DOWNSCALING IAMS RESULTS TO THE COUNTRY LEVEL – A NEW ALGORITHM

[Fabio Sferra, IIASA, +43(0)67683807326, sferra@iiasa.ac.at]
[Bas van Ruijven, IIASA, +43(0)67683807288, vruijven@iiasa.ac.at]
[Keywan Riahi, riahi@iiasa.ac.at]
[Hackstock Philip, hackstock@iiasa.ac.at]
[Maczek Florian, maczek@iiasa.ac.at]

Overview

The goal of the Paris Agreement is to limit long-term global temperature change to well-below 2C and pursuing efforts to limit it to 1.5C. However, as energy and climate policies are not set at the global level, but by individual countries, these countries have developed and submitted their own plans formulated in Nationally Determined Contributions (NDCs) and mid-century net zero emissions strategies. Assessments of future emissions and the effectiveness of climate policies are usually performed with Integrated Assessment Models (IAMs) at the global and world-region level. However, bringing together insights from IAMs with information at the country level has remained difficult, as global models usually provide results for a limited number of world regions.

Several strategies have been developed to overcome this limitation. IAMs have increased regional resolution and added individual countries as native regions to their models. However, this strategy has remained difficult due to complexity of IAMs, solving simultaneously for different modules including energy, economy and climate change. Ex-post downscaling of IAM model output is another strategy. The advantage of applying downscaling techniques is they do not require extensive computational time, since they do not increase the spatial resolution of the IAMs themselves.

This study presents a new tool for downscaling outputs from Integrated Assessment Models (IAMs) from model-native regions to the country level. The algorithm produces a range of pathways consistent with the underlying IAMs results, based on a range of criteria such as historical data, planned capacities, country-available energy resources in the form of supply cost-curves, quality of governance regional benchmarks based on IAMs results, as well as national mitigation strategies until 2050. We downscale IAMs results based on the NGFS climate scenarios and highlights the implications of the Paris Agreement for energy systems and CO2 emissions at the country level.

Methods

This paper presents a new downscaling tool aiming at providing a range of pathways at the country level based on different criteria, to explore country level pathways on energy and emissions. As a general principle, the new downscaling approach is based on combining two types of information: 1) regionally aggregated benchmarks from IAMs and 2) observed historical energy data at the country level. In the short-term, downscaled results should be in line with observed data at the country level. In the long-term, energy variables converge towards the regional IAM results and could significantly deviate from the historical data. The downscaling methodology is thus based on two pathways:

- "Short term projections" are based on extrapolation of historic trends;
- "Long term IAMs benchmarks" are based on regionally aggregated IAM results.

We harmonise both pathways so that the sum of country level results coincides with the regional IAMs results. We assume some convergence from short-term to long term projections, based on the type of scenario:

- Delayed 2°C: slow convergence
- Divergent NetZero Policies and Net zero 2050: fast convergence
- Nationally Determined Contributions (NDCs), Well-below 2°C, Current Policies: medium convergence

Finally, we adjust the carbon emissions and primary energy mix based on current INDC and the mid-century targets. However, those country-level targets are introduced as so called "soft constraints", as they could be eventually overruled by the regional constrains (for example if a given scenario/storyline is not compatible with individual targets at the country level).

Results

The downscaling algorithm provides results for 134 countries, in terms of final energy (by sector and energy carrier), secondary enegry and primary energy variables (by fuel), as well as energy related carbon emissions.

Downscaled results from the Western European region of the MESSAGE model, show that Turkey will become the largest carbon emitter in the region by mid-century, driven by increasing primary energy demand (as well as increasing GDP and population) under a current policy scenario.

Primary energy and emissions will remain rather stable over time in Germany, France, UK and Italy. Countries heavily reliant on coal-based power plants will replace it by increasing wind and solar generation (especially in Greece, Netherland) as well as natural gas (Germany, Turkey) and Hydro (Portugal).

Under a Paris Agreement 1.5C pathway, carbon emissions will rapidly declines over time, as fossil fuels will be replaced by renewable energy. By 2050 carbon emissions will approach net zero in most countries or go below zero (driven by biomass with CCS technologies).

Conclusions

We have presented a new downscaling algorithm which provides country-level results based on a range of criteria, such as historical data, planned capacities, supply cost curves and governance. Depending on the criteria, the tool provides results to the country level and therefore can be used to explore the feasibility space of low-carbon emissions pathways in line with the Paris Agreement.

The strength of the downscaling algorithm is the ability to provide country level results within a reasonable computational time, without the need to increase the regional resolution of IAMs, by combining country-level information with regional IAMs results.

The tool can be also used to enhance comparisons among IAMs results by using a common regional resolution. Therefore, the tool can be used for harmonising IAMs at the regional level in line with a given scenario/storyline, as harmonisation across models usually is done only at a global space. However, the downscaling algorithm provides results at the country level by using a set of predefined heuristic rules. The algorithm does not consider all the complex interactions between energy, climate change and the economy, that are captured by IAMs at the regional level. The downscaling algorithm minimises trade of energy (e.g., electricity) across countries, therefore trying to make all countries as energy independent as possible (to minimise the risk of producing unrealistic trade patterns in the long term). Finally, the algorithm considers country-level policies (as stated by the NDCs – Nationally Determined Contributions) aiming at stabilising emissions in 2030 and net zero mid-century strategies. To do so, the tool adjusts the primary and secondary energy mix in order to align GHG emissions with those targets. However, those country-level targets are introduced as so called "soft constraints", as they could be eventually overruled by the regional constrains (for example if a given scenario/storyline is not compatible with individual targets at the country level).

Results from this tool, can be used to enhance the level of ambition of NDCs and long terms strategies in line with the Paris Agreement based on the best available science from IAMs.