Key technologies for carbon neutrality in "warm" cities.

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Special features of urban development in Japan: Industrial-driven urban development

- Panasonic Fujisawa Sustainable Smart Town(2014)
  - Sustainable urban project for 1000 households.
  - HEMS, PV, Fuel cell, Battery, Heat pump water heater, Energy sharing.
  - Energy supply can be maintained for three days in emergency.




Special features of urban development in Japan: Industrial-driven urban development

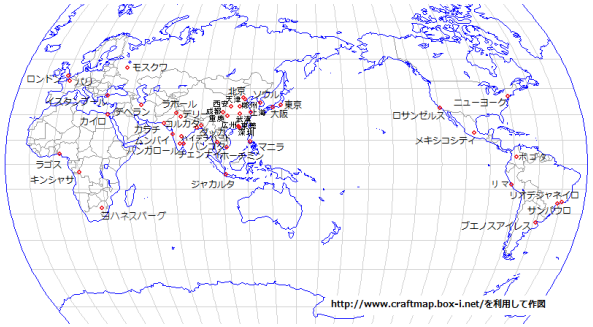
- Toyota woven city (Shizuoka, Japan)
- Test course for mobility driven by a collaborative community with a shared passion to enhance well-being for all.
- Platform for automated driving system.
- Smart Logistics.
- Next generation smart communications.
- Hydrogen energy
- Phase 1(2025 autumn) 360 residents 50,000m2
- Final: 2000 residents, 708,000m2
- https://www.woven-city.global

Expo 2025 Osaka, Japan

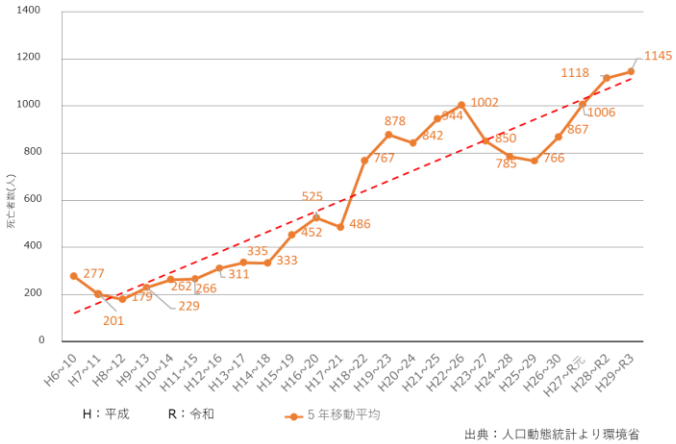
-Living laboratory for future society-

- “Ring” The world's largest wooden structure.
- 100% Carbon free electricity from renewables, nuclear and hydrogen thermal.
- Aquifer thermal storage cooling.
- Energy management system
- perovskite solar cell
- Direct air capture and e-methane

Key technology 1: Cooling



Cities over 10 million population in the world.

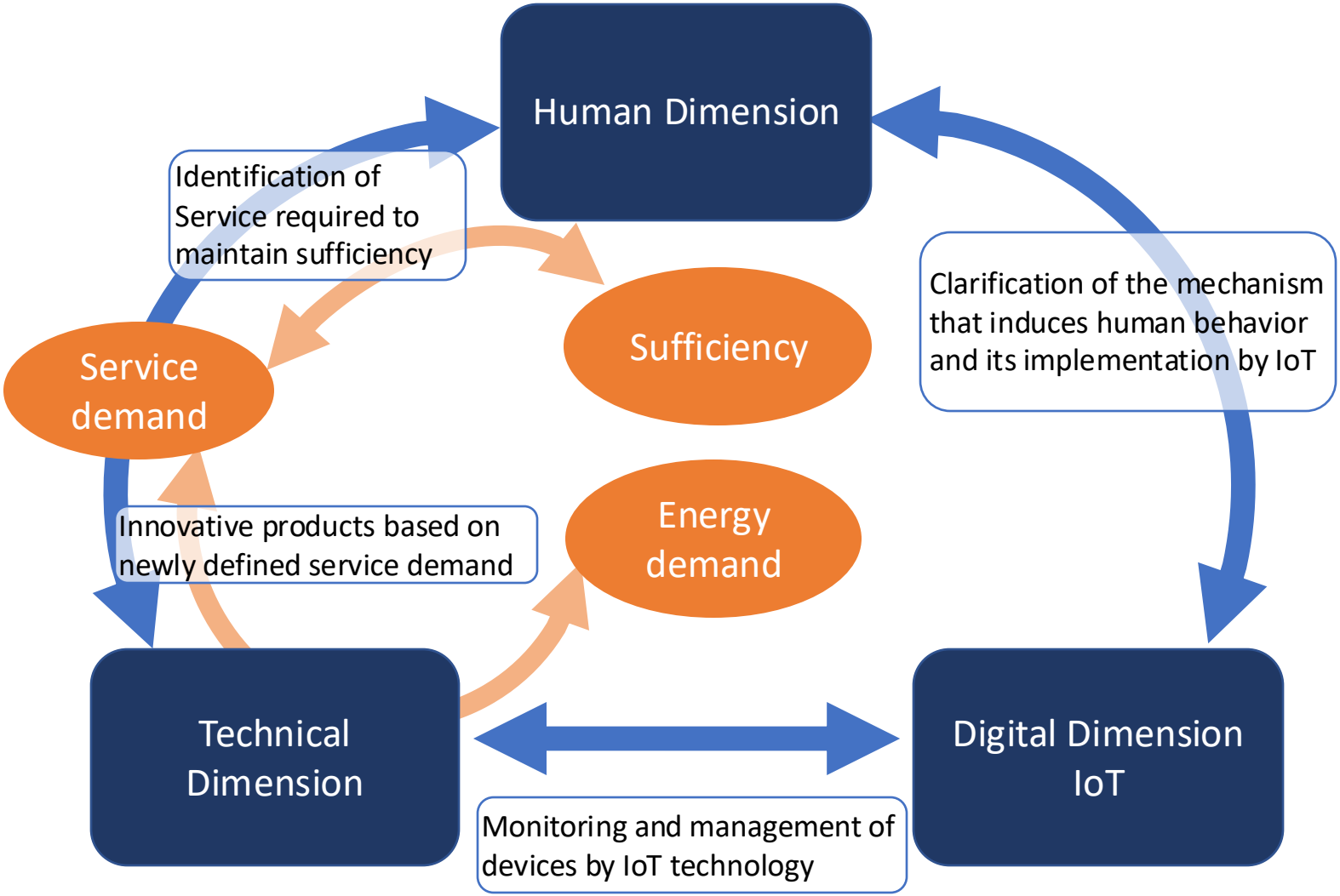


- Most cities developed in the future will be located in warm or hot regions.
- IEA: The future of Energy(2018) “Energy needs for space cooling will triple by 2050.”
- In Japan, the number of deaths from heatstroke exceeds 1,000 per year, which is several times higher than the number of deaths from natural disasters.
- Cooling is essential for keeping decent living standard, as adaptation measure to global warming.

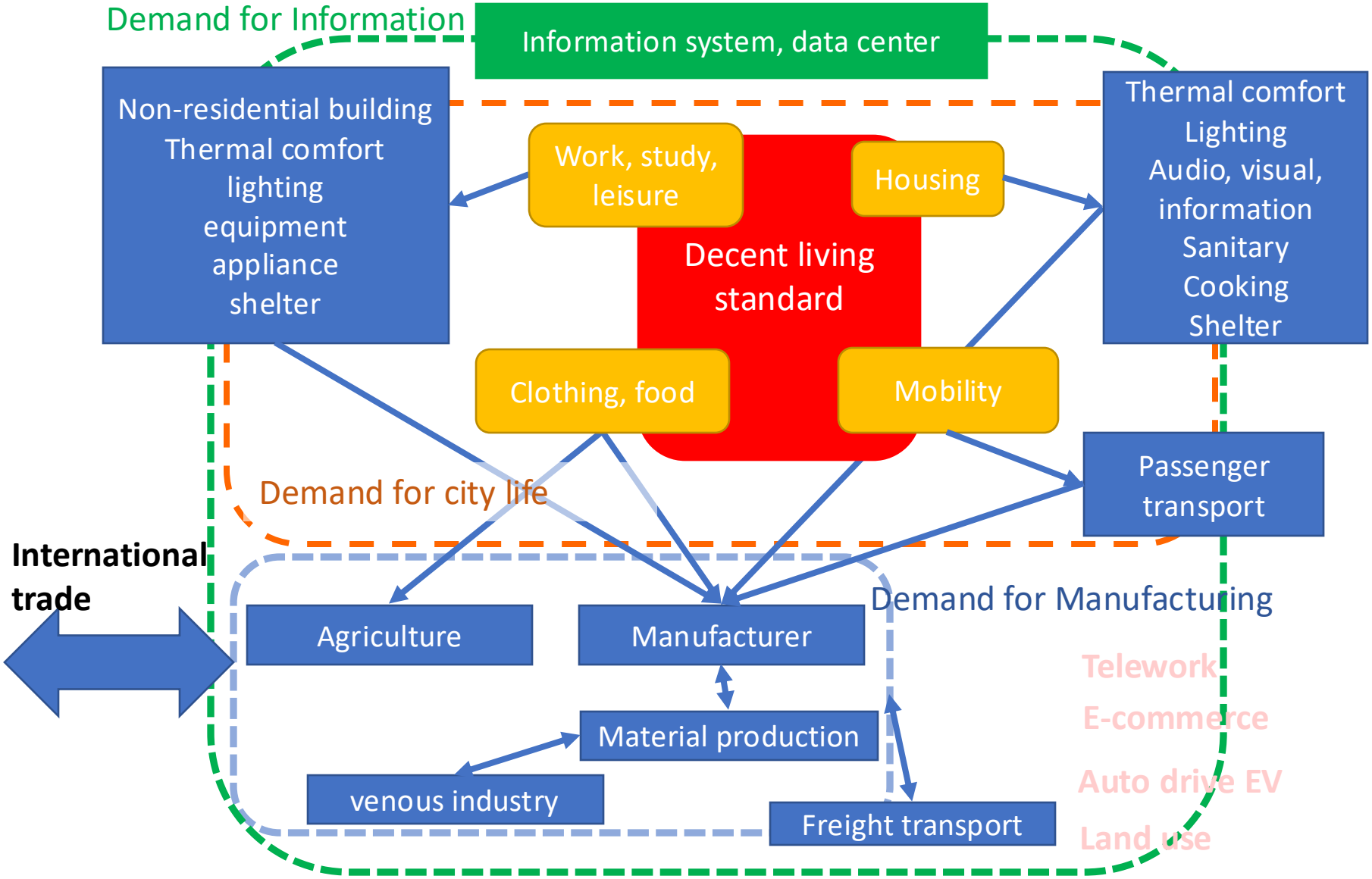
Cooling technology

- In contrast to heating technology, it mainly uses a refrigeration cycle. Power consumption is the main source of energy.
- Due to the difficulty of utilizing waste heat cascading, district heat system are difficult to apply.
- Energy demand varies with weather conditions, creating peak electricity demand.
- It can be easily applied for demand response to variable renewable electricity.
- Combination with passive cooling technologies such as natural ventilation and solar shading is necessary.
- The greenhouse effect of refrigerants is also an issue.
- It is necessary to spread efficient and innovative cooling systems.

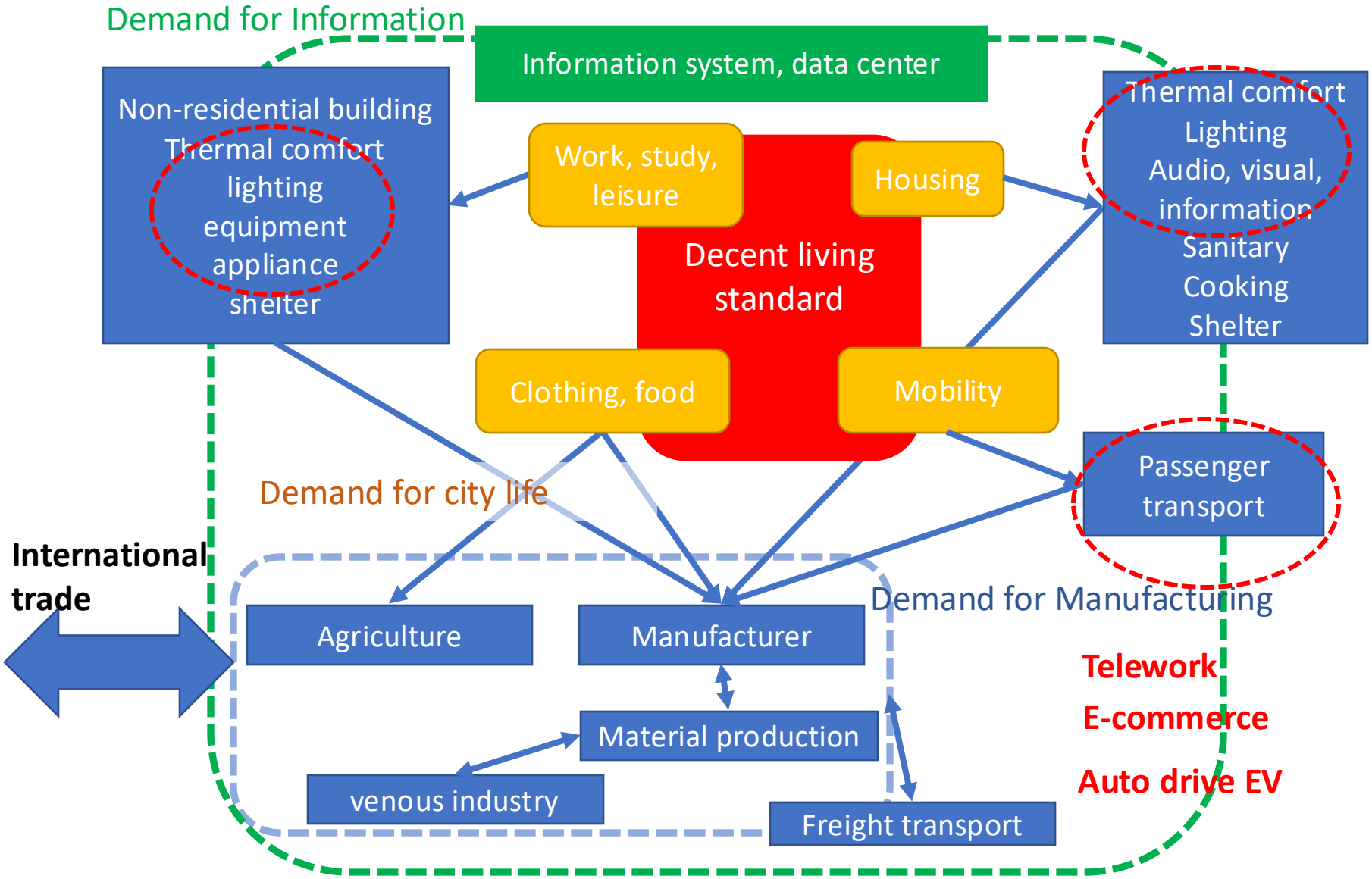
Key technology 2: Digital technology



Key technology 2: Digital technology



Digitization creates transformation across sectors



Structural Change by Teleworking

Digitalization

Telecommuting

Ride-sharing

Short-term impact

Increase in household appliance usage

Reduction in office floor space

Decrease in commuting by car

Improvement in car occupancy rates

Changes in residential preference

Easy access to public transportation

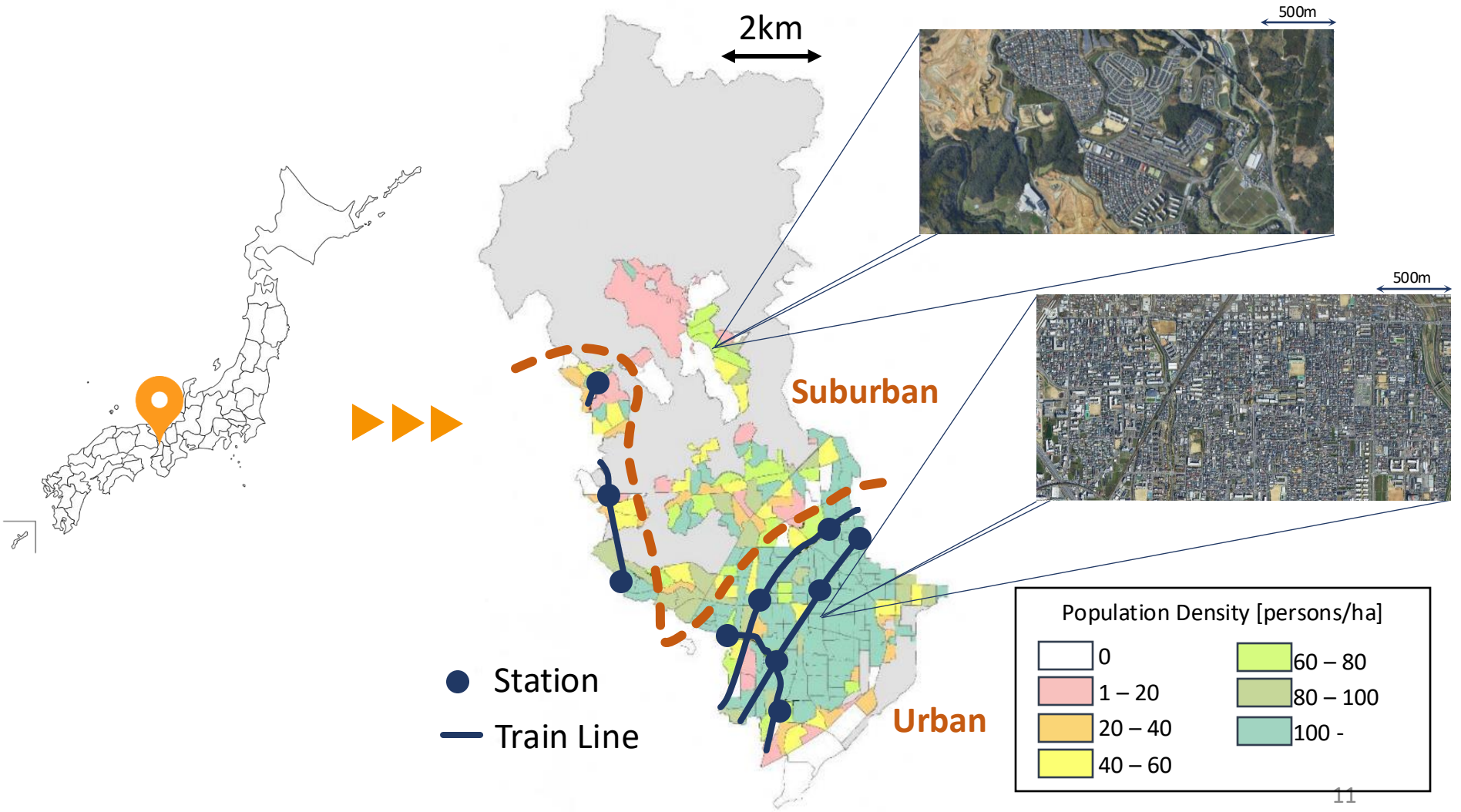
Spacious and comfortable space in harmony with nature

Long-term impact

- **Estimating the short-term and long-term impact of telecommuting and ride-sharing on urban energy consumption**

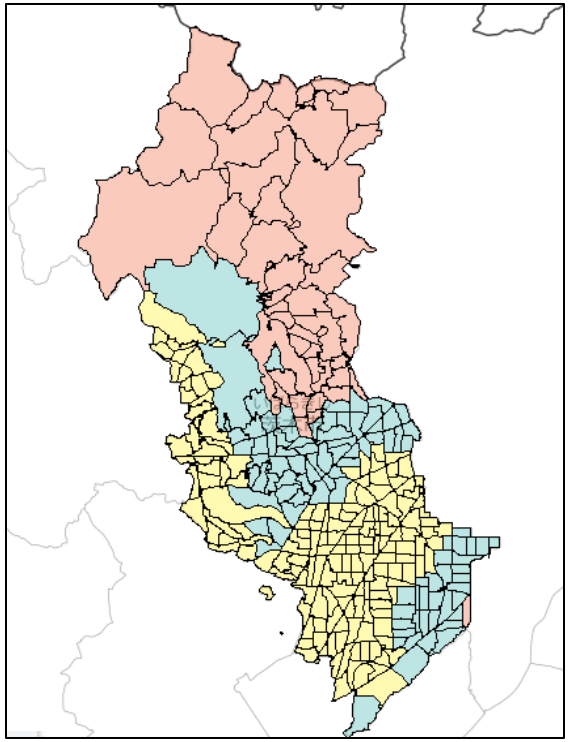
Ishihara, Shimoda, et. al. Proceedings of uSIM 2024 (2024)

Ibaraki City, Osaka, Japan

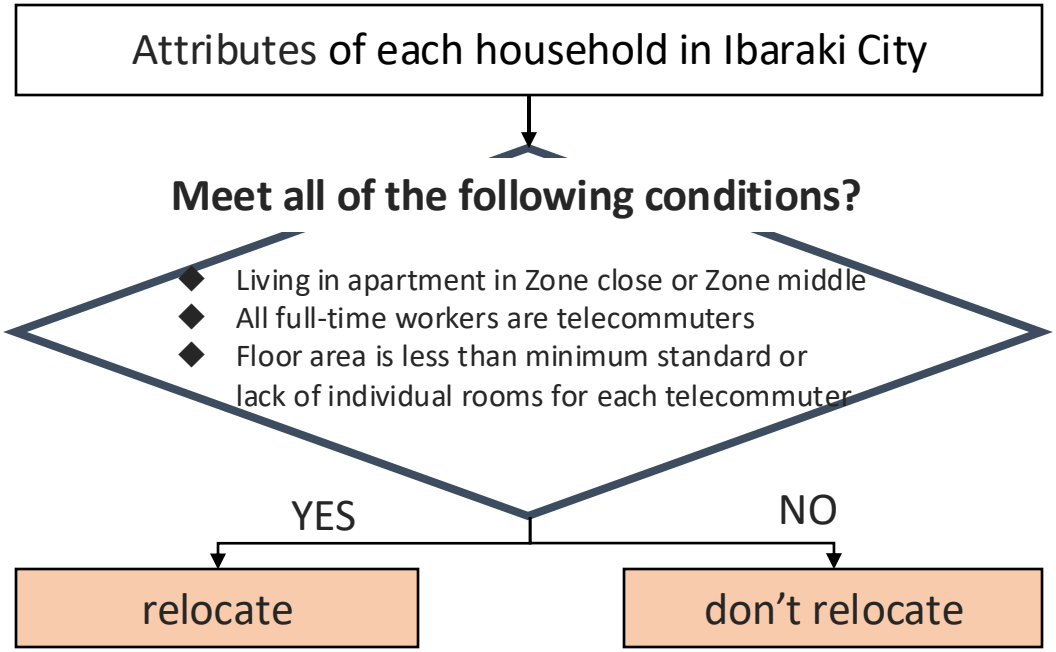


Source) https://www.city.ibaraki.osaka.jp/material/files/group/42/2-syo.pdf

DETERMINATION FLOW | Relocation



Zone far from stations
Zone at middle distance from stations
Zone close to stations



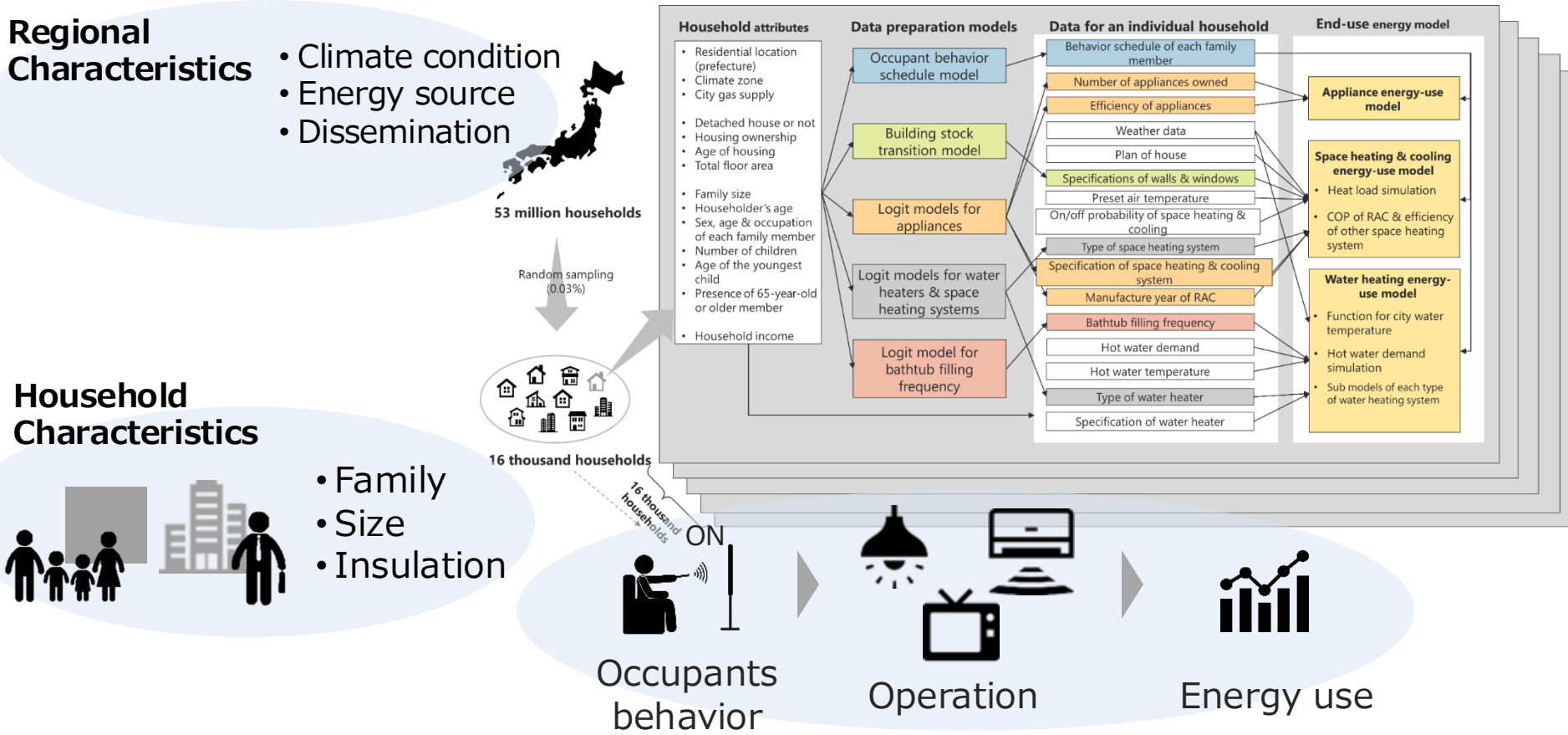
- Detached house
- Good insulation performance
- PV system
- Floor area is more than minimum standard
- Individual rooms for each telecommuter

Ishihara, Shimoda, et. al. Proceedings of uSIM 2024 (2024)

Residential end-use energy model

TREES (Total residential end-use energy simulation)

“You see the trees (buildings) and you see the forest (City)”
Bottom-up engineering model. Heterogeneity of household/building is reproduced.

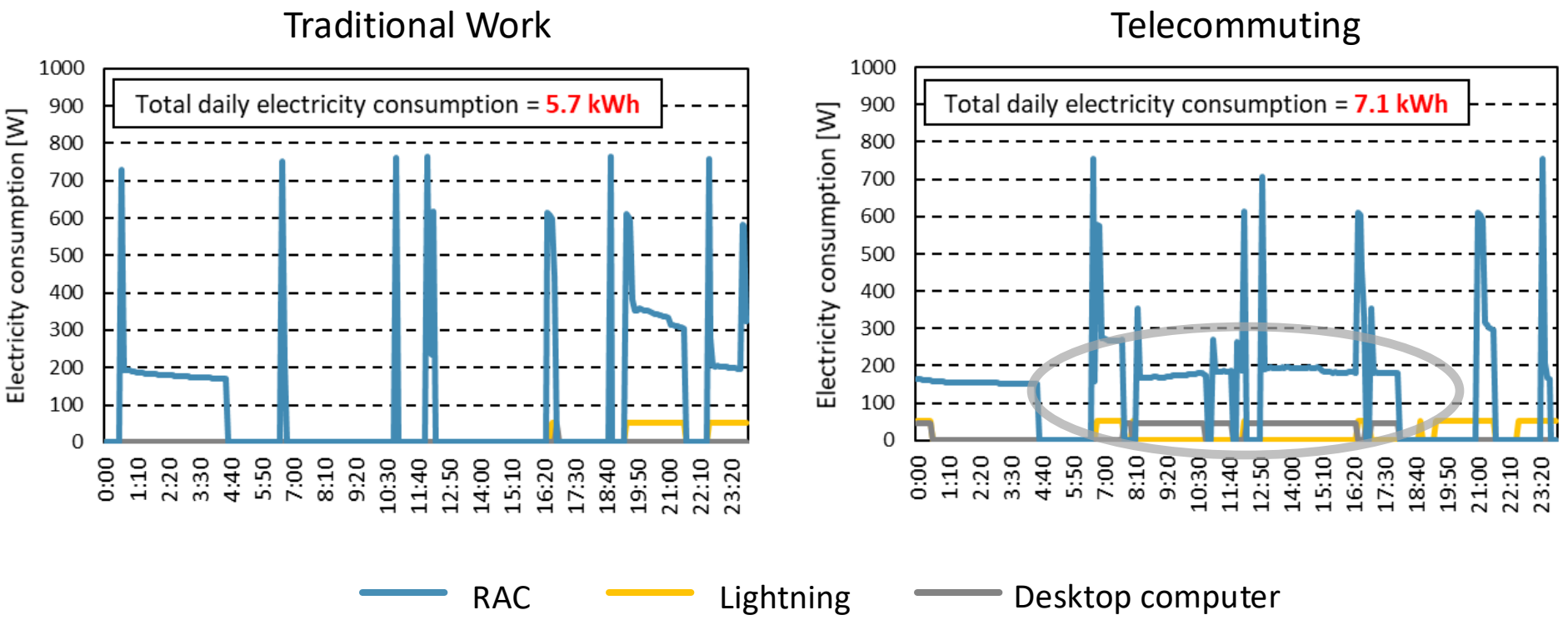


Shimoda et.al. 2021, Applied Energy

ESTIMATION | Residential

Estimation results from TREES

Electricity consumption of single-person household on a certain weekday



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ESTIMATION | Commercial

Telecommuting → Reduction in office floor space

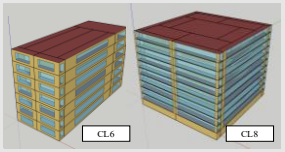
$$\Delta E_{off} = pop_{tele} \times \frac{FloorArea_{off}}{pop_{off}} \times \frac{E_{off}}{FloorArea_{off}}$$

A	×	B	×	C
The number of telecommuters in Ibaraki City		Office floor area per person		Office annual energy demand per unit floor area
Estimated in the chapter "ESTIMATION | Telecommuters"		Derived from the survey results on office floor space in central Tokyo		Estimated by **BSEM** in Kansai region, which includes Ibaraki City

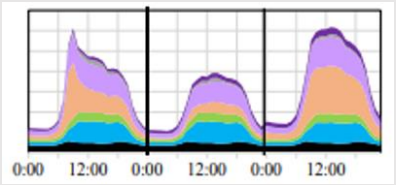
BSEM (Building Stock Energy Model) Yamaguchi et al. (2022)

categorization of building stocks

development of reference models



Quantification of energy use intensity



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ESTIMATION | Transportation

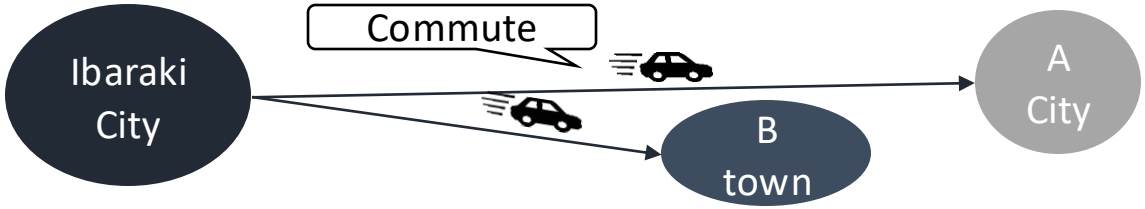
Telecommuting → Decrease in commuting by car

$$\Delta E_{car\_tele} = pop_{car\&tele} \times \overline{mileage} \times 2 \times days/MPGe$$

D The number of telecommuters who commute by car × **E** The average mileage per car commute × $\frac{2 \times 250 \text{ days}}{6 \text{ km/kWh}}$

Estimated using **Travel trip survey**

Who | Why | Where | When | How



Ride-sharing → 10 % Improvement in car occupancy rates

$$\Delta E_{car\_share} = \left(\sum_{i}^{c,s,f} mileage_i \times 2 \times days_i \right) \times 0.1/MPGe$$

c: commuting
s: school commuting
f: free

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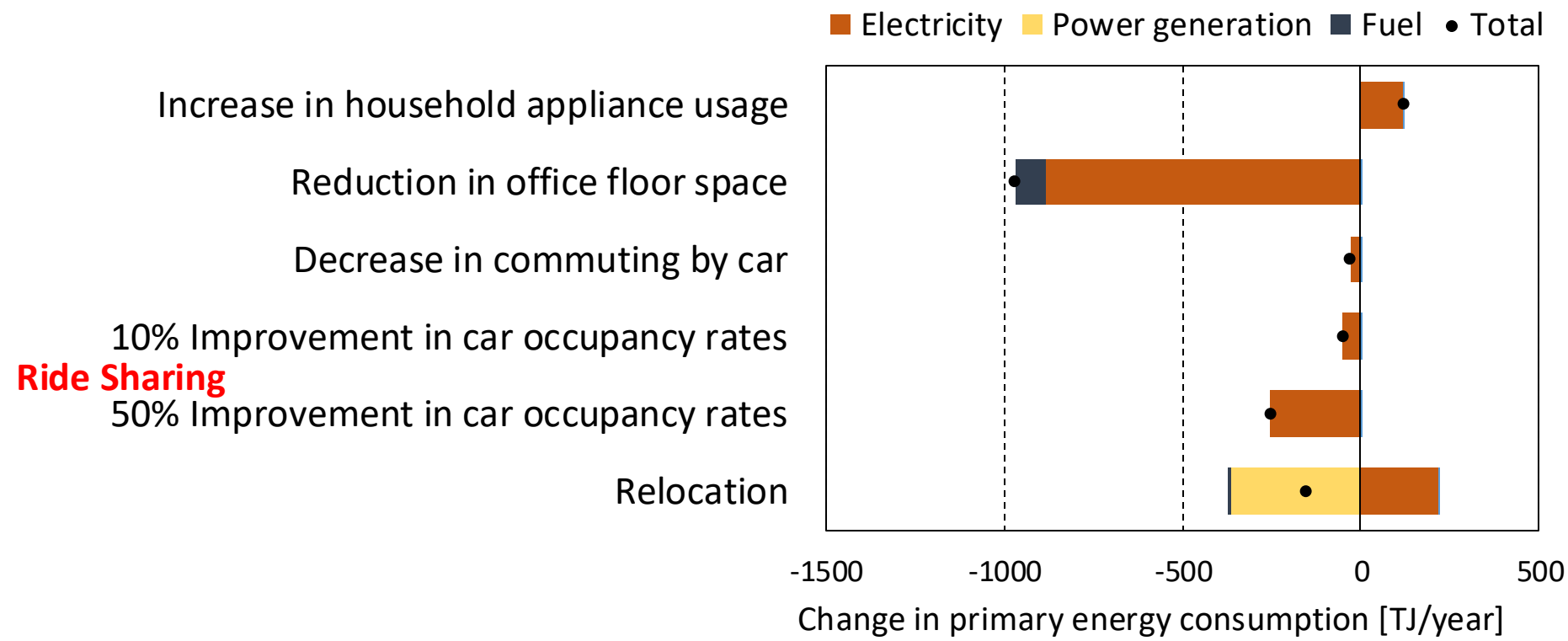
RESULT



Telecommuting

Energy saving from “Reduction in office floor space” is significant

Relocation

The electricity generation from PV systems completely offsets the increase

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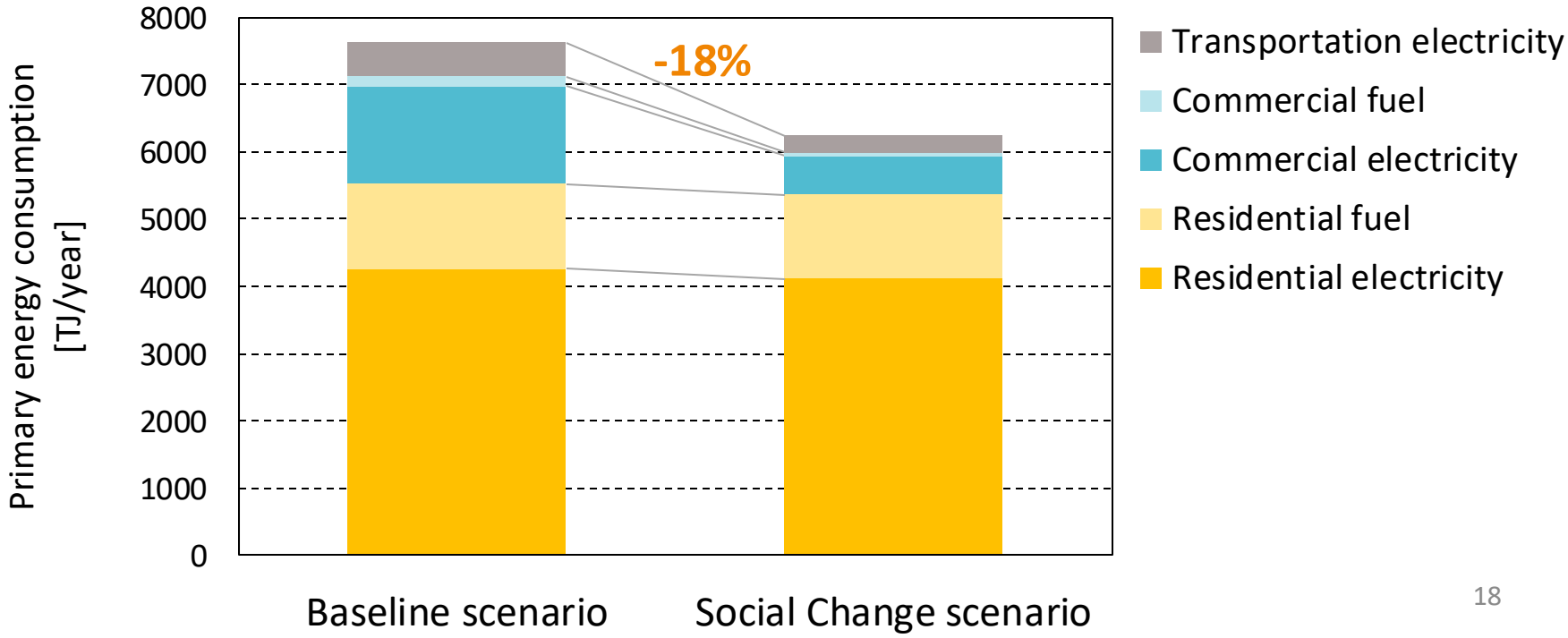
RESULT

Social Change scenario

- Relocation
- Reduction in office floor area per number of telecommuters
- 50% Improvement in car occupancy rates



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Thank you.

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