# Pathways for energy service demand in the household sector in the global regions to 2070

Session 9: Consumption trends 1

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Background

- In response to climate change, many countries have announced reduction targets toward carbon neutrality, which would reduce greenhouse gas emissions to virtually zero, in order to limit the temperature increase to 1.5° C.

- In developing countries in particular, where population and economic growth are increasing, the demand for comfortable living and living environments, as indicated in the SDGs, is increasing, and energy demand is expected to increase dramatically in the future. Under these circumstances, it is important to understand the energy consumption structure and how demand will change in the future.
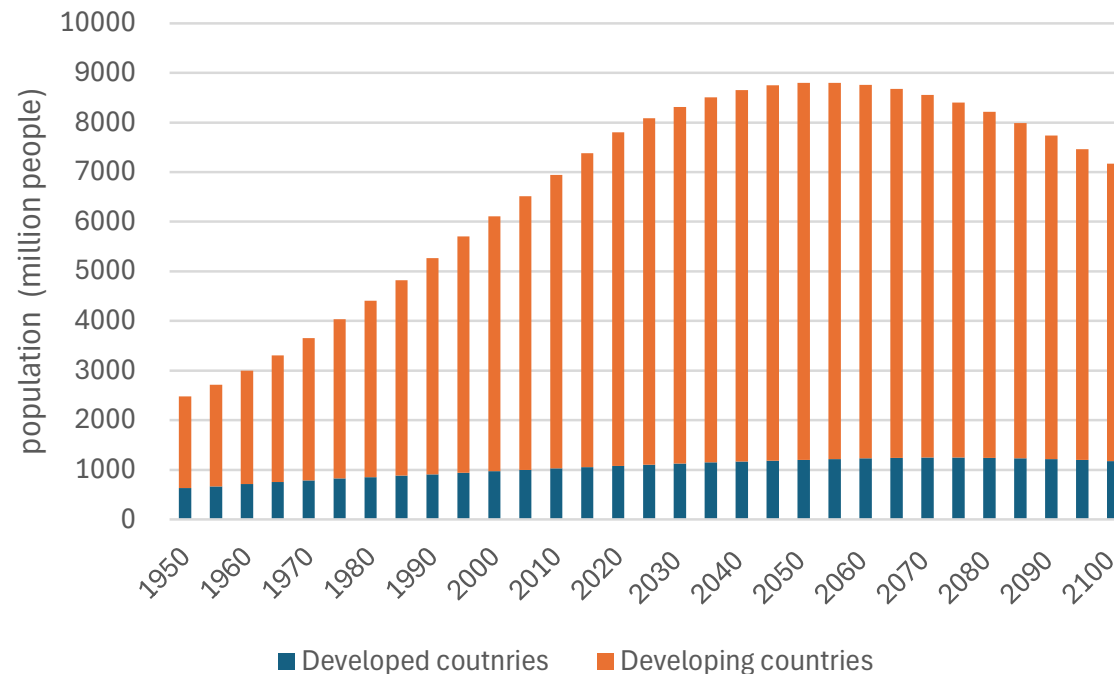
Objective

- The energy consumption of the household sector is one of the points to be focused on from the perspective of achieving carbon neutrality and even the SDGs, since it depends on our living environment and lifestyle and directly influences the richness of our lives.

- The IPCC's Sixth Integrated Assessment Report also stated the need to address decarbonized lifestyles. Therefore, this study aims to determine how different development pathways affect the energy service demand in the household sector.
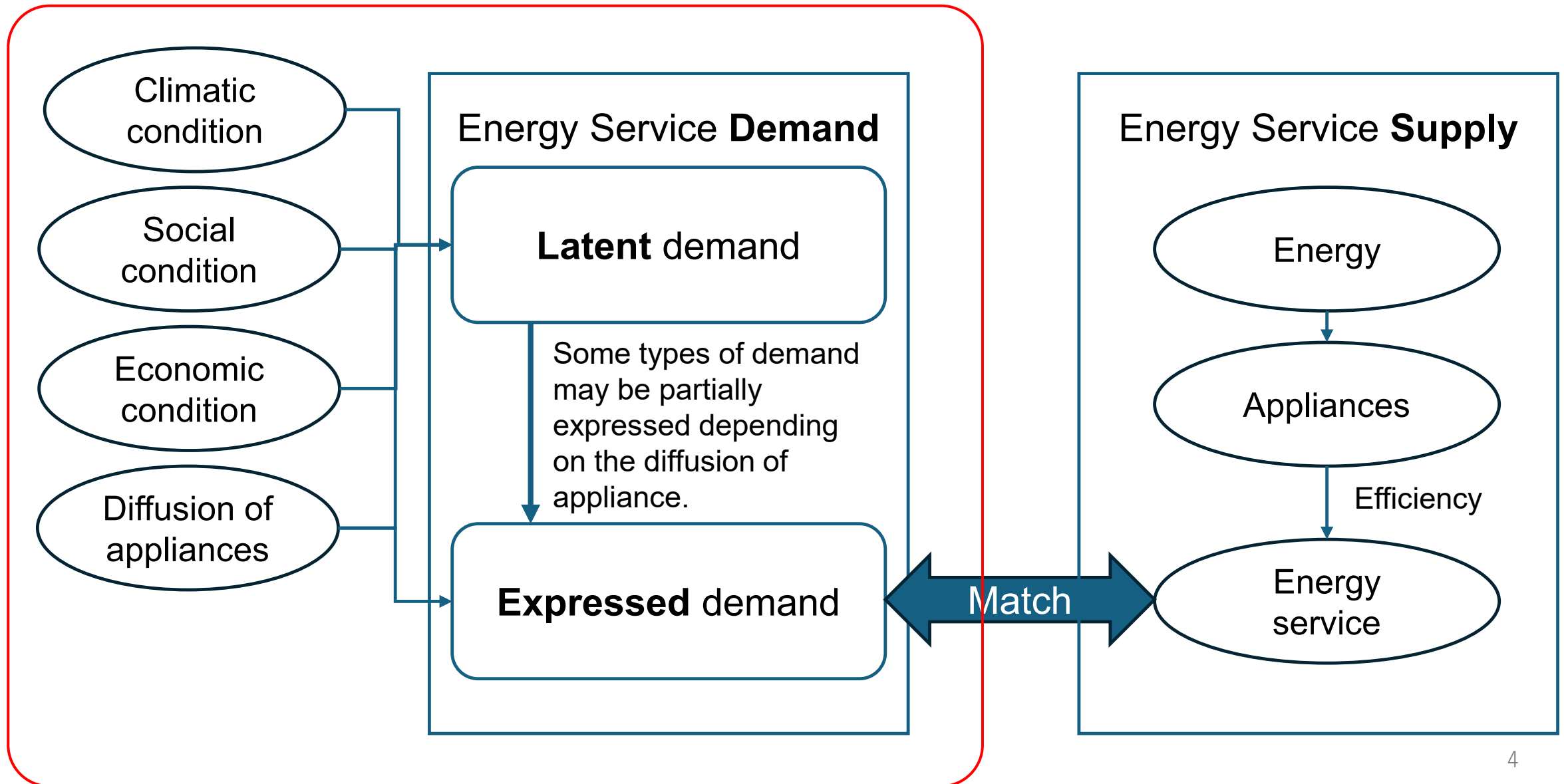
> ・・・. Many options are available for reducing emission-intensive consumption, including through behavioural and lifestyle changes, with co-benefits for societal well-being.
>
> IPCC AR6 Summary for Policymakers C.5
> https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

- Therefore, we estimated the transition pathways of energy service demand in the household sector based on different SSPs (shared socioeconomic pathways) until 2070.

Energy service demand & supply structure

Climatic condition

Social condition

Economic condition

Diffusion of appliances

Energy Service **Demand**

Latent demand

Some types of demand may be partially expressed depending on the diffusion of appliance.

Expressed demand

Match

Energy Service **Supply**

Energy

Appliances

Efficiency

Energy service

Overview of analysis method

	Contents
Subject of analysis	Energy service demand
Target year	2015 – 2070 (Base year: 2015)
Region classification	32 region
Energy service type	6 type (Heating, cooling, hot water supply, Cooking heater, Lighting, Other appliances)

Region

Code	Country	Code	Country
JPN	Japan	CAN	Canada
CHN	China	USA	United States
IND	India	XE15	Western EU countries
IDN	Indonesia	XE10	Eastern EU countries
KOR	South korea	XE2	Bulgaria, Romania
THA	Thailand	TUR	Turkey
MYS	Malaysia	XEWI	Rest of Western Europe
VNM	Viet Nam	XEEI	Belarus, Croatia, Ulraine
XSE	Rest of Southeast Asia	XENI	Rest of Europe
XSA	Rest of South Asia	RUS	Russia
XEA	Rest of Eatern Asia	MEX	Mexico
XCS	Centaral Asia(former Soviet Union)	ARG	Argentine
XME	Rest of Middle East	BRA	Brazil
AUS	Australia	XLM	Rest of Central and South America
NZL	New Zealand	ZAF	South africa
XOC	Pacific Israrnd Countries	XAF	Rest of Africa

Energy service

$$\frac{Energy\ service_t}{Energy\ service_{"base\ year"}} = \frac{Variable1_t}{Variable1_{"base\ year"}} \cdot \frac{Variable2_t}{Variable2_{"base\ year"}} \cdot \frac{Variable3_t}{Variable3_{"base\ year"}} \cdots$$

Energy service type	Variables used in estimation
Heating	Heating degree day (HDD), Number of households, Floor area
Cooling	Cooling degree day (CDD), Number of households, Floor area, Air conditioner diffusion rate
Hot water supply	Population, Change in per capita hot water demand
Cooking heater	Percentage cooking meals at home, Number of households
Lighting	Number of households, Floor area
Other appliances(*)	Appliance efficiency, Appliance diffusion rate, Intensity pf appliance use

* "Other appliances" is a energy service that includes multiple appliances and service types (e.g., refrigerators, televisions, washing machines, etc.), making it difficult to estimate the amount of energy service. Therefore, energy consumption is estimated only for "Other appliances".

How to set variables? (1)

Population and GDP

- SSP database version 1.1

- There are 5 different scenarios for SSP. We use SSP1, SSP2, and SSP3.

Cooling degree days(CDD)/ Heating degree days(HDD)

- CDD and HDD by SSP were calculated using the results of five climate models for temperatures by SSP, with a base temperature of 18℃. Since climate model results are available geographically, the results were weighted and averaged based on population distribution.

Number of households

- Estimated from the population and the average number of household members.

- Based on the past trends (1977-2020) of the average number of household members, it was assumed that the future average number of household members would continue to decline with a decreasing range of decline, eventually converge to some value. The converged values and timing vary by region.

How to set variables? (2)

Percentage of in-house meals

- Percentage of in-house meals = 1 - eating out ratio

- Eating out ratio = the consumption expenditures on eating out / consumption expenditures on food

- **Step1**: Check the historical (1990-2020) rate of change in the eating out ratio (= eating out ratio at year t / eating out ratio at year t-1)

- **Step2**: Assume that the average rate of change in the eating out ratio from 2011 to 2019 will gradually decrease and asymptotically approach 1.

  - THA (Thailand) and XE2 (Bulgaria, Roumania) were calculated using the average rate of change in the eating out ratio from 1990 to 2019, as the rate of change in the eating out ratio from 2011 to 2019 is very large.

How to set variables? (3)

Air-conditioner diffusion rate

- Air-conditioner is considered to spread as a result of climate (need for cooling) and economic growth.

- Based on the past trends (1977-2020) of diffusion rates , we also found that once a country enters the diffusion phase, diffusion rates increase with economic growth in most areas. So assuming that this trend will continue, future diffusion rates were estimated using GDP per capita.

Settings for estimation of "Other appliances"

- The following factors are expected to influence changes in energy consumption of "other household appliances"

  - Increase in the number of appliances owned, larger appliances, multiple appliances, longer usage time, and improvement in energy efficiency due to the diffusion of high-efficiency appliances

- We took the TV as a representative appliance for "other appliances", formulated the relationship between per capita GDP and TV diffusion, and estimated the future TV diffusion rate.

  - Rule 1: Energy consumption increases at an annual rate of 2% for 30 years after the TV diffusion rate exceeds 95%.

  - Rule 2: Energy consumption decreases at a rate of 1% per year for 20 years after TV diffusion rate exceeds 95%.

- Since this rule is based on data from Japan, it is not necessarily appropriate to apply it to other regions, but since it is difficult to obtain sufficient data for analysis in all regions at this time, this method was used.

How to set variables? (4)

- Case settings regarding floor area and hot water demand per capita

	Floor area	Hot water demand per capita
Case1	Average floor area of houses is constant at 2015 value.	Constant at 2015 value.
Case2	For developed countries, per capita floor area is constant at 2015 values; For developing countries, floor area per capita improved by 5%/5 years in SSP1; by 3.75%/5 years in SSP2; by 2.5%/5 years in SSP3.	Hot water demand per capita set to decrease by 2.5% in SSP1, 5% in SSP2, and 7.5% in SSP3 in 2070.

# Result "Lighting" energy service in 2070
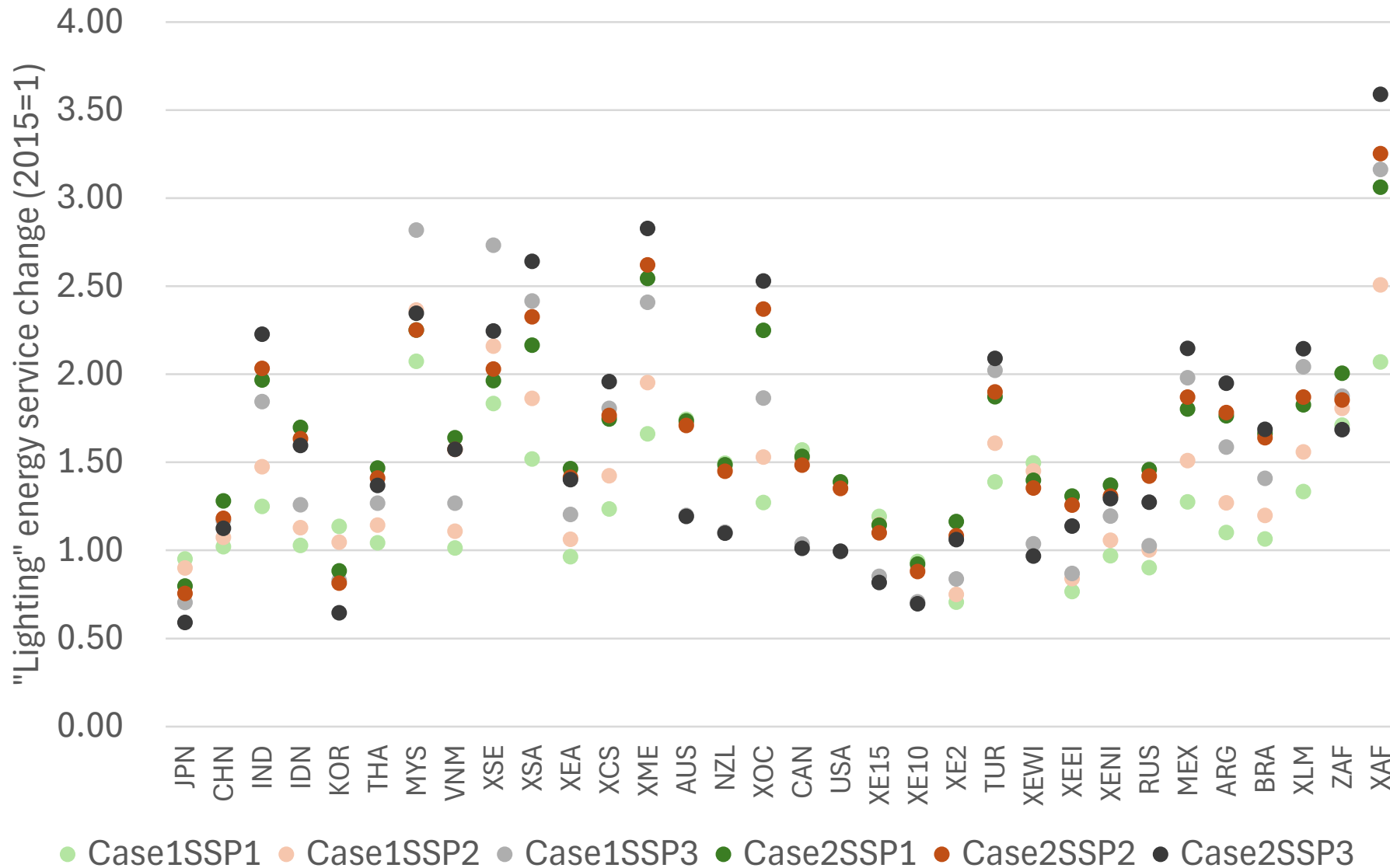
- Comparing by SSP, the growth of lighting services is significant in SSP3 for developing countries and in SSP1 for developed countries.

- 40% demand difference between SSP1 and SSP3.

- In developing countries, the difference in results by SSPs is smaller in Case 2 because SSP1 improves floor space than the other SSPs.

# Result "Heating" energy service in 2070
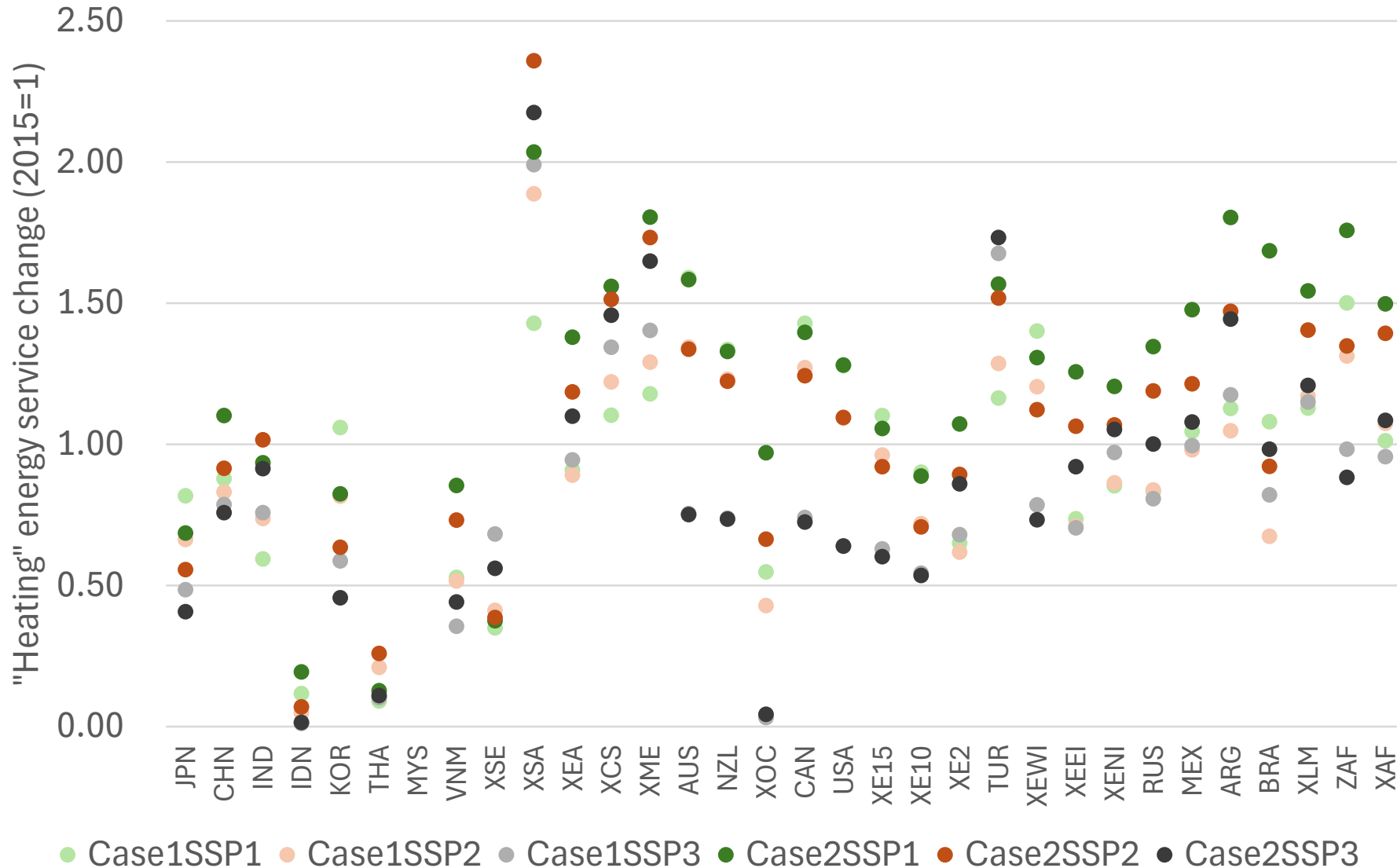
- Since heating demand will become smaller as global warming progresses, so that large demand reductions can be expected in SSP3.

- Developed countries have low growth rates in households and rapid temperature increases, so energy service demand growth is low. (JPN, XE15, XE10 etc.)

Result "Cooling" energy service in 2070
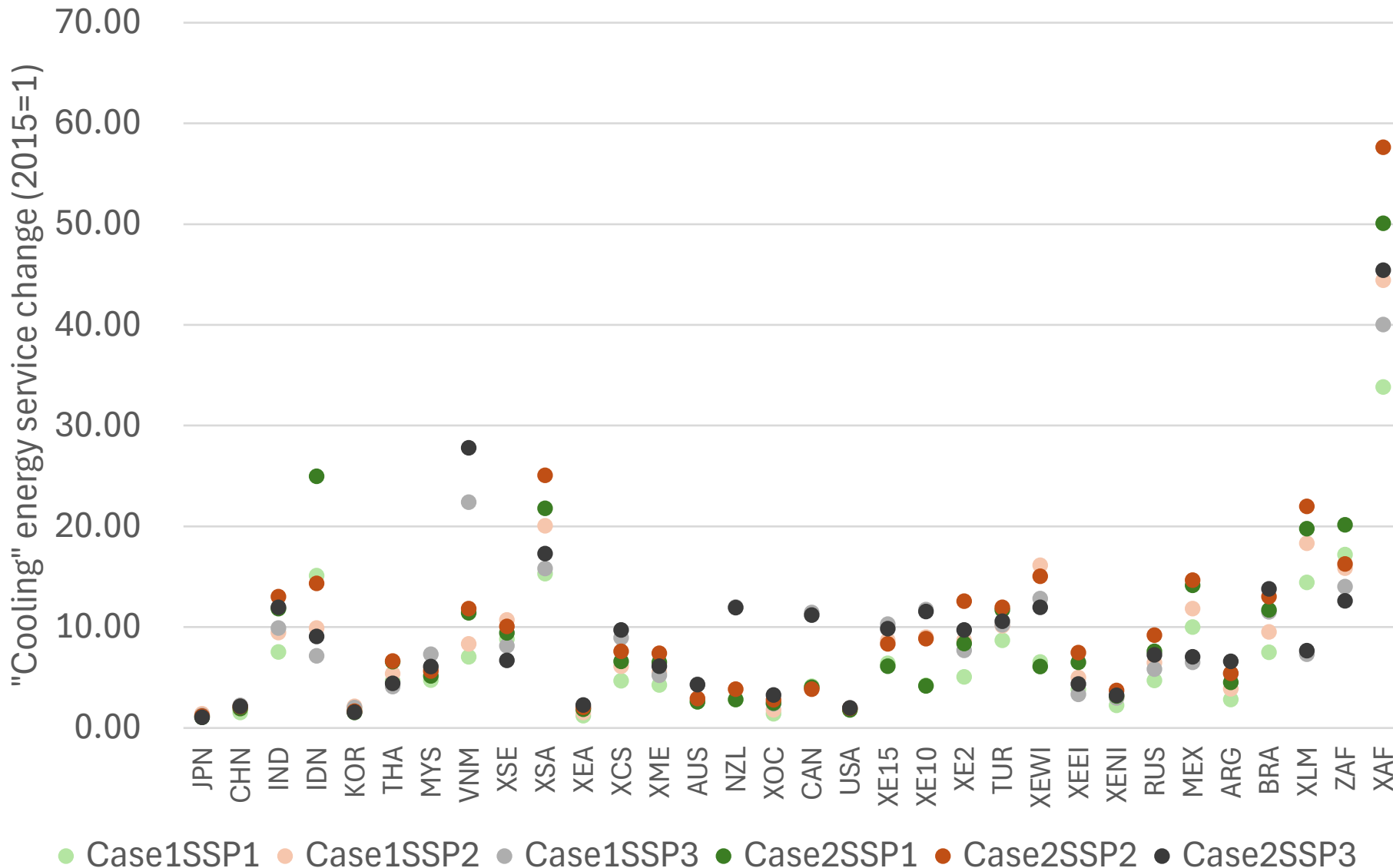
- Because air conditioners will become more widespread and "cooling" demand will emerge with future economic growth.

- The increase in demand for cooling in developing countries located in regions with high temperatures is significant. In particular, in XAF, cooling service in SSP3 will be 40 times higher in 2070 than in 2015.

Result "Cooling" energy service
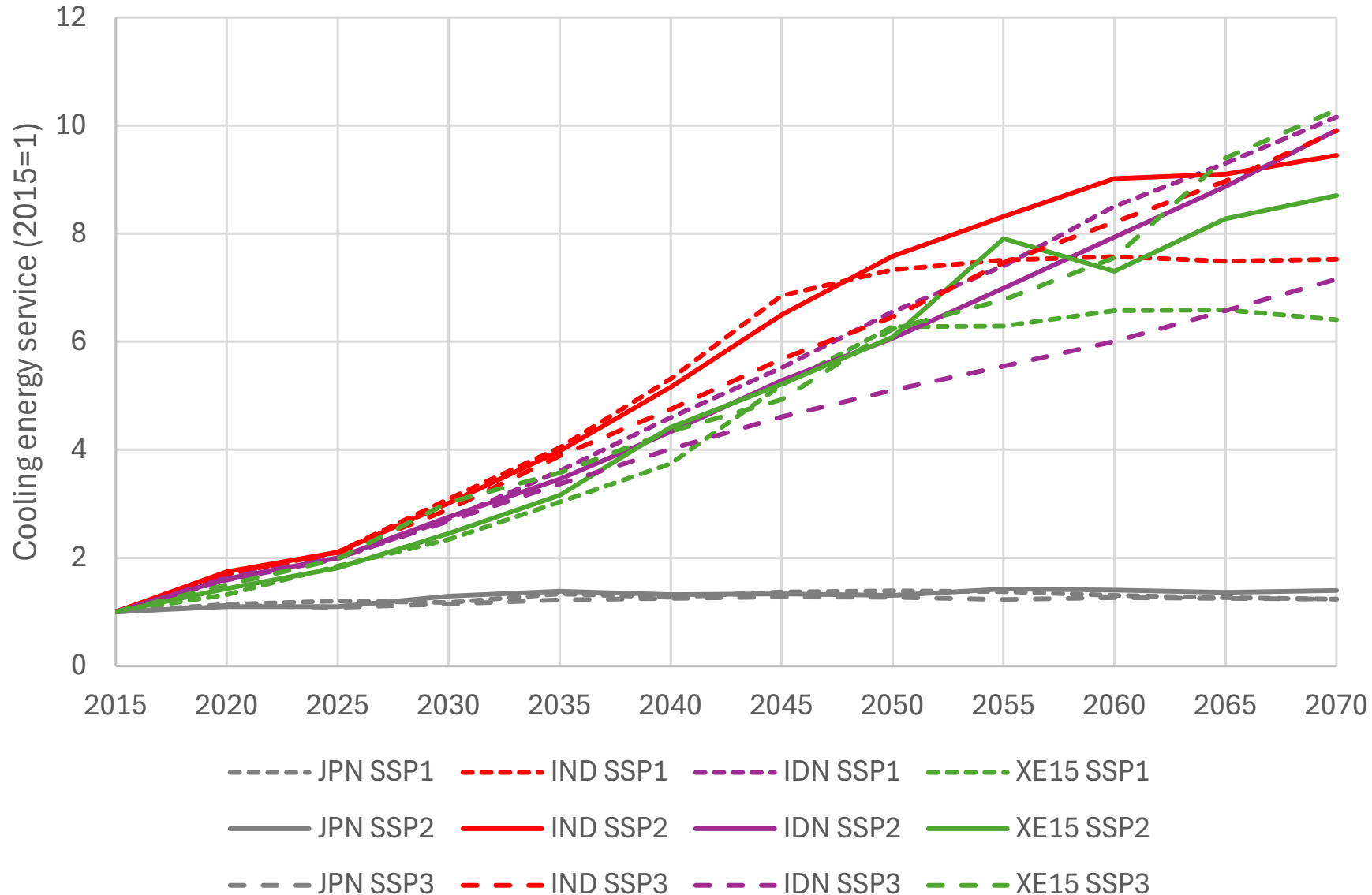
- JPN: Air conditioners are already widely used, and the difference in demand by scenario is not significant.
- XE15: Demand will increase significantly by 2070 because air conditioners become even more widely used in the future.
- IND: Demand increases dramatically due to the diffusion of air conditioners, population growth, and rapid economic growth.
- IDN: The air conditioner diffusion rate is still very low today despite the growth of the economy. As a result, SSP3 has the smallest demand among the three scenarios due to the lack of air conditioner diffusion despite the rise in temperature.

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Result "Other appliances" energy consumption
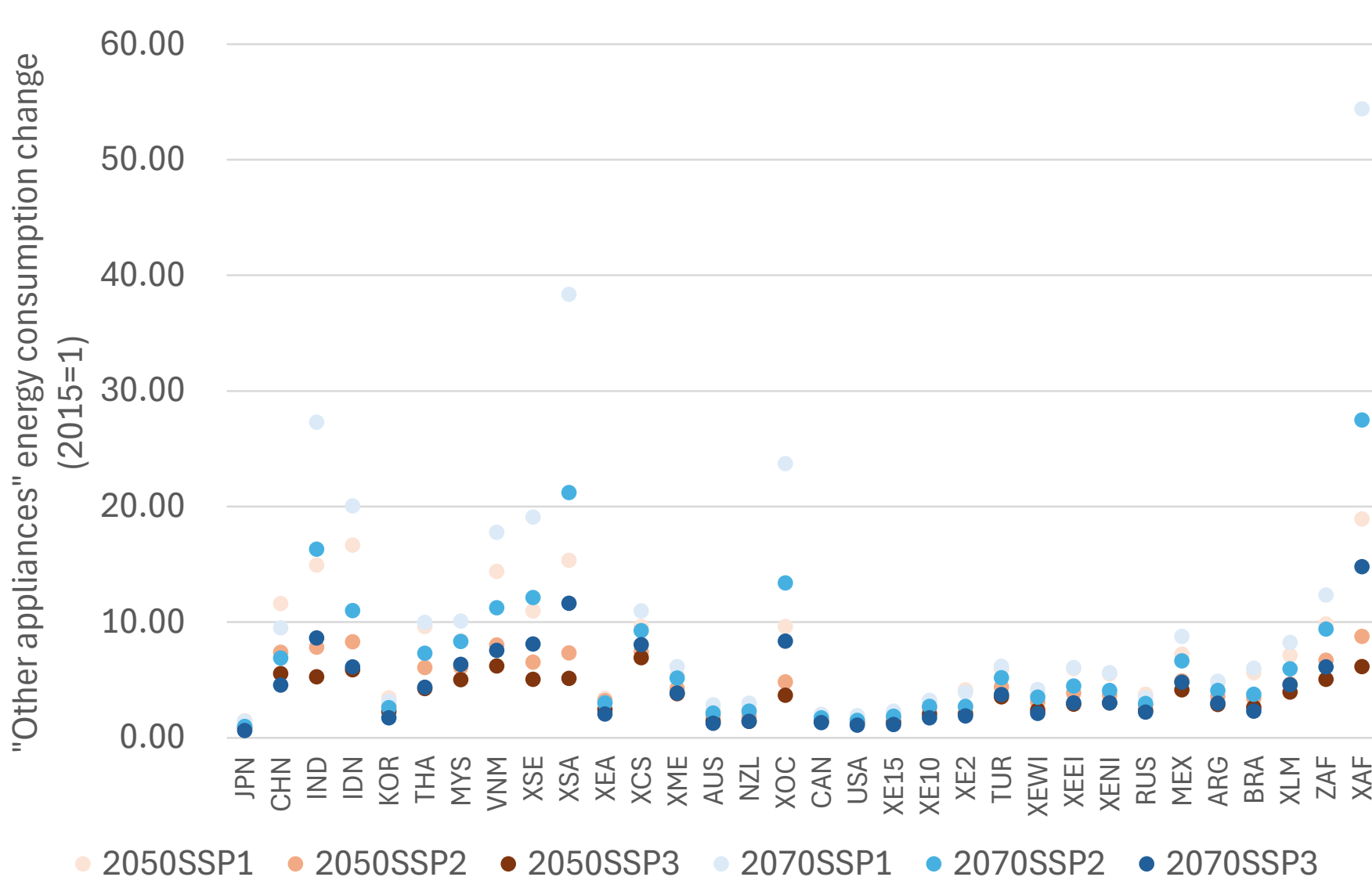
- Since the economic growth rates by SSPs vary widely, indicating that changes in demand also differ significantly by SSPs. In the SSP1 for XAF, where significant economic and population growth is expected in the future, the volume of services in 2050 and 2070 will increase dramatically by 19 and 54 times, respectively, from the 2015 level.
- Demand growth in developed countries was not as large as in developing countries. Even so, demand growth in 2050 was 0.85 (SSP JPN) to 3.74 (SSP1 XEWI), and in 2070 it was 0.62 (SSP JPN) to 4.17 (SSP1 XEWI), indicating that even among developed countries, the growth varies by region.

Summary

- In this study, the energy services demand in the household sector was estimated in 32 regions of the world by SSP scenario through 2070.

- The results show that large energy service demand will occur in the future, especially in developing countries, due to population growth and economic growth. However, slow economic growth also indicated that the diffusion of appliance may be delayed and that energy services that are needed, for example, in "cooling" services, may not be fully expressed.
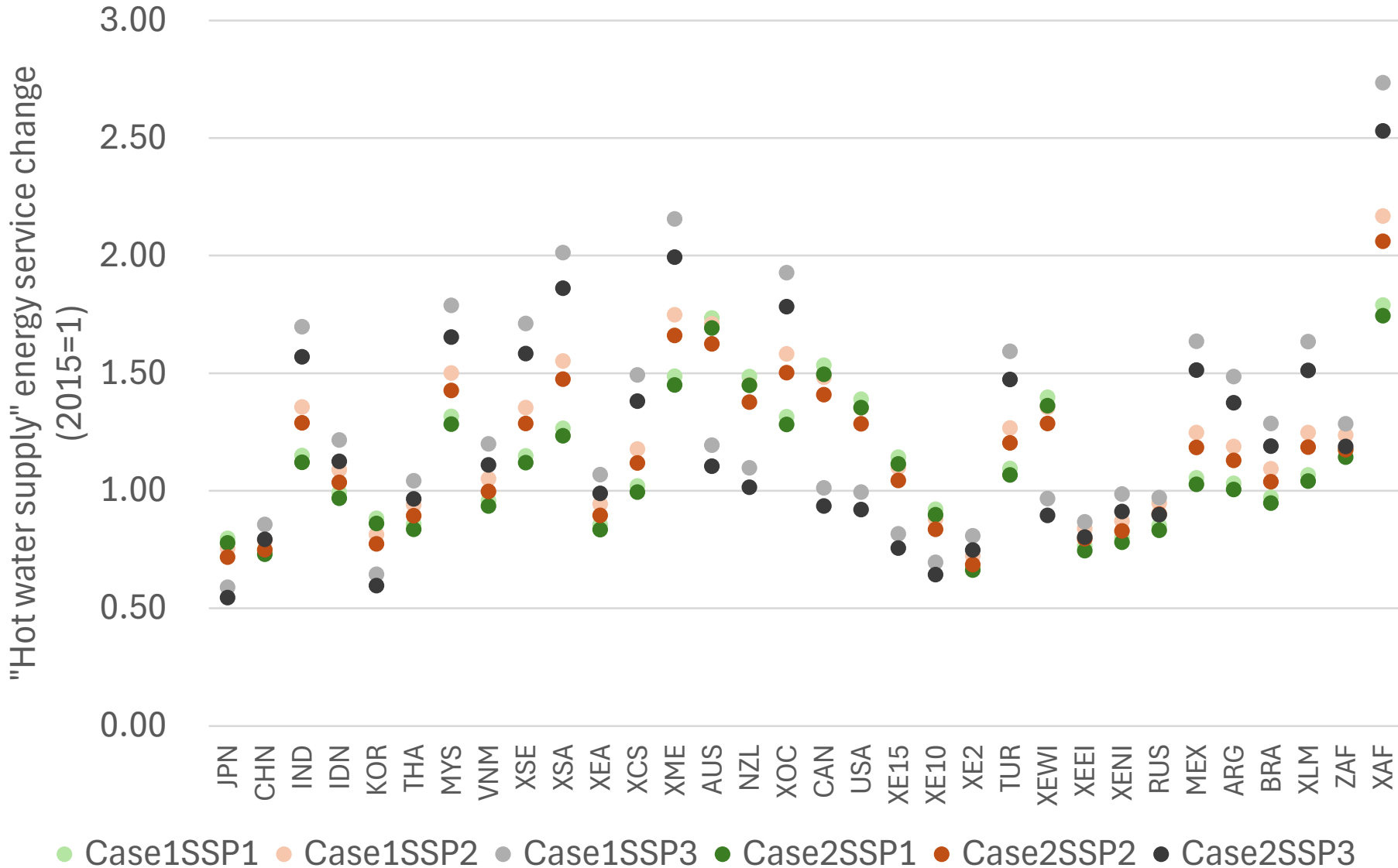
Future tasks

- But the energy consumption and GHG emissions will change significantly depending on what type of appliance is used to meet the demand. More precise service demand estimation and estimation of energy consumption and GHG emissions are future tasks.

- The regional, social, and economic variables necessary for this analysis are not well-developed in statistics, especially in developing countries, and it is difficult to grasp the actual situation in many areas.

- Some of the variables that should have been used in the analysis could not be taken into account. It is necessary to promote a more precise analysis of the current and future situation, with a focus on developing countries.

Thank you for your attention!

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Result "Hot water supply" energy service

Result "Cooking" energy service