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ORIGINAL ARTICLE

From practice to policy — exploring the travel and transformation of energy savings calculations and its implications for future energy transitions

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Abstract Improving energy efficiency in industries is imperative for sustainable transitions. This article explores the logic behind calculating energy savings from energy efficiency improvements. Based on a qualitative study of industry-research projects and policies to improve energy efficiency in Norway, the article presents different ways energy savings are estimated when assessing the viability of novel technologies. Here, energy savings are calculated as the difference in energy consumption between a proposed technology (use-case) and an alternative scenario (base-case). We discuss the heterogeneity of the chosen cases of comparison, as they are associated with a wide variety of uncertainty, contextual preconditions, estimates, and projections. Further, we trace the calculations of energy savings of one of these projects as they move from the context of research and technology assessment to official reporting. We show how the circumstances where these numbers are produced become black-boxed as the calculations are transformed and aggregated into a policy program-specific measurement "energy results" in Norway. Our findings show that the project and policy objectives and measurements point in somewhat different directions. Through this, we unpack the logic inscribed in energy savings calculations and the way these are applied to reach multiple goals.

Keywords Energy efficiency · Energy savings · Commensurability · Objectification · Governance

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Introduction

In climate change scenarios that successfully limit global warming to 1.5 degrees, improving the energy efficiency of both industrial processes and domestic buildings tend to play an important role (Creutzig et al., 2018; Grubler et al., 2018). Yet, scholars who work with socio-technical aspects of energy or sustainability transitions seldom put energy efficiency center stage (see, e.g., Köhler et al., 2019), with the exception of studies of the relationship between the implementation of policy instruments and the uptake of energy efficient technology (e.g., Lindberg et al., 2019; Scordato et al., 2018). A likely reason for this relative absence of interest is that energy efficiency is a notoriously slippery concept, "fraught with methodological problems" (Herring, 2006, p. 6) and highly susceptible to contestation (Patt et al., 2019; Shove, 2018).

There are different ways to measure the effects of energy efficiency improvements and programs. Actors such as the IEA (2019) measure the results of policy-induced improvements in energy efficiency primarily as *avoided energy consumption*, in other words energy that could have been used, but which was not, due to a specific project or technology (Shove, 2017). Through this logic, industrial plants, technologies, and interventions can *produce* energy savings if their energy use is lower compared to an equivalent entity. This suggests that demonstrating energy savings fundamentally entails calculating *difference*, either between a contemporary reality and a hypothetical counterfactual reality or between similar projects mobilizing different technological configurations.

Achieving commensurability between different things is vital in the enactment of climate policy, where the production of carbon as a standard value and currency entails that things such as planting trees, insulating a house, or driving an electric vehicle can be measured against the same yardstick (Dalsgaard, 2013). Measuring energy efficiency and energy savings also involves making different things the same. Refrigerators and heat pumps are compared by dividing their output of cooling and heating with their corresponding energy consumption, while the energy efficiency of industrial plants is established by comparing output factors such as tons of aluminum or dairy products divided by the energy consumed in the process. Energy efficiency calculations are thereby made visible in objects or representations, taking the form of numbers, models, and ratios (Patterson, 1996). In order to assess the *energy savings* of implementing new technologies (often labeled a *use-case*), their energy use is compared to what was previously considered state of the art (often labeled a *base-case*). If no object of comparison exists, one is often *imagined*, to enable a comparison. In these instances, alternative plans for new industrial plants and technologies are compared against each other *ex ante*, in order to establish the relative energy efficiency improvement and energy savings of the chosen solution. This way of quantifying the difference in performance between technologies informs the decision-making process for firms on whether to implement them. Estimating the energy savings of energy efficiency improvements makes it possible to assess operating costs and payback period of investments. Measuring energy savings is also essential for assessing the effects of energy efficiency policies. In this paper, we explore how energy savings of different energy efficiency projects in firms are produced, used, and aggregated in a bottom-up manner.

Our concern in this paper is to analyze the epistemic politics of energy efficiency and energy savings: how are these numbers produced as objects, and how are these objects mobilized practically and politically? The paper draws on qualitative data from innovation projects in Norway and thus focuses on Norwegian energy efficiency policy. The projects were situated in two large research centers for industrial energy efficiency, where the core objective was to identify, develop, and implement novel technologies for reducing energy consumption. For the actors we studied, energy costs are significant expenses, making implementation of novel technologies, processes, and practices to save energy a main concern to stay competitive. Our empirical exploration examines how these projects produce quantified energy savings and how these are employed locally to inform decisions on technology implementation. Further, we investigate how these quantifications travel from the contexts where they are made into contexts of governance, accounting, and statistics where they become key elements in strategies of energy transition in Norway. In doing so, we reiterate on a gap in energy and transitions research, namely the need for analysis of the political and institutional contexts within which concepts such as energy efficiency and energy savings are produced and performed (Lutzenhiser, 2014). This also addresses the need to better understand how processes of quantification and classification interwoven with issues such as expertise and control (Dunlop, 2019, p. 9).

We will first define key concepts and challenges with measuring the effects of energy efficiency policies. Next, we outline our theoretical foundations rooted in objectification, commensurability, and contextual mobility, which are useful for analyzing how representations of energy efficiency and energy savings are produced. Since assessments of energy savings include estimates and projections of the future, we introduce perspectives and terminology to analyze rational and fictional expectations (Beckert, 2013, 2016) and implications of inscribing such unknowns into scientific models and objects. Further, we elaborate on the particularities of the Norwegian policy context, our method and the data we have employed. Based on our data, we describe four different *types* of comparisons that are used to *constitute* energy savings in projects. The differences between these types of comparisons include whether the industrial plants, processes, or components that are compared exists or are projections of a possible future and whether their energy use is measured directly or estimated. Through this exercise, we illustrate that while the objectified and standardized energy savings calculations look similar as results, they emerge from very different comparisons. We then follow the energy results from one of these projects on its travel through different *contexts* of use, showing how calculations become black-boxed as the numbers moves away from its origin. To conclude, we show how this logic legitimizes certain policies and practices and discusses implications that this may have for sustainable transitions.

Previous research and key concepts

Scholars focusing on energy efficiency from a transitions perspective have tended either to focus on barriers for the implementation of energy efficient measures (Palm & Thollander, 2010) or on policies and policy mixes as enablers for energy efficiency implementation and overcoming barriers (Rosenow et al., 2016). To address how energy savings are constructed and used in the Norwegian context, we first elaborate on key concepts and issues with measuring the effects of energy efficiency and energy saving policies. Second, we draw on insights from theories on objectification and commensuration, before we discuss how such objectifications become part of expectations of the future and how to interpret this.

Measuring effects of energy efficiency and energy saving policies

Technically, energy efficiency involves a definition and measurement of the relation between output and input power.[1] However, it is common in the industry and organizational domain to measure the energy consumption in terms of what the machine actually produces (e.g., ton aluminum produced at a factory). As such, improving energy efficiency entails using less energy to produce the same amount of services or useful output (Patterson, 1996). Energy savings concerns the *amount* of energy that is not used (Boonekamp, 2006). Quantifying energy savings from an energy efficiency improvement, therefore, requires measuring or estimating consumption with and without implementation of an energy efficiency improvement measure (Abeelen et al., 2019).

On a macro scale, energy savings are typically measured either in a top-down fashion or through assessing energy savings bottom-up. *Top-down methods* utilize an aggregate measure of energy consumption, normalized by an exogenous variable that adjusts for scale across cross-sectional observations (Bertoldi & Mosconi, 2020). These measurements include all the policies covering the sector, autonomous effects (i.e., effects that would occur even without policies), and structural effects (changes in the activity levels). As such, while they capture all savings and corrections, separating the policy-induced savings are difficult (Bertoldi & Mosconi, 2020). *Bottom-up methods* examines the effect of measures on individual technologies or end users (Cahill & Gallachóir, 2012), or through monitoring savings by individual projects triggered by policy instruments (Abeelen et al., 2019). These methods are useful for planning, implementing, managing, and tracking the energy efficiency progress (Horowitz & Bertoldi, 2015) and can provide explanations on developments of policy programs (Abeelen et al., 2019). Bottom-up savings are also sometimes extrapolated to larger populations, program participants, or consumers (Horowitz & Bertoldi, 2015). Bottom-up assessments need additional net-to-gross adjustment efforts to approximately include behavioral changes and other factors that influence energy consumption, particularly free-rider, rebound, and (often positive) spill-over effects. Further, energy savings estimates derived from engineering calculations ex ante are characterized by uncertainties, which must be measured after implementation (Horowitz & Bertoldi, 2015). Thus, as noted by Abeelen et al. (2019, p. 1323), the different methods have been developed for different purposes and must be interpreted with caution.

[1] There are potential misunderstandings generated by how the term “energy efficiency” is used. The concepts “energy efficiency,” “energy efficiency improvements” as well as “energy savings” are sometimes used interchangeably in Norway.

There is a distinction between energy efficiency and energy savings policies (e.g., Bertoldi & Mosconi, 2020). Energy efficiency policies aim to produce a reduction in expected energy consumption levels compared to the values of a reference energy consumption baseline (e.g., business as usual scenario). Energy saving policies are by design supposed to generate a reduction in energy consumption compared to the consumption levels before implementation. As such, contrary to energy saving policies, energy efficiency policies are therefore not necessarily expected to produce a reduction in energy consumption levels compared to before implementation (because savings generated by the energy efficiency improvement do not necessarily exceed a possible increase in the expected consumption as reflected in the baseline). Several scholars have noted that energy efficiency improvements do not necessarily lead to reduced energy demand. For example, gains from energy efficiency improvements can directly or indirectly be "taken back" through market dynamics and behavioral changes, commonly referred to as the *rebound effect* (Herring, 2006; Ruzzenenti & Bertoldi, 2017). Other scholars draw on social practice theory to highlight the complexity and non-linearity between improved energy efficiency of technologies, and the various ways individuals and firms consume energy through their behaviors and practices (Labanca & Bertoldi, 2018; Shove, 2018). The limits of efficiency to address overall energy consumption are also recognized in energy *sufficiency* approaches, focusing on reducing consumption while supporting human and ecological well-being (e.g., Darby & Fawcett, 2018; Princen, 2005). These many perspectives illustrate how measuring the societal effects of energy efficiency improvements on overall energy demand is in no way straightforward. This too is a concern for energy efficiency policies, and particularly energy saving policies, since they are sometimes legitimized as a tool to reduce energy demand (Horowitz & Bertoldi, 2015), and through this contribute to a sustainable transition.

Objectification and commensuration

Calculating energy savings essentially implies making a comparison between objects, thus exploring how these objects are constructed is necessary. By objectification, we refer to the construction of boundaries, and a bounded entity with a set of attributes, with some form of stability. This entails some sort of agreement on boundaries: spatial, logical, and temporal, with respect to what constitutes the object and what is external to it. Which object to construct is thus a pragmatic choice of which differences, among endless abundance possibilities, to regard as relevant (Bateson, 2000; see also Almklov, 2008). Moreover, objects are given a selection of attributes, in our case mostly quantitative measures. Furthermore, in order to calculate a difference in energy consumption, the objects need to be constructed in such a way that they are commensurable (Espeland & Stevens, 1998). This means that the objects representing an energy efficient use-case, an industry plant, or a technology are objectified in a way that makes it possible to compare them with others by one or more shared metrics. MacKenzie (2009) noted similar dynamics while discussing the commensuration of CO_2 equivalents, where different emission sources are made commensurable. Standardized representation, including quantification, is a way of creating what we call contextually mobile inscriptions. Temporary or permanent standardization tends to black-box context, which means that information on the specificities of each case are not included. This makes it possible to aggregate, combine, and compare objects (in this case energy savings from projects), without knowing more than the properties and quantitative measures that are included in the standardized description (Latour, 1987).

More specifically, Shove (2018) catalogues the objectification process involved in constituting and purifying energy efficiency. The first step involves methods of *measuring* energy (1). These have changed over the last century, from contextually situated methods of knowing energy (e.g., manpower) to contemporary generic metrics (e.g., kWh, joules), which are more easily aggregated. Further, establishing *equivalence* (2) relies on defining meanings and measurement of "service" (or useful output). This involves choosing and separating certain dimensions of a technology (e.g., the production of light by lightbulbs) and unavoidably downgrading others (the production of heat by lightbulbs). Improvement on one particular dimension often has consequences for other features. Thus, establishing equivalence depends on elevating certain characteristics over others. The next step is *bounding* (3) the entities that are described in terms of efficiency, which entails placement of system boundaries. Claims about efficiency depend on analytically extracting the object of those claims and treating them as independent entities (e.g., the home versus the heating system) (Shove, 2018, p. 782). This is connected to *framing* (4) objects of efficiency, which involves which factors that are taken into account when estimating "energy efficiency." The last step concerns when energy efficiency *begins and ends* (5), which is often disregarded in indicators as the focus tends to be limited on the ratio of input to output (Shove, 2018, p. 783). Thus, discourses of efficiency are simultaneously time-bound (they depend on comparison) but also timeless, as the context of time is sometimes concealed in energy efficiency indicators (ibid).

Similarly, constituting energy savings from energy efficiency improvements and policies involves objectification and purification processes, in order to establish two reference points and assess the difference in energy consumption between them (e.g., between projects, over time). Cahill and Gallachóir (2012, p. 213) argue that it is difficult to attribute savings to a specific energy efficiency policy, mainly because this involves establishing a counterfactual that would represent the energy consumption trend in the absence of such measures. Uncertainties related to counterfactuals are particularly evident in cases where there is a new build (e.g., industrial plant, household) or technology, but also for retrofit actions. Here, estimating energy savings requires an *ex ante* assessment, calculating the difference between actual energy use and a reference energy use, or between two reference situations (Thomas et al., 2012). These reference situations can include the existing stock, a market, the legal minimum performance, or the best available technology (Thomas et al., 2012, p. 29). Essential to these calculations is establishing a *ceteris paribus* condition, which means ensuring that all operating conditions, except for the energy efficiency improvement, remain the same for both the base-case and use-case. However, using a reference situation as baseline induces significant uncertainties in calculation of energy savings (Thomas et al., 2012, p. 32). Following this, we need to investigate how uncertainties are addressed in modelling and projections of the future.

Uncertainties in modelling and projections

As with many processes and technologies associated with the energy transition, the objects and benefits of what is described as energy savings for practical reasons often exist in future projections, visions, or expectations (e.g., Ballo, 2015; Skjølsvold, 2014). While many scholars have explored the production of shared visions and expectations as performative for the enactment of transitions (Turnheim et al., 2020), we follow Beckert (2013, 2016) in the claim that expectations can take on different forms: they can be rational or fictional, and through this, project different "micro futures" of energy consumption. For example, some situations are characterized by certainty (and risk) and are therefore subject to calculations based on rational expectations. In the context of innovation and technology development, this may involve the measured energy consumption of an industry process under specific, known, circumstances. Other situations are characterized by fundamental uncertainty, requiring imagination based on fictional expectations. Beckert (2016, p. 43) argues that uncertainty is a prevailing condition in economic decision-making, as "the complexity and interdependencies of parameters, the unforeseeability of the reactions of relevant third parties, and the non-linearity of economic processes make the (probabilistic) calculation of outcomes of decisions impossible." With this as a backdrop, and with parallels to the philosophy of Hans Vaihinger (1924) and the sociology of expectations (e.g., Brown & Michael, 2003), Beckert (2013) argues that we act *as-if* our understanding of the future is true, even if we know that it is uncertain or even knowingly false. The formation of fictions is due to the highly intricate character of the facts, which makes theoretical treatment exceedingly difficult owing to their unusual complexity (Vaihinger, 1924, p. 19). Vaihinger (1924) and Beckert (2013, 2016) propose a pragmatic stance to fictional expectations, where actions are based on committing to a belief in the materialization of a certain future state and the pretention that the fictional depictions were indeed true representations of the future. This pragmatist orientation points to the utility of applying fictions, or as-ifs, as decision-making tools. Scientific practices frequently result in the production of fictions, which are effective means to certain ends; they are useful and expedient (Fine, 1993, p. 5).

Table 1 Firm projects, industry sector, and description

Project	Industry sector	Short description
Project 1	Metal and processing	Novel energy recovery concept, pre-heating metal utilizing internal surplus heat at an existing industry plant
Project 2	Food and beverage	Novel high-temperature heat-pump, utilizing internal surplus heat at an existing industry plant
Project 3	Food and beverage	Utilization of external surplus heat and CO_2 from existing companies to a planned industrial greenhouse
Project 4	Food and beverage	Novel high-temperature heat-pump utilizing internal surplus heat in a planned industry plant

Interpreted in this way, fictional expectations are "placeholders" in decision-making processes through which the unknowability of future states of the world and courses of events are overlooked for the moment (Riles, 2010). As such, fictions, as other visions, and expectations, are key tools in the enactment of energy transitions, which have yet to be addressed in the transition's literature. Thus, a fiction is rather a technique, more like a machine than a story, a tool for practical intervention (Riles, 2010, p. 802). Beckert (2013, p. 222) argues that fictions are important to provide orientation in decision-making *despite* the uncertainty inherent in the situation.

> Rather than leading to the recognition of the optimal choice in an objective sense, calculative assessments of outcomes should, under conditions of fundamental uncertainty, be considered fictions themselves (Dobbin, 2001); because it *appears* rational, calculation as a form of storytelling provides legitimated justifications for decisions *despite* the incalculability of outcomes. (Beckert, 2013, p. 234)

Fictions can also lead us astray, as shown in Beckert's (2016) analysis of how "stories" put forward by economists contributed to the financial crisis in 2008. This is also reflected in Dix's (2019) discussion on microeconomic forecasting and how "context is lost" when constructing commensurable futures, in his case, of educational reforms. Further, situations with fundamental or deep uncertainty require a certain degree of imagination. If rational expectations are assumed in such cases, what is then claimed to be "rational expectations" are indeed camouflaged "fictional expectations" (Beckert, 2013, p. 229). This camouflaging is important for the credibility of the analysis. As we proceed, such examples will be central as we discuss how the effects of energy efficiency improvements become objectified, and in turn, the implications when these objects are used as a basis for policy.

Methodological approach

To achieve an in-depth understanding of how calculations of energy efficiency and savings are produced in practice, and travel to the policy domain, this study draws on a qualitative multiple case study design (Yin, 2009). This allows for studying the diverse nature of such processes.

Context and case selection

In order to explore the logic of producing and applying energy savings calculations, our study examines industry-research projects in the Norwegian manufacturing industry and policies for improving industrial energy efficiency in Norway. The context of this study is two industry-research centers, which have the objectives of enabling knowledge, development, and diffusion of energy efficiency innovations. The centers include firms, technology developers, universities, and research institutes. More specifically, we focus on small-scale *firm projects* within these centers, where the objective is to develop and implement energy efficiency innovations. We draw on data from four firm projects (Table 1), involving different industry sectors, technologies, firms, and research partners. The selection of projects is based on theoretical sampling (Corbin & Strauss, 1990), with the purpose of exploring how actors negotiate and constitute energy efficiency and savings as objects and to what ends these objects are used. Thus, it was possible to conduct a systematic qualitative comparison (Eisenhardt, 1989).

Following the results from one of these projects, this study engages with Norwegian policy on energy efficiency and savings. An important strategy to promote a sustainable transition in Norway has been through government funding of innovative technologies, energy efficiency and savings measures, renewable energy production, and fuel switching (Enova, 2019a). This is handled by a government enterprise for environmentally friendly production and consumption of energy (Enova), which provides economic support to businesses and residents who adopt environmentally friendly and energy efficient technologies. The agency supports a wide range of projects, from rehabilitation of homes in the residential sector to innovation and technology development projects in the industry sector. Their programs have gradually changed since their inception in 2001, from profitable energy savings measures (in Norwegian referred to as *energy economization*) to focusing more on innovative technologies with prospects of enabling market change, reduced emissions, and efficient energy use to improve security of energy supply. In order to compare the effects of different projects, in various programs, the agency has established a bottom-up measurement: *energy results*.[2] Energy results (kWh) is a measurement to quantify energy savings from projects funded by the agency. The measurement is sometimes referred to as energy savings, but the same measurements are also applied by the agency to quantify production of renewable energy and fuel switching from fossil to renewable energy sources. The projects are also measured in terms of reduction of power demand (kW) and CO_2 equivalents. To this end, the measurements serve as tools to make comparisons across projects and demonstrate the impact of the policy programs. These measurements are also applied as indicators for goal achievement for the agency itself, where they are required to fulfill 4-year targets of aggregated results through their funding of projects.[3]

Data collection and analysis

The study is based on 17 in-depth expert interviews with firm and research partners involved in the projects (Appendix Table 2). The interviews were semi-structured with an open interview guide. The purpose was to achieve a case narrative of the development and implementation of solutions. We also draw on written sources such as project descriptions, reports, presentations, and reported "energy results" to Enova. Energy results (kWh, kW, and CO_2 equivalents) from funded firm projects are public information (Enova, 2019b). However, we avoid referencing specific numbers in order to ensure anonymity. In addition, our project group arranged three workshops with researchers, firm partners, and policymakers to discuss the topic of surplus heat utilization, which is the technological focus in all cases.

We collected most of our data in the period 2017–2019, but we also draw on data from a second industry-research center from 2011 to 2012 (Project 3). Our engagement with this multi-organizational field over time, and through different projects, has similarities with what is described by Pollock and Williams (2010) as strategic ethnography. Transcending the individual projects enabled a gradual strategic theory development through interaction with the field through different access points over time. This also allowed us to verify our results by utilizing insights from other projects that we have not studied in-depth. Our experience as research partner within the centers, arguably somewhat peripheral as social scientists among engineers, is here important for our understanding of the context. We conducted several analysis sessions, where we identified the prominent role of expectations in constituting energy savings, and how these often are black-boxed in use. To encompass these findings and enhance the clarity of the argument in this paper, we split our analysis in two.

The first part of our analysis employs data from all four projects, in order to investigate the variance in construction of *base-cases*, *use-cases*, and consequently *energy savings* as the calculated difference between them in energy consumption. Here, we employ Beckert's (2013) notion of rational and fictional expectations and Shove's (2018) analytical steps, to describe how energy efficiency of technologies is assessed and anticipated energy savings are objectified and purified in practice. We synthesize the analysis in an overview on four different types of comparisons.

In the second part, we draw on a sub-set of our data and analyze Project 4 in-depth, in order to follow the contextual journey of the energy savings. We

[2] We apply the notion "energy results" when we talk about the particular policy measurement in Norway.

[3] Energy results is a program-specific measurement in Norway, and not connected to energy efficiency and energy savings targets in EUs Energy Efficiency Directive.

chose this particular project due to the longitudinal possibility and availability of data describing the trajectory from the inception of the case in the research center to its officially reporting as energy results in the government database. By systematically reviewing the different data sources, we re-constructed the case narrative. This enabled us to study the co-production of micro futures between the researchers and firm. By triangulating (e.g., Yin, 2009) interview data, project documents, and results from public documents, we were able to "follow the object" (Latour, 1987), through different contexts of use. In this way, we could investigate the travels and transformations from the initial calculations of energy efficiency and savings by the researchers to its final reporting by the government agency as demonstrated "energy results." We identified five contexts in which these calculations appeared as models or numbers.

Constituting energy efficiency and energy savings

In the quest to improve energy efficiency, a main concern of the projects has been to quantify the potential energy savings from technology implementation. In order to estimate energy savings, the researchers must specify and frame at least two reference points that are comparable: a *base-case* and one or more *use-cases*. We find four different *types* of such comparisons in our material, which we will present briefly in three short analytical examples, before proceeding to a more elaborated discussion.

Measuring base- and use-cases directly

In some projects, the researchers were able to test and measure the energy use of both the base-case and use-case directly. For example in Project 1, the researchers studied process improvements in the extraction of aluminum from aluminum oxides through electrolysis. They separated a sub-system (a single aluminum cell in the plant) in order to test and measure the energy consumption with and without an energy efficiency measure (pre-heating of aluminum anodes). Here, the energy consumption of the base-case and use-case were measured directly, and the relative difference between the two calculated. As such, this is a case where the energy savings are based on a comparison of direct measurements. The researchers were only able to test one aluminum cell, however. Assessment of energy savings from the whole plant would require extrapolation of results from one cell to the full plant, which were not straightforward due to the complexity and interdependencies in the plant. Thus, even in settings where the base-case and use-case can be measured directly, there are elements of estimation and uncertainty.

Estimating the efficiency for a projected use-case

It is rarely technically, nor economically, feasible to test full-scale solutions before they are implemented. Instead, estimated effects of energy efficiency measures form a basis for deciding on implementation. For example in Project 2, the researchers assessed the energy savings of implementing a high-temperature heat pump in an existing industry plant. Thus, the researchers estimated the impact of implementing new technology *ex ante*, compared to existing technology at the plant. In these cases, improvements in new industry processes or specific components (use-case) are projected and compared against the current energy consumption of the existing industry process or component (base-case).

Projecting a base-case as reference point

While a use-case can be measured after it is implemented, it is sometimes compared against a projected base-case. This was the situation in Project 3, which involved a new industrial greenhouse. To demonstrate the energy savings, it was necessary to compare the energy consumption of the greenhouse (with energy efficiency measures) to a projected base-case, which was never built (the same greenhouse utilizing conventional technologies). The use-case was planned to utilize surplus heat and CO_2 from two nearby industrial plants to reduce primary energy consumption and emissions for the industry cluster as a whole. In addition, several energy efficiency measures were proposed at the greenhouse itself, such as improved insulation in glass and walls, automated curtains (regulating light and heat losses), and energy management systems. The base-case was projected based on standard solutions for similar facilities. The difference in energy consumption between the use-case and base-case was reported as results.

Here, the difference in energy consumption between the base-case and use-case is a rational expectation, estimated based on selected attributes with high degree of certainty. However, while the energy consumption of the use-case could be measured ex-post after the facility was built, and technology measures implemented, this was naturally not so for the projected base-case. Furthermore, the uncertainties involved in actually building the base-case were not reflected in the calculations. For example, since the particular site in Project 3 was on farmland, the base-case proposed would not necessarily obtain the permits from the local authorities.[4] Moreover, sustainable and cost-efficient production was at the core of the business model for the company, and one of the reasons for establishing the plant in the first place. Thus, while the *base-case* contains rational expectations of energy use, it simultaneously relies on the fundamental uncertainties of such a facility actually being built. Importantly, the firm was also dependent on funding in order to implement the measures, suggesting an interaction effect between the policies. Thus, it is important to note that allowing this base-case as a reference point, despite these uncertainties, is *not* the result of deficient evaluation practice nor suspicious calculations. Project 3 speaks to the policy objective of developing and demonstrating novel energy efficient technologies, and in order to do so through the existing policy framework, a base-case based on standard technologies must be produced to calculate energy savings.

Projecting both base- and use-cases

When assessing technologies for new industry plants (Project 4), neither the base-case nor use-case exists beforehand. In such instances, both base and use-cases are *projected* in order to estimate energy consumption and the difference between them. In this particular example (Project 4), the firm challenged the researchers to come up with novel solutions for an integrated heating and cooling system for a new processing plant. Before the researchers could estimate the relative efficiency between the technologies, they had to construct the objects for comparison. To this end, they first established a base-case of the plant with an electric boiler and district heating (which is the standard solution for similar facilities). Next, they established five use-cases of utilizing local surplus heat sources in an integrated energy system with novel high-temperature heat pump solutions. Since neither the base- nor the use-case existed, they were both future projections of the same facility. Thus, energy consumption (district heating and electricity) could not be measured directly but was estimated based on *expectations* of the plant's performance.

As the main researcher explained, the objective was to minimize the use of fossil fuels for heating and cooling by utilizing waste heat sources in an integrated heating/cooling system with high-temperature heat pumps:

> When we conducted the study we said, OK, let us remove all fossil fuels as heating sources and utilize surplus heat instead. Then we can use a heat pump, which works between 0 and 100 degrees. Therefore, the use-cases we have considered are CO_2, ammonia, ammonia-water, propane, and butane. (Researcher)

The five technology options were based on the same principle of locating and utilizing surplus heat sources, differing only in terms of which heating/cooling medium to apply. The cases were modelled with estimated energy demand, peak power, production times, and temperature requirements for processes of the new facility. By utilizing operational data from another plant in the region and plans of the new facility, the researchers searched for suitable surplus heat sources:

> First, we need to find a surplus heat source. Then we can see that with that surplus heat source we can deliver this much process heat and hopefully it matches a significant portion of what they need. That is how we construct those [use-cases]. (Researcher)

The use-cases were further specified by using estimates of future energy costs for district heating and electricity, resulting in a model (Fig. 1) comparing the different technology options by establishing equivalence on four attributes: (1) consumption of

[4] All new industrial plants in Norway must obtain building and emission permissions from the regional authorities, where demonstrating sustainable production is important. In this case, the proposed energy efficiency measures and plans for utilizing surplus heat were highlighted as essential for the co-located plants.

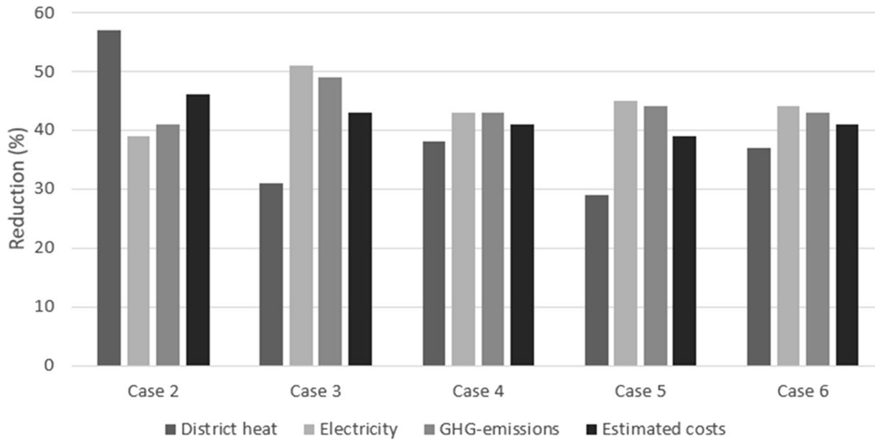

Fig. 1 Model representing the relative difference in district heat, electricity, GHG-emissions, and estimated costs between five use-cases against a base-case

district heating, (2) electricity, (3) GHG-emissions, and (4) estimated operating costs.

The attributes are estimated as relative percentage reductions on the four scales against the base-case (Use-case 1). The first two attributes are estimations of the energy consumption of the different solutions. The other two attributes are intrinsically connected to the first: reduction in GHG-emissions calculated as a weighted product of reduction in district heat and electricity (based on standardized emission factors of the energy sources in the Norwegian energy system) and costs estimated as the energy costs for district heating and electricity in the future. Furthermore, the model places the system boundaries around the projected facility excluding the impact on the surrounding energy system (e.g., district heat system) on energy optimization. This means that the model itself will not capture positive or negative effects in terms of energy exchange with surrounding households, industries, and district heating system. The product output from the facility is equal in the cases, implying that finding the "most energy efficient use-case" relies on comparing the four attributes. The model shows that *Use-case 2* gives the largest energy and cost reductions compared to the base-case.

In this example, constituting energy efficiency and energy savings implies constructing both the base-case and use-case(s) by combining different information of the projected industry plant. While the energy savings are estimated as the difference between the two projections, the base-case and each use-case, only one of the facilities can actually be built. Interestingly in Project 4, due to the new factory, the firm was to decommission an old inefficient industry plant elsewhere. Thus, in this instance there are *actual reductions* in energy consumption for the firm that were not bound to this estimated difference between technology options at the new plant, nor directly reflected in the model. In other cases (e.g., Project 3), where new facilities are built to increase production or produce new products, energy savings only exist as the calculated difference between a projected use-case and base-case. This suggests that there are multiple ways of constituting energy savings relying on expected performance of projected technologies and industry plants.

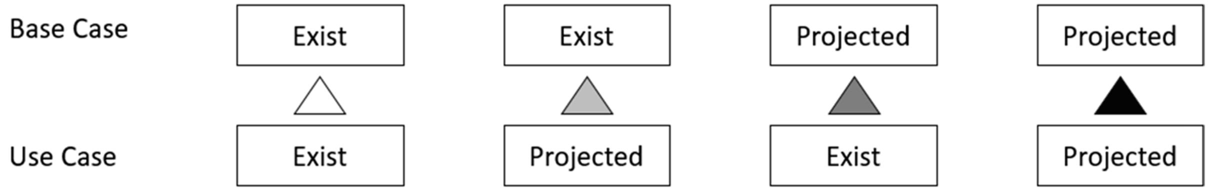

Fig. 2 Typification of energy savings as the calculated difference between a base-case and use-case(s)

Energy savings as the calculated difference between cases

As shown, energy savings are constituted as a difference between the energy consumption of a base-case and one or more use-cases. This implies comparing two versions of the "same" industry plant, process, or component. The specification, framing, and time horizons of these objects connects to whether the industrial plants or sub-processes exist beforehand, which allows testing and measuring energy consumption and output, or whether they are projected expectations of energy consumption. As shown, these cases are situated at different ontological levels, where some exists and can be measured, while others must be projected and estimated. Figure 2 illustrates how constituting energy savings relies on establishing a difference between four different combinations of the objectified base- and use-cases.

Establishing base- and use-cases implies reaching into the past, present, or future in order to construct the objects. This entails abstracting and combining de-contextualized information and excluding non-relevant elements. The objectification of cases also means that aspects that are not relevant for assessing and comparing technology options are simplified. Placement of system boundaries, impact on surrounding energy system, weighing between energy sources (and their mobility), technical complexity, implementation issues and actual system performance, and contextual factors are all issues excluded from the objects.

In the two latter combinations, energy savings exist only in the calculative comparison against a projected base-case that never has, and never will, materialize. Here, base-cases are placeholders (Riles, 2010), useful in the models to establish comparisons, but also necessary for calculating energy savings. However, it is not always certain whether a company will build the base-case facility, which technologies that will be implemented, or the actual energy consumption when a plant is operational. This is an imagined future, which sometimes contains more fundamental uncertainties than calculated expected energy use. As these are projections of future facilities, there are several uncertainties in the models, where some are verifiable only after the facility is built. These uncertainties are known to the researchers and firm partners. They are applying them *as-if* they were true. Applying *fictional expectations* (Beckert, 2013) in this sense is a pragmatic approach to guide the actors in the choice of solutions to implement. It should be noted that use-cases (especially large industrial plants) too are seldom built, nor operate exactly as planned, and should therefore be measured ex-post. However, the uncertainties of the base-cases can essentially not be verified, since they are projections that will never materialize.

Contextual mobility of calculations

Above, we discussed how energy savings are constructed and how they become mobilized as decision-making tools in and around concrete projects. We will now proceed to follow these numbers as they move to different *contexts* with diverse logics of use. Here, we continue to follow Project 4 from the researcher's model (Fig. 1) until it ends up as being reported in the form of energy results by the Norwegian government agency for energy efficiency.

Context I: estimating energy efficiency of an industry plant

As shown above, the researchers projected the base- and use-cases by combining expectations of the future plant into a model. Within the research context, it was clear for the parties involved that the base- and use-cases contain several uncertainties and simplifications. Figure 1 above shows that in Project 4, the *Use-case 2* identified by the engineers suggested the largest energy savings and costs compared to the base-case. In the project group, there were discussions about which of the cases actually was the best choice. The main energy savings from *Use-case 2* came from reduction in district heating. District heating is a local energy carrier, which in this case was saturated with surplus heat from other industries and renewable energy. Thus, while district heating "counts as the same" as electricity in the model, it was not worth as much in practice. The researchers argued instead that *Use-case 3* was the optimal choice from an environmental point of view, because it would reduce the electricity consumption more. In these discussions, system boundaries were, contrary to the initial limitation, expanded to the surrounding energy system. However, as the researcher noted, the model (and detailed project report) was a sufficient basis for the firm partner to proceed with technology developers:

> I think it is a good enough basis for decision to bring to suppliers and say: “this is how the researchers have looked at it.” Then there will be discussions like “we cannot do it like that, we have to do it like this”, but the main potential will still be there. (Researcher)

Thus, in the context of technology assessment and comparison, the actors are aware of and tolerate the uncertainty of the calculations, because they serve the purpose of providing a basis for comparing the different technology options.

Context II: deciding on technology options

For the firm, the value of the technology assessment (Fig. 1) lied in demonstrating that the overall concept of utilizing surplus heat and high-temperature heat pumps was viable regardless of heating and cooling medium. Furthermore, the model was useful when choosing between the different technology options considered at the new plant. In this context of use, the calculation and models produced by the engineers were re-contextualized with operational knowledge on working fluids, assessments of complexity, and risks of each technology option and investment costs. While *Use-case 2* and *Use-case 3* were the most energy- and cost-efficient of the options, the use of CO_2 as cooling medium in both of these use cases was considered an operational risk for the company:

> When we considered [the solutions], we based this on what was most energy efficient, and what we have experience with. Operational stability is highest on the list of priorities, and preferably, something we have experience with from before. That is where known cooling mediums come in as an important factor. The initial recommendation was CO_2, but we have way more experience with ammonia as cooling medium and it is also well established and recommended as a stable cooling medium. CO_2 is relatively new. We are not quite sure how it works in the different operations and you can get extremely high pressures when working in these areas. (Firm Partner)

Thus, the firm chose *Use-case 6* (high-temperature heat pumps and ammonia as cooling medium). In this context, they used the representations of the projected use-cases to decide the best match to reduce energy consumption and costs. Though the standardized objects were the starting points for comparison, context could be brought in when relevant. Results were re-contextualized by the firm in order to account for operational experience, implementation issues, and needs. In addition to minimizing energy consumption, the objective of ensuring operational stability and low risk was vital in the technology decision-process.

Context III: attracting funding for implementation

Following the choice of *Use-case 6*, the calculations of energy efficiency and energy savings moved to a context of attracting funding for implementation. Due to the novelty of the technology, the firm had to invest in back-up systems, meaning that they had to cover the additional costs of the new heat pump system. In this specific policy program, the company was required to demonstrate that the solutions were sufficiently novel compared to standard technologies and that energy savings would be substantial.

> […] one of the basic principles was that it had to be innovative and exceed Best Available Technology. Therefore, we had to describe why these technologies were better, or more innovative than available technologies. (Firm Partner)

The novelty requirement also entailed demonstrating that the technologies and knowledge gained from implementing them would have a wider reach, to ensure innovation diffusion to other firms. Further, there was an additionality requirement that the agency would not fund already economically viable projects. As such, the firm had to demonstrate that the project could not be implemented without government funding.

> They can only support up to a certain profitability. It cannot be *too* profitable. Usually, projects where you test novel technologies are not too profitable. (Firm Partner)

In addition to describing the proposed technologies and implementation plans, the proposed projects had to report improvements on three different attributes: energy results (kWh), power demand (kW), and CO_2 equivalents. Demonstrating these objectives meant re-introducing the base-case as a reference point, how the facility would perform with standard technology and correspondingly higher energy consumption, power demand, and CO_2 emissions. In the context of qualifying for funding, the calculations of energy savings were a means to advocate the breaking point between the reduced operating costs and the increased investment costs for the measures to be eligible for funding.

Context IV: demonstrating the effect of research and policy

The results from the project also entered the context of the research center and energy efficiency agency as a *product* of their respective activities. Here, the numbers and models justified the activities within the research center and the agency. The explicit objectives of the research center are to enable 20–30% reduction in energy use and 10% reduction in climate gas emissions from the Norwegian industry. Within the research center, Project 4 was reported to produce a relative reduction (%) in district heating and electricity demand and CO_2 emissions. The numbers included in presentations and reports demonstrate goal attainment of the research center.

The energy results were also used by the energy efficiency agency to demonstrate reductions as a result of their funding of industry projects. Here, the results from Project 4 were reported in the form of fixed, precise numbers of kWh/year, kW, and CO_2 equivalents. While the numbers stay the same as the firms' estimates, the relative calculations against the base-case became stable energy results. Through this transformation, the base-case was no longer a projection but became a calculable past, a historical point, which compared to Use-case 6 *produces energy savings*. Also, the attributes in the representation changed. When the primary energy source is abstracted to absolute kWh, the reported numbers no longer distinguished between district heating and electricity, thus removing the locational dependencies of the energy source. Nor did they indicate estimated, relative differences between potential technologies anymore, but were rather given the form of actual energy results. Previous uncertainties and contextual contingencies were black-boxed within the specified indicators of energy (kWh), emissions (CO_2), and power demand (kW).

Context V: aggregating energy results

The journey of the energy efficiency results did not end there. The estimated energy results from Project 4 were also included in aggregations of energy results

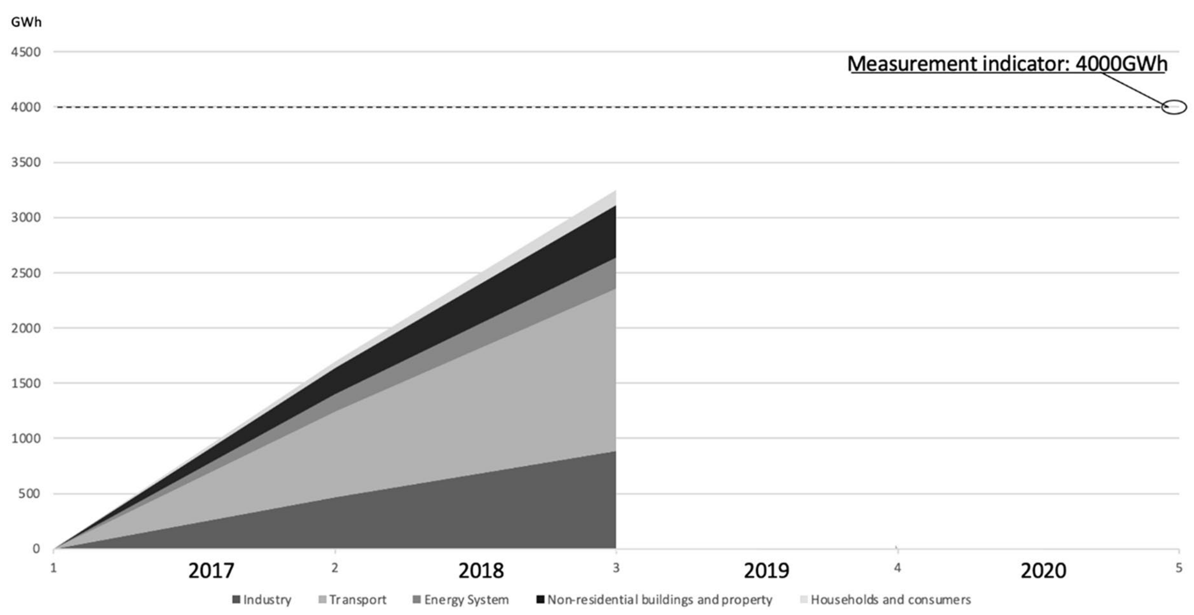

Fig. 3 Reported energy results (GWh) from projects granted funding in 2017 and 2018 (based on Enova, 2019a)

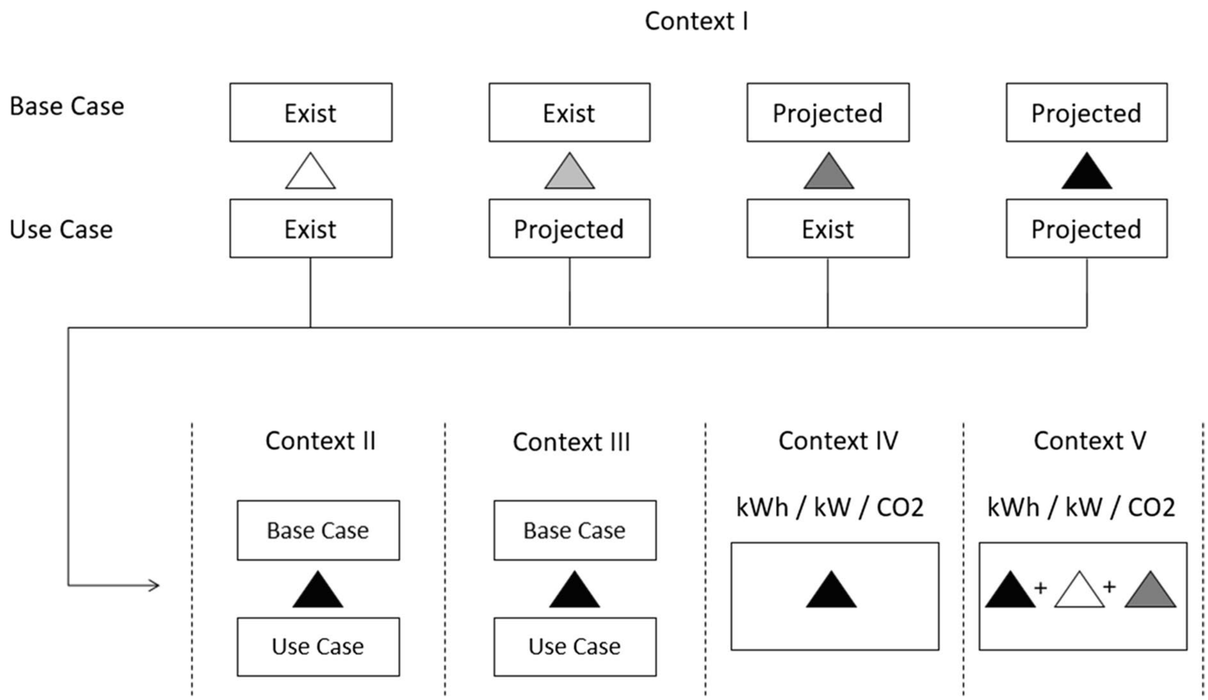

Fig. 4 Illustration of the contextual mobility of energy efficiency calculations and energy results. The four different forms of comparison (see section on Constituting energy efficiency and energy savings), and our discussion of the contextual journey of Project 4 are represented by the black triangles

by the agency. In the period 2012–2018, a total energy result of 12.25 TWh/yr was reported (Enova, 2019b).[5] The aggregation combined the energy results from a multitude of different projects (including Project 4), funded by the agency through different programs, spanning a broad range of technology solutions (e.g., implementation of heat pumps, energy management systems, fuel switching, battery banks, and renewable energy production projects) in industries as well as public and private buildings. The projects varied from complex estimates (such as in our case) to more mundane but straightforward calculations of replacing an oil furnace with heat pumps for household heating. Yet, the projects were "made the same" by cumulatively adding the energy results, as shown in Fig. 3.

The objective of this representation is to illustrate the path towards the agency's indicator for goal achievement, a 4-year target of 4 000 GWh/yr within 2020. Rather than minimizing the energy use of a certain facility, the success indicator lies in maximizing the energy results produced by their incentives and instruments. The aggregation and model are quantitative visualizations of the energy that was not used,[6] but also importantly of the energy that *continues to not being used*. Employed in this context, the logic of applying these numbers is no longer to minimize energy use at an industry plant, but to demonstrate an increasing reservoir of energy results enabled by the agency.

Discussion

The differential values, as representations of energy savings, were mobile beyond the contexts they were drawn from, as illustrated in Fig. 4. They have the trans-contextual mobility of immutable mobiles (Latour, 1995). As these numbers travel from the context in which they were constructed and calculated,

[5] The exact number of energy results and projects are continuously adjusted in the database (e.g., correcting for cancelled projects and final reporting after project completion); thus the aggregated numbers applied in this article may have changed slightly since the database was accessed.

[6] This aggregation and model also include results from projects on renewable energy production and fuel switching.

they became more idealized. The uncertainties and preconditions in the object constructions, comparisons, and calculations, as well as systemic interactions with their surroundings, were black-boxed.

The energy results carry with them expectations that are both rational (e.g., energy use of proposed technologies) and fictional (e.g., uncertain projections of the future), but whether the particular expectations are relevant depend on the context in which they are used. In the context of technology assessment and efforts to minimize energy use from industry processes, calculations of energy savings serve their purpose as placeholders, despite their rational-fictional character. The actors applying them know and accept the uncertainties and contextual preconditions, and the numbers fit the task of providing a basis for optimizing on the system level and deciding between technology options. Here, base-cases serve a distinct purpose in validating research results and improving technology. However, in contexts of demonstrating that energy results have been produced, the underlying fictional expectations of base-cases are black-boxed. While the base-cases in these projects range from existing, possible, unknown, and possibly even unlikely (as shown in Project 3), they are molded into calculable objects on equal terms. Furthermore, when addressing actual energy reductions in society following specific industry projects, systemic effects on the surrounding energy systems (e.g., reductions in district heating vs electricity) would indeed be relevant. Yet, when the energy efficiency results are applied in Context V to demonstrate aggregated energy results, such preconditions are not brought back into the calculation.

The researchers and firms do not merely *describe* energy savings of projects; it is their calculations that *produce* them. Demonstrating the difference between two projected states are performative acts (e.g., MacKenzie, 2006; Turnheim et al., 2020), in which the numbers live on as energy results in aggregations. As we have shown, the numbers are the results of comparisons of specific types of objects constructed to be commensurable. The energy results are decontextualized immutable mobiles, infinitely comparable and combinable, independent of their origin. While the numbers remain the same as they travel, the representational pragmatics they are part of change as they move from contexts where the aim is to identify the potential for minimizing energy consumption of industry processes to contexts where parties seek to demonstrate the results of their efforts. The energy results become purified (e.g., Shove, 2018), and uncertainties once known to the actors are lost in translation as the results of different forms of comparisons are aggregated, irrespective of their original contexts. Within this aggregated number and the models representing them, savings from different energy sources (district heating, electricity), ontological status (existing or projected industry plants), and certainty (rational and fictional expectations) are made commensurable. In this way, the numbers attain a "mechanical objectivity" (Porter, 1995, p. 4) through abstraction, aggregation, and assumed precision. The aggregate numbers are, as shown in the Norwegian case, the result of commensuration of projects and projections that differ widely in terms of their origins, concealing the accuracy and context of these projections.

From minimizing energy consumption to maximizing energy results

Energy savings are calculated based on different forms of comparisons — objectified and mobilized. These comparisons rely on a *hypothetical counterfactual reality* of existing and projected *non-efficient* industry plants, buildings, components, and processes — a world of outdated and wasteful processes. As they move between contexts, the results are aligned with different organizations' goals. Several actors claim responsibility of producing the results. They are demonstrable products of a research project in the center, of industry practices, as well as being triggered by the incentives of the energy efficiency agency. In this way, the numbers move between contexts transcended by different *ends-in-view*. Prominent in the first contexts are the pragmatics of *minimizing energy consumption*, visible in the researchers, firms, and agency's efforts to assess, develop, and implement technologies. Here, use-cases and calculations of energy savings serve a distinct purpose of coalition building of managers, project leaders, technology suppliers, and engineers towards selecting and implementing best-fit technology to reduce energy consumption (and operational costs) at new facilities. This also includes the agency's overall objective of enabling diffusion of novel environmentally friendly and energy efficient innovations, by demonstrating viability of technologies and energy savings in practice. Our study also shows another pragmatism concerning the accounting and *maximizing energy results*. Here, the concern is to demonstrate energy savings as the product of directed efforts by the research center, firms, and energy efficiency agency.

On the face of it, these goals should be well aligned. However, while the former is an activity that recognizes and utilizes the relational nature of comparisons, and the uncertainties of the calculations, the latter is an objectification of the energy results. This reflects a wider trend where invested funds must produce a visible output (e.g., Shore & Wright, 2015) particularly evident in the neo-liberal New Public Management infused mode of governance. In this discourse, which is also dominant in climate policy (Dalsgaard, 2013), quantifiable results are the main output of policy and research efforts. The gigantic and increasing reservoir of energy results legitimizes practices and political decisions, by demonstrating the path towards sustainability in absolute numbers.

This accounting system does indeed work as an engine, to paraphrase MacKenzie (2006), but it produces a special form of output, and governance and policy based on these numbers do have implications. The logic of producing energy results may affect choices in search of optimizing specific industry processes. Since funding is achieved by utilizing a hypothetical counterfactual reality of energy results in a program-specific definition, there is an opening for pursuing the maximization of energy results at the site level, rather than reducing energy consumption from a system perspective. For example, by placing system boundaries around the single industry plant and juxtaposing electricity and district heating, projects can potentially neglect interaction effects and industrial energy symbiosis in a regional perspective, or conversely overvalue savings in the aggregated numbers.[7] Furthermore, this measurement does not include potential market change and diffusion of technologies funded by the program, suggesting that the positive effects of these projects and policies could also be larger than shown in the indicators. Another implication of pursuing energy results is that increased industrial activity leads to an increase in energy savings even though total energy consumption increases. Since energy savings are measured as the relative difference between use- and the base-case, a new industry plant can consequently produce energy savings. Thus, every kWh of energy consumed produces a corresponding amount of energy results in the parallel world of calculation. Lastly, this way of measuring and cumulating energy savings over time implies that energy savings are continuously produced. This illustrates a threshold issue for base-cases. How long should an abandoned industry process or technology serve as base-cases that continue to produce energy savings?

It is important to note that these actors do not blindly pursue, nor govern solely based on, maximizing energy results. As shown in the provided cases, some of these issues are mitigated by the researchers and firms themselves, and potentially also by the evaluators in the application process or specific program requirements. Furthermore, recognizing that the energy results and their aggregations are based on fictional, as well as rational, expectations, and adhering to different pragmatics, does not imply that they do not have effect on the energy performance of industry processes. On the contrary, there is a connection between pragmatics of minimizing energy consumption and maximizing energy results. Only by moving energy savings into framings of producing energy results — measurable and auditable quantifications — the companies are granted funding for implementing the solutions. Thus, the incentives *succeed* in enabling energy savings for industries, through development and uptake of novel technologies. Furthermore, representations of energy savings and aggregations of energy results serve a political purpose in providing "facts" on the benefits of energy efficiency research centers and incentive programs. They are a form of storytelling (e.g., Beckert, 2013), providing legitimated justification of decisions as well as policy. However, while energy results can be a useful way of measuring the effects of policy instruments, this way of pursuing and accounting for it may lead to a drift between the increasing reservoirs of energy results and realistic estimations on reductions in energy demand, potentially threatening the legitimacy of policy within this field. Calculating and accounting for energy savings clearly has a value in policies of sustainable transitions. This paper demonstrates that there is a need for reflexivity regarding how they are used once they are decontextualized.

Conclusions

In this paper, we set out to address how energy savings are calculated in industry-research projects in

[7] In the Norwegian case, this is partly accounted for by the power demand (kW) indicator, in which the projects also report on.

Norway and to uncover how these measurements are mobilized practically and politically in the policy domain. Essential to this is how energy savings is a quantification of difference. We have shown how these calculations are constructed in several different ways, by comparing the energy consumption of old existing plants with plans for new ones, or new ones with imaginary old ones, or by comparing a projected new one to an imaginary old one and so on. These calculations contain and conceal a wide variety of uncertainty, contextual preconditions, estimates, and projections. Moreover, the calculated savings are relative measures. Energy savings can be produced both by improving and replacing an existing technology and by new builds where the savings are measured against a projected base-case. Furthermore, we traced the transformations, trans-contextual travels, and policy employment of some of these numbers. Once arrived in reservoirs of *energy results* in the policy domain, the uncertainties and contextual preconditions that are prominent in the engineering contexts are black-boxed. When aggregated and used as measurements of governance and policy, for example, to improve the effects of incentives on energy efficiency, the results are homogenized; they become representations of the same. They are, in a way, incomparable yet commensurable.

While the policy performance objective is to maximize energy results, the overall objectives are reducing energy consumption to improve energy security and contribute to a sustainable transition. For the firms, minimizing energy consumption and achieve funding to do so is the main concern. Our paper describes the ways in which energy savings calculations move between these different objectives, and through this, we highlight some of the potential pitfalls when applying these numbers to prove achievement of multiple goals. How then can we ensure that endeavors to make energy consumption more efficient do not disintegrate into theoretical exercises where the real-life consequences are uncertain? Fundamentally, the paper shows that researchers, regulators, and policymakers should be reflexive towards ex ante calculations of energy savings. A part of this reflection, and a topic for further research, will be to study the time horizons for base-cases and the role of uncertainty, assumptions, and counterfactuals in calculations. Independent ex-post evaluations, combining bottom-up with top-down assessments, or econometric modelling, could be a step towards improving these measurements (e.g., Bertoldi & Mosconi, 2020). Further, producing energy savings does not necessarily correspond to a reduction in energy consumption overall, suggesting that policy mixes focusing on sufficiency approaches could be considered (e.g., Darby & Fawcett, 2018). Lastly, methods are certainly developed for different purposes (e.g., Abeelen et al., 2019, p. 1323), and it is important to also recognize the usefulness of a measurement, such as energy results, both to measure effects of policies and to more easily compare different projects and programs. However, once produced, these results are sometimes applied for purposes other than that which they were designed for, for example, if taken as evidence for reductions in energy demand. As several researchers have noted, the connection between energy savings and reduced energy demand on a societal level is far from straightforward (e.g., Labanca & Bertoldi, 2018; Shove, 2018). As such, while *mathematical correctness* and *applicability* for policymakers can sometimes be in conflict (Abeelen et al., 2019, p. 1327), this paper suggests that also the *rhetoric* when applying such numbers should be carefully considered for energy efficiency and energy saving policies to maintain legitimacy.

Our study contains a small sample of context-dependent case studies and must therefore be interpreted with some caution, particularly when venturing outside the regulatory landscape of Norway. Future research applying different methods, targeting different types, and broader reach of projects could investigate the overall effects of Norwegian energy efficiency and energy saving policies. For example, to what extent these policies contribute to market change and diffusion of energy efficient technologies are not investigated in this paper. Another topic not explicitly elaborated upon in this paper is how projects concerning produced renewable energy and those changing from fossil to renewable energy carriers are included similarly in aggregated energy results. While this is useful for policymakers to compare the impact of different projects, it makes for a tricky rhetoric in what this aggregated number actually means when combined with results emerging from energy savings projects. These policies are also changing, and remains to be seen which indicators will be applied in the new agreement for the agency operating from 2021. However, the issues elaborated on in this paper are worth investigating in the adjusted policy framework.

Essentially, this study provides insight into processes where improving energy efficiency goes from being an engineering problem to an issue of management, governance, and policy, and how this process involves several forms of objectification and commensuration. These processes are linchpins in the interconnections between research and development, governance, and energy policy, and most likely within several other fields where science meets governance and policy. This might sound like an abstract issue and a philosophical discussion, but in times of climate change and energy transition, it points to some very real challenges for innovators, policymakers, and others who seek to accurately measure and demonstrate the development and state of changing sociotechnical systems.

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Declarations

Conflict of interest The authors declare no competing interests.

Appendix

Table 2 (Informant overview)

No	Role	Project
1	Researcher (principal researcher)	Project 1
2	Researcher (master student)	Project 1
3	Researcher	Project 1
4	Researcher (responsible for firm projects)	Project 1
5	Researcher (industry contact	Project 1
6	Firm representative (management, project leader)	Project 1
7	Firm representative (engineering)	Project 1
8	Researcher (principal researcher)	Project 2
9	Researcher (responsible for firm projects)	Project 2
10	Researcher (principal researcher)	Project 3
11	Researcher	Project 3
12	Firm representative (Firm 1)	Project 3
13	Firm representative (Firm 2)	Project 3
14	Firm representative (Firm 3)	Project 3
15	Firm representative (Firm 4)	Project 3
16	District heating network representative	Project 3
17	Municipality representative	Project 3
18	Researcher (principal researcher)	Project 4
19	Researcher (responsible for firm projects)	Project 4
20	Firm representative (project leader)	Project 4

* Project 3 is based on data collected in a different research center (2011–2012)

**Some researchers were involved in more than one projects, and two informants were interviewed twice making the total number of interviews 17

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