

Global Energy Scenarios 2050 of the World Energy Council

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In collaboration with the World Energy Council (WEC), we developed energy-economic scenarios to quantify possible pathways of future global energy system development.

In a first completed stage of the collaboration two scenarios with corresponding coherent storylines for the transport sector were analyzed with a global 15-region model. These comprise the scenario “Freeway” describing a world of limited government intervention dominated by shorter-term free-market forces, and the scenario “Tollway” envisaging a world where markets are more regulated and alternative technologies receive additional support from decision makers. These storylines and scenarios were developed in conjunction with a range of partners, including international energy suppliers and distributors, consulting companies, energy technology companies, and universities. In the first part, we present the methodology, input assumptions quantification and major results of this global mobility study. For each scenario, we show how the principal drivers of the storylines are converted into direct model input focusing on the development of assumptions on motorization rates and final useful energy. We emphasize the need for coherency of the assumptions within a scenario, especially in terms of costs dynamics of technologies and fuelling options, which are the main determinants of the results.

The applied overall methodology is a MARKAL-type cost-optimization of the energy system. We use endogenous technology learning (ETL) of key technologies, for example for electric batteries, which store energy in different hybridisation options and pure electric drivetrains.

Among results, we present shares of the technology options and the used fuels in the transport sector, and the corresponding emission pathways. For example, Figure 1 depicts the regional breakdown of CO₂-emissions in the scenario “Freeway”; the developing world accounts for the major share of emissions in 2050, whereas the developed world is almost stagnating; in this scenario, the use of alternative fuels, for example natural gas and biogas is limited, mainly caused by limited infrastructure and by market power. Figure 2 depicts the use of fuels in the personal transport subsector in the scenario “Tollway” for the Latin American and Caribbean region. In this region, a larger deployment of natural gas-fuelled vehicles becomes cost-effective, and biofuels can take a significant share due to the relatively large potential of biomass. Some of the results of the study were previously presented in a report „Global Transport Scenarios 2050“; see the following link:

http://www.worldenergy.org/documents/wec_transport_scenarios_2050.pdf.

In relation to this report, we present the underlying methodology of the study; we go into some more detail on the quantitative scenario assumptions and relate directly some major quantitative input with output results, which is not fully elaborated in the non-technical report.

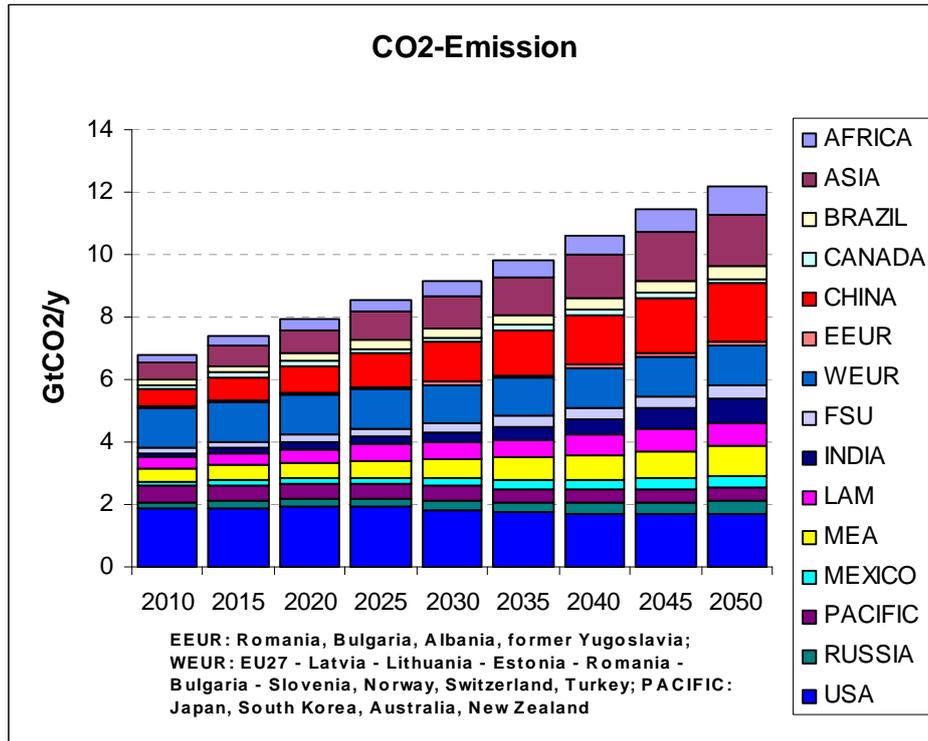


Figure 1: CO₂-Emissions from the transport sector by regions (WEC Global Transport Scenarios 2050). Results are for scenario “Freeway”, which has some similarities to a dynamics-as-usual scenario. In this scenario, growth of carbon emissions is mostly in developing regions.

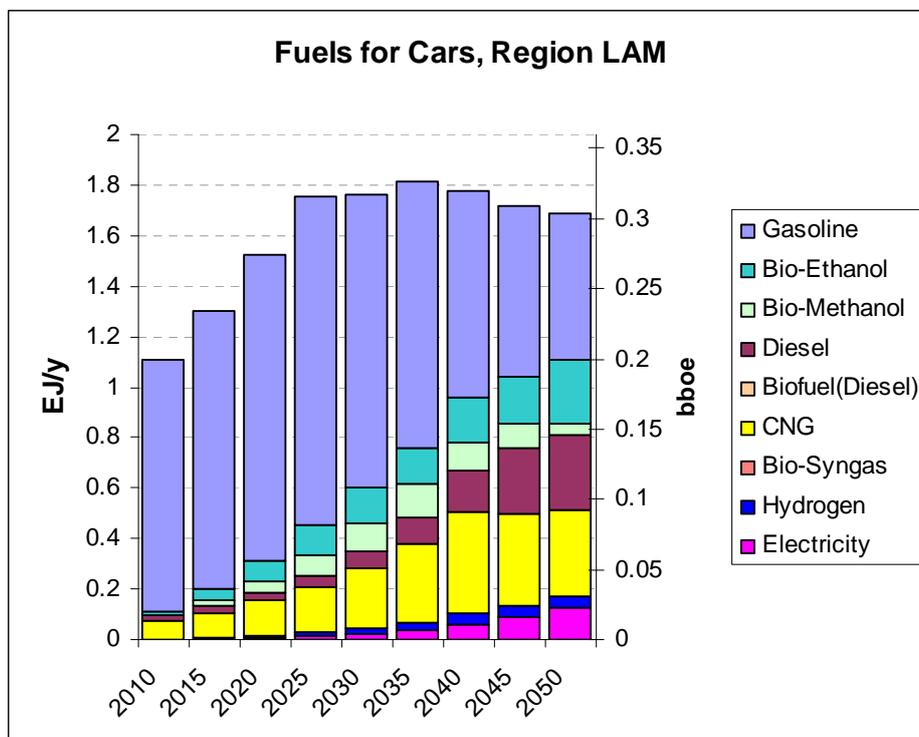


Figure 2: Fuels for personal cars in the transport sector (WEC Global Transport Scenarios 2050) for the world region LAM (Latin America and Caribbean, excluding

Brazil) in scenario „Tollway“. The scenario “Tollway” has relatively large government support of carbon reduction measures, more support for R&D of alternative drivetrains and more emphasis on domestic energy security (e.g. biofuels).

In a second part of the presentation, we broaden the view to scenarios for the whole global energy system until the year 2050. Different trajectories of the energy system are again envisaged with narrative storylines, which are transferred into a coherent set of quantitative scenario assumptions. To quantify and analyze the scenarios under the imposed constraints and assumptions, we use the global multiregional MARKAL (GMM) model, which optimizes the choice of technologies and fuels across the energy system to yield a least-cost solution. The model captures the relevant energy flows of IEA’s energy statistics balances by an aggregated set of flows and energy carriers; the reference energy system is kept relatively simple structured to facilitate the analysis of the drivers of results. Cost assumptions of major future technologies are modelled with endogenous technology learning, where key components are clustered to profit from global learning as an aggregate over all regions. Long-term issues, for example fossil resource depletion, are taken into account by an internal 100-year time horizon and corresponding supply curves.

We present the main input assumptions. In particular, we show how both current and possible future energy technologies are included in the model with their scenario-specific characteristics as well as the availability of renewable and fossil resources and energy demand projections in the different scenarios. In particular, we elaborate how the different modelling of the world regions captures the confluent dynamics of the developed and the developing world. Recent developments are incorporated into the scenario assumptions, for example the advent of cheap shale gas, and the recent developments in prices for PV installation.

We show how the scenario quantification provides a deeper insight into the implications of different scenario storylines, for example, shale gas is a major driver in North America and China, whereas the drop in PV costs has mainly a short- to mid-term impact on renewable generation. The aim is the identification of robust trends and of key drivers of the global energy system to support understanding of different options for regional and global decision makers. In the presentation, we give an overview of the identified main drivers obtained by preliminary model runs: for example, economic growth, availability of Carbon Capture, Utilization and Sequestration (CCUS), and climate change policies. We present also a range of the indicators for different aspects of sustainability for each of the scenarios: examples include indicators of economic aspects, energy access, energy security, and environmental impacts.

Publications related to the current project collaboration and model:

- WEC Global Transport Scenarios 2050 (2011), *World Energy Council*, Project Partners: Paul Scherrer Institute (PSI), IBM. ISBN: 978-0-946121-14-4
- Densing, M., Turton, H., Bäuml, G. (2012). Conditions for the successful deployment of electric vehicles – A global energy system perspective, *Energy*, **47**, 137-149