ENGAGE

Exploring **N**ational and **G**lobal **A**ctions to reduce **G**reenhouse gas **E**missions

IAM perspectives on model validation and scenario feasibility - REMIND-MAgPIE

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- WP-Lead in WP3 of ENGAGE: Global pathways reflecting the Paris Agreement
- REMIND team is also developing REMIND-EU version, thus becoming both a global and national (EU/Germany) modeling team
- Furthermore, engaged in various collaborations with other national through MILES, CD-Links, COMMIT and ENGAGE projects teams

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ENGAGE capacity building workshop

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If you're interested in the REMIND-EU work, Robert Pietzcker and Renato Rodriguez are the leading colleagues here. A first paper has just been accepted and will soon be published in Applied Energy.

A focus of our past work with national teams was on the power sector and the land-use sector, and we hosted several visiting researchers from project partners at PIK, and Aman Malik from our team went to TERI for a research exchange.

Further links for REMIND and MAgPIE

Model name: **Re**gionalized **M**odel of **In**vestments and **D**evelopment (**REMIND**)
Model type: Integrated Assessment Model (coupled economy, energy, climate system)
Model documentation: https://www.pik-potsdam.de/research/transformation-pathways/models/remind ; https://www.iamcdocumentation.eu/index.php/Model_Documentation_-_REMIND , https://rse.pik-potsdam.de/doc/remind/2.1.3
Model availability: https://github.com/remindmodel/remind (not including input data)

Model name: **M**odel of **Ag**ricultural **P**roduction and its **I**mpact on the **E**nvironment (**MAgPIE**)
Model type: Integrated Assessment Model (land-use-system)
Model documentation: https://rse.pik-potsdam.de/doc/magpie/4.2.1
Peer reviewed publication: Dietrich JP, et al. (2019) *MAgPIE 4 - a modular open-source framework for modeling global land systems*. In: Geoscientific Model Development, 12 , 4. 1299-1317 p.
Model availability: Open Source at GitHub: https://github.com/magpiemodel/magpie
(input data: https://doi.org/10.5281/zenodo.3829896)

A peer-reviewed model documentation paper for REMIND is currently under open review in GMD. If interested, please have a look and contribute to the open review by adding comments to the discussion at https://gmd.copernicus.org/preprints/gmd-2021-85/

REMIND-MAgPIE: previous applications with links to validation and feasibility

Model intercomparisons: Participation in model intercomparisons, e.g. COMMIT, CD-LINKS, AR5 database, ADVANCE (VRE integration, 1.5-2°C mitigation), EMF-27, EMF30, EMF33, LIMITS / AMPERE / RoSE

Model parts: sensitivity analysis for different parts of the model:

- ⇒ **Economics:** Luderer, G. et al. "Economic Mitigation Challenges: How Further Delay Closes the Door for Achieving Climate Targets." *Environmental Research Letters* 8, no. 3 (September 1, 2013)
- ⇒ **Fossil sector:** Bauer, N. et al. "Global Fossil Energy Markets and Climate Change Mitigation – an Analysis with REMIND." *Climatic Change* 136, no. 1 (May 2016)
- ⇒ **Renewables:** Ueckerdt, F. et al. "Decarbonizing Global Power Supply under Region-Specific Consideration of Challenges and Options of Integrating Variable Renewables in the REMIND Model." *Energy Economics* 64, no. Supplement C (May 1, 2017); Pietzcker et al. „System integration of wind and solar power in Integrated Assessment Models: A cross-model evaluation of new approaches" *Energy Economics*.
- ⇒ **Feasibility of policy scenarios:** Kriegler, E., Bertram, C., Kuramochi, T., et al. (2018): Short term policies to keep the door open for Paris climate goals. - *Environmental Research Letters*, 13, 7, doi: 10.1088/1748-9326/aac4f1.

3

Please feel free to reach out to the respective lead authors or me (bertram@pik-potsdam.de) in case of specific questions regarding any of these studies.

Insights on communication

- **Up-to-date data** as basis for model calibration and for techno-economic assumption in model has become even more important, as dynamics of technology development has increased
- **Transparent communication** about model's strenghts and weaknesses helps, and is being acknowledged by many stakeholders
- Clarity in terms of **terminology** helps a lot for discussions on feasibility (geo-physical feasibility, technical feasibility, economic feasibility, political feasibility, but also concepts of „what", „when and where", and „for whom", see Jewell and Cherp 2020 https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.621)

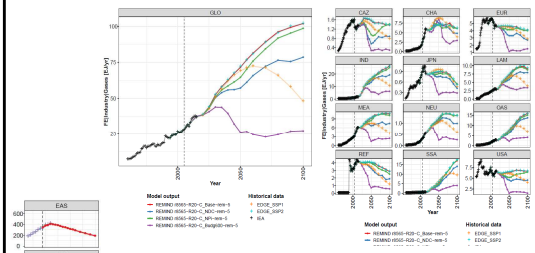
4

IAMs have been critiziced a lot for lack of up-to-date assumptions on some fast-developing technologies, thus underestimating especially PV potentials (and in turn putting excessive enfasis on technologies like nuclear and carbon capture and storage). The REMIND team, while also still underestimating the full extent of PVs dynamics from 2012-2020, consistently showed the highest potentials and widest ranges for possible PV futures, partly thanks to annual updates of the minimum bounds of what already was constructed and in the pipeline of construction.

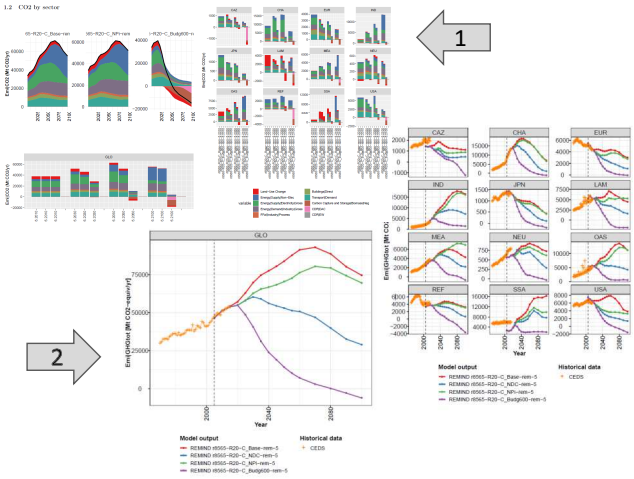
The necessary lack of granularity (temporal, geographic, sectoral) of comprehensive global models should always be acknowledged, and its implications on robust and less robust outcomes.

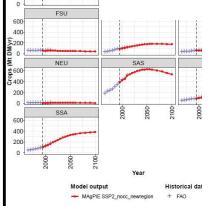
Given that the most crucial feasibility (political feasibility) is the potentially least stable concept, it makes sense to not artificially constrain the range of possible futures to narrowly, but it's important to stress the assumptions on political and societal requirements for different pathways.

Validation techniques



Model calibration: calibrate REMIND to match GDP and final energy trajectories





Model validation: automated generation of validation document including
1) plots of model results across scenarios,
2) comparision with historical data and trends and
3) trafficlight system

5

All these graphs come from big pdf files that are automatically generated after each model run and help the modeler to quickly get an overview of the key results of scenarios, and also for quickly diagnosing potential errors. The traffic-light system is used by MAgPIE for quickly identifying potential areas of concern in outcomes.

Assessment of political feasibility („Implementability")

- Bridging scenarios (*Good Practice* and *Net Zero*) have lower feasibility challenges in the „Disruption" category, and (while being inferior to immediate *cost-effective pricing* policies) considerably improve in the other four dimensions compared to the *NDC* scenario

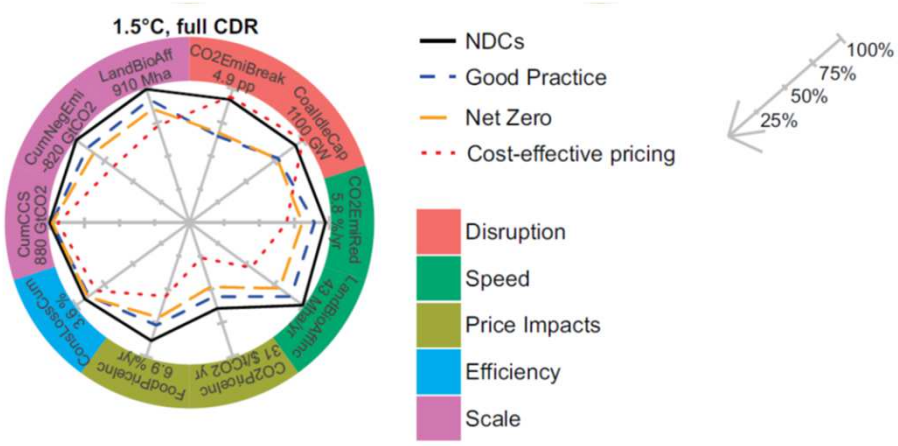


Figure 3 from Kriegler, E., Bertram, C., Kuramochi, T., et al. (2018): Short term policies to keep the door open for Paris climate goals. - *Environmental Research Letters*, 13, 7, doi: 10.1088/1748-9326/aac4f1.

6

This paper attempted to shed some light on key determinants of implementability of policy scenarios. The intuition behind it is that, all else being equal, policies are more challenging to implement, the more disruption they cause („disruption"), the faster the transitions are it would lead to („speed"), the higher price increases for food and energy would be as a result („price impacts"), the lower the overall efficiency of the policy response („efficiency"), and the larger its impact on key geo-biological systems („scale").