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# Numeric work: The efforts of calculation actors to make numbers count in climate and energy policy

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## Abstract

Policy documents suggest that quantitative information is important in the development of climate and energy policy. This is supported by quantitative studies research into the use of numbers in governance, which tends to assume that numbers have sufficient epistemic authority to be used by policymakers because they are believed to be trustworthy since they are produced through mechanical objectivity. This paper questions such assumptions, by analysing the extent of extra-calculative work when providing numeric information to policymakers. We term such efforts numeric work and analyse the extent and content of such work based on interviewed experts who are engaged with calculating climate and energy issues in the context of policymaking in Norway. Numeric work shares features with the actor–network theory concept of translation but differs due to the dialogic interaction between calculation actors and policymakers that includes efforts to improve the transparency of calculation, which counters a complete black-boxing of calculation results.

**Key words:** numeric work; transparency; epistemic authority; calculation; climate and energy policy.

## 1. Introduction: the metrics of energy transitions

Increasingly, modern societies are interpenetrated by quantitative measurements (Mau 2019; Porter 1995; Rose 1991; Sætnan et al. 2011). Not the least, the use of metrics has become ubiquitous through the governance practices inspired by the New Public Management, where policies and efforts frequently are assessed by comparing quantitative goals with quantified outcomes (Hood 1995). Such numeric practices are clearly important also in the making of climate and energy policy. The Norwegian White Paper about energy policy, (Ministry of Petroleum and Energy 2016) is an example. It contains 230 figures, on average one per page of text. It presents three types of metrics: (1) descriptive statistics, such as 'Energy consumption increased by 8 percent from 1990' (p. 23), (2) results from model-based calculations of development trends, for example 'If it is assumed that all passenger car transport is electrified, this will require approximately 7 TWh a year with the current car fleet' (p. 210), and (3) quantified policy goals, such as 'By 2030, the EU has adopted a binding target of at least a 40 percent reduction in greenhouse gas emissions compared to 1990 levels' (p. 109). The White Paper uses these kinds of climate and energy metrics to guide policymaking that addresses the supply, demand, and turnover of energy in Norway, including suggestions about how to achieve sustainable energy transitions and climate change mitigation.

Some of the literature analysing the increasing use of numbers in all areas of society tend to view this as a process where quantitative information has a quite direct influence on policymaking, decisions, and assessments (Muller 2018). To make numeric information trustworthy, governments have regulated and institutionalised the collection and calculation of many kinds of data (Desrosières 1998, 2006; Mau 2019; Porter 1995). According to Porter, such efforts are intended to provide *mechanical objectivity*, a trust in numbers based on the presumed strict quantification and use of scientific methods. This paper extends the analysis of trust in numbers by investigating how the actors engaged in providing quantitative information to policymakers in the field of energy and climate account for their practices when communicating such information. What do they say they do to help make numbers count in policymaking? The paper is also a response to the call by Sovacool and Hess et al. (2020: 14) for research into the governance of sociotechnical systems change to account for the complexity of energy transitions, since such governance largely employs numbers as we observed above in the Norwegian energy policy White Paper.

The potential power of numbers may emanate from the institutionalised procedures set up by scientists (Latour 1987; Traweek 1988) or by governments (Bijker et al. 2009; Desrosières 1998, 2006; Porter 1995) or achieved through the collective performance of researchers involved in the calculation work. Furthermore, the influence of numeric information may be a result of the growing dependence on or even obsession with numbers by a host of social actors (Mau 2019; Muller 2018). Through interviews with experts providing quantitative information about energy and climate to policymakers and other stakeholders, we have asked about their efforts to make such information to be considered authoritative. We wondered whether calculations and personal or institutional status were sufficient to achieve trust or if the experts felt a need to engage in extra-calculation activities.

How important were displays of professionalism and of adherence to mechanical objectivity?

We know that scientists may need to engage with activities like enrolment, alignment of interests, and persuasion to get their results recognised and accepted. This is what Callon (1984) and Latour (1987) call translation, which also includes negotiation of what research outcomes mean and how they should be interpreted. Thus, translation is a broad set of efforts, initially directed at other scientists but also other audiences at later stages. This paper has a more restricted focus since we explore the potential need for and importance of extra-calculative activities in the context of policymaking. Is the communication between policymakers and actors engaged in calculations presumed to be relevant to decisions regarding climate and energy primarily a transfer of numbers? We assume that some efforts that resemble translation take place, but they may be shaped by both the policymaking context and the quantitative focus in ways that we believe make the numeric work a distinct feature. At the outset, we designate the efforts as 'numeric' since numbers are the centrepiece of the extra-calculative efforts. However, it is an empirical issue how the content of such work is shaped by its quantitative focus and the policymaking. We address this in the paper.

The context of our research is climate mitigation and energy policy in Norway, a small nation where the production of energy has a relatively greater economic significance than in most other countries. This is reflected in the frequently used phrase about Norway being an 'energy nation'. Norway is a large exporter of oil and gas, but also of renewable electricity. Thus, energy—and by implication climate mitigation—gets a lot of political attention. Furthermore, Norway has a dedicated Ministry of Petroleum and Energy as well as a Ministry of Climate and Environment, in addition to several directorates and a state enterprise that are engaged in energy and climate policymaking and the implementation of such policies. Regularly, these institutions engage researchers and Statistics Norway to supply quantitative information needed by policymakers. We have no reasons to assume that the relative importance of energy to the Norwegian economy makes the involved numeric work special, but such work may be easier to observe in a fairly transparent government in a small country.

## 2. Making numbers authoritative

It is important to study extra-calculative work in contexts where quantitative information is provided because modern societies seem saturated with numbers that often are assumed to be objective, neutral, and transparent, and thus a valid basis for decision-making. Considerable institutional efforts are made to uphold this impression and thus to make numbers performative in governance and policymaking (Daston and Galison 1992; Desrosières 1998; Porter 1995; Power 1997). Quantitative information tends to be assessed as credible and authoritative (Demortain 2019), and numbers apparently have an epistemic authority that is not granted to qualitative forms of knowledge (Espeland and Yung 2019). However, calculations are often done by stripping away the actual, often conflictual, and subjective context of their production and the granular, ambiguous detail of the phenomena they claim to represent. Thus, numbers may hide as much as they reveal (Espeland 2015; Piattoeva and Boden 2020).

An important advantage with quantitative information is the potential to expand the comprehensibility and comparability of social phenomena in ways that permit strict and dispersed surveillance. Numbers may easily travel across borders and cultures and seem straightforward to interpret, facilitating the monitoring or governing 'at a distance' (Cohen 1982; Miller and Rose 1990; Scott 1998). Numeric representation in governance consists of methodologies to achieve two main political purposes: to simplify complexity in order to come to a conclusion and be able to act collectively or in the name of a collective and, in doing so, to demonstrate adherence to public responsibility and absence of personal or group bias (Rottenburg and Merry 2015: 7). This makes trust in numbers vital.

To quantify is to express in numbers what was previously stated in words for the purpose of acting, deciding, or making demands (Desrosières 2006). Motives for quantification vary, but often they amount to some means for redressing uncertainties, exerting control, overcoming distrust, or improving communication and coordination among entities, and self-improvement (Mennicken and Espeland 2019). Decision-making based on numeric information tends to be seen as rational, fair, and legitimate (Merry 2016; Miller 2001). However, the processes through which the numbers are produced are often rendered opaque. Thus, citizens are left guessing what has been overlooked or deliberately excluded and why (Mennicken and Espeland 2019; Miller 2001). People's capacity to check the accuracy of calculations is often limited or even non-existent, requiring particular training, skill, and access (Mennicken and Espeland 2019).

Quite a few scholars have engaged critically with the apparent trust in quantitative information, which they see as a pervasive but problematic feature of modern society. For example, Desrosières (1998) questions the assumed obviousness of numbers by examining the involved calculation practices and the resulting 'black boxes' constituted by the indicators, categories, scoreboards, and other accounting or statistical tools that serve both as evidence and instruments of governance. For example, he shows how phenomena such as unemployment, inflation, and poverty are measured by statistics, which then are used in descriptions, discussions, and justifications of policies. In other words, 'they [the numbers] are inscribed in routinised practices that, by providing a stable and widely accepted language to give voice to the debate, help to establish the reality of the picture described' (Desrosières 1998: 1).

In a similar vein, Porter (1995) explains the political power of numbers in modern society. He analyses how quantification works to project power over large territories and emphasises the public dimensions of quantification, the emphasis on objectivity as an adaptation to the suspicious powerful outsiders. Porter emphasises that objectivity in this context is not a question of being true to nature, but of withholding judgement and resisting subjectivities (Porter 1995: 4). Therefore, faith in objectivity tends to be associated with political democracy or at least with systems in which bureaucratic actors depend on outsiders.

Like Porter, Sætnan et al. (2011) claim that standardised, quantitative measurements represent an opportunity to observe processes of governance in an apparently neutral and objective way. Quantification represents a possibility to compare, assess, problematise, and discuss the state of the state.

Measurements contribute to accountability and manageability. Arguably, modern societies depend on quantification, for example when planning roads, schools, and hospitals (Larsen and Røyrvik 2017).

The research reviewed above accepts the importance of quantification while emphasising the need to be aware of the power and the limitations of current quantification practices and of the ways in which they involve questionable gathering, interpretation, and use of quantitative information. Accordingly, the conventions, assumptions, and biases that shape metric processes should be examined (Espeland and Stevens 2008; Espeland and Yung 2019; Lippert and Verran 2018; Merry 2016; Piattoeva and Boden 2020). Our focus on numeric work is meant as a contribution to such critical inquiry by going beyond the calculation practices to study the extra-calculation efforts calculating actors engage in to help such information to be accepted as true, or at least as of more value than expertise from other sources (Beck et al. 2017: 1,068).

To explore this, we depart from the concept of *epistemic authority*, which invites us to go beyond the issue of trust to inquire into the trustworthiness, the perceived validity, and the basis of belief in quantitative information. The concept of epistemic authority was developed in social psychology to describe why lay people accept what experts say, emphasising that such acceptance is based on subjective perceptions (e.g., Raviv et al. 1993). Other scholars accentuate beliefs in the quality of science to provide truth (e.g. Lavazza and Farina 2022). The concept of epistemic authority could be seen as a core issue in the exercise of expertise, which some see as threatened (Collins 2014; Nichols 2017) and others as challenging to navigate (Eyal 2019) or as a potential source of conflict and injustice (Anderson 2020; Traweek 2021).

Here, we consider epistemic authority as an issue of trust in the qualitative information provided to policymakers, where trust is an achievement and not a given feature of numbers. For example, Saltelli et al. (2020) claim that trust is a prerequisite for numbers to be useful but notice that to achieve trust, the underlying assumptions and limitations of models should be appraised openly and honestly. Epistemic authority may also be related to the way quantitative information becomes embedded in networks of people who use them and the techniques and routines that facilitate this embedding (Espeland and Stevens 2008: 421). From the perspective of Nowotny et al. (2001), this means that numbers need to be made socially robust. Such robustness 'will only come about when it (knowledge making) remains open to continuous social monitoring, testing, and adaptations' (Nowotny 2003: 154).

Previous studies have given particular attention to the production and use of quantitative models in governance contexts. For example, Chiodi et al. (2015) observe that the role that energy modelling plays in underpinning policy decisions increasingly is recognised and valued, but this status depends on engagement and dialogue to achieve confidence in the output of models. Silvast et al. (2020) demonstrate how modellers saw policy relevance as providing a key form of legitimacy for their models and how concerned they were when they could not engage policymakers to put their models into legitimate use. Similarly, Berman and Hirschman (2018) find that numbers have little impact unless you convince others to use them. The epistemic authority of numbers may also reflect the status or style of presentation of those who produce them (Mellor 2018) and the performance of authority (Kantor 2021). Clearly, epistemic authority is not a binary but may vary from weak to strong.

Much previous Science and Technology Studies scholarship has inquired about the purpose of numeric information and how it is made. This article expands this line of research by analysing the work done by experts providing such information when they try to make numbers count in energy and climate policy. We offer the concept of numeric work to describe such efforts and aim to clarify what is involved in such activities, seeing this as attempts to improve the epistemic authority of the interviewees' calculations, relative to policymakers. Through analysis of interviews with actors calculating information about climate and energy issues, we aim to identify what kind of activities could be included in such numeric works.

## 3. Method

The empirical focus of this article is the numeric work that experts may undertake when providing policymakers in the field of energy and climate mitigation policy in Norway with relevant quantitative information. To study this, we chose a qualitative approach based on interviews, asking if the interviewees considered activities beyond calculation necessary when providing numeric information to policymakers, and if so, why and what kind of activities they engaged in. The first author conducted twenty-four semi-structured in-depth interviews with experts strategically sampled from the field. Three of the interviewees worked in ministries, nine in directorates, and twelve in institutions doing research. All researchers and nearly all the other interviewees were trained in economics, science, or engineering.

Those outside of research worked in the Norwegian Water Resources and Energy Directorate, the Norwegian Environment Agency, the Ministry of Petroleum and Energy, the Ministry of Climate and Environment, and Enova—a so-called state enterprise established to contribute to make the production and use of energy more sustainable, which at the time of the interviews was owned by the Ministry of Petroleum and Energy. One interviewee worked in the environmental unit of one of Norway's largest municipalities. All of those working outside research were also engaged in calculation efforts to provide policymakers with numeric information, but it was not considered research.

The sample consisted of seventeen men and seven women. The interviews were carried out between April 2016 and February 2018. They were done in person and lasted from 45 to 100 min, following a flexible guide with questions exploring the numeric work of the interviewees and how they explained it. We asked about 'How do you communicate numeric information to users? What have you experienced with regard to policymakers' use of numbers? Is their understanding of numbers appropriate? Do misunderstandings easily arise? What do you do to make it easier for users to use the numbers?' Such questions provided insights into the interviewees' extra-calculation efforts when providing quantified information to policymakers.

All interviews were recorded and later transcribed inverbatim by the first author. The quotes used in the paper have been translated into English by the authors. All interviewees have been anonymised and are referred to by abbreviations.

Researchers are designated R1–R12, experts in ministries M1–M3, and those working in directorates and municipalities D1–D9. All of them were engaged in producing quantitative information.

Data gathering, analysis, and writing were ongoing and intertwined processes. We analysed data inspired by a grounded theory approach by coding data and developing categories (Charmaz 2006) but above all using an abductive approach by invoking relevant theories and concepts (Reichertz 2007). Abduction is intended to help researchers 'make new discoveries in a logical and methodologically ordered way' (p. 216). The advantage of going back and forth between analysis and writing is the constant checking if one's categories are representative of the data. The concept of numeric work emerged from comparing theories from quantification studies and findings from studies of the use of numbers in governance as a category that could cover several codes of efforts mentioned by interviewees describing extra-calculative efforts.

We present the analysis in two sections. The first provides a backdrop to the analysis of numeric work by briefly exploring the accounts of the making of quantitative information through calculation and review. The second section focuses on how the interviewees described how they performed numeric work to strengthen the epistemic authority of the numeric information they provided.

## 4. Calculation and review

Calculation and review are preconditions of numeric work. In this section, we explore how the interviewees explained these activities. This includes some considerations they had regarding the validity of the information they provided. To what extent were they concerned with uncertainties related to the methods they used and the statistical data they had available and thus nervous about the epistemic authority of the numbers they were asked to provide?

In the communities we studied, we found that some interviewees worked with model calculations, some worked primarily with developing numeric targets, and some worked with reviews. Reviewing means to assemble and manage numerical information from available sources. None of our interviewees produced descriptive statistics, but they used such data as input to their models and reviews.

The researchers and two of the employees from directorates worked with model calculations, using existing economic or techno-economic versions. Many of the interviewees did model work related to transitions to what they called 'a low-emission society'. Others made projections of energy consumption and analysed the future development of the Norwegian energy system. Engineer R4 studied the available technologies and how they could be implemented in the energy system, emphasising that such analyses required extreme amounts of data. Consequently, they had to use computer models. Yet other interviewees explained that they modelled the economic effects of different energy policies, for instance the impact of European Union's goal at that time of a 27 per cent increase in energy efficiency by 2030.

R6, a professor in economics, told that he worked in the borderland between traditional economic modelling and operational analysis to study industrial value chains, both long term to assess developments decades ahead and short term to predict outcomes next week, next year, or something in between. Another interviewee, R1, engaged with studies in behavioural economics and collaborated with psychologists, calling it experimental economics. They tested economic theory on people in a lab, using an experiment based on a computer game where the participants were asked to respond to a set of different financial situations: 'It's a large room with twenty-seven computers where participants sit in a row playing against each other, and we see if they react according to economic models. This will provide us with data.'

Other kinds of interdisciplinary collaboration were also described. Economist R12, who primarily worked with economic models, occasionally worked together with engineers. This was considered beneficial because 'they have a different modelling tradition with energy system optimisation models. Our models are not very detailed on energy carriers and that kind of thing, while their models are much more detailed.'

Economist R9 explained that when he worked with model calculations to explore potential features of a low-emission society, he started by identifying sources that gave information about what a low-emission society could be. The Climate Act was a relevant source, since it says something about how much Norway must reduce its emissions to become a 'low-emission society' by 2050. Based on such information, R9 and his colleagues tried to calculate what could be effective measures to implement now and during the next 10 years to reach the set goals. R9 described their approach as 'to largely use these models, which are numerical models that link economic activity with emissions'.

Many of the researchers worked with the so-called equilibrium models that are widely applied by economists in Norway. Economist R11 tried to explain them as 'A huge set of mathematical equations that describe how actors in the economy behave'. She said that models come in a range of sizes and that they sometimes made very small equilibrium models with only seven equations instead of 7,000. In contrast to large models, small models could be so simple that one could do the mathematical calculations on a sheet of paper instead of using a computer.

Some interviewees said that they used what they called optimisation models, intended to identify the best or the most rational actions in a given situation. Engineer D4 gave the following example with a focus on energy use: 'If you give TIMES [the model] the opportunity to analyse as it pleases, it will, for example, choose to switch to heat pumps because it is most economical and most rational and provides cheaper energy.' However, some input data could lead the model to suggest solutions that were not optimal. Thus, D4 noticed that she and her colleagues needed a watchful eye to control that 'the model did not go completely bananas'.

Five interviewees primarily worked with reviewing. They were employed by ministries and directorates. Economist M1 told that her core task was to communicate very complex matters in a compact format to policymakers. She mentioned reports from the Intergovernmental Panel on Climate Change (IPCC) as examples of complex information. Besides IPCC reports, M2 gathered information in a variety of ways. 'It's everything from meetings, conferences, many reports, and studies, to close dialogue with for example the Research Council.' Before communicating quantitative knowledge to policymakers, the interviewees themselves had to understand the information. Engineer D2 stated that scientific literature could be difficult to interpret and that it was a general problem that researchers write overly complicated. As an adviser in the science–policy interface, a common task for D2 was to ask researchers' questions like 'What is behind this research? Can you write this more clearly? Is this what you mean?' Still, he explained that understanding an issue did not necessarily mean it was easy to explain it to others and told that it was demanding to communicate climate issues and climate policy. Yet, he concluded rather optimistically. 'I think we succeed quite well in communicating to users.'

A recurring issue among the interviewees was the degree of involvement in policymaking and the navigation of facts versus politics. Engineer D5 said that his directorate had ambitions to contribute to change. He talked about their knowledge as essential for people to make good decisions. Others were more careful. For example, engineer R3 talked about making reservations about uncertainty and inaccuracy: 'I'm probably a bit of a cautious type and do not like to be so stubborn and say that this is an exact answer.' Some of the experts said that it was easier to keep their path clean by not getting too much involved in policymaking.

The fine line between advising and influencing politics had resulted in a precautionary culture in the directorate where D4 was employed. She said that the directorate was not meant to influence politics but tell facts. However, presenting facts could sometimes be perceived as exercising political influence, thus her precaution. Similarly, D3 worked at a directorate concerning costs and consequences for Norway of reducing greenhouse gas emissions. He highlighted that the role of the directorates is not to suggest and recommend measures to politicians but rather to create pure descriptions that can serve as a basis for decision-making processes. D3 did however mention that they had suggested measures to policymakers when asked for in the past and might do so again. Nonetheless, climate was highlighted as a field where the directorate did not get involved in policymaking but delivered reports concerning purely costs and consequences. This attitude is predominant in the Norwegian governance context (Christensen and Holst 2017).

The interviewees unanimously agreed that applicable knowledge had to be correct and solid and that they needed to include uncertainties and inaccuracies when they communicated quantitative information to policymakers. Before providing policymaker with information, M1 said that she often engaged with the Norwegian Environment Agency to ensure the accuracy of the information, to see that 'it is completely correct, because it is extremely important to be precise'. Their attitude could be interpreted as an effort to adhere to the ideal of mechanical objectivity but with clear reservations regarding the resulting epistemic authority. The interviewees had experience that policymakers could raise questions with respect to method, accuracy, and interpretation of the provided numbers. Such questions was not interpreted by the interviewees to mean that the policymakers doubted their professionalism and adherence to mechanical objectivity. Rather, they saw a need among policymakers to be able to understand the quantitative information that was offered to assess its relevance and quality relative to other sources of information. Thus, numeric work was often considered necessary. We proceed to analyse how such efforts were described by the interviewees.

## 5. The need for and content of numeric work

Most of the interviewees acknowledged that extra-calculation activities were needed to strengthen the epistemic authority of the numbers that they supplied to policymakers. However, a few of the interviewees claimed that they did not engage in numeric work. R10 explained that he mainly supplied quantitative information without additional efforts. 'We do the analysis and make the report, that's it! We are not working very hard trying to sell ourselves afterwards, no. We don't do that.' Probably, this was due to a long-standing relationship with the people using the information who were competent users without a need for further explanations or persuasion, users that accepted the epistemic authority of the numbers they received.

D4 also emphasised that 'we write a lot of reports'. However, authoring reports may involve efforts to make the information be seen as trustworthy, although she did not acknowledge that. On the other hand, D4 voiced a combination of frustration and indifference when she talked about demands of providing more information online when that was already easily available and understandable for anyone interested. She said that she and her colleagues resisted meeting such demands, since that would require extra efforts. It was unclear if she considered this strategy to be viable in the long run.

Thus, nearly all the interviewees, regardless of whether they worked inside or outside research, engaged in numeric work. They did not complain about lack of epistemic authority or having to do the extra efforts, even if they sometimes expressed frustration regarding policymakers' attention and availability. Rather, they described their numeric work activities as expected and reasonable, as part of their standard practices. To engage in numeric work was a normal but occasionally challenging ingredient when supplying policymakers with quantitative information.

When describing their numeric work, the interviewees emphasised the importance of finding effective ways of communicating results and establishing networks with policymakers. The concerns about communication were diverse, including how to assess its effectiveness. R6 told that he and his colleagues used experience to imagine what the target group would prefer. 'There is always a discussion about what the best way to represent findings is, but often you see what works and what does not work to represent quantitative.'

A shared assumption among many of the interviewees was that simplification was important. For example, R11 considered the search for a common communication platform with people with a different education and work experience than herself as a constant learning process. 'It's never possible to simplify enough. It is probably the main lesson after many years.' Thus, she emphasised communication efforts that meant making numbers understandable to policymakers. 'We work quite a lot with communication in relation to Excel figures and graphs and such things to make them easily understandable and clear' (R11).

Presenting numbers as graphic representations was considered a useful method, particularly when trying to explain numbers to non-economists. Most policymakers lack such training. R6 highlighted the importance of articulating both the input and the output of the calculations, arguing that graphic representations were best suited for that purpose. 'They are relatively easy to understand and give a fairly accurate picture of what is happening.' This view of graphical illustrations corresponds to Espeland and Stevens's (2008) argument that good graphical representations make complex phenomena and statistical associations thinkable and help shape information that otherwise would be hard to grasp.

R3 described customising presentations as an important point of departure when making numbers easier to comprehend. This was considered to be a complementary strategy to simplification since different audiences often had specific requirements and expectations. Accordingly, R3 would customise her presentations by simplifying complex terminology, using terms that the audience could relate to. Of course, this meant a loss of precision but was not seen as a problem. 'We both use the same term, and we may think we are talking about the same thing, but we may not do so completely, just almost' (R3).

The strategy of linguistic adaptation to suit the target audience was widespread. Quite a few of the interviewed researchers said that they primarily wrote their reports and papers in English since contributing to the international research community was an important part of their job. However, they emphasised writing in Norwegian when targeting Norwegian audiences, also because this beneficially influenced the style of writing. 'Reports in Norwegian become much more explanatory than an international article' (R5). R12 made clear that when writing to ministries 'It will typically be a piece without formalism, more like popularised science or an effort to synthesise, which is not full of equations and that kind of stuff, while technical details and detailed data will be in the appendix.' Hiding complexities could also be done by using footnotes or attachments. 'We write reports where we use some complex expressions, which must be described in tables, footnotes, or elsewhere' (D4). Thus, footnotes and attachments could be used to indicate the mechanical objectivity of the information provided.

Graphic representations and other ways of simplifying complexities were not the only strategies to make policymakers interested in appropriating quantitative information. According to D5, making titles and summaries catchy was a way to get busy policymakers interested in quantitative information. 'You can hardly expect them to read more than the summary.' D5 suggested a different linguistic strategy than simplification to stimulate policymakers to read more. He advised to use complete sentences in headings instead of single words such as 'data' and 'conclusion'. R7 said that they used medical metaphors to persuade the audience that the research was useful. 'We used terms such as diagnostic tools, condition, problems, diagnosis, measures, and cure to describe how the research could be used.' However, none of the other interviewees reported similar use of metaphors.

We interpret some of the communication efforts as ways of providing epistemic authority to numbers by improving their appeal. The interviewees tried to make numbers interesting, enchanting, and trustworthy. They did this by hiding complexities, by presenting the numbers through syntheses, or by using catchy headings or popular metaphors. These efforts involved persuasion work with simplification, catchiness or similar rhetorical moves as the main ingredients.

In addition, networking was described as important. The interviewees were concerned to engage with actors who could become users of the quantitative information that they produced. They considered such engagement crucial not only to create interest and trust in the quantitative information they could provide. It was also important to get input from potential users about what they currently found interesting and challenging in their work, to tailor information to meet their needs. In addition, R2 explained that: 'Many users have a lot of valuable knowledge, and they often know some important facts better than we do.' Thus, engagement with potential users was a two-way affair, an exchange of information.

> We have had a lot of one-way communication with users where we presented our research and talked about what we had done. After we changed the format [to become more interactive], we experienced that if they [users] report interest in a topic prior to the meeting, then they are much more interested than if we try to force a topic on them.

Policymakers' interests in numeric information were conceptualised in several ways by the experts. D8 argued that numbers were appealing to policymakers due to the ability of quantitative information to communicate action. '(I)f they [politicians] can commit to numbers, then it is a very clear way to communicate to voters that "look, we are doing something, we are setting goals, we are not chatting idly". 'On the other hand, some of the experts complained about policymakers' availability as being fluctuating and fickle. Policymakers had to be persuaded to spend time on receiving information, which was not always easy. For example, R12 reported that she had expected more people from the Ministry of Petroleum and Gas attending a conference that took place a few days before he was interviewed. This expectation was based on their positive responses in advance of the event. However, they did not show. According to R12, 'we experience very often that something else gets in the way'. R10 explained that

> Our owner, the Ministry of Finance can send us an email stating that 'we have a problem, can you fix it by June?' Then we do fix it by June because that's how the relationship between us and the Ministry is made up. At other times, the Ministry may call and say 'What the hell are you doing? You cannot say this'. With some issues, there is a close and intimate relationship, and with others it is back and forth whether we are a hair in their soup or not. We have a kind of academic independence and freedom, but we still have thematic requirements of our research that is linked to our role as a supplier to the Ministry of finance.

We observed frustration among the interviewees concerning not being listening to. Part of the frustration seemed to come from a time squeeze on their side as well as among policymakers. One of the researchers, R10, talked about the frustration he experienced trying to schedule a meeting with the minister.

> We had a meeting with the Minister 14 days ago. It was the fourth time that we had postponed the meeting and we ended up with Friday at 6 pm. And you know, they sit there with the phone under the table, all the time. Oh no, what a bunch they are. I remember in the old days, then there would be about ten politicians in addition to Secretaries of state and political advisers in such meetings.

As previously noted, many interviewees emphasised the importance of knowing their audience to be able to communicate well with them. R2 highlighted the benefits of information about whether the audience mostly consisted of economists or was more mixed, 'because then I know a little more about how I should explain matters and how specific to be'. R8 recognised that 'When giving a presentation to busy people like policymakers you do not have time for all the details and all the assumptions. You must be sharp and go straight to the main message.' Thus, the transfer of quantitative information could be made more effective through a better understanding of policymakers' views and challenges and by having dialogues rather than one-way communication. The latter observation is well known from research in the field of public engagement with science (Davies and Horst 2016; Wynne 1992), but it may not be familiar to experts calculating energy and climate issues.

However, such insights could result from experiences from networking, which involved efforts to create interest. R7 described such an initiative. 'We send out a menu of topics that we have been working on, to relevant people.' They would invite policymakers to highlight their preferences. Then, this input was used to decide who should visit those policymakers in order to give a seminar. Policymakers could also initiate contact. For example, R11 told that when he published new research in a public forum, he might get inquiries from people in his network who wanted to hear more about their latest work. 'Then they come and ask if we can organise a breakfast seminar, staff seminar, or something. We do quite a lot of that.'

Thus, the interviewees considered a wide variety of numeric work as vital to help calculations to become appropriated and appreciated by policymakers. Largely, calculations were not initiated by curiosity but by a need and willingness to serve policymaking purposes. They could be performed as a response to a particular commission but also as part of more long-term assignments or projects. Anyway, the interviewees wanted their calculations to be socially and politically relevant. Thus, they saw numeric work as important and meaningful, as something they considered carefully and wanted to improve, even if it at times could be frustrating and challenging.

At the heart of the efforts was communication to explain, simplify, and create interest in the quantitative information they wanted to provide and to establish stable relationships and the possibility of dialogue with policymakers. The aim was to make numbers interesting, understandable, and useful in a policymaking context. Networking was also emphasised as a way of facilitating dialogue that could have consequences not only for the way that the interviewees would communicate but also for understanding what calculations policymakers needed as well as how calculations could be better explained.

Arguably, a belief in the presence of a calculative rationality, a general trust in numbers in the policymaking community focusing on climate and energy was a backdrop of the accounts that the interviewees gave of their numeric work. This meant that they expected that their calculations would be considered as relevant input to policymaking even if policymakers did not appropriate the numbers without questions. The presence of a calculative rationality was not interpreted to mean that policymakers held strong calculative competence but that they generally would be willing to be informed.

In line with this, many of the interviewees reported that policymakers often requested further clarifications regarding the provided numerical information, which they considered opaque. The experts said that they needed to explain how the quantitative information was produced. This was not experienced to be a check whether the ideals of mechanical objectivity were upheld. Rather, it was a desire for greater transparency, which in turn also could improve the trustworthiness of the calculations (Nowotny et al. 2001). Efforts to improve the transparency of their calculation were important to the interviewees.

A common response when we asked about what they did to meet users' requests about explanations was like R12's. 'We place a lot of emphasis on trying to be intuitive and explain why we get the results we get; it is important that we achieve an understanding.' Such accomplishments should not be underestimated. The challenges to transform tacit to explicit knowledge are well known (Collins 1985: 51–78).

Some of the interviewees provided quantitative information to policymakers with whom they had a long-term relationship and thus were part of their network. In such cases, efforts to improve transparency might not be needed since this had already been done. In other situations, such efforts were considered necessary and challenging, echoing the problem of making tacit knowledge explicit but also other linguistic issues. 'We try in advance to find a way to reach out with what we want to say, but I think we may not fully make ourselves understood, we speak a somewhat different language' (R3). The interviewee elaborated on language differences and how they could deal with it: 'I certainly think we have something to learn about communicating more clearly, I think we have a lot of potential to be better at communicating but I don't quite know how to do it' (R3). R9 was an experienced speaker but offered a clear reservation about the achievements. 'I was satisfied with my last presentations, but it might be that the content was not so understandable for the listeners, but I have no clue.' Thus, it could be unclear to what extent such numeric work was successful.

In addition to explaining how calculations had been done, it was considered important to provide context to quantitative information, what Nowotny et al. (2001) refer to as contextualisation, which is a resource for understanding how and why calculations are done. Such work was considered necessary to make numbers understandable since the numbers in themselves might not make much sense. 'We tried to go beyond the actual results of the analysis as such and tried to put the results in context. To provide a little more meat on the bone' (R4). R2 said that 'It becomes easier to understand if you show this [quantitative information] and relate it to other relevant measures and stuff.' According to D4, it was not given that policymakers knew the difference between energy consumption, energy needs, and primary energy factors. R8 explained what could happen if quantitative information was presented in a complex way without transparency efforts. 'If we hide the results in cryptic equations, they will not be used. Then the report ends up on the shelf, and no one cares anymore.' Producing a number is of little importance unless you can explain why other people should trust and use it (Berman and Hirschman 2018).

Transparency efforts could also involve explaining uncertainties in the calculations. As previously noticed, the interviewees considered it important to inform about possible margins of error and weaknesses of data or models. M1 explained: 'We try to bring along the uncertainties and underlying assumptions when we use numbers, and then the challenge is often to be sufficiently brief. But this is something we are aware of and work with, that what we communicate is correct and precise.' However, this could be demanding. 'So, the challenge with numbers is that they soon live their own life (…). Regardless of how much you say about how uncertain it is, this doesn't go all the way in.'

Some emphasised the importance of making information verifiable. According to D4, 'if we collect data that are of uncertain quality but have great impact on the results, we will of course make room for calling attention to this (…). We try to document it (uncertainty) so it's possible to re-examine the information.' Arguably, such efforts of improving the transparency of calculation by communicating uncertainty may help in building trust, but to D4 and other interviewees this was as much a moral obligation and an aspect of being professional.

## 6. Conclusion: the meaning of numeric work

In the Introduction, we proposed the concept of numeric work to designate extra-calculative efforts needed to make policymakers interested in and willing to make use of the quantitative information offered by calculating actors, in our case experts supplying such information about climate and energy issues. As shown above, nearly all of the interviewees said that they engaged in such effort, which they perceived as important and as a normal task. It varied how they performed their numeric work, but the main ingredients were explaining what numbers meant and why they were relevant and interesting. Various strategies were employed for these ends, such as the use of graphical representations and other simplification efforts, including writing in Norwegian and avoiding technical jargon. Building networks with policymakers was emphasised to establish long-term relationships and gain insight about knowledge requirements and the contexts of interpretation. The interviewees also highlighted the need for explaining how calculations were done to provide transparency regarding how numeric information was produced.

The investigation of numeric work departed from some questions regarding the epistemic authority of numbers in policymaking in the field of climate and energy. We observed how previous research assumed that numbers tended to have some such authority, either emanating from governments' efforts to set up trustworthy institutions pursuing mechanical objectivity (Desrosières 1998, 2006; Porter 1995), from the pervasive use of quantitative information in modern society (Mau 2019; Muller 2018; Power 1997), or from scientific authority (Latour 1987). The assumption could also be derived from Foucault-inspired theories of governance by numbers (Miller and Rose 1990; Rose 1991).

However, it was clear from the accounts of our interviewees that they needed to engage with numeric work to achieve sufficient trust in or epistemic authority of numbers if their calculations should be used in policymaking. They trusted the results of their calculations, but they did not presume policymakers to consider their numbers in the same way. Extra-calculative efforts were needed.

We suggested in the Introduction that there could be similarities with the concept of translation, central to the actor–network theory, and numeric work. The accounts of the interviewees support this. According to Callon (1984) and Latour (1987), translation is a set of efforts to make the results of science and engineering interesting to audiences that may use or be engaged in supporting and promoting use of the results. Thus, a main feature is the building of networks based on the provided facts or innovations. Numeric work, as we have described it, shares the emphasis on creating interest and the building of networks. Still, there are some important differences. First, while there is an overlap in the meaning of 'explaining' and 'making interesting', the interviewees talked about explaining not only as a way of arguing the policy relevance of their calculation but also an effort to improve policymakers 'technical' understanding of numbers. Second, the accounts of the network building emphasised the need for dialogue to tailor the numeric work to specific groups of policymakers, sometimes also as input to what to calculate. Third, numeric work included efforts to improve the transparency of the calculations to open the black box of facts, at least partly. The widespread emphasis among the experts on inaccuracies and uncertainties in their calculation as part of the numeric work also contributed to transparency. Since black-boxing is an important point of departure for translation analyses of making facts interesting (Latour 1987: 108ff), this is an important difference between numeric work and translation.

The impact of social science, including economists and engineers working with techno-economic models, may be achieved in diverse and complex ways (Bastow et al. 2014). We consider numeric work as an effort to achieve such impact, in our case to persuade policymakers to use the potentially relevant quantitative information about climate and energy issues that calculation has made available. Provision of policy advice from research has been observed to be institutionalised in many contexts (Bijker et al. 2009; Jasanoff 1990; Lentsch and Weingart 2011; Owens 2010; Pielke 2007). The rationale behind such institutionalisation is mainly to ensure the quality of the science underlying such advice, which means that the institutions help policymakers with evaluating the advice they are given.

The numeric work we have investigated in this paper was different. It took place in a less formal and more interactive setting, even if we observed routines and partly institutionalised interactions with policymakers in some of the interviewees' accounts where they suggested that they had some more or less established repertoires of numeric work. This facilitated their efforts. Moreover, the interviewed researchers said that they published their research in international journals. Thus, much of it was peer-reviewed, and apparently, policymakers did not question the calculation skills of the experts.

However, in the end the practical quality of and the trust in the information were assessed through the interactions between the experts and the policymakers. As the interviewees explained, they performed the numeric work, but for this work to succeed, policymakers also had to be active. Moreover, the fact that the interviewed experts considered numeric work necessary shows that they did not consider policymakers as naive and uncritical recipients of numbers. Thus, a focus on numeric work improves the transparency of how numbers may be made to count in policymaking, in our case with respect to climate and energy.

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