TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

Evaluation of TRANSrisk case studies on integration of quantitative and qualitative tools.

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Preface

Both the models concerning the future climate evolution and its impacts, as well as the models assessing the costs and benefits associated with different mitigation pathways face a high degree of uncertainty. There is an urgent need to not only understand the *costs and benefits* associated with *climate change* but also the *risks, uncertainties and co-effects* related to different *mitigation pathways* as well as *public acceptance* (or lack of) of low-carbon (technology) options. The main aims and objectives of TRANSrisk therefore are to create a novel assessment framework for analysing costs and benefits of transition pathways that will integrate well-established approaches to modelling the costs of resilient, low-carbon pathways with a wider interdisciplinary approach including risk assessments. In addition, *TRANSrisk* aims to design a decision support tool that should help policy makers to better understand uncertainties and risks and enable them to include risk assessments into more robust policy design.

PROJECT PARTNERS

No	Participant name	Short Name	Country code	Partners' logos
1	Science Policy Research Unit, University of Sussex	SPRU	UK	
2	Basque Centre for Climate Change	BC3	ES	
3	Cambridge Econometrics	CE	UK	
4	Energy Research Centre of the Netherlands	ECN	NL	
5	Swiss Federal Institute of Technology (funded by Swiss Gov't)	ETH Zurich	CH	
6	Institute for Structural Research	IBS	PL	
7	Joint Implementation Network	JIN	NL	
8	National Technical University of Athens	NTUA	GR	
9	Stockholm Environment Institute	SEI	SE, KE	
10	University of Graz	UniGraz	AT	
11	University of Piraeus Research Centre	UPRC	GR	
12	Pontifical Catholic University of Chile	CLAPESUC	CL	

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EXECUTIVE SUMMARY

In TRANSrisk case studies, quantitative tools, such as environmental and economic impact assessment models have been jointly applied with qualitative research tools. This enabled both quantification of economic, social and environmental impacts of low emission transition pathways in a country or sector and request stakeholders' input and validation of these. The project contained five case studies with detailed analysis and stakeholder engagement via multiple rounds of information gathering (interviews, surveys, workshops). In addition, a number of limited case studies were done (with just one round of stakeholder consultation) as well as case studies in non-EU-countries.

Based on interviews with TRANSrisk case studies it can be concluded that the success of interaction between quantitative (models) and qualitative research tools (narratives and risk assessments using stakeholder inputs) largely depends on the following factors:

1. Motivation of stakeholders to engage in a research project and partake in iterations with researchers and modellers.
2. Related to that, the extent to which models produce results that are relevant for stakeholders' decision contexts.
3. The facilitation of the process by a case study leader who is both familiar with quantitative and qualitative tools.

Overall, while there are several ways to improve stakeholder engagement in analytical processes, it can be concluded that generally TRANSrisk case studies successfully mobilised stakeholders for participation in the analysis and gather their interest in the topic, even though the management of this was often time and resource intensive. Regarding the interaction of stakeholder consultation and use of models, the case studies suggest that stakeholders tend to better understand and respond to bottom-up models that zoom in at more disaggregated levels. Direct (or quick) feedback simulation models have a key advantage relative to the larger and heavier integrated assessment model, for which a single model run typically is more time consuming. On the other hand, IAMs are considered to have a great use as an instrument to explore long-term consequential impacts of a certain transition path for the wider economy in terms/units (e.g. GDP, employment, investments) that have a high relevance for national level policy makers.

1 INTRODUCTION

A main goal of TRANSrisk was to combine quantitative tools, such as environmental and economic impact assessment models (see Annex 1 for a listing of models used within TRANSrisk), with qualitative research tools (Gaast, et al., 2016). While the former are helpful in terms of quantifying the effects or impacts of a policy measure on the economy, society or the environment, the latter tools help, e.g., to assess the desirability or acceptance of these. For example, a model may estimate an impact on employment or wages, which could then be followed by a stakeholder consultation on whether these changes are acceptable. Another example of integrating quantitative with qualitative tools, as applied in TRANSrisk, is when stakeholder inputs are used to develop change scenarios (e.g. transition pathways) for the model runs. With that qualitatively collected data, models may be able to provide more accurate quantitative output. Finally, TRANSrisk case studies have applied a range of qualitative tools to explore in detail market systems for solutions identified by models with the objective to identify possible system barriers and ways to clear these (Gaast & Szendrei, 2016).

In TRANSrisk the interaction between quantitative and qualitative tools was framed around the concept of risks. In this concept, impacts of an identified solution for low-emission transition pathways were considered risks to society, the economy and the environment, obviously next to opportunities that the solution may bring about. Qualitative analysis can then be applied to value with stakeholders how important each impact or opportunity is. For example, the risk of reduced competitiveness in the industrial sector could be acceptable for stakeholders when weighted against the opportunity of environmental benefits such as lower GHG emissions. This not only helps to better understand the risks of climate policy measures, but also to assess these in a wider country policy making context.

Theoretically, in terms of focus, such a co-existence of quantitative and qualitative research tools would be complementary in many aspects. For example, stakeholder knowledge is collected and used for developing scenarios for model runs, the results of which (impacts and opportunities) are then assessed by stakeholders. Stakeholder views can then be transformed into research questions for new model runs up to the point where a solution is reached (e.g. on the design and implementation of a low-emission transition pathway) that is satisfactorily for stakeholders. Such an approach would also have the benefit of research projects becoming more interactive and dynamic, as many research projects follow a linear approach of communicating the research outcomes to policy makers, without soliciting their stakeholder input during the research process (see Figure 1). The TRANSrisk workplan included several consultation loops with stakeholders throughout the research, by also co-designing research questions with stakeholders or discussing intermediate results with them in the form of personal/phone interviews and workshops.

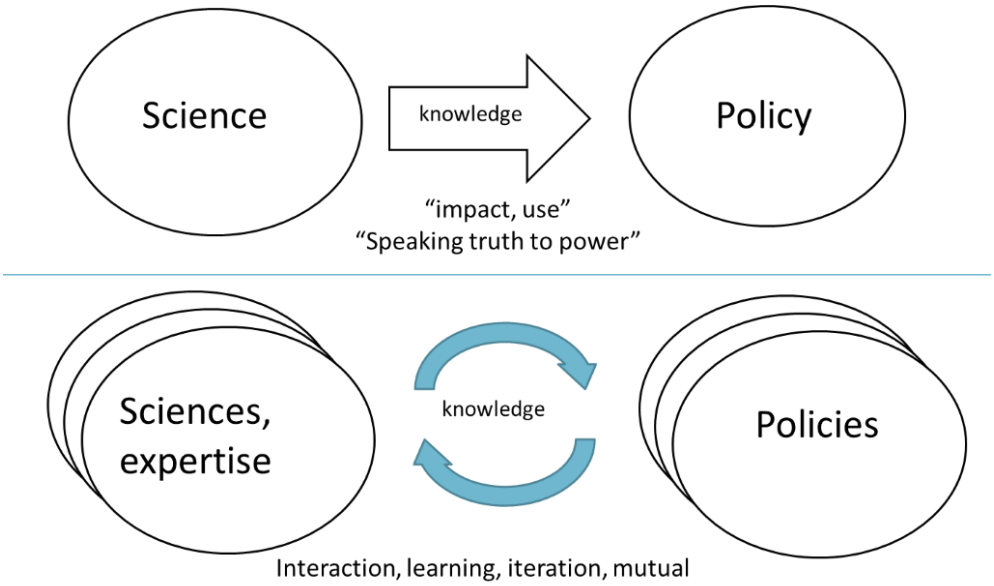

Figure 1. Linear and circular stakeholder engagement approach

Nevertheless, in the TRANSrisk case studies we learned that practice is often more complex than theory. First of all, an iterative approach assumes that stakeholders both have time to engage in the research and are interested in that. The TRANSrisk consortium realised that the 'best' or most desired or influential stakeholders are probably also the busiest people and therefore difficult to mobilise for extensive participation in a research project. Case study leaders therefore attempted to make the case studies in their country as attractive as possible for stakeholders by identifying timely policy issues and focus on these. Then, the case studies would help stakeholders in their ongoing work on the topic.

Another issue identified upfront by the TRANSrisk team is the possible mismatch between a model, as a simplified representation of a complex reality, and stakeholders' individual concerns in real life. In other words, what stakeholders find important may not be covered by the model.

Third, TRANSrisk modellers were cautious upfront about communicating expectations with stakeholders about what or what cannot be modelled. For that, a mock workshop was held in March 2016 in Athens among TRANSrisk partners so that qualitative research could improve their insights on what a model can do and quantitative researchers could practice with transforming stakeholder questions into research questions that both could be handled by a model and would result in useful answers for stakeholders. This helped to train case study in managing the integrated research approach.

By the end of the project, after completion of the case studies, consultations were held with all leaders of the detailed case studies mentioned in Task 3.1 in WP3[1]:

- Austria: co-designing a low-carbon transition pathway focusing on energy supply for the iron and steel sector.
- United Kingdom: pathways towards a low-carbon electricity system – nuclear expansion versus nuclear phase out.
- Spain: risks and uncertainties associated with a renewable energy transition.
- Sweden: decarbonising road freight transport.
- Poland: coal and renewable energy sources.

In addition, interviews were held with two case study leaders in the 'Task 3.2 countries' (limited case studies):

- The Netherlands: low-emission transition pathways in the livestock sector.
- Switzerland: risks associated with implementing a national energy strategy.

Finally, two assessments were done with partners leading non-EU country case studies (Task 3.3):

- Canada: finding common ground – the need for plural voices in lower-carbon futures of the Alberta oil sands.
- Kenya: improved charcoal value chain for lower emissions.

Within each country case study, a stakeholder engagement process was initiated to co-develop or co-design feasible and acceptable transition pathways for a specific sector or region. Many case studies had co-designed transition pathways while some were developed by researchers and informed by literature review and stakeholder interviews. Next, these pathways or scenarios were further developed to be able to use them within one or a subset of models to estimate the expected impact of the co-designed transition.

The interviews for this report served to explore and reflect on good practices and experiences on 1) stakeholder engagement, as well as, 2) on the use of stakeholder knowledge and insights in various simulation models. For each interview the case study leaders were asked to prepare a simple reporting template to sketch the various subsequent stakeholder engagement actions in the form of a timeline. During the interview this timeline was discussed in more detail in an open discussion format. The following questions were asked:

- How did you engage stakeholders in your research steps? What did the timeline of your stakeholder engagement look like?
- What are your experiences with stakeholders (both personal/phone interviews and workshop format)?
- What motivates stakeholders to take part in our research?

[1] At the end of TRANSrisk all case study leaders were invited by JIN through a questionnaire. Eight case study leaders responded, which was followed up by a bilateral interview. Due to time limitations, no response was received from the case studies in Chile, China, Greece, and Indonesia.

- How important was it to build trust and credibility with stakeholders?
- What kind of information are they happy/reluctant to share with researchers?
- How did you perceive and experience stakeholder feedback? How useful was the information you gained from stakeholders?
- How helpful was it for you to engage stakeholders in the early stage of research?
- What obstacles did you face during stakeholder engagement (planning, contacting, organising and executing both personal contacts and workshops)? Please also consider and explain good and bad practices – if any –in our circular loops.
- What are your recommendations for the future, what changes are required for stakeholder engagement?

During the interviews, case study leaders were also requested to reflect upon their experiences and lessons regarding the use of the various models.

The observations on the case studies are summarised in the following sections. The report is concluded with answers to three questions:

1. What are viable ways to motivate and mobilise stakeholders for partaking in an analytical process for designing low emission pathways for a sector or country?
2. What is good practice of integrating qualitative research tools in quantitative modelling processes and what are limitations to that?
3. What is the role of the researcher or research team in matching stakeholder interests with modelled outputs, in terms of data quality control and ability to understand both models and stakeholder perspectives?

2 EXPERIENCE WITH TOOL INTERACTION IN DETAILED CASE STUDIES (TASK 3.1)

2.1 Austria - Iron & steel sector

The case study in Austria aimed at both qualitatively and quantitatively (WEDGYN-CGE) exploring ways to lower greenhouse gas emissions in the country's iron and steel sector.

It contained four stages of stakeholder engagement:

1. Describing the policy context for the country's steel sector: during this stage interviews were held with selected stakeholders from the sector as well as generalists who also are familiar with overarching country-level policy issues. This resulted in a set of views on the sector's existing context, desired future with corresponding transition pathways.
2. A stakeholder workshop was then held with the same group to discuss interview outcomes and agree on a transition pathway with policy options, including potential risks and uncertainties, as well as attribution of actors to be involved in the pathway.
3. This was followed by a stakeholder – Modellers dialogue based on a first model run which quantified the impacts of the identified pathway. The dialogue was particularly held with the steel company, followed by further model runs.
4. The results were then communicated with the initial workshop participants for a compilation of risks, which were discussed in a
5. Final stakeholder workshop, which contributed to a deepening of the understanding of risks and uncertainties, a prioritisation of risks by sector experts (i.e. which risks should be addressed first), and development of approaches to mitigate these risks.

Stakeholder engagement in the case study was stimulated as the topic was timely for the steel sector and provided stakeholders with additional insights on impacts of a transition for the sector's carbon budget under the EU Emissions trading scheme (ETS) as well as sector-level impacts such as steel output, energy use, price effects and welfare gains or losses. Stakeholders were therefore generally interested in partaking in the case study and considering the outputs in their strategic decision making. These sector and macro level outputs were in line with the interests of the sector stakeholder, which also further triggered their interest in the case study.

In order to keep the workload for stakeholders limited, the case study partner did most of the stakeholder consultation through bilateral conversations with steel sector entities. For the workshops, discussions were made participative with interactive group discussions, based on papers prepared for the workshops (e.g. clustering risks and summarising their impacts). A key factor of success in this process was the intermediation by professional facilitators during the workshops.

2.2 United Kingdom – Nuclear energy

For the UK nuclear case study ("expand nuclear power by 40 GW or phase out nuclear power") the case study leaders made extensive use of their personal and academic network to make an inventory of relevant stakeholders. This was done during the initial stages of the TRANSrisk case study work (late 2015, first half of 2016) by organising a focus group within SPRU, resulting in a listing of potentially relevant stakeholders to be interviewed. This was described by partner SPRU as a 'snowball process': personal contacts of SPRU staff led to suggestions for other people to contact so that the group of potentially interested stakeholders gradually expanded. The quantitative analysis was performed with the help of the E3ME model. From then on, the following stakeholder engagement process steps took place:

1. A subset of the identified stakeholders was interviewed to obtain their knowledge and views on "What low-carbon electricity generation options are available to reduce CO_2 emissions while considering UK's economic, political, social and environmental priorities?" (October-November 2016).
2. Stakeholder consultation workshops were then held in March and July 2017 on two scenarios: A – no nuclear and B – nuclear expansion. At these workshops, model outputs were presented to stakeholders (using E3ME) on risks (impacts) of each scenario.
3. This consultation was extended with an online survey on the scenarios (July-September 2017).
4. Incorporating stakeholder views and preferences (incl. risks assessments), a model run was done with E3ME, the outcomes of which were discussed with stakeholders in a workshop in September 2017.
5. Finally, a re-run of E3ME took place with inclusion of stakeholder feedback during the workshop.

A key factor in the participatory part of the case study was the identification of the stakeholders, academics and researchers from University of Sussex. Through an informal process conducted by SPRU researchers who are specialist in nuclear sector, around 50 potential stakeholders were identified from government organisations, researchers, firms, consultants, NGOs, journalists, and other leaders of opinion in the subject. The long-term experience of SPRU academics provided an updated list of potential stakeholders.

With hindsight though, SPRU acknowledged that utilising data bases from nuclear industry and associations could have provided other potential stakeholders to be included from the very beginning. Another lesson learned was that inviting stakeholders for the initial focus group discussions from outside of the academia (i.e. SPRU sector exports) could have improved/enriched the initial discussion of the research questions to expand the views of stakeholders/academics.

Important for the success of stakeholder consultation workshops was the preparation by researchers of the material (handouts, briefs, etc.) so that stakeholders could effectively focus on scenarios and alternatives in order to scope down the case study. A limitation though was that, despite, the satisfying number of confirmations of attendance to the first consultation workshop

(about 20), the actual number of participants was lower. A lesson learned from that is that more efforts inviting/reminding stakeholders should be dedicated, e.g., by calling them individually. The response to second stakeholder workshop was high though, which is possibly due to the fact that it was a joint event with another SPRU project related to nuclear power, which attracted multiple European participants. At this workshop, the presentation of the E3ME results helped to discuss the economic assessment of risks and to set up the future variations/sensitivities to be tested.

At the workshop held to consult stakeholders on implementation pathways, it was observed that a rerun of the E3ME model for the two pathways, based on the comments from stakeholders, improved stakeholders' understanding of the possible risks of implementing the pathways. Based on that experience, SPRU staff recommends working closer to modellers to get better understanding of the strengths and limitations of the models, and to discuss further the results to improve the outputs for stakeholders.

2.3 Spain – Renewable energy sources for energy transitions

For this case study, no modelling was used. It was decided to first explore with stakeholders what research questions they had a specific interest in. As a result, the research focussed more on exploring the interests and perceptions of stakeholders regarding certain policies, climate change and renewable energy in a more qualitative manner. It was initially considered to deploy the GCAM model (by partner BC3) within this case study, but that was found to have too marginal additional value for the stakeholder groups given the specific research questions. If (integrated assessment) modelling would have been applied it would have been considered more relevant for national level policy makers, rather than for decision making for individual stakeholders ("macro-economic modelling serves policy makers").

Regarding the stakeholder engagement an initial stakeholder scoping was carried out (mainly desk research based); after that, the case study leader together with her colleagues assessed internally with which relevant stakeholders and stakeholder groups they already had established connections in previous projects. With the help of these 'personal' connections a series of interviews was set-up with relevant stakeholders. Those stakeholder interviews were also used to get access to the broader stakeholder networks (snowballing).

A total of 16 stakeholder interviews were held which helped to identify any knowledge gaps, as well as the design of a survey. The survey design was tested / validated internally with colleagues to check its content, phrasing and length. The intention was to have a controlled (online) survey (through SurveyMonkey). A controlled survey was deemed appropriate in order to avoid any bias stemming from the survey being circulated within a specific stakeholder community. In order to increase response levels, the survey was sent out in three rounds, which resulted in a total of 300+ respondents. With hindsight the survey could have been improved somewhat in the area of

profiling and characterising individual respondents, as it was not always easy to categorise or assign a specific role/function to stakeholder groups.

For dissemination purposes, both academic and non-academic channels were used. As a final event it was decided to liaise with the 'club of energy', which is an existing network of relevant stakeholder groups that would be receptive for the research results. Linking with this network organisation helped to increase the visibility (and impact?) of the TRANSrisk research being that has been conducted. A more non-academic audience was also addressed via a (TedX-like) public speech platform (link). During that setting the poll-everywhere tool was used to better engage with the audience. The case study leaders considered that it would have been beneficial to have hosted at least one more workshop earlier on during the research process.

2.4 Sweden – decarbonising road freight transport

This case study started with a series of in-depth interviews with key experts in the field (April-June 2017). This helped to better formulate the research questions and explore the dynamic context of the possible transition pathways in decarbonising Swedish road freight. These interviews helped to develop the transition pathway narratives in more qualitative terms. In order to be able to perform modelling, the narratives or scenarios needed to be developed in more quantitative terms (e.g. costs, implementation trajectories, possible level of market penetration, etc.). This included acquisition of better cost data and technology information, for which a survey was developed and sent out to stakeholders (July 2017). Through that better techno-economic data (e.g. costs) for the different decarbonisation options was extracted. However, it turned out that stakeholders were hesitant to provide specific cost estimates or parameter values, not so much because of possible commercial sensitivity, but because of high uncertainty ranges of such estimates (i.e. afraid to provide the 'wrong' numbers).

The advanced versions of the transition pathway narratives were presented and discussed during the first workshop (October 2017), where the narratives and input data were validated and adjusted when deemed appropriate. The workshop also provided initial ideas and input for the modelling with the self-developed excel-based bottom-up energy and cost model (PRIMES baseline data was also used). An effort was made to also perform model runs with the E3ME model, but that did not sufficiently materialise and mature to a level where a robust model run could be performed. Also, it was found that this macro-level econometric model could not provide outputs that sector stakeholders were mostly interested in.

Despite the fact that a substantial data set had been compiled by the case study leader (SEI), the reformatting or manipulation of that data to perform a robust model run with E3ME was not successful for the Swedish case study. It was found that the level of detail and, thus, the disaggregation required to perform the simulations could not be achieved with E3ME. This suggests that some additional data 'conversion' or 'in-between' step is needed to be able to use input from stakeholders and the narratives for macro-economic modelling. However, an EU-level model run

for decarbonisation of road freight at the EU level – developed with insights from the Swedish case study - was successfully performed with E3ME.

Based on the Swedish case study experience, it was concluded that when models are used in relation to stakeholders there is a need to be able to perform several iterations in a relative short time span, as it was found that stakeholder perceptions and views can change quite rapidly, within a matter of weeks and months. To capture this dynamic in modelling, the modellers and non-modellers have to cooperate closely in order to be able to run several iterations of the model.

2.5 Poland – coal and renewable energy sources

The Polish case study was based on a set of around 15 interviews with stakeholders from the energy sector, the government and environmental NGOs to discuss potential pathways to replace coal-based technologies with renewable energy options. Based on the answers, the Polish partner, IBS, formulated research questions which were used for a run of the MEMO model for Poland. Core elements of the run were impacts of such a low-energy transition pathway on energy security of supply, employment in the energy sector and wage changes.

As MEMO has a detailed coverage of the Polish economy, detailed results could be presented to stakeholders on pathway impacts. This was done at a workshop in October 2017. An important objective of the presentations of the model results by IBS was to 'correct perceptions', such as, for example, that phasing out of coal will lead to lower wages, whereas model outcomes show that wages will continue to increase, albeit at a lower rate. This stakeholder consultation workshop was very well attended (around 40 participants in Warszawa).

At the same time, the Polish case study did not show a regular iteration between stakeholders and modellers. Initial stakeholder consultation was done to consider stakeholder preferences in the model runs and model outcomes were presented to stakeholders as sector and macro-level implications of the pathways.

3 EXPERIENCE WITH TOOL INTERACTION IN LIMITED CASE STUDIES (TASK 3.2)

These case studies were considered 'limited' in the project as no iterations were foreseen between stakeholders and models. The two case studies discussed below built further on existing work or work started in another project so that either a model run was added to an already undertaken stakeholder consultation (the Netherlands case study), or a stakeholder survey was added to an existing quantitative analysis.

3.1 The Netherlands – the impact of low-emission transitions in the livestock sector

The limited case study in the Netherlands had a specific emphasis on understanding risks and impacts of two different low-emission transition pathways for the livestock sector. The co-design process of these two pathways built further upon the previous research project BIOTEAM (2013-2016, Intelligent Energy Europe),[2] which enabled the case study leader to more effectively engage with relevant stakeholders in the field, both specialists and policy makers. On top of that, because of continued informal contacts with several stakeholders in the field the case study leader was invited to a policy dialogue hosted by the Ministry of Economic Affairs and the Ministry of Environment. As a result, the selection and design of the two transition pathway technology options and the potential risks and opportunities related to these could be assessed rather efficiently. Also, the ongoing presence within such relevant stakeholder networks also contributed to a further expansion of the stakeholder base.

In addition to the stakeholder engagement activities at the national level, an online, international stakeholder consultation was held on weighing social, economic and environmental co-benefits and trade-offs of the pathways considered. This was done through a survey (with survey monkey software) which had 65 respondents.

The E3ME macro-econometric model and the TM5-FASST air pollution-human health impact model were used to quantify some of the identified risks/opportunities of the co-designed pathways. Collecting and structuring the required data input for the E3ME modelling, as well as designing the implementation trajectories for both pathways was time consuming and required several updates and iterations. It was found that an intensive and ongoing dialogue (with some trial and error) between the modelling team and the case study lead was needed to get a mutual understanding of what was needed.

Based on his detailed understanding of the specific market system within the livestock sector in the Netherlands and the increased familiarity with the E3ME model structure and interlinkages, the case study leader observed that several relevant market dynamic aspects were 'missed' or

[2] https://jin.ngo/images/jin/publications/BIOTEAM_Magazine_final_project_report.pdf

'overlooked' by the model. This was mainly due to the model design structure which aggregates or clusters multiple economic activities. It was noted that other models - that can operate at lower levels of aggregation (e.g. at the sub-sector level) - were needed to quantify such specific market dynamics. While the modelling results with E3ME for both pathways were found to be robust, for key economywide indicators, e.g. GDP and aggregate employment, the overall deviation from the baseline was minimal (ranging from about +0.6% to -0.6% for GDP, and +0.2% and -0.2% for aggregate employment). Although sector specific indicators were considerably more pronounced, the relatively small economic impact could fuel the belief or perception with non-experts or laymen that the overall impact of the transition pathway is just minimal, and might not be worth the effort. While it is known that misperceptions and misinterpretations of such modelling outputs can occur, it is found to be imperative that with the 'hard' quantitative results also a proper explanation or context should be provided.

The TM5-FASST modelling required much less data as input (e.g. both the current NH_3 emissions from livestock and the anticipated change in NH_3 emissions resulting from the low emission transition pathways) and the modelling scenarios were more straightforward to develop. However, that process benefitted greatly from the learning experience with preparing the scenarios for E3ME modelling.

3.2 Switzerland – Risks associated with implementing a national energy strategy

The main question that the Swiss case study considered was whether a higher share of renewables-based energy consumption in the country should be based on increased imports (e.g. wind farms in the North Sea or Solar power in Northern Africa) or on increased renewable energy production domestically.

The case study benefitted from co-funding from and ongoing work under the Swiss NFP70 programme 'Energy Turnaround'. However, during the initial stages of the TRANSrisk case study work in Switzerland the stakeholder engagement actions were challenging due to a lack of an extensive (personal) network in the relevant stakeholder communities (the case study leader was non-Swiss national). Based on this experience, for future projects that involve stakeholder engagement it is considered good practice to ensure sufficient ex-ante buy-in relevant stakeholder networks.

The case study started with modelling (right after TRANSrisk started in fall 2015) which continued until end of 2016. Simultaneously, Swiss PV projects were studied and project stakeholders interviewed (20-40 interviews), which fed into the research questions for the modelling. A survey was used to test what had been learned from the modelling and the Swiss PV projects. The survey was shaped as a choice experiment, basically to confirm or reject hypothesis formulated by the researchers and test scenarios envisioned. The response rate for the survey was satisfactorily,

which is considered to be partly due to the use of a professional on-line survey company. Respondents also commented that they liked the survey.

The case study results were presented to stakeholders at a workshop in September 2017. This workshop was intended to disseminate case study findings, collect feedback from stakeholders on the findings, and provide an opportunity for networking. Before the workshop, a dry-run exercise was performed to fine-tune the contents and the agenda. During the workshop, particularly the participatory role-play exercise (where individual stakeholders were assigned a different role in the electricity sector relative to their normal role/position) turned out to be insightful for participants. For that, four popular perspectives on low-emission pathways were provided and participants had to refine the Swiss energy strategy from one of those perspectives (including perspectives that they would normally not choose).

Given that the case study leader had a background in economic modelling, he was already able at an early stage to select the model (Calliope) that he deemed most suitable for addressing most of the anticipated research questions. It could answer a very specific case study question: can we supply electricity 24/7 with specific mixes of sources? However, Calliope is not an integrated assessment model (IAM), but a dedicated energy systems model that also allows for electricity sector specific model simulations. The case study leader considered the potential use of IAM models for such case studies as valuable and relevant for (national level) policy makers (e.g. Ministry of Energy), but not for decision making by specific stakeholders in the electricity system who typically face different optimization problems. An issue that needed to be addressed during the case study was that Calliope, while it improved throughout the work, had several error messages which slowed down progress and which required frequent assistance. An important success factor in the modelling was the availability of the renewables.ninja database, which was made by the same people who performed the model runs.

Due to the trans- and interdisciplinary research activities needed to perform the TRANSrisk research, the case study leader called upon the expertise of several colleagues who would have more knowledge/experience with e.g. choice experiments, modelling.

4 EXPERIENCE WITH TOOL INTERACTION IN NON-EU CASE STUDIES

4.1 Canada – Oil sand fields

The case study focussed on a lower carbon transition of the Alberta Oil Sands by identifying three possible pathways:

1. Capping the emissions from the production facility, by capping or taxing emissions.
2. Setting minimum areas of land to be protected from oil sand production.
3. A mixture of these pathways.

Impact of the pathways were quantified with help of two models (GCAM and E3ME) with stakeholder inputs collected as follows:

1. Interviews were held with 15 'generalists' which are stakeholders who were selected for their knowledge of the overarching energy system in the region and supported the formulation of pathways and research questions to explore these with stakeholders and model runs (June-September 2017).
2. With that input a first model run was done with GCAM (run by partners BC3) (January-February 2018).
3. The results were discussed with stakeholders, and with their inputs the initial pathways refined (March 2018).
4. In order to consult a wider group of stakeholders beyond the workshop participants, an online survey was conducted (with support from partner ETH, April 2018)).
5. Based on the refined partners, following runs were conducted with both GCAM (BC3) and E3ME (by partner Cambridge Econometrics) in order to: compile risks of pathways and refine pathways (May-September 2018).
6. These final results were discussed at a final stakeholder workshop in December 2018.

An important observation from this case study was that it was very difficult to engage stakeholders from indigenous communities in Alberta in the analytical process. For the case study, their contribution was important as the impacts of oil sand field are directly by them and pathways are thus very relevant for them. Nevertheless, it took a lot of time to motivate participation by indigenous community representatives in the analytical process of the case study.

4.2 Kenya – abatement in the charcoal sector

Stakeholder engagement actions in the Kenyan Charcoal case study built further upon existing connections of the principal researcher with relevant stakeholder groups. The case study leader has worked on charcoal sector regulations in Kenya in 2009, which made it easier to approach and

liaise with relevant stakeholders. The Kenyan charcoal case study from the beginning was framed within the context of Nationally Determined Contributions (NDCs). The Kenya NDC identifies Charcoal and Geothermal as sectors with the highest abatement potential. This framing also helped to attract sufficient attention from stakeholders and create relevance to the work.

The kick-off workshop was organised in June 2016 with 15 stakeholders and was organized jointly with ECN in Nairobi. Later within the same month, a national workshop was co-organised with UNDP which helped to generate additional visibility and importance to the research project (about 50 participants). The kick-off workshop helped to fine-tune and co-design the research questions and to bring focus within the research actions. Together with stakeholder's specific case study regions were selected with different drivers for the production of charcoal. Stakeholders considered that these regions were most relevant (i.e. sufficiently representative). By bringing in such focus in the early stages also helped to use the existing research resources in a targeted manner. This for example helped the collection of primary data/information.

For this case study both TIAM-ECN and Agent Based Modelling (ABM) were used. The case study leader does not have a background with using these models and was supported by project partners with modelling experience.

In relation to engaging and interacting with stakeholders the ABM modelling was found most useful as it could provide more meaningful feedback to the decision-making processes of key stakeholders in the charcoal sector even at a subnational level. The TIAM-ECN modelling was considered more relevant to consider the implications of the charcoal pathways from a broader perspective, and were considered relevant for a more limited audience (i.e. national level policy makers). However, for other stakeholder categories the TIAM-ECN modelling results were found less actionable / relevant when it comes to decision making at the level of individual stakeholders.

The case study leader indicated that – given the fact that she did not have extensive modelling experience – would have like to receive more upfront training and guidance on how to use /work with these models. Using modelling jargon / terminology was intentionally not used when liaising with stakeholders; also for stakeholder engagement purposes it was found not always meaningful to fully introduce and discuss the models, and the way in which they work ("On the ground you don't talk about ABM and models, your aim is to collect specific data/information"). The case study leader is the intermediary (or firewall) between the stakeholder and the model(s). Only when really needed stakeholders are informed about the models. For the purpose of the SH engagement, a video – explaining the use and basic function of ABM - was developed and used. Also during some interviews, modelling experts provided online presentations to explain the model and its use to the interviewees (when needed).

One challenge for hosting workshops in Kenya is that stakeholder travel needs to be facilitated with some reimbursement funding. Moreover, there are also many workshops happening in Nairobi, so one has to be very strategic and focused with yet another meeting.

One of the main observations is that a research process that relies heavily on stakeholder inputs and engagement needs to be adaptive and flexible both in terms of focus and timing. In order to

ensure that the research actions and outputs are sufficiently relevant to the stakeholders and policy makers, early involvement of and co-design the research questions/focus with stakeholders is advised. As next step – based on the research questions – the modellers indicate what they can and cannot model. After that an agreement needs to be made regarding what type of data is needed and in which specific format it has to be provided. Regarding the data collection for modelling and the processing of that data several iterations were needed before 'the right' format was found.

After that a dry run of the (ABM) model was performed and results discussed internally. The results of the second model run were shared with selected stakeholders, who were also informed about the model features via the video. These interview discussions led to additional model runs and some improvements of the ABM model.

During the final event (October 2018), again co-organised with other projects and institutes, the final results of the ABM modelling were presented. During this event stakeholders showed an increasing interest into the ABM modelling, and essentially expressed interest in mode / additional model simulations. The case study leader indicated that she would have liked to host the final event earlier to be better able to incorporate feedback received during that event.

5 CONCLUSIONS

Based on conversations with case study leaders in TRANSrisk, we have evaluated in this report how the interaction between quantitative modelling and stakeholder consultation has taken place in the case study practice, how and why it has been successful and what have been obstacles to successful integration of qualitative and quantitative methods.

Essentially, an important goal of TRANSrisk was to make results based on modelling more robust for case-specific decision-making, by incorporating data, preferences or other type of information obtained from stakeholders in model runs or evaluations of modelled scenarios. Most case studies therefore chose iterative processes where stakeholder consultations (workshops, interviews, surveys) preceded model runs, followed by other rounds of consultations with stakeholders to discuss results, disseminate these to decision makers, or collect views to be incorporated in another model run.

From the practice with TRANSrisk case studies it can be concluded that the success of interaction largely depends on the following factors:

4. Motivation of stakeholders to engage in a research project and partake in iterations with researchers and modellers.
5. Related to that, the extent to which models produce results that are relevant for stakeholders' decision contexts.
6. The facilitation of the process by a case study leader who is both familiar with quantitative and qualitative tools.

5.1 Ad 1. Stakeholder motivation

Case study leaders emphasised that stakeholders, especially the ones that are deemed of key importance for the case study context, are usually very busy and have thus limited time to support a research project. Good practice examples from case studies that managed to attract stakeholders are:

- Begin with an assessment with 'generalists', who are eventually not the target stakeholders for the case study, but who can help the researcher precisely phrase research questions so that they appeal to stakeholders' interests.
- Be flexible in terms of how to engage stakeholders, as in some stages a targeted, on-line survey can reach a larger group of people than a workshop. Also, interviews over the phone, while more resource intensive for the researcher, are an attractive, low-burden way for stakeholders to share their thoughts and information. Moreover, co-organising consultation with existing meetings proved helpful in some cases.
- Shape the case study to the interest of the stakeholders. The example of the Austrian case study clearly demonstrated how stakeholders in the iron & steel sector benefitted from the model runs and opportunities to discuss outcomes with the researchers.

- Tap into existing relevant networks and regular stakeholder meetings, or build further upon previous research or a project done within in a country, such as an ongoing research project in Switzerland or follow-up research in the Netherlands. At the same time, the existence of a network of indigenous people in Canada was not a sufficient condition for a smooth stakeholder consultation. As this community is generally vulnerable and already frequently consulted by many policy, media, research and NGO-driven initiatives, it took a long while, at least a year, to build trust and confidence within the community before TRANSrisk researchers could advance towards detailed stakeholder consultation on the oil-sand case study.
- Ensure professional organisation of stakeholder engagement. While researchers are knowledgeable of the case study content, several stakeholder consultation steps require professional approaches. The Swiss example showed how a professionally designed survey resulted in satisfactory response rates. The Austrian case study had a professionally organised and moderated stakeholder workshop.

5.2 Ad 2. Matching between level of stakeholder interests and level of modelling analysis

From the case studies analysed several examples can be taken of how researchers have struggled with making model outcomes interesting or useful for stakeholders. The Dutch livestock case study demonstrated how a stakeholder consultation revealed views on a range of market dynamics which could lead to impacts that would be positive for some stakeholders, but negative for others. Both groups of stakeholders would therefore be interested in what these positive and negative impacts could amount to, but as the model could only produce a net impact figure, this was less insightful for specific stakeholder groups. Ideally, the qualitative assessment work with stakeholders would have resulted in a discussion of which model(s) are most suitable for answering the research questions formulated (i.e. 'the stakeholders choose the model'). However, the TRANSrisk project was developed as a typical H2020 project where the suite of simulation models to be used within the project was *a priori* fixed, even though the specific co-designed research questions and expectations of the relevant stakeholder were not yet defined (i.e. 'the model chooses the stakeholders').

In the Swiss case study, it was, decided not to use an integrated assessment model as this would mainly produce results at the macro-level of the country, but not at the decision-making level of stakeholders engaged in the solar PV projects studied for the case study. Instead, an energy decision model (Calliope) was used, despite its initial faults and operational difficulties. For the same reason, Spain even refrained from using a model in the case study as the IAM that was available (GCAM) would produce results at too high a level of aggregation. In Sweden, the model was useful to produce results on low-emission options for road freight for the EU policy context, but not for the country itself.

These observations demonstrate that for successful stakeholder engagement in quantified research, the model outcomes must be relevant for stakeholders, as otherwise model run results are not useful to support stakeholders' decision making and it is very likely that the information that stakeholders can provide to modellers are too detailed and disaggregated to be included in the model runs.

A good practice example of how a model was considered interesting by stakeholders and how iterations with stakeholders improved the model, was the charcoal case study in Kenya with the application of the Agent-based model (ABM). As this model takes a decision-making context that is focused on behaviour of agents (stakeholders), its results were directly relevant for sector stakeholders in Kenya, who clearly recognised the problem description by the model (reference case) and modelled impacts of potential low-emission pathways for the sector.

Another observation is that a broad range of integrated impact assessment models can require some considerable processing time before the results can be extracted. This lead time, which can add up to days, weeks or even longer, do not align well with the need from stakeholders to obtain direct feedback. Especially within a workshop or participatory setting it is considered of great added value that the quantified impacts of scenario changes or changes in key assumptions are shown. This enables a constructive dialogue and can enrich and deepen decision making process. While it will be rather difficult to run data and computationally 'heavy' models in (near) real time, it is recommended that modelling teams also think on the development, experimentation and usage of highly simplified versions of their models (such as emulators) that can be used within participatory sessions.

5.3 Ad 3. Familiarity of researchers with both models and stakeholder engagement

Most case studies in TRANSrisk were managed by qualitative researchers with knowledge of viable ways to engage with stakeholders, and with, often, a basic understanding of modelling. In Switzerland, the case study was led by a modelling expert and, for example, in Poland, the case study was managed by a duo from the same research institute consisting of a qualitative researcher and a modeller.

Therefore, in several case studies, research leaders needed training on the models to be applied. It was considered important to work closer to modellers to get a better understanding of the strengths and limitations of the models. This also supports the interpretation of stakeholder inputs by modellers and of model outputs by stakeholders. For instance, consultations with stakeholders can result in questions or preferences that a model cannot directly handle. In these cases, there needs to be a ´dialogue´ with the modeller on how to rephrase the questions or preferences into research questions to be answered by the model. In most case study examples, this dialogue took place between the case study leader and the modeller, but this requires that the first is

sufficiently familiar with the model structure (and that the modeller is sufficiently familiarised with the dynamics of the relevant case study market system). In general, the observation is that stakeholders are not interested in a model, but only in the outputs. It is then the responsibility of the researcher to ensure that what goes into the model is in line with stakeholders´ inputs, as otherwise model outcomes will not be useful for stakeholder decision making.

5.4 Final remarks

Overall, while there are several ways to improve stakeholder engagement in analytical processes, it can be concluded that generally TRANSrisk case studies successfully mobilised stakeholders for participation in the analysis and gather their interest in the topic, even though the management of this was often time and resource intensive. Regarding the interaction of stakeholder consultation and use of models, the case studies suggest that stakeholders tend to better understand and respond to bottom-up models that zoom in at more disaggregated levels. Direct (or quick) feedback simulation models have a key advantage relative to the larger and heavier integrated assessment model, for which a single model run typically is more time consuming. On the other hand, IAMs are considered to have a great use as an instrument to explore long-term consequential impacts of a certain transition path for the wider economy in terms/units (e.g. GDP, employment, investments) that have a high relevance for national level policy makers.

ANNEX 1: MODELS USED IN TRANSRISK

Model name	Short description
E3ME	E3ME assesses the interactions between the economy and the environment. As a global model, based on the full structure of the economic national accounts, E3ME is capable of producing a broad range of economic indicators. In addition, there is range of energy and environment indicators.
TIAM	TIAM has a global scope with a world energy system disaggregated in 36 distinct regions. TIAM-ECN is a linear optimisation model, based on energy system cost minimisation with perfect foresight until 2100. It simulates the development of the global energy economy over time from resource extraction to final energy use.
WEGC-CGE	The WEGC-computable general equilibrium (WEGC-CGE) model is a global, multi-regional macroeconomic model that depicts the economy as a closed system of monetary flows across production sectors and demand agents on a yearly basis. It captures the interlinkages within the economy using national input-output tables as one core data base
GCAM	The Global Change Assessment Model (GCAM) is a global integrated assessment model with particular emphasis on the representation of human earth systems including interactions between the global economic, energy, agricultural, land use and technology systems.
MEMO	MEMO is a macroeconomic, dynamic stochastic general equilibrium model (DSGE). The model is calibrated to a single economic region, with external trade governed by an open-economy module and the multi-sector production structure set to replicate data from an input output matrix. The model can be used to examine the effect of policies on a variety of economic indicators such as unemployment, wages at sector level, GDP, sector composition, demand for energy etc.
BSAM	The BSAM model is a power sector model, focusing on the expected behaviour of power generators. It can model case study variations of the energy and climate framework on a national level and, in particular, the financial and operational behaviour of privately-owned power generation units in a deregulated electricity market.
Calliope	Calliope is a multi-scale energy systems (MUSES) modelling framework. Calliope is a framework to develop energy system models, with a focus on flexibility, high spatial and temporal resolution, the ability to execute many runs based on the same base model, and a clear separation of framework (code) and model (data).
TM5-FASST	TM5-FASST is a global source-receptor reduced model developed by the European Commission's Joint Research Centre that evaluates how air pollutants affect human health and agriculture systems. Using

	assumptions from meteorology and atmospheric chemistry, the model links emissions of pollutants in a given source region with downwind impacts.

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