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Comment on egusphere-2022-885

Anonymous Referee #1

Referee comment on "Bidirectional coupling of the long-term integrated assessment model REgional Model of INvestments and Development (REMIND) v3.0.0 with the hourly power sector model Dispatch and Investment Evaluation Tool with Endogenous Renewables (DIETER) v1.0.2" by Chen Chris Gong et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-885-RC1, 2022

Gong et al. is an excellent and important article addressing urgent research needs in the integrated assessment modeling (IAM) community. IAMs results are heavily used in IPCC reports, informing global and regional mitigation pathways and energy systems projections. Power system planning and capacity expansion is a key for system-wide deep decarbonization. Driven by the rapid decline of renewable costs and the increasing role of energy storage, higher spatial and temporal resolution and feedback are necessary to inform a reasonable capacity expansion pathway. However, IAMs typically run every 5- or 10-year modeling period. In contrast, power system operations details need to be resolved at much finer scales (such as hours) to capture meaningful dynamics, especially related to intermediate capacity dispatch and energy storage operation. The authors proposed a solution to address this bottleneck via a bidirectional coupling between a well-established IAM and an hourly power sector model, allowing bidirectional feedback between the two models. Authors leveraged the advantages of both models and, more importantly, provided theoretical bases for their approach. I appreciate authors provided extensive details about their modeling approaches and designed different thought and numerical experiments to enhance the readability.

I think this paper is suitable for publication, but I appreciate authors could elaborate a little more on the following aspects:

1) This study mainly compared results between REMIND and DIETER, demonstrating good consistency. However, It could be helpful to also compare with other studies/scenarios for some simple metrics, such as the total capacity or generation in a net-zero scenario. One primary application and improvement through this study is to enhance REMIND's capability for long-term system planning, so it's straightforward to compare with existing literature and show the literature range.

2) In Appendix E, I found the solution time for the coupled run, taking 6-10 hours for a detailed configuration under a climate policy. Understandably, bidirectional coupling takes time to solve. Still, I'm concerned that this may indicate a significant barrier to moving forward someday when more regions are added or improve German with sub-national details. Plus, with more regions, power system transmission has to be considered (I think the authors already noted this). This coupled modeling framework will ultimately be limited by computation capacity despite a well-presented theory behind the model. Therefore, a section should be devoted to discussing a little more about how the authors would envision a solution for increasing computational cost.

3) To what extent the building energy demand is consistent with the weather year (and climate projections)? i.e., what are the climate scenario assumptions to determine the building cooling/heating demand?

4) For educational purposes, a brief overview (or a table like Table A1) of detailed capacity planning models for German (or the EU) will be helpful. In the "Current modeling approaches and limitation" section, the authors just indicated: "PSMs typically have narrower spatial and sectoral scopes and shorter time horizons, but provide higher resolutions and increased technological detail". A set of citations are provided in this statement, but general readers wouldn't necessarily know what those models are or what level of resolution and technological details are.

5) My last comment will be more of a philosophical question (I don't know the answer myself): REMIND is an inter-temporal optimization model (perfect foresight), and DIETER is also an optimization model. With this bidirectional coupling, this paper presents a picture of "perfect power sector planning and operation", and even a near-term capacity projection would "know" the long-term net-zero goal. In reality, however, the lock-in emission by existing energy infrastructures is a known and major issue for deep decarbonization (for example, see https://www.nature.com/articles/s41586-019-1364-3) . In other words, power system planning never has a "perfect foresight.". The basic modeling philosophy (whether having inter-temporal optimization) would have completely different real-world implications, for example, for the financial risk of stranded assets. Even though this is a methodological paper, I would love to hear the authors' opinion about how "perfect" our models should be to capture the real-world "imperfect" human decisions.

Minor

1) In Figure 4a, I suggest changing the color scheme into a two-color version (red and blue) to indicate positive and negative price differences.

2) In Figure 13, the y-axis labels in panels a and b overlap.

3) Figure 13, panel c, why is there some discontinuity between the first two modes on the left and in the right-most few hours?