



Expanding Citizen Science: Community Action Without Primary Data Collection

SPECIAL COLLECTION:
LAW

CASE STUDIES

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ABSTRACT

Environmental planning disputes often combine questions of regulation and legislation with distinctive, place-based epistemic issues that lend themselves to citizen science approaches. Whilst these citizen science activities often concern the enforcement of regulations, here we describe the attempts of a local community group to prevent the start-up of a new biomass incineration plant by showing that it fails to comply with the relevant regulations and/or that the associated legislation has not been applied correctly. Through documentary sources and in-depth interviews, we examine the ways in which the group's work has parallels with aspects of regulatory science. In describing this work, and thinking about how to categorise it, we argue that conceptions of citizen science need to be broadened to include a wider range of activities than the traditional focus on primary data collection.

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INTRODUCTION

In June 2008, the Vale of Glamorgan Council's (VGC) Planning Committee received an application for a 9MW biomass gasification plant in the docks area of Barry, a town on the South Wales coast. Although the application was initially rejected, this decision was successfully challenged by the developer. In the years that followed, and as this permission was due to lapse, a new proposal was submitted, changing the technology and enabling painted and chemically treated wood to be used as fuel. Local concerns about the economic, health and environmental impacts of the proposed plant were raised, but planning permission was not rescinded and, despite nearly a decade of opposition, construction work began in late 2016. Campaigning against the plant continued, and a review by the Welsh Government in 2019 determined that the developer-operator should undertake a retrospective Environmental Impact Assessment (EIA). The most recent of these lengthy and often highly technical documents was submitted in July 2022, with public and statutory consultees having until the end of November 2022 to respond. The final planning decision is currently expected in early 2023, almost 15 years after the original application was submitted.

In this paper, we are concerned with how local citizens have attempted to prevent the plant's operation by using the legal and regulatory framework within which these decisions were taken and the extent to which these activities can be seen as a kind of citizen science. The analysis draws on the science and technology studies (STS) literature to set out an expanded vision of scientific work and suggest that many of the activities that the citizen group was involved in would be seen as involving science if they were to be done on behalf of the developer or the regulatory authorities. Our hope is to extend the discussion of citizen science, which is typically concerned with data collection activities, to recognise these other kinds of epistemic work.

In what follows, we introduce the theoretical tools we use to interpret our data and describe the methods used to collect these data. Following this, we provide a chronological narrative of the development of a biomass energy plant, identifying the key decisions and events before subjecting a small number of these to more detailed analysis and reflection.

LITERATURE REVIEW

SCIENCE AND TECHNOLOGY STUDIES (STS)

STS is a diverse field based around the idea that the institutions, practices, and content of science can be studied in the same way as any other cultural endeavour (for a recent overview, see [Felt et al 2017](#)). Rather than scientific truth

being the result of data and scientific mistakes the result of social factors like bias or prejudice, STS sees both as grounded in an interaction between the available data and the social and cultural resources that scientists are able to draw on and from. From this perspective, scientific knowledge is less a mirror held up to nature and more a reflection of the social relations and interests at play in the scientific community and wider society ([Shapin 1995](#), [Bloor 1991](#)).

This approach has important implications for the way science is understood and used. Scientific facts are seen as constructed rather than discovered, putting more emphasis on the assumptions and choices made by scientists, and highlighting how these often reproduce and reinforce wider networks of privilege and influence ([Longino 1990](#)). This gives rise to a more rounded and complex picture of scientific work as involving many other activities that connect the laboratory to the world outside ([Latour 1983](#)). One consequence of this has been the recognition that there are different types of science, with traditional academic science being just one of these. For those concerned with citizen science, perhaps the most important of these is the idea of regulatory science ([Jasanoff 1990](#)), which seeks to capture the role played by science, and the social interests it encodes, in the development and enforcement of regulatory standards. Definitions of regulatory science vary, but it is typically seen as encompassing a number of distinct areas, ranging from speculative research about potential harms, through the development of standardised tests and measures, to the provision of information for regulatory review ([Irwin et al. 1997](#)).

There is now a large body of work within STS that draws on these insights to reveal how the frequently technocratic use of science in policy-making and regulation excludes local knowledge and concerns by smuggling unacknowledged value statements and preferences into decision-making ([Wynne 2013](#)). The solution proposed is for more inclusive and transparent forms of decision-making that do not reify scientific knowledge but treat it in a similar way to the knowledge claimed by other groups. Whilst there are a range of different proposals and positions available within STS on this issue, ranging from the extended peer review of post-normal science ([Funtowicz and Ravetz 1993](#)) to various forms of technology assessment ([Callon et al. 2009](#), [Nowotny et al. 2001](#), [Bijker et al. 2009](#)), all would agree that the quality of planning and regulatory decisions would be improved by making better use of the range of experience and knowledge that is available.

CITIZEN SCIENCE

Just as science can be thought of in different ways, so there are different ways of thinking about citizen science ([Bonney 1996](#), [Irwin 1995](#), [Haklay 2013](#), [Prainsack 2016](#),

Dosemagen and Parker 2019, Strasser et al. 2019). For those who take a traditional view of science – that is, science as an objective, knowledge-producing activity in which methodological rigour leads to the discovery of pre-existing truths – citizen science is often seen in narrowly utilitarian terms. Typical projects use volunteers to collect data that would otherwise be unaffordable or inaccessible, but research design and data analysis remain firmly in the hands of the professional scientists (Bonney et al. 2009). In such projects, the relationship between scientists and citizens is clearly hierarchical, with cooperation based on shared interests in topics such as ecology, astronomy, or biodiversity, and societal gains typically seen as improved outreach or public understanding. There is, however, no sense that science may learn from or be challenged by these citizens.

In contrast, the STS literature suggests a very different role for citizen science. As noted above, the key claim of STS is that science is socially constructed, meaning that its content is shaped by both the available data and the cultural and material resources used to interpret them (Irwin and Wynne 1996). Applying the same approach to citizen science, we can see that, if science reproduces the privilege and perspective of elites, then citizen science offers the possibility of a science for the people, by the people (Irwin 1995, Kimura and Kinchy 2019). In this counter-establishment framing (Gordin 2021), citizen science is a bottom-up activity in which knowledge is generated by a community to challenge the regulatory science used in decisions that affect their lives and well-being (Jasanoff 1990, Irwin et al. 1997). Typical controversies include the setting of safe limits for exposure or attempts to determine if a specific installation has remained within these limits.

EXPANDING CITIZEN SCIENCE

Planning, environmental and licensing disputes involve claims about the future, with the success or failure of the application turning on the predicted impact of the new product or infrastructure. In the case of the biomass plant we are concerned with, these include questions about its effect on air quality, biodiversity, and economic development to name but a few. As the plant does not (yet) operate, the evidence that emissions will remain within the mandated safe limits, that natural habitats will not be harmed, that new employment opportunities will be created, and so on comes from the technical information provided by the developer in statutorily demanded documents such as the EIA.

Given the quasi-propositional nature of these statements, one obvious way in which community groups can oppose the application is to challenge these claims and show that the proposal does not meet the necessary standards. The idea is that if the decision-maker is constrained by the legal

and regulatory framework, then showing that the proposal does not meet these standards means that it must be rejected. For example, if the developer claims that, under one set of operating assumptions, the plant will comply with the emissions limit demanded by the regulators, the community group will seek to argue that, under a different but equally plausible set of operating assumptions, the plant will fail to comply with the same regulations and, on that basis, that permission should not be granted.

Our argument is that these challenges can, and should, be seen as a form of citizen science. It seems clear that the extant STS literature would treat both the documents submitted by the developer and their evaluation by the regulatory body as involving scientific work, even if no new data are being collected. In the same way, we want to suggest that citizen groups who contest these decisions by critiquing the evidence base are engaged in a parallel form of regulatory citizen science.

METHODS

We are currently working with a local community group that has been campaigning against the biomass plant for many years. The project is a participatory citizen science project to measure air quality, but in working with the group and seeking to understand their concerns, we have also explored their history and motivations. In doing this we have:

- examined numerous documents relating to development of the biomass plant including documents submitted by the community to public consultation exercises, technical and other reports, legal notes, minutes, letters, emails, completed freedom of information requests, press cuttings, corporate records, and transcribed video of council meetings.
- conducted 19 semi-structured interviews with eight leading members of the group who oppose the plant and two representatives of the planning and regulatory authorities; representatives of the developer-operator have so far declined to be interviewed.
- held 24 face-to-face and online meetings with members of the community group, two of which involved the deployment of small air quality monitoring kits designed by academic researchers at Fab Lab in Barcelona (Balestrini et al. 2015).

Notes were taken at all meetings and interviews were recorded and then transcribed. Interviewees were offered anonymity and given the choice of opting out of the project at any time. The written transcripts were then read alongside the reports and other documents with a view to understanding the history of the group, the expertise it has

developed and used in the past, and how our own project might complement their work.

In handling data, we followed standard practice as set out in social science texts such as Prior (2016), Edwards and Holland (2013) and Schubotz (2020). No formal coding of transcripts was carried out and no specialist software was used, but analysis and interpretation was agreed by all three authors.

THE CASE STUDY

In this section, we provide a brief introduction to the planning system of England and Wales followed by a chronological summary of the development of the biomass plant.

PLANNING SYSTEM (ENGLAND AND WALES)

The planning system in England and Wales is based on discretionary control and risk management (Grant 1992, Owens 1994). Local Planning Authorities produce local development plans that seek to balance local needs against regional and national guidance by designating different areas as suitable for particular kinds of land use. In the case of the Barry biomass energy plant, the most important statutes, regulations, and guidance in force at the time were derived from the European Union (EU), a situation that largely continues post-Brexit¹ with EU Directives transposed into various national acts, regulations, and plans.²

Within this legal framework, there is a clear order of preference for the management of waste: recycling, repair, and reuse are the top priorities followed by energy recovery, then incineration, and finally landfilling. This waste hierarchy is operated in conjunction with a proximity principle, enshrined in both EU and UK planning law, that requires waste to be dealt with as close to its source as possible. In the case of biomass energy plants, the proximity principle means that the necessary feedstock should be sourced from within an adjacent region, as any environmental gains in energy generation may be negated by transport pollution if feedstocks are imported.

In the UK, these priorities are enforced through an increasingly neoliberal or market-based governance system in which public-private partnerships (PPPs) are used to incentivise investment in particular technologies. For example, when EU Directives began making landfilling more prohibitive in the late 1990s the UK government's technical advisors responded by issuing subsidies, known as Renewal Obligation Certificates (ROCs), that encouraged PPPs to invest in new energy-from-waste (EfW) infrastructure, of which the biomass plant is an example. These subsidies not only make it more likely that the preferred technology will be adopted, they also provide an imprimatur of approval that makes public opposition more difficult.

2008: FIRST PLANNING APPLICATION AND DECISION

In June 2008, the VGC Planning Office received an application from Sunrise Renewables (Barry) Ltd to construct a "9-megawatt (MW) Biomass Gasification Plant to generate electricity from reclaimed timber" (VGOPR 2008, p. 1). The proposed plant would burn wood waste using a very high temperature technology called plasma gasification that the EC considers a form of incineration (FoE, 2009). The facility would have consumed about 200 tonnes of virgin wood chips a day, creating about 10 tonnes of residual waste known as bottom ash and fly ash. The design life of the proposed plant was 25 years, with an original operating schedule of 7:00 am to 7:00 pm on Monday to Saturday and 8:00 am to 4:00 pm on Sundays and public holidays.

The developer, Sunrise, initially asked VGC's planners for a screening opinion. This is a legal determination concerning whether the developer should undertake a formal EIA. Whilst EIAs are not without critics – e.g., they typically consider the environmental impacts of proposed developments in isolation rather than as an addition to existing sources of pollution – they are a significant regulatory hurdle (Morgan 2012, Barker and Jones 2013). The national EIA guidance at the time (Legislation.gov.uk 1999) and subsequently suggests that an EIA would be required for any development which has the capacity to incinerate more than 100 tonnes/day of non-hazardous waste (Schedule 1, 10, Legislation.gov.uk 1999). As stated above, Sunrise planned to burn 200 tonnes/day but, in a highly unusual move, VGC's planning officers concluded in August 2008 that an EIA would not be required. Instead, Sunrise was asked to meet 27 planning conditions including an Air Quality Impact Assessment, a Sustainability Assessment, a Design Statement and Visual Assessment, and an assessment of the combined effect of the developments in the docks area.

This decision not to require an EIA fell well short of what community groups were expecting. The newly formed Docks Incinerator Action Group (DIAG) and Barry and Vale Friends of the Earth (B&V FoE) began working together to enrol residents, local politicians, and elected members of the Welsh Assembly Government (now the Welsh Government) to argue that VGC's planning officers had made a basic legal error in not requiring an EIA to be undertaken. Some big businesses agreed as well: the Barry Waterfront Consortium, which in 2008 had detailed proposals to build 2,000 houses and flats in and around Barry docks, also refused to support Sunrise's application.

What happened next is a matter of some dispute. After the Vale of Glamorgan's case officer indicated in August 2008 that an EIA was not required, the Welsh Assembly Government's (WAG) Chief Planner determined in June 2009 that an EIA was required. The developer was

apparently upset at the prospect of spending more money, and their agent appealed directly to WAG officers and elected members. Three weeks later, WAG's Chief Planner reversed their determination, stating that the original scoping decision by the Vale of Glamorgan Planning Office (VGPO) was correct and that an EIA was not needed (B&DN 2010). It is not clear precisely what happened to make the WAG Chief Planner completely change direction, although community activists are convinced it represents a case of regulatory capture (Interviewee 2 2021).

In September 2009, after some limited public consultation, the VGC planning committee appeared to bring the story to an end. The elected members ignored their planning officers' advice and unanimously rejected Sunrise's planning application. Although this gave community groups and their supporters some (brief) hope, the developer immediately appealed VGC's decision to the Planning Inspectorate for England and Wales. Again, concerns about regulatory capture circulated in the community, not least because some of the Inspectorate's staff were appointed by the Welsh Assembly Government, which had just concluded that an EIA was not needed (B&DN 2010). There was a similar concern that VGC's planning officers would be unlikely to make a strong case against the plant because their local development plan had already designated the proposed site as suitable for industrial use (Quick and Thomas 2006), and it was their initial decision, now endorsed by WAG, that Sunrise was not required to provide an EIA. These fears were largely confirmed when the Planning Inspectorate agreed with the developer, VGC's planning officers and the Welsh Assembly Government that an EIA was not required. Not only did this enable the development to proceed, it left the Council with an £80,000 bill in legal costs (Jones 2015) and little appetite for further confrontation.

2015: SECOND PLANNING APPLICATION

Despite winning the appeal, Sunrise did not begin construction work immediately. The planning permission it had gained would remain in force until July 2015 (Section 56, HMG 1990) and, with this deadline in mind, Sunrise submitted a new planning application in January 2015. This document included several alterations to the 2008 plans including changing the plasma gasification technology to a gas furnace that could handle more hazardous waste wood such as painted doors and window frames, melamine, chipboard, MDF, and chemically treated wood. The increased environmental risk that this move posed was implicitly recognised in the changes made to the height of the chimney stack, which was increased from 23 m to 43 m in order to disperse emissions more widely (Povey 2017).

Neighbouring properties were consulted in February 2015, with many residents aghast. Critical views focused on a

range of technical, legal, and political issues including traffic impacts, noise, stack appearance, proximity to residential properties, lack of information, the more hazardous feedstock, a lack of guaranteed reuse of waste heat, and the potential health impact of exhaust gases and particulates. Complainants also questioned the impact on air quality, the lack of jobs created for local people, and the impacts upon the Barry Waterfront development and the Barry Island regeneration programme. Objectors from DIAG and B&V FoE correctly stated that the plant, in line with the EC's *Waste Incineration Directive* (EC 2000), is a waste disposal plant, not an energy generation plant as stated in the application (FoE 2009, Interviewee 5 2021). Despite efforts to convince VGC's Planning Committee to reject the scheme, planning permission for Sunrise's revised scheme was granted in July 2015. A number of conditions were attached, but once again there was no requirement for an EIA.

With planning permission agreed, Sunrise transferred its entire business to a new company with different owners: Biomass UK No. 2 Ltd. This disposal made Sunrise's directors nearly £2 million in profit (Companies House 2015). Weeks later, the giant UK-owned insurer, Aviva PLC, took a controlling stake in Biomass UK No. 2 Ltd. The new developer-operator began construction work immediately and at their own risk as the VGC's planning conditions remained unmet and a vital Environmental Permit still needed to be approved by the regulator, Natural Resources Wales (NRW).³

A two-year permitting process began in November 2016, when Biomass UK No.2 Ltd. submitted its application to NRW. Things got off to an unfortunate start with the initial consultation notices placed on NRW's website just before Christmas 2016 and removed on 3 January 2017, once again raising concerns about poor practice and regulatory capture. In March 2017, Barry residents visited NRW's Cardiff office and handed in 150 letters calling for an improved consultation process (Harris 2017). In addition, DIAG contacted an independent researcher whose website – known as Plume Plotter – allowed them to challenge the NRW's assessments of the plant's likely emissions by putting publicly available data into AERMOD, the atmospheric modelling software used by the US Environmental Protection Agency (Plume Plotter 2021).

Finally, in the summer of 2017, and following a number of well-attended protest marches, DIAG submitted a 130-page document to NRW's consultation (DIAG 2017). Drawing on and synthesising numerous scientific research papers and reports, the protesters rebutted many of the arguments and claims made for the plant. In the end, however, the community's efforts proved unsuccessful. After extending its deadline for public submissions of counter evidence, NRW's decision to grant the developers their permit to operate was made on 7 February 2018.

2022: PRESENT SITUATION

Despite this decision, B&V FoE and DIAG continued their campaign, informing VGC and the Welsh Government (WG) in late 2017 that the developer had built a water tower and a number of other structures on the site without planning permission (Interviewee 2 2021). Investigations ultimately led to WG reconsidering the need for an EIA for the plant. The developer, Biomass UK No. 2, responded by producing a voluntary and retrospective Environmental Statement in 2019, but WG rejected this as inadequate. In the summer of 2021, the WG's new minister for Climate Change, Julie James, confirmed that the production of a new Environmental Statement was required from the developer.

These events led to a further round of public consultation, with the community submitting a new 230-page document in January 2022 (Clarke et al. 2022) targeted at the developer's latest Environmental Statement. At the time of writing (August 2022), the developer has recently submitted yet another Environmental Statement and a further consultation period is underway. A final decision on planning permission for the plant, via the VGC and the WG, is expected in early 2023.

WHERE AND WHEN IS CITIZEN SCIENCE?

In this final section, we reflect on some of the moments that mattered in this story and how they relate to ideas of what citizen science is or is not. It seems obvious that the air quality monitoring work that we are currently working on with the community group would, if successful, be seen as citizen science. Our question is whether the earlier engagement with the technical and scientific literature summarised above, and through which claims made by the developer were challenged and the risks posed to the community articulated and defended, can also be seen as a kind of citizen science? In particular, if one aspect of regulatory science is the compilation of dossiers of information that are considered by regulatory authorities, does the work of the community group in producing their own reports constitute a citizen science version of this same activity? To explore this, we focus on DIAG's response to the consultation on NRW's granting a permit to operate completed in 2017 and their later response, (badged as Plaid Cymru) to VGC's and WG's review of planning permission (the Environmental Statements produced via EIA) in 2021/22. These consist of a 130-page document (DIAG 2017) and a 230-page document (Clarke et al. 2022), both of which challenge the developer's claims on a range of legal, political, scientific and technical grounds.⁴

The most straightforward argument – perhaps too simple to count as science at all – is the claim that because the plant can burn 200 tonnes of waste wood per day it

meets the definition of a Schedule 1 development and that an EIA is, therefore, required as a matter of law (Schedule 1, 10, [Legislation.gov.uk](https://legislation.gov.uk) 1999). Citing both the government guidance on EIAs ([Legislation.gov.uk](https://legislation.gov.uk) 2017) and the Town and Country Planning Regulations ([Legislation.gov.uk](https://legislation.gov.uk) 2015a), the community group writes that:

“The Biomass UK incinerator in Barry will burn 200 tonnes a day. This is double the amount required to be classed as Schedule 1, which automatically triggers an EIA. Yet Barry Town did not get this important protection ... The only reasonable thing to do is to obligate the applicant to pay for an Environmental Impact Assessment now, before they can be given a permit to operate ... Otherwise, Biomass UK, the Vale of Glamorgan, NRW and the Welsh Assembly Government may be in breach of UK and European law” (DIAG 2017, p. 44).

Similar procedural arguments are made elsewhere in the document as DIAG's members argue that the proposed development is inconsistent with the aims and principles of sustainable, multi-level governance. These objections are supported by reference to a range of legal instruments, which are operationalised at supranational, national, and regional levels (Supplemental File 1: Appendix A).

In other parts of the documents, the group challenge the future-orientated claims about the plant's operation. In these sections, the argument is more evidence-based, combining scientific knowledge sourced from outside the group with their own local knowledge to argue that the facility fails to meet the necessary standards. Thus, for example, by using the Plume Plotter site referred to earlier, the group was able to incorporate the community's knowledge of local topography into the assessment, something that NRW analysis had not previously offered (Hacking and Flynn 2017), to show that a central area of Barry, including both the relatively deprived Castleland ward and more affluent parts of the new Waterfront, would be affected by the deposition of the plant's waste gas outputs.

These arguments are developed through a division of labour in which local knowledge from within the community is supplemented by individual members of the group being tasked with identifying relevant specialist knowledge from outside. Interviewee 3 described this approach, which was essential if a small group was to produce the detailed dossiers needed to challenge the claims made by the developer, as follows:

“My [child] goes to [a] primary school which is just up from the incinerator. So ... I decided to get involved in whatever way I could. Without any technical knowledge at that point. Without any

knowledge of planning or anything like that ... [We] had the community knowledge and [knew] where the air monitors were ... But any information we wanted ... we'd phone [Interviewee 12] for the air quality, another lady for the planning ... Anyone [who] didn't understand certain things, they would phone us. So, [we] got the technical part done and then fed that onto the others." (Interviewee 3 2021)

Interviewee 2, who is able to recall the health impacts of earlier industries in Barry, gave a similar description:

"There [were] plumbers, electricians, and for a while ... somebody with some expertise in the building of [such plants]. The main skill was enthusiasm. That gave you other abilities. So, when you say to two or three [fellow protestors], 'Right, you go away and investigate this area. See what you come up with and then we'll analyse it.' They [would] go away and do it. There are some members of the group ... whose ability to ... research is phenomenal." (Interviewee 2 2021)

As a result of this work, the group was able to dispute a number of the technical claims made by the developer. A good example of this work can be seen in their use of the *Well-Being of Future Generations Act (Wales) 2015*, a legal requirement to consider sustainable development that is unique to Wales (Legislation.gov.uk 2015b). Under this broad heading, both rebuttal documents (DIAG, 2017, Clarke et al., 2022) consider a range of data, indicators, and targets from across the policy spectrum. They argue that the development is incompatible with this policy commitment as Barry is already suffering from relatively high levels of inequality and deprivation, that transport and other infrastructure is already at/or near capacity, and that the existing mix of industrial activity already constitutes a substantial environmental hazard. Whilst not collecting primary data, the authors of the reports marshal data from a wide range of sources in support of their claim, including:

- Biomass UK No. 2 Ltd.'s 2017 application to NRW for a permit to operate (e.g. contesting the developer's energy efficiency data, see [DIAG 2017, pp. 38–42](#)).
- VGC's travel surveys (e.g., the contestation by DIAG of the official figures for traffic congestion and pollution, p. 50).⁵
- Planning applications and related documents held by VGC.
- Public Health Wales' and others' health data documenting economic deprivation and associated health concerns in different parts of Barry.⁶
- Nongovernmental organisations, such as information about pollutants in plumes published by the anti-

biomass NGO Biofuel Watch (p. 59) and sourced from documents submitted in response to the initial planning application.

- Peer-reviewed air pollution and health reports, including research papers from the University of Leicester (p. 65) and the British Society for Ecological Medicine (p. 67).
- Local knowledge on land-use that challenges the developer's claims re: containment of pollution (p. 74) and the Site Condition Report (p. 85).
- Noise reports and a critique of this by Barry Town Council (p. 77), supplemented by local knowledge, and leading to questions about the methods used to select and aggregate data.
- Examples of accidents and hazards at similar sites and/or in the local area (p. 88).
- Environment Agency concerns about the validity of claims that wood is carbon neutral (p. 90) plus practical questions about plausibility of quality assurance claims made by developer concerning the testing of incoming fuel.
- World Health Organisation claims that nitrogen dioxide (NO₂) air quality objectives are ineffective (p. 114).
- Local knowledge of weather conditions and topography, combined with the Plume Plotter website, to challenge official emissions plume modelling by NRW and the developer (p. 116).
- Expert testimony on nanoparticles given to Senedd Petitions by Prof C. Vyvyan Howard (p. 121) that challenges predictions of the potential for harm from the plant's likely emissions of particulate matter made by the developer.

To take another example of similarly epistemic work, [DIAG \(2017\)](#) argues that the claims made about the plant's emissions and efficiency by the developer are overly optimistic. Here, the calculations and claims made by the developer are systematically deconstructed, leading to a very different conclusion ([DIAG 2017, p. 12](#)):

- The energy used to collect, chip, and transport the waste wood to be used as fuel appears not to be included in the developer's 2017 calculations even though it could and should be.
- Emissions figures for starting-up the plant with diesel fuel are given as "21 tonnes of CO₂ (gas)," but DIAG claims the intended diesel fuel will release around 30 tonnes of CO₂.
- Plant start-ups are assumed to occur twice a year, but DIAG claims the figure is more likely to be twice a day if the option of supplying peak electricity is taken. This would produce 25,000 tonnes of CO₂/year.

- Emissions from the urea and dry lime processes which reduce the emissions' toxicity and particulate levels totals 5,579 tonnes CO₂(e) on figures given by the developer, not the 4,288 that is included in the developer's later calculation.
- The feedstock fuel is said by the developer to be 100% "biogenic," yet DIAG points out that waste wood fuel is around 10% oil (plastics, paint, glue), which will release an additional 19,400 tonnes of CO₂/year.
- The waste wood contains approximately 20% water and the energy used in evaporation and heating the wood is wasted as the gasification technology is not configured to recover waste heat (via Combined Heat and Power). DIAG argues that this process reduces the energy efficiency of the plant by 5.5%.

DIAG argue that, on these calculations, the 37,000 tonnes of CO₂/year offset claimed by Biomass UK No. 2 Ltd is completely eliminated and suggest an alternative carbon-negative figure of -8,000 tonnes CO₂/year, with possible further negatives for chipping and transport.

Similar concerns appear in the 2022 rebuttal document (Clarke et al., 2022) in which the energy efficiency calculations that support the developer's claims that the plant will deliver the required performance are rejected and alternative, more pessimistic, estimates produced to show that the plant will not meet the required threshold.

CITIZEN SCIENCE AND REGULATORY SCIENCE

The activities reported above are a response to the highly procedural and centralised regulations that characterise the planning system of England and Wales in which technical expertise is needed to demonstrate compliance with the relevant standards (cf. Owens and Cowell 2011). DIAG's subsequent work, often in partnership with the local Friends of the Earth group, aims to demonstrate non-compliance with these same regulations and is represented most completely by the 130-page response to NRW in 2017 and the 230-page response to VGC's and WG's planners via one of the Environmental Statements (in early 2022).

Apart from some baseline air quality information, no primary data has been collected; indeed, it cannot be as the plant is not yet operational. Instead, what we see is the review and synthesis of a wide range of technical and scientific data that is combined with local knowledge and then mobilised to challenge the developer's proposals. Our suggestion is that, if the case made by the developers, which includes numerous technical claims intended to demonstrate how the proposed plant complies with the relevant standards can be seen as scientific, then the review, response, and critique of that same information by the community must also be scientific.

In making this argument, it is important to draw some boundaries around this more expansive definition of citizen science. One way in which we can do this is by drawing on the idea of regulatory science and the different activities that fall within this area. Whilst definitions of regulatory science are notoriously vague, and the origins of the term itself claimed to be obscure (Callréus and Schneider 2013), the idea of regulatory decision-making being informed by scientific or technical evidence is well established. If this is accepted, then responses to the regulatory use of science by citizens, regardless of whether they involve primary data collection, would, on our definition, also fall under the remit of citizen science. In contrast, objections based on other grounds (e.g., that statutory notice periods had not been followed) would not count as citizen science and nor would work on political campaigns to change the elected representatives responsible for the decision.

Finally, it is worth noting that the community group has begun to develop its capacity to engage in more traditional forms of citizen science. This move is prompted by concerns that their most recent attempts to block the planning process may not succeed, and that their approach may have to change to monitoring compliance with regulations once the plant is operational. The longer-term intention is to build links with secondary schools and to encourage students to take an interest in their local environment and wider environmental issues, but the short-term focus is very much on documenting any pollution from the biomass plant should it begin operations. Our current project thus centres on the creation of a network of air quality monitors, including both small-scale, easy-to-operate Arduino microelectronic devices and one professional, industrial-size station. The obvious irony is that even if this activity were to succeed, and regular air quality data for the town become available, it would be of little or no use in their current battles. Nevertheless, to say that this activity counts as citizen science but their previous, more relevant campaigning does not, is precisely why a more inclusive definition of citizen science is needed.

CONCLUSION

In this paper, we document a community's responses to the environmental risks they see being created by a proposed biomass energy project. Over time, this informal network of individuals and institutions has self-organized and evolved to challenge the assumptions and practices of the biomass plant's developers, the local planning authority, and the regulator. This group has developed an impressive array of technical expertise through which they have produced an alternative dossier of regulatory information that challenges the formal risk assessments made about the plant.

In opposing the development of the biomass plant, the traditional model of citizen science as data collection is of no use to DIAG as the plant is not yet operational so there are no emissions to monitor. We have, therefore, argued for a more inclusive definition of citizen science that reflects the heterogeneity of work that characterises other forms of science and, in particular, that associates it with some aspects of regulatory science. The argument is essentially one of parity: If contributing to the dossiers of information used in regulatory decisions by reviewing, critiquing, and synthesising existing work can be seen as scientific and, hence as “doing science,” then citizens engaged in the same activities in the same regulatory settings should likewise be seen as doing a form of citizen science. To suggest otherwise, is to offer an unnecessarily impoverished and restricted view of its potential.

SUPPLEMENTARY FILE

The Supplementary file for this article can be found as follows:

- **Appendix A.** Legal instruments. DOI: <https://doi.org/10.5334/cstp.503.s1>

NOTES

- 1 For example, the *Waste Framework Directive* (EC, 1975) plus its subsequent amendments. Also, the *Directive on the Landfill of Waste* (EC, 1999), the *Waste Incineration Directive* (EC, 2000) and the *Industrial Emissions Directive* (EC, 2010).
- 2 For example, the *Waste Minimisation Act* (HMG, 1998), the *Pollution Prevention and Control Act* (HMG, 1999) and the *Landfill Regulations* (Legislation.gov.uk, 2002a), the *Waste Incineration Regulations* (Legislation.gov.uk, 2002b), *Environmental Permitting Regulations* (Legislation.co.uk, 2010), and the *Waste Regulations* (Legislation.gov.uk, 2012).
- 3 NRW was created in 2013 from the Environment Agency Wales, the Countryside Council for Wales, and the Forestry Commission. At the time, licencing of environmental permits was governed by the *Pollution Prevention and Control Act* (HMG 1999).
- 4 An updated document has also been submitted as part of the latest consultation but we do not consider its contents in this paper.
- 5 Also supplemented and updated by local knowledge re: existing hazards (DIAG 2017, p. 54) and new/planned developments including residential areas, supermarkets, and leisure/tourist attractions.
- 6 For example, *Respiratory Health Annual Report* (C&VUHB 2016); *Vale of Glamorgan Well-being Assessment Consultation* (VGC-PSB 2016); *The Welsh Index of Multiple Deprivation*; *Child Index 2011* (WG 2011); Estyn Reports and research studies on health and social inequalities (DIAG 2017, p. 71).

ETHICS AND CONSENT

This research was reviewed and approved by the School of Social Sciences Research Ethics Committee (reference SREC/4079).

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

All three authors contributed to the design and conceptualisation of the overall project, with Evans taking a lead on the conceptualisation of this paper. Hacking led on data collection with all three authors contributing to data analysis and writing up.

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