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Policies to decarbonize household heating systems in East Asia :A simulation with FTT:Heat

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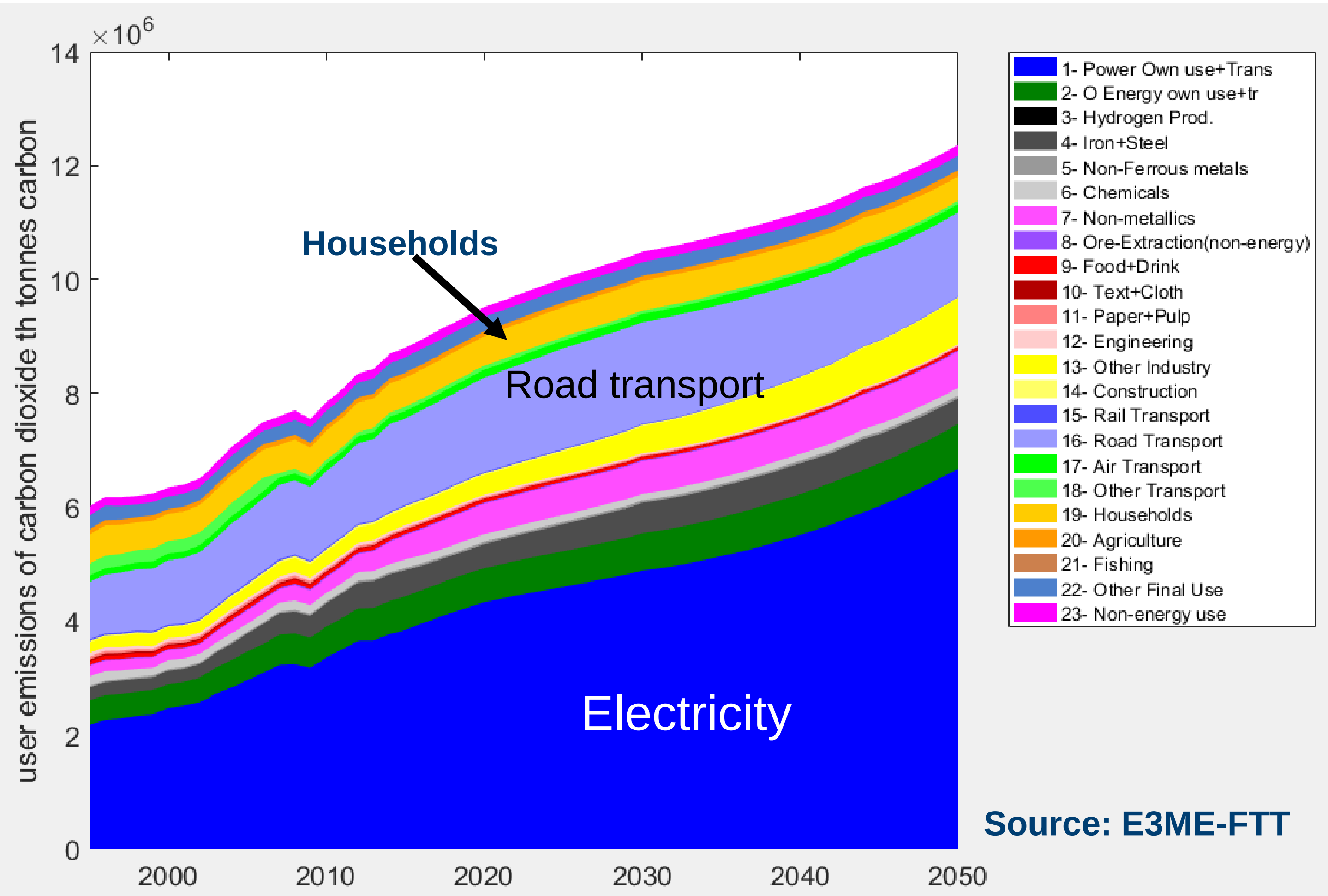
Simulating the decarbonisation of buildings in East Asia

1. Background

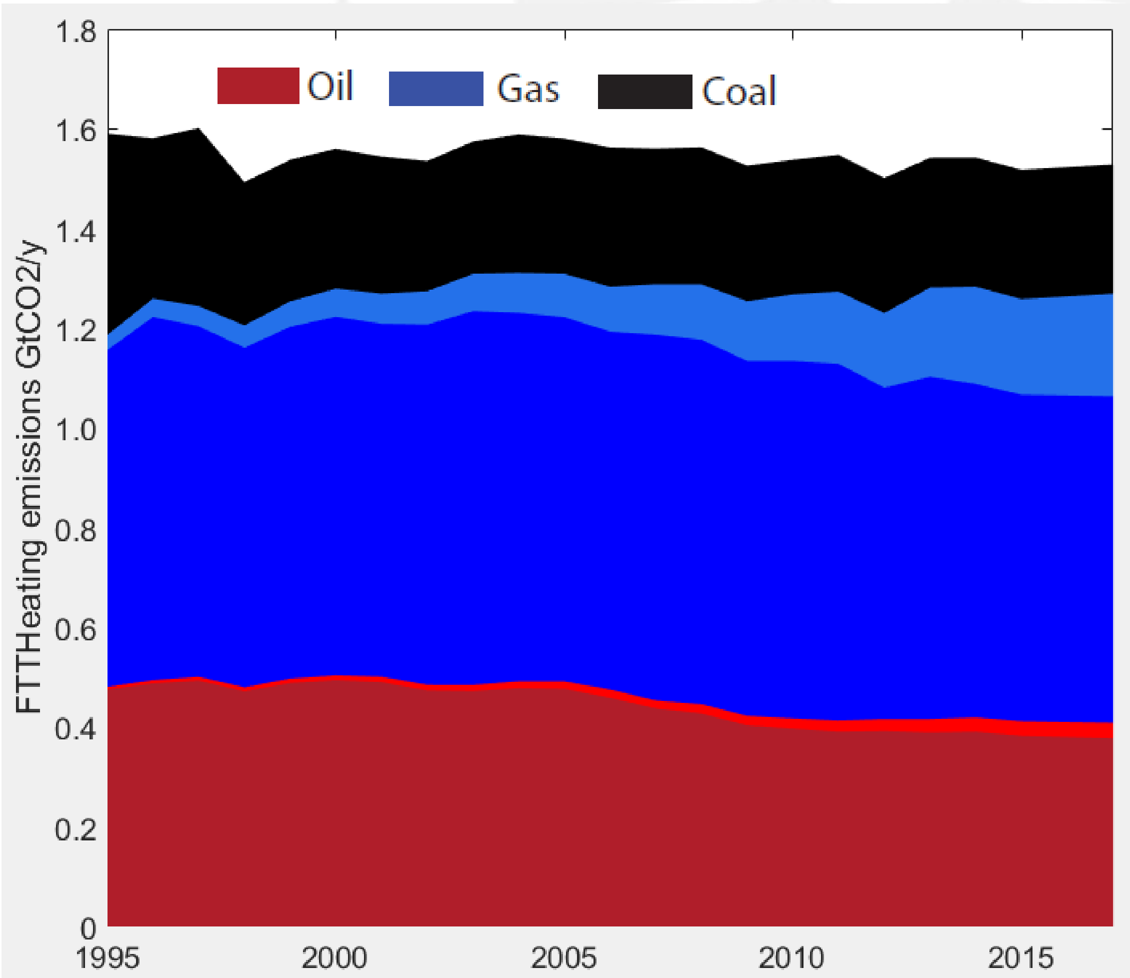
Relative importance of residential heating (space and water):

- Households are 3rd largest energy-related emitter of CO_2 (behind power and transport): around 2.2GtCO_2/y in direct emissions
- 2/3 of global (direct) household emissions are due to heating (40% of which for water heating)
- Decarbonisation of heating therefore key in mitigation scenarios, and even more important in scenarios with high ambition (1.5C target) or limited use of negative emission technologies

Global carbon emissions by sector, current trends



Direct CO2 emissions by residential heating



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Options for the decarbonisation of residential heating

1. Improved insulation of buildings

- In OECD countries, 75% of current building stock will still be in use in 2050
- Therefore, retrofitting of existing buildings is of central importance
- Does hardly reduce demand for water heating

2. More efficient heating technologies

- Replace old heating systems by more efficient ones, such as condensing boilers
- However, this can only reduce emissions by a limited extent

3. Renewable heating technologies

- Heat pumps: mostly based on electricity
- Solar thermal: ideal for water heating in countries with high levels of solar irradiation
- Biomass: modern biomass heating can be highly efficient

Technological change in heating depends on decisions by households

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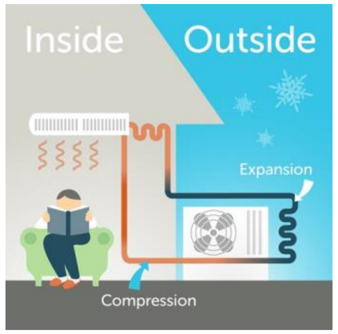

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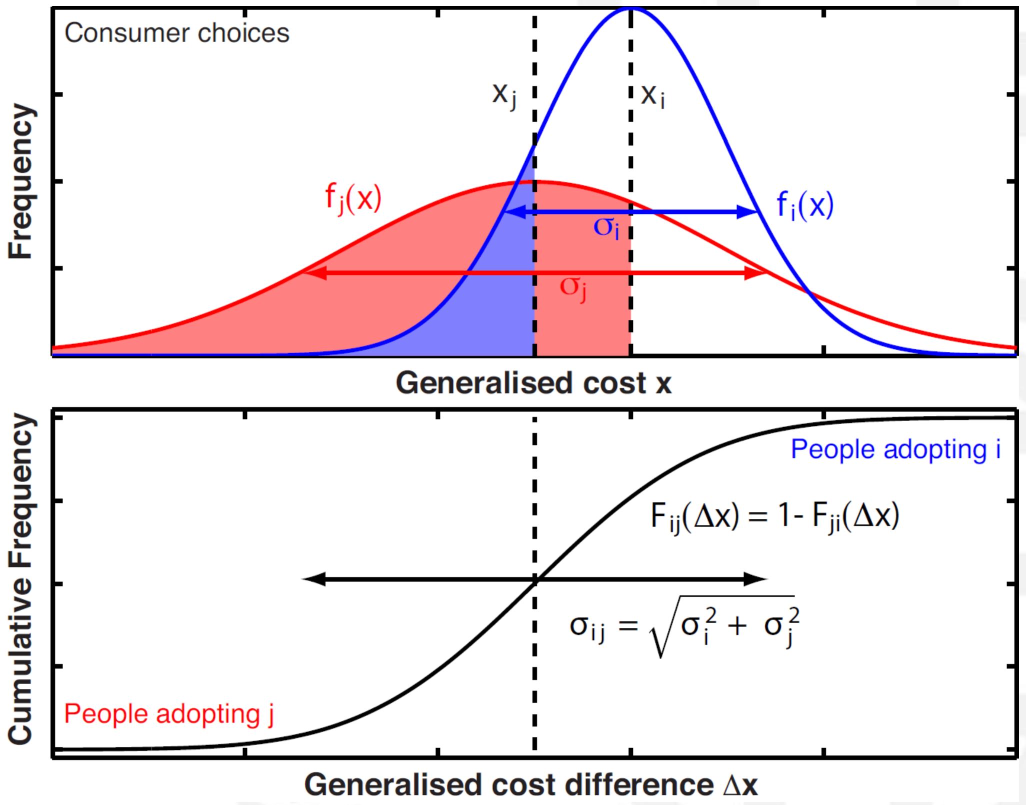

- Households replace their heating systems in time intervals related to technical lifetimes
- Choices are based on **Levelised Costs of Heating (LCOH):** combined measure of investment costs, fuel costs, and maintenance costs
- Calibration of these costs to observed preferences and trends: accounts for different comfort levels, local variations, existing policies etc.
- Behavioural assumptions: no switching back to less comfortable technologies

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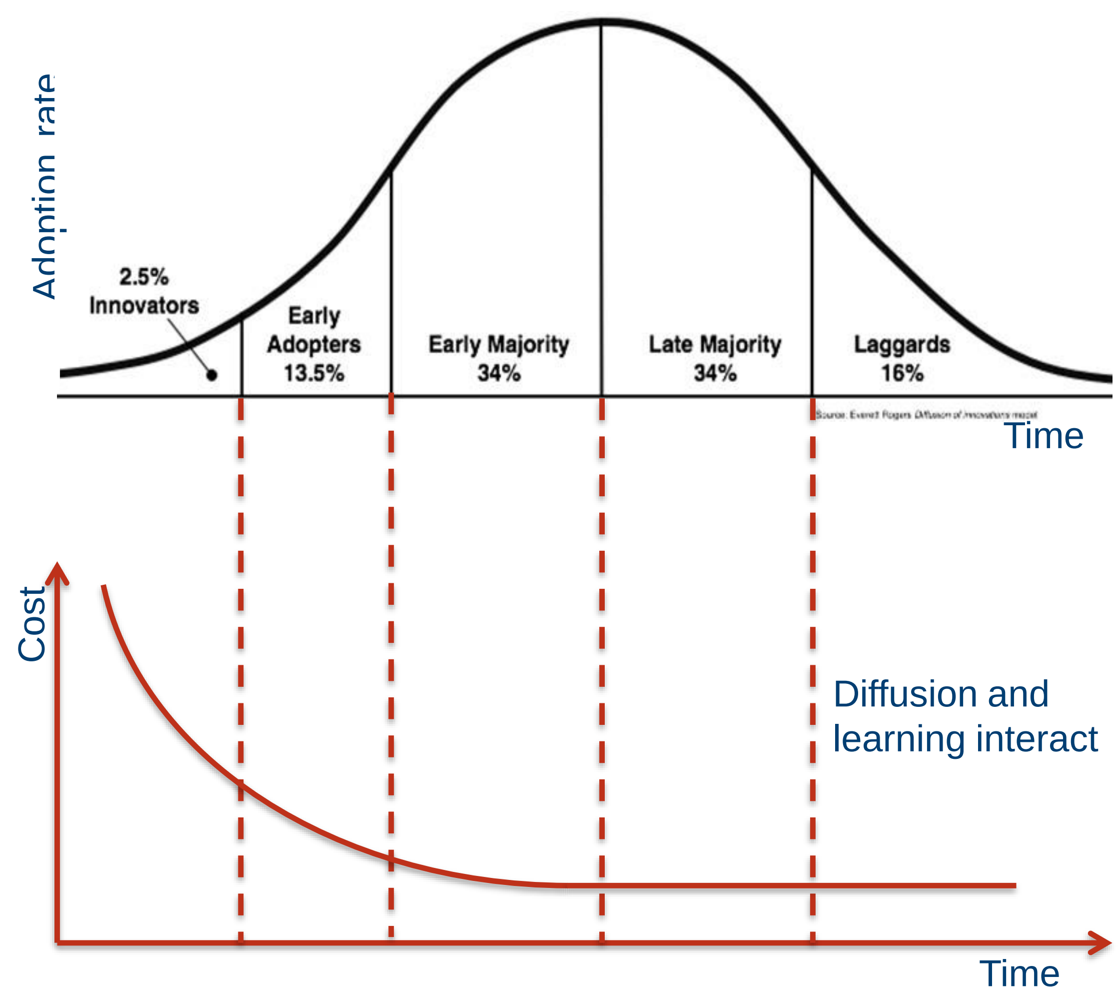
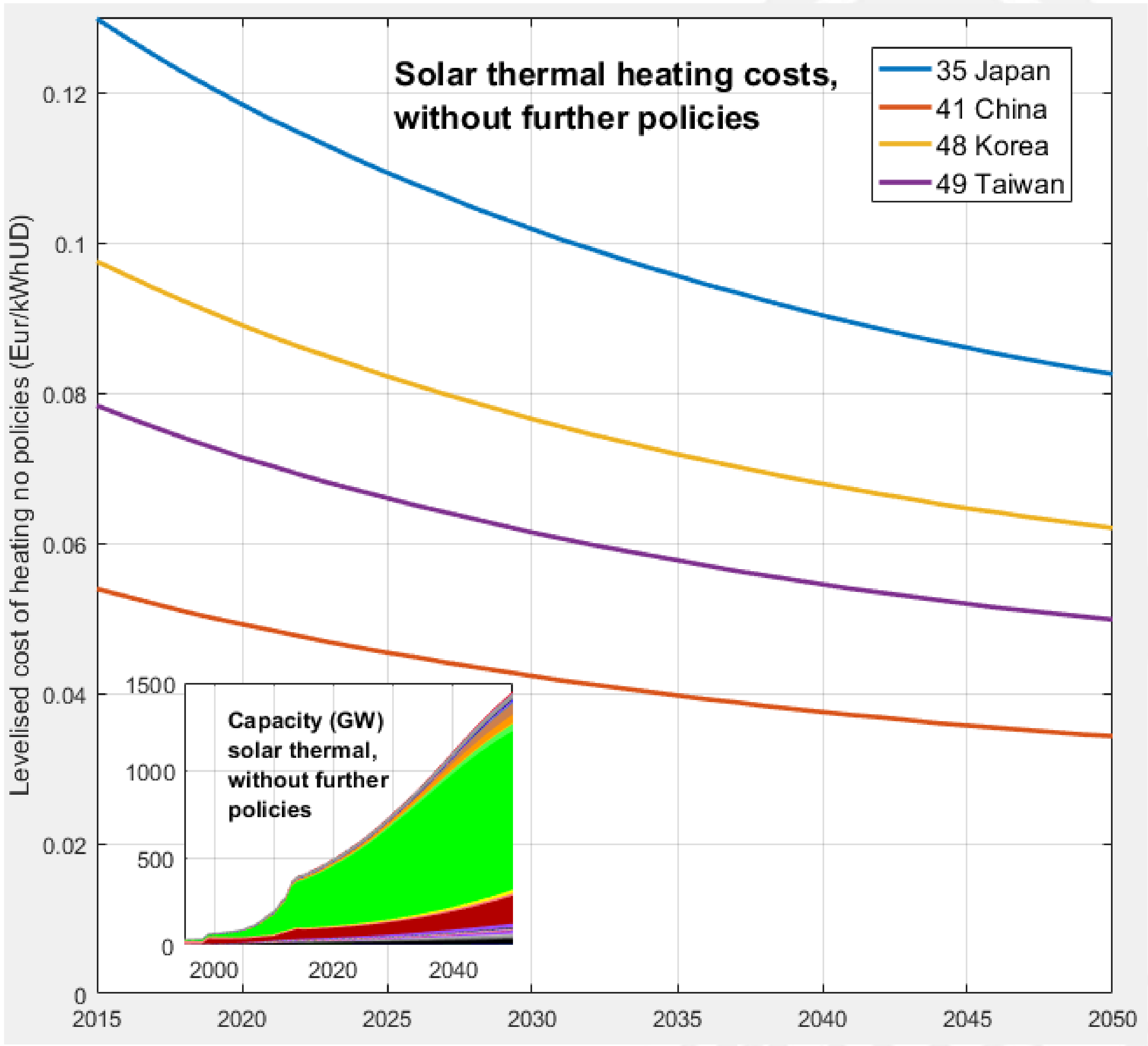
2. Model description

Technological learning within FTT:Heat
(same principle as in FTT:Power and FTT:Transport)





FTT:Heat simulation of future solar thermal heating costs, by country (assuming a continuation of current policies).

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3. Results

Dynamics in underlying costs per technology, example of Japan

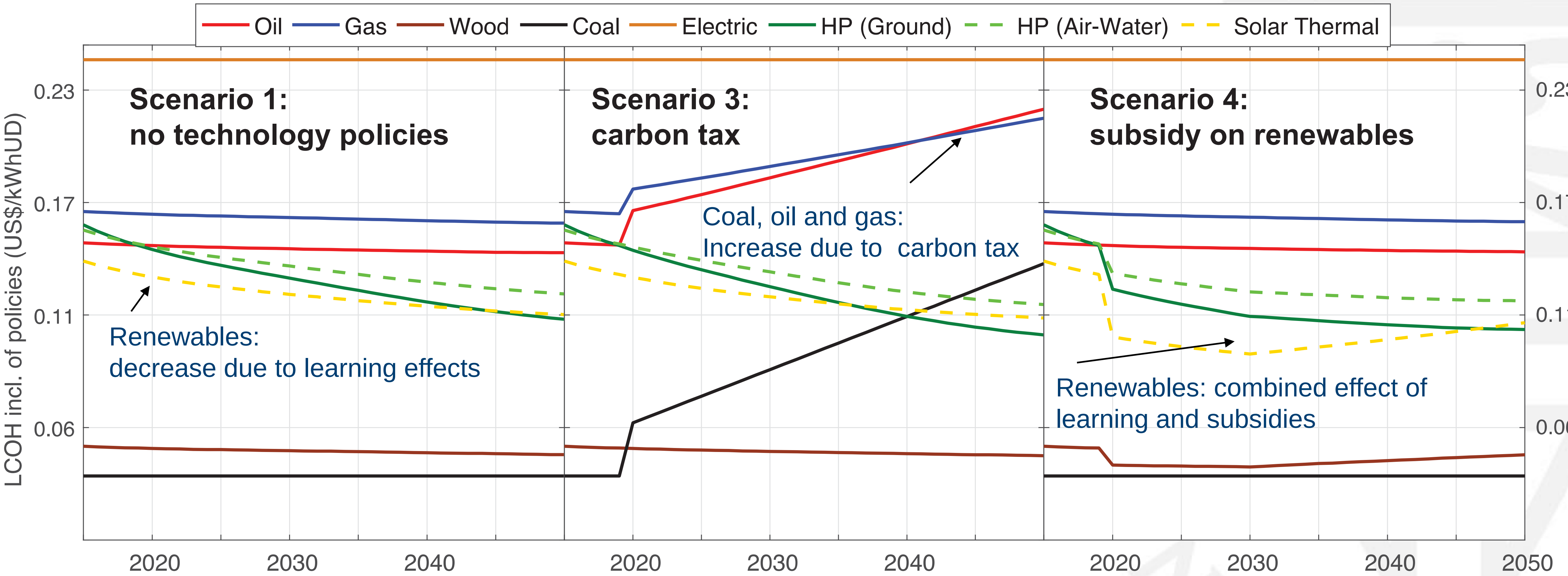

Figure: Projected average heating costs per technology in Japan (in Euro per kWh of heat), without technology policies (left), under a carbon tax (middle), and under subsidies for renewable heating (right).

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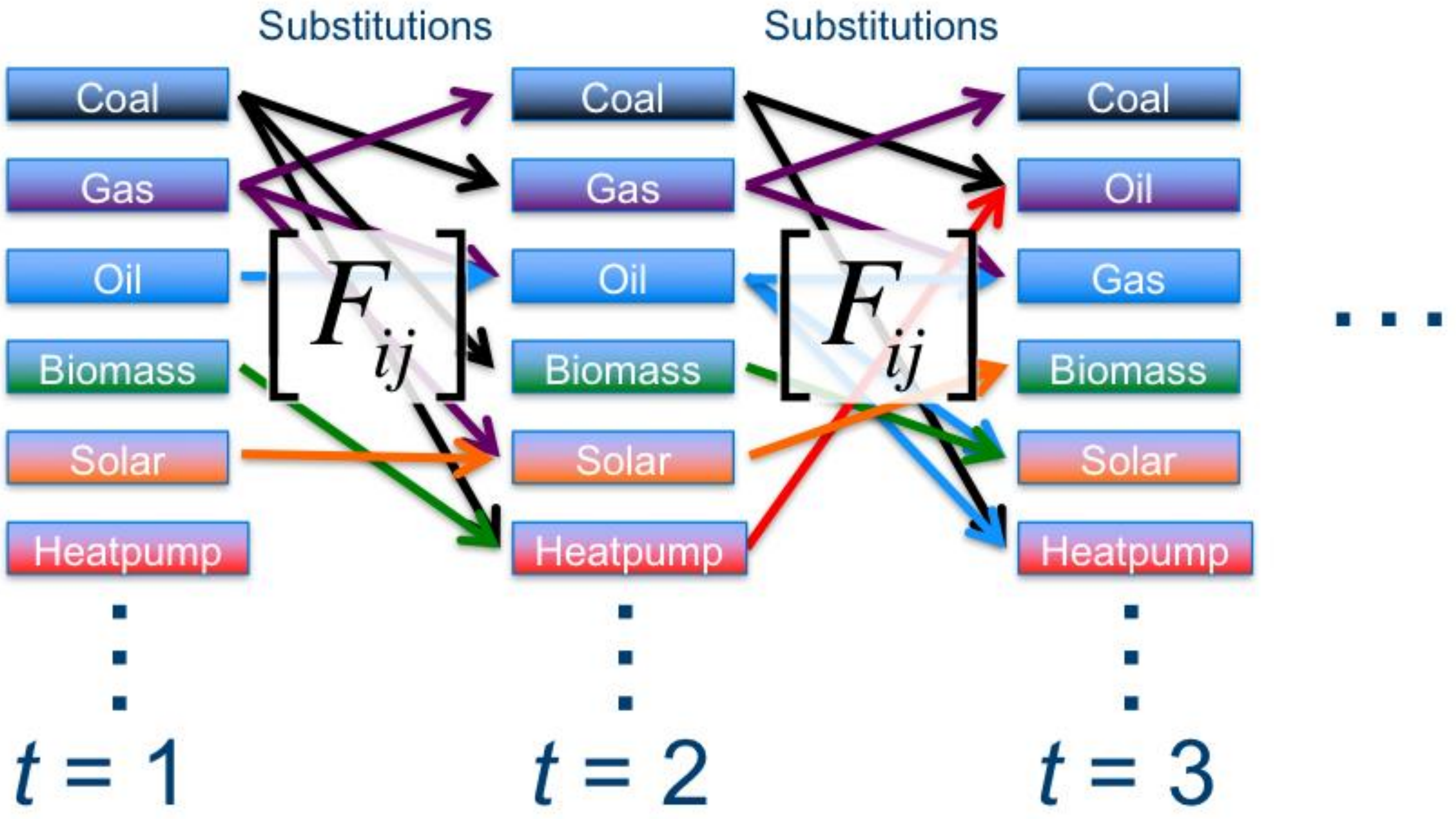
FTT:Heat – a micro-model of technology choice and substitution

- Initially developed for the European Commission, then expanded to global coverage

The model simulates:

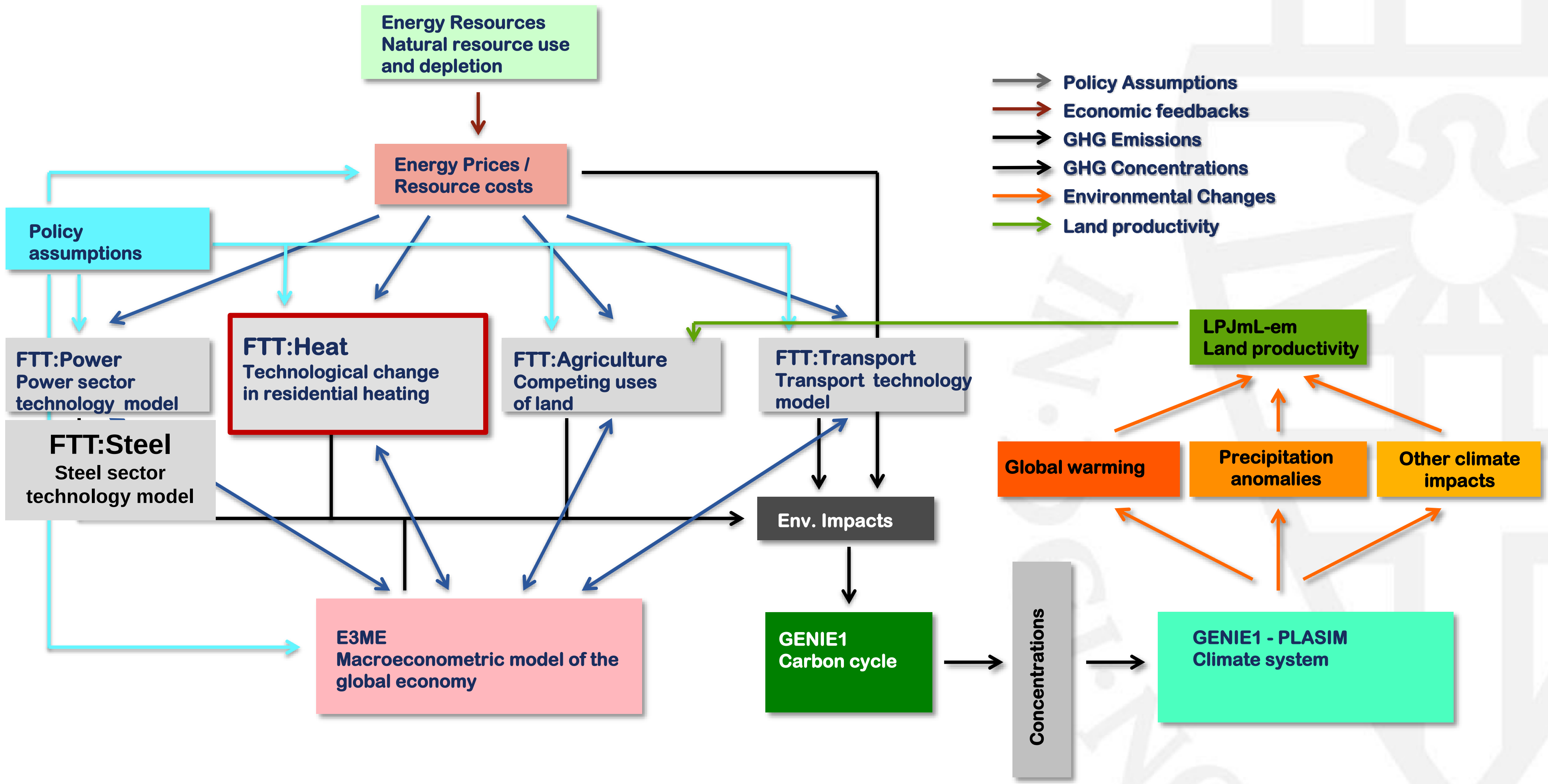
- The future replacement and diffusion of heating technologies (combined for space- and water heating)
- By households worldwide (59 world regions)
- Based on dynamical shares equations (the FTT method – no optimisation)

- **Exogenous driver: trends of residential heat demand**



J.-F. Mercure, Energy Policy 48, 799-811 (2012)

FTT:Heat as a part of E3ME-FTT-GENIE



- Simulation of macroeconomic feedbacks (GDP, employment, etc.)
- Dynamic integration with FTT:Power allows simulation of effects on the power sector, such as the increase of indirect emissions from electricity production

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Policy scenarios

Scenario	Policies targeted at technology uptake	Insulation policies
Baseline	No new policies	No improved insulation
S1	No new policies	Improved thermal insulation of buildings, lowering the demand for space heating to50-150 kJ_{UE}/m2/ HDD by 2100
S2	Carbon tax of US$29/t$CO_2$ (from 2020 onwards), linearly increasing to US$114/t$CO_2$ by 2050	Improved thermal insulation (as in S1)
S3	Carbon tax of US$57/t$CO_2$ (from 2020 onwards), linearly increasing to US$229/t$CO_2$ by 2050	Improved thermal insulation (as in S1)
S4	Subsidy payments of 25% on upfront investment costs of modern renewables, paid from 2020–30, phased out afterwards	Improved thermal insulation (as in S1)
S5	**S3+S4**	Improved thermal insulation (as in S1)

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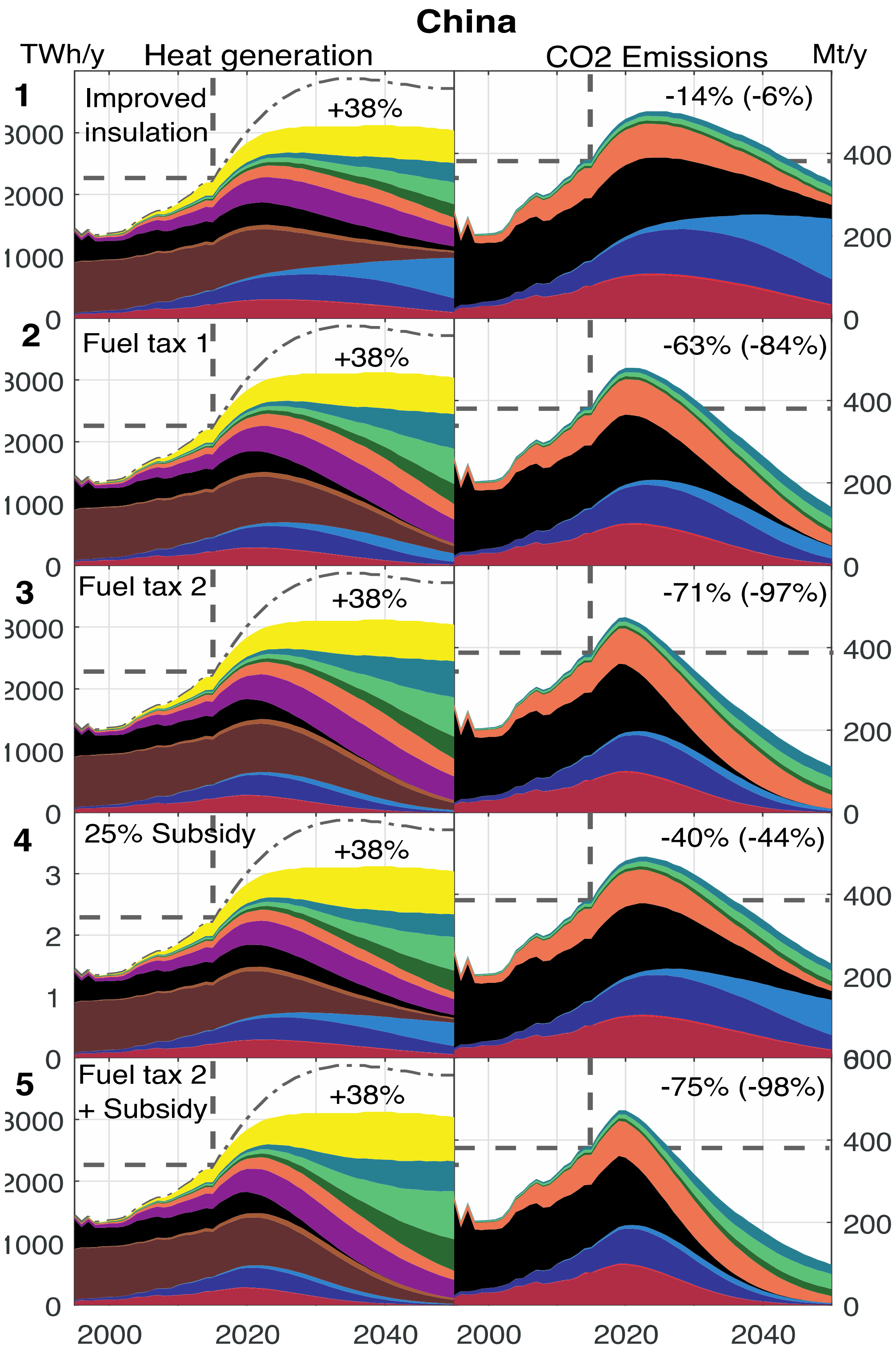
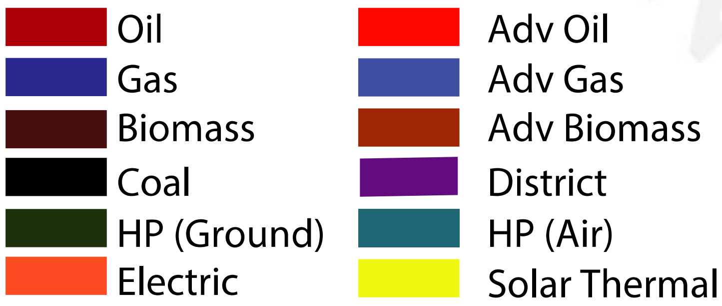


Scenario projections for China

- Large increase of heat demand, even under improved building insulation, due to increasing incomes
- Decreasing use of coal and biomass
- Increasing uptake of renewables, already observable under current trends
- Global leader in solar thermal heating
- Peak of CO2 emissions around 2030, -14% in 2050
- Policies could lead to -75% in 2050

Figure: Projected technology diffusion (left) and CO2 emissions (right) in China's residential heating sector, scenarios (a-e).



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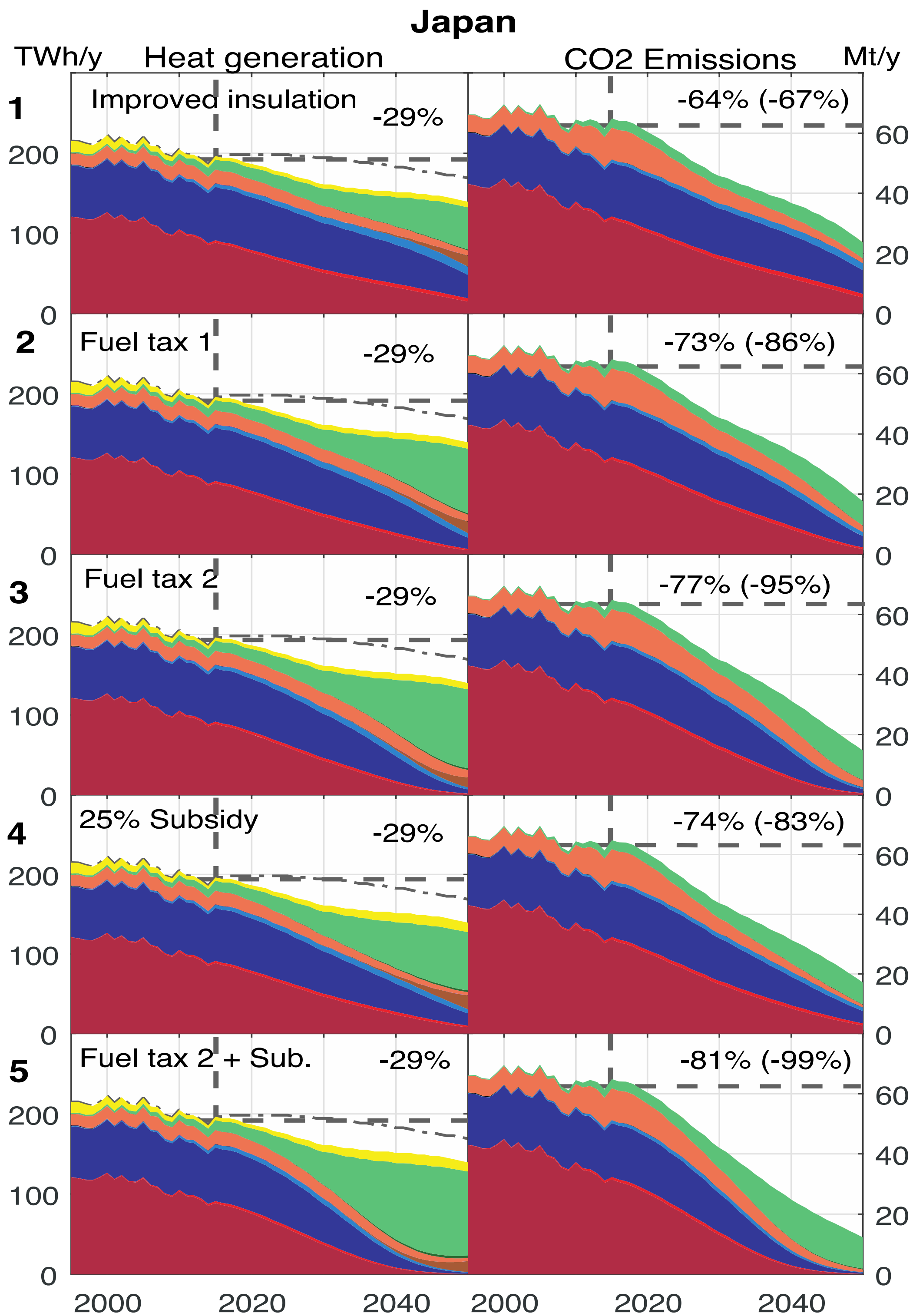
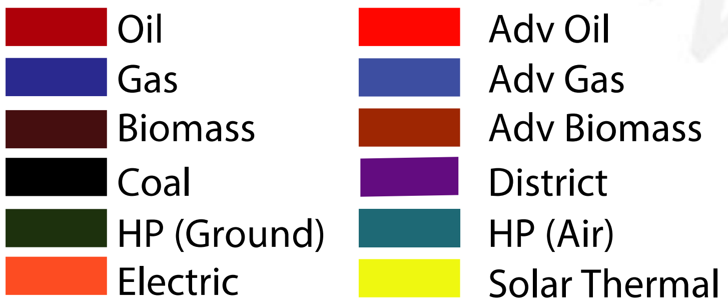
3. Results



Scenario projections for Japan

- Gradual decrease of heat demand with improved insulation (-29% in 2050)
- Decreasing market shares of oil heating
- Increasing uptake of heat pumps, already under current trends
- When power sector is decarbonised, total CO2 emissions could see a decrease by 64% under current trends
- Policies would allow reduction by -81% in 2050

Figure: Projected technology diffusion (left) and CO2 emissions (right) in Japan's residential heating sector, scenarios (a-e).



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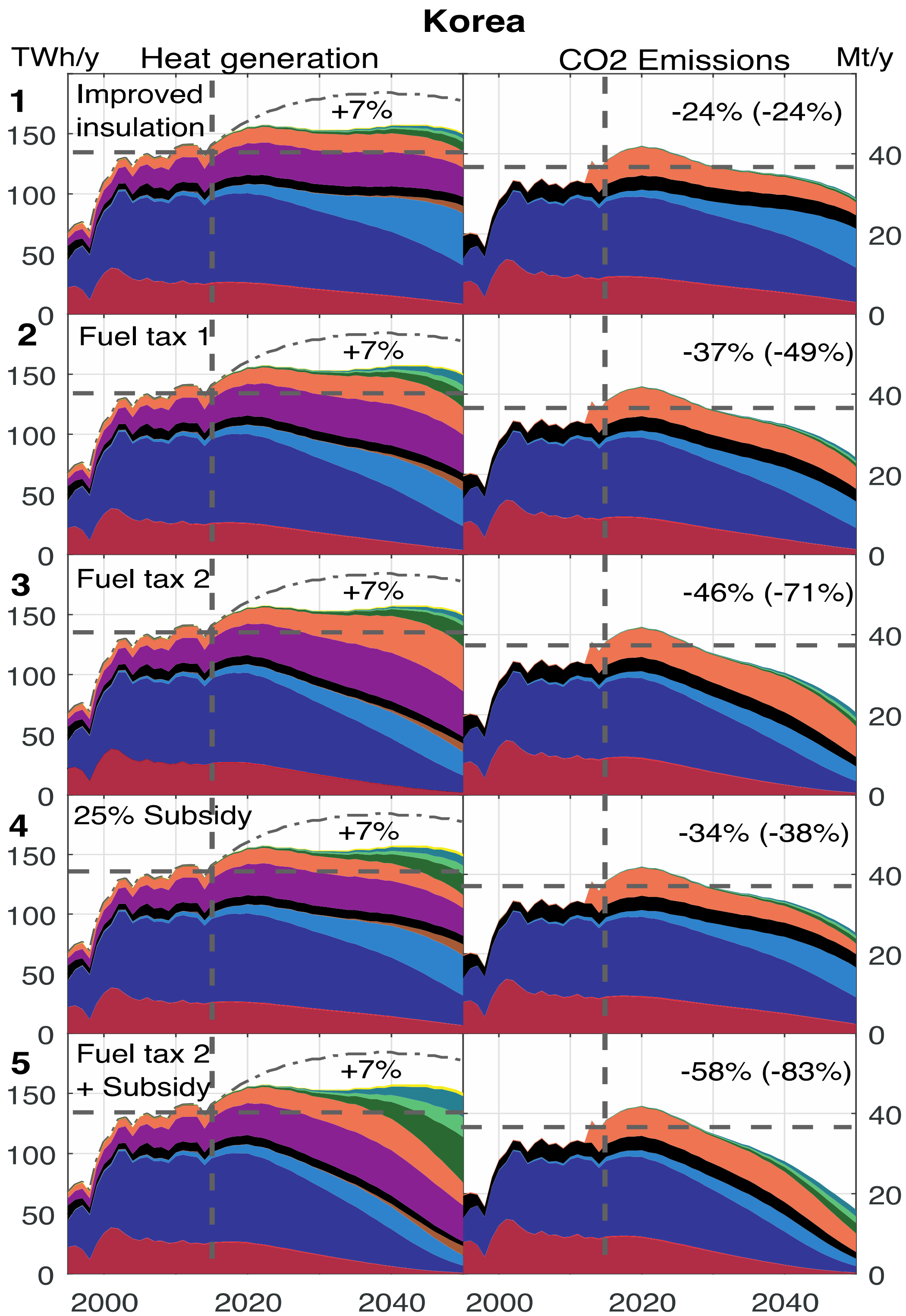
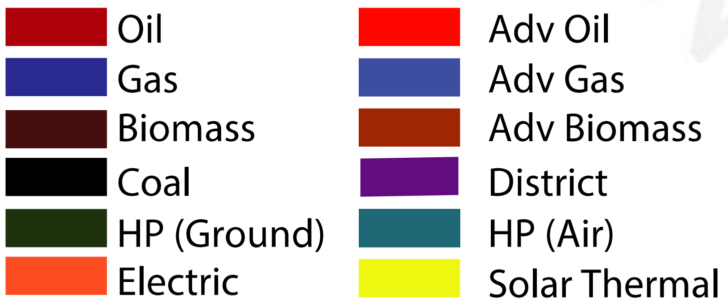
3. Results



Scenario projections for South Korea

- Slightly increasing heat demand
- Continued dominance of gas and oil heating, increasing share of district heating
- Only very slow uptake of renewable heating
- Still, more efficient gas heating could reduce CO2 emissions by 24% in 2050
- Policies could reduce total emissions by -58% in 2050, but net effect highly depends on power sector

Figure: Projected technology diffusion (left) and CO2 emissions (right) in South Korea's residential heating sector, scenarios (a-e).



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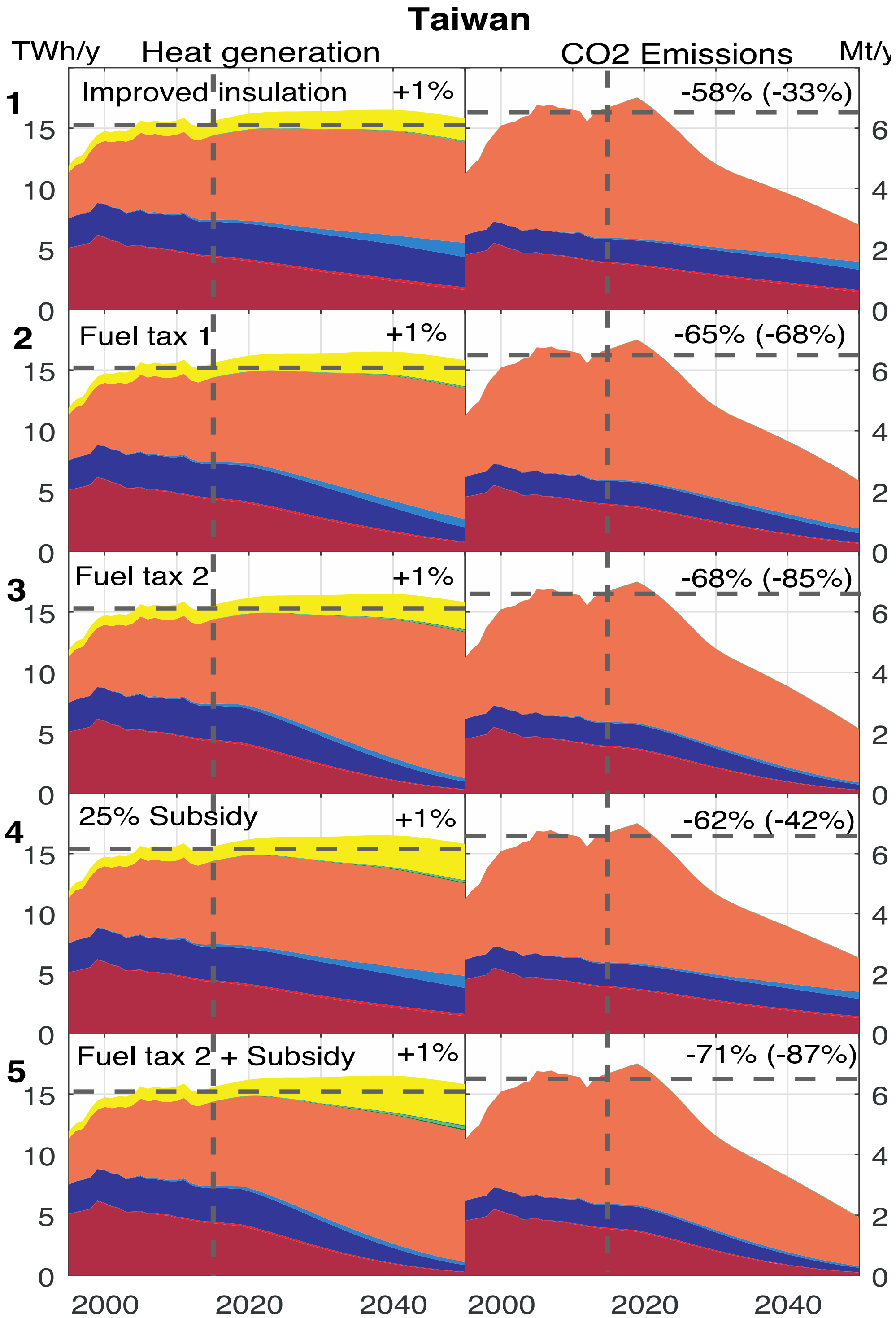
3. Results



Scenario projections for Taiwan

- Heat demand dominated by water heating, therefore not affected by improved insulation
- Large share of direct electric heating
- Increasing uptake of solar thermal heating
- Policies could increase the uptake of solar thermal, and induce phase-out of fossil fuels
- Key for reduction of overall emissions is the decarbonisation of the power sector

Figure: Projected technology diffusion (left) and CO2 emissions (right) in Taiwan's residential heating sector, scenarios (a-e).

Oil | Adv Oil
Gas | Adv Gas
Biomass | Adv Biomass
Coal | District
HP (Ground) | HP (Air)
Electric | Solar Thermal

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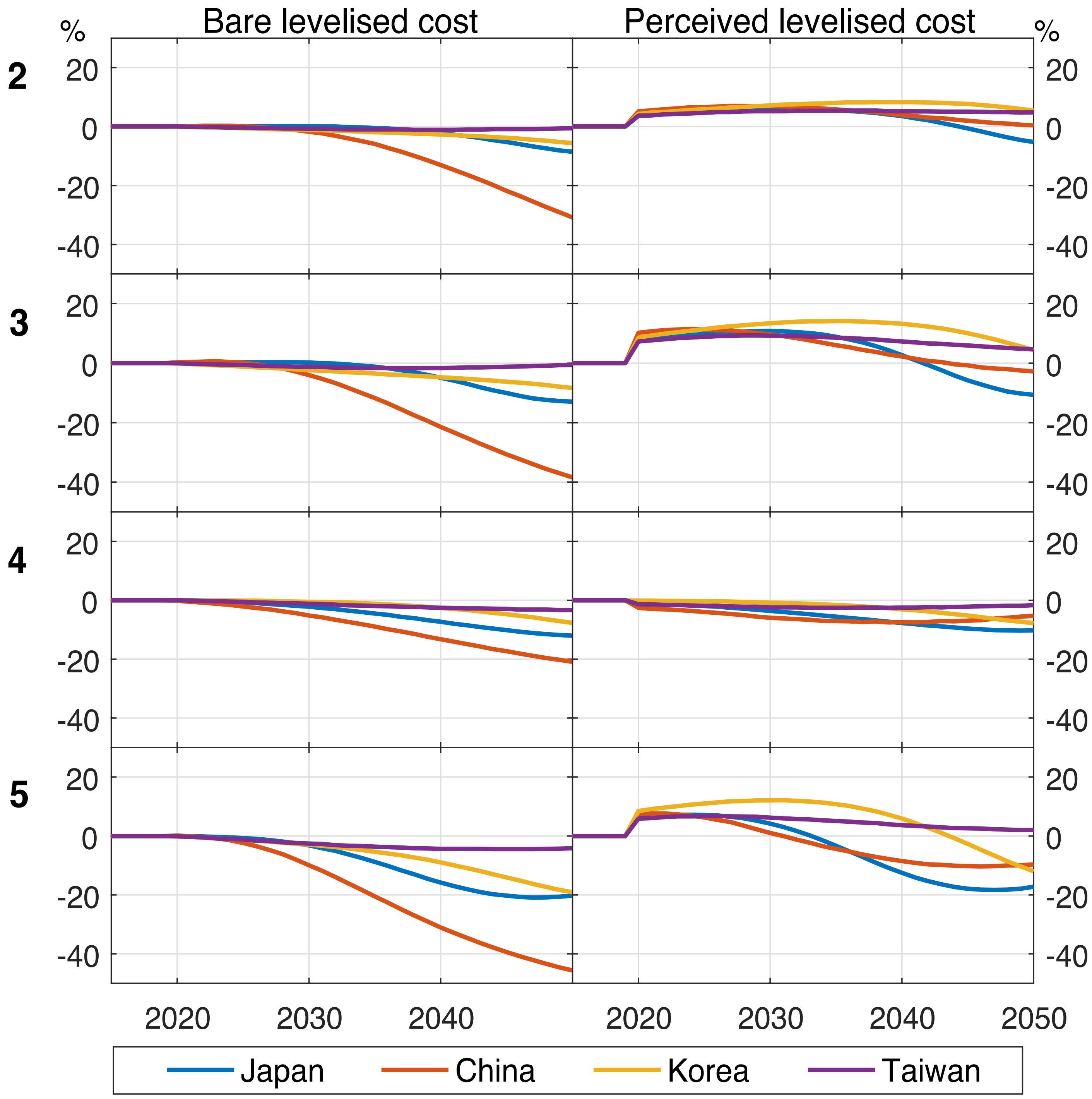
3. Results



- Savings from energy expenses exceed the additional costs of new heating systems in all countries
- Net reduction in heating costs of 5% in South Korea, 20% in Japan, and up to 40% in China
- Subsidies lead to more efficient systems and lower overall costs
- Costs for households would increase initially due to carbon taxes

Figure: Projected changes in average heating costs per country, relative to scenario a (in %).
Left side: engineering cost estimate.
Right side: cost as perceived by households (including intangibles).

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Dcarbonisation of residential heating in East Asia is achievable in 2050, based on existing technologies

1. **Substantial policy effort required:** such as carbon taxes and subsidy payments
2. **Policy mixes** more effective than carbon tax on its own
3. **Initial cost increases** for households, followed by savings in the medium term

Even under strong policies, an ambitious decarbonisation likely takes decades

1. **Slow turnover:** technology lifetimes of 20+ years, 75% of buildings still in use in 2050
2. **Diverse preferences:** households behave differently, no 'representative agent'
3. **Inertia:** households and industry need time to learn and adjust

   a) **Imperfect information:** lack of knowledge, relevance of social influence, 'wait and see'
   b) **Industry constraints***:* limited capacities and know-how for new technologies

Waiting for too long can result in a 'lock in' situation,
which may require the 'scrapping' of heating systems later in time.
This would require even more stringent policies.

Thanks for your attention!
Questions?
Remarks?

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