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Abstract

Emissions of CO_2 from energy-intensive industries stand for a substantial part of the fraction of the greenhouse gas emissions that contributes to global warming and climate change. Among the policy and technological instruments for reducing CO_2 emissions are market-based policies and optimised technological processes including Guarantees of Origins, climate quotas, renewable energy carriers, energy efficiency and recirculation of energy and wastes. This article reports from a study of local energy practices that seek to fulfil both global climate ambitions and economic ambitions at company level. We identify three main local operationalisations of energy sustainability, relating to the energy carrier, energy efficiency and energy circularity, which are sought connected to the global climate ambitions through concepts of sustainability, politics of sustainability and rhetoric of sustainability. At heart of the challenge of performing this connection is the necessary adaptation of frames and scales to account for emissions and emission reductions. This article shows the complex relation between local practices and global consequences, and how some policy instruments on the one hand takes such connections for granted while on the other hand defines frames that allows for different pathways between the two.

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Think locally, act globally: local energy practices and global climate commitments

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Keywords: Energy sustainability, CO_2 emissions, energy policy, global warming, climate change

1 Introduction and background

As one of several measures to counter global warming and climate change, sustainable industrial energy practices have received increased attention. While energy production still relies heavily on fossil fuels contributing to significant CO_2 emissions, addressing energy *consumption* is still a prioritized strategy to ensure energy sustainability and mitigate climate change. Explicit goals for energy efficiency is manifest at many societal levels, from the local and regional/national level, where a particular example is energy efficiency goals via the EU – through the EU Energy Efficiency Directive and other mechanisms such as EU ETS (emission trading scheme) and Renewable Energy Directive – to the global level as reflected by the Kyoto protocol (United Nations 1998) and the Paris agreement (United Nations 2015). The connection between consumption practices and global emissions are seemingly clear in regions with fossil power production. Such connections are less obvious in regions relying heavily on renewable energy production. In this article we trace how such connections are argumentatively constructed in a context of surplus renewable electricity production.

While power production in Norway is largely based on hydro-electric production and 98 % of the national electricity production comes from renewable energy sources, access to reliable and reasonable priced electricity has extended the range of application (i.e. cooking, manufacturing, heating of buildings) and increased focus on electrification of traditionally fossil based industries (i.e. offshore oil production). Also, following the integration of the Norwegian and the European power markets, Norway now has a net export of electricity (SSB.no). Sustainable industry practices in Norway are still framed within the paradigm of energy efficiency reflected in national policies and incentive systems (i.e. dedicated energy fund administered by the state enterprise Enova). However, the link between local energy practices and global emissions is blurred. In this article we argue that the connections between local energy practices and reduced carbon emissions in a Norwegian context is not given – it rests on conditional arguments traversing scales from the local to the global, sometimes in intractable ways.

With the different scales at which sustainability is brought into relevance, the discourse withdraws from simple tales of causes and effects. To understand energy sustainability as a multifaceted phenomenon akin to practical and ontological as well as discursive realms, particular attention needs to be paid to the translations that take place to support scale-transcending discourses. Inspired by the approach to controversy research of Science and Technology studies (Sismondo 2010, Latour 2005) and the particular research tradition and literature on framing and overflowing (Callon 1998), we set out to explore how authorities and regulators' approaches to climate change is coupled with local industrial energy practices in Norway. The occasion for addressing and accessing this is a large research project supported by the Norwegian Research Council, aiming at implementing energy efficiency measures to empower Norwegian industry to become the worlds' *greenest* - operationalised by a 20-30% reduction of energy use, and a 10% reduction of climate gas emissions[1].

The connection between local energy efficiency practices and global emission reductions are dependent on a consistent reference practice with respect to system boundaries. The aim of this article is to answer the following question: *how are connections constructed between local energy practices and global climate sustainability, and how are seemingly incommensurable scales aligned into environment-political acceptable reconciliations?*

1.1 Reaching the targets

In this study we investigate the connections between local industrial energy practices and global climate sustainability in terms of reduction in emissions of climate gases, and we explore how energy-intensive industries form connections between local energy practices and global climate sustainability.

1.1.1 Energy efficiency

Energy efficiency is a valued strategy for mitigating climate change. However, the link to reduced carbon emissions is ambiguous; in best case it is indirect, in worst case it is missing. In general, energy efficiency refers to using less energy to produce the same amount of services or input (Patterson 1996, 337). A similar definition has also been adopted by the European Council as 'the ratio of output of performance, service, goods or energy, to input of energy' (Directive 2012) and IEA "more services for the same energy input, or the same services for less energy input"[2]. As Shove (2017) notes the purpose is at first sight plain:

> *"to reduce the amount of energy used and the carbon emissions associated with the design and operation of things like buildings, domestic appliances, and heating and cooling technologies, or with the organization of bureaucratic, business or industrial processes" (Shove 2017, 1).*

Ideally, energy efficiency has a double positive impact. While the overall system performance – useful work done – remains stable, energy consumption and the related emissions as well as energy costs for the consumer will decrease, implying that energy efficiency may work for both the climate and for the wallet[3]. These implications have resonated well with political efforts leading to a multitude of policy instruments to promote energy efficiency. In Norway, the most prominent policy instrument is the state enterprise Enova which through the Norwegian Energy Fund provides financing to energy efficiency initiatives, projects and technologies in both households and industry. Also, the government has a multitude of requirements for new industry establishments to use the best available technologies and investigate possibilities for utilizing surplus heat sources.

While the climate effect of energy efficiency rests on the assumption that a fixed system based on fossil-fuelled production that increases its energy efficiency will use less energy and emit less CO_2, criticism has been issued that this assumption is not always true. While short term and long term impacts are debated, the argument is that reduction in energy costs induced by energy efficiency, lead to rebound effects resulting in an actually *increase* in energy use and CO_2 emissions (Herring 2006).

[1] Source: the home page of HighEFF: https://www.sintef.no/prosjekter/higheff/.
[2] See http://www.iea.org/topics/energyefficiency/.
[3] However, accounting for energy efficiency and gas emissions may be challenging, since the system boundaries within which the calculations are done are often unclear and uncertain, and they also tend to be permeable. Callon (1998) has topicalised these challenges through the concepts of framing and overflowing, and in practice these phenomena pose challenges to studies and accounts of energy systems (see e.g. Haavik, Røyrvik, and Lindheim 2017)

A more fundamental critique is raised by Shove (2017) arguing that the fixation on energy efficiency misses the target of what energy is, what it is for, and that it essentially contributes to stabilising carbon intensive practices instead of replacing them. .

According to Shove (2017) the issue with energy efficiency policies is that they work to actually support unsustainable practices; "the problem with efficiency policies is that they are much too effective, not in reducing demand but in reproducing and stabilizing essentially unsustainable concepts of service" (Shove 2017, 7).

In a commentary to counter this critique Fawcett and Rosenow (2017)[4] argue that the aim of energy efficiency programmes should be to reduce the *total energy consumption* levels rather than focusing solely on relative efficiency improvements. This is in line with (Wilhite and Norgard 2004, 1003) argument that we need a new policy paradigm which "one that aims at combining *efficiency of technology*, with *sufficiency in energy services*, leading to significant *reduction in energy use*[5].

1.1.2 De-carbonization policies

In the early days of public discourse and research on global warming issues, much of the focus was on chlorofluorocarbons (CFCs) that lead to depletion of the ozone layer and – similarly to CO_2 – prevent radiation from exiting the atmosphere. The experiences from the regime of forbidding the use of CFC gases as working medium in a broad range of products and processes showed that when alternatives exist, hard constraints may be effective to promote change. However, prohibition is generally not a preferred strategy, at least not in the western hemisphere where the combined expectations to democracy and the free market shrink its legitimacy and thus play a marginal role in many consumer contexts. In parallel with the efforts to reduce the use of CFC gases, acid rain resulting from SO_2 represented another serious environmental problem. During the 1990'ies, however, acid rain went from dominating the environmental debate to being a learning piece for market based environmental governance. The *cap and trade* regime adopted in the US to solve the acid rain problem has been described as a success – and a success recipe – and when the EU ETS[6] was launched as the main strategy to respond to climate change, it was inspired by this SO_2 cap and trade scheme (Chan et al. 2012, Brown, Hanafi, and Petsonk 2012). The EU ETS regime was introduced to Norwegian industry in 2008.

The bearing idea of cap and trade is that the market provides cheaper and more efficient instruments than do hard regulations when the goal is to reduce the use of a product or a process when (nearly) equally good alternatives do not exist. By putting a price on a product and regulating the total allowances instead of the individual usage, those who can easiest replace the product will do so, while those who are depending stronger on the product, and can afford to pay for it, will do so. In addition there is a slow, but steady reduction of the total allowances. In this manner, the prices for discharging CO_2 will in theory steadily increase, while the users also get some time to migrate to alternative products or processes.

One challenge with the ETS is that it is so tightly connected to market principles, while in practice the assumption of perfect markets is frequently faced with the market's many imperfections (Callon 1998). Constructing a market, the agents and goods to be taken into account – the precise boundary or framing – needs to be explicit, in order to have a consistent price calculation and facilitating transparent trading. However, such boundaries are always challenged, and there is no framing without overflowing – externalities that are not accounted for (Callon 1998). For example, when a Norwegian steel factory is charged for emitting CO_2, two types of overflowing may occur: First, due to this extra cost, the final steel product will be more expensive to produce, the price will be higher, and hence products from countries

[4] https://bricommunity.net/2017/11/02/what-is-right-with-energy-efficiency/
[5] https://www.researchgate.net/publication/258260636_Equating_Efficiency_with_Reduction_A_Self-Deception_in_Energy_Policy
[6] The European Union's Emission Trading Scheme for greenhouse gases.

outside the ETS market will be relatively cheaper and take a higher market share. Second, the Norwegian factory may choose to outsource the steel production to a country outside EU, where they can emit CO_2 without incurring extra costs. Hence, several exceptions have been put in place to mitigate leakage of businesses to countries without – or with less strict – regulations.

A debated policy instrument in Norway is the CO_2 compensation for increased electricity prices due to the EU ETS induced price increase on fossil-fuelled power production. While the Norwegian energy balance is characterized by a surplus of renewable electricity from hydro-production, the participation in integrated power markets (NordPool) has led to import of increased prices from fossil-fuelled power production in Sweden and Denmark. Since this implies increased prices also for the hydro-electric consumers in Norway, industries which are in risk of carbon leakage can receive compensation for the price difference by the Norwegian government.

Another policy instrument based on a market principle relevant for this context is the Guarantee of Origin (GO). This financial policy framework assumes an integrated power market in Europe allowing businesses in a market where a product's carbon footprint is a demanded quality to buy GOs to account for their primary electricity input coming from renewable sources. The rationale for this is that industries can document a *green* origin of their energy consumption[7] and thus increase the value of renewable electricity.

As we shall see, these policy frameworks serve an important role in connecting local industry practices to the global climate targets.

2 Method

The article is based on interviews, field visits and document studies of local practices of Norwegian industry companies. In the article we mainly report on findings based on case studies of energy intensive industries in the process and metal sector, but other sectors (i.e. industrial food sector) and actors (public municipalities, business networks) are also represented in the material. While some of the companies are co-located in industry parks hosting a multitude of companies, the interview material also include cases of single-plants located in rural areas. A key selection criteria was to include cases based on their efforts to recover, reuse and reduce energy consumption, but the material also include cases without concepts for utilizing surplus energy locally.

Particularly interesting for this study was efforts to re-use excess heat from industry processes, waste water, as well as two examples of utilization of CO-rich off-gas – a waste gas from ferro-alloy production – as an energy carrier for heat production. In addition, we conducted on-site interviews with representatives of three stand-alone energy intensive companies within the metal and process sector in Norway. Also here, utilization of CO-rich off-gas and/or surplus heat for power production and/or district heating was fronted as existing or wanted strategies for sustainability. The material also includes interviews with facilitators and companies in a newly started co-located industry network with an expressed ambition of becoming more energy sustainable. Finally, interviews from a former project in a second industry park in the industrial food industry as well as a city neighbourhood were reused. The industry cluster which was re-analysed for this purpose was previously examined in 2010 and involves four industrial food companies. Both of these cases also included efforts to reuse surplus heat and strong focus on energy efficiency, and parts of the material was found particularly relevant for tracing the connection between policies and industry practices.

We studied energy strategies qualitatively to explore how the businesses argue for their energy choices, and to scrutinize the traces to and from high-level policies such as national and EU energy policies, and global environmental climate goals reflected by the Kyoto protocol and the Paris agreement. The main set of interviews was conducted in the period from autumn 2017 to autumn 2018 and included field visits and

[7] In the context of this article, green should be understood as *climate sustainable*.

interviews with representatives from the companies. In total, the study involves interviews with industry companies, energy companies (including district heating provider), coordination actors responsible for infrastructure and development of an industry park, as well as public actors (local municipalities, regional support actors). The main interview extractions are however based on the industry representatives.

One to two persons were interviewed in each company, and the interviewees represented the managerial level as well as the engineering level and operational personnel. A semi-structured interview guide was prepared and used as a departing point for the interviews. Topics covered in the interviews included energy efficiency strategies, energy sources and use, energy recycling and circular economy, the EU ETS for CO_2, and other taxation regimes related to energy consumption and residual gases and waste. While the interview guide was of good help, particularly in the initial interviews in the first cluster, the discussions tended to take a more open and explorative turn as we developed a richer understanding of the topics. During all interviews, two researchers collaborated, allowing us to discuss particular issues both before and after interviews, and thus to have a richer repertoire when analysing the material from the interviews.

All interviews were audio recorded and transcribed. Thereafter, an iterative coding process was initiated, whereby themes and topics where identified and refined. In addition to the interviews, public documents on the energy efficiency measures, energy use and emissions in the industry park, official statements, and government emission allowances were scrutinized to achieve a thorough understanding of the industry park and its framework conditions. Also key national and European policy documents on energy efficiency, EU ETS and taxation regimes (Directive 2012, Brown, Hanafi, and Petsonk 2012) were important sources of information.

3 Framing "sustainable" industries: Energy- input, efficiency and circularity

While the metal and process industries are highly energy-consuming industries with significant CO_2 output, this industry is acknowledged publicly by Norwegian environmental organizations as an environmental friendly industry park both in a national and international context. The main arguments for framing the industry as environmental friendly are the energy practices including energy input, recovery and exchange as well as energy efficiency measures within the companies. Hence, articulating the industry as *sustainable* or *green* largely rests on arguments of *energy input*, *energy efficiency* and *energy circularity*.

3.1 Energy input and proximity

Much of the energy-intensive process and metal industry in Norway is located in close proximity to hydro-electric plants ensuring stable access to electric power and minimal transmission leakage. Access to traditionally reliable low-cost hydro-electricity has been characterized as a key frame condition and competitive advantage for Norwegian industry where wages are generally higher than they are for many of the competitors. Proximity to hydro-electric power is held by several informants as their key environmental competitive advantage. By drawing on comparisons with similar plants in the Nordic countries or Europe with respect to availability and usage of renewable sources, the scrap metal plant is labelled the most energy friendly in the world:

> *"What contributes the most here is our proximity to hydro-power. There are no other such steelworks in Scandinavia; our competitors are further south in Europe. So, it is this proximity to hydro-power that is decisive when we see on the PowerPoint presentations that we emit considerably less CO_2 compared to the rest of the steel industry."*

While the energy production is in one sense outside the system boundaries of the individual companies (or a larger industry park), the proximity to this renewable energy source is a key argument connecting the industrial activities in the park to a green discourse.

The biographies of kilowatts are seldom documented, and the actual physical electrons in the power grid are not accounted for when energy practices are portrayed. Hence, system boundaries defining the reference for energy regime accounts may well be set to include adjacent renewable energy producers to support the argument that the energy carrier is hydro-electric power from the region:

> *"You know, we have eight hydropower plants in the region, we produce 5-6 TWh and we export a surplus of 1%. And everything goes into the central grid, so where the electron goes is hard to say. Theoretically, we should use everything here in the region."*

The increasing integration between the Norwegian and European power market and the policy instruments taking a "European power market" for granted, is a subject of controversy that challenges the 'input argument'. The controversy is to some extent connected to the missing transparency of import and export of electricity from the region which especially becomes acute when discussing the policy instruments which assumes an integrated power market in Europe such as GOs (Guarantees of Origin) and the effect of EU ETS and CO_2 compensation on electricity prices. The proximity and use of hydro-power is here used non-falsifiably in an argument that the total emissions from the park must also account for the emissions generated by the production of the power consumed by the park, and implicitly that this may gives an industry park a relative environmental advantage.

> *"…in addition we depend on EU, and EU is not sure how they shall price the CO_2 and how this compensation… I hope the Norwegian government will see to that those who only use hydropower… you have to look at, in a way, the total emissions. Both in relation to power production, but also CO2 emissions in the other end. Or else we will be punished."*

The argument of CO_2 compensation for industries relying on hydro-power is made by looking at 'total emissions'. Thus, industries in close proximity to renewables are 'punished', since the price increase for electricity from power producers from fossil fuels are imported to the park, while the electrons produced by these non-renewable resources are not necessarily so. Expanding the system boundaries to include the regional hydro-power production indirectly serves the argument that proximity to renewable energy sources should not be punished by an additional CO_2-fee for the power production.

At the same time, the transformative and fast-travelling nature of power makes Euclidian space a dubious reference for the origin of electric energy. When the physical process of energy production is black-boxed into the form of a GO document, an indispensable context of power production gets lost at the price of immutability and mobility[8], as the document – in the self-contradictory form of a tradeable certificate – represents a final breach between the greenness of energy as a commodity and the brownness of its genesis:

> *"… in addition there are these… to sell Guarantees of Origin and those things is also a contra-productive instrument. The largest actor in Europe is Iceland! There is not a single power line from Island to Europe, and still they establish a data centre in Germany that has Guarantees of Origin from Iceland. It is totally nuts, it is only speculators that think that this is positive. Of course, those things… if those instruments become standard it will have a devastating effect on the industry."*

The example illustrates a problematic aspect of the market policy where the local practice of acquiring GO's only through highly intractable ways is connected to the global goal of reduced carbon footprints. While the policy instrument assumes a true integrated power system, the integration involves ruptures that are bridged with methods that allow policy references to cross, but not their electron and hydrocarbon referents. The traveling of electrons is in this case transparent in the sense that they cannot travel from Iceland over the Nordic sea to Germany. Essentially, as one of the informants notes, the implementation of

[8] See Latour (1986) for an elaboration of the functions of immutable mobiles.

GO's separates the 'green' from the physics and into a political product, thus disrupting the link between physical proximity to renewable energy production and actual use of renewables.

> *"When you separate it from the physics and make a political product out of it, like this, making it possible for someone who live near a coal-fired power plant south in Europe merely to buy a guarantee, a piece of paper, and to show it to the neighbour and say: 'look what I've got, I use renewable energy!'"*

Although the GO's do not affect the CO_2 compensation, informants argue that it can disrupt the environmental reputation of their hydro-electric input, as GO's impose extra costs even though the power according to the proximity argument comes from renewable sources:

> *"Yes, you get a compensation for the CO_2 tax on the power, since our power is renewable. Even though it is an issue with those Guarantees of Origin, that even if you use only hydropower you have to buy the Guarantee, a little… it doesn't cost much, but it is a nice extra income for the power companies."*

3.2 Energy efficiency

The companies in the industry park have also sought to improve the efficiency of sub processes in isolation, and of the overall energy efficiency within the boundaries of the individual companies. The informants draw on a traditional energy efficiency discourse of 'doing more with less'. The industries have succeeded in continuously increasing the efficiency of their processes, using less and less energy on each unit produced:

> *"We work continuously towards (…) new methods. We have reduced the power use the last ten years. Before we used 103-110 kW per ton burnt material, now we use around 70. So it is a job all the time to cut the energy use."*

The objective of comparison is in this case the historical energy expenditure of the individual company. Another informant reflects on the improvement in energy utilisation in this way:

> *"Yes, the last 5-10 years there has been a focus on work to reduce energy consumption in this company. That has resulted in 4-5 applications for investment grants, for energy reducing projects."*

The energy intensity [9]of the products is used for comparisons between similar industries. These efforts are clearly fronted by the informants as economic rational both by acquiring government support for capital investments in energy efficiency measures as well as lowering operational costs. In addition to being an economic incentive with direct contribution to the bottom-line, one also argues for connecting energy intensity to a discourse valid within the system boundaries of the whole European power system.

> *"And when it comes to energy, there is no doubt that when we work to reduce the energy consumption, it is both because it is environmentally sound, since we influence the energy balance in the whole Europe. But to save energy is of course also an economic incitement."*

This shifting of the frame of reference from local to regional, thus up-scaling the range of scope and extent of efficiency, requires an additional expansion of the system boundaries to the European energy balance that rests on an underlying argument that green hydro-electricity that is not utilized locally can affect the

[9] Energy intensity is calculated as units of energy per unit of GDP.

energy balance in Europe by displacing fossil power production. Thus, integration of the power markets here 'work in favour' of the connection between the individual local efforts and global sustainability.

3.3 Energy circularity

While most Norwegian energy-intensive industries share the beneficial frame condition of renewable hydro-power as the primary energy source[10], a key argument for several informants is energy *circularity*. In addition to drawing links between local energy- input and efficiency, some cases where several co-located companies utilize waste streams argue that energy circularity is a key measure for sustainability. This includes recovery of excess heat from cooling water and hot gases to be used internally, externally or through energy recovery systems (heat to power). Surplus heat from the industry is often used for district heating in nearby towns, public buildings, soccer fields or as primary heating source for nearby industries. Particularly interesting was two distinct cases of external utilization of CO-rich off-gas in 'circular' concepts where recirculation of the gas is one of the central arguments for connecting the park to a green discourse. This gas is a by-product of the ferro-alloy production process, and while the gas releases significant amounts of CO_2 in the combustion process (even more than alternative energy sources such as propane and crude oil), the gas would otherwise be flared. The fact that it is already a 'waste material' makes it an eligible energy carrier that otherwise would remain a waste material with flaring as the only option, implying that all contained CO_2 would be released anyway. One of the informants reflects on the environmental benefits of using this by-product when discussing the upcoming and still uncertain revision of the EU ETS regime in 2021.

> *"You know, the CO gas is so special that it might well be made exception for. It is, after all, a real societal treat or an environmental treat. If we don't use it, it will disappear unused, or through that flare… () What we do is that we bring it into our processes and use it for heating and redistribution of energy."*

As with the proximity argument connecting energy-intensive processes to hydro-electric, green power, the utilization of CO-gas is also a matter of energy input, although with the difference that CO-gas releases considerable amounts of CO_2. The labelling of CO-gas as an "environmental treat" situates the by-product in a circular context, where the use of this resource for heating and redistribution of energy is beneficial compared to the alternative; the gas would be flared only to emit the same CO_2 without contributing to any useful work. On top of that, additional energy sources would have to be used for "heating and redistribution of energy". The connection to a green discourse is hence made through housekeeping principles that do not account for the dispositions in the neighbourhood. One of the CO-gas consumers interviewed argues that it actually has a negative effect on the internal company's accounting of environmental product declarations as well as the reporting of emissions to the EU ETS. Since the CO-gas releases more CO_2 in the combustion process than alternate fuel sources, it affects the company negatively both through the environmental product declarations as well as the emission reporting to the government[11].

> *"CO gas does not really contribute positively to that account. There is more CO_2 in the CO gas than in oil."*

The argument for still keeping the CO gas as primary energy carrier is partly pecuniary, but the informants also maintain the – with reference to circularity – green argument by playing with system boundaries to support the argument's validity in a wider context of an industry park:

[10] Provisio: as mentioned already, in an integrated energy market the physical source of energy is not always easily tractable.

[11] These emission rates are then the basis for EU ETS credits.

"First, there is the economy. When we summarise, it is profitable to utilize the CO gas. And second, it is part of a local, in a way, environment concept, too. It would be pretty strange if we should contribute to flaring of the CO gas over there, it would have resulted in even similar and even higher CO_2 emissions"

While changing to alternative fuels would reduce the individual company's overall CO_2 output, this would be in disfavour of the total CO_2 output of the park. Thus, understanding the link between local industry practices and the effects for the industry park requires a minimum of sensitivity to energy and waste accounts within different system boundaries.

"There is a risk associated with going solo, to think individually and do individual projects that are best for us but not necessarily for the total, the best total result for the industry park. It would be good if also the government shared that perspective."

As one informant notes, sketching an alternative scenario where more hydrocarbons are used, circular concepts can thus reduce the amount of "virgin" hydrocarbons:

"…it can be an alternative to what I call virginal hydrocarbons as an energy carrier."

A similar argument for climate sustainability is found in the recirculation of water in an industry cluster.

"We use the water five times, or for five different objectives. There are two small hydropower plants, all the water comes in one place and flows out one place, so those two hydropower plants produce around 26 GWh. It is used for cooling of ovens, it is used for smolt (salmon) production and then there is ordinary household usage, shower, drinking water and those applications. So, five different areas of application for the same water."

The connection between circularity and climate sustainability goes through efficient use of the water resources, having it contribute to as many work processes as possible (doing as much *useful work* as possible).

The connection between a circular concept and the green discourse is thus closely linked to the scale of reference – the system boundaries. Still, we see that after having lent support from these frame conditions, the arguments sometimes live their own, de-contextualised but circular lives and are forwarded unconditionally to support a specific energy choice, as if re-use per definition is always more preferable from an environmental perspective. An interesting perspective is the argumentation for establishing new industries to utilize surplus energy, in this case excess heat

"That you get a little surplus in the economic balance is of course good, but it is just as important that you have a footprint that actually shows that we have reduced the CO_2 in total because then the energy we produce will be 'green'."

The argumentative link between new industry and reduced CO_2 here depends on the circularity of energy. However, while the energy recovered and re-used might provide an improved footprint for the industry delivering surplus heat, the link to global emissions will be intertwined with other conditions and scales regarding the total impact account in the new industry.

The connection between circularity and climate sustainability is also articulated at sector level by some of the informants referring to a fresh report on green competitiveness (Hedegaard and Kreutzer 2016), indirectly demonstrating this principle by subtly drawing a connection between circular economy, competitiveness and climate sustainability:

"There are many examples of circular economy, and you know this Expert Committee for Green Competitiveness, they were here a while ago, and delivered their report last year. One part was

> *the roadmap for the process industry, and in that roadmap our park is mentioned in positive terms in two areas: energy efficiency and circular economy."*

Where the travelling of the electrons through the national and European grid cannot be easily traced, the water and gases are directly used and are traceable within the system. However, if the analytical system boundaries are drawn around individual companies, the CO_2 emissions would appear to be higher than with alternative fuels. The argument for climate sustainability needs scaffolding from accompanying, scale-adapted system boundaries. An important question, whose answer will always be empirical and context specific, is what set of framework conditions – and at which scales – local industry processes need in order to build both strong arguments and strong practices of climate sustainability.

4 Discussion

The relations between local energy practices and global climate sustainability are so intricate because the pathways, fluxes and effects of the relations are not only of a physical, but also of a conceptual, political and rhetorical nature. Leaving the controversies on human induced climate change aside[12], we seek to understand the paths and the qualities of these connections, and to make them explicit in order for the discourse on energy sustainability as a means to meet climate goals to become more transparent. The current study is merely a starting point of this work, a pinprick that does not aim at providing an exhaustive account of these relations, but to bring into the discourse elements that may facilitate the alignment of arguments and transparency of contradictions. The concept of sustainability, the politics of sustainability and the rhetorics of sustainability – as they appear in concert with the physics of sustainability – reminds us that the climate system is not merely a climatological system, but it is, in the widest meaning of the term, a *sociotechnical* system. In the following we shall discuss particularly those aspects of this system with social connotations, to see how they infiltrate the technical/physical aspects.

4.1 *Concepts* of sustainability

The discourse on green industry practices as a response to climate challenges leans heavily towards the combined concepts of energy input (or proximity to energy inputs), energy efficiency and circulation of surplus energy and waste material streams. However, such concepts are in need of frames of reference to produce the connection from local industry practices to global emission reductions. As showed above, the informants craft these routes between the local and the global by drawing on different system boundaries depending on which concept of energy sustainability to be articulated.

The concept of energy input involves framing the connection physically, combining claims of the proximity of the industry to hydro-power plants with the physical, probable, route of electrons to the electricity consuming industry processes. The concept of energy efficiency expands the system boundaries to an integrated European (or Nordic) electricity market where reduced energy demand locally displaces fossil-fuelled energy production in Europe, essentially connecting the local efforts with global emission reductions. The concept of circulation extends the system boundaries from the single company to involve companies connected through energy circulation, by referring to the total reduction in CO_2 emissions and input of 'virgin' energy sources from the framed system instead of the single company.

[12] Important, however, we here (and in general) acknowledge the physical (including meteorological, oceanographic and geological) mechanisms and processes justifying the global climate and temperature diagnosis and goals established in the Kyoto protocol and the Paris convention, and the operationalisation of these in the form of restrictions of emissions of CO_2 and other climate gases.

While the connections between the local and the global 'makes sense', they are not unequivocal. An obvious theme to address is the different system boundaries articulated depending on the concept under scrutiny, while they in practice exist at the same time. While the flexibility of a Nordic electricity system provides benefits in the form of reliable supply (physical energy), for example, the import of energy prices (political energy) must be compensated. The frames of references involve a continuous inclusion and exclusion of political and material elements.

The problem does not necessarily lie in the particular traces produced between the local and the global in different contexts, but rather that these alternate 'routes' between the local and the global co-exists seemingly without contradiction. While our informants draw on the (probable) physical route of green electrons, companies purchasing GO's in other countries can make the same connection by drawing on the political route of the 'greenness' of electrons. The challenge of justifying local 'energy input' can either be viewed as a problem of accountability (not being able to trace the actual electrons from the hydropower plants) or a problem of greenwashing fossil-fuel energy production by separating the 'greenness' from the electron. However, the co-existence of these two possible routes complicates the connection between local energy practices and global emissions and opens the possibility of double accountancy by aid of certificates of origin.

Similarly, alternative routes can also be challenged for the other concepts of sustainability. While the connection between local energy efficiency and global emission reductions begs a political question outside the control of the companies; to what degree is the saved energy really *saved*, as in *not used* and does it actually reduce fossil-fuelled energy production elsewhere? What *conditions* does recirculation of surplus energy presuppose in order for it to be sustainable? This is particular interesting for the example of establishing new industries in order to utilize surplus heat as indicated by one of the informants. Whether this represents an 'actual' decrease in emission is depending on several other conditions; does it imply closing down of industries elsewhere? Would it be built anyway? The routes between the local and global are inherently intertwined with infrastructures, policies and political considerations.

4.2 *Politics* of sustainability

Accounting for energy sustainability may be challenging since system boundaries within which calculations are done are often unclear and uncertain, and they also tend to be permeable. Callon (1998) has tropicalized these challenges through the concepts of framing and overflowing.

The level of analysis – that is, the system boundaries within which energy calculations are done and energy choices are justified – is a crucial aspect of the building of a strong argument. Inclusion and exclusion – an essential political activity – is at play when informants sometimes argue with reference to a single company, and other times to industry parks, regional or national systems.

Often, the latter is the case, as when arguing that using CO gas as a primary energy carrier is preferable from a sustainability perspective with reference to a larger context of a park or bi-lateral cooperation between companies. In the alternative case with the CO-consuming companies using alternative energy carriers such as oil/propane, many of these would actually have lower emission rates, although the emissions from the industry park as a whole would be higher.

The development of 'circular economy' as a field represents a step-change from an energy sustainability perspective. Not due to the degree to which circular economy contributes to energy sustainability, but because the politics of defining the circle democratises energy sustainability. But there are sustainable democracies, and not so sustainable democracies; if it is up to each and everyone to define the context – the frame – of circulation, without respect to the actual global emission reductions the circulation contributes to, the politics of sustainability will eventually experience serious challenges when faced with the *realpolitik* of nature. That is why any argument of sustainability *must* connect to the global scale.

4.3 *Rhetorics* of sustainability

While industrial energy practices defend their partake in the global sustainability discourse both through concepts (of input quality, efficiency and circulation) and politics (of defining the frames for inclusion and exclusion with respect to recirculation), careful articulation of concepts and politics is indispensable for their argumentative strengths. We will here refer to this articulation as the rhetorics of sustainability. While the input and quality of energy carriers as well as the recirculation of energy and waste materials have an inherently argumentative power with respect to sustainability within a given, local context, these variables are not equipped to travel independently out of each particular context. For the concepts and politics of sustainability to travel across and articulate[13] locales, contexts and scales, vehicles of considerable range are required, and such vehicles of articulation are fuelled with rhetorics, inter alia.

Rhetorics is a crucial ingredient of not only the discourse on, but also the practical achievement of climate sustainability. Through rhetorics, arguments are ordered and mechanisms are accounted for. One of the qualities of rhetorics is that they allow for different worlds to exist in parallel. When, for example, the share of renewable power usage in Norway is discussed, fractions differ largely. Some state that «Only 14% of Norwegian power is 'renewable'» (Europower 2018), others say that "Norwegian electricity production is 100% renewable and covers two thirds of our total energy consumption"[14]. There are also reports stating that almost all electricity consumption in Norway stems from renewable sources:

> *"Norway is an energy nation that is self-contained with electricity produced from renewable sources. Most of our electricity comes from hydro-power. This amounts to 96% of the electricity in the Norwegian grid. The rest domes from heat power and wind power"*[15]

The differences in fractions reported result from a variation in accounting methods. For example, reports of energy regimes tend to obscure the difference between produced energy and consumed energy. This may be used strategically to shape an argument. If, for example, the message is that Norway contributes positively to climate sustainability, one could state that « Norwegian electricity production is 100% renewable and covers two thirds of our total energy consumption ». If, on the other hand, one wants to convey a message that Norway does not do enough for the climate, one could say that «only 14% of Norwegian power is 'renewable'». If both these statements are true, they form a paired disagreement that has limited deliberative potential in a discourse since they – with their different referents – form parallel arguments that do not, at any point, tangent each other. Together, however, more than anything they work as arguments for status quo, since they do not weaken each other.

Another mechanism that contributes to confusion and lets contrasting arguments exist without real confrontation is the Guarantee of Origin (GO). However, upon issuing the guarantees, *renewability* is identified and separated from the physical electricity that is transmitted through the grid[16]. Electricity is a commodity that must be produced at the same time as it is used, and since all production is transported through the same grid it is not possible to establish whether the electricity from the sockets is made from renewable, fossil or nuclear sources. This opacity gives rise to substantiated doubt; for example, in 2015 Norway exported 122,9 TWh measured as GOs, while only 14,8 TWh was exported, measured as physical electricity[17].

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[13] Note that articulation refers both to the process of connection/coordination, and communicative formulation.
[14] https://www.energinorge.no/politiskesaker/utbygging-av-fornybar-energi/
[15] http://enerwe.no/kraft/norge-importerte-strom-i-hver-femte-time-i-fjor/
[16]http://www.statnett.no/Global/Dokumenter/Kraftsystemet/Opprinnelsesgarantier/Hvordan%20kan%20en%20forbruker%20av%20elektrisitet%20forsikre%20seg%20om%20at%20eget%20forbruk%20er%20dekket%20av%20fornybar%20energi.pdf
[17] https://stromvalget.no/artikkel/1436/sannheten-om-opprinnelsesgarantier

Surely, GOs address climate sustainability by stretching to establish connections between local power production and global power trade, but leave the connections obscure and unavailable for inspection. In terms of rhetorics, they represent hard arguments but little trust.

5 Conclusions

We set out explore how environmental policies rooted in globally negotiated diagnoses and their associated protocols and agreements are translated and articulated locally in terms of energy practices. The approach reflects the prevailing dogma "Think global, act local"; while changes appear at a global scale, they are solved at a local scale. Having followed the trail from Paris to local industry practices in Norway, following signposts like energy input, energy circularity and Guarantees of Origin, we have made sense of local practices answering to demands from both the global climate threats and the local bottom line.

While the identified contents of energy sustainability are reasonable in themselves, they are not necessarily effective in the world, a world whose energy policies works to – with the words of Shove (2017) – consolidate energy practices instead of changing them. There are several mechanisms contributing to the weakening of otherwise potential powerful measures: energy saved in one place tends to be spent elsewhere, often with the need of extra material and energy in that new process; recirculation of waste and energy may uphold practices that from a climate perspective need to be downscaled. While these mechanisms are outside the control of individual companies, they may also impede the transport of the effects of local practices all the way back to the global climate – and hence threat to make the trail from Paris to rural Norway a one-way trail.

In this article, we discuss how the discourse on energy sustainability allows this driving pattern to exist despite clear evidences of where we are heading in terms of reaching our climate goals continue to materialise in IPCC[18] reports. We identify three dimensions of sustainability, three junctions where particular care should be taken in order for energy management to actually support sustainability. These are concepts of sustainability, politics of sustainability and rhetorics of sustainability – all of which allows for contradicting arguments and practices to exist in parallel so as to impede the fulfilment of global goals such as those reflected in the Paris agreement.

There are no simple solutions to this intricate problem of local-global practice-politics and the issue must obviously be addressed from many angles simultaneously, with engineering, political and cultural tools. One of these angles could be to rework the *think globally, act locally* dogma; as we have seen, local acts are not easily aligned to the global goals. While the local is always palpable and possible to oversee, the global is too wide for anyone to grab or to govern, and to wake the feeling of responsibility – and we are reminded about the tragedy of the common, now seriously upscaled. How can we possibly act globally, in order to influence something as impalpable as the climate? It is not easily done, but we suggest that it must be done through representational practices.

The UN system for global representation has arenas for representing research and politics. The Conference of the parties (COP) is the decision-making body of UN on climate issues where all countries are represented, the Intergovernmental panel on climate change (IPCC) is a UN anchored panel representing all nations and transforming a large body of climate research into representative reports with recommendations. In this article, we have explored local energy practices and how they only vaguely and ambiguously are connected to such global issues such as COP decisions and IPCC recommendations, not to speak of climate systems. We suggest that a reason for this is the considerable degree of freedom for local actors to articulate these connections. One way to deal with this problem could be to reduce the degrees of freedom, and allow representative bodies to state more binding requirements that will work to ensure a

[18] Intergovernmental panel on climate change - https://www.ipcc.ch/.

habitable climate in all the locales of the world also in the future. Serious commitment to sustainable energy practices requires us to think locally, and act globally.

In order to ensure that our measures to build sustainability are not perverted, they should be anchored first and foremost in globally binding agreements and not in market-based incentives. We are not saying that economic incentives for energy sustainability do not work, or that freely negotiable guarantees of origins and climate quotas do not work, but there are indications that they do not work as effectively and quick as we need since there are too many pitfalls associated with their local operationalisation.

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