INTERNATIONAL TRANSPORT ENERGY MODELING (iTEM): A COMPARISON OF NATIONAL AND INTERNATIONAL TRANSPORT ENERGY AND CLIMATE POLICY STRATEGIES AND SCENARIOS

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Overview

Models of global transport energy demand and greenhouse gas (GHG) emissions play an important role in the discussion of policy options for addressing climate change, sustainable development, and other international goals. Stakeholders in these discussions use model results to assess projected growth in transport activity and emissions, both in non-policy or BAU scenarios, and under enacted or potential policies at the national and sub-national level.

The second International Transport Energy Modeling (iTEM2) workshop, hosted by Chalmers University, was conducted in Gothenburg, Sweden (Oct 25-26, 2016). iTEM2 brought together 35 transport and energy modelers from the academic and research institutions, government, industry, and NGOs to collect and compare projections from 12 global transport energy models. In contrast to the previous, 2014, iteration of the workshop, the focus of iTEM2—and the present paper—was to include a broad set of models referenced by participants in international transport policymaking. We present a diverse set of models developed by teams from academic research groups, non-government and intergovernmental organizations, and private firms. These models have a variety of structures derived from distinct methodological traditions, and were constructed for different purposes—yet are all comprehensive, representing the transport systems of all countries of the world, either individually or in regional groups. Comparison of projections is complicated by this diversity, as the models include, for instance, both multi-sector integrated assessment, and sectoral (transport-focused) 'bottom-up' models, and because modeling teams adhere to different standards in disclosing and publishing their methods.

The iTEM2 participants reflect the range of comprehensive sources of projected transport activity, energy demand and GHG emissions available to transport policymakers. This paper contributes knowledge of the range of such projections; changes in projections over time; and relates the differences in projections to modeling methods, input data, policy assumptions and other sources.

Methods

All participating models, except Shell, submitted business-as-usual (BAU) projections. A BAU scenario can be the scenario that best represents modelers' projection of the future without major changes in existing policies. In practice, modeling such a scenario requires modelers to interpret:

- whether near-term targets with fixed dates will be renewed, extended, or tightened after those dates have passed;
- whether, and how, stated long-term policy goals will be translated into concrete policy, including whether long-term goals will be implemented using mechanisms similar to current goals; and
- how socioeconomic drivers, such as population, demographics, or GDP, will change in the future.

Most models published extensive sets of scenarios elsewhere. The policy scenarios submitted to iTEM2 in general make attempts to model a world where carbon emissions are mitigated in order to achieve the 2-degree target or 450 ppm, except Shell where Mountains and Oceans scenarios represent different views of how public policies are likely to have more (Mountains) or less (Oceans) influence on the development of cleaner fuels, improvements in energy efficiency and reductions in GHG emissions.

Other model comparison exercises, such as those led by Stanford's Energy Modeling Forum (EMF), require participating teams to adopt a predefined, common BAU scenario—including populations, GDP, oil prices, and policies—or to calibrate model outputs to an official projection such as the Annual Energy Outlook (AEO) or the World Energy Outlook (WEO). For those types of exercises, research questions focus on understanding models' behavior given common assumptions in the BAU and in the alternative scenarios.

In contrast, the iTEM2 comparisons placed emphasis on exploring the full extent of uncertainties in the BAU given the wide range of assumptions, modeling types, and modelers' beliefs regarding current policy, as reflected in their BAU scenarios. Therefore, we made no attempt to synchronize the assumptions for the BAU. Instead, we collected underlying assumptions in these models to highlight the major drivers that contribute to the divergent results in the BAU and a low-carbon policy scenarios. The policy scenarios, for those models that developed them, showed a range of potential CO_2 reductions out to 2050, based on differences in scenario assumptions, particularly those related to behaviours, technology, and cost.

Results

In the BAU scenario, the estimated total energy use range from 121-167 EJ in 2030 and 151-234 EJ in 2050 for the transport sector (Figure 1, right). The majority is liquid fossil fuel, followed by biomass liquids, electricity and natural gas in Shell and U.S. EIA's WEPS+ model (not shown). At the regional level (figures not shown), the largest variations of estimates are for China, followed by the United States and the Middle East. For most models, the policy scenarios take several years to diverge from the BAU, with noticeable reductions in total fuel use occurring in 2030-2035. Despite increases of biomass liquid, electricity, hydrogen and natural gas from very low levels, liquid fossil fuels are projected to continue to dominate transport energy demand in both the BAU and the climate policy scenarios up to 2050. In the BAU scenarios, transport CO_2 increases by 60-100% between 2010 and 2050, proportionally similar to energy growth, reflecting little decarbonization of fuels in the BAU. Of the available low-carbon scenarios available, only MoMo achieved a 2050 CO_2 level below the 2010 level. The CO_2 levels are higher than some identified as needed from transport as part of a global 2 degree scenario (e.g. IEA ETP 2017).

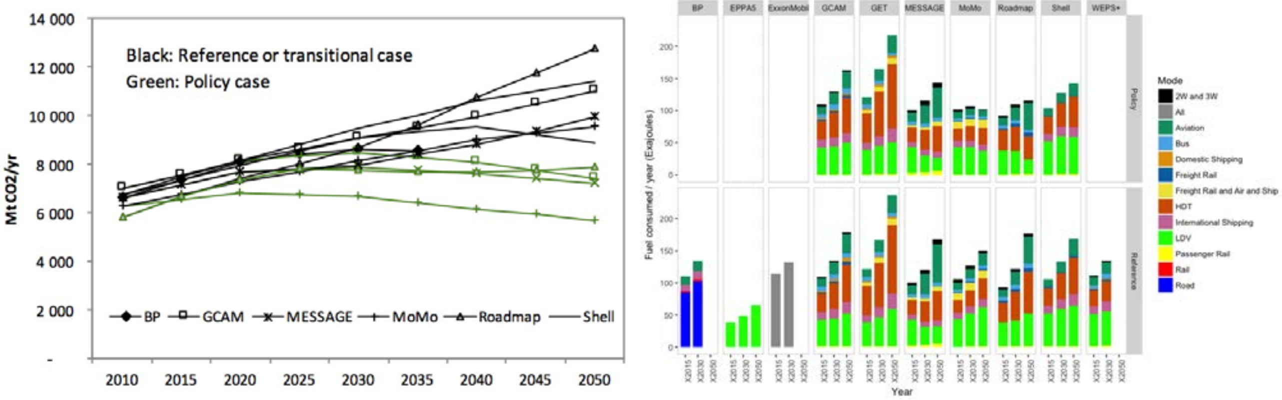

Figure 1: Transport CO_2 emissions (left) and energy use by mode (right) in the BAU and in the climate policy scenario. Models shown are BP, MIT-EPPA5, ExxonMobil, Pacific Northeast National Laboratory (PNNL)-GCAM, Chalmers-GET, International Institute of Applied Systems Analysis (IIASA)-MESSAGE, International Energy Agency (IEA)-MoMo, International Council on Clean Transportation-Roadmap, Shell, and U.S. Energy Information Administration (EIA)-WEPS+.

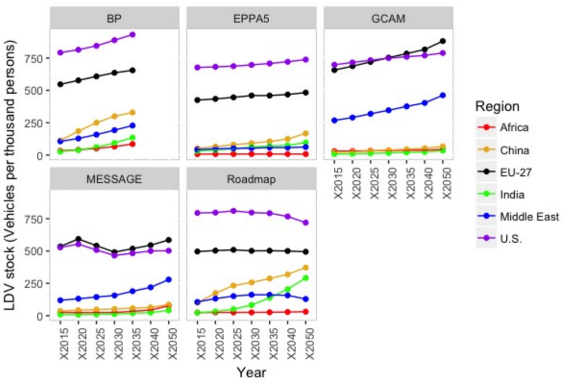

Figure 2: Projected vehicle ownership per thousand people in the reference case.

Non-light-duty-vehicle transport, particularly the aviation, shipping and truck freight modes are growing at a faster pace compared to road passenger transport, with broad consensus on this point across models (Figure 1, right). The largest uncertainties for road passenger transport come from demand growth and vehicle ownership rates. Figure 2 shows the very wide variations in estimated vehicle stock per person for selected regions by different models, reflecting different underlying assumptions and estimated relationships between population, income and ownership rates.

Conclusions

The iTEM2 comparisons affirm that reducing transport CO_2 emissions in 2050 significantly below current levels will require significant changes beyond even those envisioned by modelers' low-carbon scenarios. These changes may include as-yet-unforeseen advances in technology, altered patterns of behaviour, and strengthened climate policies and the uncertainties of those are large. Autonomous vehicles and mobility-as-a-service (MaaS) are prime examples of those possibilities. Over the next several years, as countries explore the need to scale up climate policy ambitions as part of the Nationally Determined Contribution (NDCs) and long-term low GHG emissions development strategies called for by the Paris Agreement, globally comprehensive and regionally consistent tools can aid country-focused modeling and analysis to ensure that national-level progress is consistent with global climate goals. Different countries may need to choose the type of models that will be best suited for their needs and data availability.