Climate change modelling information

Quarterly report – Q2 2019 report

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Climate change modelling information

Quarterly report – Q2 2019 report

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Jerome Kisielewicz
4th Floor
Avenue Marnix 17
1000 Brussels
T +32 (0) 2 275 01 00
F +32 (0) 2 275 01 09
jerome.kisielewicz@icf.com
www.icf.com

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Prepared by	Yann Verstraeten, Ralitsa Donkova
Checked by	Jérôme Kisielewicz
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Executive summary

This report is part of the “Climate change modelling information” series commissioned by the European Commission. It presents relevant modelling developments reported by key international climate modelling institutions. This issue focuses in particular on developments linked to nationally determined contributions (NDCs), mid-century strategies and the link between climate and the Sustainable Development Goals (SDGs).

The main reported developments concerns:

- the integration of bottom-up data or models into global models (e.g. JRC-GEM-E3 model, WITCH model);
- the integration of multiple country-level models (GAINS-China and GEOS-Chem); and,
- the better integration of technology-specific options in existing models (e.g. technology-specific non-CO_2 emissions abatement and Direct Air Carbon Capture and Storage technology).

A call for more transparency with regard to the techno-economic assumptions behind integrated assessment models (IAMs) was also voiced by modellers to improve comparability of models and parameters.

The first section of the report is dedicated to modelling developments linked to the **SDGs** – it is worth highlighting that only a limited number of developments were reported on this topic. The research team behind the World Induced Technical Change Hybrid (WITCH) model is working on new features and applications of the model and developing new datasets to better understand the link between climate and the other SDGs. At national level, researchers from the Peking University analysed the health and economic impacts of different air quality control measures, a key SDG goal for China.

The second section focuses on modelling developments linked to the implementation of **mid-century strategies**. It provides an overview of recent developments occurring at EU, China and Mexican level.

Various developments linked to the implementation of the **NDCs** are reported on in the third section. These include publications on topics such as multilateral linking of emissions trading systems (ETSs) or the water-energy nexus in Portugal. It also introduces a new report by The Rhodium Group on their new models and datasets providing information on how policies may impact GHG emissions and the implications for meetings national climate goals.

Lastly, a range of **other** recent climate modelling developments are reported on in the last section. The other development concerns for example the improved integration of the Brazilian bottom-up Land Use and Energy System (BLUES) model into the global CGE model TEA and the publication of a new inter-model comparison on the role of Direct Air Carbon Capture and Storage (DACCS) in achieving 1.5ºC and 2ºC scenarios.

The report concludes with a summary of mission reports from modellers who were supported to attend the International Energy Workshop (IEW), the Energy Modelling Forum (EMF) Snowmass workshop under this project. The report also includes an overview of relevant upcoming events for the climate modelling community.

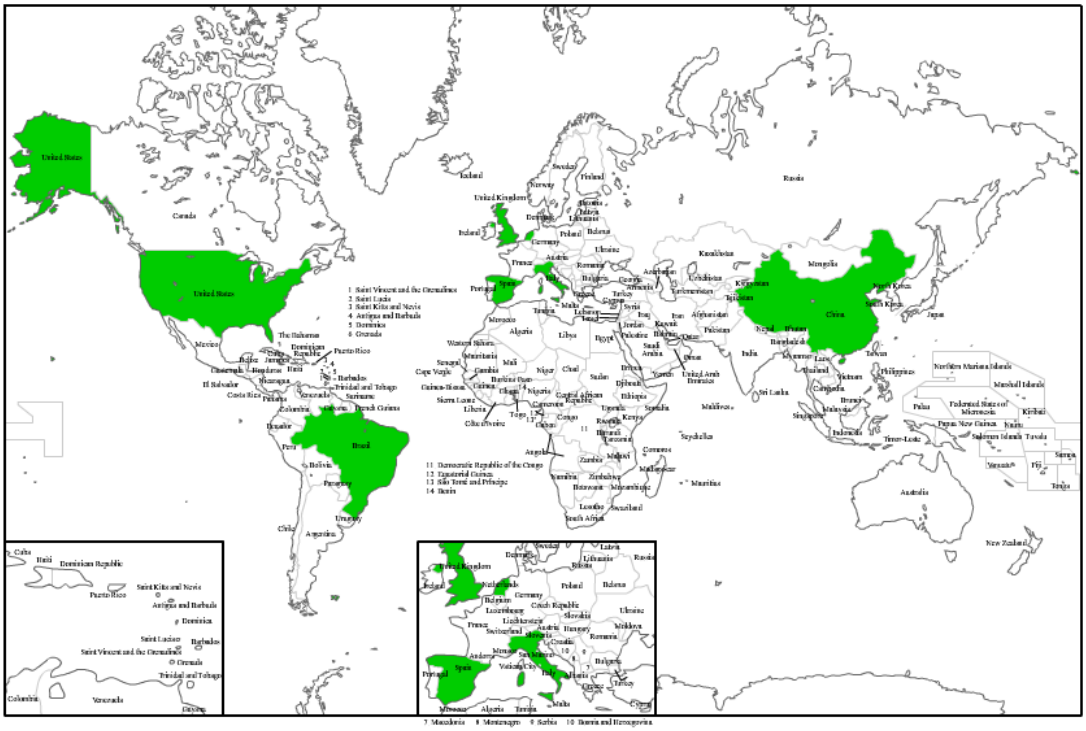
1 Introduction

This report is the second quarterly report of 2019 under the series “Climate change modelling information” financed by the European Commission. The objective of this series is to inform the European Commission and the wider climate change and energy modelling community about recent and relevant modelling developments linked to policy developments. The data

presented in this report were collected through an open survey sent to more than 200 modelling teams worldwide and open from 9 August to 23 August 2019.

The survey asked modellers to report relevant modelling developments with a focus on the implementation of Nationally Determined Contributions (NDCs), mid-century strategies and the links between climate and the sustainable development goals (SDGs). Although the objective of this report is to present an extensive list of recent developments, it cannot be considered as exhaustive. For this quarterly report, responses came from seven countries (see Figure 1.1), nine different organisations and covered ten different modelling developments and projects. Additional research was also undertaken to complement the survey results.

Figure 1.1 Geographical coverage of climate change modelling developments reported through the online survey (n = 10)



Source: ICF, 2019. Climate change modelling information Q2 2019 survey.

The modelling developments discussed in this report are summarised below and further described in the coming chapters:

Modelling developments linked to the SDGs:

- Better coverage if air pollution and water usage to cover SDGs (Italy)
- Tackling air pollution: Analysing the health and economic impact of air pollution (China)

Modelling developments linked to the implementation of mid-century strategies:

- Abatement of non-CO_2 emissions through technology-specific end-of-pipe abatement options (Spain)
- Policy application of the IPAC model (China)
- New fact sheets on the long-term, low-emissions pathways of 11 countries (Netherlands)
- Low-cost policy options for achieving Mexico's climate goals alongside long-term social benefits (Mexico)

Modelling developments linked to nationally determined contributions (NDCs):

- A new model on multilateral linking of emissions trading systems (UK)
- Full disaggregation of electricity generation and raw water use in the water-energy nexus model in Portugal (Spain)
- New projection models and datasets on progress towards achieving the NDCs in all countries (USA)

Other modelling developments:

- Improved integration of the global TEA model with the Brazilian bottom-up BLUES model (Brazil)
- First-ever inter-model comparison on the role of Direct Air Carbon Capture and Storage (DACCS) in achieving 1.5ºC and 2ºC scenarios (UK)
- Comparison of techno-economic assumptions across national and global IAMs (Austria)

2 Modelling developments linked to the SDG

- At the European Institute on Economics and the Environment (EIEE), the research team behind the World Induced Technical Change Hybrid (WITCH) model is working on new features and applications of the model and developing new datasets. The WITCH model has recently been applied to the implementation of the NDCs taking into account the latest developments reported at COP24. The model has also been improved to: (1) better integrate air pollution and water usage in order to better understand the link between climate and other SDGs; and (2) improve its sectoral coverage, notably by improving the model's description of the building sector, which would allow to better assess policies including those aiming to change behaviours.

  These updates led to different publications. For example, a recent article on the food security implications of climate change mitigation shows that poorly designed climate mitigation policies could increase the number of people at risk of hunger. In another article, researchers compared different effort-sharing approaches (e.g. equal cumulative per capita emissions, contraction and convergence, grandfathering, greenhouse development rights and ability to pay) for calculating national carbon budgets and emission pathways with the cost-optimal approach. Their analysis shows that some approaches lead to extreme outcomes in terms of division of the global carbon budget across countries. While the outcomes of the approaches should not be regarded as top-down calculated targets and budgets for countries, they should inform the discussions on ratcheting-up of mitigation efforts according to the authors.

- At the Institute of Environment and Economy (IoEE) at Peking University, a team of researchers is analysing the health and economic impact of air pollution control in China. The results of their research include:

  – In their recent article in *Frontiers of Environmental Science and Engineering* researchers presented the modelling of the impacts of economic restructuring and technology upgrade on air quality and human health. They use a comprehensive model framework integrating an air pollutant emissions projection model (GAINS-China), an air quality model (GEOS-CHEM), and the health IMED/HEL model to analyse the impact of various policies on air pollution and health effects in the Beijing-Tianjin-Hebei (BTH) region in China. The model establishes a data interface between economic input/output data and the emissions inventory of atmospheric pollutants in the BTH region. The researchers construct and test several scenarios to analyse the effectiveness of policy pathways in improving air quality. The results show that the policy pathway of industrial technology upgrading (i.e. reducing the emissions intensity of industries) can be effective, while the pathway of industrial structure

adjustment (i.e. adjusting the proportion of industrial value-added) shows mixed effectiveness. Furthermore, they find that the analysed policy pathways will be efficient in reducing pollution of primary pollutants and fine particles, but not ambient ozone pollution. As ozone pollution is projected to increase in the BTH region, it will require additional mitigation strategies.

- In another article in *Environment International*, the researchers from Peking University compare the health and economic impacts of $PM_{2.5}$ and ozone pollution at the provincial level in China. The study compares the $PM_{2.5}$ and ozone pollution-related health impacts based on an integrated approach. The research framework combines an air pollutant emissions projection model (GAINS), an air quality model (GEOS-Chem), a health model using the latest exposure-response functions, medical prices and value of statistical life (VSL), a general equilibrium model (IMED/CGE), and a health model (IMED/HEL). The results show that at the national level the health and economic impacts from ozone pollution are much smaller than the impacts from $PM_{2.5}$ pollution except for per capita morbidity and expenditure. However, at the province level there is an unequal geographic distribution of the health impact and economic burdens of $PM_{2.5}$ and ozone pollution. Eastern provinces in China suffer greater health damage and economic loss related to $PM_{2.5}$, while western provinces are more affected by ozone pollution. The economic and health impact of ozone pollution is also much more difficult to mitigate.

3 Modelling developments linked to the implementation of mid-century strategies

- Researchers at the European Commission's Joint Research Centre are working on improving the global, multi-region, multi-sector Computable General Equilibrium (CGE) model JRC-GEM-E3. In their July 2019 article in *Energy Economics,* they integrate the abatement of non-CO_2 emissions (methane, nitrous oxide, and fluorinated gases) into the JRC-GEM-E3 through technology-specific end-of-pipe abatement options. The integration preserves much of the bottom-up information, and hence better captures the costs of non-CO_2 abatement options. Specifically, the new approach better captures the non-linearities of different abatement options/technologies. The application further shows the importance of modelling non-CO_2 emissions explicitly.
- The Integrated Policy Assessment Model for China (IPAC) developed by the Chinese Energy Research Institute and used as one of the key tool to evaluate energy and climate change policies in China was recently applied to draft the Guidance on High Quality Growth of Energy, which is expected to be announced by the Chinese government in the coming months.
- New quantitative analysis from WRI Mexico identified low-cost policy options (including policies, measures and technologies) for achieving Mexico's long-term climate goals alongside long-term social benefits. The researchers used the Energy Policy Simulator (EPS) developed by Energy Policy Solutions LLC. It is an open-source, peer-reviewed tool available for Canada, China, India, Indonesia, Mexico, Poland, and the USA. The EPS model estimates the application of different policies that affect energy use and emissions in various sectors of the economy, and includes different policy mechanisms such as carbon tax, fuel economy standards for vehicles, reducing methane industrial leakages, and accelerated technological advances. It is a computer simulated non-equilibrium model, which allows for stock carry-over between periods and gradual changes in parameters without the need to recalculate general parameters for specific sectors. The model is particularly useful for estimating progressive improvements in efficiency.

4 Modelling developments linked to the implementation of the nationally determined contributions (NDCs)

- Researchers at the Economic and Social Research Council (ESRC) Centre for Climate Change Economics and Policy (CCEEP) at the London School of Economics have developed a new general model to analyse the potential efficiency gains and cost distribution of multilateral linking of emissions trading systems (ETSs). Such multilateral linking of permit markets would allow for an emissions permit issued in one jurisdiction to be used in any of the linked jurisdictions, and therefore cost savings could become available due to increased efficiency and stability. Multilateral linking could be used to achieve the Paris Agreement goals in a cost-effective manner. The authors use two decompositions of the efficiency gains. The first is decomposition into effort- and risk-sharing gains, and the second is into jurisdiction-specific and aggregate gains. This allows for rigorous analysis of not only the cost saving, but also of the distributional issues arising from effort- and risk-sharing. An application of the model on the Paris Agreement pledges and data on the power sectors of five real-world jurisdictions (Australia, Canada, the EU, South Korea and the USA) show that multilateral linking of the ETSs could generate annual gains of up to USD 3.26 billion (constant 2005 USD), split roughly between effort- and risk-sharing. The working paper is available here.
- Researchers at the Department of Applied Economics at the University of Vigo have further developed the water-energy nexus model in Portugal by improving its sectoral coverage. The objective of this research is to better understand the interconnections between climate change policies and the declining availability of raw water in the country. The research included the full disaggregation of electricity generation (with six renewable technologies) into the model. It also includes raw water use for all the sectors of the economy (in addition to the usual sector “distribution of water”). This development contributed to a better understanding of the impact of climate change on water resources, the economy, and the indirect impact from reduced hydroelectricity use on the electricity mix and prices.
- Researchers at the Rhodium Group[1] are currently developing a new model and dataset that provides economy-wide, 6-gas historical estimates from 2000 to 2018 for all countries. They are also developing a set of comparable projections for each country under today’s policies (only taking into account adopted and/or legislated text and discarding aspirational goals) under a range of uncertain future parameters, including key energy technology costs; energy market outcomes (i.e., fuel prices); and economic growth scenarios through 2030. Rather than assuming NDCs are met, Rhodium’s assessment looks at actual economic, technology and policy changes in real-time to allow decision-makers to assess how countries are doing today, and what more needs to be done. Most global emissions datasets rely on data from 2010 or at the latest 2014 (5-10 years old). Technologies and policies are moving rapidly and lack of up-to-date data makes it difficult to assess today's state of affairs. Rhodium will be assessing national and global emissions for the previous calendar year to give the community immediate access to information about how countries progressed in the recent past. This work will be publicly available on the group’s website.

[1] The Rhodium Group represents one of the few consultancies included in our database of climate change modellers. It is the first time they are reporting on their ongoing projects.

5 Other modelling developments

- Researchers at the Coppe Institute at the Federal University of Rio de Janeiro are working on improving the integration of the global CGE model TEA with the Brazilian bottom-up Land Use and Energy System (BLUES) model as it is used to analyse the Food-Energy-Water (FEW) nexus. The key scientific challenge in the FEW nexus analyses is the representation of water use in the BLUES model. The food, energy and water systems are interrelated, and water use is the main outcome in the energy and land use systems. The soft-linking procedure used for the integration of bottom-up BLUES model into TEA provides macroeconomic consistency to the national model. This work is in progress, and there are no publications yet.
- A team of researchers across RFF-CMCC European Institute on Economics and the Environment (EIEE), the Grantham Institute at Imperial College London, the MaREI Centre, and Politecnico di Milano have published a new inter-model comparison on the role of Direct Air Carbon Capture and Storage (DACCS) in achieving 1.5ºC and 2ºC scenarios. DACCS is an alternative negative emissions technology (NET) with the potential to significantly reduce the mitigation costs of climate action, and it can be used in conjunction with other NETs. DACCS is increasingly gaining attention as a CO_2 sequestration option, but as it is in its early development stages the risks associated with its deployment are yet unknown. In their latest article, the researchers add two synthetic direct air capture technologies for CO_2 removal and sequestration (aqueous hydroxide solutions and amine-modified solid sorbents) to the TIAM-Grantham model. The TIAM-Grantham model is an IAM developed by the Grantham Institute based on the ETSAP-TIAM model. Additionally, the model was inter-compared with the WITCH integrated assessment model. The key limitation of DACCS deployment is the rate at which it can be scaled up. The authors find that due to the required sorbent production and the energy input required for large scale deployment, DACCS should be used *alongside* other mitigation options in a diversified portfolio of mitigation strategies, rather than instead of.
- A recent article in *Energy* compares the techno-economic assumptions across national and global IAMs of climate change. The team behind the publication is led by researchers at the International Institute for Applied Systems Analysis (IIASA) and includes researchers from 19 science and policy institutes around the world. The study reviews the techno-economic assumptions in the electricity sector among 15 different global and national IAMs with a focus on their application in Brazil, China, the EU, India, Japan and the USA. It concludes that techno-economic characteristics and the representation of technologies differ among models, and those differences need to be accounted in the comparisons of numerical parameters. To improve comparability of assumptions across national and global IAMs, the authors call for publishing techno-economic parameters together with documentation of the technology representation.

6 Key lessons learnt from recent modelling events

6.1 International Energy Workshop (IEW), 3 - 5 June 2019

The key lessons learnt reported by modellers who benefited from the support of the Commission to attend the IEW can be clustered in different groups:

1. There is a need to nurture more cooperation among modelling institutions and support access to modelling tools to a wider group of countries, more specifically:

- Collaboration between modelling institutions is key in advancing data and modelling, and in making the tools and data available more widely.
- Workshop such as the IEW are beneficial for Small Island Developing States (SIDSs) as they provide opportunities to get exposed to different modelling tools and create research networks. Researchers from SIDS countries should be given more opportunities to attend.
- Countries vary tremendously in terms of the availability of data and modelling capacity in the field of energy. For example, there is very little emphasis on gathering data and modelling energy demand in Africa, and very often the continent is modelled as a single entity despite widely varying energy demand across countries. As licensed models and data prevent access and use, there needs to be a move towards open source models. This would encourage and advance collaborative model development and transparency.

2. The movement towards more integrated models able to better capture interdependencies between policy areas should be further supported as it is key to achieve a successful and just low carbon transition. Specific messages include:
   - It is important to deal with energy poverty in the context of development and climate change. Energy demand is likely to continue to increase, especially in developing countries. Therefore, advanced decarbonization technologies should be more affordable so that sustainable poverty eradication strategies can be encouraged in developing countries.
   - It is important to integrate research on energy systems with research on other systems (e.g. infrastructure needs, pollution, health care). Thinking in terms of systems and how these systems interact will enhance existing research programs and open up new research avenues. There has already been a lot of effort to link energy systems models with other systems models (e.g. transport, economic models), but this type of collaboration needs to be encouraged further and the models and data should be available as open source.
   - Future 1.5ºC and 2ºC scenarios assume aggressive energy supply transformations *and* significant demand reduction. This has implications for human development and the ability to end poverty. For example, projections for energy use per capita in Africa are low, and it is unlikely that many countries in Africa will realise their SDGs given the persistent energy poverty.
3. Other key lessons learnt include:
   - Even though the outputs and estimates of energy models vary widely, they all show that the transition is possible within the specified timeframe. Storage, temporal resolution and spatial resolution are the three key components for achieving the energy transition.
   - Hydrogen is a key technology in the field of long-term storage and transport. The level of deployment of hydrogen will depend on how its cost develops in the future. At the moment, there is little consistency in modelling hydrogen cost and use and as a result the estimates vary tremendously.

6.2 EMF Snowmass workshop, 16 – 19 July 2019

The EMF Snowmass workshop focused on the interaction between the finance sector and climate change. Both practitioners from the financial sector (public and private banking, private finance) and integrated assessment modelers interested in how to better link IAMs

with finance sector analysis attended the workshop. Key lessons learnt from the discussions include:

- There is considerable interest in the finance sector (e.g. insurance institutions, central banks, development banks) in using outcomes of IAMs in order to better identify and quantify climate related risks for the financial sectors. These risks are both physical (e.g. climate impact risks) and linked to the impact of climate change policies.
- IAMs can be a key provider of information to inform risk assessment of financial institutions. Compared to alternative providers like the IEA, their strength lies in a broad exploration of the scenario space, their integrated systems perspective, and their relevance for climate policy making. Drawbacks are their large number, lack of granularity, lack of (bi)annual updates, and lack of communication strategies geared to stakeholders. Examples of first IAM-finance sector collaborations are the banking pilot of the UNEP Finance Initiative and exchanges between the IAM community and the Network of Greening the Financial System. The IAMC has founded a scientific working group on the use of scenarios for financial risk analysis[2]. More support will be needed to reinforce these collaborations.

6.3 Future modelling developments to look out for (include relevant web pages)

- Integration of industrial ecology and IAM, especially on the demand side (See https://www.decentlivingenergy.org/)
- A new project on energy poverty and electrification in the DRC based on a high resolution geo-spatial model (See http://www.erc.uct.ac.za/groups/esap)
- Soft-linking IAMs with macro models to better understand implications of the transitions to distributions and on indicators of financial stability (JPI Axis Project CHIPS and H2020 project NAVIGATE)
- Improved modelling of the future development of supply and demand side measures that can alleviate decarbonization bottlenecks. This will allow formulating more granular visions of carbon neutral societies and their possible configurations. (H2020 project NAVIGATE)
- Modelling economic impacts of extreme events (JPI Axis Project SLICE) and better integrating climate impact and mitigation pathway modelling (H2020 project NAVIGATE)
- Modelling multi-objective sustainable development pathways taking up the UN 2030 SDG agenda (JPI Axis Project SHAPE)
- Viability / Feasibility assessment of mitigation pathways (H2020 project ENGAGE, will be an important topic in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC)
- Upcoming work and activities from the Integrated Assessment Modeling Consortium (IAMC) Scientific Group on Scenarios for Climate-related Financial Analysis.
- A white paper on the interaction between climate change and the financial sector will follow the conference (unpublished yet).

[2] http://www.globalchange.umd.edu/iamc/scientific-working-groups/financial-analisis/