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Involving stakeholders in scenario-building: Lessons from a case study of the global context of Norway's climate policies

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This paper assesses the relevance and outcome of involving a transdisciplinary group of stakeholders in a scenario-building research project. The scenarios describe plausible external, long-term conditions with the aim to improve the knowledge basis of a national (Norwegian) government pursuing climate policy targets for 2030 and 2050 under uncertainty. The scenario process has two phases with quite different roles for the participants. In the first, the aim is to create broad engagement and participation in exploring narratives for how key external conditions might develop and form premises for the national climate strategies for Norway. The ambition in this phase is to deduce a handful of wide-ranging and distinctly different, qualitative scenarios. The second phase is devoted to translating the narratives into quantitative projections for the Norwegian economy and greenhouse gas emissions by means of linking global and national largescale models. We claim that research projects building and using scenarios have significant potential to benefit from involving a broad stakeholder group in developing qualitative narratives. The second phase involves complex quantitative simulations. In order to provide scientific rigor and credibility to the scenarios, this phase primarily calls for scholars with technical skills, knowledge on the research frontier and modelling experience. Nevertheless, later use of these scenarios in numerical policy studies can gain from resumed researcher-stakeholder interaction.

KEYWORDS

scenario building, stakeholder involvement, uncertainty, economic and technological modelling, intuitive logics methodology

1 Introduction

Systematic scenario-building of how the future might evolve has become a widespread and useful approach for addressing research topics subject to fundamental uncertainty. The resulting scenarios are not predictions but a set of plausible futures that can enhance in-depth, nuanced understanding of how key uncertainties may play out and impact the future outcomes of near-term policy changes. Scenario exploration is particularly widespread in studies of the societal drivers and implications for greenhouse gas emissions. The international research communities involved in analysing mitigation pathways have made large efforts to study how uncertain socio-economic, political and technological drivers may affect the future. The *Shared Socio-economic Pathways* (SSPs) framework is a prominent contribution to this strand of the scientific literature. It comprises qualitative storylines as well as quantified pathways simulated by means of complex models and model systems, including economic, technological, and integrated assessment models. See O'Neill et al. (2017) and Riahi et al. (2017) for introductions to the storylines and the model simulations, respectively, and https://depts.washington.edu/iconics/ for recent publications using SSPs.

The research topics addressed by scenarios include actions to mitigate climate risks, policies to abate emissions and strategies to account for interplays between climate action and other sustainable development goals. Despite their obvious relevance to policymaking and other decision-making, researcher-driven projects tend to lack broad stakeholder engagement (O'Neill et al., 2020). This is in contrast to how scenario planning has been used for more than half a century by public and private organisations as a tool to inform and improve strategic decisions (Amer et al., 2013). As shown by, for instance, Voinov and Bosquet (2010), organisational reforms and structural changes are implemented with less conflict and more success when the preceding scenario planning actively involves the stakeholders.

Subsequently, it is reasonable to expect that involving stakeholders has a large potential also for scenario analysis in research. O'Neill et al. (2020) acknowledge that scenarios should be inclusive and aim to capture the range of relevant perspectives and uncertainties. Such an "interactive social science" approach between stakeholders and researchers (Caswill and Shove, 2000) does, however, encounter a dilemma in that scenarios based on advanced models will be challenging for stakeholders to engage in and relate to, due to their cognitive complexity (Sterman, 2015).

In this paper we illustrate that also researcher-driven and technically complex scenario projects can benefit from (more) stakeholder involvement, but this will require knowledge about when, who and how to involve. We assess the roles of stakeholders in a scenario-building research project, *Plausible Futures*, that studies the uncertain future context of Norway's climate policy strategies from today towards becoming a low-emission society by 2050. Stakeholders are viewed as those being impacted by the climate policy strategies, that contribute in some way to the *Plausible Futures* project or just have an interest in it. *Plausible Futures* consisted of two phases, one qualitative and one quantitative. The main characteristics of qualitative storylines *versus* quantitatively modelled pathways are summarised by Vliet et al. (2010); see Table 1.

In the first phase of the *Plausible Futures* project, the aim is to systematically explore a handful of qualitative narratives about how decisive, external conditions might develop and form premises for the national climate policy strategies for the three imminent decades (2020–2050). The process was organised as a 2 days' intensive workshop. It was led by an experienced facilitator who designed, prepared and presented the process for the participants and guided the group through the whole process. The methodological approach was inspired by *Intuitive Logics* methods (Amer et al., 2013). The methodology suits the idea of our first phase well as it gives stakeholders a natural role by emphasising subjective views and brainstorming processes. In turn, their involvement can increase the acceptability for policy changes.[1]

Besides being valuable research contributions in themselves, the outcomes of the first phase form the basis for model simulations of alternative global futures and the implications for the Norwegian economy in phase 2. Phase 2 is devoted to translating the narratives into alternative, numerically simulated projections for the Norwegian economy and greenhouse gas emissions by means of linking global and national largescale economic and energy system models.

Our assessment calls attention to aspects of the stakeholder activities that turned successful and recommendable and can be generalised also to other cases. We also report some unsatisfactory outcomes and lessons learned, since negative experiences can also inform forthcoming scenario projects and their process designs. Our findings suggest that the characteristics of the two phases call for different stakeholder roles. While involving a relatively broad transdisciplinary stakeholder group turned out to be extremely rewarding in the first, explorative phase of the research project, specialised technical skills, training within economic and technological numerical modelling and insight into the relevant research frontier are central criteria when selecting participants in the second phase. Subsequently, we conclude that the most practical is not to involve stakeholders other than the specialised research group in this second phase, but we also reflect on measures to improve the conditions for stakeholder participation. This includes arranging collaborative sessions that iterate between the qualitative and quantitative scenarios as well as developing user-friendly model interfaces. Finally, outcomes of the two scenario-building phases can further form baselines for studies of climate policy, which would constitute another phase where stakeholders as key agents will be topical.

Section 2 describes the research tasks of the first, qualitative phase of developing narratives, before discussing the implications for stakeholder participation and our chosen approach. Section 3 contains similar information on the second, quantitative phase, where the narratives are translated into the applied portfolio of quantitative models. Section 4 looks ahead to the role of stakeholders in further use of the scenarios in researcher-driven and/or stakeholder-driven climate policy analysis. Some recommendations and concluding remarks are presented in Section 5.

2 The first, qualitative phase

2.1 The explorative process

The *Intuitive Logics* method we used for building explorative scenarios consisted of three main working stages: (i) identifying driving forces for global changes ahead, (ii) discussing and assessing their uncertainty and impact, and (iii) systemising the driving forces into a few selected scenario narratives. The process and the outcomes of phase 1 are thoroughly reported in Fæhn and Stoknes (2018).

Before starting the scenario development, it is pivotal that the participants:

- agree on the scenario question, i.e., which parts of the future the work will look into,

1 For a comparison between the *Intuitive Logics* methodology and other approaches, see Amer et al. (2013).

TABLE 1 Characteristics of storylines and models.

Storylines	Models
Qualitative	Quantitative
Capture future worlds in stories, ideas and visions	Capture future worlds in numbers and rules on systems' behaviour
All aspects important to stakeholders can be included	Inclusion of aspects depends on data availability
No rules for validation on current system	Validated on current system
Above leads to large flexibility	Above leads to limited flexibility
Social effects included	Hard to include social effects
No fixed set of assumptions	Fixed set of assumptions
Not always internally coherent	Internally coherent
No clear system understanding	System understanding
No data needed	Need for data

Source: Vliet et al. (2010).

- specify the strategical scope, i.e., use and purpose of the scenarios, and
- define their target groups. i.e., who has interest in learning from and using the scenarios.

The scenario question is a question that guides the scenario research and writing. Each of the selected scenarios will give distinct answers to this question. A project description expressing the purpose of the scenarios already existed. The team agreed on the following final formulation of the specific scenario question: "What future external drivers are particularly decisive for the design and performance of Norway's climate policy strategies in the period 2020–2050?"

The strategical scope of the scenarios, i.e., how they will be employed, is essential to set before the scenario development starts (Heijden, 2004). After discussion, the following strategical scope was formulated: "Provide high-quality research that can contribute with novel methods and results to the international knowledge frontier and inform national climate and energy policymaking aimed at transforming Norway to a low-emission society within 2050". Finally, the key target groups for the scenarios and the research results were confirmed by the team; see Section 2.2 below.

As a framing for stage (i) of the qualitative phase, the team was given the task of reflecting on which issues and/or driving forces for change that, in their individual view, had been underestimated or overlooked by mainstream thinkers and analysts in the last 30 years. The discussions that followed served as a mind-opener for the next task of proposing global driving forces for the upcoming 30 years. Through a creative brainstorming process, around 60 driving forces were listed. Then, consistent with the scenario question, they were assessed to be "particularly decisive for the design and performance of Norway's climate policy strategies in the period 2020–2050". In collaboration, they were clustered and the most influential selected into 11 distinct drivers. These are listed in Table 2.

Stage (ii) of assessing the 11 drivers was performed in groups of 3–4 persons. The work involved judging how each driver was expected to develop and the degree of certainty of the outcome. The drivers with a low uncertainty are assumed to affect all futures. Six drivers with high uncertainty and high impact, however, are considered critical: The combinations of their outcomes can take the future in very different directions. See Figure 1.

The assessment categorised the following three drivers as the most significant and fundamental: the degree of "access to fossil fuels", the strictness of "global climate cooperation" and the prominence of "green norms and preferences". The remaining three uncertain factors in Table 2 are all related to technological development, in "clean technologies", "power storage" and "carbon capture and storage", respectively. These are considered to causally depend on the three fundamental drivers. The workshop discussion then performed a causal and qualitative cross-impact analysis to explore correlations between the three fundamental drivers (Amer et al., 2013). Main conclusions from the stakeholder discussions were that the future strictness of "global climate cooperation" correlates with more "green norms and preferences" and less "access to fossil fuels". Therefore, we decided to use "access to fossil fuels" and "green norms and preferences" as main axes in the two-dimensional scenario uncertainty space as illustrated in Figure 2, while "global climate cooperation" is inserted as a third, diagonal axis.

Four scenarios materialise in the quadrants. See Figure 3. The last stage (iii) of the workshop was to "visit" these four futures. The task of the stakeholders was to explore, visualise and describe these four systematically different scenarios with regards to the demographic, economic, political, technological and cultural aspects over time. In a logical way, they span the range of potential future worlds based on qualitatively different and equally plausible outcomes of key uncertain and highly impactful driving forces. The workshop participants were also asked to structure the descriptions of the drivers into three chronological periods, one covering each decade of the period 2020–2050. This gives a narrative structure to the scenarios, with a beginning (2020–2030), a middle (2030–2040) and an end (2040–2050). We explored these four scenarios using both qualitative, causal forecasting, but also backcasting (i.e., viewing the timelines from the perspective of the year 2050 as if in hindsight; see Robinson, 2003). Fleshing out these narrative timelines was done by tapping

TABLE 2 The 11 most influential drivers, their certainty, impact and independence.

Drivers	Certainty assessment	Impact and independence
Fossil fuels access	Uncertain (scarce or abundant)	Significant
Green norms and preferences	Uncertain (rapid or slow)	Significant
Global climate cooperation	Uncertain (strong or weak)	Significant
Clean technologies	Uncertain (success or failure)	Dependent
Power storage technology	Uncertain (success or failure)	Dependent
Carbon capture and storage	Uncertain (success or failure)	Dependent
EU climate policies	Certain	Ambitious and binding
World demand for electricity	Certain	High
Evolvement of the digital economy	Certain	Rapid
Cities' role as political agents	Certain	Strong
Extreme weather events	Certain	Frequent

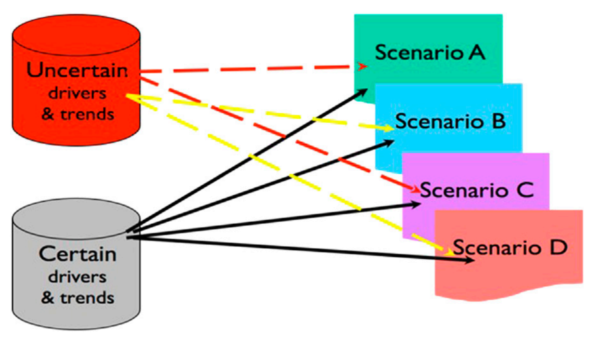

FIGURE 1
Building of scenarios based on drivers. Source; Fæhn and Stoknes (2018).

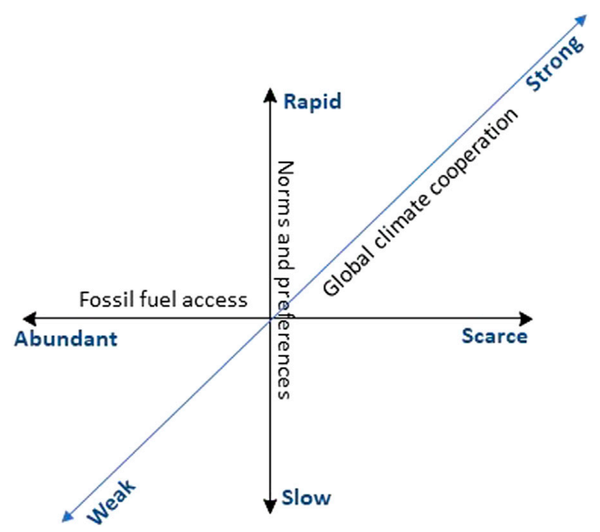

FIGURE 2
Axes of the scenarios. Source; Fæhn and Stoknes (2018).

into the knowledge and imagination of the team about the future unfolding time-dimension of plausible trends, structures and events.

The scenarios were named SPLIT! CLEAN! DARK! and RICH! They are described in detail in Fæhn and Stoknes (2018). Here we only give a short summary of the narratives.

Scenario SPLIT! is characterised by a still sustained high demand for oil and other fossil fuels in the less developed world, while rapid evolvement of green norms and preferences takes place in the developed part of the world, including Norway. This is reinforced by binding and ambitious treaties among the richer countries. The clue is that we get a split world with increasing inequalities and tensions between the regions.

Scenario CLEAN! resembles many of the existing scenario analyses of a successful transformation to a 2°C world. It shows the coincidence of a rapid global shift to green norms and preferences, scarce fossil fuels and a binding and ambitious climate agreement. Coordinated efforts worldwide alleviate the transformation process for Norway.

Scenario DARK! has the opposite characteristics. National security and near-term interests split the world, increase internal conflicts and result in severe climate change and expensive climate policies for any government having mitigation ambitions.

Lastly, the occurrence of fossil fuels scarcity drives an energy-technological revolution in Scenario RICH! where renewable energy generation and energy efficiency improvements become competitive, despite only slow and insignificant changes in norms and preferences and a weak global climate treaty. The prosperity of the world is high, but unevenly distributed. The temperature rise is moderate.

A fifth scenario, placed in origin, can also be extracted from this systemised information. It is called BASE! and represents a middle way with no extreme outcomes in any direction for any of the uncertain drivers.

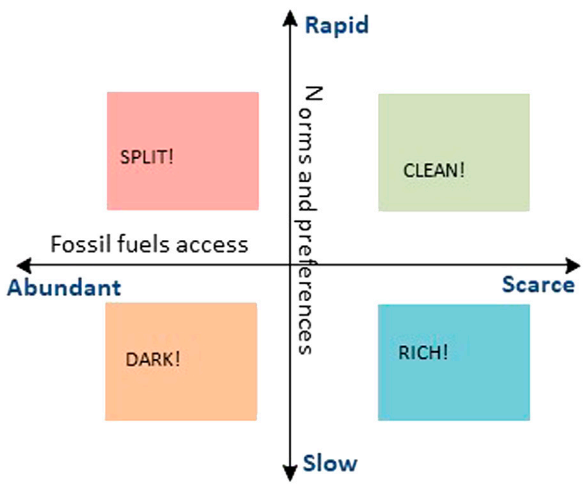

FIGURE 3
Scenarios. Source; Fæhn and Stoknes (2018).

2.2 Implications for stakeholder involvement

The *Intuitive Logics* approach has been frequently used in scenario planning at the corporate level. It assumes that decisionmakers base their assessments on implicit mental models that represents the complex relationships among future economic, political, technological, social, cultural and environmental factors (Wright et al., 2019). The aim of the method is to base the scenarios on the most influential conditions and their complex interplays, in order to both raise awareness about and challenge these mental models.

This technique has strong bearing on the characteristics, composition and dynamics of the participatory group. First, it is evident from the description of the explorative process above that all the scenario team members should be capable of handling complex interplays of drivers and their impacts in a constructive manner. In order to obtain credible and consistent results, the team dynamics should spur creativity and mutual confidence, in which a willingness to share one's mental models about the uncertain future in an open and frank way is crucial. This relies on analytical, collaborative and communicative skills among the participating stakeholders.

Second, the diversity of workshop participants' knowledge and expertise should ideally match the diversity of the future domain being mapped, i.e., insight into current and coming trends and characteristics of relevant drivers from the economic, technological, political, social, demographic and cultural domains. Importantly, the experts should also have insight into *past* developments within these domains. Since scenarios are about exploring uncertainties and discontinuities, it is particularly useful to reflect on what driving forces for change that have been underestimated by decisionmakers. This may provide insights into how mainstream thoughts are locked into certain patterns of perception, leading to skewed assumptions and biases.

Third, it is pivotal that the participants are capable of understanding the purpose and further use of the scenarios. As evident from the strategical scope of the scenarios and the scenario question of the research project, the purposes of the narratives are at least fourfold: A) The methodological approaches and results from the qualitative scenario development are aimed at contributing with novel insight to the research frontier. B) The narratives are the main basis for phase 2 of the project *Plausible Futures*, aimed at providing alternative quantified projections of the Norwegian economy by means of global and national model tools. This role has bearing on the focus in the explorative phase 1. C) While projections are useful in themselves, they are likely to be used further as baselines for how climate policy action and other decisions by economic agents might perform within different external settings. Global markets, technological development and cultural trends will be essential external preconditions for a small, open economy such as the Norwegian. Introducing similar policies into the different scenarios can function as a robustness check of the policy strategy. D) Last but not least, the qualitative scenarios aim at providing national policymakers and other decisionmakers with relevant contexts for their decisions from today towards the mid-century low-emission society. All these purposes of the research in *Plausible Futures* should be acknowledged by the workshop participants during their work.

These standards for insight and analytical skills can run counter with an additional aspiration, namely, that the team represents, or is well-acquainted, with the target groups of the research. Prior to phase 1, the researchers organising the workshop had made a tentative list of relevant types of stakeholders, characterised by either representing sectors with high greenhouse gas emissions, organisations concerned with climate change or groups affected by climate change and/or climate policies. This list formed part of the basis for picking the workshop participants:

- ministries, public agencies and parliamentarians,
- businesses, labour unions and NGOs,
- the general public, social and mass media, and
- the international research community.

With these guidelines as backcloth, we composed a workshop team that consisted of the ten central researchers in *Plausible Futures* from economic, technological and psychological sciences, as well as the eight members of a *Transdisciplinary Forum* that was associated to the project. Its members were selected by the researchers to complement their own competence. The members represented public administration, politics and business, as well as research disciplines not well covered by the internal group, including politics, business science and energy engineering. A majority of the participants were Norwegian and well-acquainted with the Norwegian political and/or business context, while several international participants brought a diverse set of outside views.

Our evaluation concludes that the workshop was well-composed in terms of competence, intellectual capacity and creativity. We encountered but insignificant challenges with putting together the workshop team. We used our relatively large network and were mostly met with interest and approval. The internal cooperation was constructive and productive. The main deficiency was that parts of the target group were not well represented. The national and international research community was dominant, and policymakers also had a prominent representation. Business stakeholders were present, however, only from the employers' side. Labour organisations were not represented, nor NGOs. Moreover, the general public and media were not represented. However, this was intended, as we prioritised the criteria on relevant competence, analytical capacity and understanding of research processes over target group representation. In retrospect, labour organisations and NGOs could have represented the perspectives of the public whilst also possessing the desired competence and understanding, so that the much of the trade-off could have been avoided. This said, we consider it even more relevant to involve the media and general public in eventual use of the scenarios in policy studies, which was not part of the *Plausible Future* project but rather will constitute a third phase; see Section 4.

3 The second, quantification phase

3.1 Describing the process

The results from the first phase are useful in their own right for researchers and stakeholders analysing the low-emission transformation. However, aspirations of the *Plausible Futures* project also included simulating the scenarios quantitatively. Two economic computable general equilibrium (CGE) models, the global SNOW model and the country model of Norway SNOW-NO, have been used in tandem for this purpose.[2] In addition, one global energy system model, ETSAM-TIAM, has been simulated to provide key technological input into the SNOW model. The three models are described in more detail below and documented in Fæhn and Yonezawa (2021), Rosnes et al. (2019)[3] and Loulou and Labriet (2008), respectively.

The quantified scenarios will not specifically reflect all details and facets of the narratives resulting from phase 1 but focus on technological, economic, emissions and climate aspects of the future. The task in phase 2 is to translate the drivers identified in phase 1 within these domains into relevant parameters in the model system.

Phase 2 was also split in three stages. The first involved simulations of the ETSAP-TIAM model. Our first task consisted in mapping the existing literature using forward-looking economy-technology-climate model systems. The search identified many similarities between our scenarios CLEAN! DARK! and BASE! with the SSPs developed in the research community using integrated assessment models: SSP1 ("Sustainability"), SSP5 ("Fossil-fuelled development") and SSP2 ("Middle of the road"), respectively. As in our approach, the SSPs consist of a handful distinct descriptions of futures presented in two forms: as qualitative narratives with multifaceted characteristics and as model-simulated quantified pathways; see O'Neill et al. (2017) and Riahi et al. (2017).

SSP1 is a scenario where the prospects for reaching global climate goals are relatively good, thanks to economic strength, fast technological progress and relatively low energy consumption. In SSP5, on the contrary, the world faces severe challenges with meeting climate goals. It has low economic growth, high population growth, high energy consumption, trade barriers and a slow technological development within renewables and energy efficiency. SSP2 is a middle case; it is here interpreted as a business-as-usual pathway where current trends are prolonged.

The resemblances found across our CLEAN! DARK! and BASE! scenarios on the one hand and the SSPs on the other, led us to use IIASA's SSP database[4] as a starting point and to restrict our first quantifications to these three scenarios. By means of SSP information on GDP, population and technological change, the ETSAP-TIAM model was simulated to obtain pathways for the demand for energy services by end-use sector and region. To match energy consumption in the SSPs, preference parameters for the end-use categories in ETSAP-TIAM have been calibrated for each region and sector. There are 15 regions and five end-use sectors, the latter split into all in all 35 sub-niches. The calibrated preference deviations from scenario to scenario are interpreted as reflecting to what extent norms and preferences develop in a green direction. The assumptions on energy service demand, in turn, have bearing on the entire energy system, including energy carriers, energy production technologies, investments in transmission grids and energy transformation options in end-use niches.

Importantly, the SSPs assume unchanged climate action, and they disregard climate change and the subsequent impact on the global economies and societies. For the Norwegian society it is reasonable to expect that these factors constitute influential parts of the external context. A main purpose of the ETSAP-TIAM simulations is, thus, to investigate the impacts of the scenarios' global climate action and global warming *via* productivity and GDP effects, technological investments, deployment and learning. In the CLEAN! scenario, the goal of the Paris Agreement on keeping global warming well below 2°C, is assumed to be met, while in DARK! the global warming can reach 5.7°C (IPCC, 2021), with severe estimated impacts on productivity and GDP (Burke et al., 2015). In the BASE! scenario, the "nationally determined contributions" pledged in the Paris Agreement are interpreted as the business-as-usual policies ahead. This will not suffice to keep global warming below the agreed temperature limit. For a closer description of the parameterisation and output from the ETSAP-TIAM simulations, see Lind et al. (2022).

In the second stage of phase 2, detailed energy system information is provided from the ETSAP-TIAM simulations and used as input in the global SNOW model. The procedure is that the energy system model's output of energy supply and its mixture, investments in supply and transmission capacities as well as the subsequent carbon emissions are used as input into the global SNOW model. Output on energy supply, technological mixture and CO_2 emissions from the ETSAP-TIAM simulations are given in Table 3 (aggregate numbers).

2 While the global SNOW model (**S**tatistics **No**rway's **W**orld model) treats the global economy endogenously, the SNOW-NO model has a more detailed representation of the small, open Norwegian economy, but an exogenously modelled global economic context.

3 The version of SNOW-NO used in *Plausible Futures* is further developed since the documentation was published in 2019; however, an updated documentation (in English) is forthcoming. See www.ssb.no.

4 https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about

TABLE 3 Global energy and emissions results from ETSAP-TIAM simulations.

		CLEAN!		DARK!	
		2050	2100	2050	2100
Primary energy supply		510 EJ	600 EJ	860 EJ	1180 EJ
CO_2 emissions		7 Gt	2 Gt	41 Gt	64 Gt
Supply transport fuels		65 EJ	68 EJ	122 EJ	140 EJ
Supply electricity		66 EJ	99 EJ	120 EJ	155 EJ
Shares	Renewables	60%	73%	40%	40%
	Fossils	6%	2%	40%	45%
	Other[a]	34%	25%	20%	14%

[a]Other includes nuclear and CCS-abated fossils.

The procedure in the SNOW model is to calibrate energy efficiency parameters and CO_2 emissions coefficients at SNOW's sectoral and regional levels to match the results from ETSAP-TIAM. Also, backstop technology trends can be extracted, which help estimating marginal abatement costs. For more on calibration procedures for global CGE models like SNOW based on sectoral information from external sources, including energy system model simulations like ETSAP-TIAM, see Fæhn et al. (2020a). There, an example is given that illustrates how a naïve baseline, merely relying on macroeconomic drivers without any adjustments in efficiency assumptions and altered technological compositions, is likely to fail.

There are complicated matching tasks involved in this linking. Main challenges are that the sectoral nomenclatures and aggregations are incompatible, and that units differ. As evident from Table 3, ETSAP-TIAM measures activities in physical units. The sectors are classified in terms of energy technology criteria. SNOW, on the other hand, uses monetary value units and categorises activities based on type of output. An illustrative example is road transport. ETSAP-TIAM classifies sub-sectors based on type of vehicles (automobile travel, bus travel, 2 and 3 wheelers, trucks) and measures quantities in terms of numbers of vehicles, travel distances and demanded energy units. SNOW measures all economic activity, including transportation, in dollars. The transport activities are allocated to the sectors of the firms that actually carry them out. Some sectors dominate in terms of transport activity, like households, commercial transportation services and the wholesale and retail trading, but virtually all producers of goods and services are involved in transporting to some extent.

These differences imply that matching across models can only be made by inaccurate and time-consuming approximation procedures. Different regional aggregation also complicates the linking but is easier to handle, though not straightforward. It is worth mentioning that Norway is not a separate region in ETSAP-TIAM, as it is in SNOW. The largest challenge when comparing model results was that the model teams did not have deep insight into each other's models and scientific disciplines. The ETSAP-TIAM team consists of engineers affiliated in *The Institute for Energy Technology*, while the SNOW experts are economists from *Statistics Norway*. Neither time resources in the project *Plausible Futures* nor previous collaboration experience sufficed to facilitate a smooth communication. Inaccurate matching was inevitable, but since the scenarios have but an illustrative purpose, this is considered acceptable and little effort was devoted to iterating the model simulations for further convergence.

Even if Norway is an individual country in SNOW, the country is modelled in less technological detail on emissions sources and abatement options than in the country model SNOW-NO. Moreover, SNOW-NO includes all greenhouse gases. Thus, in the third stage of phase 2, SNOW-simulated pathways made advantage of simulations on SNOW-NO that provide information on Norwegian future emissions composition and abatement costs. The calibration is performed by adjusting substitution elasticities across energy sources and across energy and capital input technologies. The simulations used emissions and abatement input from SNOW-NO simulations, some of which are documented in Bye et al. (2021) and Fæhn et al. (2020b). As opposed to the tandem use of ETSAP-TIAM and SNOW, the matching of outputs across SNOW and SNOW-NO is less complicated. This is explained by both models being CGE models, having virtually the same sectoral dissolvement, using the similar programming approach based in the GAMS-MPSGE tool (GAMS, 2020) and, last but not least, the two models are handled by the same research team within the same research institute (*Statistics Norway*).

Documentation of the complete scenario set using SNOW is not published, but some scenarios that already have been utilised, are documented. This applies to the CLEAN! and BASE! scenarios; see Böhringer et al. (2021) for published descriptions of the projections and Fæhn and Yonezawa (2021) for a published study of Norwegian policies using these as baselines in SNOW simulations. The scenarios are based on updated assumptions compared to the ETSAP-TIAM simulations, both for the BASE! and CLEAN! scenarios. For calibrating energy and emissions trajectories consistent with BASE!, Böhringer et al. (2021) have used the reference scenario from EIA (2017). The CLEAN! scenario is derived from scenarios compliant with the 2°C limit in https://iiasa.ac.at/models-tools-data/iamc-15degc-scenario-explorer. It is worth noting that both the BASE! and the CLEAN! scenarios are less optimistic in terms of limiting CO_2 emissions than the corresponding in the ETSAP-TIAM simulations; this is an update in line with the assessments in IPCC (2021).[5]

3.2 Implications for stakeholder involvement

The quantified scenarios focus on technological, economic, emissions and climate aspects of the future, thus will not specifically reflect all details and facets of the narratives resulting from the first phase, i.e., the expertise can be somewhat narrower. On the other hand, the quantitative phase of the project is technically complex involving numerous trial-and-error

5 As Böhringer et al. (2021) focus on medium-term results by 2030, while Lind et al. (2022) mainly report longer-run results, an accurate comparison is not feasible, however, we observe that the deviation is larger for the CLEAN! than for the BASE! scenario. One explanation is that the ETSAP-TIAM-simulated CLEAN! scenario limits warming to 1.5°C without overshooting, while the SNOW simulation of CLEAN! is based on 2°C as the limit.

simulation exercises. Participants need technical and mathematical skills, experience with modelling and insight into previous research contributions in the field. These guidelines led us to limit the participants to the handful of researchers in the project with the relevant backgrounds and not involve other stakeholders.[6]

As mentioned, even when limiting to technically experienced researchers from different modelling (energy systems vs. macroeconomic) communities, communication challenges persisted. Different modelling tools and teams forced us to simplify the matching procedures, accept more deviations and step down the number of scenarios.

To facilitate dialogue with policymakers on numerical scenarios, the *Plausible Futures* project also developed a novel model with less complexity and a user-friendly interface. This *Green Transition Model* is a partial energy model and is described in Stoknes et al. (2021). It is a "what-if policy-simulator" used to simulate investment policies against projections. Up to now, the only scenario used as baseline projection is BASE! but it can also be used to explore other baseline scenarios' outcomes on future greenhouse gas emissions and economic indicators like energy sector employment, operating costs, the revenues from exports of petroleum and power and their impact on the nation's oil fund.[7] The advantages of this model are its relatively simple structure, few inputs and outputs and a pedagogic user interface. The model is easy to simulate, and results can immediately feed back into the policy discussions. Some presentations with policymakers and other stakeholders have been made, but so far no extensive interactive sessions have been completed.

Even if the role of stakeholders in phase 2 was restricted, the quantitative model outputs can still feed back to the qualitative reasoning in the explorative phase 1. Through iterations, the quality and consistency of the results from both the qualitative and quantitative phases could improve. One way of organising this is by follow-up sessions with the participants of phase 1. The stakeholder group of phase 1 would, thus, *indirectly* have a say on the quantification procedures. Moreover, by increasing the stakeholders' acquaintance with the results from both of the two phases, the scenario material would more likely be spread throughout their networks and obtain further impact. The *Plausible Futures* project did originally not plan for facilitating such iterations and, hence, was not able to add the necessary resources and time budgets. We will come back to this approach in Section 4.

4 Using scenarios for policy studies

Beyond the insight that can be extracted from the scenarios *per se*, the scenarios will be used in future model studies of climate policies, where the quantified projections from the second phase will serve as alternative baselines. The intention will be to assess the robustness of (Norwegian) mitigation strategies to uncertain (global) future drivers. This *third* phase will expectedly benefit from stakeholder involvement. Research investigating future implications of climate policy are of informative value not only to the international research community but also to Norwegian stakeholders and even to policymakers in other countries. Model-based numerical research and analysis is in high demand among policymakers as a support for their decisions. Suitable outlets of policy studies, thus, include both international, peer-reviewed journals and applied analysis reports aimed at Norwegian or international audiences. Even in scientific journals policy-relevance of research findings is called for, particularly for studies that address urgent policy topics like the climate and energy crises.

Climate change mitigation is often diagnosed as a "wicked problem", meaning that assessments and responses are bound to take place in a confusing, complex and uncertain context. Wright et al. (2019) describe and discuss "wicked problems" in detail. Key characteristics are that they involve or affect many stakeholders with diverse values and backgrounds, that decisions take place in complex and uncertain contexts, and that *best* or *optimal* resolutions will not exist, only those that are *good enough*. One implication for our case is that results of climate policy studies will look different from the angle of the numerical modellers on the one hand and of policymakers and other user-groups on the other. While model-based research inevitably will have to simplify the context and narrow the focus in order to emphasise the particular contribution of the work to the research frontier, stakeholders need to place the findings in a complex setting and combine the new insight with numerous societal concerns, political understanding and practicability considerations.

These different approaches call for dialogue between researchers and stakeholders in order to broaden the perspectives of them all. Mutually beneficial dialogue in the science-policy interface should be the aim. On the one hand, this will facilitate that users of the studies get acquainted to the necessity of simplifying and narrowing the focus in model-based analysis. On the other hand, involved researchers will gain insight into how policymaking is a result of numerous political and practical concerns. When successful, such dialogue will generate a more robust knowledge base for policymaking, while simultaneously ensuring that the research is communicated in a policy-relevant manner, becomes more visible in the public debate and obtains societal impacts (Wesselink et al., 2013).

Alongside the use of the scenarios as baselines for model-based policy assessments facilitated and conducted by the researcher group, it can be desirable that stakeholders on their own initiative actively use the insight from the scenario-building processes and results in their internal policy assessments and decisions. A precondition for this to happen is that the results are thoroughly explained and communicated back to potentially interested stakeholders, as discussed by, e.g., Cairns et al. (2013). Stakeholder involvement in an iterative process between phase 1 and 2, like we described in Section 3.1 above, would enhance the knowledge of the stakeholders about the scenarios and strengthen the likelihood of action. From a critical perspective, we must recognise that despite creating considerable initial engagement and enthusiasm among key stakeholders in the first phase, and

6 It is worth mentioning that phase 2 largely took place during the pandemic, which added complications to close communication. The pandemic impeded the original plan of regular reporting to stakeholders but has not influenced our general advice against active stakeholder involvement.

7 Besides having simulated BASE!, the research team has used the model for policy studies reported in Stoknes et al. (2021).

despite having presented the qualitative and quantitative results from the two phases in various stakeholder-involved events, our activities have not yet been sufficiently tailored to stimulate broad and active use of the scenarios among stakeholders. Investing more in improved user interface is also a way to go; see Section 3.2.

Communication processes cost resources and time both for the researchers and the involved stakeholders. With conflicting interests among stakeholders there is also a risk of running into stalemates or trigging a tense atmosphere among the stakeholders, an implication inherent in handling "wicked problems". Thus, patience and prioritisation of stakeholder communication and dissemination are needed in the research project plans and, if any, the mutual benefits can take years to materialise.

5 Recommendations and concluding remarks

The main lessons from the research project *Plausible Futures* are that involving a broad transdisciplinary stakeholder group in the first, qualitative scenario-building phase is likely to be extremely rewarding and should be planned for in future scenario-building initiatives that aim to support policymaking and/or other stakeholder decisions. However, turning scenarios into quantitatively described pathways is a highly technical task and too complex to gain from involving potential user-groups. Adding an iterative process between the qualitative and quantitative phases deserves consideration. Our preliminary experience with developing a user-friendly model is still too scarce to support clear conclusions but seems promising. These activities can increase the stakeholders' understanding of the quantified pathways but will come at a cost.

Lessons from stakeholder involvement in scenario development in case studies like ours, can be generalised to other cases with 'wicked problems' on the research agenda. Likewise, our research agenda and design have benefitted from the published experiences from previous case studies. However, as for research in general, the literature is affected by "publication bias", i.e., the inclination to primarily publish positive findings and success stories. Subsequently, the potential learning spillovers from unsuccessful interventions are missed, and this weakens the evidence on best practice. Taking the risk of such bias seriously, we have also presented some premises and choices in our project that produced but small or negative results. These are also worth taking notice of for future scenario-building projects.

One aim not yet fulfilled is to exploit the scenarios in policy-studies. In particular, one explicit purpose of building scenarios in *Plausible Futures* is to use them as alternative baselines in later robustness analysis of Norwegian climate policy strategies. Based on our own experience from applied research, the large scenario planning literature and the more limited literature on previous scenario research, we conclude that this future research phase has a large potential to benefit from stakeholder involvement.

Besides researcher-driven analyses, qualitative and quantitative scenarios can also actively support climate policy assessments conducted as part of internal decision-making in stakeholder organisations. To obtain the necessary knowhow in the organisations, even closer communication with and guidance from the scenario-building community will be required. We have specified a couple of activities that can help building such internal knowhow, especially knowhow in quantitative analysis: One is to involve the stakeholders in follow-up sessions that iterate across the qualitative and quantitative scenarios, another is to build simpler and more user-friendly tools and guide stakeholders in their use.

Whether researcher-driven or stakeholder-initiated analysis, successful researcher-stakeholder dialogue will gain both parties. Researchers will gain in terms of improving how their findings can be presented and understood by recipients. The research will become more visible and the likelihood of having societal impact will increase. In turn, stakeholders in policymaking and business activities will benefit from such 'interactive social science' in the form of more well-founded, research-based decisions.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Not all the data are published, only described qualitatively. Requests to access these datasets should be directed to tfn@ssb.no.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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