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Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
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Dissertation summary

Quantitative information is often assumed to have a strong, direct effect on policy and decision-making. This dissertation is a critical comment to such assumptions. It questions the strength of the epistemic authority of numbers and argues that the ideal of mechanical objectivity of calculations may have limited impact on policymakers. The research is mainly based on interviews with actors who provide quantitative information to policymakers and with policymakers, both politicians and experts in the government administration in Norway.

Three research papers make up the core of this dissertation. They address different aspects of the provision of and the relation to epistemic authority with respect to quantitative information in the field of climate and energy policy. Paper 1 discusses how policymakers construct, interpret, and employ two Norwegian superior numeric targets, the first related to greenhouse gas emissions and the second to the energy efficiency of buildings. A key finding is that both targets were resulted from a co-production of science and politics – a range of events, circumstances, and actors – over a long period of time and with differences regarding the relative importance of science and politics. Paper 2 focuses on the extra-calculative work by actors that engage in the provision of quantitative information to policymakers. Such efforts were needed to make numbers understood and considered relevant to policymakers. The concept of 'numeric work' was developed to designate these additional activities. Paper 3 examine the use of numbers and how they are perceived by policymakers. Drawing on domestication theory the paper shows that quantitative information was not used unconditionally by policymakers. Rather, three narratives of domesticating numbers were found among the interviewees. Together, the papers demonstrate that numbers were not transferred in a linear manner from experts to policymakers as assumed in the common linear-autonomy models.

In the introductory tie-up and conclusion essay, the epistemic authority of quantification is further explored by focusing on science-policy relations. Through a theoretical framework of bicameral models inspired by Bruno Latour and Robert Jomisko, combined

with the concepts of socialisation of technoscience and modalities, I explore how science-policy relations influence the epistemic authority of numbers. The main finding is that science-policy relations concerning quantification in Norwegian climate and energy policy are inter-relational. The analysis show that both the experts providing the calculations and the policymakers play an active role in shaping the epistemic authority of quantitative information and thus how it is made use of. Furthermore, this dissertation show that experts and policymakers' interactions are messier than what is suggested by Latour's bicameral framework for analysing science-society relationships. Therefore, the dissertation argue that epistemic authority is provided through, and shaped by, a 'hybrid interactional model': close, interdependent, and repeated processes of interaction between experts and policymakers.

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This dissertation is a project set by the research project Center for Sustainable Energy Studies (CenSES), funded by The Research Council of Norway. Just months before going into this project I finished my master's degree in science and technology studies (STS). I was proud and happy, yet saddened to have reached the finish line. I wanted to do more research and learn more about the field of STS. Thus, the employment as a PhD candidate at the Department of Interdisciplinary Studies of Culture, NTNU, was an exciting and much wanted, next destination for me. I was eager to get started and felt enthusiastic and privileged for the opportunity I had been given.

Six years have passed, six enriching, challenging, and exciting years. Writing these final words, I realise that endings get me emotional. It is surreal and liberating to cross the finish line, yet I am also a little sad that it is over. However, don't get me wrong, it is extremely satisfying to be done. Many people have contributed to this research, to whom I am forever grateful.

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Trondheim, March 2022

Susanne Jørgensen

Table of content

1. Introduction: Numbers in Norwegian climate and energy policy

There was once a little goatling who had learned to count to ten. When he came to a puddle, he stood for a long time and looked at his reflection in the water. “One,” said the goatling. A calf walking nearby heard this.
“What are you doing?” asked the calf.
“I am counting myself,” said the goatling. “Shall I count you too?”
“If it does not hurt,” said the calf.
“It does not. Stand still, then I will count you too.”
“No, I dare not. My mother may not even let me” said the calf and withdrew. But the goat kid followed and said:
“I’m one, and you’re two, one-two.”
“Mother!” roared the calf and began to cry, and then the mother came to the calf, the farm’s bell cow herself.
“What are you roaring for?” said the bell cow.
“The goatling is counting me!” roared the calf.
“What is this about?” said the bell cow.
“I’m counting,” said the goatling. “I have learned to count to ten, like this: I am one and the calf is two and the cow is three, one-two-three.”
“Oh, now he counted you too!” cried the calf. And when the bell cow realised what had happened, she became terribly angry.
“I’ll teach you to make fun of my calf and me! Come, my calf, and we will punish him.”

The excerpt is from the story “*The goatling who could count to ten”* by the Norwegian author Alf Prøysen (1975). It is about a little goatling who starts counting all the other animals, much to their reluctance. Nevertheless, the counting proved handy when all the animals had to board a ferry, which only takes ten passengers. The story is about numbers and the meaning of counting. Numbers have a particular meaning in the field of climate and energy, for example, as targets and indicators related to sustainability transitions. Numbers related to climate and energy policy are the focus of this dissertation.

The context of this dissertation is Norway, where energy has greater economic importance than in most other countries. Policymakers describe Norway as an 'energy nation' which emphasises the vital role of energy production. Norway is a large exporter of oil and gas, but also renewable electricity. Thus, energy – and by implication also climate mitigation – gets a lot of political attention. Norway has a rather transparent government which contributes to greater ease in observing the construction and usage of quantification.

Three clarifications must be made before continuing. First, three articles make the foundation of this dissertation. For the most profound understanding of this dissertation, I advise readers to read these articles first, after this introduction. The articles are found after the summary and synthesis essay. Second, in the summary and synthesis essay, I use the term 'experts' to describe actors that provide quantitative information to policymakers, such as researchers, economists, engineers, and employees working with quantitative information in ministries and directorates. In the articles employees in the ministries and directorates are considered as both experts and policymakers: in paper 2 they are considered experts based on their role as providers of quantified information and numeric work to policymakers. In papers 1 and 3 employees in ministries and directorates are considered policymakers since their use and provision of numbers is involved in and impact policymaking. Third, for language variation, I use different terms when addressing quantification: numeric information, quantification, quantitative information, numbers, and measures. For the purpose of this dissertation, they are synonyms.

Climate change: perhaps the greatest challenge humankind has faced (IEA 2021), is affecting every country in the world, disrupting national economies and the lives and livelihoods (UN 2020). To secure the planet's future, humankind must strengthen the global response to the threat of climate change by keeping a global temperature rise well below 2°C, preferably to 1.5°C, above pre-industrial levels, as called for in the Paris Agreement (UN 2021). Limiting global warming requires limiting greenhouse gas emissions, preferably net-zero, by 2050 (IEA 2021). The challenge calls for a sustainability transition, which involves "fundamental changes in socio-technical systems such as energy, food or transport that aim to address grand challenges in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Markard et al. 2020: 1). Sustainability transitions are measured by quantitative achievements of quantitative goals. This is clearly shown in the Paris Agreement where countries are required to plan and report on their efforts to reduce greenhouse gas emissions (UN 2021). The agreement works on a five-year cycle of increasingly ambitious actions. That is, every five years, countries are expected to update and tighten their national emission targets. The EU recently increased its numerical goal of emission reduction from at least 40% to at least 55% by 2030. Norway, not part of the EU, has followed suit and tightened its goal from 40% to at least 50% and towards 55% reduction by 2030, compared to 1990 levels (NDC 2020).

Thus, quantification is central in the making of climate and energy policy. This is clear from national and international policy documents. The latest Norwegian White Paper on energy, "Energi til arbeid" (Meld. St. 36 (2020-2021), concerns long-term value creation from Norwegian energy resources. When reading the report, we see how numbers are important for formulating goals for future achievements. The national climate goal is presented as "at least 50 per cent and towards 55 per cent emission reduction" (p. 7), and other goals are similarly articulated, such as: "... a goal of 60 GW of offshore wind by 2030 [for the EU], and 300 GW by 2050" (p. 8) and "by 2030, all new heavier vans, 75 per cent of new long-distance buses, and 50 per cent of new trucks will be zero-emission vehicles" (p. 33). The White Paper illustrates how essential numeric information is to explain achievements, for example, "[s]ince the government took office in 2013, more than 16 TWh of new renewable power production have been developed" (p. 33). Also, at a detail level, numbers are invoked: "Rockwool's rock wool factory in Moss has gone from boiling coke in production to installing a new electric melting furnace, which reduces emissions by about 80 per cent" (p. 37). Moreover, quantification is used to compare Norway to the rest of Europe: "[i]n 2019, energy consumption from renewable sources was 19.7 per cent in Europe compared to 73.7 per cent in Norway" (p. 21). The report demonstrates the importance of quantification when articulating the present situation and policy targets in the field of climate and energy.

In climate and energy policy, targets are quantified, and indicators are constructed to be able to measure achievements. Numbers seem to offer a widely appreciated form of authority emanating from a belief in "mechanical objectivity": a form of objectivity that strives to eliminate human intervention in the observation of nature, either by using machines or through rigorous procedures (Daston 1995: 19; Daston and Galison 2007: 121). Knowledge based completely on explicit rules such as strict quantification through measurement, counting, and calculation can therefore be characterised as mechanical objectivity (Porter 1995: 7). The issue of importance is what we may call the epistemic authority of quantitative information. The concept of epistemic authority has been developed in social psychology to describe why laypeople accept what experts say, emphasising that such acceptance is based on subjective perceptions (Raviv et al. 1993). It is a form of trust that may emanate from the producers' position in an institution, a scientific discipline, or other sources of academic charisma (Clark 2008). Sharon Traweek (2021) uses the concept to discuss problematic aspects of the exercise of epistemic authority within and between disciplines. Others complain about the lack of trust in science, about what may be considered as the loss of epistemic authority in science (e.g., Collins 2014).

This dissertation questions the strength of the epistemic authority of numbers and argues that the ideal of mechanical objectivity (Daston 1995) may have a limited impact on policymakers. In different ways, the three articles in this dissertation study how epistemic authority in particular cases of quantification may be constructed, negotiated and perceived in the context of climate and energy policy. Policymakers are not uncritical recipients of numeric information, which is acknowledged by the experts providing the information, who interact accordingly with policymakers. Thus, we may see the experts as employing what Sheila Jasanoff (2007) calls "technologies of humility": disciplined methods that accommodate scientific knowledge.

The reports from the Intergovernmental Panel on Climate Change (IPCC) demonstrate how the quantification of climate and energy issues struggles to achieve epistemic authority. To illustrate this, I briefly discuss the media coverage of how the latest IPCC report, *Climate Change 2021: The physical science basis* (IPCC 2021 a) has been received by political parties in Norway.

The United Nations founded the IPCC in 1988 to act as the body for assessing the science related to climate change. IPCC's purpose is to provide governments with scientific information that they can use to develop climate policies, in addition to providing key input for international climate change negotiations. As the amount of published climate science knowledge is unmanageable for policymakers, IPCC regularly provides assessment reports, which are comprehensive summaries made by scientists who assess the thousands of scientific papers published each year about climate change: its impact, future risks, and options for adaption and mitigation (IPCC 2021 b). The term 'summary' may be misleading as the reports tend to be quite long. The last report published in 2013/2014 was close to six thousand pages. For this reason, a summary of the summary is made for policymakers.

Since the first report was published in 1990, reports have been issued every few years. During 2021 and 2022 the sixth report in the series will be issued. A portion of the sixth report, *Climate Change 2021: The physical science basis* was finalised in August 2021 (IPCC 2021 a). The report states that the consequences of climate change are stronger and developing faster than scientists had thought. The changes will be more far-reaching and, in many cases, irreversible. To limit global warming to 2°C, preferably 1.5°C, by the year 2100 (compared to the pre-industrial year, 1850), the report argues that we need to treat climate challenges as an immediate threat that must be acted upon now. UN Secretary-general António Guterres declared the climate status to be 'code red' for humanity. He also said the report must be the death knell for coal and fossil energy sources before they destroy our planet, and asked all countries in the world to stop all exploration for fossil fuels (UN Secretary-general 2021). The report concludes that if nothing changes, we may experience 1.5°C as soon as the 2030s.

What type of work goes into the IPCC reports? I argue that they are the outcome of numeric work. In the paper, *Numeric work: the efforts of calculation actors to make numbers count in climate and energy policy,* we define numeric work as the efforts of calculation actors when they engage in the provision of quantitative information to policymakers. The concept addresses the additional activities considered necessary by calculation actors to provide quantitative information with authority, and to make such information trustworthy and robust. Obviously, calculations are not enough when there is a need to synthesise climate research. One would expect a document like the IPCC reports to have a strong epistemic authority based on the amount of underlying scientific knowledge. However, the media coverage of Norwegian political parties' reaction to the IPCC report shows that the epistemic authority of the reports is limited.

The leader of the Green Party, Une Bastholm, expressed that the report terrified her and reminded her how life-threatening Norwegian oil policy is. Deputy leader of the Red Party, Marie Sneve Martinussen, had a similar reaction and called the report a shocking warning to the world community: "We must say no to new oil exploration (…) We need a new environmental and industrial policy which is not tailored for the oil CEOs". The Socialist Left Party leader, Audun Lysbakken, called for action by telling the government to stop twiddling their thumbs on the climate issue. In line with the Green Party and the Red Party, the Socialist Left Party believes that Norway must stop oil exploration. Sveinung Rotevatn, the Minister of Climate and Environment and Deputy Leader of the Liberal Party, believes that what emerges from the report is a clear message that more countries must promise to cut more than what has been already agreed to. In agreement with the other parties mentioned, the Liberal Party believes that the production of oil and gas must be scaled down more quickly (NRK 2021).

By contrast, the Labour Party, the Conservative Party, the Centre Party, and the Progress Party, all believe that there is still room for new, undiscovered oil and gas fields in Norway, even though the climate crisis is here now (Dagsavisen 2021). The Labour Party's energy and environmental policy spokesperson, Espen Barth Eide, said that they would use the entire government toolbox to restructure the economy and help struggling industries cut emissions. Furthermore, he emphasised that Norway has major advantages in the industries that would cut world emissions, yet if we are to use those advantages to create new industrial jobs, it requires that society acts now (NRK 2021). The Labour Party still believes that the oil and gas industry must be developed, not phased out entirely (Arbeiderpartiet 2021). Likewise, the Conservative Party pursue a policy where oil extraction should be reduced, not phased out. Then Norwegian Prime Minister, Erna Solberg, from the Conservative party said that she takes the report very seriously and that emissions must be cut. Yet in discussions, Solberg refers to Norway's White Paper "Klimaplan for 2021-2030" (Meld. St. 13 (2020-2021); a plan that accounts for concrete measures that will cut the country's emissions by 50% in total by 2030 (NRK 2021), as opposed to the IPCC reports.

The Progress Party has long been opposed to unilateral Norwegian climate measures, which they believe have minimal significance for global emissions. When asked how alarming the report is, the Progress Party First Deputy Leader, Ketil Solvik-Olsen, answered, "I register that it is very alarming and will offer great challenges". He went on to say he is more worried about the left wing's aim to phase out oil and calls such an approach "headless" (NRK 2021; Nettavisen 2021).

The media coverage of the IPCC report shows division among Norwegian political parties. It provoked strong reactions from the Green Party, the Socialist Left Party, and the Red Party. Their rhetoric indicates that the report and its numeric information were taken at face value, leading to the demand that Norway stop exploring for new oil and gas sites. The Liberal Party has also called for action, however, they believe it must be taken by other countries. The Conservative Party and the Labour Party seem to accept the report in general terms, but their response in practice has been more lukewarm. The parties acknowledge that climate issues are urgent and that actions are needed, yet, Solberg holds to measures suggested in a White Paper, made prior to the IPCC report, when she describes how to deal with climate change, now classified as an immediate threat. This suggests that the then Prime Minister was not affected by the IPCC report. The Progress Party expressed doubt about the report but did not consider it worrisome.

It is not surprising there are split views among the political parties. What *is* surprising is the varying authority the report was given. A report made by hundreds of scientists who reviewed thousands of scientific papers which were based on advanced models, technology, satellites etc. *should* have substantial epistemic authority. The media coverage shows that the report has epistemic authority in the political environments that are receptive to it, such as the Green Party, the Socialist Left Party and the Red Party. The report does not, however, have epistemic authority in the doubting political communities, such as the Conservative Party and the Progress Party. Consequently, the report has what can be called “relative epistemic authority”: an authority that is relative to the audiences and the eventual mediators present in the debate. Moreover, the need for a summary of climate science, such as IPCC reports, demonstrates that such information does not, in itself, display authority, or at least that the authority is relative and requires mediation. The White Paper illustrates the importance of quantification in the field of climate and energy, while the IPCC report demonstrates that the authority of numbers is not obvious. This suggests a substantial need for numeric work to mediate quantitative information.

Quantitative information is often assumed to have a direct effect on policy and decision making (Muller 2018) and to be performative in itself. This dissertation is a critical comment to such assumptions using a science and technology studies (STS) perspective where science and technology, and their interaction with people are considered social activities (Sismondo 2010). Therefore, numbers’ performativity must be examined. The three papers in this dissertation explore three questions in numerical performativity: 1) How are targets in climate and energy policy articulated and acted upon? 2) What additional work by calculating actors is considered necessary when presenting numeric information to climate and energy policymakers? 3) How is quantitative information made sense of and used by climate and energy policymakers? In the summary and synthesising section, I analyse how science-policy relations influence the epistemic authority of numbers in Norwegian climate and energy policy. This dissertation seeks to contribute to the social study of quantification through qualitative research interviews and the examination of documents pertaining to the enactment and use of quantitative knowledge in Norwegian climate and energy policy. I aim to provide a perspective on political decisions that are poorly elucidated: how numbers are provided with epistemic authority.

In the next section, I offer a summary of each of the three articles that form the basis of this dissertation. I then discuss previous research about the authority of numbers before going on to present the theoretical toolkit I used to synthesise the findings of the three papers. In the cross-cutting analysis and discussion, I examine the common threads of the articles – what can they tell us when read together as one story? I then present a more comprehensive section of the methods used in my study as an extension of the methods sections of the articles found after this summary and synthesis essay.

2. Summary of papers

This dissertation consists of three papers: 1) "Transitions through numbers. A critical inquiry into superior numeric targets in climate and energy policymaking", 2) "Numeric work: the efforts of calculation actors to make numbers count in climate and energy policy" and 3) "Guided by numbers. The domestication of quantitative information by Norwegian climate and energy policymakers".

All three papers explore and discuss, albeit in different ways, the epistemic authority of quantification in the field of climate and energy policy. Paper 1 discusses the construction and perception of superior numeric targets and how they are managed by policymakers. Paper 2 explores experts' efforts to construct numbers and make them count. Paper 3 is concerned with policymakers and civil servants' sense-making and enactment of numbers. In the cross-cutting analysis, I will provide a more comprehensive analysis of what can be learned from the papers when they are read together as one story. But first, a summary of the three papers.

2.1 Paper one: Transitions through numbers. A critical inquiry into superior numeric targets in climate and energy policymaking [1]

This paper analyses what we call superior numeric targets in climate and energy policy, which are targets intended as a basis of formulating more detailed sub-targets that may be used to guide concrete policymaking. Quantitative targets have a central role in directing governance, and in the assessment of the achievements and the efforts made to reach aims: thus, it is important to study their emergence. The paper is a contribution to the study of governance related to sustainability transitions, mainly to clarify what is involved when such governance is based on quantification.

Drawing on interviews and political documents, this paper explores the biography (Hyysalo et al. 2019) of two superior targets within climate and energy policy and how Norwegian climate and energy policymakers have considered them. The first target is

[1] In revision. This paper is co-authored with Knut Holtan Sørensen.

Norway's climate target under the Paris Agreement: reducing greenhouse gas emissions by 50%-55% by 2030 compared to 1990 levels. The second target is Norway's energy target of an annual improvement of 10 TWh in the energy efficiency of buildings by 2030. The former target is quite broad, the latter more specific. The two targets are not independent but as the paper shows, their relationship is discursive and not quantified.

The paper show that both targets had a dynamic journey as outcomes of several events, circumstances, and actors. However, findings show two distinct biographies, considered as a set of stages. The superior numeric target of reducing greenhouse gas emissions was consolidated, accepted, and embedded through co-production of science and politics, resulting in considerable mobilisation of relevant actors. In contrast to the first superior target, the 10 TWh target met with much more friction. The target was first consolidated and adopted by politicians nearly a decade after it first was proposed. Still, it was not embedded in the government administration although more qualitative goals of energy efficiency improvements definitively were pursued. The 10 TWh target was co-produced by science and politics, but it was mainly a political decision.

The paper shows that governance by numbers is not straightforward, at least not with respect to sustainability transitions. Still, the perspectives of quantification studies are fruitful to make sense of the governance of such transitions.

2.2 Paper Two: Numeric work: the efforts of calculation actors to make numbers count in climate and energy policy [2]

This paper focuses on how numbers are provided with epistemic authority: by studying the efforts of calculation actors who work with climate and energy issues. The paper draws on interviews with relevant experts in Norway: scientists, economists, engineers, and civil servants working in ministries and directorates; who provide quantitative information about energy and climate to policymakers.

[2] In revision. This paper is co-authored with Knut Holtan Sørensen.

This paper departs from assumptions that quantitative information has inherent epistemic authority and that such numbers shape policymaking, decisions, and assessments (Muller 2018). Previous research sees epistemic authority as emanating from authoritative institutions (Desrosières 1998; Porter 1995), from the pervasive use of numeric information in modern society (Mau 2019; Muller 2018; Power 1997), and from scientific authority (Latour 1987). One important finding of this paper is, however, that calculation efforts are often insufficient to provide quantification with such authority. The interviewees' accounts show that they do not assume that the quantitative information they produce is trusted without further effort. Thus, activities beyond calculation work were needed. My co-author and I introduce the concept of 'numeric work' to designate these extra-calculation activities.

For quantification to be incorporated in climate and energy policy, experts consider numeric work necessary. Numeric work is done both orally and in writing, mainly focusing on making quantitative information understandable, trustworthy, and interesting to policymakers. This is done through articulation work: attempts to explain how the quantitative information is produced and thus why it should be considered trustworthy because the processes of calculation are made transparent (Strauss 1988; Strauss 1985) and translation efforts (Callon 1984; Latour 1987). Translation efforts mainly include communication strategies to make quantification interesting to, and understandable for, policymakers.

This points to an interesting feature of science-policy interactions. The relationship between scientists and policymakers is often assumed to be linear and a one-way street: where scientists move knowledge into society or policy without mediation efforts. What we see in this case is that, firstly, science-policy relations are not one-way. The experts are interested in engaging with policymakers and other potential users to increase the possibility of embedding their information in climate and energy policy. Secondly, experts do not detach themselves from their knowledge. Numeric work such as simplifying, explaining, persuading, and engaging with policymakers – in the phase of making quantitative information and after having disseminated it to society – illustrates that experts don't detach from the numbers.

The main finding is that for numbers to be understandable, trusted, and interesting to policymakers, they need to be mediated. The necessity of numeric work demonstrates that politicians are not naïve and uncritical recipients of numbers. The paper show that, in the end, it is policymakers who decide policy and thus if numbers count or not. To conclude, experts are concerned about the epistemic authority of the numeric information they have produced, and make efforts to strengthen it.

2.3 Paper Three: Guided by numbers: The domestication of quantitative information by Norwegian climate and energy policymakers[3]

As opposed to Paper 2, which focused on experts' efforts to *produce* quantification with epistemic authority, this paper studies the *use* of numbers and how they are perceived by policymakers in energy and climate policy. As indicated in Paper 2, the need for numeric work demonstrates that politicians are not naïve and uncritical recipients of numbers. This paper aims to question the assumption that quantitative information is used unconditionally in activities such as policymaking, by empirically studying how policymakers describe their use of numerical information and how they make sense of it. Drawing on domestication theory, the paper explores policymakers' distinct practices and sense-making as well as involving cognitive activities related to learning of numeric information (Sørensen 2006).

This paper draws on interviews with members of Parliament, policymakers, and civil servants working in climate and energy-related ministries and directorates.

Empirically, we find three main narratives of domesticating quantitative information in climate and energy policy. The first and most dominating narrative is *the pragmatic narrative.* The interviewees that have a pragmatic relationship to numbers have no preference for either quantitative or qualitative information but need the information to be correct and powerful. The second narrative is *quantitative work;* the interviewees in this category have work tasks that are related to the pursuit of quantitative targets. This makes their relationship to numbers routine and not a choice. However, they have a

[3] In revision. This paper is co-authored with Knut Holtan Sørensen and Marianne Ryghaug.

nuanced relationship to the generalisability and uncertainty of numbers. The third narrative is the *ambivalent narrative;* the people with this view regard numbers as good and convincing information, but also as difficult to understand and communicate.

Based on policymakers' accounts, this paper argues that quantitative information is not used unconditionally in climate and energy policymaking.

2.4 Questions raised by the papers

When the three papers are read together, they consider the epistemic authority of quantification in climate and energy policy in different ways. Paper 1 explores the construction of superior numeric targets' epistemic authority. Paper 2 argues that efforts beyond calculation work are necessary to provide quantification with epistemic authority. Paper 3 addresses how relevant policymakers and civil servants perceive the epistemic authority of quantitative information. The papers argue that users of quantification, such as policymakers and civil servants, are just as important for embedding such information in climate and energy policy as the producers of quantification. This implies that the epistemic authority of numbers depends on a manifold of actors and arenas.

Based on the papers, I ask two main questions: "How are quantification in climate and energy policy provided with epistemic authority?" and, "How do science-policy relations influence the epistemic authority of numbers?". These questions are answered throughout this summary and synthesis essay. In the next section, I investigate how quantification has been understood in scholarly literature. I then point to the importance of questioning the performance of quantification, and the value of science and technology studies in accounting for the complex relationship of social, cultural, and scientific aspects. This leads to the cross-cutting analysis where the epistemic authority of quantification is further explored by focusing on science-policy relations.

3. Studies of quantification

I focus on producers and users of numbers in Norwegian climate and energy policy. I explore the work of actors who provide numerical information to policymakers, and how policymakers make sense of, and use such information. In this section, I first describe the role of numbers in governance, before presenting the three 'founding fathers' of the social studies of quantification. Then, I go more deeply into how previous research has understood numbers and its understanding of how numbers are made authoritative. Finally, I describe what I aim to contribute with this dissertation.

3.1 Governing by numbers

When something is quantified, it often appears more secure, well-founded, and credible (Demortain 2019). Numbers appear to create trust, are easy to relate to, and provide a clear basis for action (Daston and Galison 1992; Desrosières 1998; Porter 1995; Power 1997). Numbers' authority seems to originate from the way they are made – a production that is seemingly based on strict procedures that strive to eliminate all forms of human interventions, or what is called "mechanical objectivity" (Daston 1995: 19; Daston and Galison 2007: 121; Porter 1995: 7). Numbers are described as "a key mechanism for the simplifying, classifying, comparing, and evaluating that is at the heart of disciplinary power" (Espeland and Stevens 2008: 414). Numbers give legitimacy to political power in democracies by appearing as public rhetoric of disinterest in situations of contestation (Rose 1991). As numbers have become important in governance, numbers' authority has become overrated. Thus, scholars often distinguish between hard numbers and soft words, between quantitative and qualitative information, where quantitative knowledge is often granted a higher authority than qualitative information. Scholars in many disciplines emphasise that one must be aware of the power and limitations of current quantification practise, and how they involve questionable gathering, interpretation, and use of quantitative information (Sætnan et al. 2011; Larsen et al. 2016).

During the 1980s, a shift in public administration happened, where governments attempted to promote standardised procedures and more internal control (Hood 1995).

The strategy was called, “New Public Management” (NPM). The idea of NPM is to create market-like conditions within the government and non-profit sectors; and, thus, to run these more like businesses (Muller 2018). NPM reforms are driven by economic, social, political, and technological factors and are usually the results of financial or welfare crises – highlighting the need for greater efficiency in the public sector. The growing dominance of NPM is also associated with the ascendance of neoclassical economics and the neoliberal accounting movement, which embodies a commitment to interventions and control which are more indirect and distant seeking to act on, and through, the interests and motivations of subjects and organisations (Rose and Miller 1992). This means that, in the NPM ideology, policies and efforts are assessed through comparing quantitative goals with quantified outcomes. Such quantitative monitoring practices can be found in almost all areas of society. One example of NPM in the field of climate and energy is Enova, a state enterprise established to contribute to meeting Norway’s climate commitments and the transition to a low-emission society. Enova is particularly working to make the production and use of energy more sustainable. They distribute grants to private individuals and companies who implement energy efficiency measures. Budgets and targets are decided on in four-year agreements with the Ministry of Climate and Environment. In the current agreement, Enova aims to contribute to emission results through the removal of the equivalent of 1.2 tons of non-quota CO2, as well as producing innovation results in the amount of 5 billion NOK in triggered innovation capital. Enova tracks work and the status of agreed-upon targets through frequent reporting.

Quantification is generally an important issue of policy – which I study through the strategic research site of Norwegian climate and energy policy. Numbers can be used to guide decision-making, point out directions for social development, benchmark such developments, and formulate specific targets. This dissertation studies quantification related to such activities: in both specific numeric information – Norway’s greenhouse gas emission target, for instance – and quantification more generally, in the climate and energy field.

3.2 The emergence of quantification studies

As modern society became more and more governed by numbers, scholars engaged critically with trust in quantitative information. Berman and Hirschman (2018) state that studies of quantification cluster around four broad questions: 1) What shapes the production of numbers? 2) When and how do numbers matter? When does quantification make a difference? 3) How do we govern quantification? How *should* we govern quantification? 4) How should scholars *study* quantification? This dissertation joins the ranks of studies described in 1 and 2. In the following pages, I describe the development of quantification studies, of whom Alain Desrosières, Theodore M. Porter, and Michael Power were central.

The French school of quantification was built up throughout the 1980s-1990s by Alain Desrosières and a group of like-minded researchers. Their focus was on the classifications that undergird quantification, and the production and use of statistics (Mennicken and Espeland 2019: 226). Desrosières published the much-cited book, *Politics of large numbers,* in 1998. His commitment to the dissemination of statistical information and his interest in history led him to play a key role in the development of the critical approach to statistics. 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 and statistical tools that serve as instruments of governance. Desrosières shows how phenomena such as unemployment, inflation, and poverty are measured by statistics, and then are used in the description, discussion, and justification of policies. In his words, "[the numbers] are inscribed in routinized 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).

Desrosières described quantification as a means "to express in numbers what was previously expressed in words" (Desrosières 2016: 184). The attractiveness of numbers arises from their aura of impersonality, objectivity, and universality – these lend numbers legitimacy. Yet, Desrosières argues that data is not 'something given'; rather, data is constructed in accordance with certain procedures, using certain measurement tools, and with numerous choices being made throughout the entire process of quantification. Quantification is a task, a social activity, and an inextricably *technical* and *social* practice. It is *technical* in that it involves measurement and *social* in that it involves agreement and conventions (Desrosières and Knott 2005).

During the same period the French school of quantification was emerging, scholars in Germany and North America were working on the production and influence of statistics (e.g., Porter 1986; Hacking 1990; Daston 1988). Like the French school, they focused on the application and practical consequences of probability and statistics for fields such as administration, public health, insurance, law, and the economy. They also investigated the resources, the classifications, and the coordination that were required to produce statistics. They also considered how quantification changes the way people understand their world and act in it (Mennicken and Espeland 2019: 226). In his ground-breaking book, *Trust in numbers,* Theodore M. Porter (1995) analyses how trust in numbers has historically been produced and explains the political power of numbers in modern society. The book offers a critical analysis of the rigours of quantitative analysis. Porter describes quantification as a "technology of distance", as something that replaces trust in people with trust in numbers. Trust in numbers is derived from their ability to appear objective, impersonal, fair, and safe (Porter 1995: 8). Quantification seems to be an exemplary practice for the production of objectivity, as it replaces arbitrariness and idiosyncrasy. However, the objectivity of quantification has nothing to do with objective truth. It has to do with the exclusion of judgement, and the struggle against subjectivity. Porters' main message is that while qualities do not travel well beyond the local communities where they are culturally valued, quantities seem to be more easily transportable: the more precise the better. According to Porter, traditional face-to-face dealings have lost their importance and have been replaced with longer chains of interaction and 'faceless' forms of dependency. Porter argues that the change in dependency happened in the economic and social transformation in the USA and Western Europe during the 19th century. As a result, quantitative and procedural forms of accountability have become increasingly important. Porters' historical examples from the realms of cost-benefit analysis, insurance, and accounting, show how numbers have been used to gain universal trust and how official numbers are perceived as valid.

In a political culture that idealises the rule of law, it seems bad policy to rely on mere judgement. Arbitrariness and bias are the most usual grounds for the criticism of bureaucratic officials. This makes the appeal of numbers especially compelling; a decision made by the numbers – or by explicit rules of some other sort – at least has the appearance of being fair and impersonal; in other words: “quantification is a way of making decisions without seeming to decide” (Porter 1995: 8). The use of ‘scientific objectivity’ thus provides an answer to the moral demand for impartiality and fairness. Porter speaks of ‘mechanical objectivity’ – producing knowledge by rules to avoid personal biases or preferences affecting the outcome – when explaining how quantification gains its objectivity and authority. In line with many others (Rottenburg et al. 2015; Silvast et al. 2020; Sætnan et al. 2011; Lippert and Verran 2018), Porter is critical of quantifications’ assumed objectivity, and shows that considerable efforts may be required to produce epistemic authority. Thus, mechanical objectivity may not be enough.

Another important area of quantification scholarship is critical accounting studies. Accounting is recognised as crucial for the development of capitalism and for apprehending the cognitive infrastructure of capitalism., including how standardised methods for valuing and pricing are created. In the 1970s, Anthony Hopwood and a group of accounting scholars challenged the view of accounting as a technical, objective enterprise, insisting instead that the sociological, organisational, and social-psychological dimensions of accounting practice were crucial for understanding how accounting techniques are created and used (Mennicken and Espeland 2019: 227). Two decades later, Michael Power (1997) published the book *The audit society* where he shows how quantification is at the heart of economic entities, corporations, markets, and the people that inhabit them. Power critically examines the meaning, nature, and effects of auditing and explores ‘audit’ as a principle of social organisation and control. Decentralisation of the nation-state in the twentieth century led to an ‘audit explosion’ where individuals and organisations suddenly found themselves subject to new or more intensive accounting and audit requirements. The concept of the audit society goes even further, designating what is considered ‘new and important’ public administration practices, demanding that everything be converted into numbers for knowledge-based policy decisions, and thereby make them auditable. Power argues that numbers are not something that just "exist", but that they must be 'designed to be applicable' within defined limits in society. He also warns that auditing tends to have unintended and dysfunctional consequences for the practices that are being audited.

Espeland and Stevens' (1998) examination of commensuration provided a springboard for subsequent work on metric power. Recently, research has turned to quantification and commensuration in transnational governance (Merry et al. 2015; Rottenburg et al. 2015) and what some have termed the "algorithmic society" (Mennicken and Espeland 2019: 227). As new metrics and technologies enter society, quantification research grows and seems to be entering a stage of maturation and consolidation (Demortain 2019); various journal special issues, edited volumes, and literature reviews testify to this (e.g., Mennicken and Espeland 2019; Berman and Hirschman 2018; Larsen and Røyrvik 2017; Bruno et al. 2016).

Quantification research is abundant in multiple disciplines: sociology, accounting, social anthropology, history, and philosophy, to name a few. In STS, scholars have focused on: numbering and enumerated entities (Verran 2010; 2015); the relation between numbers and authority (Asdal 2008; 2011; 2014); the intersection of quantification and qualification; and the neologist term 'qualculation' (Cochoy 2008; Callon and Law 2005). Other STS perspectives on quantification examine how valuing something relates to numbering it (Helgesson and Muniesa 2013; 2017); indicators (Bowker and Star 2000; Lampland and Star 2008); and numbers as immutable mobiles (in actor-network theory: Latour 1987). Across research disciplines, themes such as governance by numbers, performance measures, and the relationship between valuation and quantification have been studied (Mennicken and Espeland 2019).

3.3 A critique of linear thinking regarding calculation practices

Much of the quantification literature focuses on calculation practices: in regards to framing, validity, and reliability (Sætnan et al. 2011; Porter 1995; Larsen et al. 2017), the question is, however, if calculation practices give a correct picture of the situation.

Calculations are typically done by stripping away the actual context of their production – often conflictual and subjective, – and the ambiguous detail of the phenomena they claim to represent. Thus, it is argued that numbers may hide as much as they reveal (Espeland 2015; Piattoeva and Boden 2020). What makes understanding calculation practices vital is that quantification is a pervasive feature of current societies. "The 'modern' world sometimes describes itself in seemingly magical numbers that hang in mid-air, unconnected either to a grammar or a grounding" (Guyer et al. 2010: 37). Such observations may raise questions about the epistemic authority of numbers and how such authority is made. Thus, the conventions, assumptions, and biases that shape metric processes should be critically examined (Espeland and Stevens 2008; Lippert and Verran 2018; Merry 2016; Espeland and Yung 2019; Piattoeva and Boden 2020).

A range of scholars have emphasised the importance of studying calculation practices empirically (Rose and Miller 1992; Mennicken and Espeland 2019; Rose 1991; Miller 2001). Through Foucault-inspired theories of governance by numbers, Rose and Miller study science-policy relations, but with a linear perspective where numbers are seen as performative (Rose 1991; Miller and Rose 1992; Miller 2001). According to Miller and Rose (1990), numbers may easily travel across borders and cultures and seem straightforward to interpret, facilitating monitoring or governing 'at a distance'. Rose (1991: 686) notes that 'to count a problem is to define it and make it amenable to government'. Miller (2001) argues that the political rationalities of government could be captured by looking at the technologies employed – calculations being one of them. "Calculative practices should be analysed … as the mechanisms through which programs of government are articulated and made operable" (Miller 2001: 379).

Abeelen and collaborators (2019) have pointed to the need for an expanded view of calculation practices. They highlight the occasional conflict between mathematical correctness and applicability for policymakers as a reason to expand the scope of calculation practices. Næss and Sørensens' (2008) study of Life-cycle assessment (LCA) showed that producers and users disagreed about the usability of such tools. Researchers considered LCA to provide important insights, while users experienced the tool as complicated. Næss and Sørensen observed that researchers were responsible for the development of knowledge, while others, and especially politicians, were held responsible for the application of the knowledge. They conclude that such a division of labour may lead to non-use of calculation because industry people and policymakers experience the numeric information as too complicated to be relevant. Thus, the scope of study regarding calculation practices must be widened.

This dissertation seeks to provide a broader perspective on calculation practices by studying the construction, perception, and enactment of the epistemic authority of quantification in climate and energy policy. More concretely, I explore the work by actors who provide numeric information to policymakers, and how policymakers make sense of, and use such information. This dissertation focuses particularly on the extra work beyond calculation practices in trying to provide epistemic authority to quantification, particularly in the field of climate and energy. The focus is also on science-policy relations as they are performed in the context of the provision of quantitative information.

A recent study by Johansen, Almklov and Skjølsvold (2021) emphasises the need to study the circumstances under which quantitative information is produced. They show that the context of calculations surrounding energy savings in Norway has been made invisible and forgotten as the calculations are transformed and aggregated into a policy programme. In other words, when calculations arrive in the policy domain, uncertainties and contextual preconditions that are prominent in the engineering context are 'black-boxed' and expected to be accepted by users (Latour 1987). Reinertsen and Asdal (2019) introduce the concept of 'reflexive objectivity' to designate a calculative process that first *integrates,* then *decouples* qualitative problems and qualitative potentials through a sequence of rhetorical moves. Reinertsen and Asdal's research, in addition to Latour's, points to the need for a broader perspective on calculation practices.

The literature analysing the increasing use of numbers in society tends to view the effect as a linear process where quantitative information is supposed to have a direct effect on policy, decision-making, and assessment (Muller 2018). Inspired by colleagues (Sørensen, Aune and Hatling 2000), I criticise the linear model of knowledge transfer and argue that the model has four fundamental flaws concerning quantification in climate and energy policy. The first flaw is the model's assumptions of asymmetry between producers and users: where producers are seen as active, essential, and as defining knowledge; while users are seen as reactive and limited in the scope of their actions. Second, linear models presuppose the existence of generally shared goals, and it is taken for granted that people need to know certain, often decontextualised, facts about nature. Third, the assumption that researchers and policymakers generally agree on what the relevant issues and fruitful concepts are. Sørensen et al. (2000) state that in reality, a major problem for modern science and technology is that their results are increasingly meaningless outside narrow, specialist communities. The relevance of results to others must be constructed, and the work of creating relevance is demanding. Finally, linear models produce stories with beginnings and endings that are too well-defined and seemingly track the movements of numbers in society with ease.

This dissertation shows that producers of numeric information in climate and energy policy do not necessarily have the same goals as users. Thus, both producers and users may be seen as active, essential, and as defining quantitative knowledge in climate and energy policy. This dissertation also shows that producers must construct the relevance of quantitative information through comprehensive efforts. One of the main findings herein is that quantification isn't a linear story from beginning to end. Science-policy relations concerning quantification in Norwegian climate and energy policy are inter-relational. I discuss this in the cross-cutting analysis.

In this section, I discuss existing literature on quantification and its understanding of how numbers are made authoritative. The research presented above accepts the importance of quantification. However, it also emphasises the need to be aware of the limitations of quantification practices, involving: questionable gathering, interpretation, and use of numbers. This review demonstrates the need for a wider view of practices related to the provision and use of quantitative information in policymaking.

4. Studying quantification with an STS toolbox

Previously, we saw that research emphasised the need for the further empirical study of quantification. This dissertation contributes to that request with a focus on policymaking. This dissertation aims to empirically explore how the epistemic authority of climate and energy quantification may be constructed, perceived, and enacted in Norwegian policymaking. As shown in the introduction and earlier research, achieving epistemic authority is not as easy as might be expected. The STS toolbox contains several theoretical perspectives that are well suited for analysing quantification and how epistemic authority may be constructed, perceived, and enacted. In this section, I present and explain the theoretical framework that I use in the cross-cutting analysis of the articles in this dissertation.

4.1 Opening the black box of quantification

Briefly explained, STS has developed from a critique of traditional science and viewing society as a binary, and further, challenges the perception of science as simply providing facts that are discovered through the study of nature. STS is a constructivist approach where science is understood to be co-produced with society. STS scholars have been particularly interested in studying how science is made. In the 'laboratory studies', scholars (Latour and Woolgar 1991; Traweek 1988; Knorr-Cetina 1995) entered laboratories to study work done by scientists. Going into laboratories was described as 'opening black boxes' (Latour 1987). When science is black-boxed, it appears as what Latour calls 'immutable mobiles' – facts that travel unmodified through the world. Entering laboratories was a way to explore complexities, relationships, networks, and other aspects that construct science. Since quantifications are constructions, it is obvious to study quantification from a constructivist perspective.

STS does not only explore the inside of laboratories, but also potential users and uses of science. As users may have a different understanding of the same reality, STS views them as equally important when exploring why some scientific findings are established and others are not.

To explore how the epistemic authority of quantification is created, in the context of climate and energy policy, I draw on Latour's (2004) bicameral model and a transposed version of the model introduced by Jomisko (2015) and also employed by Unander (2019). The bicameral models focus on the importance of science-policy relations when institutionalising science, such as quantification, in society or policy. I include two additional concepts that provide more depth to the analysis of science-policy relations: 'modalities', to analyse rhetorical efforts in the attempt to institutionalise quantification; and 'socialisation', to explore activities aimed at helping quantification become institutionalised in climate and energy policy. In the following, I present the framework in more detail.

In *Science in action: How to follow scientists and engineers through society*, Latour (1987) emphasises the importance of studying science in the making. To explore how scientific knowledge becomes, – or does not become – 'black-boxed', one must study the production of scientific facts. In this dissertation, I follow both producers and users of numeric information regarding climate and energy issues, exploring how they relate to the epistemic authority of such information, and to what extent the experts' calculations result in immutable mobiles that can travel unmodified through policymaking processes. Latour (1987) suggests that black-boxing work and the making of immutable mobiles happen primarily at 'centres of calculation' such as laboratories. Inside centres of calculations "specimens, maps, diagrams, logs, questionnaires, and paper forms of all sorts" (Latour 1987: 232) are collected and tied together as new and 'compressed' two-dimensional representations (Michael 2017: 39). Centres of calculations are sites wherein techno-scientists bring together and combine heterogeneous components such as experimental materials and technologies, particular analytic and calculative skills, and various inscription devices (Michael 2017) to escalate the trust in numbers. Through such mechanisms, the inscriptions of more and more events and classes of events are 'cascaded' and condensed into simpler and simpler inscriptions. Crucially, these increasingly simplified representations yield increasingly stable knowledge, that is, harder and harder facts (Michael 2017: 39-40). Knowledge that is stabilised, resilient, and credible rests, in part, on complex practices of representation that takes place in centres of calculation (Michael 2017: 40). The experts I interview may be considered to work at centres of calculation, without assuming that their level of personal professional ambition is on par with what Latour and Michael suggest happens inside centres of calculation.

In Latour's (2005) view, society is an assemblage of humans and non-humans. Therefore, human and non-human elements should be treated symmetrically when studying the epistemic authority of quantification in the climate and energy field. Both humans and non-humans have agency, hence, they influence and are influenced by each other. In this dissertation, such symmetry suggests that non-human elements – policy documents, climate targets and numerical indicators, for example – are equally important as the human elements – researchers and policymakers, among others – in the efforts to provide quantification in climate and energy policy with epistemic authority.

4.2 Socialisation: Embedding the epistemic authority of numbers

Numbers may be provided with epistemic authority through socialisation processes. The socialisation of research and innovation is a concept that highlights the importance of embedding and enacting new knowledge in society, and the efforts to achieve it (Bijker and d'Andrea 2009; Sørensen 2013; Solbu and Sørensen 2022). The socialisation perspective implies that the embedding of new scientific knowledge requires a very comprehensive set of tasks distributed over many areas (Sørensen 2013). Bijker and d'Andrea (2009) identify six areas of socialisation: scientific practices, scientific mediation, scientific communication, evaluation, governance, and innovation. Further, the authors introduce the concept of "socialisation agents" to describe all actors "involved in activities that somehow contribute to the social embedding of science and technology" (Bijker and d'Andrea 2009: 72). Consequently, there can be many agents of socialisation. Sørensen (2013) highlights that the concept of 'agents of socialisation' helps identify who should be expected to do the work of bringing research out of scientific institutions and into use. He further argues that we should not forget non-humans as potential socialisation actors, thus, we need to add to the number of socialisation areas that Bijker and d'Andrea identify. According to Solbu and Sørensen (2022), socialising new knowledge means trying to bridge the gap between research, development, and the relevant social worlds of appropriation. When we study socialisation, we focus on actors, areas, and arguments to help the appropriation of new knowledge, such as numeric information about climate and energy.

It is, however, important to remember that socialisation processes may not necessarily result in the acceptance or the embedding of new knowledge in society (Solbu and Sørensen 2022). In the cross-cutting analysis, I explore the comprehensive set of tasks socialisation actors contribute to embedding climate and energy policy quantification with epistemic authority.

4.3 Science-policy relations

Socialisation is relevant in the study of science-policy relations, which is another way to frame this dissertation. Literature on science-policy relations presents ideal types of science-policy interaction (e.g., Pielke 2007), where scientists are the providers of facts and policymakers the receivers (Sørensen, Aune and Hatling 2000). STS scholars have critically questioned this relationship and have provided empirically-based work that focuses on relationships in practice. They have also called for more research into how scientists transfer knowledge in real-world science-policy interfaces (e.g., Heidenreich 2017; Beck 2011; Davies 2008).

Social scientists have long studied science-policy relations, and although the linear model has been repeatedly – and severely – criticised; to some extent, it is still the dominating perception among climate scientists, policymakers, and advisors (Pielke 2007; Jasanoff and Wynne 1998; Beck 2011). The issue is that the linear model is based on the assumption that science and society are two distinct spheres. Interaction between science and politics is described in this model as "unidimensional, linear and one-way: from science to policy" (Beck 2011: 298). Such a description raises boundaries between science and politics by placing 'truth' in the realm of science and leaving 'power' to the political arena (Karhunmaa 2020). In this ideal, scientists' relationship with policymakers is described as 'speaking truth to power' (Jasanoff 2011). In this view, scientists are assumed to be 'pure scientists' or act from a 'servicing' position without interference from society (Pielke 2007; Turnhout 2019), which is not what the literature suggests in real-world applications (e.g., Heidenreich 2017; Beck 2011; Davies 2008).

Sundqvist et al. (2017) apply the one-world and two-world perspective to discuss interactions between science and policy. In the two-world perspective, the scientific and the policy spheres are understood as independent and separated by considerable distance. In contrast, the distance between science and policy is close in the one-world perspective. The authors conclude that science-policy interactions are more nuanced than presented by the one-world and two-world perspectives and argue that "science-policy interactions are neither linear nor single-directional but contain an irresolvable tension that has no single best solution" (p. 16). I explore whether the experts and the policymakers are separated in distant spheres, if the spheres are close, or something in between. And further, how the interactions of experts and policymakers influence the epistemic authority of numbers.

Jasanoff (1990) address the distance between the scientific and the policy sphere and identifies a paradox in scientific advice. On the one hand, distance between the scientific and the policy sphere adds legitimacy to scientific advice. On the other hand, in practice, successful examples created meeting points "where scientific as well as political conflicts can be simultaneously negotiated" (Jasanoff 1990: 237). In other words, science advisers maintain the distance to policymakers as a frontstage performance, while in backstage activities (practice), they try to narrow the distance by interacting with policymakers (Sundqvist et al. 2017). I explore here whether there is such a dual performance in my material among experts providing numeric information, as described by Jasanoff.

While the linear model presupposes epistemic authority among the researchers/experts, in research about a voluntary professor group that actively sought to influence Finish energy policymakers, Karhunmaa (2020) provides an example of a science-policy relation that fluctuates between linear and collaborative modes of interaction. That said, the professor group did not think the separation between science and policy was large enough. The group argued that current decision-making failed to consider scientific knowledge sufficiently, and presented itself as the solution. The professors would have liked to introduce more formalised scientific knowledge into policymaking, and thus improve decision-making (see also Sundqvist et al. 2015). In line with the linear model, the knowledge production of the group occurred in a small, closed circle, during the drafting of reports, for example. The group aimed to deliver this knowledge to policymakers in a linear manner, but at the same time, their extensive communication activities and public interventions led the professor group beyond the linear model. While the professor group produced its reports in a closed circle; from the beginning, the reports were structured to have a policy impact and engage a wide audience. The professor group did not adhere to a linear model: where research aims are derived from the scientific literature, and results are delivered unilaterally to policy. Thus, the epistemic authority may not only be located in the realm of science, but also in the realm of policy through the impact on scientists' work.

In the cross-cutting analysis, I discuss science-policy interactions among experts and policymakers in climate and energy policy. I ask whether epistemic authority is limited to experts – as opposed to policymakers – and if it, therefore, adheres to the linear model. I analyse whether experts' interactions fluctuate between linear and collaborative modes and explore if there are science-policy interactions that do not cohere with either of the above.

In their study of Norwegian scientists, Arnøy and Sørensen (2012) provide an example of a more dynamic practice of science-policy relations in establishing 'the hydrogen society': a vision of the future among Norwegian policymakers. Instead of establishing facts independently and apart from politics, scientists made considerable efforts to promote hydrogen to energy policymakers. Hence, scientists did not act according to the linear-autonomy model. The authors show how hydrogen scientists went beyond the simple role of 'advisor'. They participated in the making of broader energy policy proposals, as well as communicating a clear message that the government needed to increase its investment in hydrogen research and development. Moreover, advice was provided to policymakers in diverse ways. Formal and informal channels were used, such as writing official reports, sending unsolicited letters to policymakers, frequent meetings with policymakers, and collaborating with other scientists to enhance the trustworthiness of the advice. The scientists actively promoted advice and were suppliers of advice when solicited by policymakers. As such, the scientists pursued a range of strategies and practices when providing advice to policymakers. Similar findings were discovered by Tøsse, Sørensen and Ryghaug (2012), who found that climate scientists were engaged in efforts to make facts about the climate accessible, useful, and relevant to the public – as well as user groups. Climate scientists in the study viewed 'good science' as something that could potentially be useful. These findings suggest that the scientific and policy spheres are less separate than suggested in the linear model.

Arnøy and Sørensen (2012) suggest considerable diversity concerning the way scientists relate to policymakers, and the institutions providing scientific advice. They further propose that rather than focusing on scientific advice as an activity in itself, we should focus more broadly on the interaction between scientists and policymakers. They suggest studying the interaction between scientists and policymakers, on the premise that both parties have some autonomy and pursue their own agendas. Moreover, the hybrid forums where scientists and policymakers interact should be studied, since diverse social interests may be present. Furthermore, the authors point to the interdependence between scientists and policymakers as an important aspect when studying their relationships (Arnøy and Sørensen 2012: 109). It is these issues specifically that I will discuss in the cross-cutting analysis.

Regarding the use of research in policy decisions, Weiss (1977; 1979) argues that the use of research appears to be a much more diffuse and circuitous process than described in the linear model. According to Weiss, the major use of research among policymakers is not the application of specific data to specific decisions, but rather, as a source of ideas, information, and orientations to the world. Hence, policymakers' use of research may be described as situation-dependent, and consequently pragmatic. Thus, policymakers' use of research is reflexive, not linear. When research-based knowledge is not used, Naustdalslid and Reitan (1994) argue that this can often be explained by the fact that it has not been adapted to the users' needs to any great extent. In the cross-cutting analysis, I examine the epistemic authority of numbers in Norwegian climate and energy policy and how it is influenced by policymakers' use and experts' efforts of adapting quantification to policymakers.

The studies of science-policy relations reviewed above are concerned with the quality and the mediation of science. In such a perspective, the numbers resulting from the experts' effort to calculate climate and energy issues need to be *made* performative, since they cannot be considered performative in themselves. Thus, it is pertinent to ask about the influence the studied experts exercised concerning climate and energy policy. I examine whether the experts actively promoted numeric information to policymakers, or whether they simply offered advice when consulted. I also explore whether or not their efforts were in line with the linear autonomy model.

4.4 Following experts and policymakers through bicameral models

Nowotny, Scott and Gibbons (2001) criticise the linear model and argue that science and society are mutually invasive and invaded; instead of 'spokespersons' communicating with each other, a much more plural and democratic environment has been created in which 'experts' have proliferated – the *agora*. 'Agora' describes the new public space where science and society, markets and politics must co-mingle to become socially robust (Nowotny et al. 2001). Nowotny and collaborators present the 'agora' as a normative approach in considering how science and society should meet to make science socially robust. In a simplified manner, we can think of the 'agora' as meeting places where science/experts and laypeople/policymakers relate. I borrow the concept 'agora' to study meeting places where experts and policymakers meet to mingle about quantitative information related to climate and energy policy.

In his book *Politics of nature: How to bring the sciences into democracy* from 2004, Latour offers a way to structure the agora. As a critique of the linear transfer of knowledge, Latour presents the bicameral model: a system where dialogue between scientists and policymakers plays a key role. Instead of a sharp distinction between facts and values and politics and science, Latour argues that dialogue between these four categories is important to make science socially robust. The bicameral model illustrates how dialogue should happen. In the bicameral model, science and politics should be chained together in four 'chambers' with their own processes where everyone in principle can participate (though not in the same way).

Figure 1 illustrates the science-policy relations as described by Latour. The process in the first chamber is called *perplexity.* Questions may arise from scientists or other actors, but scientists are the driving actors who explore the questions. In the next chamber, *consultation,* potential solutions and answers to questions asked in the first chamber are discussed. Latour emphasises the importance of the participation of as many actors as possible in the consultation chamber, so that science and values are discussed constructively to prevent the emergence of unnecessary conflicts between science and politics. The third chamber is called *hierarchy*. Based on the consultation process, solutions and propositions shall be ranked. In the fourth chamber – *institutionalisation,* the chosen solution or proposition is given the status of *correct* (and others discarded as incorrect) (Latour 2004: 109; Ryghaug and Sørensen 2008: 164).

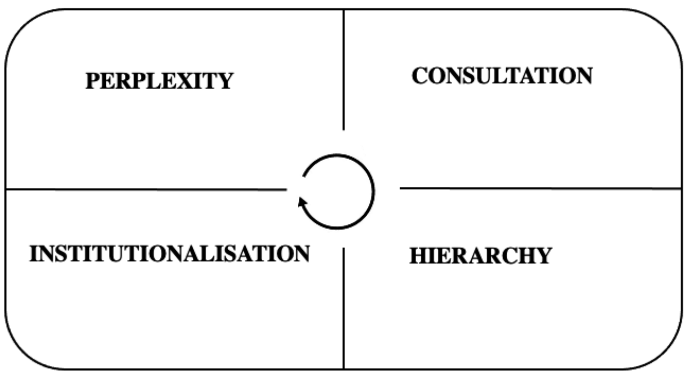

Figure 1: The architecture of the bicameral according to Latour.

Latour uses the bicameral model to argue the most effective methods for dialogue between science and politics to achieve democratic institutionalisation of science. I was inspired by the model for my analysis but I do not use the entire comprehensive framework. According to Latour, the model is complex and can consist of many actors, but I look at particular actors: experts who provide quantitative information to Norwegian policymakers for climate and energy policy. For the purposes of this dissertation, I only use the bicameral model for the chamber labels: perplexity, consultation, hierarchy, and institution. I use these labels as tools to structure processes when studying meeting places ('agora') for the institutionalisation of quantification in climate and energy policy. Moreover, I use the labels to structure my empirical analysis. I do not apply the model according to Latour's normative intentions, although I do have Latour's normative perspective in mind. However, I focus on the empirical analysis in my three papers. This dissertation is an empirical study of the hybridisation processes; it does not evaluate them.

In my analysis, inspired by Latour's bicameral model, the focus is on producers of quantification and their activities in institutionalising quantification in climate and energy policy. Since the aim of this dissertation is to explore both producers and users of quantification in the field of climate and energy, I also need a 'user perspective', which is not a prominent part of Latour's model. Thus, I was also inspired by Jomisko (2015), who offers a 'user perspective' when creating an alternative to Latour's bicameral model. In contrast to Latour's model, where scientists are the driving actors: asking questions and consulting public entities, Jomisko's model turns the roles around and makes policymakers the driving actors that ask questions, aiming the consulting toward science. Moreover, Jomisko's model is developed from an empirical analysis of policymakers' learning processes such as 'policy learning'. Figure 2 illustrates the science-policy relations as described by Jomisko.

Jomisko's model allows us to analyse how science-based knowledge is used in policy learning and how policy learning processes evolve as they move through society. Jomisko applies the same labels as Latour on the chambers, but the processes inside the chambers are different. In the *perplexity* chamber, we study what policymakers wonder about and who decision-makers turn to when they need help, answers, or knowledge. When this occurs, a series of processes follow: first, a '*consultancy of science'*, where experts may need to come together to advise policymakers and help them make decisions in complicated cases. Then, a '*hierarchisation'* is created out of the outcomes from the science consultation. Finally, – possibly – an '*implementation'* of policy. Jomisko's model covers the whole process from when a policy question is asked until a potential solution is implemented or dismissed. Thus, Jomiskos' bicameral model should be fruitful in analysing science-policy relations from a policymakers' point of view.

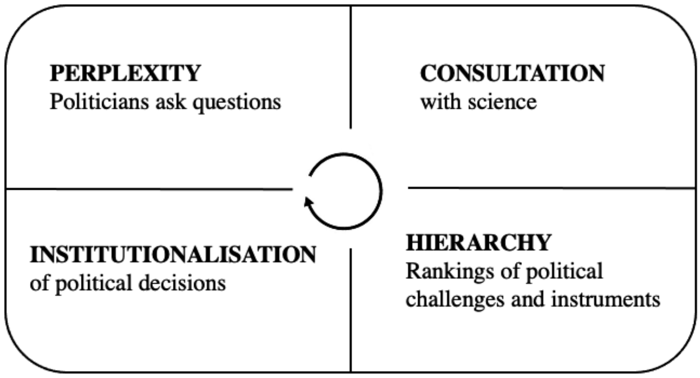

Figure 2: Bicameral model inspired by Jomisko.

This dissertation explores how researchers and policymakers provide quantification with epistemic authority in climate and energy policy. I consider a combination of elements from Latour and Jomisko's bicameral models as beneficial, and I emphasise that both models are used here for the purpose of empirical analysis and not for normative assessments. Together, I expect the frameworks to provide insights into the relationships between the producers and users of numbers in the field of climate and energy, and further, how those relations may influence the epistemic authority of numbers.

Achieving epistemic authority is about making quantification socially robust, making numerical information into immutable mobiles. Rhetorical practices obviously play a role in efforts to construct epistemic authority for the numbers in focus. Quantification can be provided with epistemic authority but it can also be challenged by using 'modalities' (Latour 1987) – a sub-concept I use in the analysis. Latour describes modalities as statements that strengthen or weaken the validity of information – in this case, quantitative information. Modalities are used to guide the reader or listener in a certain direction: positive modalities are statements that hide how a fact is made to make it solid enough to appear truer and more correct; negative modalities are statements that point to the basis of the claim or case, to raise doubts about the truth of what is being said. In this manner, “the status of a statement depends on later statements” (Latour 1987: 27), and thus, the epistemic authority of quantification depends on statements made by the producers and users of numerical information. Only when a statement is inserted into other statements without further modification, can the statement become a closed file: an indisputable assertion, a ‘black box’ (Latour 1987: 23). When a statement is ‘black-boxed’, modalities disappear. In studying the actors that construct and perceive quantitative information in climate and energy policy, this dissertation shows how different modalities are expressed and how quantification becomes a closed black box, or not.

These theoretical perspectives can help to understand how quantification in climate and energy policy is provided with epistemic authority. Moreover, an analysis of quantification in Norwegian climate and energy policy can contribute to a broadening of the perspectives in the social studies of quantification. I use this section to outline a theoretical framework that hopefully will widen the view of quantification studies related to policymaking. In introducing two types of bicameral models, I explore the process of stabilising and institutionalising quantification in climate and energy policy. Moreover, I suggest the concepts of socialisation and modalities as supporting concepts in studying how numbers are provided with epistemic authority. Lastly, I discuss the science-policy relations of experts and policymakers in climate and energy policy, and how these relations influence the epistemic authority of numeric information.

5. Cross-cutting analysis: Meeting in the agora to institutionalise numbers

This dissertation aims to understand how numbers are provided with epistemic authority by studying their construction, perception, and enactment in Norwegian climate and energy policy. I now return to the three papers and discuss some main findings, using the theoretical framework outlined in the previous section. The cross-cutting analysis is intended to comprehensively analyse what can be learned from the papers when they are juxtaposed.

I refer to the papers as Paper 1, Paper 2, and Paper 3, which is the same order as they appear in this dissertation. A brief reminder about the content of the papers: Paper 1 shows that superior numeric targets may not be as authoritative and guiding as assumed. Further, the paper finds that such targets do not necessarily emerge from the realm of science: they may also be outcomes of policy-driven processes. Paper 2 shows that experts constructing quantification believe numbers are used too scarcely. Hence, experts consider numeric work – efforts beyond calculation work – necessary to provide numbers in climate and energy policy with epistemic authority. Paper 3 demonstrates that civil servants are worried that quantification is taken too literally by policymakers – who seem to have a rather pragmatic relationship to numeric information. Crystallising throughout these papers is the theme of interaction between science-policy relations and enactments, and how they affect the epistemic authority of climate change and energy numbers. In this analysis, I explore the relationship between experts and policymakers, and how they circumscribe the epistemic authority of numbers in climate and energy policy. The analysis is followed by a discussion and concluding remarks.

This dissertation illustrates the limitations of the epistemic authority of quantified information, the challenges involved in providing such authority, and thus, trust in numbers. Consequently, it is a critique of the linear-autonomy model that presupposes that numbers have inherent epistemic authority when transferred from science to policy. When I use the bicameral models as a framework in the cross-cutting analysis it is because all three articles that form the core of this dissertation disprove the linear-autonomy model. It is also because I want to see how an alternative understanding of science-policy relations, as represented in the bicameral models, work out when considering the articles' findings.

In addition to the bicameral models, socialisation processes can also describe how numbers are provided with epistemic authority. By focusing on actors, areas, and arguments that may help the adoption of numeric information in climate and energy, socialisation is critical about the linear transfer of science (Bijker and d'Andrea 2009; Sørensen 2013; Solbu and Sørensen 2022). Socialisation is another way to make numbers relevant to policymakers through efforts beyond calculation work. It is important to highlight that socialisation processes may not necessarily result in the acceptance or the embedment of numeric information. In this section, I explore the comprehensive set of tasks socialisation actors contribute to the institutionalisation of the epistemic authority of quantification, in the field of climate and energy policy specifically.

5.1 Interwoven bicameral models

To study science-policy relations, I use a bicameral approach inspired by Latour (2004) and another by Jomisko (2015). I structure science/expertise-policy relations concerning the four chambers found in both models: perplexity, consultancy, hierarchy, and institution. 'Consultation' and 'hierarchy' are activities that are intertwined in my data and thus difficult to distinguish. Consequently, I have merged these chambers in the cross-cutting analysis. I use the bicameral model framework to explore what kind of perplexities policymakers and experts raise with quantification. Are their questions based on common ground? This framework allows me to further study how policymakers and experts discuss numbers and the outcomes of their consultations. Finally, I analyse how and when quantified information is institutionalised in climate and energy policy.

5.1.1 Perplexity

In Paper 1, my co-author and I found that the target to limit global warming to 2°C itself went through its own process before becoming institutionalised and embedded in international policy through the Paris Agreement. As such, the 2°C target went through a process quite similar to the one described in the bicameral models. Accordingly, the superior numeric targets we explore in Paper 1 are the result of previous perplexities, consultations, hierarchies, and institutionalisation processes.

The superior numeric targets' biographies show that there is a scientific basis for the targets, which makes the targets relevant to analyse with a Latour inspired model. The paper further shows that the targets are politically determined, making it relevant to draw on Jomisko's model as well. In Paper 1, we see a meta perplexity related to the 2°C target, which affects expert and policymaker perplexity. Both of the superior numeric targets we discuss in the paper are articulated in response to the overarching target of limiting global warming. The paper shows that to keep global warming less than 2°C, or preferably 1.5°C, other numeric targets are needed. The global target of climate change mitigation has led to an increased interest in energy efficiency and the limitation of greenhouse gas emissions. Questions about what the numeric targets should be raise two perplexities. First, the energy efficiency target derived from the question, 'how much more energy-efficient can we expect buildings to become?', while the second addresses the emission reduction target, namely, 'how much emission reduction is needed to keep us within the 2-degree target?'. Given the observations in the paper, we see that the superior numeric targets in turn also become perplexity-generating. When superior numeric targets are present, they generate more work for experts who have to develop and create, for instance, sub-targets and accounting systems. The paper shows that both the 10 TWh and the emission reduction target are points of departure for policymaking, including calculation of strategies, development of indicators to assess progress, etc. The experts' focus on achievements makes their perplexities target-driven.

In Paper 2, we study the efforts of actors who provide quantification to policymakers, which the actors believe are necessary to make numbers in energy and climate policy epistemic authoritative. The perplexity, as it may be observed in this paper, lies with the experts. The experts' perplexities are a response to the perplexity-generation feature of superior numeric targets. Paper 2 clearly illustrates that superior quantitative targets generate more work for experts. The experts seemed to have a two-fold workload – requested work and work that has been undertaken through their own initiative. Whereas requested work emerges from task-driven perplexities, unrequested work reflects a kind of curiosity-driven perplexity.

Curiosity-driven perplexities mostly lead to work funded by, for instance, national and international funding agencies. This means that the perplexities emerging from the researchers' curiosity, to some extent, is limited by the agencies' decisions, which are often related to the development of policies regarding climate and energy, with climate mitigation as a guiding challenge. Obviously, such work is only done by researchers. The employees in ministries and directorates do not do curiosity-driven calculation work. Their tasks mainly consist of requested and frequent deliveries of quantification to policymakers, known as 'task-driven' perplexities. Researchers, of course, also engage in requested efforts, which are usually funded through commissions from the government.

In Paper 3, we observe some accounts of policymakers' perplexities, which are not independent of the superior numeric targets. The paper analyses policymakers' practices, understanding, and sense-making of quantification. Unsurprisingly, it demonstrates that policymakers need knowledge to develop and decide on measures; thus, their perplexities reflect concern regarding problem-solving with respect to climate and energy. Policymakers need numbers to be able to audit, to measure achievements of, for instance, measures to reduce greenhouse gas emissions and the improvement of energy use in existing buildings, as we saw in Paper 1. However, the paper also shows that even though policymakers expect to be served numbers, they may not use them.

All the papers show that the processes of developing perplexities among experts and policymakers are hierarchised, in the sense that the processes reflect, and have to respond, to existing superior quantitative targets. Furthermore, it is mainly the perplexities of policymakers that shape the efforts that form the basis of consultation, since they or their support actors generate commissions for researchers and the experts working in the government. Therefore, they shape the research programmes that fund the efforts of the researchers.

5.1.2 Consultation and hierarchisation

Regarding the question of how much buildings could be expected to become more efficient, discussed in Paper 1, the Arnstad committee came up with the number 10 TWh annually by 2020. The size of the target is based on some calculations, but the report is mainly the outcome of consultations in the committee, the details of which we do not have access to. What we do find in Paper 1 is that, after the target appeared in the Arnstad report, it goes through a messy and continued consultation phase with many participants. A decade goes by from the time the target appeared until the government finally agrees upon the target, a decade of consultation mainly in the political domain, with input from industry and environmental organisations. As late as 2020, detailed strategies were still lacking, as well as instruments to achieve the target. In the paper, we also see that those who are going to work to achieve the 10 TWh target voice uncertainty about its factual basis. Both experts and policymakers express questions about the target's origin, and the knowledge underlying it. Despite the questions, it is still treated as a given, which shows that it has attained some epistemic authority, mainly through political efforts, not so much due to research.

The consultation regarding the emission reduction target was different from the 10 TWh target. The consultation phase of the emission reduction target reflected a co-production of science and policy, although still dominated by politics. This target is not only connected to the overall target of limiting global warming, which was institutionalised in the Paris Agreement in 2015, but also anchored in the Parliament through two climate compromises. Consequently, the consultation about the size of the target is a process that happened after the idea of having such a target was already institutionalised. The scientific basis of the target is the knowledge of anthropogenic global warming, presented in the series of IPCC reports, which are fairly uncontroversial in the Norwegian context.

Experts' consultation efforts illustrate how embedding quantification in climate and energy policy requires a comprehensive set of tasks, distributed over many arenas. Part of the consultation consists of scientific mediation, related to what Latour (1987) calls 'modalities' – statements to strengthen or weaken the validity of the information. Experts' extra efforts beyond calculations – numeric work – can be described as the making of positive modalities, since they attempt to strengthen the validity of numeric information, and thereby increase policymakers' trust in numbers. As reported in Paper 2, the interviewed experts consider numeric work necessary to make their quantitative information understandable and interesting to policymakers. The paper further illustrates that policymakers need consultations to be able to qualify the numbers they want to use.

Experts' consultation efforts to make numbers understandable and trustworthy to policymakers may also be described as socialisation – processes that help the appropriation of numeric information and embed them in climate and energy policy (Bijker and d'Andrea 2009; Sørensen 2013). As demonstrated in the paper, consultations happen in many arenas, and in a variety of ways: experts simplify complex quantification, both orally and in writing; they adapt language and the layout of reports and engage with policymakers. The experts are important socialisation actors in providing policymakers assistance in the sensemaking of quantified information intended to be used in climate and energy policy.

Some of the experts do not engage in consultation with potential users regarding their numbers. This is due to established relationships with certain groups of users, characterised by making frequent requests and frequent receptions of numeric information. Consultations are therefore considered unnecessary by the experts, because sufficient preconditions for trust, for epistemic authority, have already been established through previous consultations.

Latour (2004) describes a dialogue between experts and policymakers as the ideal to achieving a democratic institutionalisation of science. Paper 2 shows that dialogues in the chambers of consultations and hierarchy may be considered, not only an achievement to improve democratic decision-making, but also a necessity for institutionalisation. Experts must be in dialogue with policymakers for the numeric information to become institutionalised.

In Paper 3, we see again that, without consultation, policymakers struggle to understand and access numeric information. The paper shows that consultations regarding how quantitative information should be understood and how it is policy-relevant, happen through a diffuse and shifting relationship between science and politics. Some of the policymakers express experts' reporting of quantification was too challenging to understand. Therefore, they need consultation with experts to get the numbers explained. The outcome of such consultations could be that the numbers are appropriated into policymaking, but it could also lead to a discarding of the information if it does not fit the political framework in which the decision is to be made.

The paper demonstrates that appreciation of, and trust in, quantitative information is not created only by the experts, it is an interactive achievement. The paper further shows that policymakers have a pragmatic relationship to numeric information. The epistemic authority of the numbers in question has to be established, and policymakers then hierarchise knowledge based on what is considered most relevant at the time. Sometimes, this precludes further use of the numbers offered. This process, in turn, leads only to the institutionalisation of the knowledge considered most relevant – sometimes quantified information, at other times more qualitative knowledge like narratives (Næsje 2002).

5.1.3 Institutionalisation

Institutionalisation means, in my case, that the numeric information that has been offered to policymakers is adopted in the relevant political decision-making processes. In Paper 1, we learn that the 10 TWh target became institutionalised through a co-production of knowledge and politics – driven mainly by politics. An appendix in the Arnstad report presents some calculations to support the target, but the institutionalisation happened mainly through political processes. We may wonder why it took more than a decade to institutionalise the 10 TWh target, but this may indicate that, too often, energy efficiency targets are not met with sufficient enthusiasm.

The paper further shows that the institution chamber is not necessarily the final stop when numbers move through the bicameral processes. New questions about institutionalised numbers may lead to new rounds of perplexities, consultations, and hierarchisations. The emission reduction target is an example of an institutionalised number that became open for new perplexities and consultations, not because one wanted to discard having a numerical target to reduce emissions but to make it more ambitious. Norway signed the Paris Agreement with an emission reduction target of 40% by 2030, as compared to 1990 levels. Hence, such a target was institutionalised. What is special about the emission reduction target is that it is expected to change every five years, reporting increasingly more ambitious targets to the UN. This means that the institution chamber is reopened, and the target moves to the perplexity chamber again, where new questions about how much emission reduction is *now* needed to keep us within the 2-degree target are asked.

Hence, we may say that the target has undergone a reflexive institutionalisation. An upgrade of the emission target happened in 2021, and the perplexity and consultation processes resulted in the new target of 50%-55%, which is institutionalised until the chamber opens again. Unlike the 10 TWh target, where political consideration dominated the institutionalisation, the emission reduction target is institutionalised based on a clearer co-production of science and politics. Overall, the paper demonstrates that superior numeric targets do not move in a linear manner from perplexity chamber to institutionalisation, they instead need to travel through all chambers – sometimes several times.

In Paper 2, we see that numbers are not so easy to relate to, and not immediately understandable to policymakers. Experts' accounts show that considerable consultation efforts are needed to make numbers understandable, trustworthy, and relevant to policymakers. This means that the epistemic authority of numbers in climate and energy policy must be co-produced with relevance. Without relevance, numbers are not institutionalised. Accordingly, numeric work is required for numbers to become institutionalised, although sometimes the socialisation efforts are unsuccessful.

Paper 3 confirms the necessity of consultation efforts. It shows that numbers are usually not institutionalised without consultation with experts. Most policymakers have a cautious relation to numbers. This is demonstrated through the four narratives of practices and the use of numeric information as a basis for policymaking. The paper further shows that policymakers have a selective and rather pragmatic perplexity, which influenced the institutionalisation of numeric information. Policymakers use numbers only if they are considered fruitful and relevant for the case at hand. In other words, policymakers are looking for information to make decisions. Policymakers' use of numbers may further be described as contingent and as a diffuse and circuitous process, as emphasised by Weiss (1977; 1979). Accordingly, comprehensibility and relevance become a mix that influenced policymakers' choice of information.

Many of the employees in ministries and other governmental agencies have work tasks related to achieving superior numeric targets related to climate and energy policy. Hence, targets were institutionalised prior to the activities of these actors, thus, institutionalisation is not their choice to make. Their work tasks involve numeric targets that were decided in political agreements, making their work tasks with numeric information routine, expected and involuntary. Some of these actors find numeric information as good and convincing information, yet others describe numbers as uncertain and difficult to understand. In this way, these actors have to relate to numbers despite some of their ambivalent feelings about them.

5.2 Hybrid interactions in a spiral of bicameral models

In the analysis, we see that experts do not act according to the linear model, but rather as socialisation actors performing a comprehensive set of tasks in many areas to help the appropriation of numeric information in climate and energy policy. In the consultation and hierarchy chambers, the experts employ positive modalities – simplifying complex information and writing in Norwegian, for instance – to make numeric information relevant to policymakers. However, one of the main findings from my research is that policymakers are not naïve and uncritical receivers of numbers. Experts' socialisation efforts may be insufficient to provide numbers with epistemic authority due to policymakers' pragmatic relationship to numeric information. This may result in the discarding of numeric information, and in turning to qualitative information instead due to its perceived relevance to a particular decision. This is exemplified by a study of the Norwegian Parliament's decision-making in the question of subsidising heat pumps. Members of Parliament ended up using moral arguments to dismiss the supplied quantitative information in deciding that industrial actors could be subsidised when they acquire heat pumps, despite the numbers made available suggesting households should be supported while subsidising industry was not needed (Næsje 2002). This illustrates what may happen when experts' socialisation efforts with numbers encounter the domestication processes of policymakers. The socialisation efforts of experts cannot control how numbers are domesticated or discarded.

As a critique of the linear-autonomy model, my findings illustrate that not only are there interactions between experts and policymakers, but repeated processes of interaction. There is a spiral of bicameral models related to how quantification becomes institutionalised – or not – in climate and energy policy. It is not only experts or only policymakers that ask questions – both do. Policymakers and experts have a shared interest in counteracting global warming, even if they operate in somewhat different contexts. They both ask what can be done. Further, both experts and policymakers have an interest in consulting with each other to find solutions and propositions that may help them institutionalise quantification as a process to achieve climate mitigation.

The analysis shows that we do not need to be anxious about numbers being transferred in a linear manner from perplexity to institutionalisation, as indicated by the arrow in Figure 3. This is an important point because if numbers were transferred in a linear manner, the process could be described as 'science speaking truth to power' (Jasanoff 2011). Inspired by the critique of linear thinking by Sørensen et al. (2000), I argue that efforts at a linear transfer of numbers would lead to several challenges to the epistemic authority of numbers in climate and energy issues. First, that would imply a problematic asymmetry between experts and policymakers, where experts would be considered active, essential, and as defining knowledge, while policymakers would be seen as passive receivers of numbers, with a limited scope for their actions. Second, the numbers would most likely be decontextualised, becoming facts that do not address relevant issues, risking that the provided numeric information would become irrelevant for policymakers. Third, without dialogue between experts and policymakers, the information might be considered too complicated to understand, and therefore meaningless outside narrow specialist communities. Hence, a linear transfer of quantified information would undermine the social robustness of that information.

This dissertation demonstrates that Jasanoff's (2011) preferred alternative model of science-policy relationship – 'virtuous reason' – is much closer to the practices observed in the three papers. The model implies that both experts and policymakers strive to achieve what is considered 'good' for society. In the model, Jasanoff suggests replacing 'truth' in the 'science speaking truth to power' equation with 'relevance' as the standard of evaluation for research in policymaking.

Numbers in climate and energy policy must travel through all chambers and involve all actors – facts, values, experts, and policymakers – to become institutionalised. The reason I draw a spiral in the middle of the bicameral model is to illustrate that the institutionalisation of numbers in climate and energy policy can be seen as the result of several rounds in the chambers. The spiral also emphasises that the beginnings and ends of quantification are not a linear story; institutionalisation is not necessarily the endpoint, new perplexities may arise. Further, I place both experts and policymakers in all the chambers to show that science-policy relations in quantification in Norwegian climate and energy policy are close, hybrid, and inter-relational.

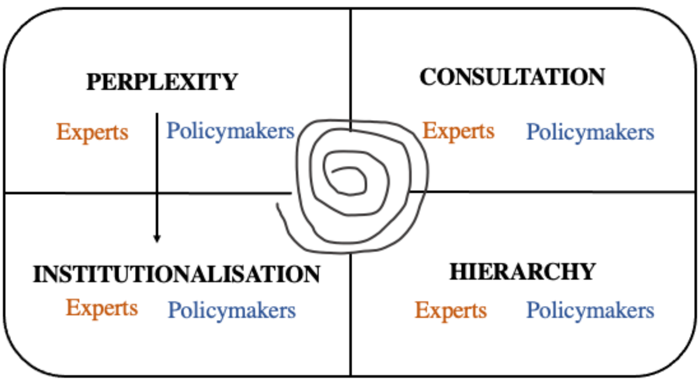

Figure 3: Numbers assumed transfer vs. the complex travel numbers make to become institutionalised in Norwegian climate and energy policy.

When I use the architecture of Latour's bicameral model and refer to Jasanoff (1990), it is not primarily to reflect ideals about how science-policy relations ought to be but to emphasise that in practice, it seems necessary for experts and policymakers to engage in dialogues about numeric information if the numbers are to be institutionalised in policymaking. The main point in bicameral models is that matters of fact and matters of concern are assembled through dialogue. Walking through the chambers, we see that the provision of epistemic authority to numeric information in the area of climate and energy is dependent on both matters of fact and matters of concern. Involving experts and policymakers in the process of institutionalising numbers in climate and energy policy, the bicameral process helps to connect matters of fact with matters of concern. We see that the numbers must pass through all the chambers, and all actors, to be institutionalised. Further, there may be a lot of matters of fact that have been calculated, but the facts are not policy-relevant until they also are matters of concern. In other words, policymakers must consider numbers as relevant, as matters of concern, for the numbers to become institutionalised as matters of fact. Moreover, the articles in this dissertation show that matters of concern can trigger a need for matters of fact. Counteracting global warming may, for instance, trigger demand for facts about how to limit the rising temperature. However, interpreted as two frameworks to describe how numbers may be provided with epistemic authority, both Latour and Jomisko's bicameral models come up short by being too neat and not embracing the messiness of real-world implementation.

6. Discussion and conclusion: Two integrated realities that influence the epistemic authority of quantification

The ambition of this dissertation is to get an understanding of how numeric information in Norwegian climate and energy policy is provided with epistemic authority. Initially, I raise two questions: 1) How is quantification in climate and energy policy provided with epistemic authority? and 2) How do science-policy relations influence the epistemic authority of numbers?

To study these research questions, I employ a set of STS tools: the bicameral model and the concepts of socialisation and modalities, as well as the STS scepticism of linearities and binaries. The bicameral model inspired me to explore the relations between experts and policymakers in the field of climate and energy, and how those relations influence the epistemic authority of numbers that are meant to be useful to policymaking. The concept of socialisation gives insights into actors, arenas, and arguments that are supposed to support the institutionalisation of numbers and their epistemic authority. The concept of modalities is employed to study rhetorical practices used by experts and policymakers to validate or weaken the epistemic authority of numbers. This theoretical framework makes it possible to investigate how numbers in climate and energy policy are provided with epistemic authority and how it is affected by science-policy relations.

The findings in this dissertation show that quantified information in climate and energy issues is not authoritative in itself, as presupposed by the linear-autonomy model. Throughout the dissertation, we have seen the challenges involved in providing quantified information with epistemic authority. Thus, the linear-autonomy model does not explain how numbers in Norwegian climate and energy policy may be described and employed for policymaking.

As already noted, the model of 'virtuous reason' is Jasanoff's (2011) preferred alternative to the linear-autonomy model. I have already suggested that the model fits the descriptions I have provided for the relationship between experts and policymakers. The question is whether numbers in climate and energy policy are provided with epistemic authority because the experts speak relevance to policymakers.

I present bicameral models as a framework for studying science-policy relations and their influence on the epistemic authority of numbers. What I gain from thinking in terms of the chambers is that, in science-policy relationships, we do not need to be anxious that numbers are being transferred in a linear manner from experts to policymakers. Inspired by the bicameral models, I show that the institutionalisation of quantification depends on dynamic science-policy interactions between producers and users of numbers. Further, the framework illustrates that experts and policymakers are interdependent. Experts want their work to be used, and policymakers are expected to engage in research-based information and expertise.

However, the bicameral model as described by Latour displays a form of linearity in the expectation that science should regularly move sequentially through the chambers. I find the movement of quantified information between experts and policymakers less linear than suggested by Latour. In the cross-cutting analysis we see that even though I divide the chambers, I suddenly refer to another chamber than the one I was supposed to be in. This indicates that experts and policymakers, in the climate and energy field, do not act according to the linear-autonomy model, but it also suggests that their interactions are messier than what is suggested by the bicameral framework.

By thinking in terms of the chambers, I show that both producers and users are actors with agency and agendas that influence the epistemic authority of numbers. I further show that they are integrated, but without politics necessarily governing research, or vice-versa. I show that experts acknowledge policymakers' need for 'technologies of humility': disciplined methods that accommodate scientific knowledge (Jasanoff 2007). I further show that experts accommodate numeric information with socialisation efforts in order to make numbers relevant to policymakers, as suggested by Jasanoff in the model of 'virtuous reason'. However, policymakers' pragmatic relationship to numbers makes the interaction between experts and policymakers more of a hybrid than what Jasanoff describes in 'virtuous reason' and Latour suggests in his bicameral model.

The issue of science-policy relations is one way to frame the understanding of how numbers in climate and energy policy are provided with epistemic authority. It is easy to think that one should separate science and policy due to the wording 'science-policy relations'. However, research methods have spread far beyond the scientific sphere, and policymakers may have higher education, hence, they cannot be assumed to be pure policymakers, untouched by knowledge about research methods and the scientific sphere. Experts and policymakers may appear in both the scientific and policy spheres, thus, there can be no linear distinction between politics and science.

An important aspect of science-policy relationships that needs to be addressed, is the selection processes that may be involved in the provision of quantitative information. Socialisation efforts do not necessarily lead to the incorporation of numeric information in climate and energy policy. Employees working at directorates and ministries may intervene as a third party in science-policy relations. These actors have close ties to politicians and members of Parliament, and part of their tasks is to review quantitative information and thereafter provide what they consider to be useful and relevant to certain policymakers. Political positions may also influence the science-policy interaction. Policymakers in government have access to information from ministries and directorates, while policymakers who are not in government do not have that same opportunity to consult with such experts. Science-policy relationships are not as tightly integrated into the latter scenario.

In this dissertation, we observe both experts and policymakers as active, essential, and defining of numbers' epistemic authority. Consequently, dialogue between experts and policymakers is fundamental for the epistemic authority of numbers. Rather than 'science speaking truth to power' and 'science speaking relevance to power', findings in this dissertation show that numeric information from experts is often not considered true nor relevant without interacting with policymakers. Accordingly, science-policy relationships in Norwegian energy and climate policymaking may be described as 'power and truth speaking to each other'. This does not mean that truth is relative, but that, ultimately, relevance is crucial for it to be used. Illustrated by the title – *Count me in* – the epistemic authority of numbers depends on the mutual trust of experts and policymakers.

Consequently, I argue that epistemic authority is provided through what I term a ‘hybrid interactional model’. The model implies close, interdependent, and repeated processes of interaction between experts and policymakers in providing numbers for climate and energy policymaking with epistemic authority.

7. Methods: An empirical study of the role of numbers in climate and energy policy

Methods are not a picture of reality, they are not the truth. Methods are performative that "re-craft realities and create new versions of the world" (Law 2004: 143). They are descriptions based on choices in methodology, theory, and analysis. Knowledge is created through a messy process that involves making interview guides, doing the interviews, and doing the analysis (Law 2004). "We need not hear interview responses simply as true or false *reports* on reality. Instead, we can treat such responses as *displays* of perspectives and moral forms" (Silverman 2001:112). Methods are something you do in practice, and there is no single best way to interpret empirical data, only many recipes for good quality analysis.

Research papers have a limited space to discuss methodological choices. In this section, I provide some overarching methodological reflections and explanations of my methodological choices, and the processes of data gathering and analysis in more detail.

This dissertation is written in the field of science and technology studies (STS) and applies a constructivist perspective. Constructivism considers reality as created, in the sense that we understand it based on various social factors often co-produced with material aspects. The phenomenon studied in this dissertation is quantification in Norwegian climate and energy policy and how it is provided with epistemic authority. Norway was chosen as a strategic research site for two reasons: Norway has a rather transparent government that may make it easier to observe the construction and usage of quantification. Further, since you cannot study the whole world, I chose my home country as the research site. However, I do not consider the findings particularly Norwegian, or limited to the climate and energy policy field, although I cannot claim that they are typical, the observed processes exist and may be found in other contexts also.

7.1 From documents to research interviews

To understand how policy-relevant numbers in the climate and energy field are constructed, perceived, and enacted, I conducted qualitative research interviews with researchers/experts and policymakers. Relevant policy documents were also used as data. This produced empirically grounded observations of socio-technical interactions, which is the dominant methodological tradition within STS. I could have chosen solely document analysis as my data basis, but it would have most likely ended up as one-sided research. Document analysis does not give sufficient insights into the processes related to quantification, how numbers are communicated and how they are perceived and employed (or not). Researchers/experts and policymakers have expertise and experience in constructing and using quantitative information, thus their contributions have been fundamental to understanding the role of quantification in Norwegian climate and energy policymaking.

Interviews provide us with detailed and holistic process descriptions, several perspectives covering different interpretations and closes gaps in research that are not covered by document analysis (Weiss 1994: 9-11). Through interviewing, one can obtain rich and detailed descriptions of research topics all from the interviewee's perspective. We also learn about context that would otherwise be closed to us (Weiss 1994: 1; Kvale 2009: 21). Although interviewing is a method for understanding the world from the interviewees' point of view (Kvale 2009: 21), it is important to remember that an interview is a retelling of something that has happened or something one thinks, intends, feels, etc. In other words, it is a representation of the interviewees' experienced reality. Interview data are "contextual, linguistic, narrative and pragmatic" (Kvale 2009: 37), in the way that the data distilled from an interview is a product of the interaction between interviewer and interviewee (Rapley 2004: 16; Weiss 1994: 65). Through interviews with researchers/experts and policymakers in the field of climate and energy, I acquired rich descriptions about their relationships to quantification and extra-calculation activities. Findings in this dissertation are representations of the interviewees' reality coloured by my choices of analysis and theoretical frameworks.

Interviewing as a method are divided into three phases: planning, implementation, and follow-up work. The planning phase is about selecting and recruiting interviewees, designing interview guides, and acquiring knowledge. The implementation phase is the actual interview situation, while the follow-up work consists of transcription, reflection, and analysis (Kvale 2009). I moved back and forth between these phases when working with this dissertation. For instance, the original interview guide had to be altered after performing the first interviews when I realised the need for more follow-up questions. Another example of movement was when I only considered it relevant to interview political advisors after embarking on the analysis. Moreover, writing three papers based on the same data made a constant movement between the phases necessary.

7.2 Planning: Who, what, and how without knowing the field

In the planning phase, I selected and recruited interviewees, designed interview guides, and acquired the knowledge necessary prior to the actual interview. Studying construction, perception, and enactment of quantification in the field of climate and energy policy required specific interviewees. The interviewees were chosen based on their function in central institutions and organisations related to Norwegian climate and energy policy: Parliament, ministries and directorates, and research and development, for instance. The interviewees were able to express themselves in a reflective manner about how numbers are constructed, perceived, and enacted in Norwegian climate and energy policy, hence, it is a purposeful sampling of interviewees. Recruitment happened through emails. Most of the emails were sent directly to the person of interest, except for two members of Parliament and the cabinet minister, who were contacted through their secretaries. In the emails, I wrote briefly about my PhD-project and why the person was considered relevant as an interviewee for my project.

7.2.1 Expert interviews: To be a newcomer among experts

Entering new and unknown fields of research often means that you have limited competence in the field. I was new to this research field and chose to use that to my advantage. Much of the methodological literature believes that it can be advantageous for interviewers to have little knowledge, so they may legitimately appear like an ignorant and curious novice (Undheim 2003: 29). Moreover, this can make the situation safer for the interviewee and lead the interviewee to speak openly and honestly (Rapley 2004: 22). Most of the interviewees willingly shared their perspectives in response to my questions about quantification in climate and energy policy. On the other hand, the scholarly literature also shows that novices may be in danger of not gaining respect from their subject, and thus be given little or no time for interviews (Kvale 2009: 159; Undheim 2003: 29; Weiss 1994: 13). Additionally, not being familiar with the interviewees' jargon can make it difficult to understand what is being said and to thereby ask follow-up questions. It may be particularly challenging to interview experts.

The interviewees in this dissertation work in public agencies with webpages such as the Norwegian parliament, the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Environment Agency, the Ministry of Oil and Energy, the Ministry of Climate and Environment, Enova (a state enterprise and the environmental unit in one of Norway's municipalities), and institutions doing research and development. This gave me the opportunity to acquire knowledge about their workplace, work tasks and education in advance of the interview. As I had done brief background research of the interviewees prior to the interviews, I was not a novice in its purest form. Still, the information acquired prior about the interviewees varied. On some company webpages, interviewees information was presented such as resumes, education, pictures, and other achievements, while others shared limited or no information.

In the literature, interviewing people who are competent in the position they have, such as policymakers and researchers, is called an "expert interview" (Bogner and Menz 2009; Weiss 1994). Scholars describe 'experts' as people who possess key positions in society, which are associated with power, privileges (Undheim 2003: 4), and having special knowledge about social facts (Gläser and Laudel 2004: 10). Interviewing experts may also be termed as "studying upwards" (Nader 1972). It is not the experts themselves who are the object of the investigation, rather, their function is as an interviewee who provides information about the real objects being investigated (Bogner and Menz 2009: 47), which in this case, is how quantification is constructed, perceived, and enacted in Norwegian climate and energy policy.

The concept of the expert interview has not always been considered a distinct form of interviewing, and in recent years expert interviewing as a separate method has been under debate (Bogner and Menz 2009: 44). Who are the experts? Couldn't anyone be considered an expert? Experts in political processes. Experts in household electricity consumption practices. Experts on driving electric cars. Is it not the case that regardless of the research questions, researchers are looking to interview experts in the field? This is where the distinction between 'experts' and 'laypeople' comes in. Much of the methodological literature distinguishes between the two as: experts are those selected to be interviewed by virtue of their position, while laypeople relate to people as private individuals (Bogner and Menz 2009; Weiss 1994). Despite this distinction, it may be difficult to draw the line between laypeople and experts, as people can function as both in the same situation. However, based on the description of experts as people who are interviewed by virtue of their position, I defined the interviewees in this dissertation as 'experts'.

Boger and Menz (2009: 46-48) present three types of expert interviews. First, as an *exploratory tool*: the interviewee can be used to establish a better understanding of the research field, which can make it easier for the researcher to define issues and pose questions. Second, as a *systematic expert* interview: experts are used to gain access to the knowledge he or she possesses. It is thus not the expert as a person who is interesting, but the information about the actual research object they provide. Third, as a *theory generator:* to gain insight into the subjective dimension of professional knowledge, not as an interviewee for the researcher to obtain fruitful information and clarification on a given topic. The interviews I have conducted are a mix of exploratory tools and systematised expert interviews. Since the research field was unknown to me at the beginning of the project, the first interviews gave me a better understanding of the field and thus made it easier to prepare issues and create questions for the following interviews. As systematic experts, the interviewees have given me access to the experts' knowledge of my field of research: how quantified information is constructed, perceived, and enacted in Norwegian climate and energy policy.

Research that presupposes conducting expert interviews can mean great opportunities to gain insight into unknown terrain, however, one can encounter challenges: particularly related to getting access to interviewees. Undheim (2003: 26) points to several challenges concerning access to experts: the expert does not know who you are, the expert believes s/he has nothing to contribute, and the expert does not see how s/he benefits from participating in an interview. In addition, from the experts' point of view, participating in research may be perceived as threatening (Undheim 2003: 24). Additionally, expert interviews usually are done during working hours, which may be challenging in terms of logistics: finding time in their busy schedules often filled with other duties. Further, interviewing politicians and people in power may be challenging, since they are used to answering only ready-made questions (Tjora 2021). This may make it difficult for the researcher to get insight.

For me, getting access to the experts I considered important for this dissertation was relatively easy. I believe Norway's rather transparent government made it easy to have an overview of who was important to interview for this dissertation and to get access to them. Only a few of my preferred experts did not participate due to parental leave or lack of time. I consider the selection of interviewees as a group that represents the Norwegian field of climate and energy in a broad and heterogeneous way. My interviewees spoke on behalf of their profession, which partly seemed to come with guidelines (written or unwritten) for how personal they could be in their answers. In a couple of situations, I experienced that the interviewees did not want to respond to certain questions or that they wanted to withdraw some of the information they had shared.

My experience of entering an interview situation with limited competence in the area was ambiguous. At times it was challenging to follow the conversation as the interviewees used terminology that was not familiar to me. However, researching this unknown territory has been mostly positive. Making clear to the interviewees that they are the experts, not me, seemed to help make the interviews into conversations where information was exchanged in a harmless and informal way. As the number of interviews conducted increased, so did my knowledge of the research field and it became easier to follow the interviewees.

7.3 Implementation: Interviews in person and over phone

The implementation phase required considerable logistics. Nine of the interviewees worked in my home city, Trondheim, the rest worked in Oslo, the capital of Norway. My original plan was to conduct all interviews in person at the interviewee's workplace. According to the literature, meeting interviewees at their work facilitates a relaxed atmosphere for the interviewee (Tjora 2021: 135). It was easy to schedule meetings in person with the interviewees that worked in my home city. The rest of the interviewees demanded more planning. I made four trips to Oslo to meet interviewees at their workplaces. Two trips in 2016 and two in 2018. I conducted several interviews on each trip, which required: making appointments with interviewees, ordering plane tickets, booking a hotel, and checking maps for distances, busses, and trains to get from one interview to the next. A crucial part of logistics when doing several interviews back-to-back is to schedule breaks and time to eat between interviews. I learned this the hard way being pregnant and hungry.

Six of the interviewees working in Oslo were not able to meet during the four trips I made, accordingly, phone interviews became the solution. Phone interviews have been criticised for being short and unable to provide rich enough data (Shuy 2003). In some of the phone interviews, the time factor was consistent with Shuy's point, but I do not view the phone interviews as more formal. In fact, many claim that phone interviewing is well suited for brief instrumental, as well as longer expressive exchanges (Shuy 2003; Sturges and Hanrahan 2004; Christmann 2009). The lack of non-verbal communication and the possibility to capture diversity are other well-known concerns. Still, I found phone interviews to provide both short as well as longer expressive conversations, in line with Christmann (2009). Although some of my phone interviews can be characterised as short, they were of high quality and provided rich data. Interviewing politicians raises some challenges with getting access, particularly because they are busy (Undheim 2003). Occasionally, this made interviewing by phone the only viable option.

7.4 Being pregnant with empirics and baby

During the data collection in 2016, I was pregnant. Being a pregnant researcher had some impacts on my interviews. In some situations, the growing belly was a natural icebreaker. Like the weather, pregnancy is a relatable subject of conversation to many. The pregnancy talk created a safe space where the interviewees and I exchanged a few personal words before the interview started. In other situations, the pregnancy was more challenging than rewarding for the research.

A challenge related to pregnancy in the data gathering process was the asymmetrical power relationship between the researcher and the interviewee, which often is pointed to as a possible challenge in the literature (Kvale 2009: 74). The challenge is often followed by strategies for how the researcher can deal with being superior to one's interviewees. I argue that the asymmetrical relationship is more complex than that. The researcher is not always the one in power. In one of my interviews, I felt discriminated against. The male interviewee stared at my body several times during the interview. I will never know if this happened because I am a woman, was pregnant, or if he was aware of his actions. This situation impacted the outcome of the interview. I asked all my prepared questions, but the follow-up questions were rather short since I wanted the interview to be over. I will not go further into this topic at this time, but as a woman and junior researcher, I believe it is important to address such challenges.

What have two pregnancies and parental leaves provided to this dissertation? For the dissertation work, time is one of the rewarding aspects of being out of the office. Time for the research field and society to evolve has resulted in interesting aspects for the dissertation. Further, distance from work gave me the opportunity to see the work with "new" eyes and new perspectives. On a personal note, two kids have enriched my life in ways I never thought was possible, and the work-home balance naturally manifested itself.

7.5 The empirical basis of this dissertation

Empirically, this dissertation draws upon a purposive-sampled set of 33 semi-structured in-depth expert interviews. Table 1 shows that the data set represents a broad spectrum of the Norwegian climate and energy field.

Table 1: Overview of interviewees

Period	**Interviewees**	**Key**	**Location**	**Method for collecting data**
2016 spring/autumn 2018 spring	12	Researchers in the economy, engineers	Oslo and Trondheim	In-person
2016 autumn 2018 spring	12	Employees in ministries and directorates	Oslo and Trondheim	In-person
2016 autumn 2018 spring	5	Members of Parliament	Oslo	Three in-person, two over the phones
2018 autumn	3	Political advisors	Oslo	Phone
2016 autumn	1	Minister	Oslo	In-person
Total	**33**			

Twelve of the interviewees were from the research and development field: economists or engineers that produce energy statistics, and who engage in modelling of energy production and use for policymaking. The researchers' primary expertise was in the production of numerical information by employing standard methods in their field. They were all eminent researchers with experience. The researchers had some knowledge about how their work is being used, hence, I consider the selection of researchers as robust in the study of how numbers are provided with authority.

Twelve others worked in directorates and ministries such as the Norwegian Water Resources and Energy Directorate (NVE), Norwegian Environment Agency, the Ministry of Oil and Energy, the Ministry of Climate and Environment, and Enova – a state enterprise whose main task is to work towards Norway's transition to a low-emission society. One of the interviewees was a Minister, and one worked in the environmental unit of one of Norway's municipalities. Five of the interviewees were Members of Parliament and had seats in the Standing Committee of Energy and the Environment. The committee has a total of seventeen seats, which means I interviewed almost one-third of the committee for this dissertation. The remaining three interviewees were political advisors to members of Parliament. In Norway, political advisors are politically hired, and working closely with members of Parliament make the advisors just as hands-on with respect to policymaking as the members of Parliament themselves. The interviewees from the policy field covered the whole spectrum of Norwegian politics, making the selection of interviewees multifaceted and illustrated in Table 2 below.

Table 2: Overview of the political parties represented by the interviewees

Political party	**Interviewees**
The Green Party	1 man
The Progress Party	1 man
The Conservative Party	1 woman
The Christian Democratic Party	2 men (one MP, one advisor)
The Socialist Left Party	1 man
The Labour Party	2 women (one MP, one advisor)
The Liberal Party	1 woman (advisor)
Total	**5 women and 4 men**

The availability of expertise was slightly different depending on the size of the party and whether they were in government or not. Political parties in government have access to more knowledge from ministries and directorates than the opposition does since these ministries and directorates are connected to the parties in government. This suggests that policymakers' enactment of numeric information may depend on the political party and whether it is in government or not. That the size of the party impacts their access to expertise was emphasised by Unander (2019) who found that small parties used knowledge provided by environmental organisations more frequently than larger parties. This also applies to my findings: the interviewee from the Green Party, one of the smallest parties in the Parliament, referred to environmental organisations as legitimate and useful sources of knowledge, while interviewees from larger parties talked about environmental organisations as a surplus source of information that had a varied impact on their policy decisions.

It is important to explain that the employees working in the ministries, directorates, and Enova are considered as both experts and policymakers. In Paper 2 they are considered experts based on their role as providers of quantified information and numeric work to policymakers. In papers 1 and 3 they are considered policymakers since their use and provision of numbers is a way to be involved and impact policymaking. Based on their dual role, employees working in ministries, directorates, and Enova may be called policy developers. Their role of simplifying quantification and providing such information to policymakers is a way of leading people to act in certain ways from a distance, hence, they can be called "centres of calculations" (Latour 1987). In addition to interviews, policy documents and reports have been used as data. This data has been analysed using simple content analysis with a focus on the role of numbers in the arguments. An overview is provided in Table 3 beneath.

Table 3: Overview of documents and reports

Documents and reports
White Paper 13, 2020-2021 Climate plan for 2021-2030
White Paper 36, 2020-2021 Energy for work
White Paper 25, 2015-2016 Energy policy towards 2030
White Paper 21, 2011-2012 Norwegian climate policy
Climate agreement (2008)
Climate agreement (2012)
Climate change act (2018)
Enova Annual report (2020)
IPCC report: Climate Change 2021: The physical science basis
Innst. 318 S, 2016-2017: Representative proposal for a stronger commitment to work to achieve the goal of 10 TWh energy efficiency
The Arnstad report: Energy efficiency in buildings. An ambitious and realistic plan towards 2040
The Office of the Auditor General (2015): Investigation of the authorities' work with energy efficiency in buildings

7.6 Follow-up work

After the interviews were conducted, they had to be transformed into text through transcriptions. I transcribed the interviews myself. Through this activity, I got to know my data better. Transcribing one's own interviews is emphasised as preferable in the literature as it prevents the information from getting "lost" when moved from the recorder to paper, and from paper to the analysis process (Tjora 2021: 176). Structures do not exist in the data before the researcher analyses the data and construct labels, come up with names for categories, and apply them as findings from the data.

According to Charmaz (2006), the fundamental, intermediate step between data collection and writing articles is memo-writing. Writing memos may be a way for the researcher to become actively engaged with the data, develop ideas, and fine-tune subsequent data-gathering. Documenting thoughts may lead to comparisons, connections, and to crystallising questions and directions not seen prior to putting pen to paper (Charmaz 2006). After each interview, I prepared memos, which included immediate thoughts and reflections about the interview: things I found interesting, or aspects particularly emphasised by the interviewee, for instance. Moreover, I have documented my thoughts the past six years on a sporadic log and through free writing. Writing memos and logs without being restrained to length or grammar has resulted in fruitful ideas, and further, felt liberating whenever I had a writers-block or was in the start-up phase of a new article.

The analysis of all three papers in this dissertation was inspired by Charmaz's (2006) grounded theory, which emphasises coding and the development of categories to make sense of data. First, I did open coding which involves naming words, lines, or segments of data. The codes should stick closely to what the data is about (Charmaz 2006: 46). For instance, my open codes were 'condensed information' and 'lack of time'. Following, I did axial coding; which is a selective phase where the most significant or frequent codes are used to create categories and reassemble the data you have fractured during open coding (Charmaz 2006: 60). Examples of axial coding categories were 'persuasive numbers' and 'pragmatic knowledge needs'; consequently, connections, similarities, and differences across the interviews that were not visible earlier, became visible. This process transformed independent anecdotes into research findings.

Grounded theory is a method where data gathering, analysis, and writing are ongoing and intertwined processes. I switched between working on paper and the computer. First, I read the interviews on paper while highlighting words and paragraphs I found interesting and made notes. Then, I open coded the material using Atlas.ti – a computer-generated program where you can code your data and afterwards play around with the codes by arranging them in different manners. Open coding resulted in a large amount of data, so to see what the data was about, I organised and sorted it using axial coding. I not only used Atlas.ti to organise and sort data, but also sticky notes and spread sheets. The combination of analysing data on the computer and on paper helped me grasp what the data was about, and I became more secure on the findings I chose to represent in this dissertation. An example of the coding process is shown in the example below. The text piece is from one of the interviewees that worked at a directorate.

Table 4: Example of coding of interview data

Content	**Open codes**	**Category**
We are looking for condensed information, primarily because we cannot absorb large chunks of information, we have too little time, so we are very specific, and we are specific on two levels. What is the essence of the Nature Conservation Environment Report? What are the most important things? Then there is the specific level where there is talk of measures. A lot of politics is about proposing measures, making a law, restricting, adopting, setting goals, etc - do something!	Condensed information. Lack of time. Act!	**Pragmatic knowledge needs**

Central to grounded theory methods is a continuous interaction between the researcher and the data. Using the same data for several articles has required several returns to the data to make new codes and to look for connections not observed earlier. The movement between data and writing happened – not just in the start-up phase of new articles, rather, it was a continuous movement throughout the dissertation work. The advantage of going back and forth between analysis and writing is the constant checking if one's categories are representative of the data.

Grounded theory is a theory discovered from the empirical findings of social research rather than using data to prove, or dismiss, a priori assumptions (Charmaz 2006). This does not mean that I did not have pre-set plans or theoretical concepts in mind when I entered the research field. I embarked into the field with an open mind, willing to let the research journey and findings from my data guide me towards new approaches, concepts, and theories. Concepts that inspired and contextualised my work from the outset were 'mechanical objectivity' (Daston 1995; Daston and Galison 2007; Porter 1995) and 'epistemic authority' (Raviv et al. 1993; Clark 2008; Traweek 2021). The concepts were used throughout the research, in Paper 2, Paper 3, and the summary and synthesis essay. Even though Paper 1 does not refers to the concepts, it addresses the authority and objectivity of numbers.

Other theories and concepts were altered or abandoned in the process through the 'abductive approach' in grounded theory (Reichertz 2007). Abduction is intended to help researchers "make new discoveries in a logical and methodologically ordered way" (Reichertz 2007: 2016), bringing together things that had not yet been associated with each other, abandoning old convictions, and allowing new ones.

One example of altering concepts, and allowing new things to enter the scene, is the 'numeric work' concept my co-author and I developed in Paper 2. Calculation practices and their implications are much addressed in previous quantification research (e.g., Sætnan et al. 2011; Porter 1995; Larsen et al. 2017; Rose and Miller 1992; Mennicken and Espeland 2019; Rose 1991; Miller 2001), hence, I was interested in exploring calculation practices among experts that provide quantitative information about climate and energy to policymakers. As an STS scholar, I was not only interested in experts' calculation efforts, but also policymakers' understanding, and use, of numbers – and the interaction of the two. When I analysed the data, I found that, the efforts of actors who engage in the provision of numeric information to policymakers went beyond calculation. Thus, my co-author and I saw the need to alter the concept of calculation practices and to introduce a new concept to include efforts beyond calculation work. Numeric work became a central concept in my study of how numbers are made and used to count in climate and energy policy.

7.7 It can always be otherwise

In retrospect, it is easy to say what could have been done otherwise. Looking back, there are additional issues that could have been raised, other questions that could have been asked, and other actors that could have been interviewed to address the role of quantification in climate and energy policy. For instance, I wanted to interview people working in the climate and energy sectors in the municipality of three of Norway's largest cities. Due to the time limit, this was not achievable. Time and space are limited in a dissertation, so choices must be made, and the researcher must stick to her choices. The policymakers and researchers interviewed in this dissertation are a robust selection, which represents the Norwegian landscape of producing and using numerical information in climate and energy policy. Hence, I consider the number of interviews sufficient to address the issues undertaken in this dissertation. Also – because I experienced a kind of saturation point during the last interviews – much of what came out, I had heard before.

There are no reasons to assume that the findings in this research are particularly Norwegian, or exclusively related to climate and energy policy. I chose climate and energy policy because of the specific role quantification has in that policy field, but numeric information is used in different policy fields across the world. As noted by scholars, modern societies are increasingly interpenetrated by quantitative measurements (Mau 2019; Porter 1995; Rose 1991; Sætnan et al. 2011). This makes it important to study how quantification is constructed, perceived, and enacted.

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Paper one: Transitions through numbers. A critical inquiry into superior numeric targets in climate and energy policymaking[4]

Abstract

Policy discourses that address sustainability transitions are intersected by a host of goals and quantitative targets that are meant to guide efforts to achieve such transitions. This paper analyses what we call superior numeric targets in climate and energy policy, which are overarching, quantified articulations of missions for sustainability transitions. This paper uses interviews and political documents to investigate how policymakers in Norway establish and enact two superior numeric targets. One asks for limiting greenhouse gas emission by at least 50% and up to 55% by 2030, the other for an annual improvement of 10 TWh in the energy efficiency of buildings by 2030. We proceed to discuss how science and politics have been co-produced in the making of the superior targets. We intend the paper as a contribution to the study of governance related to sustainability transitions, mainly to clarify what is involved when such governance is based on quantification, combining perspectives from sustainability transition studies and quantification studies. We identify two distinct biographies. The superior numeric target of reducing greenhouse gas emissions was consolidated, accepted, and embedded through co-production of science and politics, resulting in considerable mobilisation of relevant actors. The 10 TWh target met with much more friction. It was after some years decided by Parliament but not embedded, because actors in the government administration were sceptical and less enthusiastic about being mobilised to enact the target. Thus, the paper shows that governance by numbers is not straightforward, at least not with respect to sustainability transitions.

Keywords: Sustainability transitions; Superior numeric targets; Climate and energy policy; Quantification

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1. Introduction

Policy discourses that address sustainability transitions are intersected by a host of quantitative targets that are meant to guide efforts to achieve such transitions (Akenji et al. 2016; Morseletto 2019; Rosnow et al. 2017). There is a hierarchy of policy objectives, where some are overarching, while others are derived from the primary ones. Parris and Kates (2003) usefully distinguish between goals that are "broad, qualitative, statements about objectives" and targets are quantitative and make goals specific with end points and timetables (p. 8068). Morseletto et al. (2017: 657) defines a target as a meaningful reference value that expresses a desired operational policy outcome in a synthetic (often numerical) manner, while the related concept of 'goals'are non-operational overarching objectives that usually require targets to achieve them. The use of the terms may not always be rigorous, but they do have different meanings.

In this paper, we study what we call superior targets, which are targets intended as a basis of formulating more detailed sub-targets that may be used to guide concrete policymaking. We study two such superior targets within climate and energy policy. One is quite broad, the how much greenhouse gas emissions should be reduced within a given timeframe, and one more specific, how much energy efficiency in buildings should be improved. The two targets are not independent but as we shall see, their relationship is discursive and not quantified.

We analyse how these two superior targets have been established and how Norwegian climate and energy policymakers have considered them. In principle, the two superior targets are devices to orchestrate climate change mitigation according to international agreements, including the shaping of sub-targets and policy instruments. We intend this as a contribution to the study of governance related to sustainability transitions, mainly to clarify what is involved when such governance is based on quantification. We explore the journeys of superior numeric targets in the climate and energy field to analyse their dynamic and how they are managed by policymakers. The latter will in turn will influence the impact of the targets on relevant sustainability transition efforts.

In 2015 almost all the countries in the world pledged to make efforts to limit global warming when signing the Paris Agreement: a legally binding international treaty on climate change (UNFCCC 2022). Global warming should be kept well below 2°C (and preferably 1.5°C) compared to pre-industrial levels (year 1850). To achieve a global goal such as limiting global warming, requires national targets. Therefore, at the heart of the Paris Agreement are the Nationally Determined Contributions (NDCs), the superior numeric targets set by each country of how much they pledge to reduce national greenhouse gas emissions. The impact of making such superior national is in their ability to result in further action such as the articulation of new sub-targets. The global goal of climate change mitigation was upheld the UN Climate Change Conference in Glasgow in 2021 where world leaders gathered to discuss how to limit global warming to 1.5°C. One outcome was that a decision that carbon dioxide emissions must be reduced by 45% by 2030, compared to 2010 levels (COP26 2021).

As a signatory of the Paris Agreement and UN climate convention, Norway – the research site of this paper – is committed to reduce emission and strengthen sustainability measures in order to limit the increase in the global average temperature. This paper uses interviews and political documents to investigate how policymakers in Norway establish and enact superior numeric targets in the field of climate and energy. The category of policymakers includes Members of Parliament (MPs) but also experts working in relevant ministries and government agencies since they provide policy suggestions and assessments of consequences in their formal role as advisors to politicians, even if they do not decide policies.

The two superior national targets we analyse have different scopes; one wide-ranging – greenhouse gas emissions – and one more specific; improvement of the energy efficiency of buildings. Although the latter could be seen as a response to the former, there is not a close link between their establishment, maybe because the policy concern for energy efficiency in Norway emerged already in the 1970s (Sørensen 2007). Thus, we analyse their establishment separately. Similar superior targets are found in many other countries, but the processes of making and applying them may be easier to observe among policymakers in a fairly transparent government in a small country such as Norway.

We have chosen to analyse the making of the two superior targets as biographies, to emphasise temporal aspects of the involved policy practices. The targets have a history that we want to explore. Here, we take inspiration from Hyysalo et al. (2019), who outline a comprehensive method for studying the biographies of artefacts and practises. They emphasise the advantages of multi-sited (Marcus 1995) and diachronic investigations to clarify the social shaping processes involved and their temporality, not the least with respect to applications and users. In the case of the two superior targets that we study, the Norwegian climate and energy policymaking community plays a dual role; it is involved in the setting of the targets as well as in their enactment. Both targets have emerged over time, and the community operates at multiple, although interconnected sites.

We expect the biography of superior numeric targets to be complex. Here, we learn from Morseletto et al. (2017) and Randalls (2010), who show that the 2°C target that used to be the objective of global climate change mitigation, has been the outcome of a range of events, circumstances, and actors – over a long period of time. It emanated from scientific efforts regarding climate sensitivity, but increasingly became an object of international politics. It was stabilised through a complex web of coproduction of science and politics (van der Sluijs and van Eijdnhoven 1998; Miller 2004). These studies are useful as points of departure for our analysis, in particular the finding of Morseletto and collaborators who describe the construction of the 2°C target as conducted in four phases: framing, consolidation and diffusion, adoption, and disembeddedness. They may be seen as four possible stages in the biography of a superior numeric target. Scholars who have studied the climate targets of the EU also find them to be a long-term outcome of hybrid, largely political processes that have shaped their dynamic journey, (e.g., Kulovesi and Oberthür 2020; Leipprand et al. 2020; Skjærseth 2016).

In the framing stage, targets are science-driven and regionally considered. Consolidation and diffusion happen through national or international agreements when a superior target proves to be able to catalyse interest and broader consent of decision-makers by being easy, broadly appealing, and memorisable. The third phase, adaption, happens when a superior target is decided, while Morseletto and collaborators describe the fourth stage as a disembodiment of the target, officially recognised, but without any established method for a successful implementation. However, alternatively, we consider the possibility that the fourth stage is embodiment in the sense that the target is followed up with implementation measures.

When we analyse the biographies of the two superior numeric targets, we will see if they follow such a four-stage development. Furthermore, we pursue questions related to numeric governance of sustainability transitions with regard to climate and energy issues. In the next section, we introduce some theoretical perspectives that may be fruitful to such analysis.

2. Governing sustainability transitions by numbers

Governance is receiving increasing interest in sustainability transitions research (Köhler et al. 2019; Sovacool et al. 2020). Clearly governance is central to make transitions happen, but attention has mainly been directed at innovative ways of doing governance and the need for system or regime changes (Loorback 2010; Geels et al. 2016; Geels 2019). From the widely used multilevel perspective, it is unclear what role one should give to governance through superior numeric targets. Do they originate in the landscape to provide changes in the regime, or it is something that occurs with the regime? Can such targets lead to radical change?

The issue of radical versus small-step or mundane change strategies invites reflections regarding the promises of the latter form (Sørensen et al. 2019). We consider the use of superior numeric targets in climate and energy policy as a well-established government practice and in that sense mundane. However, the effects may not be mundane. For example, superior numeric targets may be points of departure for what recent policy discourses label missions (Mazzucato 2021; Jansen et al. 2021). Missions are not just calls for innovation but also for broad mobilisation of actors to achieve the intended changes. Superior numeric targets involve, as we shall see, intentions of broad mobilisation to reach the targets.

Thus, we believe that sustainability transitions studies may benefit from including perspectives from the growing field of quantification studies, noticing the pervasive role of calculative practises in modern political culture (Desrosières 1998). Thus, 'governing by numbers' and the quantification of governance are seen as vital to study (Miller 2001; Mennicken and Espeland 2019; Rose 1991). Demortain (2019: 974) argues that "numbers are a technology of governance and … one may 'govern by numbers' (…). Quantification is a generic technology of government". How is such governance enacted?

Measurements and calculation are included in many governance issues and practises (Berman and Hirschman 2018; Mennicken and Espeland 2019). "Calculative practises should be analysed … as the mechanisms through which programs of government are articulated and made operable" (Miller 2001: 379). Setting numeric targets is a particularly important mechanism since they are a precondition of measuring achievements; a cornerstone of New Public Management practices (Rottenburg and Merry 2015: 6). Quantitative targets direct governance and are required for the assessment of achievements to reach the aims, such as sustainability transitions in the area of climate and energy. Studying how such targets are established and enacted provides important insights into the governance of sustainability transitions. This means to give attention to collective mobilisation capabilities rather than to a Foucauldian emphasis on governmentality aspects of numeric targets, and thus to study the importance of political coalition building in the making of targets (Demortain 2019).

As suggested by Morseletto et al. (2017) in the study of the case of the 2°C global warming objective, superior numeric targets may not primarily be the outcome of scientific calculations, although science may play a significant role. Anyway, we assume that politics will be important. Here, we draw on Jasanoff (2004) and her idiom of co-production of knowledge and politics as designating a process through which both science and political governance are ordered and stabilised. Thus, we study the establishment of the two superior numeric targets as co-productions but with an open mind regarding the relative importance of science and political action in the processes as an empirical issue. We apply a constructivist approach in the sense that we examine how targets are made and used by involved actors.

The two superior targets we study seem to be recognised parts of promissory policy discourses related to global warming; if the targets are reached, that will help mitigate climate change. This may be an important aspect of their stabilisation. At the same time, they are potentially ordering devices that may help alleviate the discourses. It is clear from recent Norwegian policy documents that the government has established a comprehensive accounting apparatus to oversee, and to govern, sustainability transitions related to climate and energy (Meld. St. 13 (2020-2021); Norwegian Environment Agency 2020). This role of accounting practices based on indicators and other metrics are central in studies of numeric governance (Power 1997; Berman and Hirschman 2018). We analyse if the two superior targets function as ordering devices and that this, in case, is recognised by policymakers.

Through such considerations, policymakers may also notice other features of superior quantitative targets. For example, Rottenburg and Merry (2015: 11) claim that quantitative representations have become the most robust way of making arguments appear as objective. Moreover, numbers are argued to provide trust, to allow comparability (Porter 1995; Strathern 2000), and to facilitate auditing (Power 1997). This means that superior quantitative targets may help to increase the transparency of political processes and democratic involvement (Demortain 2019). In this paper, we analyse if the interviewed policymakers share such claims. If they do, they also suggest that superior numeric targets are important tools in sustainability transition policymaking.

3. Methods

We chose a qualitative approach to respond to the research questions, combining document analysis and interviews. Data collection was functional to answer our research questions: how Norwegian climate and energy policymakers consider superior quantitative targets and how they account for their articulation and enactment of such targets. With respect to the superior target regarding greenhouse gas emissions, we studied relevant documents published after the so-called climate compromise in the Norwegian Parliament in 2008 (Ministry of Climate and Environment 2014), above all White papers and a review of policy options with respect to climate change mitigation

(Norwegian Environmental Agency 2020). The superior target regarding energy efficiency in buildings was explored using energy policy documents coming after the report from the so-called Arnstad commission (Ministry of Local Government 2010), where the target of 10 TWh annual reduction of energy consumption in buildings first appeared.

The first author interviewed a group of policy actors that well represent policymakers in the Norwegian climate and energy context. She conducted 21 semi-structured in-depth interviews. 12 of the interviewees worked in relevant ministries or government agencies, six were Members of Parliament (MP) and had seats in the Standing Committee of Energy and the Environment. One of these MPs was a previous Minister of Oil and Energy. The committee has a total of seventeen seats, which means almost one-third of the committee was interviewed. The remaining three interviewees were political advisors to MPs. The interviewees were asked about what kind of knowledge they considered having most impact and was most persuasive, including how they considered superior quantitative targets. We consider the interviewed experts from the ministries and the government agencies as policymakers since they provide policy suggestions and assessments of consequences in their formal role as advisors to politicians, even if they do not decide policies.

The interviews took place between June 2016 and February 2018. 15 were conducted in person, lasting 45-90 minutes, whilst the remaining six were conducted by telephone, with calls ranging from 25-45 minutes. All interviews were recorded and later transcribed in verbatim. 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; Members of Parliament are designed MP1-MP6, political advisors PA1-PA3, employees in ministries M1-M3, and those working in directorates, agencies, and municipalities D1-D9.

We consider the interviewees to be competent in their positions as politicians, advisors, and civil servants and thus to be experts (Bogner and Menz 2009; Weiss 1994). Experts may consider the researcher as a potential critic and thus not wanting to share much information (Bogner and Menz 2009). However, in our study it was easy to establish rapport with the interviewees who eagerly shared information and their points of view. In general, the political culture in Norway encourages openness and the topic of our research was considered important. Of course, the responses may have been strategic in their emphasis and filtered for reasons of appearance. However, given the diversity of the interviewees in terms of position, the fact that the MPs and political advisors came from most parties in the Parliament, and the high degree of consistency of the response, we consider the information to be reasonably comprehensive and trustworthy

We have analysed interview data with inspiration from grounded theory, with open coding where we coded everything we considered of relevance in the transcripts as the first step. The second step was axial coding and involved identifying relationships among the open codes. That way we were able to see categories across the data, for example ‘origin of numbers’ or ‘enactment of numbers’. Such categories served as the basis for further analysis together with the developed theoretical concepts. Thus, we have used an abductive approach (Reichertz_2007). The documents were examined primarily to observe how the superior quantitative targets were established and articulated and how they were linked to other targets, indicators, and calculations. In the analysis, we focused mainly on timelines of important event to pursue the biographical approach. Even though we write about several steps of analysis, the actual process was more complex. We went back and forth between data and analysis during the entire writing process.

Thus, we have collected and analysed data in a manner that is quite common in qualitative social science (Tjora 2018). We believe our findings to be robust and have tried to make the analysis transparent by using quotes from interviewees and documents in the text. Social science climate and energy research offers many possibilities regarding framing and methods (Sovacool et al. 2018). This paper might have improved by including an analysis of relevant debates in the Parliament, which could have allowed for checking and extending the findings from the interviews.

In the next section, we discuss how the interviewees in general talked about numbers as expressing political targets, before we turn to the two superior targets which is the focus in this article: greenhouse gas emissions and energy efficiency in buildings. Finally, we draw some conclusions.

4. Governance by number: policymakers' assessments

Quantification studies have put a lot of emphasis on the state's systematic collection of information to provide statistical overviews of increasing parts of society as a basis for bureaucratic power. Moreover, quantification facilitates governance by restricting frames of interpretation of social and economic issues and thus imposing standards (Desrosières 1998; Mennicken and Espeland 2019; Demortain 2019). Numeric targets are necessary tools to allow for assessments and interventions. From this perspective, we would expect policymakers working with climate and energy issues to be committed to such targets as centrepieces of their practices. To explore this, we asked the interviewees about the general benefits and effects of formulating quantitative targets.

They mentioned several aspects. One issue was that numeric targets facilitated auditing of achievements. D9, who worked in an organization where the centre of attention was to reach numeric targets related to increased energy efficiency and growth in the supply of renewable energy, explained that such numbers were important because "they give us a sense of speed". Likewise, his colleague, D8 told that numbers were used to check "did we get to the finish line?" The emphasis on auditing was not surprising given previous research on the issue (Power 1997; Mennicken and Espeland 2019).

D3 provided more detail. He explained that through the Paris Agreement, Norway is committed to report internationally its efforts to meet the requirements. The numeric targets defined the work needed to fulfil the agreement. However, the assessment of achievements through auditing was no simple matter. D3 expressed the need for a well-functioning management and calculation system, which would ease documentation and help see the need to revise the efforts to reach the targets.

> These are our targets, this is what we have done so far, this is what we intend to do, this will give us an emission path roughly in that direction, is it sufficient or not for us to reach the targets? What more are we going to do?

Another advantage of numeric targets was their ability to facilitate robust ways of communicating action and accomplishments to the public: “look, we do something, we set targets, we do not just talk the talk” (D8). The way targets were linked to action was argued to help to improve the transparency of political processes and democratic involvement, like the observation by Demortain (2019).

The main task of D6 was to oversee that the numeric targets were achieved. He explained that the targets he worked with, had several functions and further, that different contexts required different target setting processes: “in some settings, it is important to have a target that you are sure to reach, while in other settings the target can be ambitious”. Ambitious targets were considered motivational. D6 and his colleagues did their best to help reaching ambitious targets. If the target had been set significantly lower, they probably would have slowed down the pace of work; hence not achieving possible results. He underlined that it is easy to overestimate the meaning and accuracy of numbers, yet in his view numeric targets did not have to be correct to motivate: “9 or 10, it does not matter, we have to start with number one anyway”. Such motivational aspect adds an affective dimension to otherwise instrumental tools.

However, the interviewees did not experience quantitative targets as unambiguously beneficial. One employee in a ministry, M3, told that policymakers sometimes would get tempted to set an ambitious target despite knowing that it could be difficult to achieve. Policymakers’ preference for high ambitions was a topic that appeared in the interview with D8 as well: “there are of course political ambitions to achieve as much as possible and the target should be ambitious, but it should not be a castle in the air”. D8 pointed to the importance of having targets to strive for, yet the targets had to be realistic. Ambitious targets were ok, but if they were overambitious, assessment of achievements became less meaningful.

To sum up, as we expected, the interviewees considered numeric targets to be useful. They helped to assess actions, accomplishments, and they motivated. Moreover, they could provide robust ways of making arguments public, appearing as objective and improving the transparency of policy processes to allow for democratic involvement. Numbers could invite trust and provide comparability. In the next sections, we shift the focus to discuss in some detail the two superior numeric targets that are the focus of our study. The interviewees considered such targets as useful, but how did they emerge (biography) and how were they acted upon?

5. How superior numeric targets are made and enacted. A biographical analysis

In the analysis of the biographies of the two superior numeric targets, we pursued the stage model drawn from Morseletto et al. (2017), used the co-production idiom (Jasanoff 2004) as a backdrop, and looked for mobilisation efforts linked to the targets. The latter includes a focus on political coalitions but also on the use of the targets to develop instruments, indicators, and sub-targets to achieve the overall objectives. How did the superior numeric targets become a part of quantitative governance in the field of climate and energy?

Case I: The biography of the superior target of cutting greenhouse gas emissions

Norway's climate policy is anchored in the Parliament through two political compromises in 2008 and 2012, supported by a broad coalition of nearly all political parties (Ministry of Climate and Environment 2014) and further articulated through the White Paper on Norwegian climate policy (Meld. St. 21 (2011-2012). The two so-called climate compromises contain both targets and instruments for achieving the targets. In 2008, a superior numeric target of cutting greenhouse gas emission was established, following a previous White paper on Norwegian Climate Policy (Meld. St. 34 (2006-2007). The White paper based its proposal of a superior numeric target on evidence from climate science and was a clear example of a co-production of science and politics. The first decision on a superior numeric target resulted in a broad mobilisation of experts in the government administration to produce a comprehensive plan for how to reach the target and an overview of available instruments and their effects (Norwegian Environment Agency 2010). Thus, the target was consolidated and fairly quickly adopted.

However, the target proved to be dynamic. The decision by the Parliament in 2008 about the superior numeric target of 30 % reductions in greenhouse gas emission by 2020 appear with hindsight above all as a determination to have such a target. December 12th, 2015, Norway joined the Paris Agreement and committed to a Nationally Determined Contribution target of at least 40 % reduction in non-quota greenhouse gas emissions by 2030 compared to 1990 levels (NDC registry 2016). The climate target was included in the Norwegian Climate Change Act (Lovdata 2017). When joining the Paris Agreement Norway pledged to update and tighten their national emission targets every five years. For this reason, in 2020 when EU announced to cut its carbon emissions by at least 55%, Norway, which is not part of the EU, followed suit and upgraded its climate target to at least 50% and up to 55% by 2030 compared to 1990 levels (NDC registry 2020).

In January 2021, the government presented the Climate plan for 2021-2030 (Meld. St. 13 (2020-2021). The introduction states that the government is certain of fulfilling the target of at least 40 % emission reductions by 2030, as stated in the Paris Agreement. However, the latest Climate plan was a strategy of meeting the old target of 40% emission reduction by 2030. When the plan was publicised, the Norwegian government had already decided to upgrade its climate targets to at least 50% and up to 55% reduction. However, the plan explained that it would take time before the new targets were established in regulations. Still, in April 2021, the government proposed to implement the new climate targets – reducing emissions with at least 50% and up to 55% by 2030, and 90-95% by 2050 – in the Climate Change Act (Prop. 182 L (2020-2021).

The changing ambitions of reduced emissions have stabilised this superior target also by embedding it in wider policymaking. The target was not disembedded (Morseletto et al. 2017) but led to comprehensive policy efforts. In 2020, the government administration updated and extended its 2010 review of climate science and menu of policy instruments to mitigate climate change (Norwegian Environment Agency 2020). The achievements in terms of actual reductions may be questioned, but there is no doubt that the target led to considerable mobilisation of efforts.

How was this situation considered by the interviewees? Quite a few of them commented upon the ambitiousness of the targets. Some explained this by Norway wanting to be a role model for other countries on target achievements. M3 at the Ministry of Oil and Energy saw climate as an issue with shifting political and public attention, but always important. Climate concerns have remained high on the agenda of Norwegian governments because these are important issues, although the emphasis may change.

M3 was concerned with the numeric targets that they and their subordinate agency shared. "It would have been really great if we could set very ambitious targets for reduced CO_2 emissions through the agency's activities already next year". However, targets such as reduced CO_2 emissions would not produce significant results already the coming year. "It might be that the work we do at the moment will contribute to important reductions of CO_2 emissions in 10, 15, or 20 years". For this reason, he explained, climate targets usually were long-term and ambitious and could be challenging to communicate. He continued by saying that climate policy is characterised by nice words, high targets, and ambitions. Pointing to previous climate agreements, M3 explained that the way targets such as the 2020 targets on greenhouse gas emissions are accounted for, is "completely incomprehensible to other people". Moreover, he argued that Norway's commitment to EU targets led to confusion and opacity for most people, since solutions and mechanisms to achieve the targets were based on EU calculations and EU policies that might not be relevant in the Norwegian context. This complicated a broad mobilisation to pursue the superior target.

The capacity of political documents to stabilise numeric political targets was explained by political advisor, PA1, who highlighted the significance of the information in the White Paper on climate strategy towards 2030. "It is a valuable document in terms of information for us because it describes a lot of facts in relation to the status of climate work and the follow-up of the target and how far we have come in climate work".

When we turn to issues related to mobilising to reach the targets, the interviewees gave a more moderate impression than the policy documents. MP4 first described Norway as a country that is known for being at the forefront of important issues – gender equality, achieving an open-minded society, taking responsibility for major societal challenges in general – but when it came to climate issues, she described it as a contested area. This may seem surprising, given the broad political coalition behind the superior numeric target of emission reductions. However, she explained that in the political landscape, the traditional left probably had a different main objective than the traditional conservatives, implying different preferences for the use of policy instruments.

According to MP6, no calculations of costs were done prior to strengthening the target of limiting global warming, from 2°C to 1.5°C in the Paris Agreement. The only thing that was certain was that the costs would increase dramatically when the new target was to be attained. Moreover, MP6 told that there are few agreed-upon measures to reach the target. He described the targets as very ambitious, but yet with little drive with respect to initiatives. The only shared obligation is to report regularly on progress. Thus, he was in some doubt regarding how well the superior target of emission reductions was embedded in government efforts.

The experts in the government administration were more concerned with the challenges of making sense of the superior target and the involved policymaking, not the least within EU. While Norway is not a member, EU policies are watched carefully. D3 told that "understanding the EU targets is one thing", but also emphasised that EU is providing analyses that show what is possible, what relevant measures will cost, and the consequences of different policies. In connection with the Paris Agreement, an international research project was established with the aim of accelerating clean energy innovation, which is considered essential to climate change mitigation. M2 and colleagues at the Ministry of Oil and Energy became responsible for following up this project and to report Norway's achievements. M2 described it as a top-down project where "Obama, Erna [Norway's Prime Minister at the time], and the whole gang made the decision to carry out the project, and then it came to us to find out how to specifically realise the targets". His tasks involved reporting figures from the state budgets, communicating with the Research Council of Norway, and producing overviews of achievements in technological areas such as hydrogen, solar energy, and bioenergy. Thus, his work proceeded from the superior target of reduced greenhouse gas emissions but with distinct challenges in how to pursue it.

Other interviewees such as D2 pointed to the complexity of calculating emission reductions in a globalised world of international trade. The target of reducing emissions by at least 50% and up to 55% is set with respect to Norwegian territory, yet what Norwegians do may affect the emissions of other countries. D2 offered the case of China as an example. Norway has large imports from China but cannot control how Chinese factories operate. The guiding principle is that countries must manage the emissions within their borders. Yet, D2 explained, Norway may induce other countries to reduce emissions by making demands with respect to the production of, for example, imported biofuel. Thus, the issue of impact on emissions in other countries is quite complex. An added complexity that was mentioned, was emissions from international shipping and aviation.

D2 explained that when one think of reduction of emissions one often considers end-of-pipe cuts, reducing emissions from industry, coal power, transport, etc. This involves measures such as transitions to renewable energy and improved energy efficiency. He explained in more detail what challenges emission reduction targets could encounter. “You use land areas for example to plant forests, but if you also are going to produce bioenergy, that also requires space so then you have a competition about land”. Due to such challenges, he described communication about climate and climate policy as complex and demanding. Stating the superior target was easy, explaining how it should be achieved was difficult. Thus, mobilisation was a challenge, not the least because of the difficulties in translating the target into practices.

The climate policy documents highlight the importance of improved energy efficiency to achieve reduced greenhouse gas emissions (Norwegian Environment Agency 2010; 2020). Thus, we should expect the biography of the superior numeric target of reducing energy consumption in buildings to display some tailwind. However, the story is more complicated and demonstrates considerable challenges in consolidation, adaption, and embedding.

Case II: The biography of the superior target of cutting 10 TWh annually in buildings

Energy efficiency, not the least in buildings, has been a long-time political concern in Norway with efforts to use a varied set of instruments with limited success (Sørensen 2007). Thus, the framing stage was passed when in December 2009, the Ministry of Local Government took a new initiative. They appointed a working group (called the Arnstad commission) to provide input to an action plan for improving the energy efficiency of the building sector. The committee consisted of key players in the construction industry, R&D institutes, and government, and it was asked to propose targets and the instruments needed to reach them, both for new and existing buildings. A report, later called the Arnstad report after the name of the chair, was submitted to the Ministry in August 2010 (Ministry of Local Government 2010).

The context outlined in the report is the challenges society faces in the field of climate and energy to curb global warming, noticing that several international studies argue that improved energy efficiency is the simplest and cheapest mitigation measure. The operation of buildings is estimated to contribute to approximately 40% of the total energy consumption in Norway as well as in the rest of Europe. The report acknowledges that improved energy efficiency of buildings will contribute to reduced greenhouse gas emissions and improve security of energy supply, in addition to being profitable (p. 12). Thus, this was argued to be a key area for policymaking.

The Arnstad commission assumed that the government must set specific targets for the improvement of energy efficiency in buildings. In appendix B, the report explained how they ended up with 10 TWh as a realistic annual energy saving potential. It was calculated based on assumptions about three factors: 1) area projection, meaning the rate of new buildings and the extent to which existing buildings are refurbished each year, 2) the level of ambition of reduced energy use by estimating the effects of future regulatory levels for new construction and rehabilitation, compared with the current standard, 3) the estimated additional costs for different levels of ambition and estimates of what triggering grants should be (p. 62). Johansen, Almklov, and Skjølsvold (2021) show that calculating and measuring effects of energy efficiency policies may be challenging but this was nevertheless the basis of the Arnstad report.

Based on the committee's calculations in combination with the desire of a CO2-free construction sector and the suggestion of a previous report to the Ministry of Oil and Energy (Lavenergiutvalget 2009), they decided on the target of reducing supplied energy for the operation of buildings with 10 TWh annually by 2020 (pp. 62-70). According to the Arnstad report, existing building stock had the largest energy saving potential. This made the implementation of energy efficiency measures through renovation of buildings crucial to achieve the target. The group described the target as very ambitious but one that could be achieved with a combination of strict regulations and generous subsidies (p. 68).

Reaching the target also presupposed a significant improvement of the competence of the construction industry (p. 68). The report underlined the need for massive motivational and information measures to trigger action. Information about energy efficiency would be particularly important for private homeowners, who manage a major part of the existing building stock (pp. 38 and 53). Despite their decision on the 10 TWh target, the Arnstad commission emphasised the need for a new, more thorough and detailed study of the efficiency potential.

The report was well received by the industry and environmental organizations, but the target was not adopted by the government at that time. The White paper on Norwegian climate policy that led to the so-called climate agreement in 2012 (Meld. St. 21 (2011-2012), the Arnstad report was mentioned, but the proposals were moderated with reference to other policy work (Norwegian Environmental Agency 2010). The White paper put much emphasis on improved energy efficiency of buildings as a climate mitigation effort, but this was stated like a goal, not a numeric target. Possibly because the White paper expressed considerable optimism that existing policy instruments were sufficient to drive energy efficiency efforts. Seemingly, the superior numeric target was shelved.

Then, three years later, the Office of the Auditor General of Norway examined the government's efforts to improve energy efficiency in during the period 2009-2015. They strongly criticised the authorities: the employed instruments had so far contributed little to achieve a significant reduction of the energy consumption of buildings. The Office also stated that there still remained a great need for information about energy efficiency measures, and for a coordination of the administration's efforts since the individual agencies preferred to inform only about their own instruments (Riksrevisjonen 2015). This meant that the superior numeric target proposed by the Arnstad commission was back on the table.

In 2016, the target began to be consolidated. Then, the Parliament finally adopted the target of 10 TWh of annual energy savings in buildings but now to be reached by 2030, not 2020. The Standing Committee on Energy proposed that "the Parliament asks the government to set a target of 10 TWh reduced energy consumption in existing buildings compared with the current level" (Innst. 318 S (2016-2017). This plan should be included in the budget proposal for fiscal year 2018 and provide concrete targets for reductions in specified parts of the building stock and a package of existing and new instruments to realise them.

However, adoption encountered friction. When the plan appeared in the budget proposal, the proposal repeated the claim of the White paper on Norwegian climate policy (Meld. St. 21 (2011-2012) that existing instruments were sufficient to achieve the target. "More than 10 TWh of energy savings will be realised by 2030 through the rehabilitation of existing buildings, changes in energy use because of the demolition of old buildings, and other energy efficiency measures in existing buildings. The existing instruments in the area are sufficient to realise this saving" (Prop. 1 S (2017 – 2018) p. 151). In 2019, the political coalition in government agreed to realise the target of 10 TWh energy savings in buildings by 2030 (Granavolden declaration 2019).

Despite the decision in Parliament in 2016, as late as in 2020, the annual report of the state enterprise responsible for implementing government energy efficiency measures just qualitatively acknowledged that the potential for reducing energy consumption in buildings was great (Enova 2021). It also noticed that accessible and profitable measures were yet to be realised. In Enova's view, this was due to the lack of professional energy competence among building owners and the small financial gains from investments to improve the energy quality of buildings. Another identified problem was that rehabilitation and renovation initiatives often lacked a comprehensive plan for the building's energy quality. The report noticed that these barriers must be reduced to trigger the energy saving potential (Enova 2021: 23). The target of annual cuts of 10 TWh by 2030 was not mentioned in this or any of the previous annual reports.

Both industrial associations and environmental non-governmental organizations (ENGOs) have criticised the government for a lack of concrete measures to reach the target of a reduction of 10 TWh in the energy consumption of buildings by 2030. For example, the largest and oldest ENGO in Norway – Norges Naturvernforbund (Friends of the Earth Norway) – argued as late as in 2021 that far too few measures have been implemented (Norges Naturvernforbund 2021). Industry was also critical to the slow implementation (Hessedal 2019).

Our interviewees provided mixed responses to the 10 TWh target and thus illustrated the friction. Those working in Enova had been developing strategies to reduce the energy use of buildings for many years. The achievements were reported annually to the Ministry of Oil and Energy. When the interviews were undertaken, there was still no aim specifically directed at the building sector but with clear expectations that energy efficiency improvements together with new renewable energy should contribute to increase access to energy in Norway with 7 TWh annually. D9 described this quantitative target as important to the Ministry. "In meetings, the Ministry is very concerned about how we stand compared to the quantitative target".

The emerging target of an annual reduction of 10 TWh was a topic in several of the interviews, not the least because it was considered overly ambitious. Several were concerned with the origin of this superior target and critical of its knowledge base. D9 told that 10 TWh was a number that “suddenly just appeared”, and he was uncertain what it meant. However, another employee at Enova, D8 did not find this vagueness odd since he saw this as a common feature of the origin of numeric targets in energy policy. “If you look back in time, you will see that it is very much like holding the finger up in the air”. The same interviewee told that when numbers are presented in official reports, they end up looking solid and safe, even when really, they are pretty much without any solid ground. D7 argued that numbers expressing how much one could save on this and that measure, seemed to consolidate themselves, like rules of thumb. Referring to the Arnstad report, D8 described how he thought a number could be managed to provide authority.

> Okay, so they made an estimate, but where does that figure come from? Then you go back and find reference after reference. Then you see that some things emerge from someone who at one point just were thinking about a number based on experience and such. Sound judgement may have been exercised, but it’s like saying something in a meeting that someone later refers to, others write reports based on that reference, and suddenly somebody are referring to that report, and before you know it, another report is referring to that report, which again is used as a reference in a fourth and fifth report and so on. Suddenly it appears that the numbers are almost scientific.

After appearing in the Arnstad report, D8 explained that the 10 TWh target was seized by interest groups and policymakers. Even if the report shows that the target was based on admittedly rough calculations, several of the interviewees questioned how the target became 10 TWh. Why not another figure? D8 saw the target as a “round and nice number”, suggesting it might be an aesthetical choice. Similarly, D6 emphasised that one should not underestimate the importance of catchy numbers, using the EU202020 targets as an example. He explained that precise estimates such as 10.854 do not work, so forgiveness will be provided if you round off a little to make the target easier to communicate.

Also, temporal aspects were described as important with respect to calculating and setting targets, including estimates of an exact date for the achievement. D8 argued that the further ahead in time the target was to be reached, the less accurate the calculations would be. He saw such superior numeric targets mainly as setting a direction for actions and as a tool to focus efforts.

The Norwegian Water Resources and Energy Directorate (NVE) had been assigned the task of analysing how to reach the 10 TWh target. One of the advisors at NVE, D5 described the process. “We used the TIMES model [an energy scenario model] to see how the distribution between different energy carriers in the energy system will develop, and also savings measures”. According to D4, another advisor at that directorate, the analysis was not straightforward due to lack of clarity of the target. “What do they mean by existing buildings in 2030? What do they mean by reduced? In relation to the absolute level today or what it would be without measures?”. An additional complexity emanated from the many actors who engaged with the target.

> We had opinions about what we should do and clever ideas, the Ministry of Oil and Energy had opinions, and the politicians had their opinions. Some politicians said this because they were ambitious, while others wanted to take it down a bit, so yes, it [the calculation] was very difficult (D4).

The Arnstad report claims that the numeric target of 10 TWh annual reduction of energy consumption in the building sector was partly based on calculations, but the report only presented the results, not how they were obtained. This seemed to lead the interviewees to describe the target as having an unknown pedigree. While the policy documents suggest that the target was consolidated and adopted, the experts in the government agencies considered the target to be a political construct and not a co-production where science had been made use of. The critical attitudes of the experts may explain why embodiment was slow.

6. Discussion and conclusion

The two biographies of superior targets that we have analysed, may fruitfully be considered as a set of stages. With the greenhouse emission reduction target, we saw that the framing stage already was passed when we started to study its establishment. It was consolidated, adopted, and embedded. The target was based on a broad political compromise and scientific consensus and mobilised actors in the government to develop and assess instruments to reach the target. It was embodied, not disembodied like in the stage model proposed by Morseletto et al. (2017). Thus, our findings regarding the greenhouse emission target suggest that superior numeric targets may be effectful ways of governing towards sustainability transitions, at least in the sense that they may generate a lot of activity and mobilise actors for its purpose.

This is reflected in the interviewees' appreciation that the superior targets were articulated through numbers. Numeric targets were more precise and easier to communicate. They also noticed that round figures looked nice and high ambitions could be motivating, although not always. Aesthetics and not only calculation was important for the targets to be inspiring, consolidated and accepted. Demortain (2019) suggests that governance through quantification also may help to increase the transparency of political processes and democratic involvement. However, the interviewees' accounts did not support this assumption. Rather, the need for comprehensive calculation work related to the superior targets suggest that such governance requires expertise to become transparent. Thus, quantification may add to the complexity of understanding policymaking for sustainability transitions.

It is also noteworthy that in the case of the greenhouse emission reduction target, the policy efforts to implement it were not derailed by the changes in its numeric articulation to increase the level of ambition. Instead, the changes were accommodated without much concern. Typically, D3 used the mundane term 'technical adjustments' when describing the need to revise and expand the measures when numbers of the superior target changed. Moreover, we observe a stabilisation of the superior numeric target where reflexivity has become inherent in the process. The outcome of the climate change conference in Glasgow in 2021 demonstrates this. All countries agreed to maintain the 1.5°C from the

Paris accord as well as to re-examine their national plans and targets; possibly increase their ambitions again by the end of 2022 – just a year after the previous update (Harvey et al. 2021).

The biography of the second superior target was different in interesting ways. We began our analysis with the so-called Arnstad report (Ministry of Local Government 2010) while noticing that the framing has started much earlier (Sørensen 2007). In contrast to the first superior target, the 10 TWh target met with considerable friction. This was not because improved energy efficiency of buildings was given low priority, because such goals occur frequently in climate and energy policy documents. Rather, the problem was that the goal was believed to be achieved without the need for additional government intervention. When finally, this belief was politically overruled, friction continued because relevant experts in the government agencies were sceptical about the target regarding its scientific basis and its level of ambitions. The target was first consolidated and adopted by politicians nearly a decade after it first was proposed. Still, it was not embedded in the government administration although more qualitative goals of energy efficiency improvements definitively were pursued. This illustrates the complexities that may occur in the development of superior numeric targets, showing that governance by numbers to achieve sustainability transitions may be challenging. The situation also shows that the superior numeric target of greenhouse gas emission reduction did not pave the way for the 10 TWh target, even if energy efficiency occasionally was linked to climate change mitigation in the relevant policy documents.

The biography of the superior numeric target of greenhouse gas emission reductions demonstrates the importance of co-producing science and politics to achieve stability of the target. The possible consequence of a deficient co-production is shown by the second biography. Generally, energy efficiency policies appear as informed by research as well as political consideration, but this was not the case with the 10 TWh target that mainly was a political decision. This made the target vulnerable to scepticism among the government experts that were responsible for implementing the target, even if they formally accepted to calculate potential sub targets and strategies of implementation as well as consequences of the strategies. The effectiveness of these efforts remains to be seen. Political agreement about targets may not provide sufficiently for actions to achieve sustainability transitions, to trigger mobilisation.

Thus, our study shows that governance by numbers is not straightforward, at least not with respect to sustainability transitions. Still, the perspectives of quantification studies are fruitful to make sense of the governance of such transitions. The policy documents we have studied, abound with numeric targets and information. Thus, sustainability transitions studies will benefit from a greater interest in governance by numbers: how it may be performed, the kind of obstacles that it may encounter, and the processes of mobilisation of actors to fulfil the numeric targets. As we have argued, superior numeric targets regarding climate and energy issues are a quantified way of articulating missions for sustainability transitions. That makes them important to study.

7. References

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Paper two: Numeric work: the efforts of calculation actors to make numbers count in climate and energy policy[5]

Abstract

Quantitative information is important in the development of climate and energy policy, but the extra-calculative work needed when providing such information to policymakers have received less attention. This paper aims to fill this gap by studying the efforts of calculation actors who work with climate and energy issues. What do they do to make numbers count in policymaking? Numbers are often believed to be produced through mechanical objectivity, which should provide them with epistemic authority. However, the accounts of the interviewed experts who provide energy and climate calculations describe the need for efforts beyond calculation to improve understanding and trust among policymakers. We conceptualise the efforts as numeric work. This includes articulation work and translation efforts, which they see as necessary to help making numbers count in policymaking.

Keywords: Numeric work, Translation, Articulation work, Calculation, Epistemic authority, Energy policy

[5] In revision. This paper is co-authored with Knut Holtan Sørensen.

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 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 (Meld. St. 25 (2015-2016) 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 policy-making 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 (Mau 2019; Porter 1995; Desrosières 1998; 2016). According to Porter, such efforts are intended to provide mechanical objectivity, a trust in numbers based on 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 make numbers count in policymaking? The paper is also a response to the call by Sovacool, 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), by governments (Bijker, Bal and Hendriks 2009; Desrosières 1998; 2016; Porter 1995), or achieved through the collective performance of researchers involved in the calculation work. Further, the influence of numeric information may be a result of the growing dependence on or 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 authoritative. Are calculations and personal or institutional status sufficient to achieve trust or do the experts feel a need to engage in extra-calculation activities?

To explore the need for and potential importance of such extra-calculative activities, the paper introduces the concept of 'numeric work'. Such work may mainly involve the display of professionalism and status underlying their calculations, the demonstration of adherence to mechanical objectivity. However, given the quite intensive debates about climate and energy issues that we observe in newspapers and social media, we suspect that further efforts are needed to strengthen the epistemic authority of the supplied numbers. For example, there may be a need for explanations of what numbers mean and clarifications regarding how they are calculated or for persuasion efforts to make policymakers interested in and able to employ the results of the calculations. We develop the concept of numeric work based on theoretical considerations that form the basis of an analysis of what the interviewed experts said they need to do to make their numbers count in policy decisions.

The context of the research is climate mitigation and energy policy in Norway, a small nation where the production of energy has a relatively greater economic importance 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 – get a lot of political attention. Furthermore, Norway has a dedicated Ministry of Oil 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 particular, but it may be easier to observe such work in a fairly transparent government in a small country.

2. Making numbers authoritative

Numeric work is important to study because modern societies seem saturated with numbers that often are assumed to be objective, neutral, and transparent. 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' (Miller and Rose 1990; Cohen 1982; 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 expressed in words for the purpose of acting, deciding, or making demands (Desrosières 2016). 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 is used in descriptions, discussions, and justifications of policies. In other words, "they [the numbers] are inscribed in routinized 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" (p. 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 emphasizes the public dimensions of quantification, the emphasis on objectivity as an adaption to the suspicious powerful outsiders. Porter emphasises that objectivity in this context is not a question of being true to nature, but of withholding judgment and resisting subjectivities (p. 4). Therefore, faith in objectivity tends to be associated with political democracy, or at least with systems in which bureaucratic actors depends on outsiders.

Like Porter, Sætnan et al. (2011) claim that standardized, 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 accept 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. Thus, the conventions, assumptions, and biases that shape metric processes should be examined (Espeland and Stevens 2008; Lippert and Verran 2018; Merry 2016; Espeland and Yung 2019; 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: 1068).

To explore this, we use the concept of epistemic authority, which invites 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 2021). 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), others as challenging to navigate (Eyal 2019). On the other hand, Traweek (2021) highlights how the exercise of epistemic authority within and between disciplines creates conflict and injustice. Anderson (2020) worry that epistemic authority may silence marginalised groups due to their lower rank in academic hierarchies (e.g., Anderson 2020).

We consider numeric work as efforts to achieve epistemic authority of quantitative information. What may be involved in such endeavours? Numbers may hold epistemic authority due to the status of those who produce them, due to style of presentation (Mellor 2018), or due to performance of authority (Kantor 2021). 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). 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 recognized 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. Thus, numeric work may be required to attain confidence and relevance.

Similarly, Berman and Hirschman (2018) find that numbers have little impact unless you convince others to use them. This may require enrolment, alignment of interests, persuasion, and negotiation of what numbers mean and how they should be interpreted, in brief what Callon (1984) and Latour (1987) call translation. Numeric information may need to be made understandable and interesting to policymakers. Translation theory also proposes that actors may try to embed their numeric information in relatively stable networks with policymakers. We explore the presence of such activities in the interviewees' accounts. Thus, translation may be a vital component of the numeric work performed by our interviewees. The question is what kind of translation efforts they engage in.

Saltelli et al. (2020) claim that trust is a prerequisite for numbers to be useful but notice that trust is not an inherent property of numbers. To achieve trust, they claim that the underlying assumptions and limitations of models should be appraised openly and honestly. Thus, epistemic authority of numbers may require that they are made socially robust (Nowotny et al 2001). Such robustness "will only come about when it (knowledge making) remains open to continuous social monitoring, testing and adaptations" (Nowotny 2003: 154). According to Gibbons (1999: C82), there are of three main aspects of social robustness:

1. It is valid both within and outside the laboratory.
2. Validity is achieved through involving an extended group of experts, including 'lay' experts.
3. Because 'society' has participated in its genesis, such knowledge is less likely to be contested than that which is merely 'reliable'.

With numeric work to improve the epistemic authority robustness of numeric information, we consider the second aspect to be particularly important. Thus, numeric work may need to improve the transparency of the making of quantitative information for policymaking, to allow policymakers the possibility of some monitoring of the underlying calculation efforts.

Calculation efforts tend to be opaque or invisible to outsider. Drawing on Anselm Strauss (1985; 1988), we assume that numeric work involves articulation work; attempts to explain how the quantitative information is produced and thus why it should be considered trustworthy because the processes of calculation are made transparent. Articulation work is a kind of 'work to make work work' (Schmidt 2002: 19). It may be defined as the work that is invisible and unplanned: "work that gets things back 'on track' in the face of the unexpected and modifies action to accommodate unanticipated contingencies. The important thing about articulation work is that it is invisible to rationalized models of work" (Star and Strauss 1999: 10). Thus, we need to carefully analyse the interviewees' accounts of their extra-calculation activities.

Much previous STS 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. Moreover, we have identified two main ingredients of numeric work, articulation work to improve the transparency of the involved calculation efforts and translation focusing on explaining numbers and their relevance as well as embedding them in appropriate networks. The analysis explore the potential content of these two categories.

3. Method

The empirical focus of this article is the numeric work that by 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 (NVE), the Norwegian environment agency, the Ministry of Oil 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 Ministry of Oil 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 minutes, 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 to the interviewees extra-calculation efforts when providing quantified information to policymakers.

All interviews were recorded and later transcribed in verbatim 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.

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 also using abduction 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 was first discovered as a category to cover several codes, then elaborated through the use of relevant theory, and then furthered developed through repeated analysis of the data.

As previously defined, numeric work designates the efforts of experts who provide quantitative information to policymakers to make the information being perceived as authoritative. We assumed two categories of efforts to be important: articulation work and translation. 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 the two categories of numeric work, exploring why such work was considered necessary and what kind of articulation work and translation efforts the interviewees engaged in 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 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 future development of the Norwegian energy system. Engineer R4 studied 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 economic effects of different energy policies, for instance the impact of EU's goal at that time of a 27 percent increase in energy efficiency by 2030.

R6, a professor in economics, told that he worked in the borderland between traditional economic modelling and operations 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 optimization 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 ten 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 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 7000. 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 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 IPCC reports 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 advisor 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 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 a belief in mechanical objectivity but with clear reservations regarding the resulting epistemic authority. Policymakers could raise questions with respect to method, accuracy, and interpretation of the numbers. This necessitated the numeric work that we analyse in the next section.

5. The need for and content of numeric work

The interviewees' accounts made it clear that activities beyond calculation were needed to provide the numbers that were supplied to policymakers with epistemic authority. In their accounts, we recognised articulation work as well as translation efforts. Numeric work was done both in writing and orally. However, a few of the interviewees claimed that they did not engage in numeric work. R10 explained that he mainly supplied quantitative information without numeric work. "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 to 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.

When inquired about numeric work, D4 responded by emphasising that "we write a lot of reports". However, authoring reports may involve both translation and articulation work to make the information trustworthy. On the other hand, she voiced a combination of frustration and indifference when she talked about demands of providing more information online that was easily available and understandable for anyone interested. Since that would require extra efforts of her and her colleagues, they resisted. Numeric work may be refused but eventually external expectations may be difficult to neglect.

Thus, nearly all the interviewees, regardless of whether they worked inside or outside research, engaged in numeric work, but they did not complain about lack of epistemic authority. Rather, they described their efforts as expected and reasonable, as part of their standard practices. To engage in numeric work was a normal ingredient when supplying policymakers with quantitative information.

Numeric work I: Articulation work

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 would be willing to be informed.

In line with this, many of the interviewees reported that policymakers often requested further explanations about provided numerical information, which they considered opaque. In other words, policymakers asked for articulation work. The experts needed to explain how the quantitative information was produced. Greater transparency meant trustworthiness (Strauss 1988). A common response by the interviewees when we asked about what they did to meet users' requests about explanations was similar to 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).

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, articulation work might not be needed since it had been done previously. In other situations, articulation work was 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 articulation 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) refers to as contextualisation. Such articulation work was necessary to make numbers understandable since the numbers in themselves might not make much sense. "We tried to go beyond the actual analysis results as such, 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] in relation 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 articulation work. "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).

Articulation work could also involve showing uncertainties. 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 articulation work of communicating uncertainty may help building trust, but to D4 and other interviewees this was more of a moral obligation or an aspect of being professional.

Numeric work II: Translation efforts

When presenting the translation model, Latour (1987) introduces a comprehensive assemblage of both simple and challenging rhetorical and social strategies to provide alignment and trust in scientific results, making them to be seen as facts. The interviewees employed more limited translation strategies. They were mainly concerned with finding effective ways of communicating results and with engaging in network building. The concerns about communication were diverse, including how to assess its effectiveness. R6 told that he and his colleagues used past 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 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 translation efforts that meant making numbers understandable. “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 make numbers understandable to non-economists. Most policymakers lack such training. R6 highlighted the importance of articulating both input and output of calculations, arguing that graphic representations were best suited for that purpose. “They are relatively easy to understand and gives a fairly accurate picture of what is happening”. This view of graphical illustrations corresponds to Espeland and Stevens’ (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 making numbers easier to comprehend by customising presentations. This was described as a complementary strategy to simplification since different audiences often had specific requirements and expectations. R3 customised her presentations by simplifying complex terminology, using more popular terms. 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 translation strategy of linguistic adaption to suit the target audience was widespread. Quite a few 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 a 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).

Graphic representations and other ways of simplifying complexities were not the only strategies to make policymakers interested in quantitative information. D5 told that getting busy policymakers interested in quantitative information, titles and summaries had to be catchy. "You can hardly expect them to read more than the summary". D5 suggested a linguistic strategy 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 strategies.

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

In addition, networking was important. The interviewees were concerned to engage with actors who could become users of the quantitative information that they produced. Such engagement was considered important 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'. Some of the experts described policymakers' availability as 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 Oil 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. It could be at other times the Ministry calls and says '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 fly 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. Damn, 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.

Many interviewees emphasised the importance of knowing their audience 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 presentation to busy people like policymakers you do not have time for all the details and all the assumptions. You have to be sharp and go straight to the main message”. Thus, translation 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 (Wynne 1992; Davies and Horst 2016), but not necessarily familiar to experts in energy and climate issues.

Such insights could result from networking, which involved efforts to create interest, such as the initiative described by R7. “We send out a menu of topics that we have been working on to relevant people”. They invited 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 organize a breakfast seminar, staff seminar or something. We do quite a lot of that”.

Thus, translation efforts as well as articulation work were considered vital to make calculations useful and potentially effective. Largely, calculations were not driven by curiosity but 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. At the heart of the efforts was communication to achieve transparency of the work underlying calculations and to make numbers interesting, understandable, and useful in a policymaking context.

6. Conclusion: the meaning of numeric work

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; 2016; Porter 1995), from the pervasive use of quantitative information in modern society (Mau 2019; Muller 2018; Powers 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 experienced a need for extra-calculation efforts to achieve sufficient trust in or epistemic authority of numbers in order to make their calculations count in policymaking. We have termed such effort as numeric work because it was intimately related to the calculations that were the main task of the interviewed experts. They trusted the results of their calculations, but they did not presume policymakers to consider their numbers in the same way. Further efforts were needed to provide sufficient epistemic authority.

From theoretical considerations, we expected numeric work to include articulation work and translation efforts. In general, as we have seen, the interviewees' description of their numeric work fell well within these two categories. Their articulation work was mainly about making the quantitative information more transparent, informing about how it had been calculated and the uncertainties involved. Translation efforts above all addressed communication issues: how to make the information interesting, understandable, and relevant. Many emphasised simplifications as an important communication strategy, but other approaches were also mentioned, such as the use of graphic presentations and metaphors. In addition, the interviewees considered networking through establishing and developing contact with policymakers as important because having such relations facilitated both articulation work and translation efforts.

The difference between articulation work and translation efforts is not clear-cut, but we see the two kinds of numeric work as mainly complementary. One is providing transparency; the other is contributing understanding and engagement. Arguably, there could be challenging interferences, for example between explaining uncertainties in the calculations and simplifying the resulting information. However, the interviewees did not complain about such difficulties. Mentioning uncertainties and making reservations about the numeric information was considered part of being professional. Still, there could be frictions between translation efforts to be brief and interesting and articulation work to explain how one obtained results and the uncertainties involved. We interpret the interviewees accounts to indicate that translation sometimes would be seen as more important than articulation work.

The experts working in ministries and directorates had formal channels through which they communicated results. Thus, their numeric work was at least to some extent institutionalised, even if they also communicated more informally with policymakers. This was different for the interviewed researchers. Despite networking, their accounts of their numeric work suggest that it was not institutionalised or routinised. The contact with policymakers was contingent; it varied with policymakers' needs and the places where researchers and policymakers interacted. Reports could be distributed through formal channels, but not always, and meetings and seminars were not standardised or occurring routinely. They always had to be organised. The contingent character of numeric work was also evident from the interviewees' frequent emphasis that they tried to improve their communication strategies, for example by moving from monologs to more interactive presentations.

The impact of social science, including economist and engineers working with techno-economic models, may be achieved in diverse and complex ways (Bastow, Dunleavy and Tinkler 2014). Numeric work may be seen as an effort to achieve such impact, to engage in providing quantitative information that could be relevant to policymakers. Provision of policy advice from research has been observed to be institutionalised in many contexts (Bijker et al. 2009; Jasanoff 1990; Owens 2010; Pielke 2007; Lentsch and Weingart 2011). 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.

Numeric work as we have investigated in this paper is different. It provides quantitative information, which implicitly may be policy advice, in a less formal and more interactive manner. The assessment of the quality of the information is established in the interaction between the experts and policymakers, through articulation work and translation efforts. As the interviewees explained, they performed the numeric work, but for this work to succeed, also policymakers must be active. The fact that the experts considered numeric work necessary also shows that policymakers are not naive and uncritical recipients of numbers. Quality and trust are not created only by the experts, it is an interactive achievement. Thus, a focus on numeric work improves the transparency of how numbers are made to count in policymaking, in our case with respect to climate and energy. However, in the end, it is policymakers who decide policy and thus if numbers count or not.

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Paper three: Guided by numbers. The domestication of quantitative information by Norwegian climate and energy policymakers[6]

Abstract

Concepts like 'the metric society' and 'the tyranny of metrics' suggests that increasingly, policy and governance are shaped and steered by quantitative information. This paper engages critically with such assumptions by using domestication theory to analyse how actors in the Norwegian climate and energy policy field make sense of, assemble, and employ numeric information. Through analysis of interviews with politicians and employees working with climate and energy issues in the Norwegian government administration, we identified three main categories of narratives of domesticating quantitative information: pragmatist, quantitative work, and ambivalent. Politicians were found to mostly articulate pragmatic narratives, while employees in the administration presented either of the two latter categories. All interviewees highlighted the need for more cautious and reflexive approaches to numeric information rather than enthusiastically using such information. The policymakers seemed to be guided by numbers, but numbers were not always decisive.

Keywords: domestication, numeric information, quantitative knowledge, climate and energy policymaking, audit society, metrics

This paper is awaiting publication and is not included in NTNU Open

[6] In revision. This paper is co-authored with Knut Holtan Sørensen and Marianne Ryghaug.

Appendix 1

Sample of interview guide to producers of quantification about climate and energy issues.

Background

- Age?
- Education/work experience?
- Can you say a little about your work and your skills?
- What kind of projects are you working on?
- What are you interested in when it comes to energy and climate?

Production of numbers

- Are you asked to produce, or do you produce of your own interest?
- If someone orders information from you, who orders?
- What methods do you use? Describe.
- Where do you get information/data material from?
- Do you have partners or does production only take place within the company?
- Time and cost to calculate?
- What do you think has the most impact? Descriptions, sample studies, etc. and qualitative info such as figures and statistics, etc.?
- Which method of argumentation do you think works best in energy and climate policy? Is it the good stories or examples, the hard numbers, or something else? Do you have any examples of this?

How do you usually present the results of the calculations you make?

- Are there figures, diagrams, numbers (tables) with explanations, numbers (tables) without explanations?
- Are the results presented as models?
- What should the numbers describe?
- Do you also use more descriptive representations without numbers? When? How often?

- How are results presented? (Reports, articles, lectures, teaching?)
- What do you consider to be good and bad representations? Why?

Tell me a little about how you hand over/offer the numbers to those who want/need them

- Who is interested in your work? Why?
- Who do you perceive as important users of your work? Why?
- Do these have the same educational background as you? If not, what kind of education/skills? Do you know the users? Long-term cooperation?
- How do you communicate results to users?
- Is it difficult to communicate?
- Do you talk to them? Do you make reports? Do you give lectures? Do you teach? Meetings? Calling? email?
- Do you find that people understand the numbers you provide?
- How is the numerical material interpreted? Is it the case that different users interpret the material differently?
- What do you do to make it easier for users to use the numbers? Persuasion?
- What are effective communication methods for different user groups to understand the results?
- Do you use different representations and presentations of figures to different audiences?
- How do you experience others using the numbers? (Administration, politicians, business?). Is it in line with how you want the numbers to be used? Why/why not?
- What have you experienced when it comes to the user's use of numbers? Is the understanding of numbers good? Do misunderstandings easily arise?
- If the numbers are not used as you intended them to be, do you have any thoughts on what could be the reason for this?
- What are your views on the relationship between you as producers of numbers and users' use of numbers?

Wrapping up

- Is there anything you want to add?
- Do you have tips for relevant information sources, or other people I should interview?
- Is it okay if I contact you again with any further questions?

Appendix 2

Sample of interview guide to users of quantified information about climate and energy issues.

Background

- Age?
- Education/work experience?
- What are your work tasks?
- What are you interested in when it comes to energy and climate?

Specific case

- What is the Standing committee of Energy and the Environment working on now?
- Can you tell me briefly about the committee work around the latest Energy Report?
- Where did you get info about the topic? What kind of information was it? (what kind of knowledge? Other reports?)
- How did you process/use the info?
- How was the group working on this composed? (Interdisciplinary?)

Collection of information on energy and climate issues

- What kind of information do you need in your work? (Numbers, descriptions, statements, sample studies?)
- How do you collect/receive info? (Meetings, specific bookings, lectures?)
- Where/who do you obtain knowledge from?
- Why exactly those environments? (Established relationships/networks, acquaintances?)
- What info/production environments do you trust?
- What quality criteria do you have about knowledge?
- Is it easy/difficult to use info?
- Do you understand numbers?

- What is the easiest information to use/understand?
- What do you think has the most impact? Descriptions, sample studies etc. and info such as numbers, statistics, etc.? (Qualitative or quantitative)
- What is relevant when and in what context?
- Which method of argumentation do you think works best in energy and climate policy? Is it the good stories or examples, the hard numbers, or something else? Do you have any examples of this?
- What do you think we lack knowledge about in the energy and climate area?

Wrapping up

- Is there anything you want to add?
- Do you have tips for relevant information sources, or other people I should interview?
- Is it okay if I contact you again with any further questions?

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