# China's Electricity Future: A Provincial Scenario Analysis towards 2050

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Introduction

- Providing affordable, reliable, clean electricity in China requires a robust planning process that accounts for uncertainties

- Robust capacity planning in the power system requires characterizing the uncertainty on future electricity demand

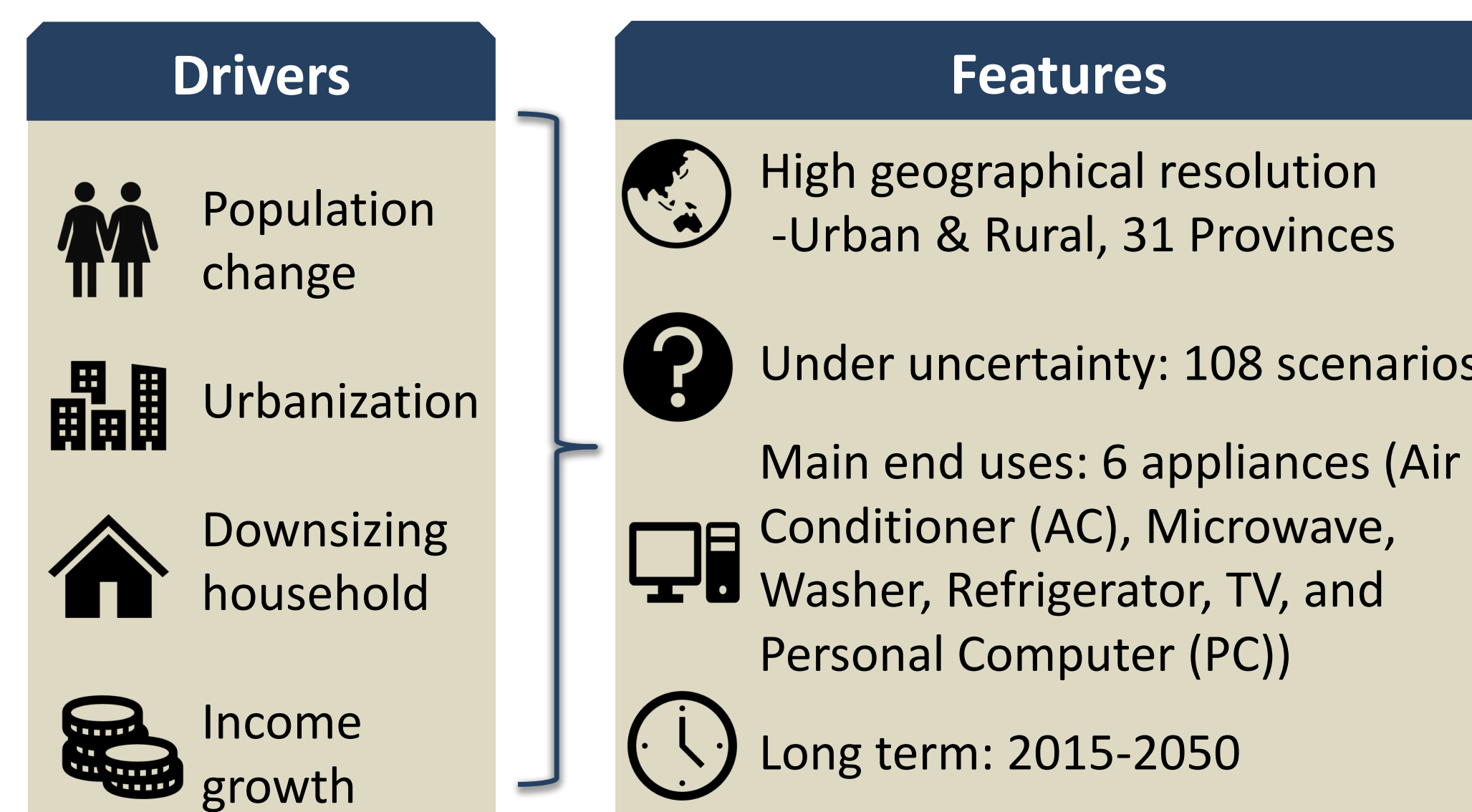- Electricity demand from the residential sector is growing fast
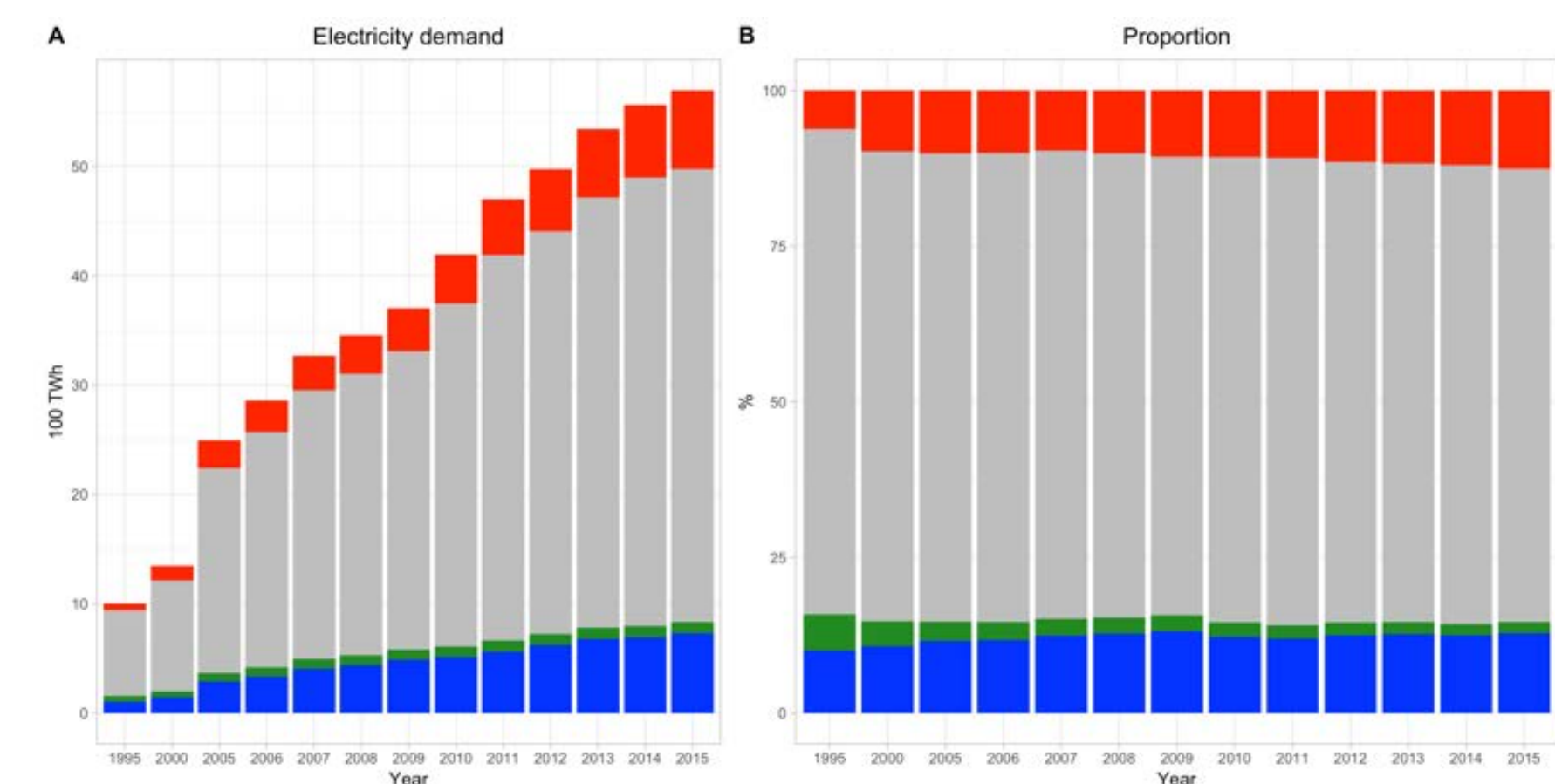
- There is an urgent need to identify and understand the drivers of future electricity demand in the residential sector

- This research directly contributes to projection of future electricity demand in the residential sector from the bottom-up
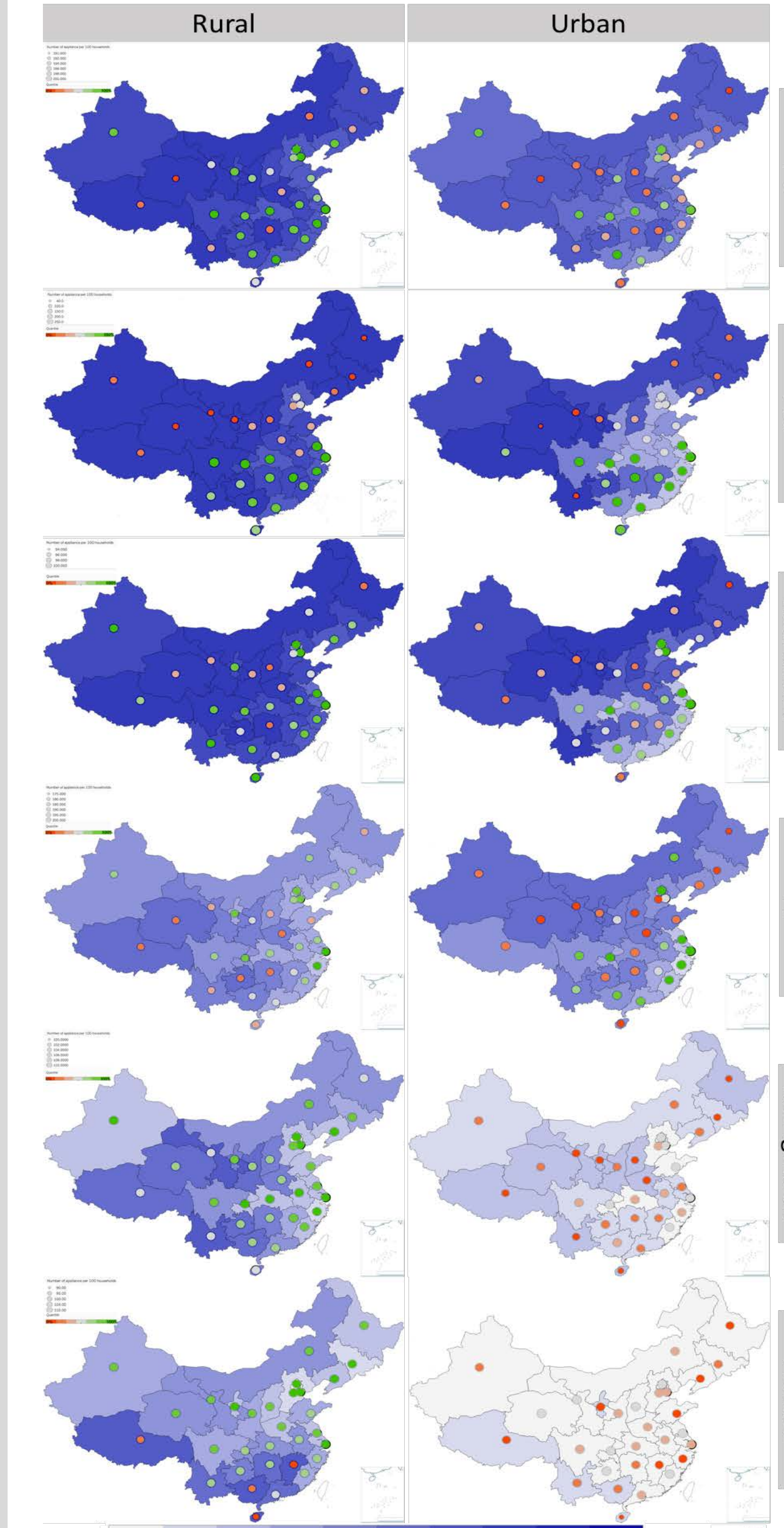
Objective

To project China's electricity demand from the residential sector for the 2015-2050 period at a provincial level, under different demographic and socio-economic scenarios:

- **Saturation**: Penetration of household electric appliances per household

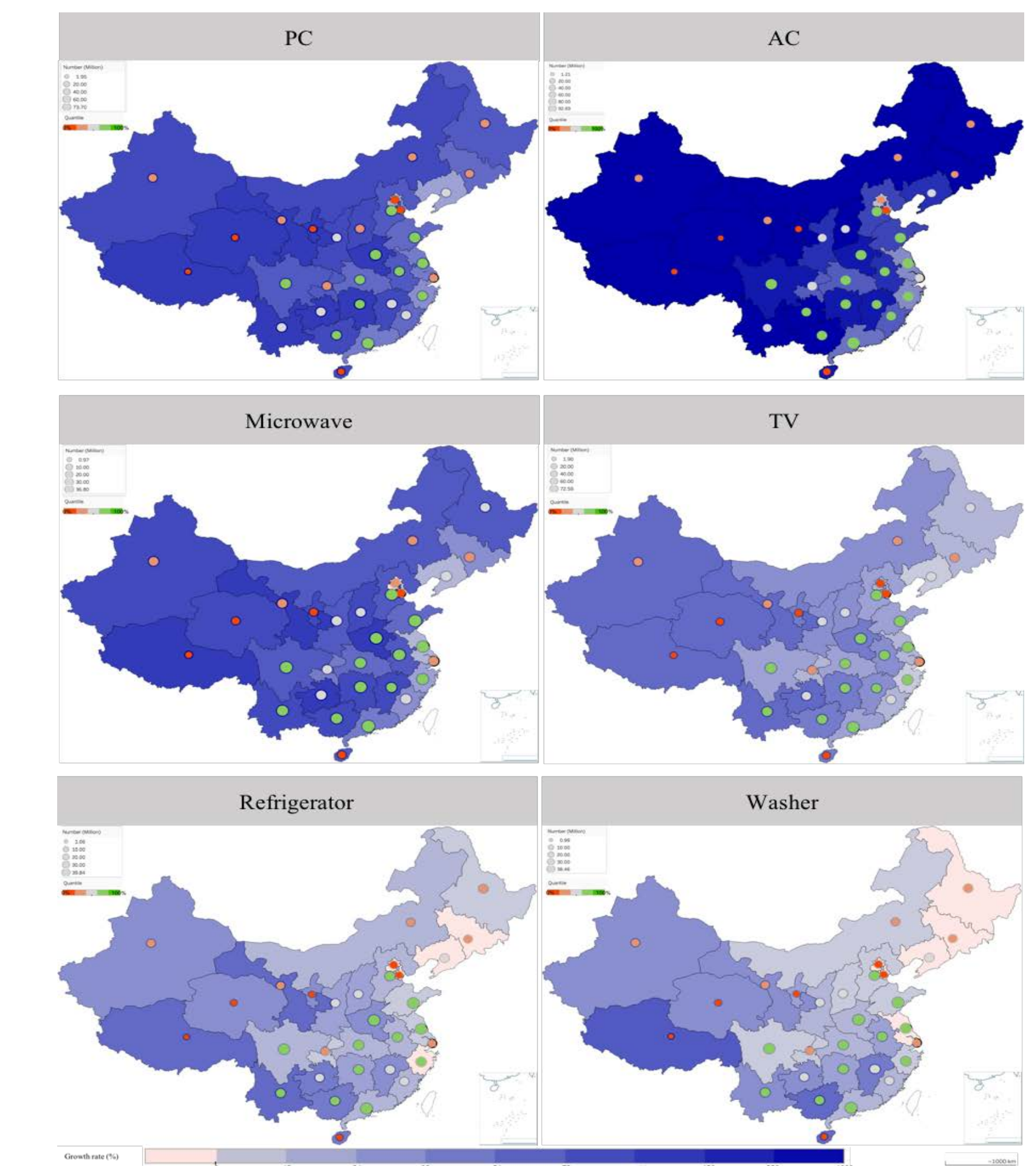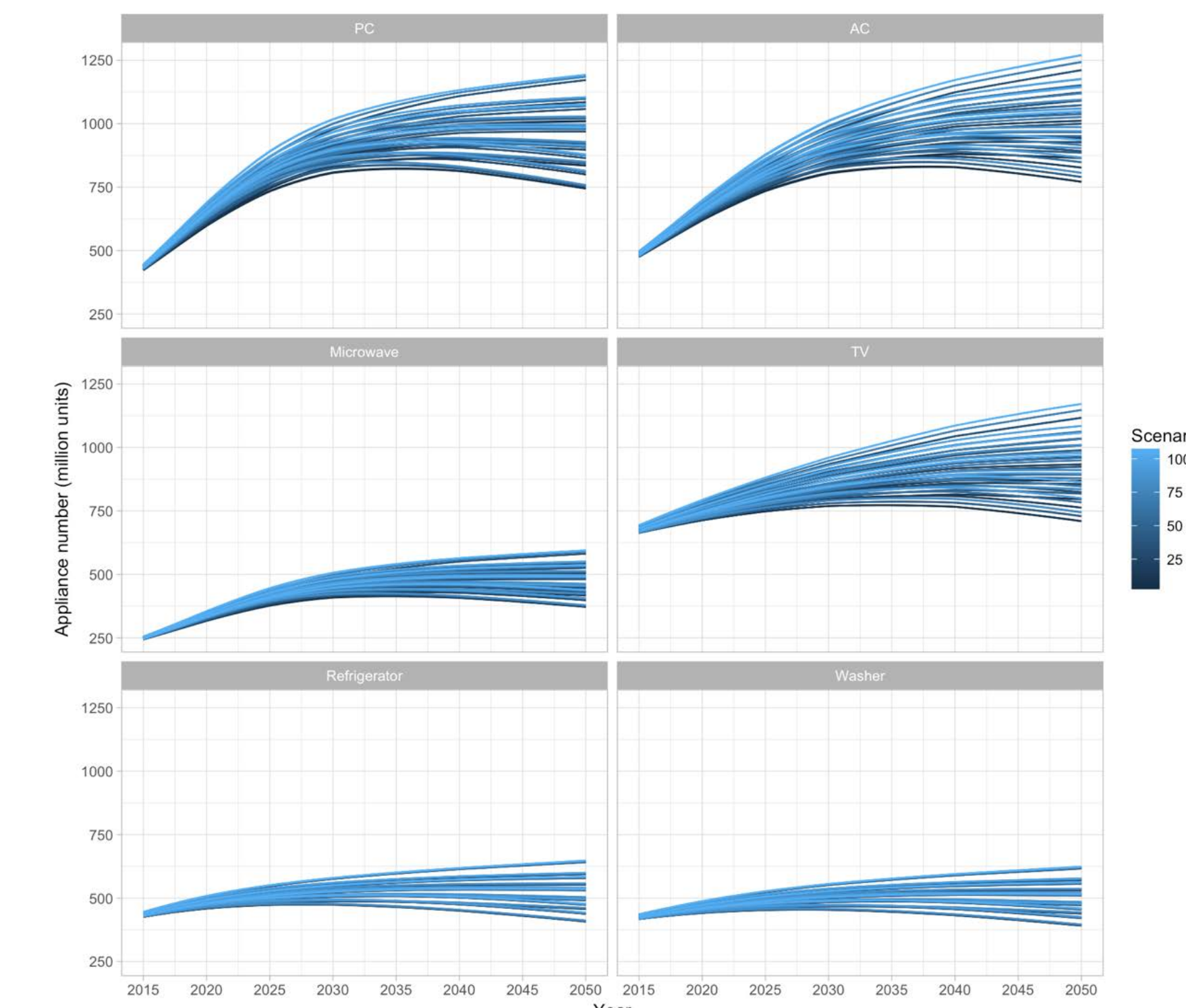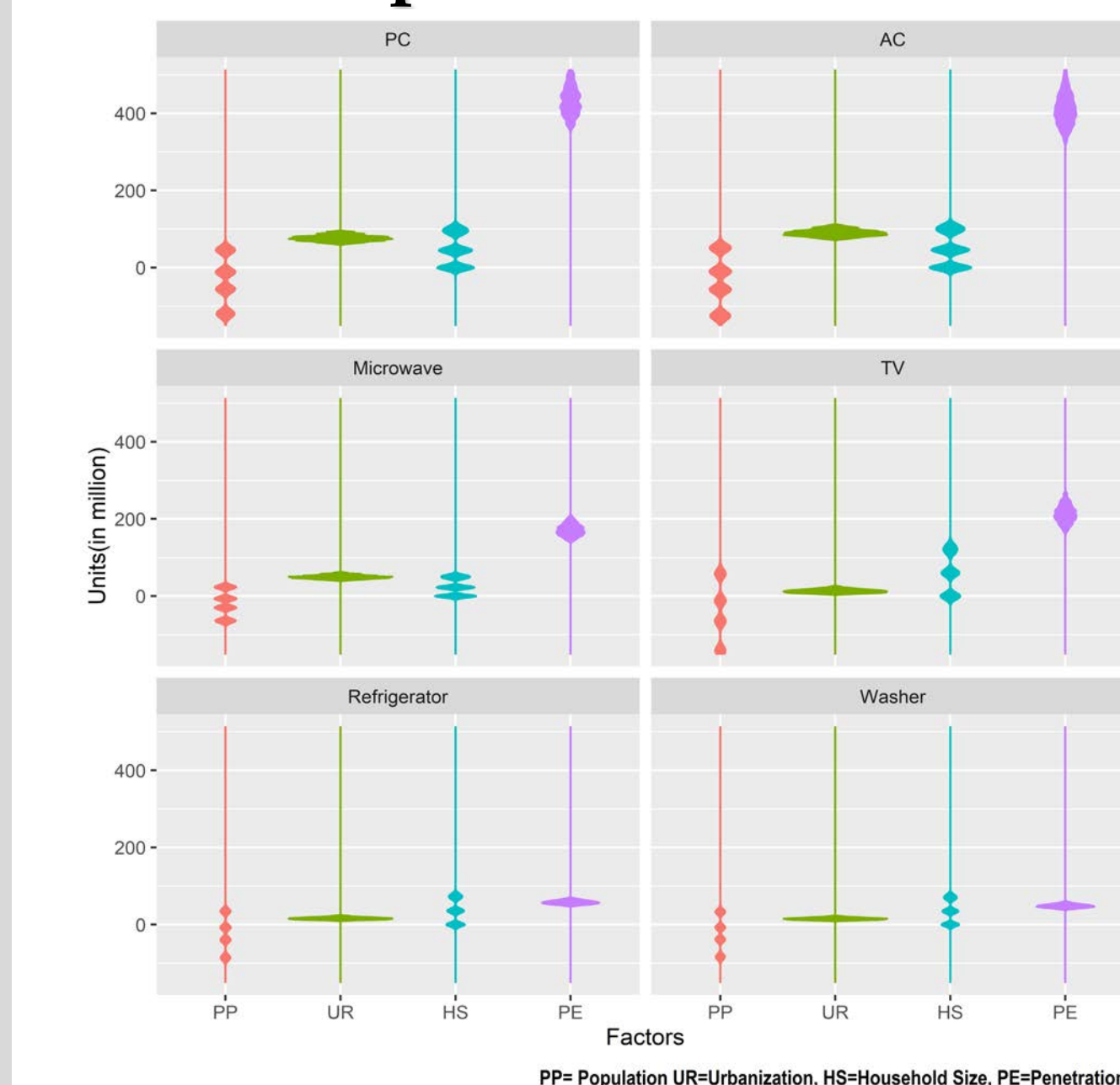- **Total end-use equipment**: Total number of units of each appliance in a province

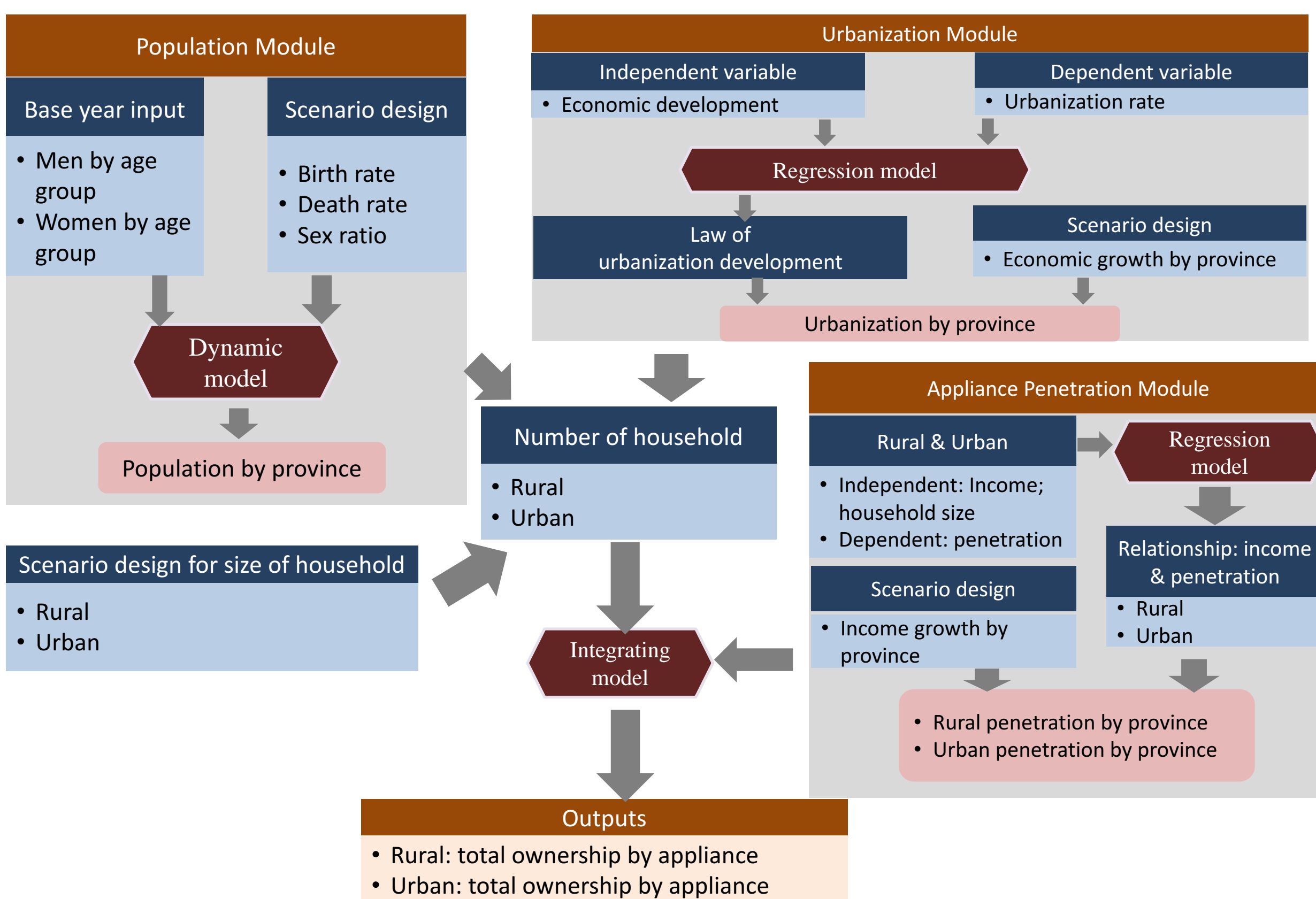| Drivers	Features
Population change	High geographical resolution -Urban & Rural, 31 Provinces
Urbanization	Under uncertainty: 108 scenarios
Downsizing household	Main end uses: 6 appliances (Air Conditioner (AC), Microwave, Washer, Refrigerator, TV, and Personal Computer (PC))
Income growth	Long term: 2015-2050

Method

Framework

Integrating model

$$E_{i,k,t}{}^{s} = E_{i,k,t}{}^{s,r} + E_{i,k,t}{}^{s,u} = PE_{i,k,t}{}^{s,r} \times NH_{i,t}{}^{s,r} + PE_{i,k,t}{}^{s,u} \times NH_{i,t}{}^{s,u}$$

Population

$$P_t = P_{t-1} + B_{t-1,t} - D_{t-1,t}$$

Urbanization

$$ln(M - UR_{i,t}) - lnUR_{i,t} = \alpha x_{i,t} + \beta + \varepsilon_{i,t}$$

Appliance penetration per household

$$ln(N_k - PE_{i,k,t}) - lnPE_{i,k,t} = \alpha x_{i,t} + \gamma + \varepsilon_{i,t}$$
$$ln(N_k - PE_{i,k,t}) - lnPE_{i,k,t} = \alpha ln(x_{i,t}) + \gamma + \varepsilon_{i,t}$$

Data

Module	Variable	Year	Source
Population	Population	2010	6th Population Census of the People's Republic of China
	Death rate		
	Birth rate		
Urbanization	Urbanization rate	2005-2014	National Statistical Yearbook 2006-2015
	GDP		
	Population		
Household size	Household size	2013	Statistical Yearbook for 31 provinces 2014 & 2015
Penetration	Penetration rate	2000-2012	Statistical Yearbook for 31 provinces 2001-2015
	Per capita income		

Scenarios

Module	Variable	No.
Population	National TFR and allocated to provinces	4
Urbanization	Per capita GDP growth	3
Household size & Penetration	Household size	3
	Per capita income growth	3

Decomposition model

Log mean Divisia index (LMDI) method

$$\Delta E = \Delta E_{PP} + \Delta E_{UR} + \Delta E_{SZ} + \Delta E_{PE}$$
$$\Delta E_J = \sum_i \sum_{Area} \left(W \times ln \frac{J_{i,T}}{J_{i,0}} \right), \forall J \in (PP, UR, SZ, PE)$$
$$W = \frac{E_{i,T}{}^{Area} - E_{i,0}{}^{Area}}{lnE_{i,T}{}^{Area} - lnE_{i,0}{}^{Area}}$$

Results

Penetration of appliances per household

Impact of each driver

Total appliances owned

Future work

- Develop a bottom-up framework to characterize electricity demand scenarios

- Create a tool to forecast long-term electricity demand at the hourly temporal scale

Conclusion

Penetration of appliances

- Differences between urban and rural regions will narrow
- Current disparities between regions will tend to disappear
- Appliance penetration growth will be led by adoption of ACs and PCs

Total appliances owned

- Most appliances will be owned by urban households
- Appliance ownership will be concentrated in Eastern China
- Under some possible future scenarios, appliance ownership will reach a peak during the analysis period
- PCs owned by households in 2050 will almost triple

Impact of drivers

- Penetration of appliances (as function of income) has a higher impact than population, urbanization, or household size on the estimated total number of appliances
- Reductions in ownership are due to population decline

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