Climate change modelling information

Quarterly report – Q1 2019 report

13 June 2019

Submitted to:

European Commission

DG Climate Action

Climate change modelling information

Quarterly report – Q1 2019 report

A report submitted by ICF SA

Date: 13 June 2019

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Document Control

Document Title	Climate change modelling information, Quarterly report – Q1 2019
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Date	13 June 2019

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Project Number: 2019.3743			
Title: Climate Change Modelling Information Newsletter – 1/2019			
Linguistic version	Media/Volume	Catalogue number	ISSN
EN HTML	Electronic Files/Volume_01	ML-AA-19-001-EN-Q	2599-9516
EN PDF	PDF/Volume_01	ML-AA-19-001-EN-N	2599-9516

* The ISSN remains valid as long as the title of the serial remains unchanged. Please inform us of any title changes and/or the cessation of publication.

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1 High-level executive summary

This report under the “Climate change modelling information” series, presents relevant developments reported by key international climate modelling institutions. This issue sets a particular emphasis on nationally determined contributions (NDCs), mid-century strategies and the role of finance in addressing climate change.

Research suggests that current Integrated Assessment Models (IAMs) do currently not clearly represent the interactions between finance and money creation and climate as well as the risks posed by climate damages to the economy. The first section of the report highlights several recent modelling efforts made by Cambridge Econometrics and the French Development Agency to address that gap which sought to better represent the interactions between the financial, macroeconomic and biophysical spheres in their E3ME and GEMMES models, respectively. Various publications showing the increasing recognition from academia and central banks of the threats posed by climate change to the financial system are also highlighted as well as the need to better represent carbon-related systemic risk factors in macroeconomic and financial stability assessments.

The second section focuses on recent modelling developments linked to the implementation of mid-century mitigation strategies. A paper published by the Deep Decarbonization Pathways (DDP) project describing the innovative pathway design framework used to model mid-century low-emission pathways for 16 countries in the lead up to the twenty-first Conference of the Parties is presented. The ongoing modelling efforts by Climateworks Australia to develop a new model as part of the Decarbonisation Futures project is also highlighted.

The third section focuses on ongoing efforts by the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE) linked to the implementation of nationally determined contributions (NDCs). These consisted of developing new applications for the Total-Economy Assessment (TEA) model and including social and environmental variables in their energy model called Model of Long Term Expansion (MELP).

Various modelling developments linked to Sustainable Development Goals (SDGs) are reported in section four. These include publications from the Council on Energy, Environment and Water (CEEW) on scaling rooftop solar in India, improvements in the World Induced Technical Change Hybrid (WITCH) model by the European Institute on Economics and the Environment (EIEE) and integration of existing models by the Joint Global Change Research Institute / Pacific Northwest National Laboratory (PNNL).

A range of other recent climate modelling developments are reported in the last section with a particular focus on research exploring the potential economic and climate impacts of restructuring the Chinese industry and a comparison with other regions and countries across the globe.

2 Introduction

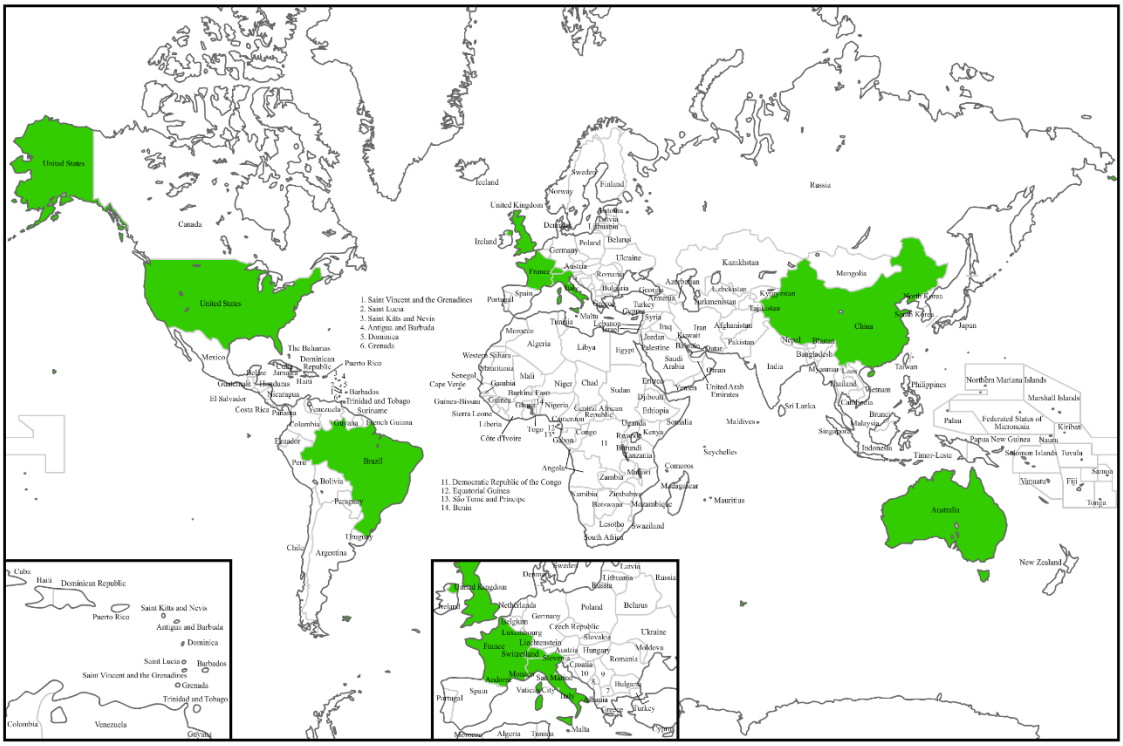
This report is the first quarterly report of 2019 under the series “Climate change modelling information” financed by the European Commission. The objective of this series is to inform the European Commission and the wider climate change and energy modelling community about recent and relevant policy modelling developments. The data presented in this report were collected through an open

survey sent to more than 200 modelling teams worldwide and open from 14 May 2019 to 24 May 2019.

The survey asked modellers to report relevant developments with a focus on the implementation of Nationally Determined Contributions (NDCs), mid-century strategies and the role of finance in addressing climate change. 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 8 countries (see Figure 2.1), 10 different organisations and covered 10 different modelling developments and projects.

Additional research was also undertaken to complement the survey results.

Figure 2.1 Geographical coverage of climate change modelling developments reported through the online survey (n = 10)



Source: ICF, 2019. Climate change modelling information Q1 2019 survey.

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

Modelling developments linked to the role of finance in addressing climate change:

- Money, Finance and Climate: The Elusive Quest for a Truly Integrated Assessment Model (France)
- General Monetary and Multisectoral Macro-dynamics for the Ecological Shift (GEMMES) (France)
- E3ME Global Macro-econometric Model (United Kingdom)
- The Climate Target Gap Is Widening. Can We Close It by Including Climate Finance in SSPs? (Switzerland, United States)
- A Climate Risk Assessment of Sovereign Bonds' Portfolio (Switzerland, United States)
- Climate Transition Risk and Development Finance: A Carbon Risk Assessment of China's Overseas Energy Portfolios (United States)

- Macro Focus- What central banks can do to fight climate change (Sweden)
- Climate Change and the Irish Financial System (Ireland)
- Climate change challenges for central banks and financial regulators (United Kingdom)

Modelling developments linked to mid-century strategies:

- A pathway design framework for national low greenhouse gas emission development strategies (France)
- New model as part of the Decarbonisation Futures project (Australia)

Modelling developments linked to nationally determined contributions (NDCs):

- The TEA model: analysing national carbon budgets (Brazil)
- Improvements of the Model of Long Term Expansion (MELP) as part of the SINAPSE project (Brazil)

Modelling developments linked to Sustainable Development Goals (SDGs)

- Scaling Rooftop Solar report (India)
- World Induced Technical Change Hybrid model (Italy)
- Model integration by the Joint Global Change Research Institute / Pacific Northwest National Laboratory (PNNL) (United States)

Decarbonisation:

- Impacts of export restructuring on national economy and CO2 emissions: A general equilibrium analysis for China (China)
- Modelling deep decarbonization of industrial energy consumption under 2-degree target: Comparing China, India and Western Europe (China)
- Modular energy systems Simulation Environment model (MUSE) (United Kingdom)
- Model-based assessments for long-term climate strategies (Netherlands)

3 Modelling developments linked to the role of finance in addressing climate change

- The financial intermediation necessary to the accomplishment of a horizon of global carbon emission neutrality during the second half of the century is still far from clear. In a 2018 article, the French Development Agency (AFD) proposes to address this research gap through a critical analysis of the most recent research papers attempting to integrate the specificities of finance and money in the climate-economy nexus. The article poses that current Integrated Assessment Models (IAMs) derived from the famous Dynamic Integrated Climate-Economy model (DICE) are not appropriate to clearly represent the different channels by which finance and money could destabilize the well-established equilibriums between growth and climate damages. New possibilities are therefore explored borrowing from the post-Keynesian thinking for the key role they give to money, to more complex systems for their capacity to tackle the interactions between financial balance sheets, and ecological economic thinking which fully considers the non-substitutability between financial and natural capitals. The paper advocates for greater convergence between the financial sector reform's agenda (in particular, to dampen the intrinsic financial instability linked to climate change) and climate policy design (in particular, the need for finance flows to be

consistent with a pathway towards low GHG emissions and climate-resilient development as set out under Target 2 of the Paris Agreement)[1]. (France)

- The “General Monetary and Multisectoral Macro-dynamics for the Ecological Shift” (GEMMES) developed by the French Development Agency (AFD) is one of the few economic modelling tools to integrate the impact of climate change into country GDP and debt forecasts. The model makes it possible to combine the impact of global warming and the increased scarcity of natural (energy and mineral) resources with the dynamics of capital, private and public debts, and under-employment. Finally, it takes into consideration the way in which the reduction of inequalities facilitates the resilience of a national or regional economy. There are currently three versions of GEMMES: one at the global level, one at the European level, and a third version adapted to the Brazilian economy.

  Recent developments of the GEMMES include:

  – Since end of 2018, the model is available in an online application accessible to all. Three modules - climate, economic and political - enable users to "play" with the data to visualize their impacts on the economy or greenhouse gas (GHG) emissions.

  – Other GEMMES model applications are being studied for Côte d’Ivoire, Vietnam, and Colombia. Their specific features are being developed thanks to partnership with local economists.

  – The GEMMES model has been calibrated to the world economy in an article by Bovari et al. (2018). The model combines the effects of global warming with the pivotal role of private debt to simulate various planetary scenarios. The application of GEMMES at global scale shows that: i) the +2 °C target is already out of reach (absent negative emissions); ii) the long-term (resp. short-term) results of climate change on economic fundamentals may lead to severe economic consequences without the implementation (resp. in case of too rapid an application) of proactive climate policies. Global warming (resp. too fast transition) forces the private sector to leverage in order to compensate for output and capital losses (resp. to lower carbon emissions), thus endangering financial stability; iii) Implementing an adequate carbon price trajectory, as well as increasing the wage share, fostering employment, and reducing private debt make it easier to avoid unintended degrowth and to reach a +2.5 °C target.

- The Cambridge Econometrics (CE) team has further improved their E3ME Global Macro-econometric Model to better recognise the role of the financial sector in providing resources for any investment-intensive transition. Until now, E3ME has only implicitly taken into account the treatment of money – investment has been largely determined by expectations of future output levels based on current activity as explained in Pollitt and Mercure (2017)[2][3]. Ongoing developments are therefore seeking to introduce a full set of financial balances

[1] The issue of endogeneity of money has been further discussed in follow-up paper published in 2019. The paper provides a critical analysis of the ecological economic thinking according to which more accurate reflection of money and finance in modelling frameworks is needed. The paper suggests overcoming the limitations through institutionalist perspectives that understand money as a language through which value is created and legitimized.

[2] Pollitt, H., Mercure, J-F., 2017. The role of money and the financial sector in energy-economy models used for assessing climate and energy policy. *Climate Policy*. Volume 18, 2018 - Issue 2Available at: https://www.tandfonline.com/doi/full/10.1080/14693062.2016.1277685.

[3] A follow-up paper led by Jean-Francois Mercure building on the results from current EU research (with DG ENV) will soon be published in the Climate Policy journal.

to better represent the interactions with the financial sector and the process of money creation. Furthermore, researchers are currently trying to connect E3ME with the first of a new generation of financial network models to assess the potential global loss in value of fossil-fuel assets and the uptake of key low-carbon technologies in the most emissions-intensive sectors. This is conducted under the "Financial risk and the impact of climate change" project funded by the UK Natural Environment Research Council (NERC)[4].

- Researchers from the University of Zurich and Boston University published an article in November 2018 analysing the use of climate finance in Socio-Economic Shared Pathways (SSPs). While SSPs have emerged as the standard framework to describe the trajectories that will deliver the necessary transformation of production and consumption, research suggests that the gap between climate targets and the actual world socio-economic trajectory is widening. The article poses that this is mainly explained by the fact that SSPs have so far neglected the role of the financial sector. To narrow the gap, the authors propose a novel research agenda to account for the role of the financial sector and its expectations in the SSPs. (Switzerland, United States)
- The role of finance in addressing climate change and the need to represent the financial sector in financial risk assessment models is increasingly recognised by academia and financial organisations alike.
  - Researchers from the University of Zurich and the Boston University published an article stressing the lack of methodologies to price climate risks and opportunities in the value of financial contracts as one of the main barriers to align finance to sustainability. As traditional financial pricing models cannot accommodate the deep uncertainty that characterises climate risks, as well as the presence of incomplete markets and endogeneity that characterise the low-carbon transition, authors propose to develop a climate risk assessment methodology under uncertainty that contributes to fill this gap. Using IAMs the authors find that investments alignment to a credible 2°C trajectory can strengthen the sovereign fiscal and financial position by decreasing the climate spread, while a misalignment to a 2°C trajectory can increase it, with financial risk implications for its investors. This analysis is intended to support investors and financial supervisors in the understanding of the conditions for the onset of climate-related financial risks and strategies for their mitigation.
  - The lack of sound and transparent metrics to assess development finance institutions' exposure to climate risks and their impact on global climate action has been further emphasised by Monasterolo et al. (2018) in a paper published in November 2018. By applying a novel climate stress-test methodology for portfolios of loans to energy infrastructure projects of two main Chinese policy banks, the authors show the banks' exposure to economic and financial shocks that would result in government inability to introduce timely 2°C-aligned climate policies and from investors' inability to adapt their business to the changing climate and policy environment. It is demonstrated that negative shocks are mostly concentrated on coal and oil projects and vary across regions. Given the current leverage of Chinese policy banks, these losses could induce severe financial distress, with implications on macroeconomic and financial stability.
  - In a research paper published in March 2019, Swedbank AB highlights that banks are exposed to climate-related financial risks through i) physical

[4] This project aims to develop a robust characterisation, quantification and communication of climate-related transition risks, in particular linked to UK's financial and economic stability.

effects from extreme weather events or changing climate conditions and (ii) the impact of transition to a lower-carbon economy. The report points to the lack of data and the inability of standard central bank macroeconomic models to take climate change into consideration as the main challenges for quantitative assessment of the risks associated with climate change. Swedbank also encourages central banks to step up in research, improve disclosure and asses their own balance sheets to mitigate climate-related risks, and highlights the key role of central banks in influencing the financial systems. (Sweden)

- In an Economic Letter published in March 2019 the Central Bank of Ireland highlights the need to adapt current modelling tools to incorporate the impact of both short-term weather events and long-term climate change. The need to improve climate-related risk assessments to guide future financial regulations and the policies of central banks has been formulated in an article published in 2018 by Campiglio et al. (Ireland & United Kingdom)

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

- The Deep Decarbonization Pathways (DDP) project published a new paper, "A pathway design framework for national low greenhouse gas emission development strategies". The article describes the innovative pathway design framework used to model mid-century low-emission pathways for 16 countries in the lead up to the twenty-first Conference of the Parties. It further shows how it can support the development of sectorally and technologically detailed, policy-relevant and country-driven strategies consistent with the Paris Agreement climate goal. It further discusses how it can be used to engage stakeholder input and buy-in; design implementation policy packages; reveal necessary technological, financial and institutional enabling conditions; and support global stocktaking and increasing of ambition.
- Climateworks Australia is currently developing a new model as part of the Decarbonisation Futures project. Since the latest developments were reported in this quarterly series[5] this project has progressed through the modelling phase and is now interrogating results, with a view of publishing the findings in the near future. . The project involved the creation of a number of narrative scenarios, spanning from no/little action through to action consistent with action to achieve well below two-degrees. The recent modelling task quantified these scenarios, based upon the assumptions of each narrative scenario. A report presenting these results will soon be published.

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

- Researchers from the COPPE, Universidade Federal do Rio de Janeiro have used the Total-Economy Assessment (TEA) model to simulate national carbon markets for the 18 regions of the model and assess alternative policies to achieve the Brazilian NDCs. These developments were conducted in a context of increased deforestation by landholders encouraged by government policy since 2016. Ongoing deforestation is putting Brazil's contribution to the Paris

[5] See the Q9 of March 2019.

Agreement at risk and requires other parts of the economy (e.g. industrial sectors) to increase their emission ambitions to counterbalance the loss incurred by deforestation.
As part of the SINAPSE project, COPPE is also seeking to include social and environmental variables in their energy model called Model of Long Term Expansion (MELP) using Data Envelopment Analysis (DEA). Initial results have shown that renewable power plants contribute more to allocative efficiency than fossil fuel ones, both in terms of social and environmental aspects.

6 Modelling developments linked to Sustainable Development Goals (SDGs)

- The Council on Energy, Environment and Water (CEEW) has produced the Scaling Rooftop Solar report, a new model study focused on assessing the role of roof-top solar power in India's decarbonisation process.

  The research, which targets India's urban residential households, models the competition of rooftop solar in India with centralised electricity supply, analysing the role of various government policies in incentivising rooftop solar energy in the country.

  Distributed solar energy is a critical part of India's larger solar ambition. However, while the national and state governments have been pushing for rooftop solar in Indian residential sector, the progress has been far from satisfactory. The analysis seeks to understand the reasons for the slow uptake of solar rooftop in India and aims to model its evolution in Indian households. It also aims to identify policy insights for a faster penetration of this energy source in the electricity generation mix, as envisaged by the Indian government. (India)

- Researchers from the European Institute on Economics and the Environment (EIEE) have improved the World Induced Technical Change Hybrid (WITCH) model. These developments consist of improving the air quality and expanding the model to include Direct Air Capture (DAC) technologies using data from the US National Academy of Science report on DAC. These improvements have enabled to better model synergies and trade-offs between air pollution and climate policies, and explore the potential issues associated with this particular negative emissions technology. (Italy)

- Researchers from the Joint Global Change Research Institute / Pacific Northwest National Laboratory (PNNL) are integrating existing models with the purpose of enhancing the spatial and temporal representation of key underlying processes and determine their climate implications.

  The final objective of the project focuses on enabling integrated assessments at national, state/province and sub-annual levels, as most decisions and sector-related investments face the need for information at these levels. (United States)

7 Other modelling developments

- Modellers from the Peking University have applied the Integrated Model of Energy, Environment and Economy for Sustainable Development (IMED) Model in a study seeking to assess the potential economic and CO2 emission impacts of export restructuring under various export structure patterns and climate policy scenarios. In the context of the ongoing trade war between China and the US, sectoral adjustment for China’s export appears to be vital to transform the Chinese economic structure. With this background, researchers analysed if restructuring exports away from low-value products towards higher, added value,

products (following the approach taken by Japan, Germany and US) could affect China and the world economy, as well as carbon emissions.

The study results show that China's export restructuring from low to high-quality products is beneficial both in terms of boosting China's Gross Domestic Production (GDP) and consumption in 2030 under all the non-climate policy scenarios, although the export volume will decrease. In the same time, it is calculated that CO2 emissions per GDP and total employment will both decrease under all the scenarios. Furthermore, findings suggest that the transport equipment sector will gain in terms of output, employment and CO2 emissions by contrast to the textile sector. Overall, results suggest that encouraging export of service, transport equipment and reducing export of textile would be effective for China's economic development and CO2 emission reduction. (China)

- The Institute of Energy, Environment and Economy of Tsinghua University, has recently published an article exploring the possible transitions of industry sector under 2°C target applying a 14-region energy system model (Global TIMES). The socio-economic uncertainty was considered by introducing Shared Socio-economic Pathways into scenario design. Moreover, a comparison between China, India and West Europe was conducted, to provide information on the key challenges for regions at different industrialisation stages.

  While global industrial energy demand and CO2 emissions are expected to grow in reference scenarios, changes in socio-economic developing pattern could slow down the emission growth. However, under 2°C target, at least 118 Gt of additional emission reduction is required from 2010 to 2050, which would require great energy structure changes including rapid electrification. The study shows that improvement on energy intensity could be reduced by over 60% and 50% respectively for emerging economies such as China and India, by mid-century compared with 2010's level. (China)

- Modellers from Imperial College London have improved their Modular energy systems Simulation Environment (MUSE) model.

  MUSE simulates energy system transitions on the long term, using a partial equilibrium model of the energy system based on iterative microeconomic supply-demand data. Using a bottom-up approach to the technology characterisation MUSE enables a high degree of detail on technical and environmental evaluations, where capital, fixed and operating costs, emissions, and fuel consumption for each technology are modelled.

  The recent developments applied to the model focus mainly on reforestation modelling, including new features like the mechanisation in the agricultural sector or direct land use change emissions, to represent alternative ways of capturing CO2 besides carbon capture and storage, such as the reforestation potential. (United Kingdom)

- The PBL Netherlands Environmental Assessment Agency has recently published an article emphasising the role of model-based assessments for long-term climate strategies.

  With the aim of mapping out the road to limit global temperature increase to well below 2°C and to pursue efforts to keep warming below 1.5°C, the report emphasizes the need of developing a combination between local and global perspectives, converting global temperature targets into local greenhouse gas emission targets. This involves country-specific energy, land use, agricultural and economic aspects, for which the use of an integrated modelling toolbox proves necessary in order to cover all sectors and provide a solid quantitative background.

The study also remarks the importance of exchanging information between the various models to enable rich and consistent assessments. In the case of the European Commission, this would involve the addition of technology-detailed information from energy models that can feed into economy-wide models and assess their competitiveness and employment implications.

The insights presented in the report underline how exhaustive model-based analysis can enrich long-term strategy and provide quicker results and emission reductions, allowing countries to consider more ambitious pathways. (Netherlands)