Exploring the role of baseline scenarios from the IPCC SRES and AR5 in assessing very ambitious mitigation targets

P. Marbaix[(1)], A. Ferrone[(2)], J.-P. van Ypersele[(1)]
(1) Georges Lemaître Centre for Earth and Climate Research, Université catholique de Louvain, Louvain-la-Neuve, Belgium (corresponding author: philippe.marbaix@uclouvain.be)
(2) Observatory for the Climate and the Environment, Luxembourg Institute of Science and Technology (LIST), Belvaux, Luxembourg

Université catholique de Louvain

With support from the Walloon Region, Belgium

1. Objectives of the study

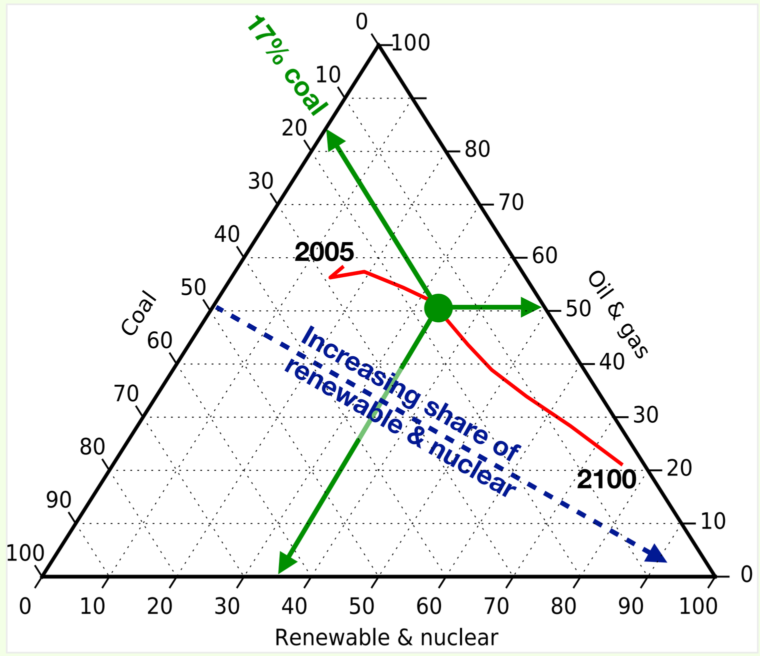
Baseline scenarios are future projections for the anthropogenic drivers of climate change in the absence of explicit climate policy. Baselines are important for most scenario analysis, as the feasibility, costs, and possible risks involved in reaching a mitigation goal may strongly depend on these references.

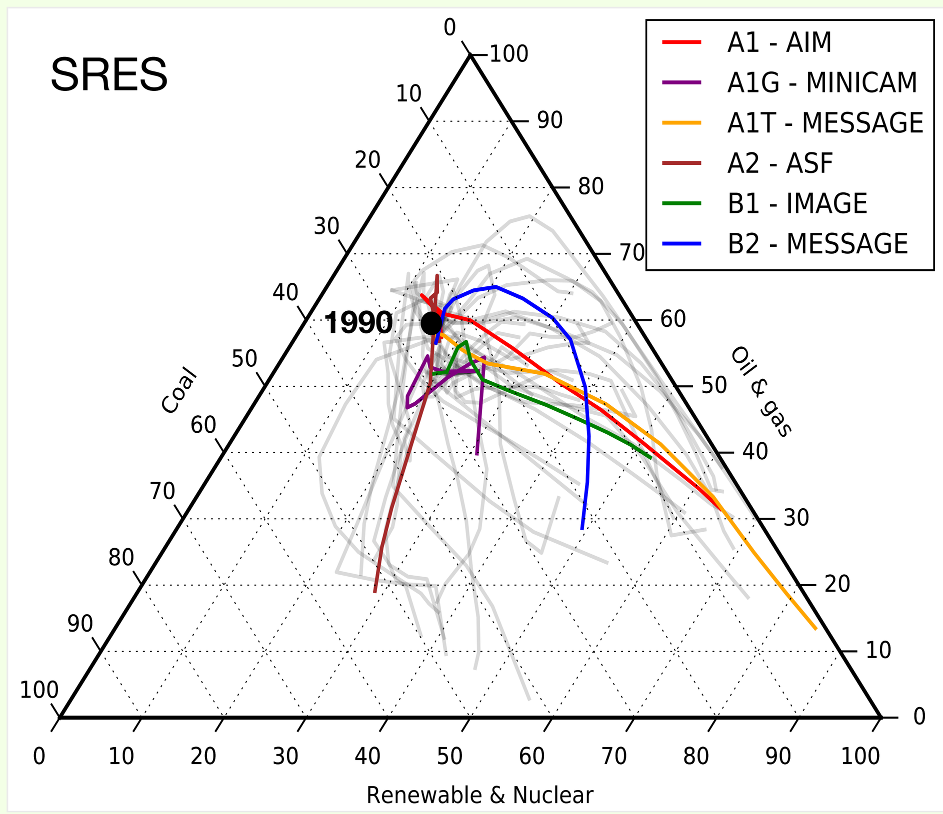
Scenarios from the IPCC SRES (2000) report were based on sets of different assumptions (storylines) described in the report, and were widely used including in AR5 (2014). For AR5, Working Group III relied on a new database of scenarios. In this database, baselines appear broadly consistent with a continuation of recent trends, although a subgroup includes improvement in the energy intensity of economic output. In the same period, a new set of alternative assumptions was developed under the name "Shared Socio-economic Pathways" (O'Neill et al. 2013, Climatic Change). Socio-economic and emission data corresponding to these SSPs have been developed and will be made publicly available (IIASA 2016 and Riahi et al. 2016).

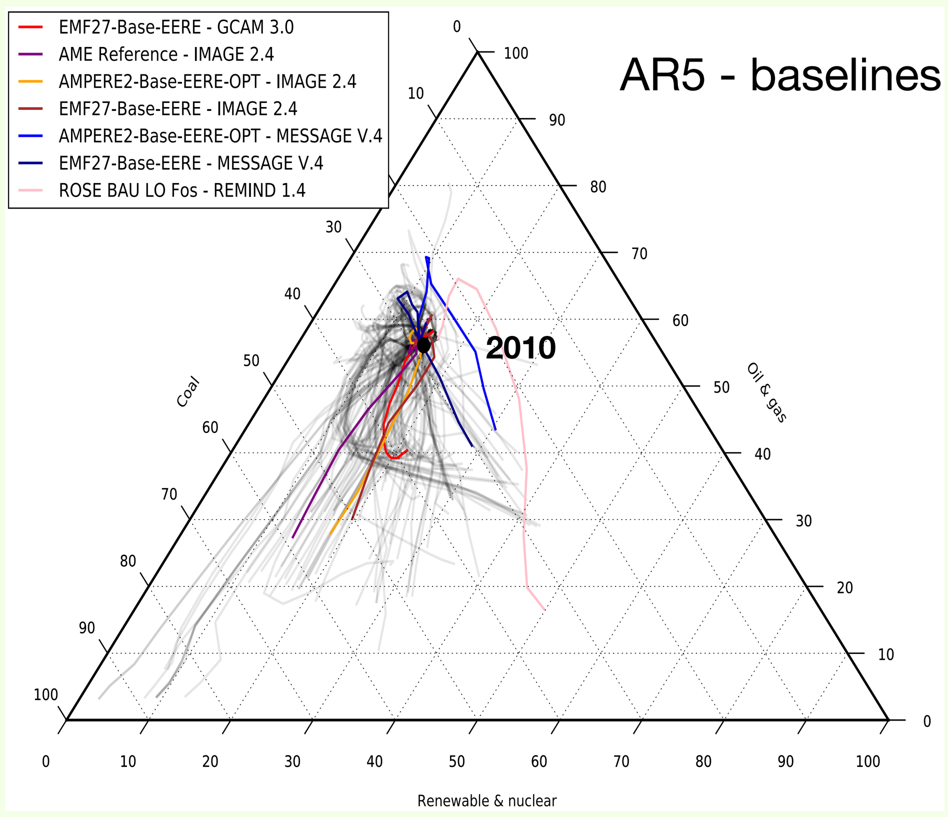
In this poster, we provide a preliminary comparison of some of the baselines from the two main available scenario databases, SRES and AR5, focusing on the evolution of the fossil / non-fossil energy mix. We then compare these 2 scenario groups to AR5 scenarios compatible with 1.5 and 2°C targets.

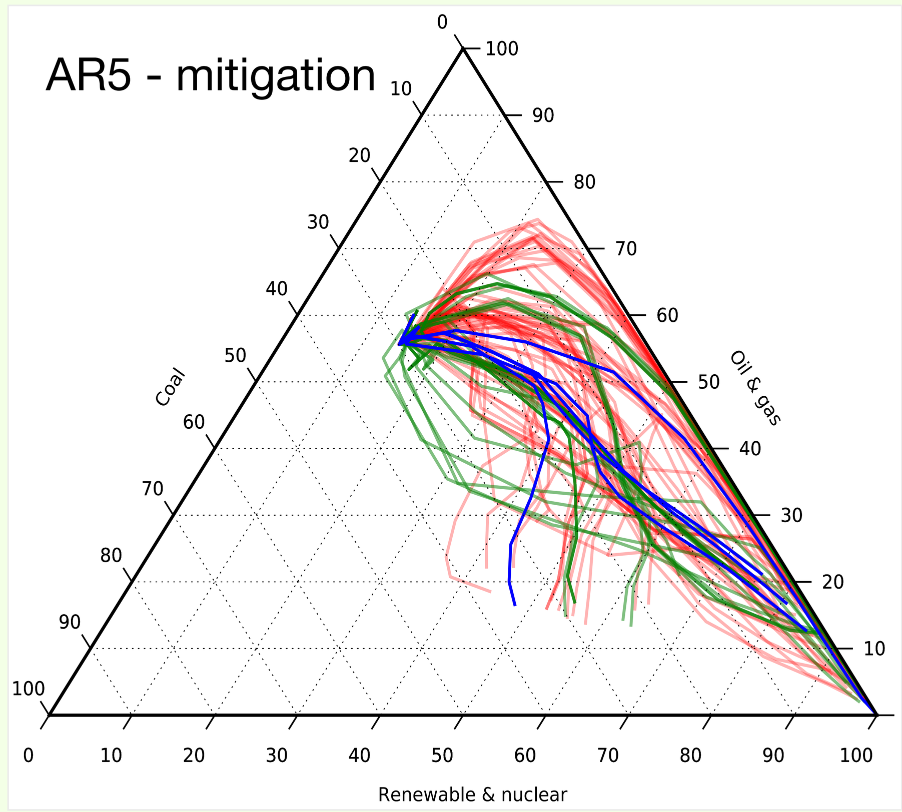
2. 'Energy mix' ternary diagrams

The SRES presented an analysis of the evolving contribution of energy use to GHG emissions in the form of a ternary diagram showing the share of energy coming from 3 sources of decreasing carbon intensities - coal, oil and gas, renewables and nuclear. The diagram on the right shows the principles; on such diagrams, the value on one axis is entirely defined by the 2 others due to the constraint that the total share is 100%.









3. IPCC SRES scenarios

The left panel shows the shares of primary energy for fossil and non-fossil fuels presented as in figure 4-11 of SRES (2000). The coloured lines show the 4 'markers' and 2 additional illustrative scenarios; the light-grey lines show the other SRES scenarios from the 4 'families'.

Notes: Missing data for 'non commercial energy' was accounted for as in the original figure, which is quite closely reproduced (with minor design differences and the exception of one non-marker scenario, possibly related to the update of the database after completion of the SRES report).

4. IPCC AR5 WGIII baseline scenarios

On the right panel, the complete set of baseline scenarios is represented by the grey and coloured lines. The coloured lines highlight scenarios with the lowest temperature increase in 2100 (all those with a temperature increase below 3.8°C above pre-industrial, an arbitrary limit for illustrative purposes). The 3 axis are identical to those of the SRES. While AR5 presents several primary energy ternary diagrams (WGIII chapter 7), a directly comparable one is not included in the report to our knowledge.

There are marked differences between SRES and AR5 baselines, with many SRES scenarios showing a move away from coal while many AR5 baselines include more coal.

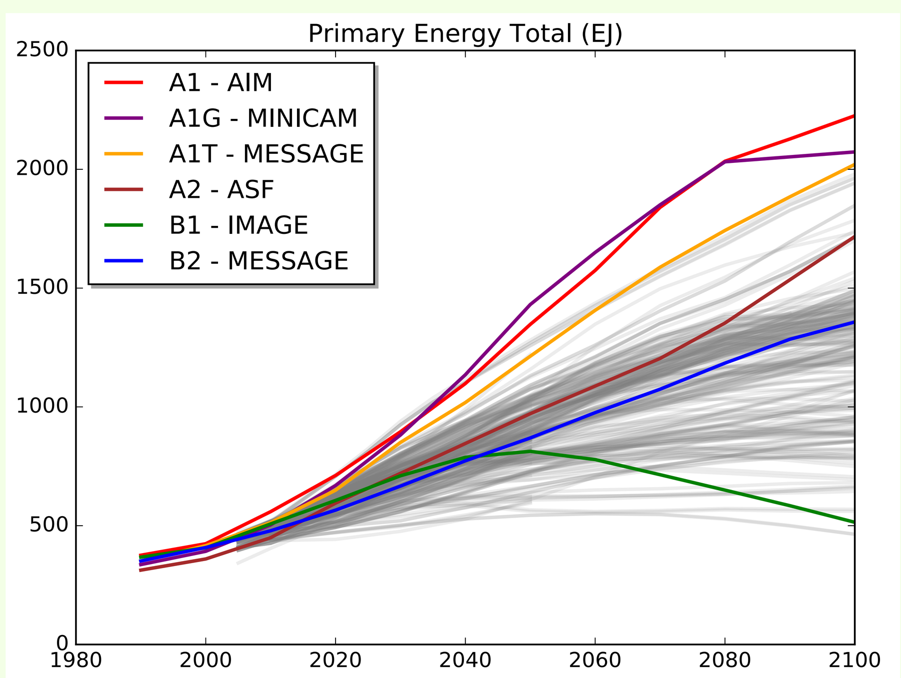
Notes: scenarios with primary energy amounts in 2010 substantially different from AR5 estimates were not included, for example in the few cases with renewables + nuclear equal to less than 8 EJ, which suggest that an energy source is missing.

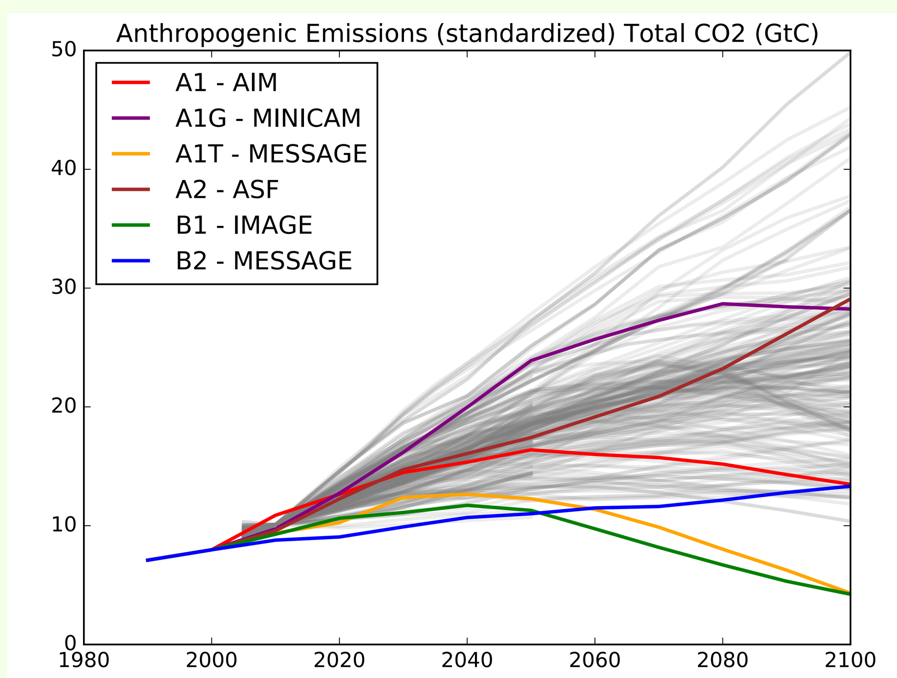
5. Comparison to AR5 mitigation scenarios

Red lines show scenarios likely (> 66% chances) below 2°C global mean temperature (GMT) increase above pre-industrial in 2100 that belong to IPCC WGIII policy categories called « idealised ». In this category, action can be immediate and have full flexibility regarding timing, location, and type (IPCC 2014b).

Green lines show scenarios likely below 2°C GMT increase (/pre-industrial) from the other categories (including scenarios with climate policies starting in 2020 or 2030 and uncategorised ones).
Blue lines show all scenarios with a least 50% chances to stay below 1.5°C in 2100. Continued or increased use of coal is made possible by CCS (Carbon Capture and Storage) in some of these scenarios.

Comparing the 3 above diagrams suggest that the evolution of the share of energy sources in scenarios such as SRES B1, A1 or A1T, with decreased coal use and increasing share of non-fossil sources, is not found in AR5 baselines. The share of energy sources in these SRES scenarios is thus closer to the share which characterises many mitigation scenarios, including some that limit GMT increase to below 2°C or even 1.5°C. Compared to these SRES cases, mitigation scenarios contain a faster move to non-fossil sources, at least for the cases that do not involve very large usage of CCS (almost absent from baselines as it is clearly motivated by mitigation).





6. World primary energy and total CO_2 emissions in baseline scenarios

The left panel shows the total world primary energy use, while the right panel shows total CO_2 emissions (including industrial and land-use related). In both panels, the coloured lines relate to the SRES markers and other illustrative scenarios, while the grey lines relate to AR5 baseline scenarios.

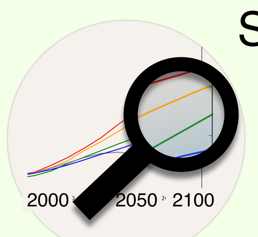
Comparing scenario generations shows that the AR5 scenarios correspond to a range of energy use that is broadly similar to the SRES, with a little less energy use in AR5 at both ends of the range (normalising using recent data may change this a little). By contrast, CO_2 emissions at the end of the century are larger in all AR5 baseline scenarios than they are in at least 2 SRES scenarios, one marker (B1) and one of the two additional illustrative scenarios (A1T). This is consistent with the ternary diagrams, and suggests that a key difference between the scenario generations is that AR5 baselines contain many scenarios in the upper part of the range of CO_2 emissions per unit of primary energy in the SRES, while the SRES contained scenarios with a larger decarbonisation of energy.

7. Tentative conclusions

Comparing SRES and AR5 baseline scenarios shows a larger usage of carbon intensive energy sources in AR5. Both the 'energy mix' (see 3. and 4.) and total energy use (see 6.) suggest that AR5 baselines broadly follow pathways similar to SRES A2. To what extent this reflects improvements in the modelling of the energy systems (which was limited in at least some of the models used for the SRES) or different hypotheses about technological progress or policies that can be included in « baseline » scenarios, remains an open question.

This question could be important, as the effort needed to satisfy a low GMT increase goal appear larger when starting from a more distant baseline. However, if the societal objectives are not limited to climate, but truly integrate a range of sustainable development goals (unlike, for example, in SRES A2), one may also wish to consider alternative ways to estimate the 'effort' needed to reach these: is it relevant to estimate the distance between an objective and a virtual 'baseline' representing a World that nobody wants, trying to isolate climate from other sustainable development goals while they are in fact interacting?

Scenario analysis tool



The databases built to facilitate access to emission scenario data have a large potential. This work is based on a new analysis tool ('ScenWorks'), which has the following objectives:

- to **facilitate the preparation of graphs** exposing features of emission scenarios and their drivers, including scenario selection based on diverse criteria that may involve calculations;
  A key aspect is modularity: to provide a framework connecting modules selecting runs, making calculations or graphs in a way that can be extended to new data and diagrams
- to ensure that every graph built with this framework **can be easily reproduced**, thanks to a dedicated « scripting language » describing all graph-specific features. The challenge is to avoid hard-coding scenario-specific data handling, so that input parameters include all information needed to build the graph (programming is in Python and SQL).

This is a work in progress; we will make it open-source if it becomes sufficiently stable. Feedback on our objectives and first achievements would be appreciated, thank you!

References: IPCC SRES (2000), Special Report on Emission Scenarios and IPCC AR5 (2014): www.ipcc.ch
● SRES scenario database: IPCC DDC, http://sedac.ipcc-data.org/ddc/sres ● AR5 WGIII scenario database: IIASA, https://tntcat.iiasa.ac.at/AR5DB ● SSP scenario database: https://tntcat.iiasa.ac.at/SspDb ● Riahi et al. (2016): The Shared Socioeconomic Pathways (…) An overview http://dx.doi.org/10.1016/j.gloenvcha.2016.05.009