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Climate Services Workshop Joint Conference

Assessment of Climate Change Impact on South Korea's Electricity Demand with Uncertainty

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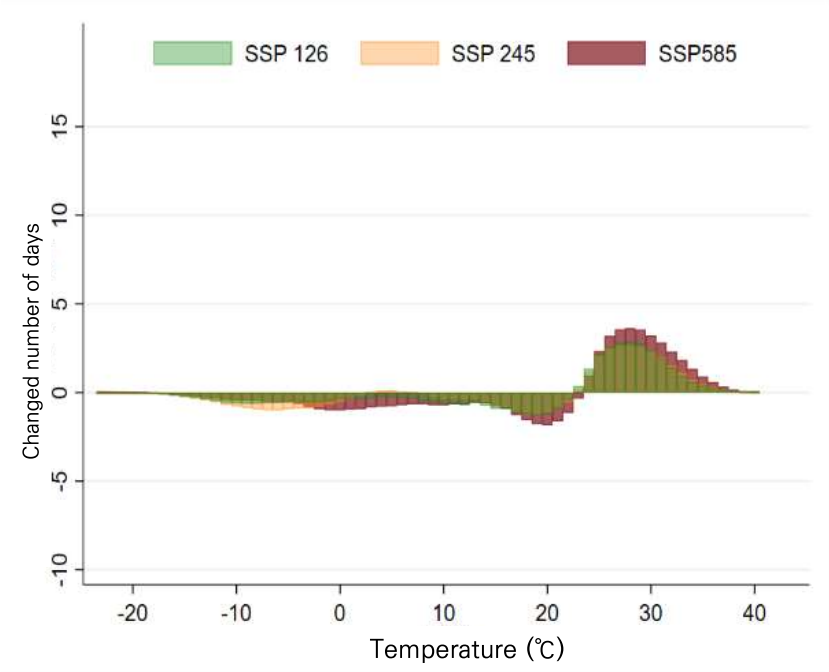
II. Introduction

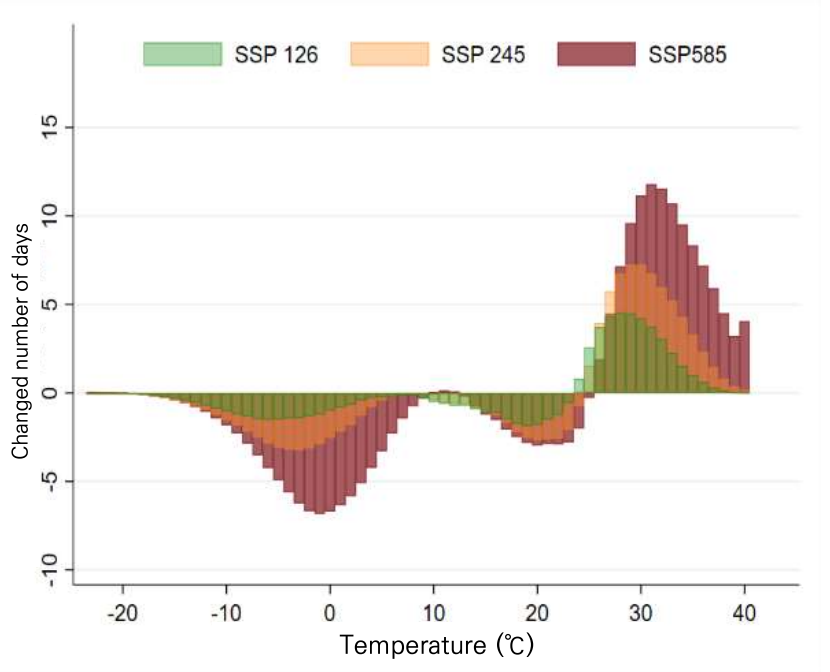
Why do we care?

〈Change in Distribution of Temperature Bin due to Climate Change〉

〈2021~2040〉



〈2081~2100〉



How this change affect electricity consumption in S. Korea?

Feature of this study

- Use the latest climate change scenarios

Scenarios	Period	Global Climate Models
SSP126, SSP245, SSP585	2021~2040, 2041~2060, 2081~2100	CanESM5 (CAN), GFDL-ESM4 (USA), ASSESS-ESM1-5 (AUS), 5ENSEM (KOR)

- Consider the uncertainty of climate change impacts
  - Uncertainties from the results of global climate models
  - Uncertainties from the results of econometrics analysis

- Estimate the temperature response curve as precise as possible
  - Used 4^{th}-order polynomial to capture nonlinearity
  - Employed the fixed effect panel analysis to control omitted variable bias

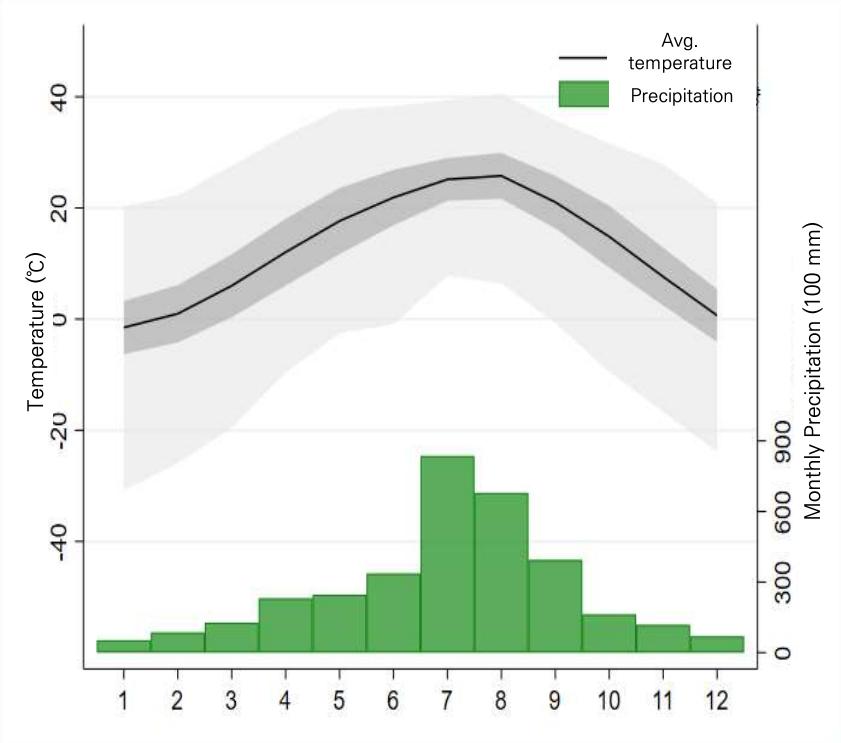
II. Data

Data

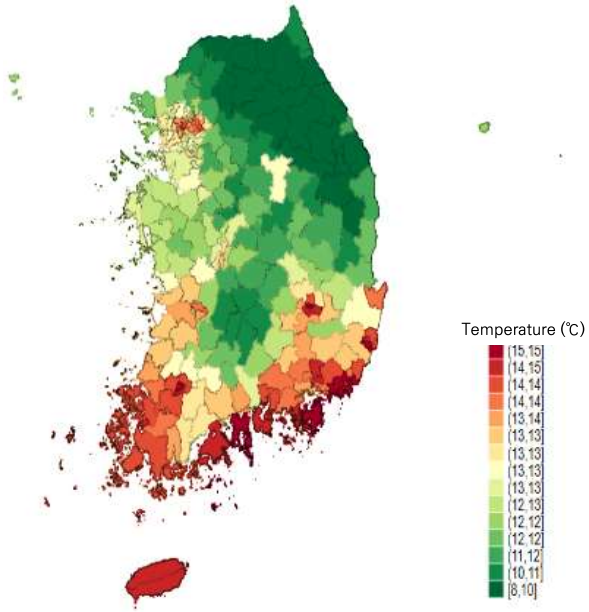
		Spatial unit	Time unit	Source	Note
Past weather information	Temperature (min, max), Precipitation	County	2011–2018, Daily	Korea Meteorological Administration (KMA)	• MKPRISM from KMA
Past electricity consumption	Monthly electricity consumption, number of contract	County	2011–2018, Monthly	Korea Electric Power Corporation (KEPCO)	• Residential sector • General sector
Future weather information	Temperature (min, max), Precipitation	County	2021–2100, Daily	KMA, IWMI	• CanESM5 (Canada) • GFDL–ESM4 (US) • ASSESS–ESM1–5 (AUS) • 5ENSEM (S. Korea)

Climate in South Korea

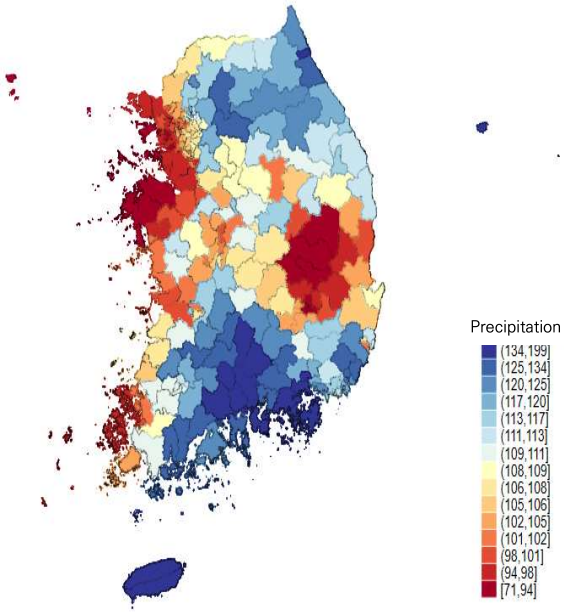
〈Average Temperature and Precipitation (2000~2019)〉



〈Average Temperature〉

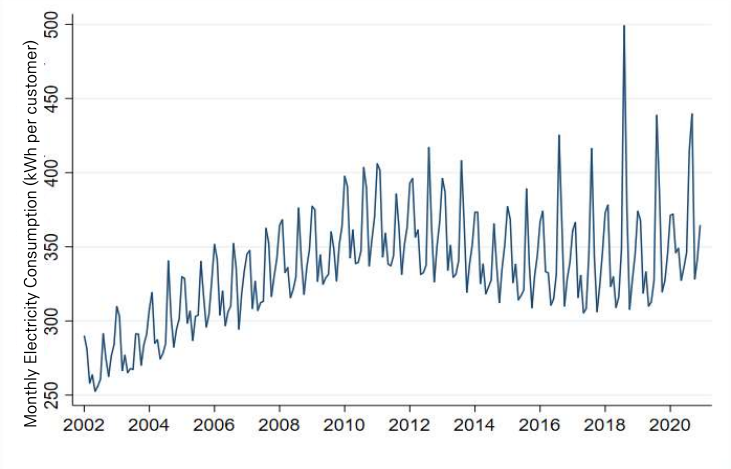


〈Monthly Average Precipitation〉

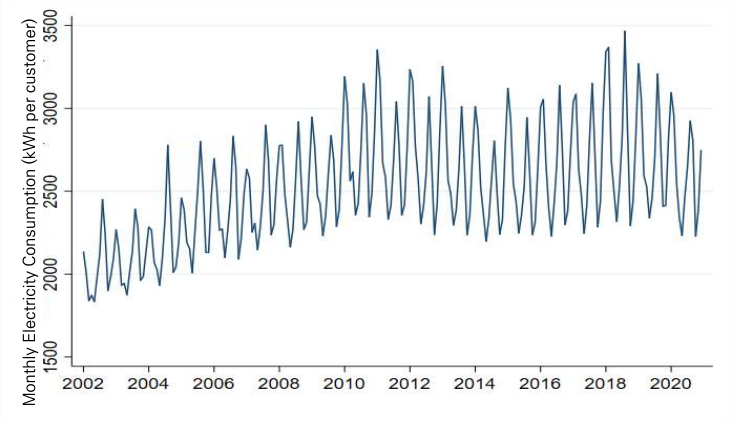


Past Electricity Consumption in South Korea

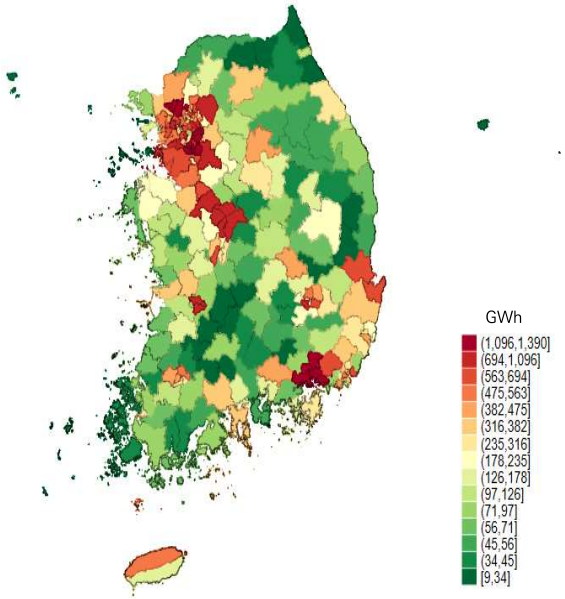
〈Residential Sector〉



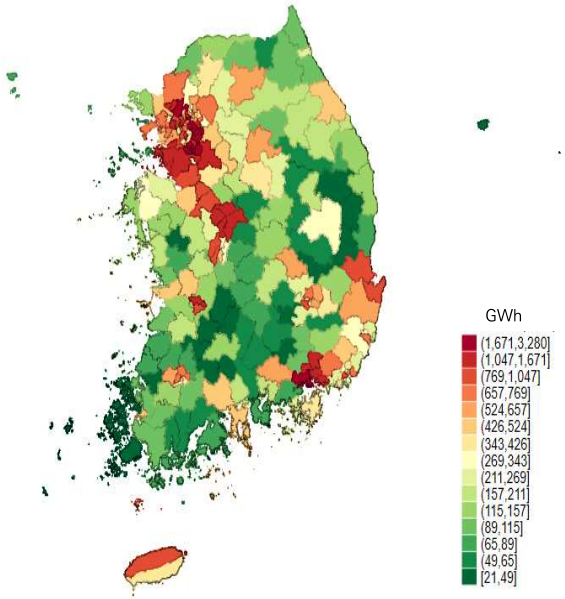
〈General Sector〉



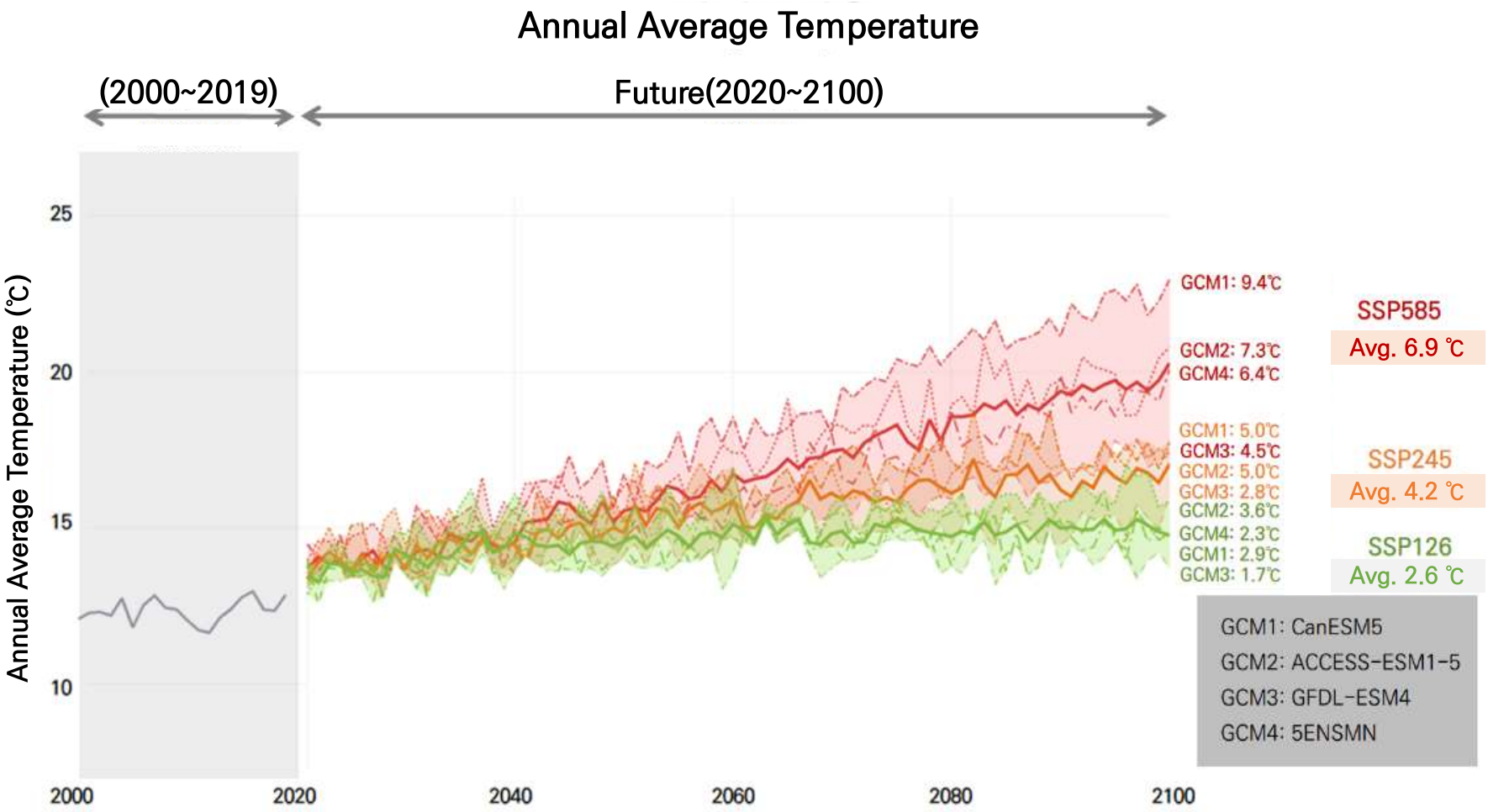
〈Residential Sector〉



〈General Sector〉



Climate Change in South Korea



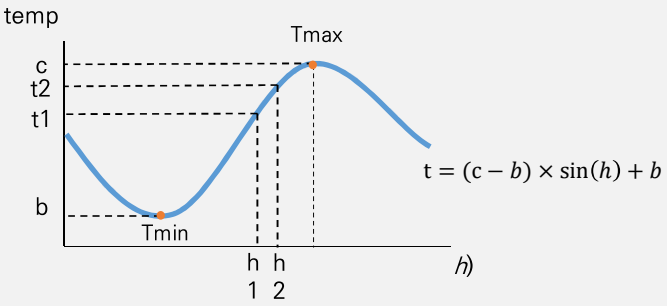
III. Method

Method(1)

1.Construct temperature bin

- Convert daily temperature to hourly temperature
- Construct monthly temperature bin by using hourly temperature

$$Tbin_{t,j}^{temp} = \sum_{d=1}^{D} x_{d,j}^{temp} \qquad \forall\, t = \sum_{d=1}^{D\in\{30,31\}} d$$



2. Estimate temperature response curve

- Analyze the relationship between electricity consumption and temperature bin

– Use 4th–order polynomial to reflect the nonlinearity
– Use the fixed effects to control omitted variable bias

$$y_{i,t} = \beta_0 + \beta_j \cdot f_j\left(h, Tbin_{i,t}^{h}\right) + P(prcp) + \delta_i + \tau_t + \varepsilon_{i,t}$$

$$f_j\left(h, Tbin_{i,t}^{h}\right) = f_j\left(\sum_{h=-20}^{40} h \times Tbin_{i,t}^{h}\right) \quad \text{and} \quad P(prcp) = \gamma_1 \cdot prcp_{i,t} + \gamma_2 \cdot prcp_{i,t}^2$$

- $y_{i,t}$: county–level monthly electricity consumption per customer
- β_j : coefficient of each order in function f
- δ_i : county–level fixed effect
- τ_t : time fixed effect
- $\varepsilon_{i,t}$: error

Method(2)

3. Compute future electricity consumption change with climate change scenarios

- Compute the change in temperature bin in each scenario
- Compute the change in electricity consumption by using the temperature response curve and future temperature bin change

$$\Delta y_{i,t+1} = \sum_{h=-20}^{40} \alpha_h \times \underbrace{\left(Tbin_{i,t+1}^{h} - Tbin_{i,t}^{h}\right)}_{\text{change in temperature bin between t and t+1}}$$

- $\Delta y_{i,t+1}$: the change in electricity consumption per customer in county-level
- α_h : coefficient of temperature bin h
- $Tbin_{i,t+1}^{h}$: the exposed time in each temperature bin at time t+1
- $Tbin_{i,t}^{h}$: the exposed time in each temperature bin at time t

4. Consider uncertainty

- Randomized simulation with the assumption that GCMs and coefficients in the temperature response curve are distributed in a certain shape
- Uncertainty from GCMs

$$P(GCM_i) = p$$

$$\sum P(GCM_i) = 1$$

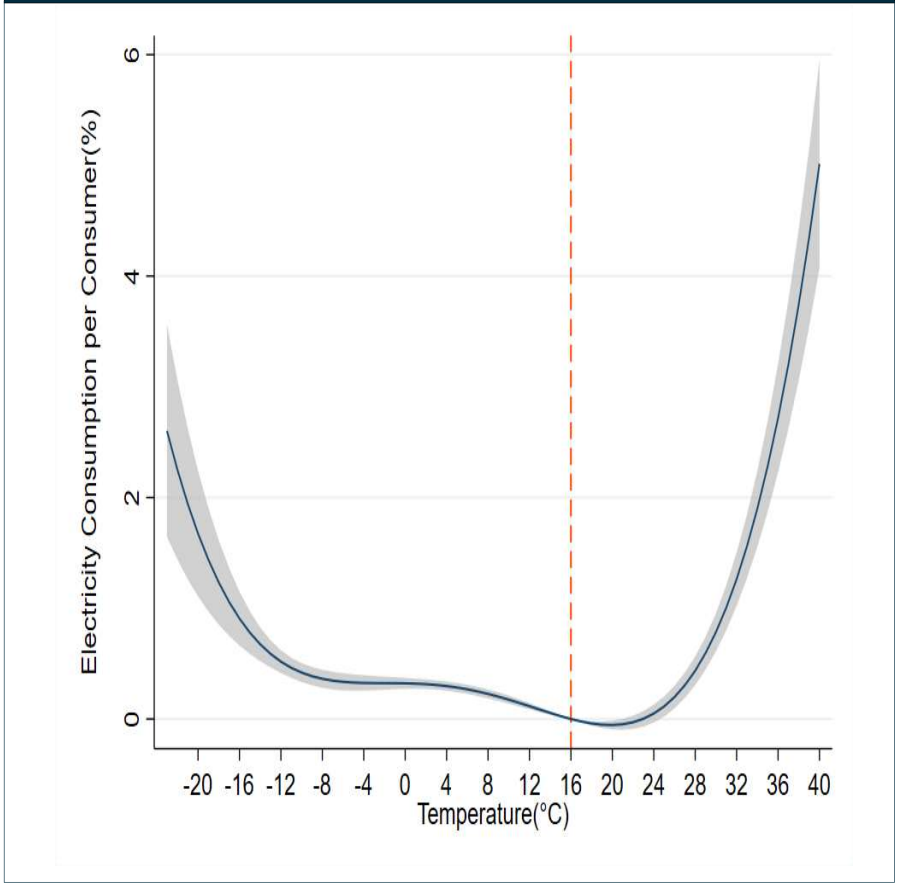
- Uncertainty from econometric analysis

$$N \sim (\alpha_h, \delta_h)$$

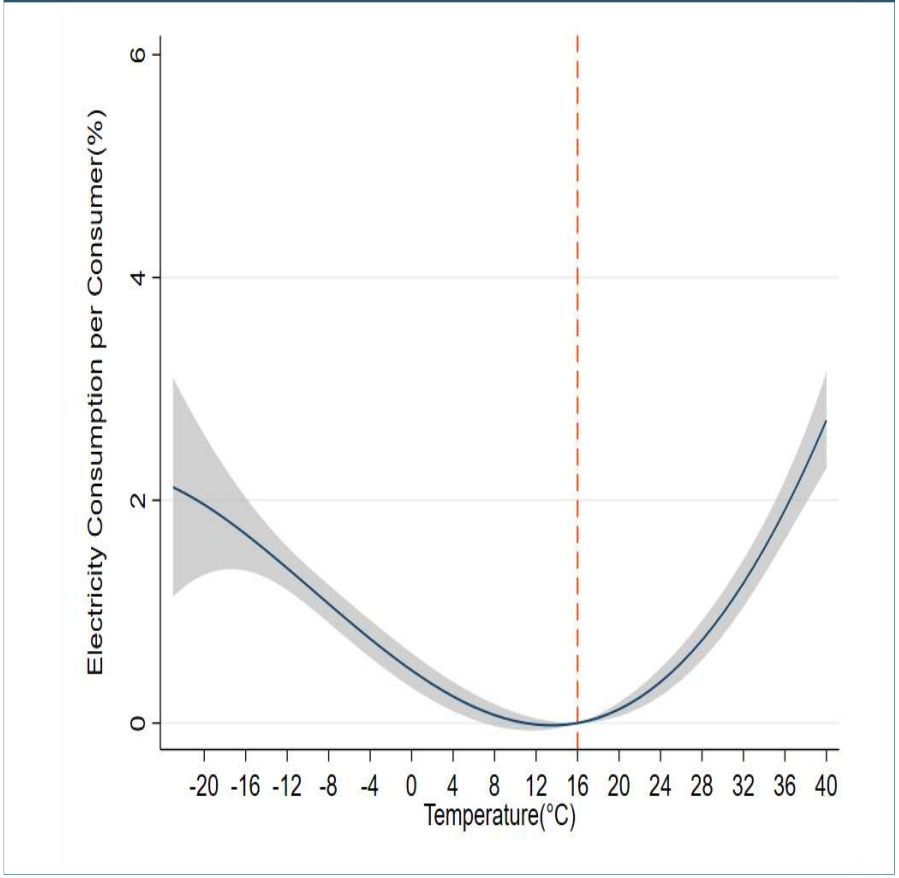
IV. Result

Temperature Response Curves

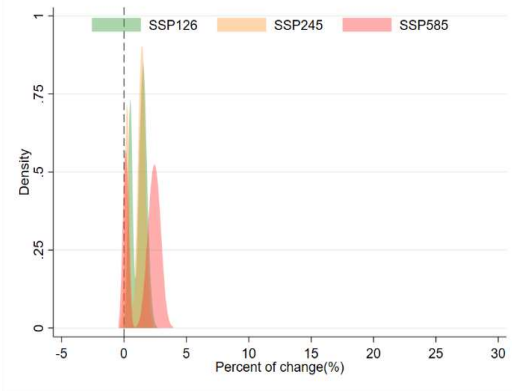
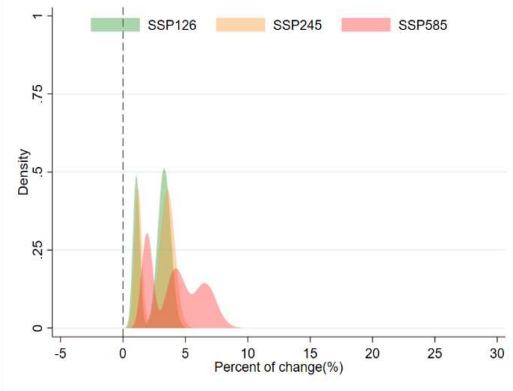
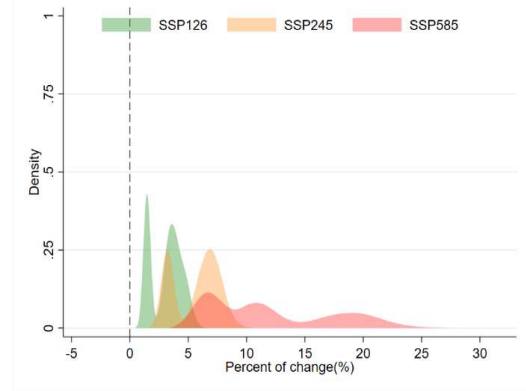
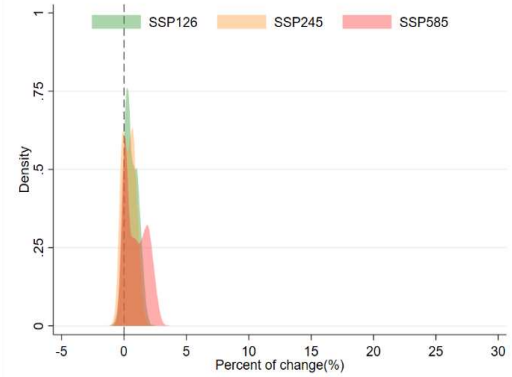
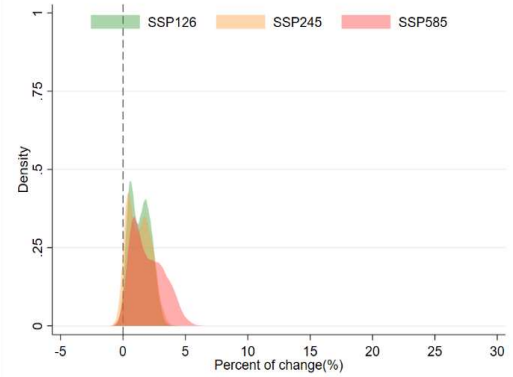
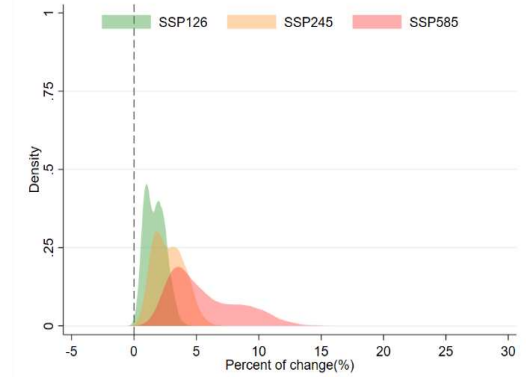
Residential sector



General sector

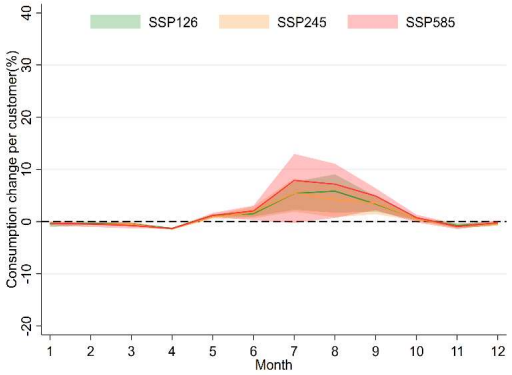
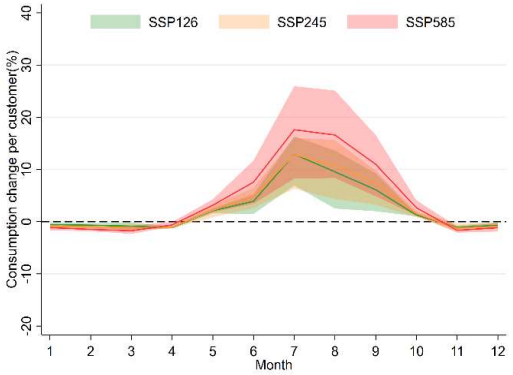
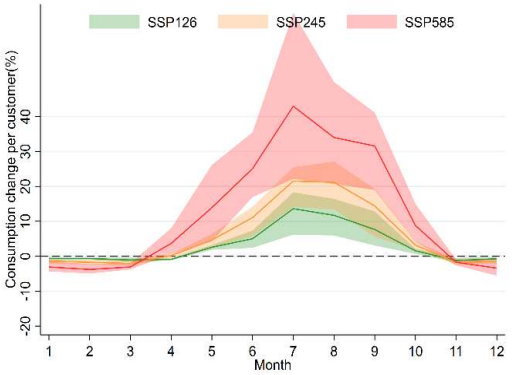
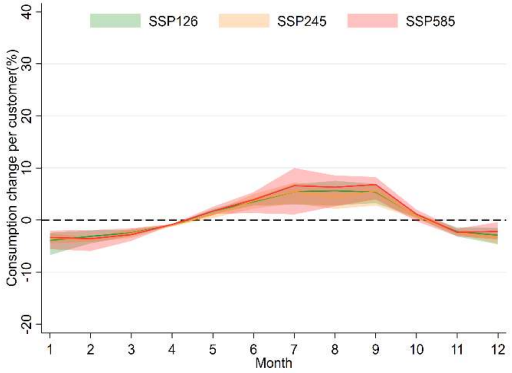
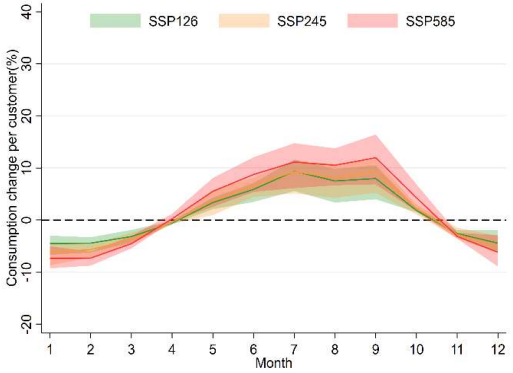
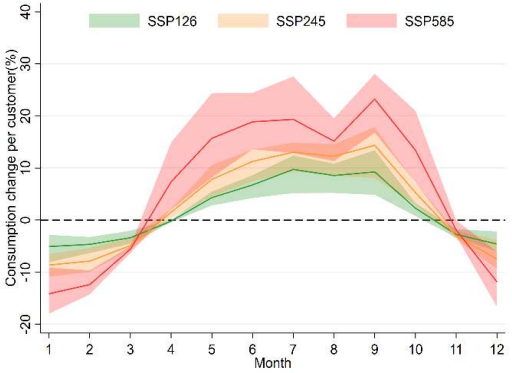


Future Electricity Consumption Changes

	2021~2040	2041~2060	2081~2100
Residential sector			
General sector			

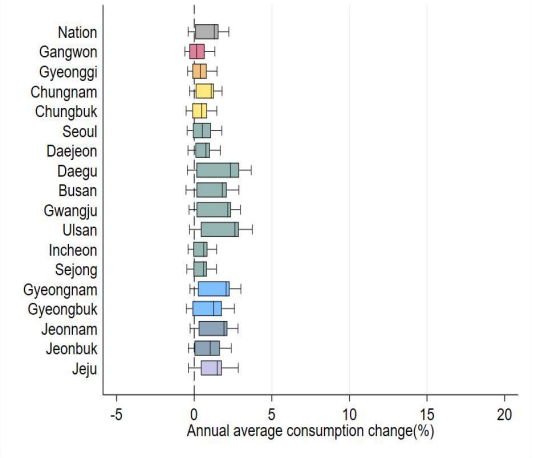
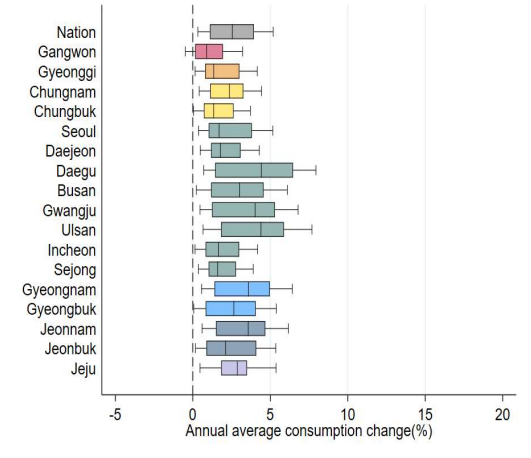
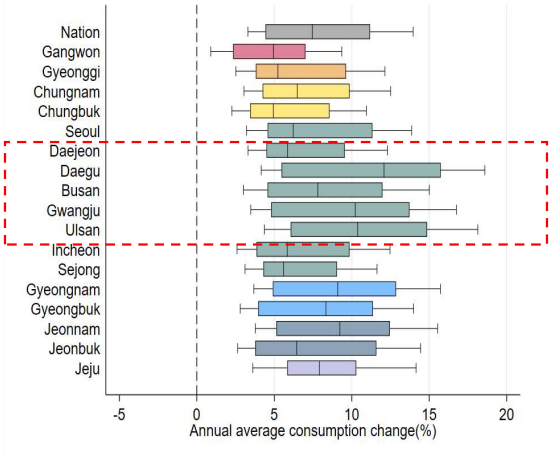
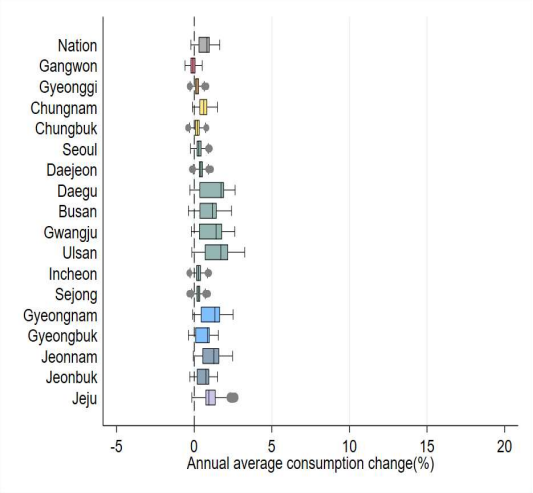
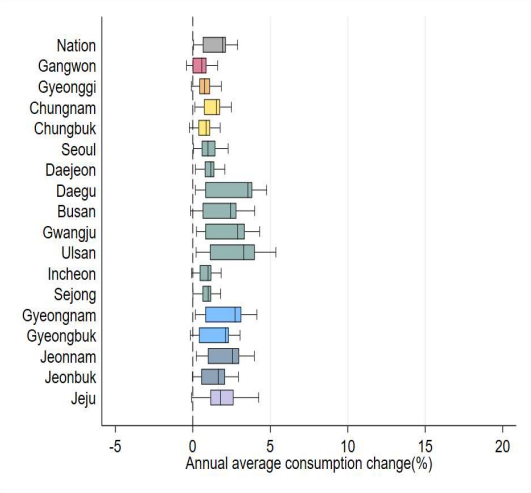
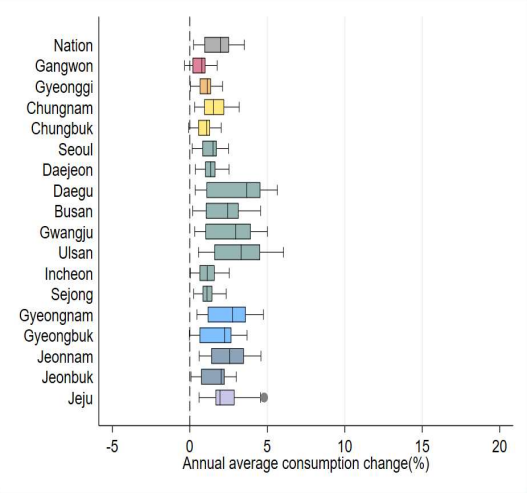
- Both sectors' electricity consumption will increase in the future.
- The magnitude of changes depends on the period and SSP scenarios.
- Uncertainty will grow over time.
- The highest increase in electricity consumption is projected under SSP585 during 2081–2100, with the greatest uncertainty.

Predicted future electricity consumption in different months

	2021~2040	2041~2060	2081~2100
Residential sector			
General sector			

- Electricity consumption significantly increases in summer
- Predicted decrease in electricity consumption during winter

Future Residential Electricity Consumption Change in Different Regions

	2021~2040	2041~2060	2081~2100
SSP585			
SSP126			

V. Conclusion

Conclusion

- Residential and general electricity consumption are temperature-sensitive
- Climate change will increase electricity consumption in South Korea

	Time: 2081~2100		
	SSP126	SSP245	SSP585
Residential Sector	1~7%	2~10%	4~27%
General Sector	1~4%	1~8%	1~15%

- Climate change impacts vary by season, increasing summer consumption and decreasing winter consumption
- Electric company may need to expand their generation facilities to fulfill increase summer demand, which will raise the cost of providing electricity

Thank you