ADVANCE

Advanced Model Development and Validation for the Improved Analysis of Costs and Impacts of Mitigation Policies

newsletter

February – 2016

ADVANCE: highlights from project work

The ADVANCE project aims to improve energy economy and integrated assessment modelling tools (IAMs) to better inform policy makers on different climate mitigation options and their impacts. With this ADVANCE Newsletter we are pleased to present selected project highlights.

The potential of wind and solar for power sector decarbonisation

The variable renewable energy sources (VRE) wind and solar photovoltaics are likely to account for a significant share of future power systems. This is indicated by high annual growth rates: in the period from 2009 to 2014 wind capacity had an annual growth rate of 19% and solar PV capacity had an annual growth rate of 50%. Also, 164 countries defined ambitious renewable targets by early 2015 and many of them have adopted renewable support schemes. Integrated energy-economy-climate models now provide the scientific underpinning of these developments.

ADVANCE modelling teams have developed and evaluated new modelling approaches for power sector modelling. These approaches substantially improved the knowledge about the potential of VRE for power sector decarbonisation and the 2°C-consistent climate stabilization.

In the past, integration of large shares of VRE in the power system was accompanied by great uncertainties related to the variable nature of wind and solar. This was reflected by the representation of VRE integration challenges in IAMs: a few models assumed no integration challenge at all, while other models assumed strict upper limits of VRE integration at a specified share in total power generation.

ADVANCE developed an evaluation framework for the power sector, which allows assessing the ability of different modelling approaches to represent crucial power sector dynamics, and thus identifying strengths and limitations as well as areas for model improvement. The framework was applied to six participating IAMs, leading to a new level of model understanding and transparency. **Scenarios produced with the new model versions lead to a more robust view on VRE deployment in climate policy scenarios, and project a much higher contribution from wind and solar (Figure 1). Prior to the ADVANCE analysis, global net VRE shares averaged over the second half of the century in a 2°C climate policy scenario ranged from 18-64%, after ADVANCE model improvements were introduced they increased to 46-75%: an increase of the model-average by 20 percentage points.**

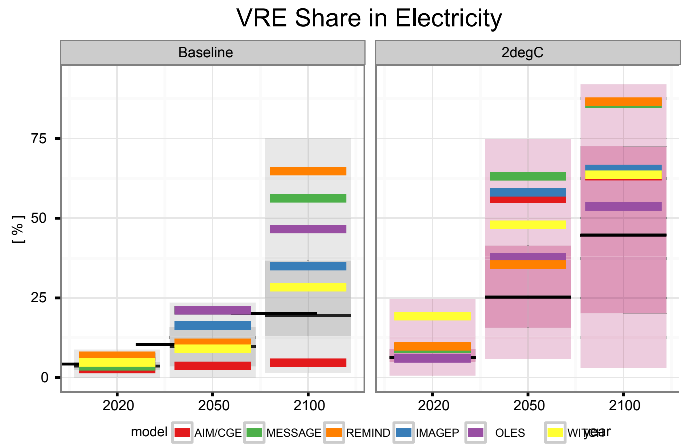

Figure 1. Share of VRE in electricity supply for Baseline and 2°C climate policy scenarios. The shaded areas indicate 25th-75th-percentile ranges (dark shading) or full ranges (light shading) of scenarios from the AR5 database without climate policy (grey), or 2°C-consistent[1] (purple). The black line indicates the median of the full range of scenarios from the AR5 database for the respective scenarios.

[1] "2°C consistent" refers to the IPCC scenario categories I and II, which result in a stabilization of GHG concentrations at 430-530 ppm CO2e by 2100.

The findings of this analysis will be published in a Special Issue in the journal Energy Economics in mid-2016. New data sets and new modelling approaches will be shared with the entire modelling community to advance VRE modelling and allow for a more accurate power sector representation.

The role of the transport sector in climate change mitigation

Integrated Assessment Models tend to have a relatively stylized representation of energy demand sectors and a significantly more detailed representation of energy supply modules. However, estimates with technology-detailed sectoral models suggest that energy demand can contribute considerably to emission reductions. This is why ADVANCE put great effort into improving representation of demand sectors, and especially the transport sector.

ADVANCE model improvements resulted in a better representation of technology development, model choice and shift, infrastructure capacity and costs as well as consumer heterogeneity and behaviour. The improved models participated in two comparison exercises that delivered insights on future trends in the absence of climate policy interventions, as well as on the transport sector transformations required for climate change mitigation.

Future projected pathways of transport related CO2 emissions can be decomposed in terms of the changes in crucial drivers, such as the growth in transport demand per capita (measured as kilometres travelled per capita), changes in the modal structure of transport (e.g., private vs. public transport), vehicle fuel efficiency, or the emissions intensity of the fuel used (measured in grams CO2 per kilometre travelled). **One of the main results of this exercise is that transport emission reductions in climate change mitigation scenarios are highly dependent on efficiency potentials and the switch to alternative fuels, while structural change in the use of modes only plays a minor role (see Figure 2).**
However, varying projections of technology development of alternative drive train vehicles in terms of cost and efficiency can lead to different fuel mix and efficiency potentials. Moreover, activity growth and projections of future transport demand span a wide range and are a key uncertainty in projections.

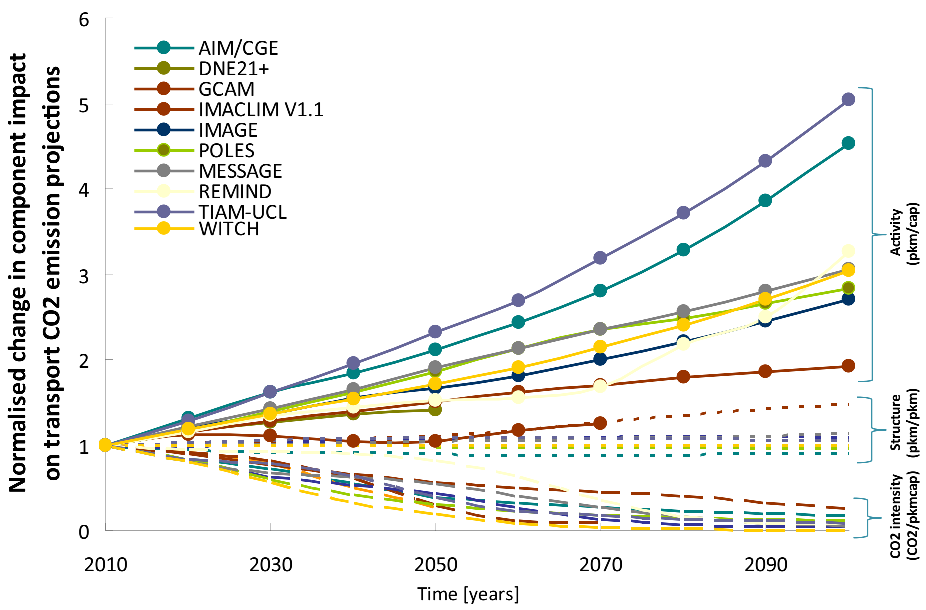

Figure 2. Transport CO2 emissions to reach the climate mitigation target of 450 ppm are decomposed based on their drivers: emission intensity of fuel used (Intensity), modal structure shift (Structure) and transport demand (Activity). The figure depicts the change in total emissions as a result of the change in these drivers. While emissions from CO2 intensity decline over time to reach the mitigation target, emissions from activity and structure can either remain constant or even increase.

The second comparison explored the modelled elasticities of transport energy demand to changes in fuel prices. These elasticities are an important indicator of the responsiveness of the transport sector to market-based policy instruments (such as CO2 pricing or increased fuel taxes), or changes in energy prices (e.g., increases or decreases in oil prices). To this end, multiple fuel price shock scenarios were run by the models to test the transport oil demand responsiveness. Ten years after the price shock the inherent oil demand elasticities of the models are in the same order of magnitude as empirically found historical gasoline elasticities. In the second half of the century, the demand response varies widely across models, with some models showing little response due to feedback effects, while other models show sustained energy demand responses.

The two comparison studies have improved our understanding of transport model dynamics, transport mitigation strategies and key uncertainties and helped to identify the main areas for further model improvements.

The model development and model behaviour comparison results will be published in a Special Issue in the journal Transportation Research Part D: Transport and Environment in 2016.

Consumer vehicle choices and their effects on mitigation costs

In the past, IAMs have typically relied on average "per-capita characteristics" of consumers and have, therefore, fallen short in representing behavioural factors in a detailed way. However, the latter often constitute important barriers to the adoption of new technologies, and these barriers can have major effects on the required energy transformation to achieve stringent climate targets.

This is why the ADVANCE team aimed to better capture heterogeneity and consumer behaviour on the demand-side of the energy system. As part of this work, it looked at the transport sector and especially at the behavioural aspects in modelling purchase decisions of light-duty vehicles (passenger cars and trucks). The ultimate goal is to better understand which incentives might help to nudge consumer behaviour towards a low-carbon transformation of the global light-duty vehicle market.

Besides the direct costs of vehicle technologies such as vehicle investment, operation and maintenance, and fuel, the team represented non-monetary vehicle purchase considerations as additional 'disutility costs'. Such additional costs account, for instance, for range anxiety, risk aversion, lack of refuelling or recharging infrastructure, as well as low model availability in the early days of the alternative fuel vehicle market. These features vary in a heterogeneous way for different types of consumers, as well as across countries.

The improved representation of vehicle purchase decisions via inclusion of non-cost barriers to technology adoption has thus far led to a number of valuable insights: **Alternative fuel vehicles show a lower and slower uptake over the coming decades at least until technologies and their requisite refuelling or recharging infrastructure have increased market penetration. Such delay has a relevant effect on cumulative greenhouse gas emissions coming from the transport sector. If non-cost barriers continue to persist over the long term, stronger price-based policy incentives may be required to incentivize mitigation of light duty vehicle emissions (Figure 3).** In addition, non-price-based measures could be needed in the early-market phase to transform the light duty vehicle sector. For example, policies supporting early-stage recharging or refuelling infrastructure could bring down these barriers, while vehicle purchase subsidies could help compensate for them in the early-market phase.

Seven IAMs are currently involved in this analysis, with IIASA managing the process. Teams are working toward the completion of a joint multi-model paper, to be published in mid-2016.

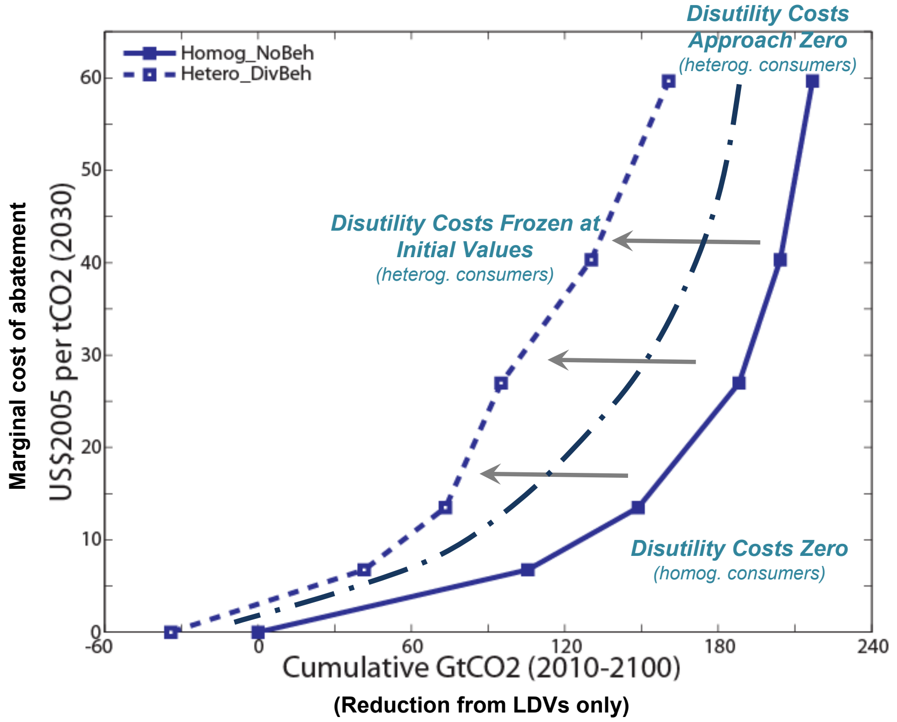

Figure 3. Marginal CO2 abatement is represented as a function of the carbon price: when incorporating heterogeneity and behaviour into the model (a leftward shift of the MAC curve), a given carbon price has a lower impact on spurring light duty vehicle-related emissions reductions.

Climate Policy amidst Uncertainty, Risks and Expectations

Progress towards mitigating climate change has been hampered by the large uncertainties surrounding its impacts and solutions, and the different approaches to valuing the associated risks. ADVANCE shows how this needs not to be the case. The polarization in the public and political debate over climate change has been exacerbated by the uncertainties which characterize it. On the one hand, it has been interpreted as a reason for postponing emission reductions, while on the other hand, it has been used as a precautionary argument in favour of stringent mitigation.

In principle, climate policies should consider the uncertainty characterizing the future impacts of climate change and the cost of mitigating it. However, quantifying such uncertainties is a complex and difficult task, involving the collection and analysis of future multiple scenarios based on scientific data, model runs, and experts judgments.

How should this vast body of information be synthetized and aggregated in a set of policy recommendations in the face of these uncertainties and different views of coping with them? This is the question that underpins the article “Selection of Climate Policies under the Uncertainties in the Fifth Assessment Report of the IPCC” (L. Drouet, V.Bosetti and M.Tavoni, FEEM, DOI: 10.1038/nclimate2721), published online by the journal Nature Climate Change.

The researchers have drawn on the vast amount of data and information collected in the three volumes of the Fifth Assessment Report on Climate Change of the IPCC. The information considered relates to climate scenarios, future temperature projections, climate change impacts and mitigation costs. They transformed this wealth of data into climate policies using different criteria from decision sciences. **The analysis of these variables, the related uncertainties and risk assessment has produced a study that, rather than defining a single optimal climate policy, allows decision-makers and the public to translate their preferences with respect to deep uncertainty, risk, and time into climate policy recommendations (Figure 4).** Uncertainty is indeed a crucial factor in determining climate policies; the traditional methods to treat uncertainty are unsatisfactory, and reframing the climate change debate in terms of analytic risk management creates a bridge between the more precautious scientific approach and the efficiency-based policy perspective.

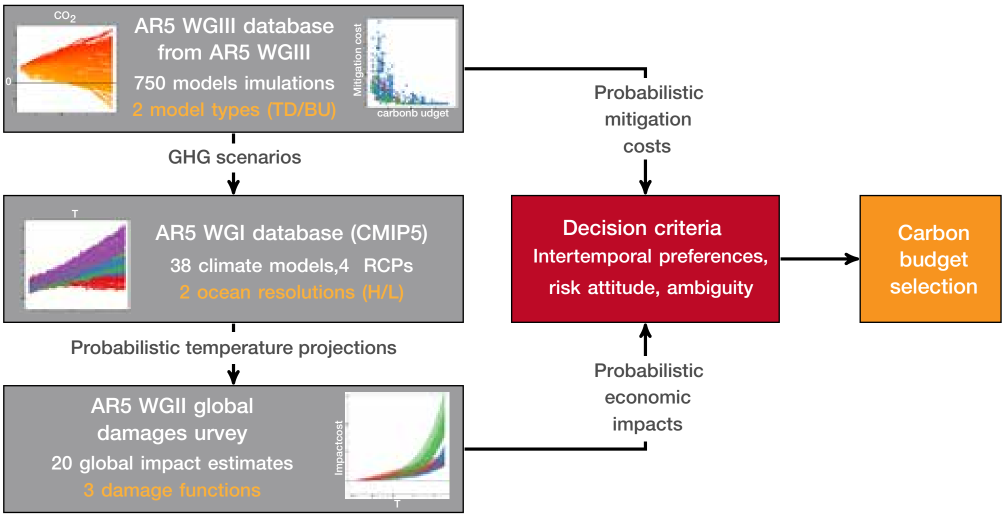

Figure 4. Diagram illustrating the methodology to select carbon budgets under uncertainty. The AR5 provides all information needed to generate greenhouse gas emission scenarios and mitigation costs (AR5 WG III), temperature projections (AR5 WGI) as well as global economic impacts (AR5 WGII). Based on this information, a set of decision rules and preferences lead to the selection of specific carbon budgets.

ADVANCE discussions with experts, policy and business

ADVANCE engages in a continuous, open dialogue with experts and stakeholders to validate the chosen approaches and share project achievements. Experts, policy and business representatives gave their say on the role and use of models on a number of occasions.

In early 2015 ADVANCE organized an **expert workshop on technological and behavioural options to increase energy efficiency in buildings**. Experts agreed on the high potential for energy savings in the sector and on the need to better represent such potential in global long-term models. This however is a big challenge as models do not have the necessary level of detail yet.

Stakeholder and expert workshop on energy efficiency in buildings on 20-21 January 2015 in Utrecht (NL).

In September 2015 the ADVANCE and wholeSEM projects organized a **public panel discussion on the role of IAMs in long-term public and private decision making**. The panel was composed of modellers and representative from Shell and the UK government. While both policy and business representatives acknowledged the support provided by the models to decision making processes in their organizations, they also expressed concerns about increasing model complexity and related difficulties in understanding and interpreting model results. They would welcome easier-to-use tools as well as greater transparency.

Joint wholeSEM-ADVANCE panel discussion on 15 September 2015 in London (UK).

ADVANCE gave a major contribution to the **8th Annual Meeting of the Integrated Assessment Modelling Consortium** held in November 2015 in Potsdam. The meeting gathered 140 representatives from the IAM and collaborating communities to discuss the state of the art of integrated assessment modelling. ADVANCE participated in all sessions of the 3-day meeting with presentations on model developments and related insights for policy action. It also contributed numerous posters to a poster session on latest highlights in IAM modelling.

newsletter

ADVANCE consortium

- Potsdam-Institut für Klimafolgenforschung (PIK), DE
- Internationales Institut für angewandte Systemanalyse (IIASA), AT
- Ministerie van Infrastructuur en Milieu (PBL), NL
- Fondazione Eni Enrico Mattei (FEEM), IT
- JRC - Joint Research Centre - European Commission (IPTS), ES
- University College London (UCL), UK
- Société de Mathématiques Appliquées et de Sciences Humaines (SMASH), FR
- University of East Anglia (UEA), UK
- Institute of Communication and Computer Systems (ICCS), GR
- Université Pierre Mendès France (UPMF), FR
- Norges Teknisk-Naturvitenskapelige Universitet (NTNU), NO
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), DE
- Universiteit Utrecht (UU), NL
- Enerdata SA (NRD), FR

Associated collaborators

- Pacific Northwest National Laboratory (PNNL), USA
- National Center for Atmospheric Research (NCAR), USA
- National Institute for Environmental Studies (NIES), JP
- Research Institute of Innovative Technology for the Earth (RITE), JP

ADVANCE contacts

Project coordination
Dr. Gunnar Luderer and Dr. Elmar Kriegler, project leaders
Laura Delsa, project manager

Potsdam Institute for Climate Impact Research
Telegraphenberg A 31
P.O. Box 60 12 03
D-14412 Potsdam

Phone: +49 331 288 25 28
E-mail: delsa@pik-potsdam.de
www.fp7-advance.eu

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