Global modeling activities and a new study on national mitigation policy

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Annual international AIM workshop

@ Tsukuba, Japan

2017-2018 activities

- International projects
  - ✓ CD-LINKS: multi-sectoral assessment (SDGs)
  - ✓ EMF33; Bioenergy
  - ✓ AgMIP; Food security
  - ✓ COMMIT; National mitigation assessments
  - ✓ IPBES and WWF study: Ecosystem
  - ✓ SSP; Harmonizing and downscaling
- 1.5 °C mitigation studies
- Broader sustainability assessments
  - ✓ Food, water, land, energy and ecosystem
- Economics in climate change impacts
  - ✓ Hydropower (Zhou et al.,2018)
  - ✓ Cooling water (Zhou et al.,2018)
  - ✓ Energy demand change (Park et al., 2018)
  - ✓ Labor productivity (Takakura et al., 2018)
  - ✓ Agricultural yield (Fujimori et al., 2018)
  - ✓ Flood (Takakura et al. in prep)
  - ✓ Heat stress (Takahashi et al. in prep)

IPCC 1.5 SR citations

1. Liu, J., Fujimori, S., Takahashi, K., Hasegawa, T., Su, X., Masui, T. (2018) Socioeconomic factors and future challenges of the goal of limiting the increase in global average temperature to 1.5 ° C. Carbon Management 1-11.
2. Zhang, R., Fujimori,S., Hanaoka, T. (2018) The contribution of transport policies to the mitigation potential and cost of 2 ° C and 1.5 ° C goals. Environmental Research Letters 13 (5), 054008.
3. Park, C., Fujimori. S., Hasegawa, T., Takakura, J., Takahashi, K., Hijioka, Y. (2018) Avoided economic impacts of energy demand changes by 1.5 and 2 ° C climate stabilization. Environmental Research Letters 13 (4), 045010.
4. Takakura, J, Fujimori, S., Takahashi, K., Hijioka, Y., Hasegawa, T., Honda, Y., Masui, T. (2017) Cost of preventing workplace heat-related illness through worker breaks and the benefit of climate-change mitigation. Environmental Research Letters 12 (6), 064010.
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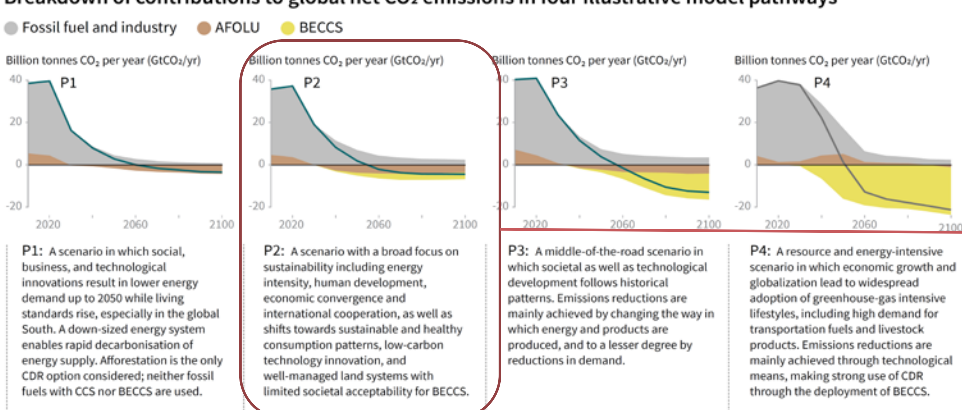
7. Fujimori, S., Su, X., Liu, J., Hasegawa, T., Takahashi, K., Masui, T., Takimi, M. (2016) Implication of Paris Agreement in the context of long-term climate mitigation goals. Springerplus 5 (1), 1620.
8. Hasegawa, T., Fujimori, S., Takahashi, K., Yokohata, T., Masui, T. (2016) Economic implications of climate change impacts on human health through undernourishment. Climatic Change 136 (2), 189-202.
9. Hasegawa, T., Fujimori, S., Shin, Y., Tanaka, A., Takahashi, K., Masui, T. (2015) Consequence of climate mitigation on the risk of hunger. Environmental science & technology 49 (12), 7245-7253.
10. Ishida, H., Kobayashi, S., Kanae, S., Hasegawa, T., Fujimori, S., Shin, Y., Takahashi, K., Masui, T., Tanaka, A., Honda, Y. (2014) Global-scale projection and its sensitivity analysis of the health burden attributable to childhood undernutrition under the latest scenario framework for climate change research. Environmental Research Letters 9 (6), 064014.
11. Hasegawa, T., Fujimori, S., Shin, Y., Takahashi, K., Masui, T., Tanaka, A. (2014) Climate change impact and adaptation assessment on food consumption utilizing a new scenario framework. Environmental science & technology 48 (1), 438-445.
12. Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., et al. (2013). A global water scarcity assessment under Shared Socio-economic Pathways – Part 1: Water use. Hydrology and Earth System Sciences 17, 2375–2391. doi:10.5194/hess-17-2375-2013.

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



Many other coauthored papers

AIM SSP1

SPM Figure 3b

ASIA-PACIFIC INTEGRATED MODEL

Highlights in 2018

nature climate change
LETTERS
https://doi.org/10.1038/s41558-018-0230-x

AgMIP achievement

Risk of increased food insecurity under stringent global climate change mitigation policy

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SCIENTIFIC DATA

- SSP/RCP based gridded information
  - Generated by AIM
  - Full SSP/RCP matrix is available

OPEN

Data Descriptor: Gridded emissions and land-use data for 2005–2100 under diverse socioeconomic and climate mitigation scenarios

Received: 11 May 2018
Accepted: 15 August 2018
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Priority in 2019

- Asian assessments
  - ✓ Mid-century strategy along with NDC updates
- Multi-sectoral assessments for Asia
  - ✓ Mitigation and SDG dimensions
    - ➢ Land-energy-water-ecosystem
  - ✓ Impacts and adaptation

Energy Transformation Cost for the Japanese Mid-century Strategy: Energy System Feedback Effects in an Economic Model

Outline

- Background
  - ✓ Current understanding of macroeconomic costs in deep decarbonization scenarios
- Objective
  - ✓ What if energy system information is fully integrated into an economic model?
- Method
  - ✓ A new integrated modeling framework with iterations
- Findings
  - ✓ The new approach is effectively decrease macroeconomic cost.
  - ✓ Energy end-use modeling particularly service and industry sectors are key.

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Background

- Mid-century strategy is needed to be established after Paris Agreement
- Macroeconomic cost is one of the concerns shifting towards low carbon system
- Economic model is a tool to estimate macroeconomic costs.
- CGE models tend to project policy costs higher than energy system models
  - ✓ Parameter calibration is based on historical substitution parameters but it would not be the case for the future (deep decarbonization)
- Renewable energy is also another concern for CGE models where we need to address physical feasibility of power supply

Core questions

- What if we incorporate energy and power system appropriately into economic model
- Is macroeconomic cost still high to be concerned?
- If it is different, what would be the key elements in that modeling framework?

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Method overview

- AIM/Enduse [Japan] (called AIM/Enduse hereafter), and a power dispatch model, AIM/POWER, are inter-linked with the multi-sector economic model AIM/CGE
  - ✓ Represent energy, power economic system characteristics appropriately
- Iterate the exchanges of information among the models
- Two illustrative scenarios for Japan
  - ✓ w/ and w/o mitigation climate change mitigation
    - ➢ 80% reduction in 2050

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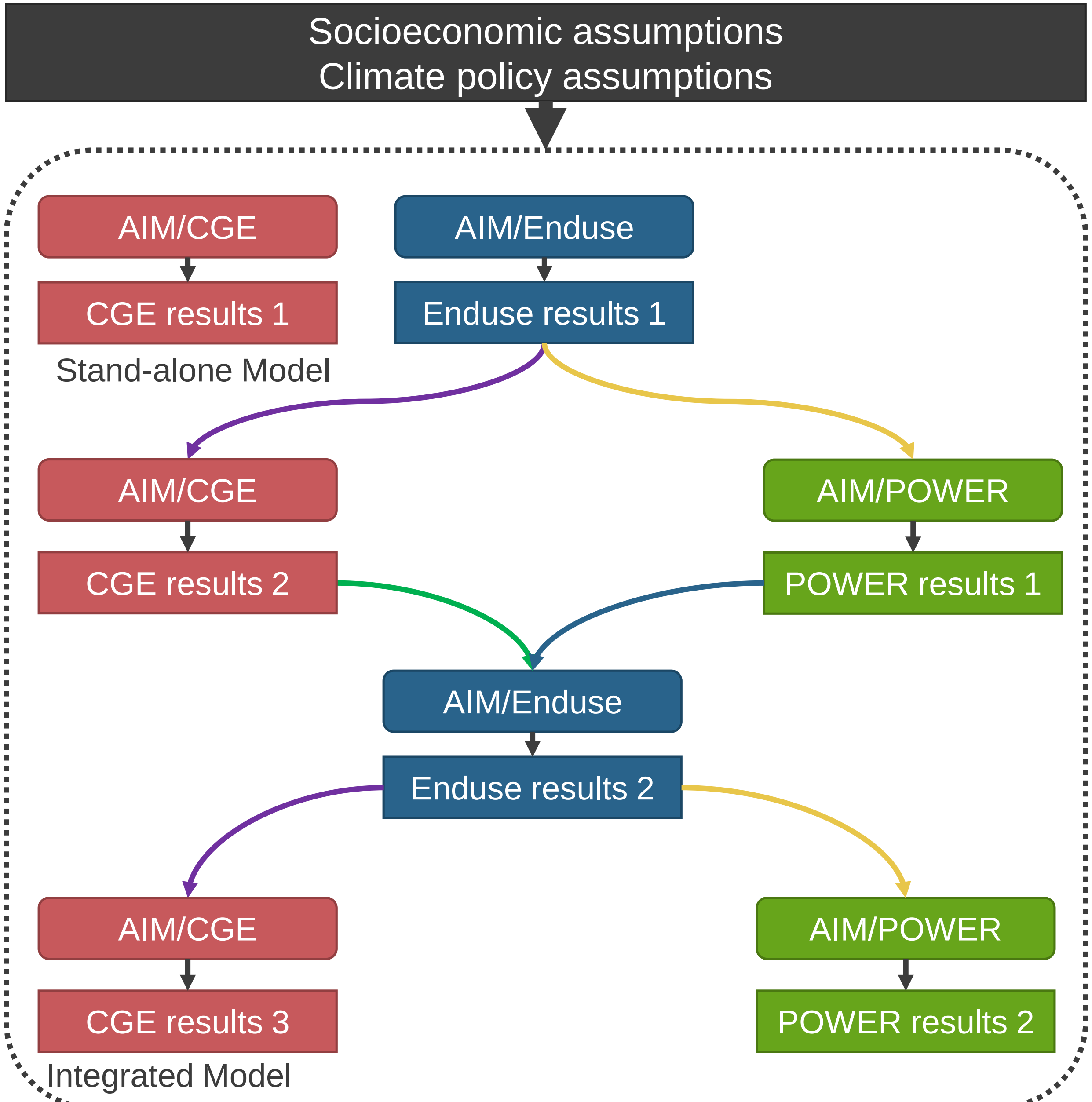


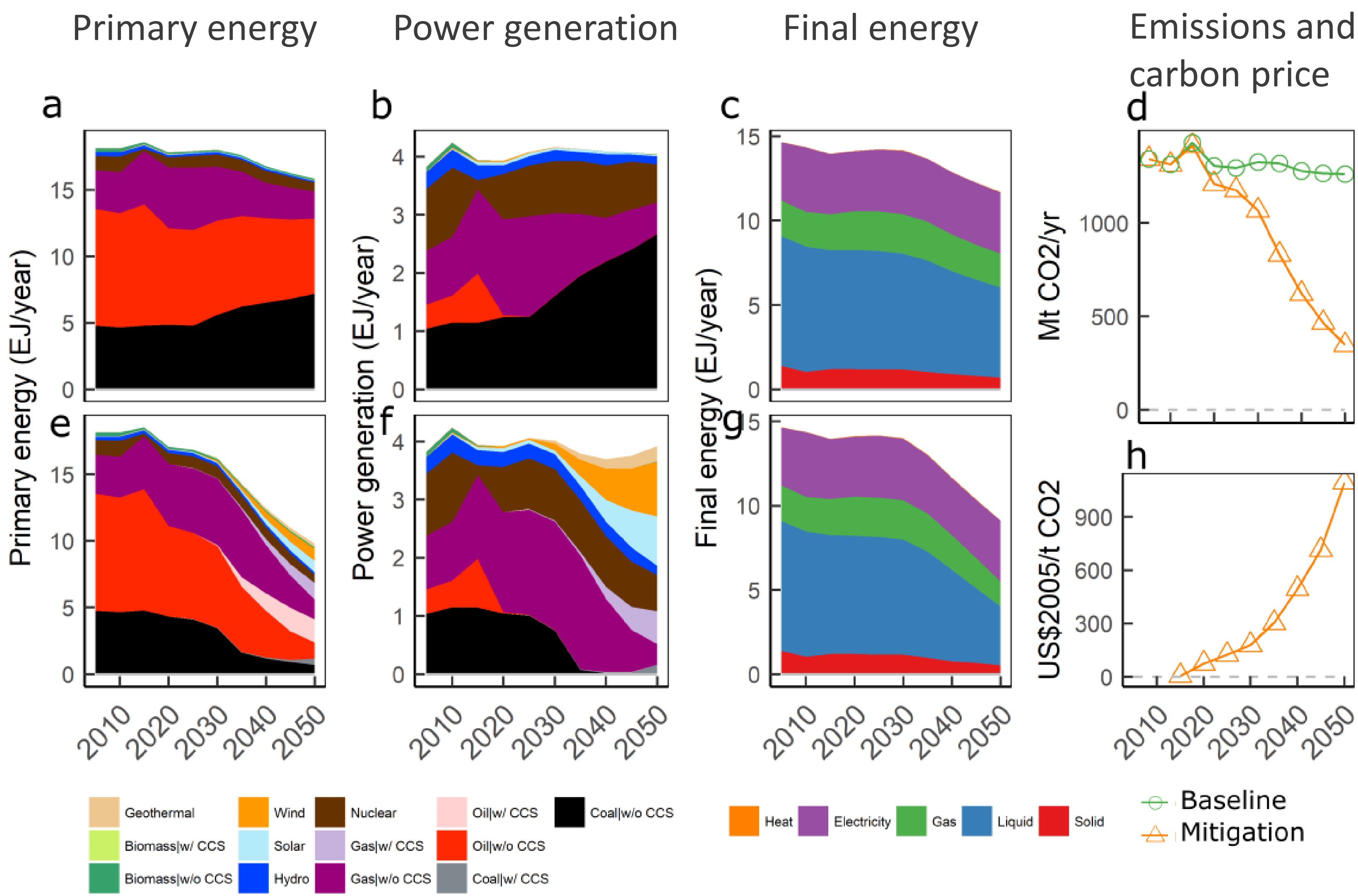
- GDP changes
- Household consumption changes
- Industry and service sectors output
- Energy Prices

- Power generation share by energy sources
- Battery capacity
- CCS installation
- Final energy consumption by sectors and energy types
- Investment of energy end-use sectors
- Carbon prices
- Transmission losses

- Power capacity by technologies
- Electricity demand

- Curtailment rate
- Capacity factor by technologies
- Battery for short-term fluctuation

Results



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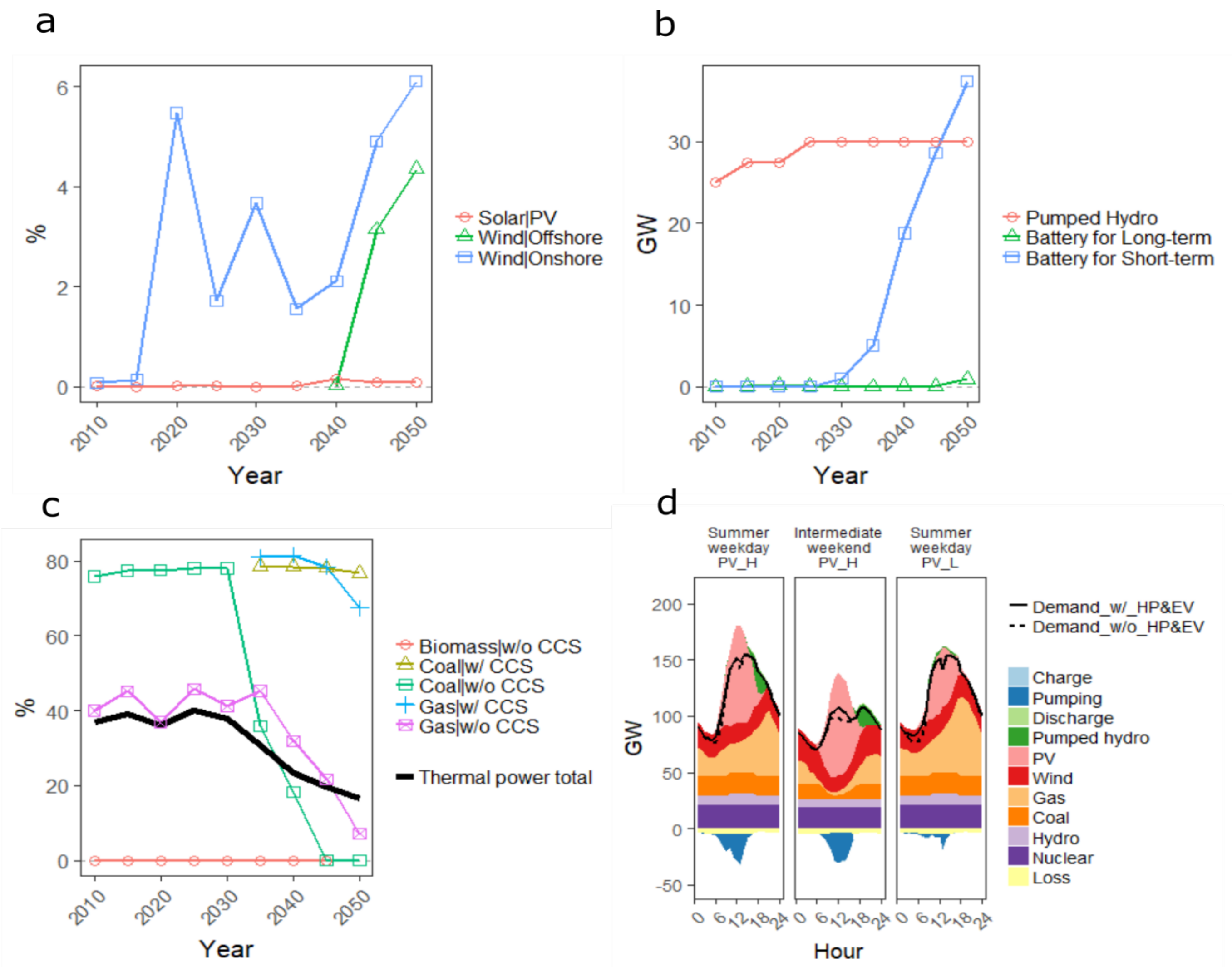
Effect of large scale variable renewable energy penetration



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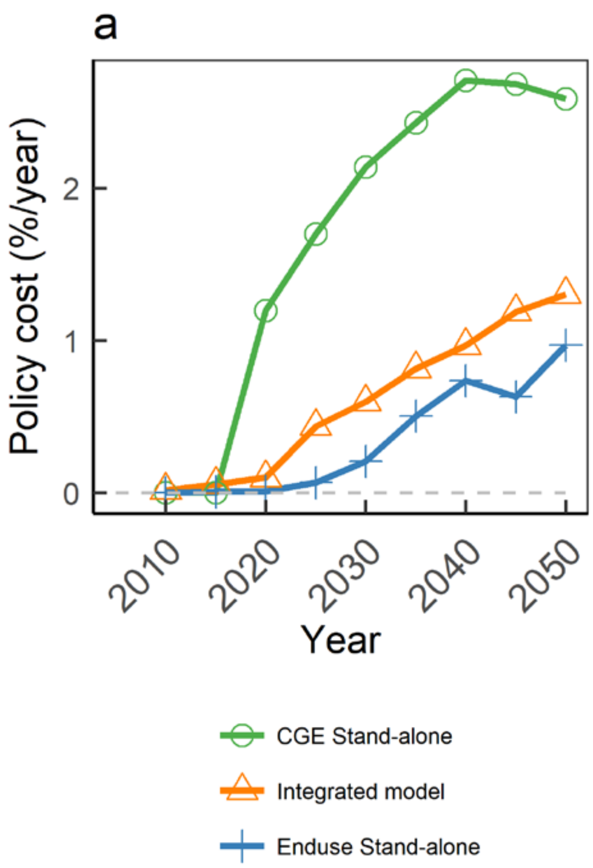
Climate policy cost



- AIM/CGE stand-alone is higher than AIM/Enduse stand-alone or integrated model
- Technological variation scenarios exhibit similar tendency

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Which sector's representation contributes to this policy cost changes

	Energy supply	Industry	Service	Transport	Residential
scenario 1	off	off	off	off	off
scenario 2	off	off	off	off	on
scenario 3	off	off	off	on	off
scenario 4	off	off	off	on	on
scenario 5	off	off	on	off	off
scenario 6	off	off	on	off	on
scenario 7	off	off	on	on	off
scenario 8	off	off	on	on	on
scenario 9	off	on	off	off	off
scenario 10	off	on	off	off	on
scenario 11	off	on	off	on	off
scenario 12	off	on	off	on	on
scenario 13	off	on	on	off	off
scenario 14	off	on	on	off	on
scenario 15	off	on	on	on	off
scenario 16	off	on	on	on	on
scenario 17	on	off	off	off	off
scenario 18	on	off	off	off	on
scenario 19	on	off	off	on	off
scenario 20	on	off	off	on	on
scenario 21	on	off	on	off	off
scenario 22	on	off	on	off	on
scenario 23	on	off	on	on	off
scenario 24	on	off	on	on	on
scenario 25	on	on	off	off	off
scenario 26	on	on	off	off	on
scenario 27	on	on	off	on	off
scenario 28	on	on	off	on	on
scenario 29	on	on	on	off	off
scenario 30	on	on	on	off	on
scenario 31	on	on	on	on	off
scenario 32	on	on	on	on	on

$$GDPLOSS_s = \sum_{(s,j)\in SJ} a_j X_j + e_s$$

Each scenario's GDP loss

Each sector's on/off

	Estimate	Std. Error	t-value	Pr(>|t|)	
(Intercept)	0.918	0.057	16.111	< 2e-16	***
2030	0.150	0.060	2.516	0.0128	*
2035	0.451	0.060	7.578	1.75E-12	***
2040	0.725	0.060	12.182	< 2e-16	***
2045	0.900	0.060	15.121	< 2e-16	***
2050	1.029	0.060	17.286	< 2e-16	***
Energy Supply	0.398	0.034	11.570	< 2e-16	***
Industry	-0.404	0.034	-11.753	< 2e-16	***
Service	-0.501	0.034	-14.587	< 2e-16	***
Transport	0.036	0.034	1.033	0.3028	
Residential	-0.182	0.034	-5.288	3.54E-07	***

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Conclusions and Discussion

- Macroeconomic costs are not so large if energy system information is appropriately reflected in economic models
- General perception of climate change mitigation costs in terms of macroeconomic losses can change.
  - ✓ Can this conclusion generalized to other countries?
- The industry and service sectors' energy consumption and production functions
  - ✓ GDP accounting coming from household consumption is controversial because household expenditure increase associated with expensive energy technologies directly increase GDP.