Long-Term Technology Diffusion and Near-Term Implications under Stringent Climate Change Control

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Outline

- Multi-model comparison exercise on global technology diffusion: what are the technologies needed to reach stringent climate goals?
- Several single-model exercises with the TIAM-ECN model: what are the changes required in the transport sector, what are the effects in terms of employment associated with the use of renewables?

NSS 2014

Nuclear
Security
Summit
2014 The Hague

The Nuclear Security Summit 2014 was held in The Hague earlier this week.

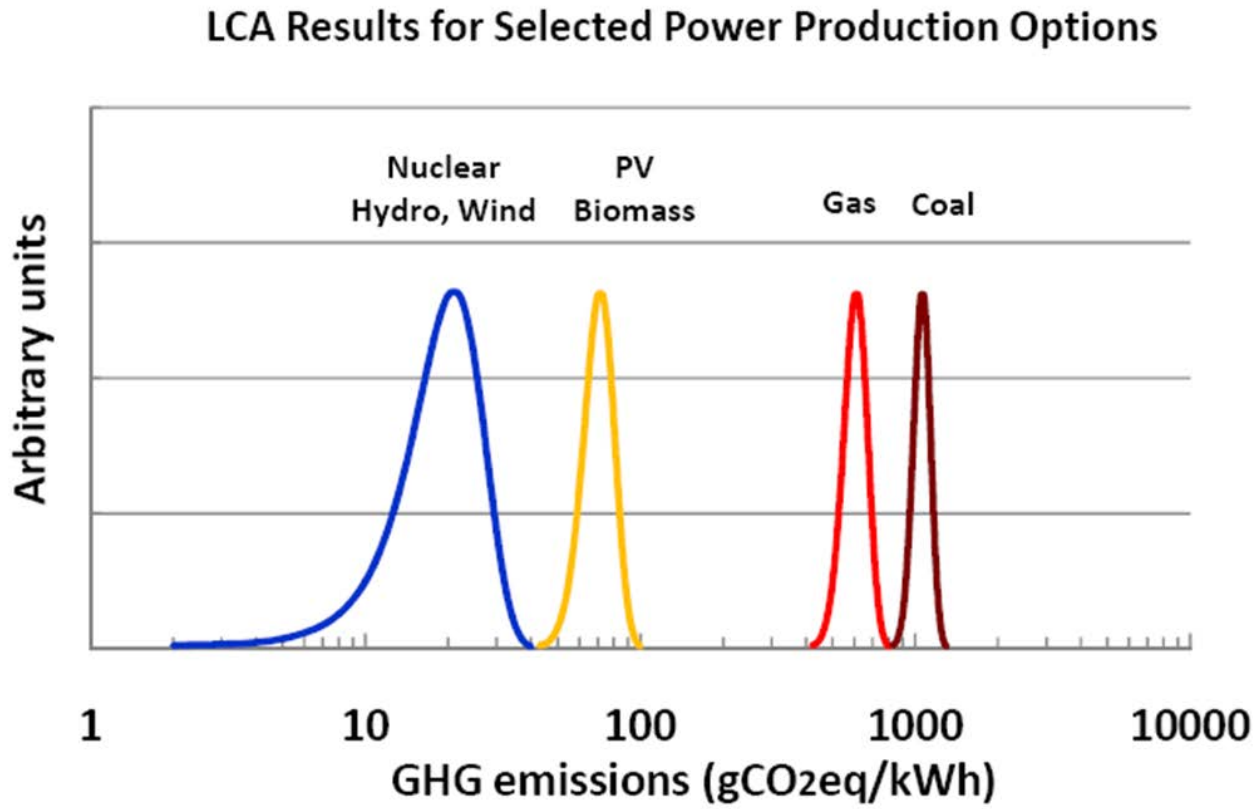
Nuclear terrorism

- The need for large summits like the NSS shows again that nuclear energy possesses intrinsic risks that seriously impede its role in meeting expanding global energy requirements.
- In addition to risks for nuclear terrorism, the ‘classical’ drawbacks associated with nuclear power are: radioactive waste, reactor accidents, nuclear proliferation (and lack of disarmament).

Nuclear energy

- Nuclear energy still possesses a number of advantages, in terms of e.g. energy security, air pollution, and economics (under conditions).
- This is why the use of nuclear power globally is currently expanding, even while some countries have decided to phase it out.
- Also, progress is being booked on all aforementioned obstacles and handicaps of nuclear power.
- If over the next couple of years world leaders can agree on the adoption of a global climate treaty or stringent regional climate action, then nuclear energy is likely to benefit substantially.

Carbon footprint of nuclear energy



LIMITS project

- Large FP7 project from the European Commission (DG CLIMA, 10 partners, total EU contribution 3.5 M€, FEEM coordinator).
- “Low Climate Impact Scenarios and the Implications of Required Tight Emission Control Strategies”.
- 6 core models: GCAM (PNNL), IMAGE (PBL / Utrecht University), MESSAGE (IIASA), REMIND (PIK), TIAM-ECN (ECN) and WITCH (FEEM).
- The goal is to analyze the feasibility of meeting a 2°C climate target, as well as the required technologies, costs and regional implications.

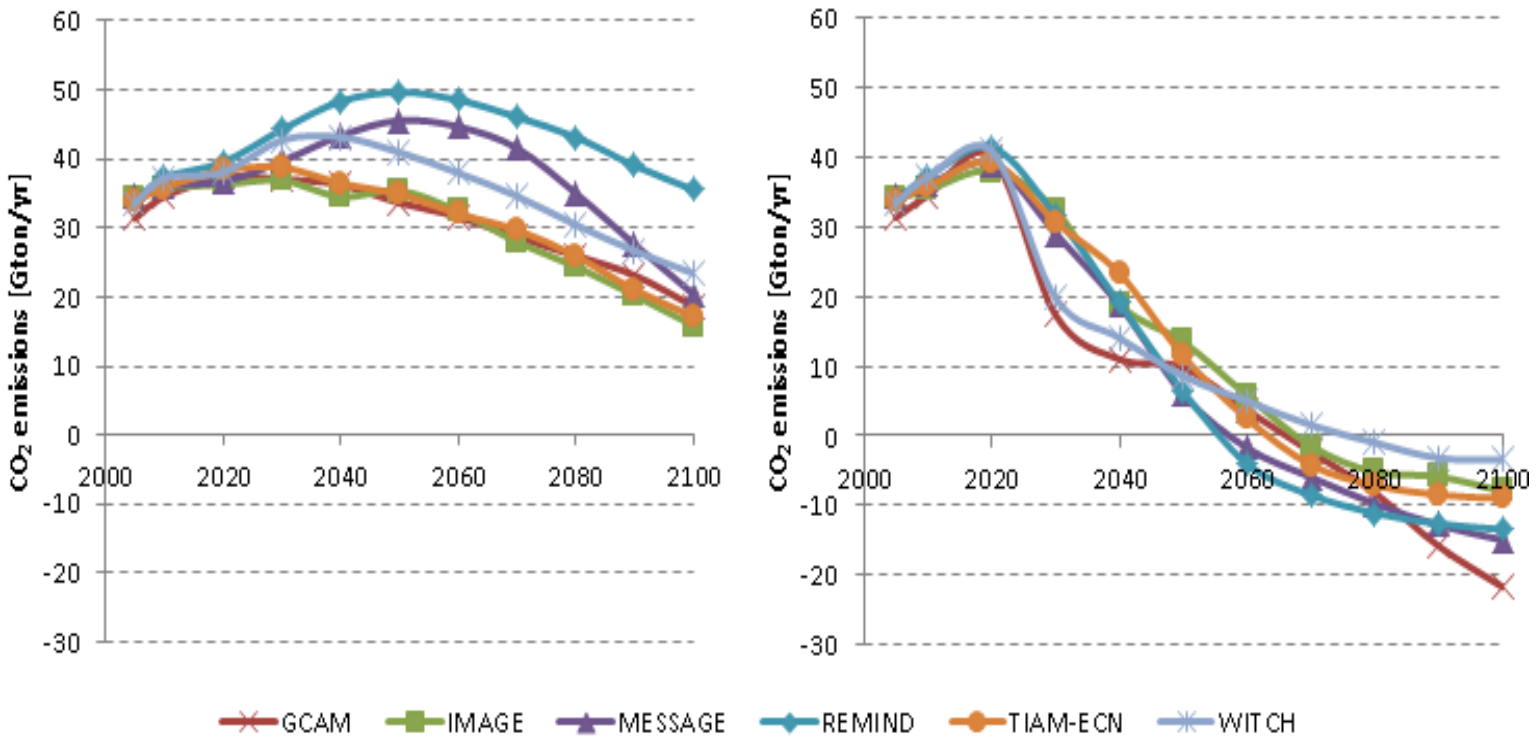
LIMITS scenarios

- **Base:** Baseline (BAU) involving no climate policies and a large-scale continuation of fossil fuel usage for all main energy services.

- **StrPol**: Stringent regional climate and energy policies with enhanced Copenhagen Accord ('plus') pledges during the 21st century.

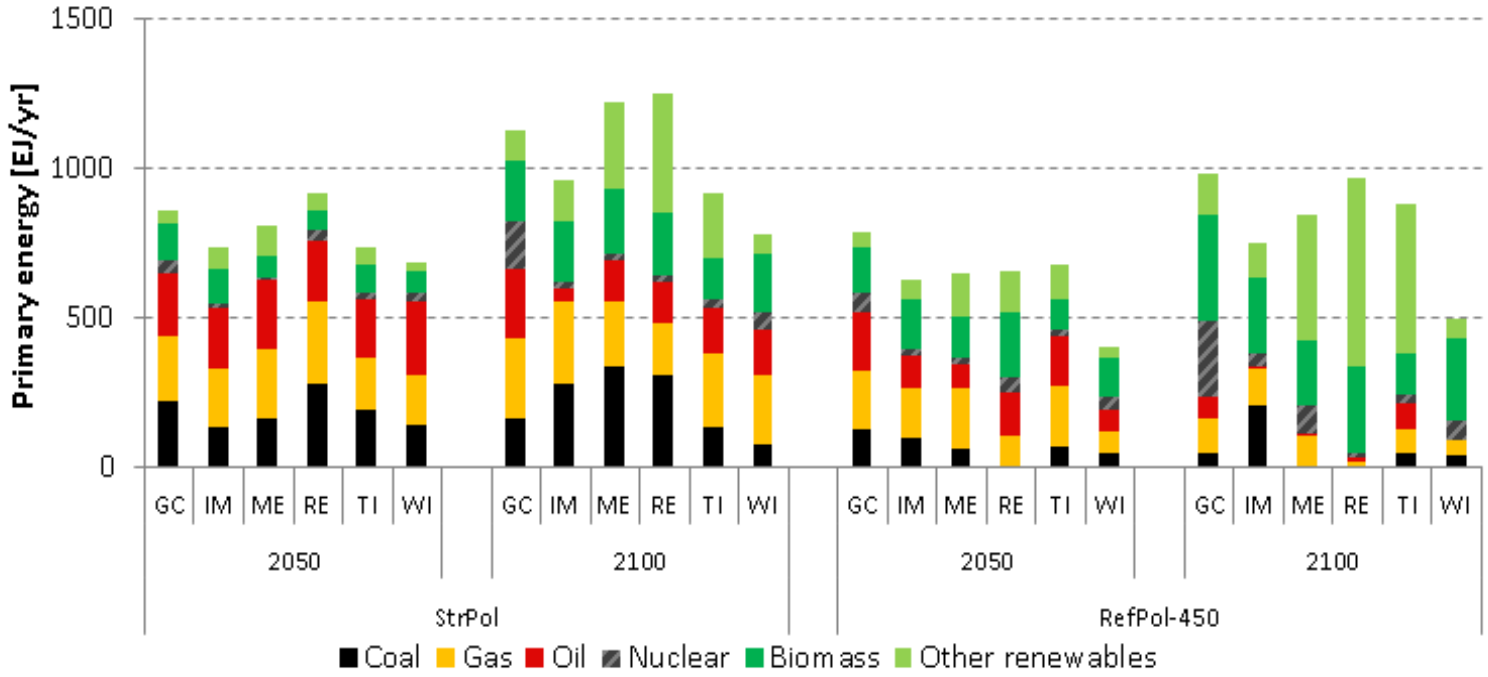
- **RefPol-450**: Reference regional climate policies (Copenhagen pledges) until 2020 and global coordinated action to 2.8 W/m2 from 2020.

CO_2 emissions



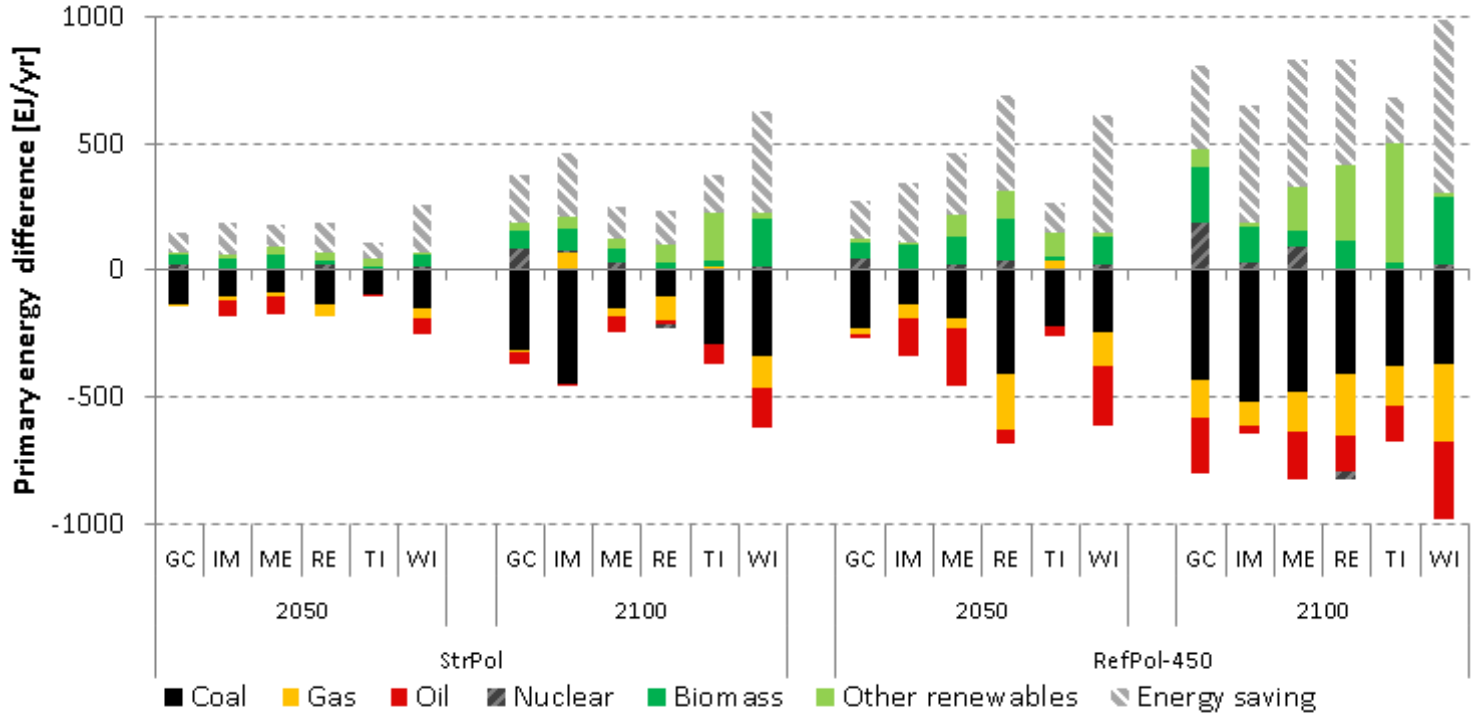
Global CO_2 emissions in scenarios StrPol (left) and RefPol-450 (right).

Primary energy



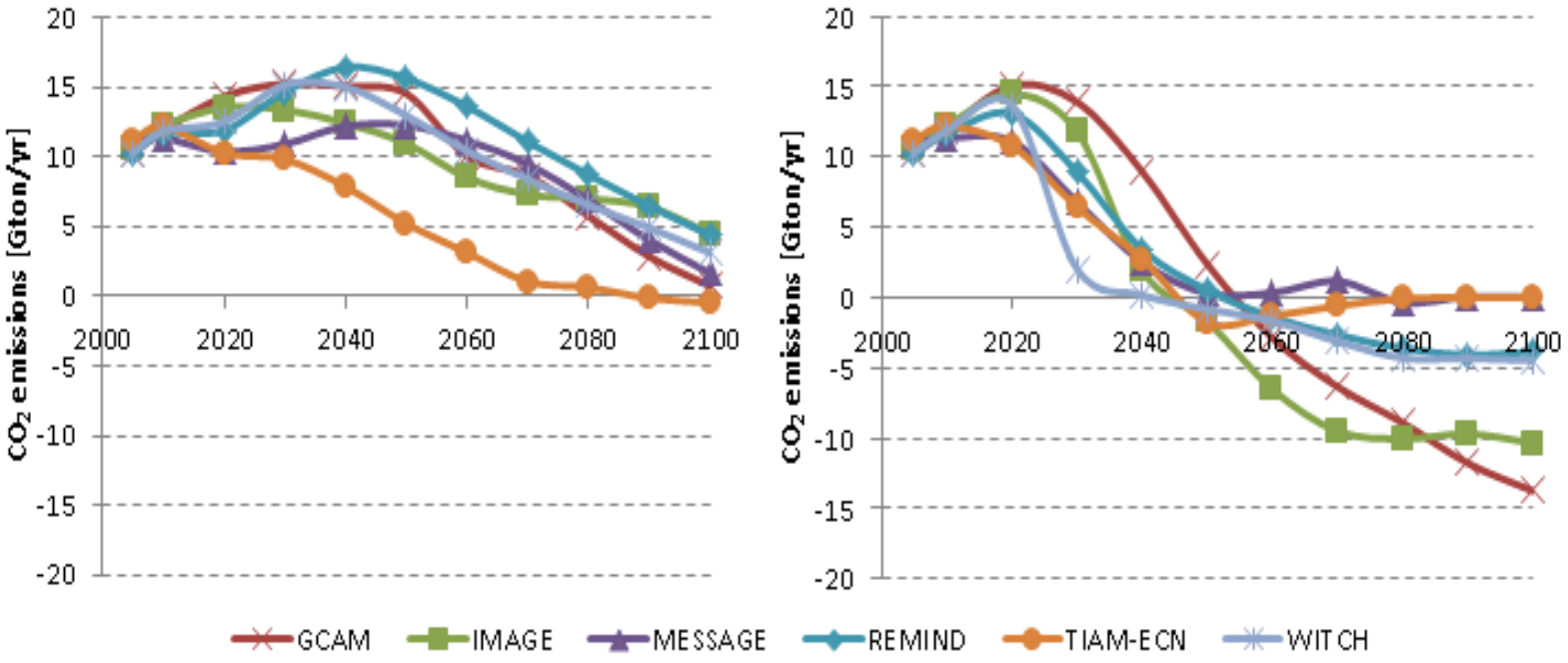
Global primary energy use in 2050 and 2100 in scenarios StrPol and RefPol-450.

Primary energy change



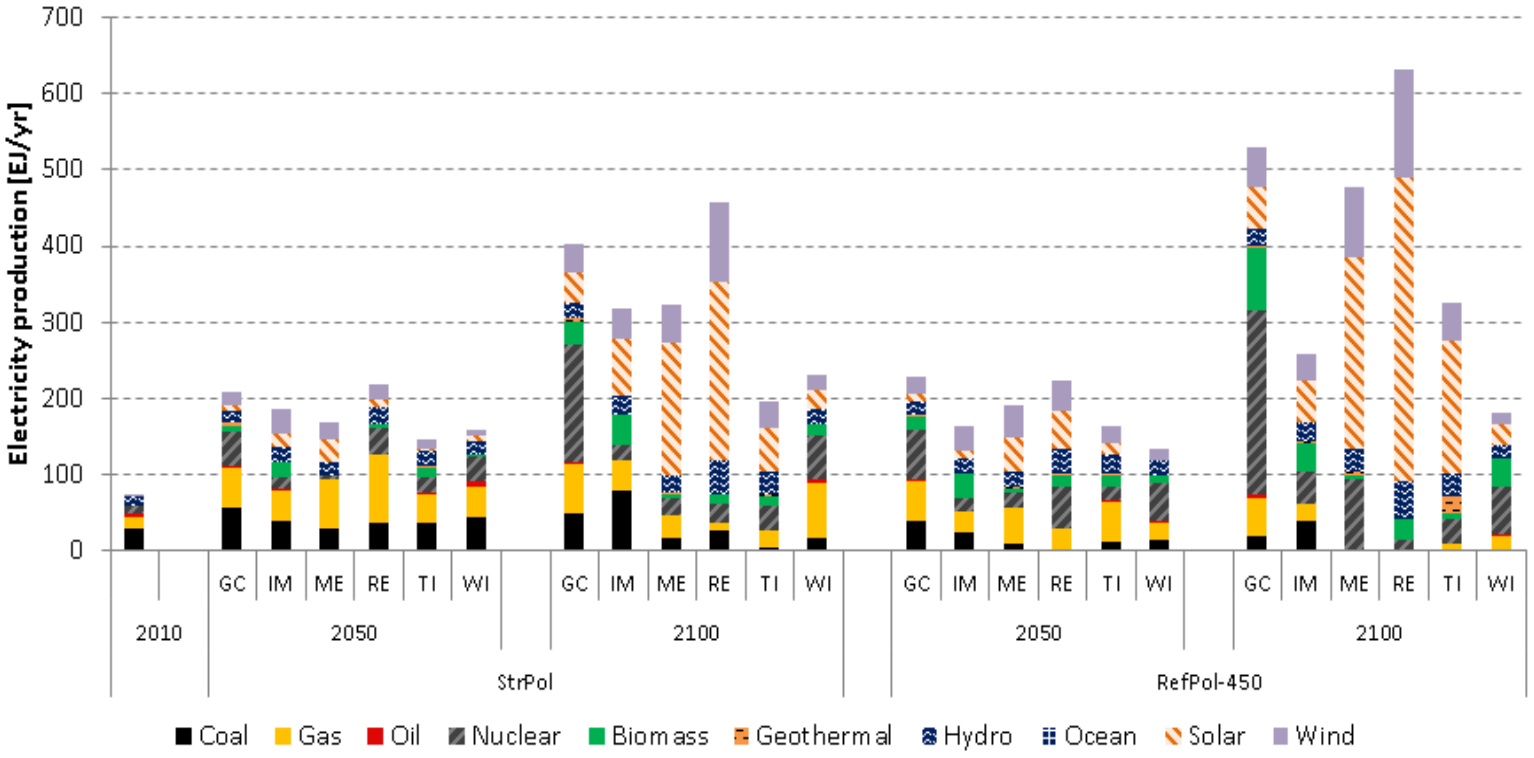
Global primary energy change from Base to scenarios StrPol and RefPol-450.

Power sector CO_2 emissions



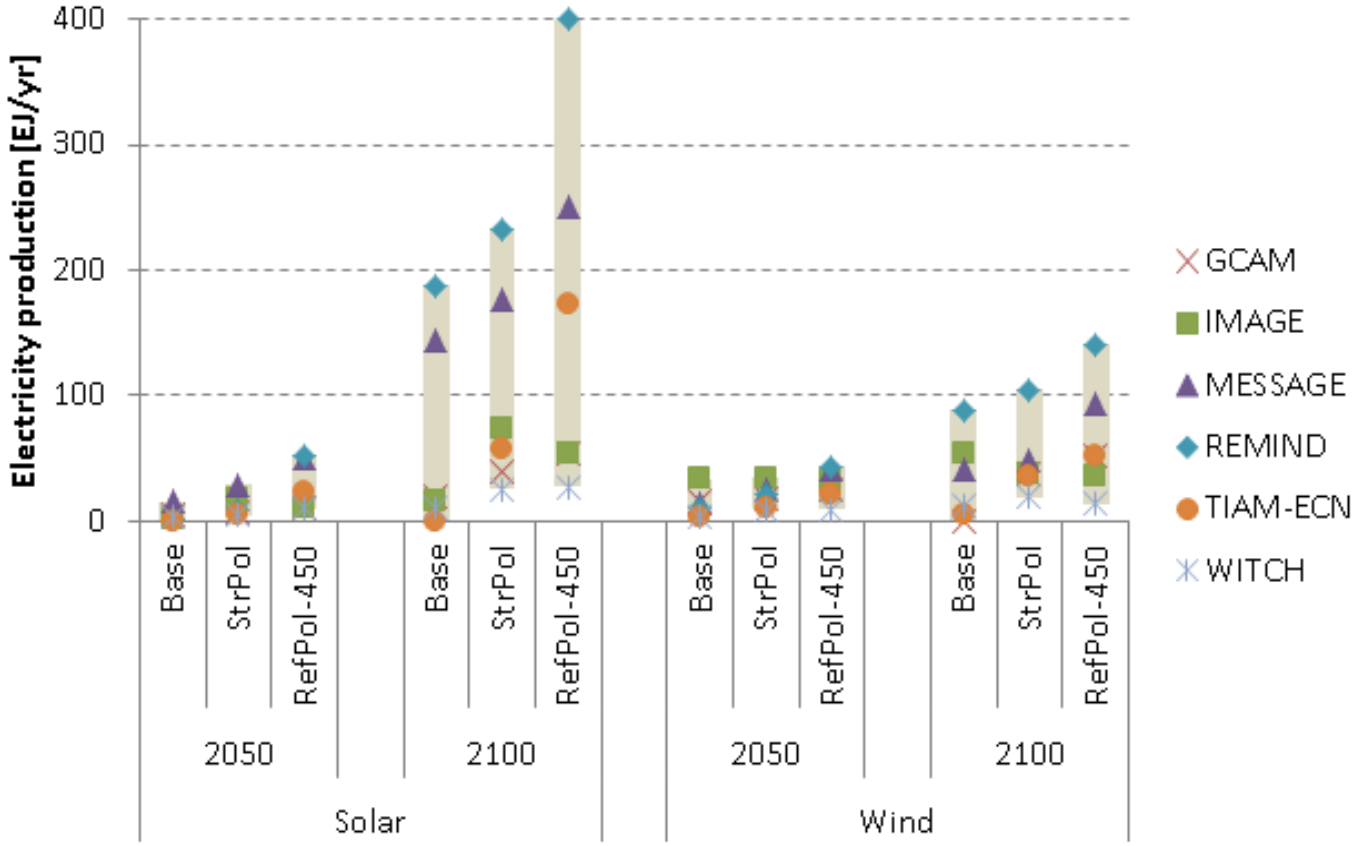
CO_2 emissions in the power sector for scenarios StrPol (left) and RefPol-450 (right).

Electricity production mix



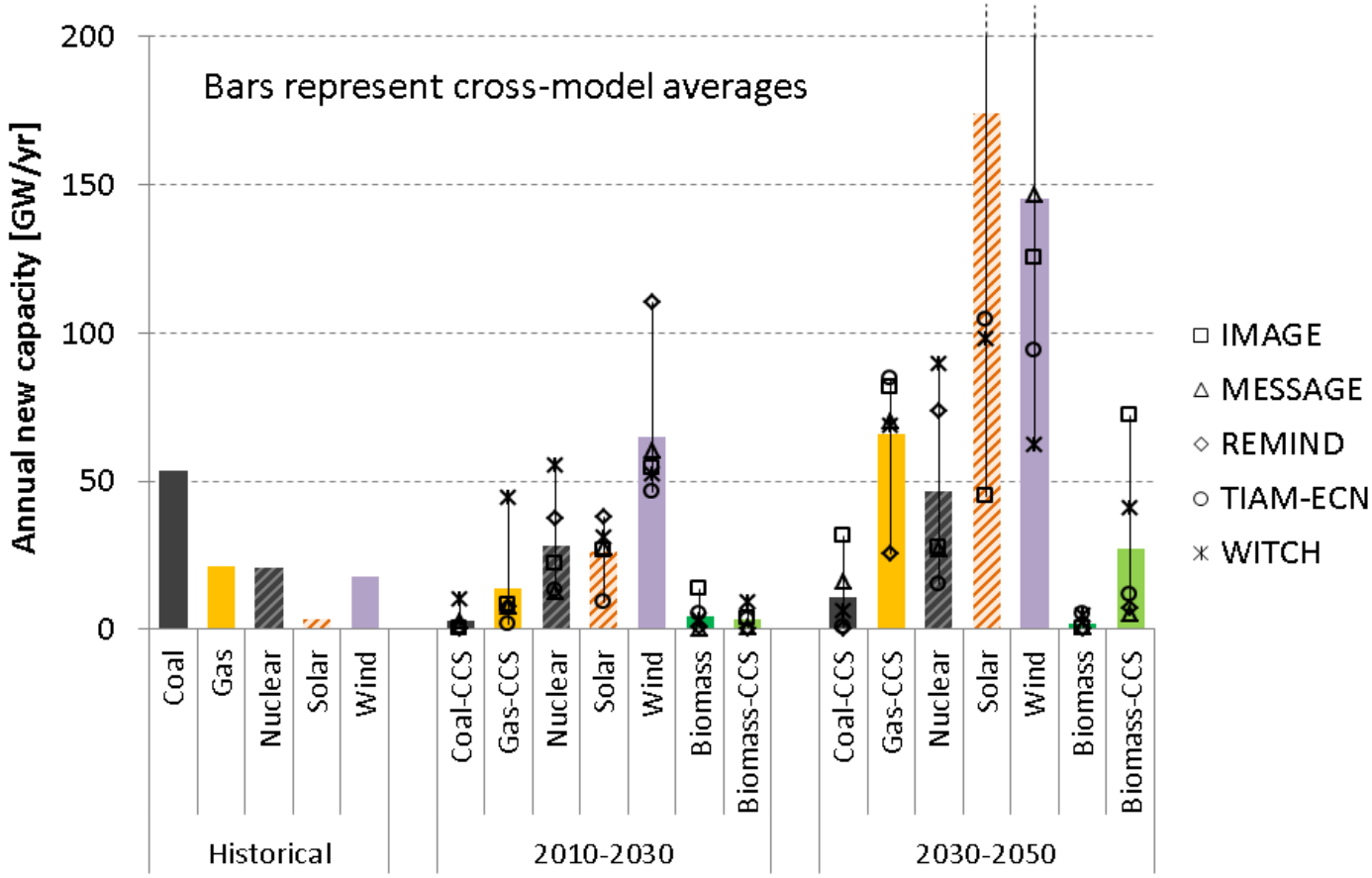
Electricity production mix in 2050 and 2100 for scenarios StrPol (left) and RefPol-450 (right).

Solar and wind power



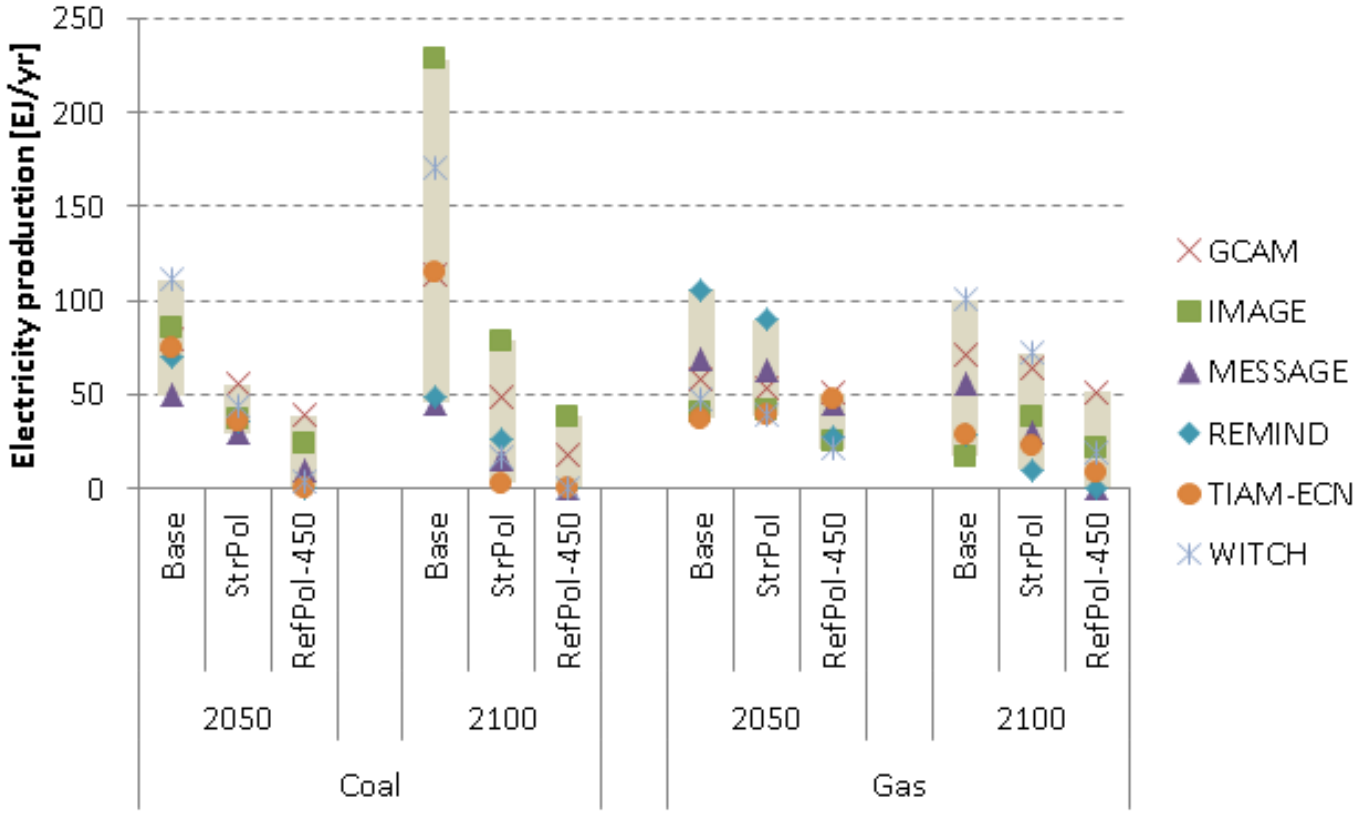
Electricity production from solar and wind energy in 2050 and 2100 in scenarios Base, StrPol and RefPol-450.

Annual capacity additions



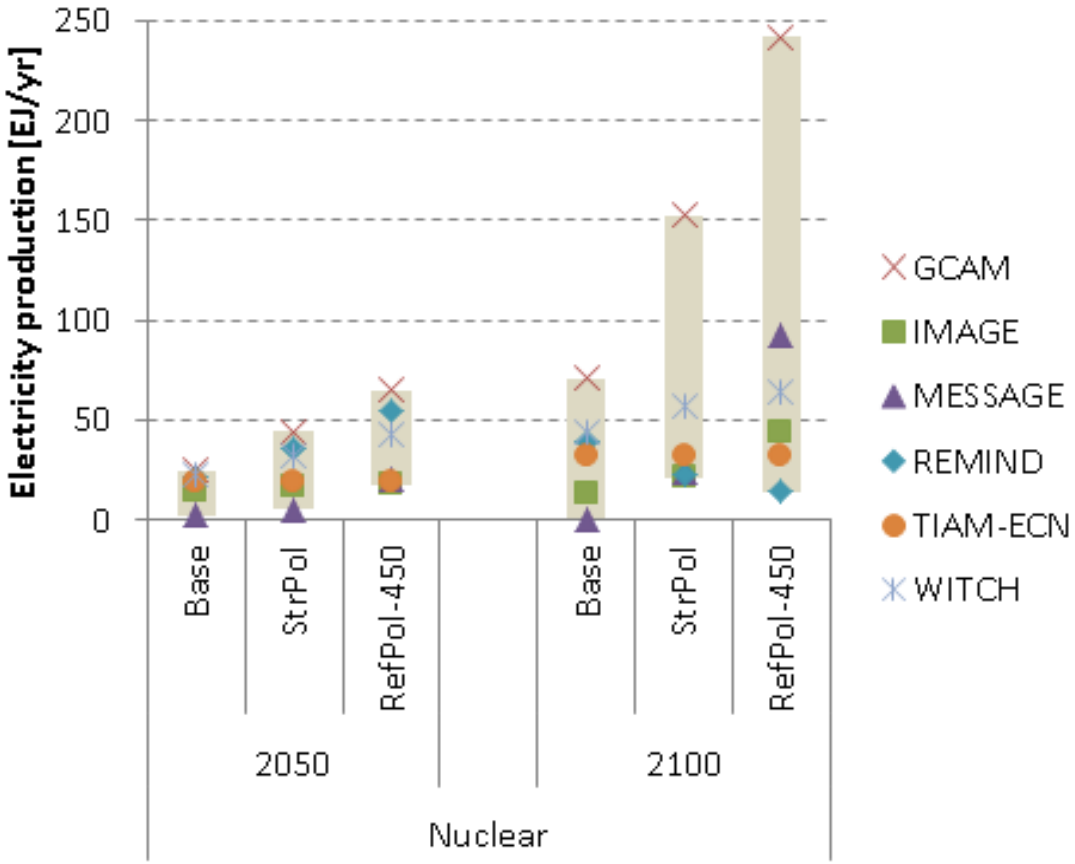
Average annual capacity additions (history and short to medium term future) for various fossil-based and low-carbon energy technologies in the RefPol-450 scenario.

Coal and gas power



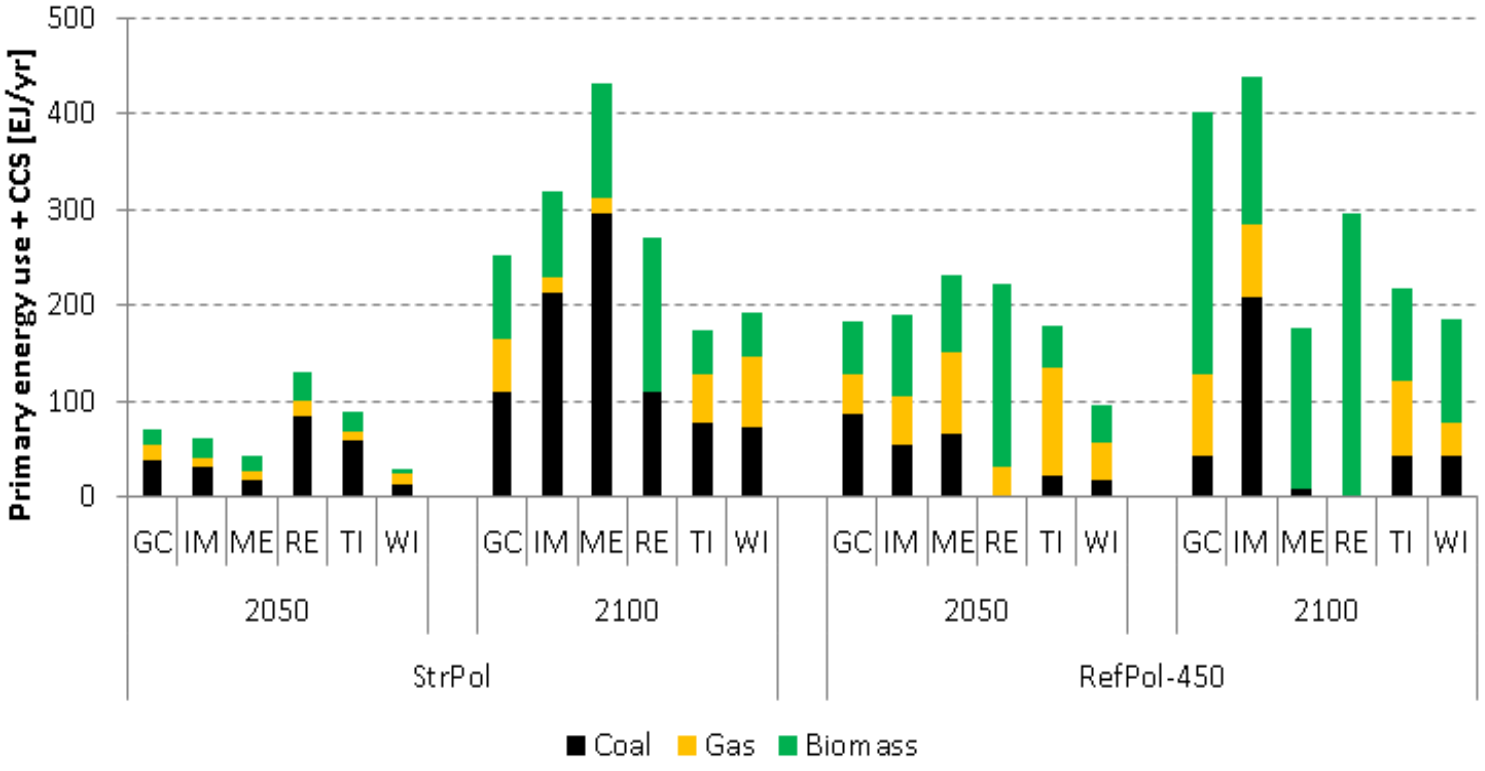
Electricity production from coal and gas plants in 2050 and 2100 in scenarios Base, StrPol and RefPol-450.

Nuclear power



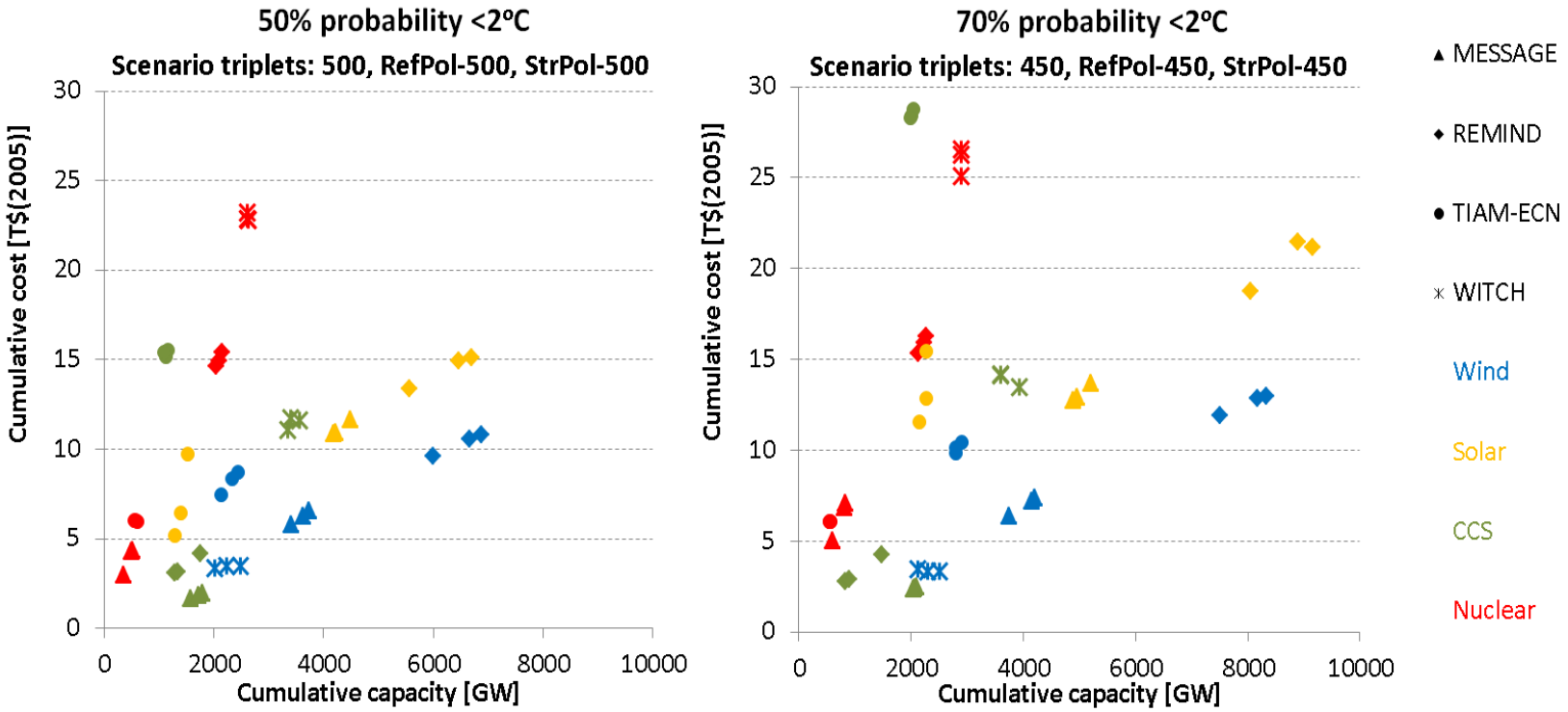
Nuclear power production in 2050 and 2100 in scenarios Base, StrPol and RefPol-450.

Primary energy with CCS



Primary energy use in combination with CCS
in scenarios StrPol and RefPol-450.

Technology cost versus capacity



Cumulative cost versus capacity until 2050 for four low-carbon power supply options in scenarios 500, RefPol-500 and StrPol-500, respectively, scenarios 450, RefPol-450 and StrPol-450.

Main technology insights LIMITS

- In order to reach a 2˚C climate change control target, CO_2 emission reductions need to be much larger than under the (enhanced) Copenhagen pledges: CO_2 emissions need to become negative some time during the second half of the century.
- Fossil fuels need to be reduced substantially, but need not to be phased out, since CCS can compensate for their emissions; because from 2050 e.g. the power sector needs to generate negative CO_2 emissions, biomass plus CCS could become a (challenging) necessity.
- Our models foresee varying scales for the diffusion of different low-carbon energy technologies, which expresses the multitude of pathways to get to 2˚C, hence the public sector may not need to pick winners but rather should design generic low-carbon energy policy.
- The private sector needs to prepare for massive renewable power, new fuels and CCS diffusion and R&D over the next several decades.

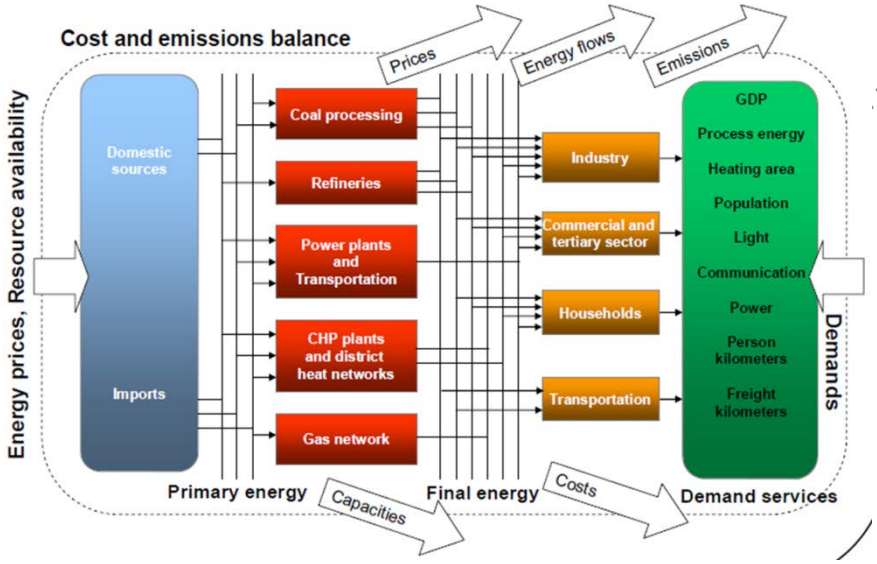
Energy technologies versus systems

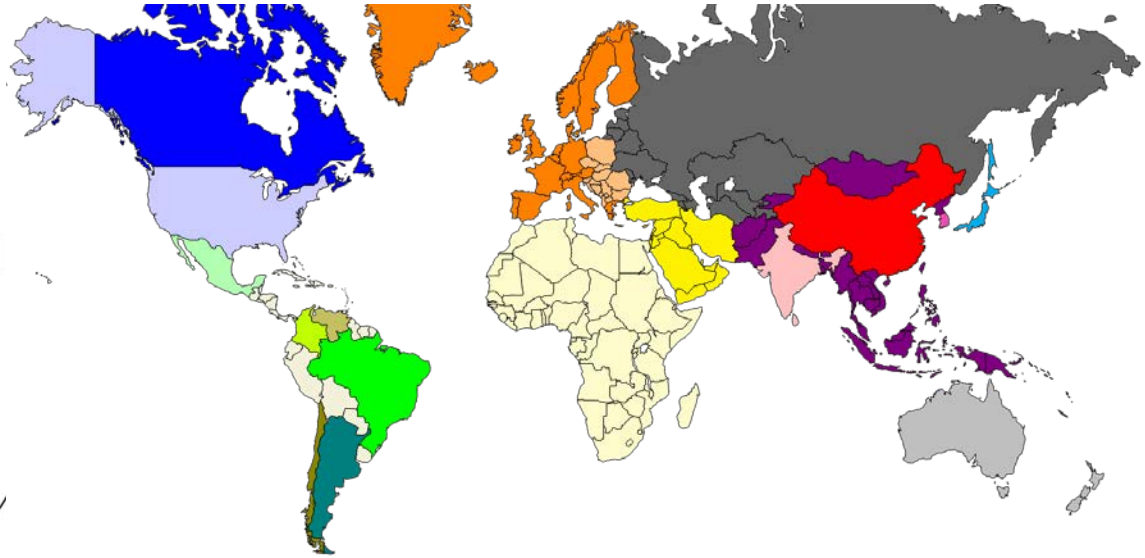
- Technologies never operate alone, but are always part of larger energy infrastructures, and depend on e.g. resource availabilities.
- Hence, in addition to performing analyses of individual energy options – which we do at ECN – one should study technologies as components of larger systems.

- This is what we (**Tom Kober** and **Hilke Rösler)** do with the bottom-up technology-rich integrated assessment model **TIAM-ECN**.

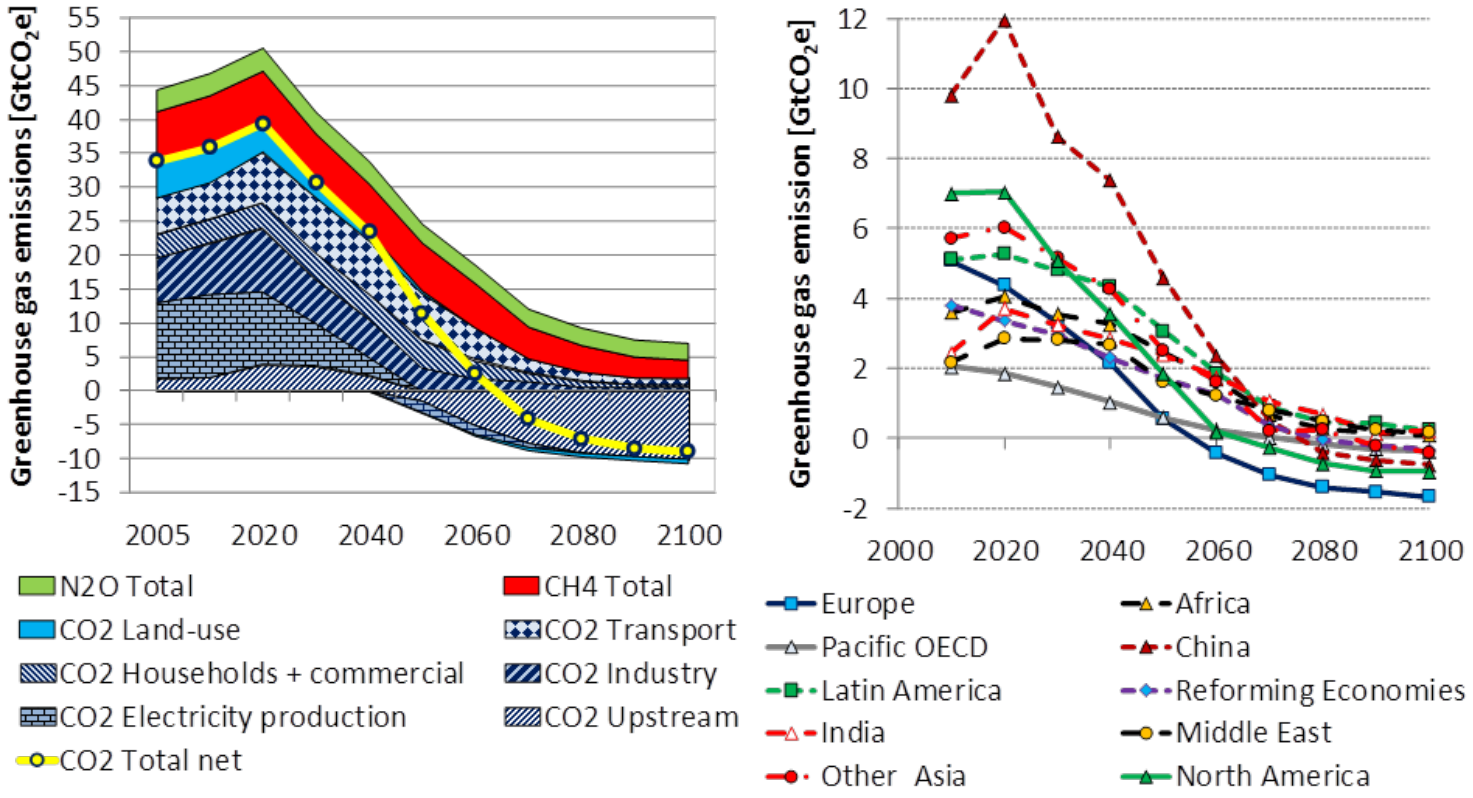
Energy system model: TIAM-ECN

- Linear programming energy system cost minimization model.
- Many energy technologies (thousands) in all main sectors.
- Particular strength in power and transport sector (recent projects).
- Special module to reflect main climate dynamics.
- Global coverage with regional disaggregation (20 regions).



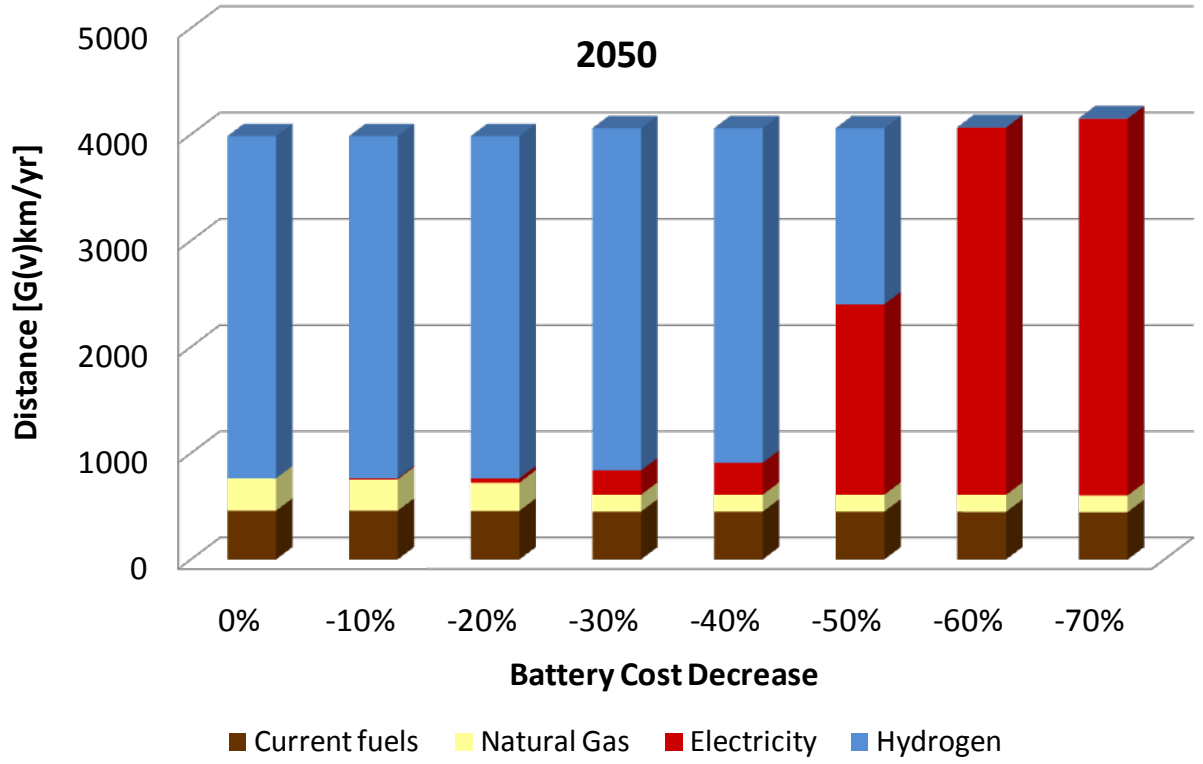


TIAM-ECN: 2°C climate change target



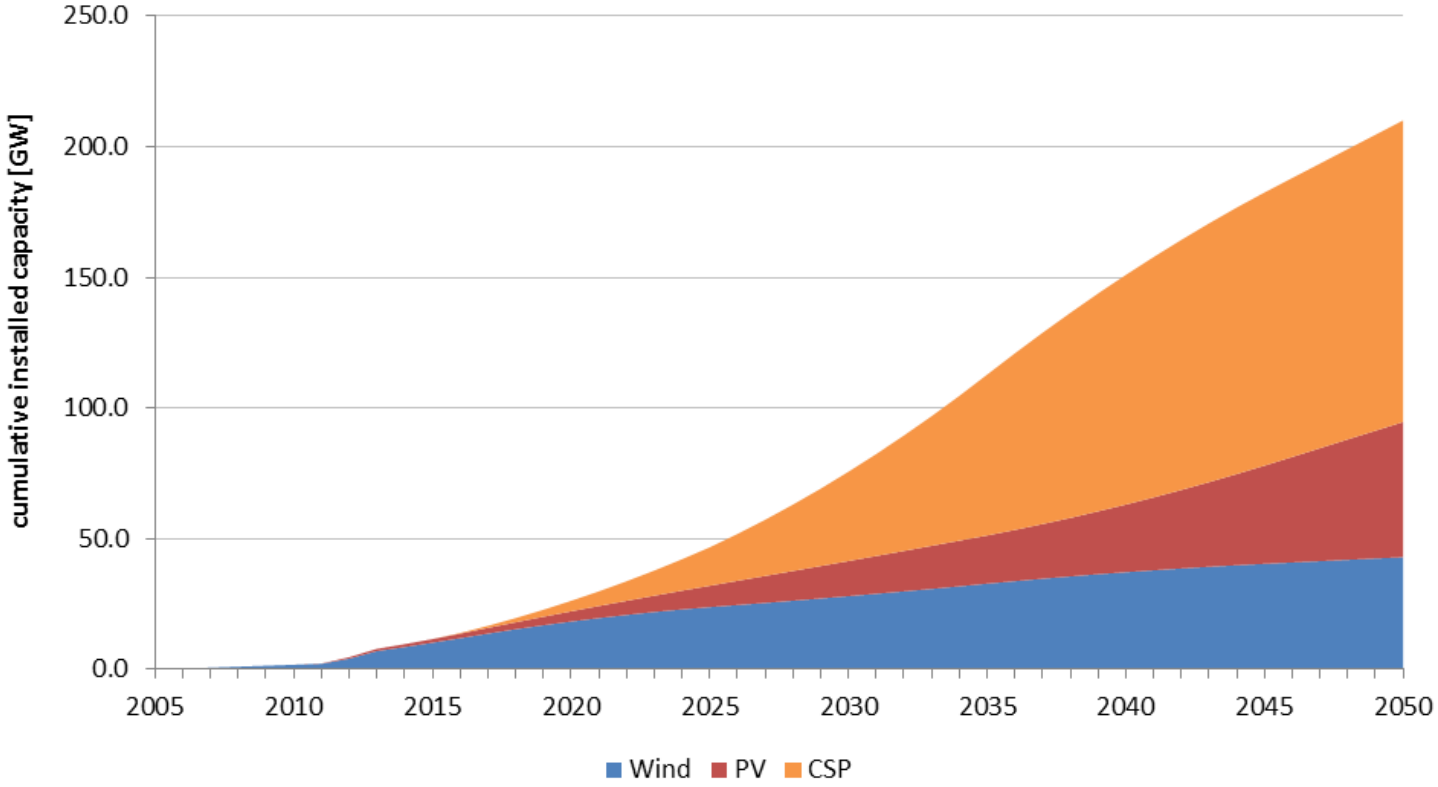
Global GHG emissions by type / sectors (left) and regions (right) in a BAU scenario achieving 2.8 W/m2 climate forcing with least-cost long-term mitigation efforts.

TIAM-ECN: car diffusion in Europe



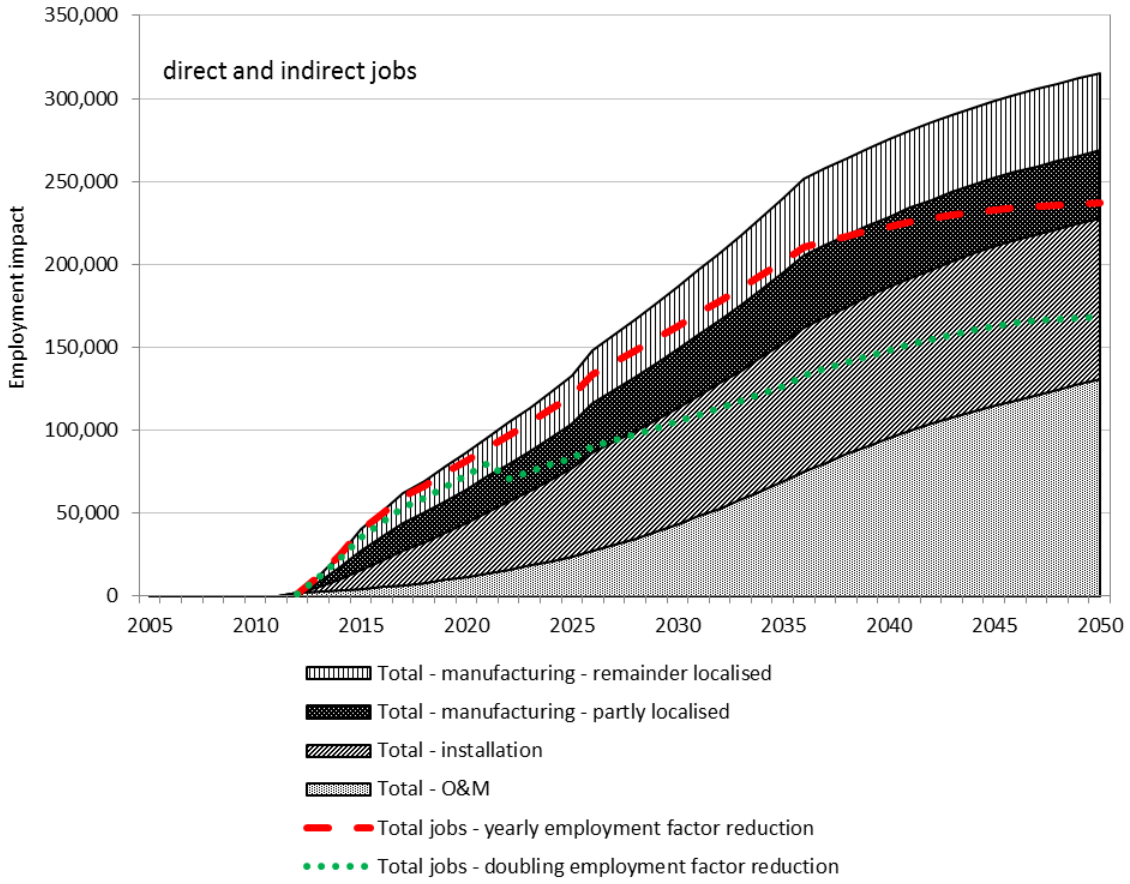
Distance travelled in 2050 by type of energy carrier (in G(v)km/yr) for passenger cars in Europe under stringent climate policy and 100 $/bl oil prices with varying assumptions for the cost of batteries (in % reduction relative to the baseline).

TIAM-ECN and the Middle East



Cumulative capacity for three renewable energy technologies for the Middle East.

Renewable energy employment



Total direct and indirect renewable energy employment in the Middle East.

Selected publications

- van der Zwaan, B.C.C., “The Role of Nuclear Power in Mitigating Emissions from Electricity Generation”, Energy Strategy Reviews, 1, 2013, pp.296-301.
- van der Zwaan, B.C.C., H. Rösler, T. Kober, T. Aboumahboub, K.V. Calvin, D.E.H.J. Gernaat, G. Marangoni, D.L. McCollum, “A Cross-Model Comparison of Global Long-Term Technology Diffusion under a 2°C Climate Change Control Target”, Climate Change Economics, 2014, forthcoming.
- Kober, T., B.C.C. van der Zwaan, H. Rösler, “Emission Certificate Trade and Costs under Regional Burden-Sharing Regimes for a 2˚C Climate Change Control Target”, Climate Change Economics, 2014, forthcoming.
- Rösler, H., B.C.C. van der Zwaan, I.J. Keppo and J.J.C. Bruggink, “Electricity versus Hydrogen for Passenger Cars under Stringent Climate Change Control”, Sustainable Energy Technologies and Assessments, 5, 2014, pp.106-118.
- van der Zwaan, B.C.C., L. Cameron, T. Kober, “Potential for Renewable Energy Jobs in the Middle East”, Energy Policy, 60, 2013, pp.296-304.