Alternative pathways for deep emission reductions with low energy demands and low carbon prices considering a car- and ride-sharing society

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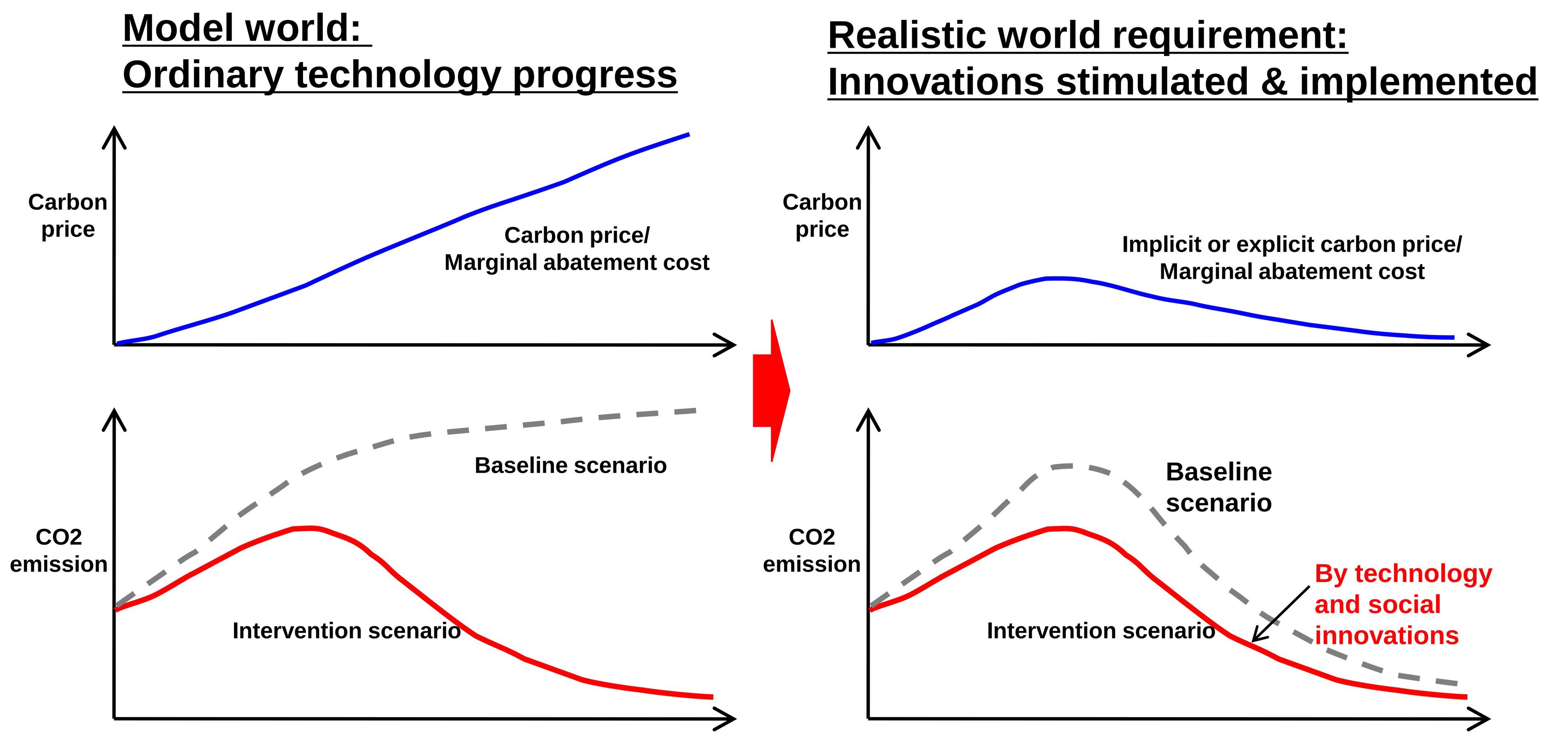
Abstract

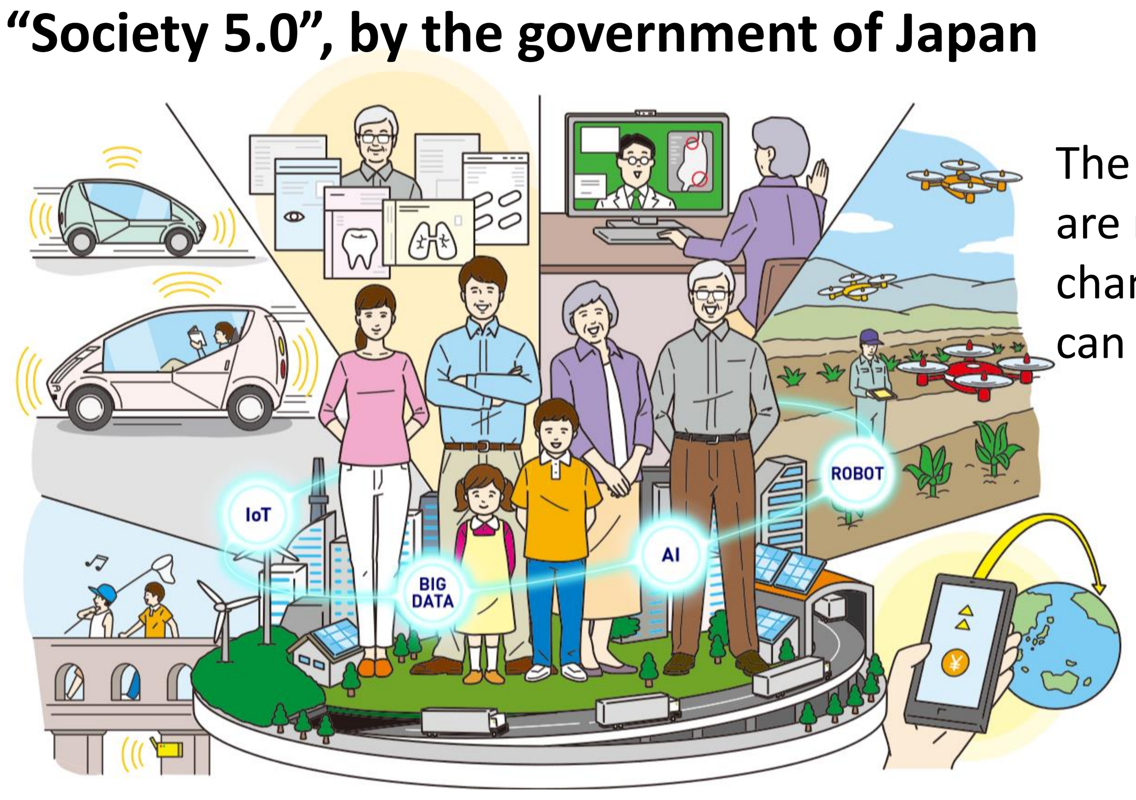
This study developed a scenario where completely autonomous cars are realized, and car-sharing and ride-sharing prevail due to rapid progresses of IoT and AI technologies. The impacts on the energy demands and CO_2 emissions in transportation sector as well as on the energy supplies were analyzed with a global energy systems model, DNE21+. The results show the cost competitiveness of new technologies such as EV and FCV despite their high initial costs, and greatly low CO_2 emissions from transportation even in a non-climate policy case. In addition, for the 2 °C-consistent pathway, lower CO_2 marginal abatement costs in the sharing scenario are estimated to be much lower than those in the standard scenario.

Background

✓ Low carbon prices are key for deep emission cuts to be implemented in the real world. Achievements of low energy demand in the baseline are essential.



A technology and social innovation concept, "Society 5.0", by the government of Japan



The progresses of IoT, and AI are rapid, and the potential change drastically in society can be expected.

References
Akimoto K., et al. (2008) Climate Policy 8, S46-S59.
Fulton L., et al. (2017) Three Revolutions in Urban Transportation.
Grübler A., et al. (2018) Nature Energy 3, 515–527.

Model: DNE21+

- Linear programming model (minimizing world energy system cost)
- Evaluation time period: 2000-2100
  Representative time points: 2000, 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050, 2070, 2100
- World divided into 54 regions
  Large area countries are further divided into 3-8 regions, and the world is divided into 77 regions.
- Bottom-up modeling for technologies both in energy supply and demand sides (about 300 specific technologies including end-use techs. are modeled.)
- Primary energy: coal, oil, natural gas, hydro&geothermal, wind, photovoltaics, solar-thermal, biomass and nuclear power
- Interregional trade: coal, crude oil, natural gas, syn. oil, ethanol, hydrogen, electricity and CO_2
- Existing facility vintages are explicitly modeled.

Scenario assumptions for autonomous car

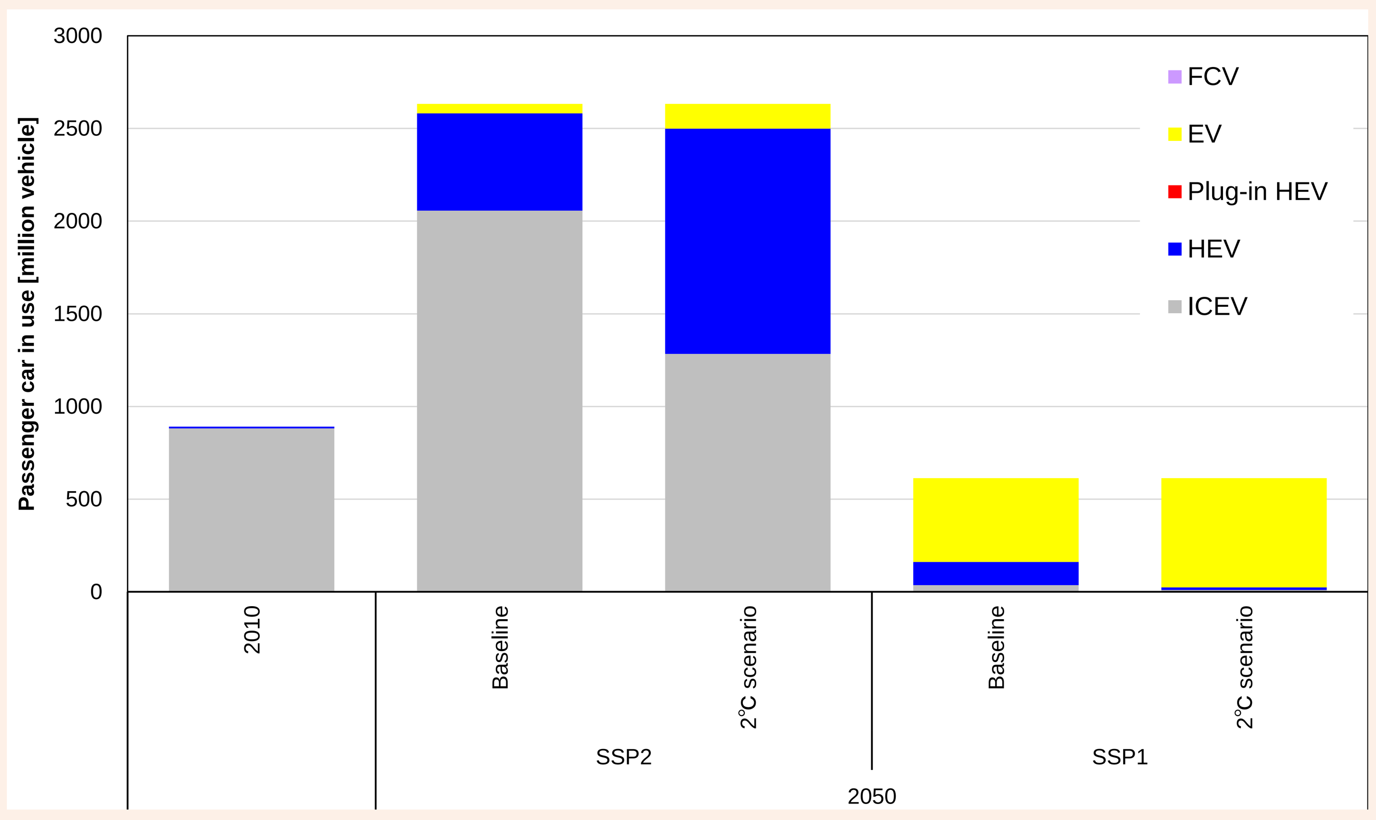
✓ The achievement of completely autonomous car: after 2030
✓ The additional prices of autonomous car: +10,000 $ per car in 2030, +5,000 $ in 2030, and +2,800 $ in 2050
✓ Operation ratios of autonomous car: 3 times more than the conventional cars
✓ Ride sharing: 1.75 persons per car in average in 2050, and 2.0 persons in 2100 (conventional cars: 1.1-1.5 persons per car in average in 2050, and 1.1-1.3 persons in 2100)

Direct emission reduction effects by the induced ride-sharing, and indirect effects through steel production reductions by the induced car-sharing were considered.
Decrease in car sales by car-sharing: **-53%** in 2050
→ Decrease in steel productions: **-4%** in 2050

Model analyses

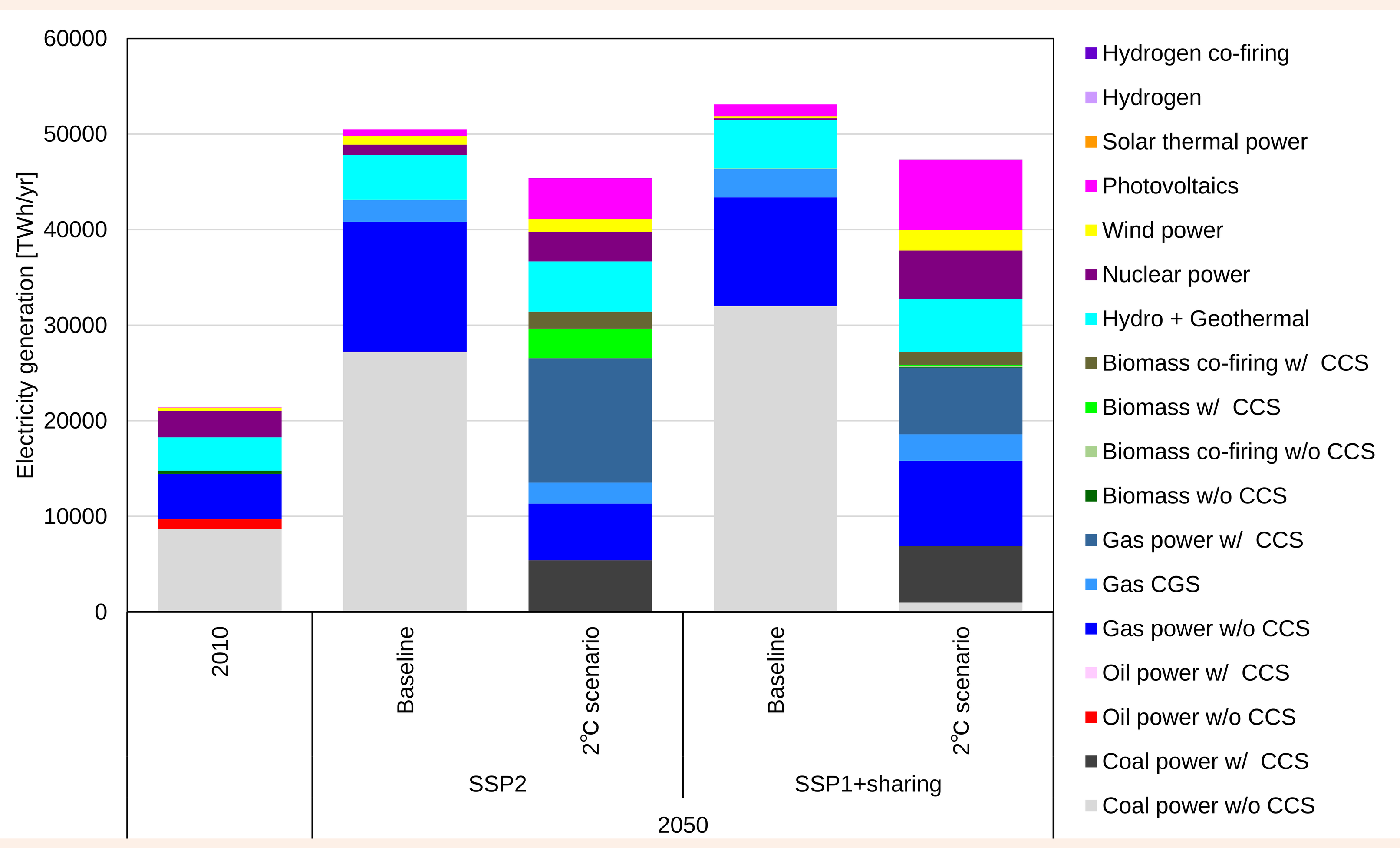
MAC in 2050 for 2 °C: **180 $/tCO2** in SSP2 vs **100 $/tCO2** in SSP1+sharing
✓ MAC in SSP1 with car- and ride-sharing assumptions is much smaller than in the standard scenario, SSP2.

Number of vehicles owned in 2050



* 2 °C scenario: -40% emission reduction by 2050 compared to 2010

World Electricity



✓ Even under high initial costs, EVs are cost-effective in many regions due to high operation ratios in the SSP1+sharing scenario than the SSP2 not only for 2 °C but also for Baseline.
✓ CO_2 emissions from transport in the sharing scenario are much lower than in SSP2
✓ BECCS and gas power with CCS in the SSP1+sharing scenario are much smaller than in SSP2 due to the decrease in MAC.

Energy consumption in transportation sector