, though they are being developed [22].

Dutch policymakers support smart biomass use mainly because of its innovative aspects. Compared to biopower, it is less clear how such valorisation will count against environmental goals such as shares of renewable energy and CO_2 emission reduction targets. Beyond the subsidy for decoupling steam, Park Cuijk benefits from some governmental support, within the context of the Dutch

'top sectors' innovation policy. On a rhetorical level, the acceptance of smart biomass use is high, manifesting itself in a governmental vision on the bioeconomy [9] and a specific Biobased Economy programme within the ministry of Economic Affairs. Also on the European level, the bioeconomy concept is widely embraced and is anchored in the Horizon 2020 programme.

Community acceptance

Community acceptance relates to local stakeholders and authorities that are involved in or affected by location decisions. Conceptually, three aspects have been identified as relevant for community acceptance: distributional justice, procedural justice and trust. We subsequently discuss them in relation to the case of Park Cuijk.

Distributional justice

Distributional justice is about sharing burdens and benefits fairly. The reopening of the biopower plant as such will not alter the existing status quo in the community of Cuijk. The balance of distributional justice may shift, however, with a step from biopower to integrated biomass valorisation. Some actors in the community can be expected to win, while others lose. The municipality may be among the winners, as further innovation at Park Cuijk aligns with its ambition of being a regional economic hotspot [7]. Neighbouring industries may benefit from the cheaper centralised steam production. In the region, farmers are likely to benefit because of responsible manure processing, and horticulturists may profit from cheaper, pure CO_2.

If any community members lose, it will be people living near the plant. The envisioned manure digesting comes with risk and, possibly, nuisance. These problems are partly mitigated by the fact that the planned digester will be operated by trained chemical plant operators in the controlled environment of an industrial park, at some distance from any housing (500 m–1 km). This industrial setting contrasts with the more distributed use of digesters on farmers' premises, which are known to have caused lethal accidents [20, 26] and smell [42]. Good housekeeping is, however, no guarantee that opposition from neighbours, often framed as 'not in my back yard' (NIMBY), will be absent.

Procedural justice

Procedural justice is about fair treatment in fair processes. Standard legal frameworks enable members of the Cuijk community to react to requests for permits which are needed for building an additional plant, such as the manure dryer. There is, however, no direct (financial) participation of people living nearby, which, by contrast, does happen at some wind parks. More informally, the power company uses a combination of openness and professional communication skills in trying to manage the social environment. An example of such activities is the 'sniffing Cuijk' event (in Dutch: 'ruiken aan Cuijk'), where people living nearby were invited to go and see and smell for themselves.

Trust

The trust of community members in a revived Park Cuijk does not depend on justice aspects only. Another important aspect is the trust in expertise. Experts saying that industrial manure digestion is safe is no guarantee that people living nearby will perceive it as being safe. Misinformation can easily be spread by lay people via blogs and social media, where it can contribute to unfounded concerns. The previously mentioned campaign 'kink the sausage', which is related to a movement opposing intensive cattle farming, illustrates how easy it is to spread all kinds of information that has not been checked with experts first.

Discussion

Comparison with acceptance of renewable energy innovation

In comparison with the social acceptance of renewable energy innovation, as discussed by Wüstenhagen et al. [44], the acceptance of a smart biomass use project is different. Reflecting on the results for the Park Cuijk case, we identify differences in three aspects.

The first aspect is something we call object fuzziness. For renewable energy innovation, the object of social acceptance is more or less clear: it is often a single entity that produces a single product, such as a wind park, a biomass-fired power plant or solar energy on rooftops. For smart biomass use, however, we have several entities, which, in mutual interaction, co-produce different types of products simultaneously. As for the case of Park Cuijk, we can distinguish, among others, a power plant, a manure-drying facility and a biorefinery plant. One strategy that could be used to investigate social acceptance would be to artificially remove such entities from the overall scheme and to investigate their acceptance in isolation. This is, however, only of limited value, because the very acceptance of every entity will, to an extent we do not know, also be dependent upon the fact that its functioning is integrated into the broader smart use scheme. It is an open question how such separately investigated acceptance dynamics should be added up. Social scientists and other parties involved in the development of smart biomass use have to accept that the object of social acceptance is a relatively diffuse, not clearly defined, patchwork.

The second differentiating aspect is the importance of recursive patterns in the dynamics of social acceptance. A sophisticated smart biomass use scheme, such as the

one designed for Park Cuijk, requires that pieces of the puzzle are added over time, leading to renewed social acceptance dynamics that only partially build on earlier experiences. This is unlike the expansion of, for instance, an established wind park, where the puzzle was already complete but only grows bigger. Such leapfrogging of acceptance dynamics implies that the typical U-curve for community acceptance of renewable energy innovation (high acceptance upfront—(relatively) low during siting phase—back to a higher level once up and running) ([43] ([44], p. 2685) is unlikely to apply to sophisticated smart biomass use projects. Rather, we can expect (repetitive) W-curves.

The third aspect on which the social acceptance of smart biomass use differs from renewable energy innovation is inter-firm trust. Wüstenhagen et al. identify intra-firm acceptance and also the role of trust for community acceptance. When analysing situations of smart biomass use, we should, however, add the issue of *inter*-firm acceptance in relation to trust. In established markets, low trust levels between firms can, to some extent, be exchanged for a higher control level [27]. Detailed contracts, for instance, are a way of handling trust issues between business partners. This is, however, not easily done in innovative settings, such as that at Park Cuijk. Scholars in innovation policy argue that such obligations could stop creative processes at their very roots ([28], p. 5, referring to [45]). With firm control mechanisms absent, some basic confidentiality is needed so that participants will not act opportunistically. In order to move forward, this confidence has to increase over time.[5] Such inter-firm trust is always important for innovative projects, but for smart biomass use this is even more so, because it often requires cooperation outside traditional value chains; the aim is to have sectors cooperate that used to be strangers to one another. In an emerging bioeconomy context, the enhancement of such trusting relationships, on the institutional, organisational and personal levels, is important to get the ball rolling [2].

Representativeness of Park Cuijk as a case study

In this section, we will reflect on three questions: to what extent does the Park Cuijk case represent bioenergy, to what extent does it represent an extension of bioenergy towards smart biomass use and to what extent does it represent the ideal of smart biomass use that a great proportion of policymakers embrace.

There are limitations on the extent to which the Cuijk biopower plant represents bioenergy. At least two other biopower options are relevant: the (co-)production of green power from biogas, and the co-firing of biomass at coal- or gas-fired power plants. These additional biopower options are likely to instigate different types of social acceptance dynamics. Production of power (and heat) from biogas often happens under a different regime of ownership: the electricity consumer often owns the plant, which is often also smaller in size than the Cuijk power plant. In contrast, the co-firing of biomass happens at power plants that are much bigger than the plant at Park Cuijk. Such fossil-based power plants commonly lean on long international biomass supply chains, which are susceptible to sustainability debates that are more polarised than debates relating to regional biomass collection. Biogas is part of the smart use concept at Cuijk, as a product of the digester, but the gas will not be transformed into electricity. Biofuels are not part of the Cuijk scheme, but eventually could still become one of the products of the envisioned biorefinery plant.

The extension from bioenergy to smart biomass use is coloured by the site-specific character of the case. The fact that the location is pre-given implies that the interests of the involved business partners are asymmetric. If the existing power plant is to remain off-line, the whole concept of smart biomass use at Cuijk loses ground. This may be less the case in smart use projects which are greenfield. At Cuijk, the power company's interests are location bound: reviving an existing power plant. The farmers' cooperative's interests are in responsible manure processing, which is region bound and in that sense more flexible. The interests of the involved life sciences multinational are even not location bound; the probing of innovative enzymes that enhance industrial manure digestion could take place anywhere in the world. In a greenfield situation, different interests can, in principle, be negotiated and traded off upfront. In the case of Cuijk, however, the power company is already locked in because of the available power plant, reducing the company's manoeuvring space. A single case study, as performed, cannot, however, clarify whether such a site-specific character enhances or impairs a project's social acceptance. On the one hand, the asymmetric interests of proposed business partners may put processes of inter-firm trust building under stress. On the other hand, the availability of existing industrial processes to build on may give a smart biomass use project a head start, compared to having to start from scratch.

An interesting question is to what extent the case represents the general ideal of smart biomass use. Issues of social acceptance may, for instance, be different if they start from economic interests that are rooted in biomaterials, rather than in bioenergy. Another relevant dimension for any smart biomass use project is complexity. This involves, at least, the number of business partners involved and the number of biomass processing steps embraced. Compared to the options commonly listed in policy-oriented reporting (cf. [3, 29] and [23]), the complexity of the envisioned Cuijk scheme seems greater. The more complex a smart biomass use concept

becomes, the greater the object fuzziness one can expect with respect to processes of social acceptance.

Further comparative case study research

We stated that our single case study can, in the terminology of Yin, be considered as an 'exploratory device' ([46], p. 40): a prelude to other studies about the social acceptance of smart biomass use. The points mentioned in this Discussion section can be summed up to produce the following relevant comparison grounds for investigating processes of social acceptance:

- smart use concepts, rooted in different types of bioenergy, such as the co-firing of biomass and power generation from biogas and biofuels;
- smart use concepts where the main initiative is non-energy based, such as those rooted in the materials sector or another sector;
- smart use concepts that start from a (relative) greenfield situation, instead of an existing site;
- smart use concepts concerning different degrees of complexity, such as the number of relevant business partners and the number of envisioned biomass processing steps.

Conclusions

We conclude that the extension from bioenergy towards smart biomass use does not necessarily enhance a project's social acceptance. Such a broadening brings opportunities, but introduces new challenges at the same time. Compared with the social acceptance of renewable energy innovation, the social acceptance of smart biomass use is fuzzier, more open to recursive patterns and more dependent upon inter-firm trust. Importantly, embracing the principle of smart biomass use instigates the question of how biomass use can be optimised—either with or without purposes relating to energy. Nevertheless, the Park Cuijk case shows that taking bioenergy as a starting point for smart use is promising in terms of enhancing energetic and economic efficiency levels.

We suggest further comparative case study research on the social acceptance of smart biomass use. We identified the bioenergy types, the sector that takes the initiative, the greenfield character of the project and the complexity of the smart use scheme as relevant variables for such a comparison.

Endnotes

[1]IMI (Institute for Societal Innovation) event about cascading in the bio-economy, Leiden, the Netherlands, 17 December 2013.

[2]The performance of the biomass plant at Cuijk has been studied by Dutch social scientists before, as part of a broader sample of case studies, but these scholars confined themselves to aspects of combined heat–power production instead of the broader smart biomass use principle we address in our paper. Furthermore, they report limited data availability on, among other aspects, social characteristics [31].

[3]The professionals interviewed were Koen den Houting (Essent, 25 November 2013), Joris Kloek and Peter van Paridon (DSM, 7 January 2014) and Ben Rooyackers (MESTAC, 10 December 2013).

[4]Interview with Koen Den Houting (Essent) on 25 November 2013.

[5]Inter-firm trust may grow as follows. It may start in a fragile way from calculus-based trust [34], where participants dryly judge whether participation is promising or not, to the level of relational trust (ibid.), where repeated interactions have provided more clarity about mutual expectations and reliability, thereby setting the stage for exploring a more long-term future instead of being preoccupied with daily matters only. When relational trust arrives on the scene, the mutually invested resources are likely to increase. Furthermore, emotions come into play. This may, at the end of the day, even lead to a kind of shared identity [18] [5]. In this process, any evidence of a free rider problem, alternatively called behaviour that reflects a 'tertius gaudens' (a 'rejoicing third': [4, 39], as referred to in [28]), is likely to undermine emerging levels of inter-firm trust.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

JG designed the study, performed the case study and drafted the paper. One interview was carried out by LA and JG, and two others by JG. LA and PO both participated in the design of the study and in the interpretation of the results. All authors revised the manuscript critically and approved the final content.

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