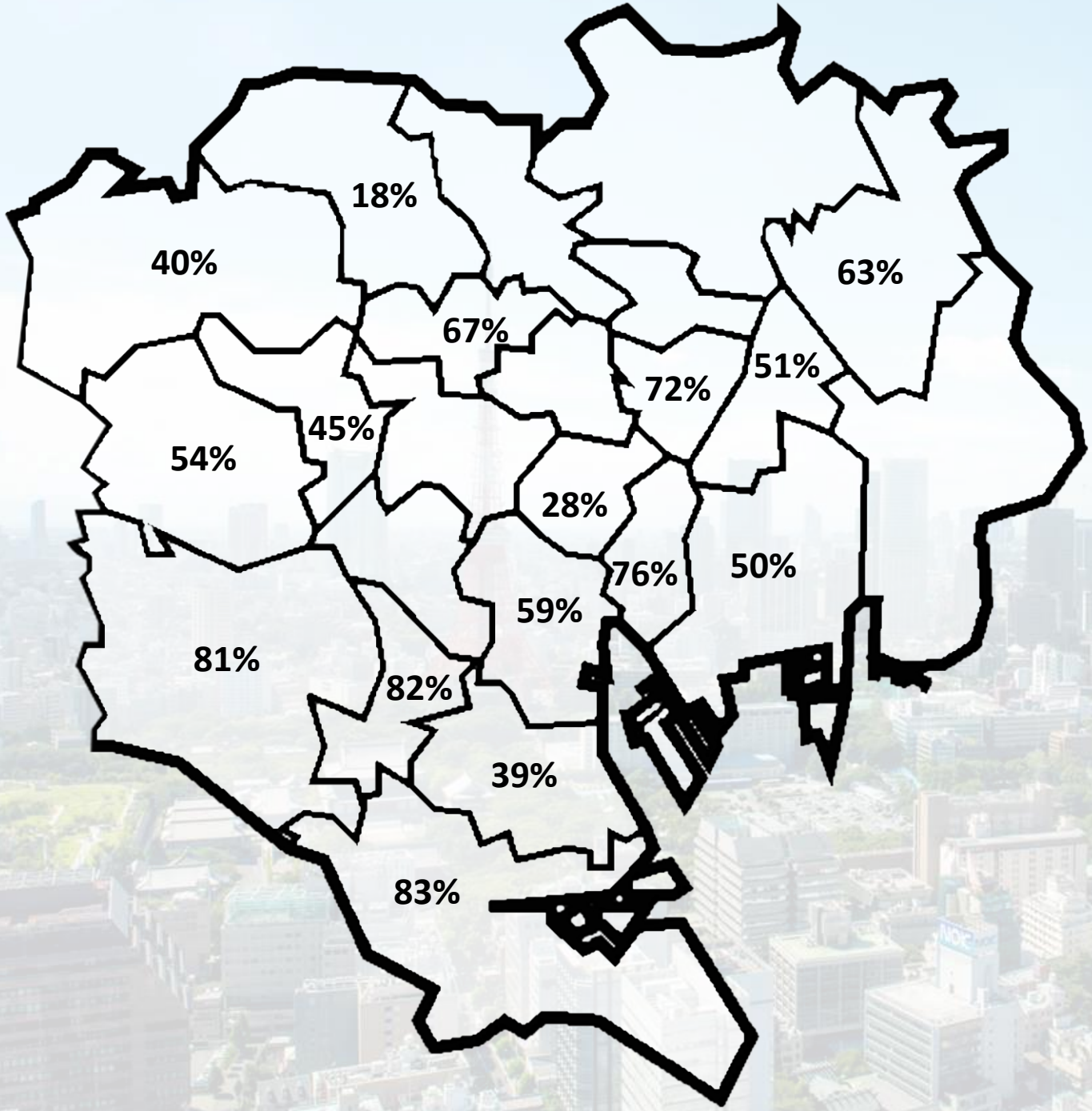
Pathways towards a Sustainable Tokyo

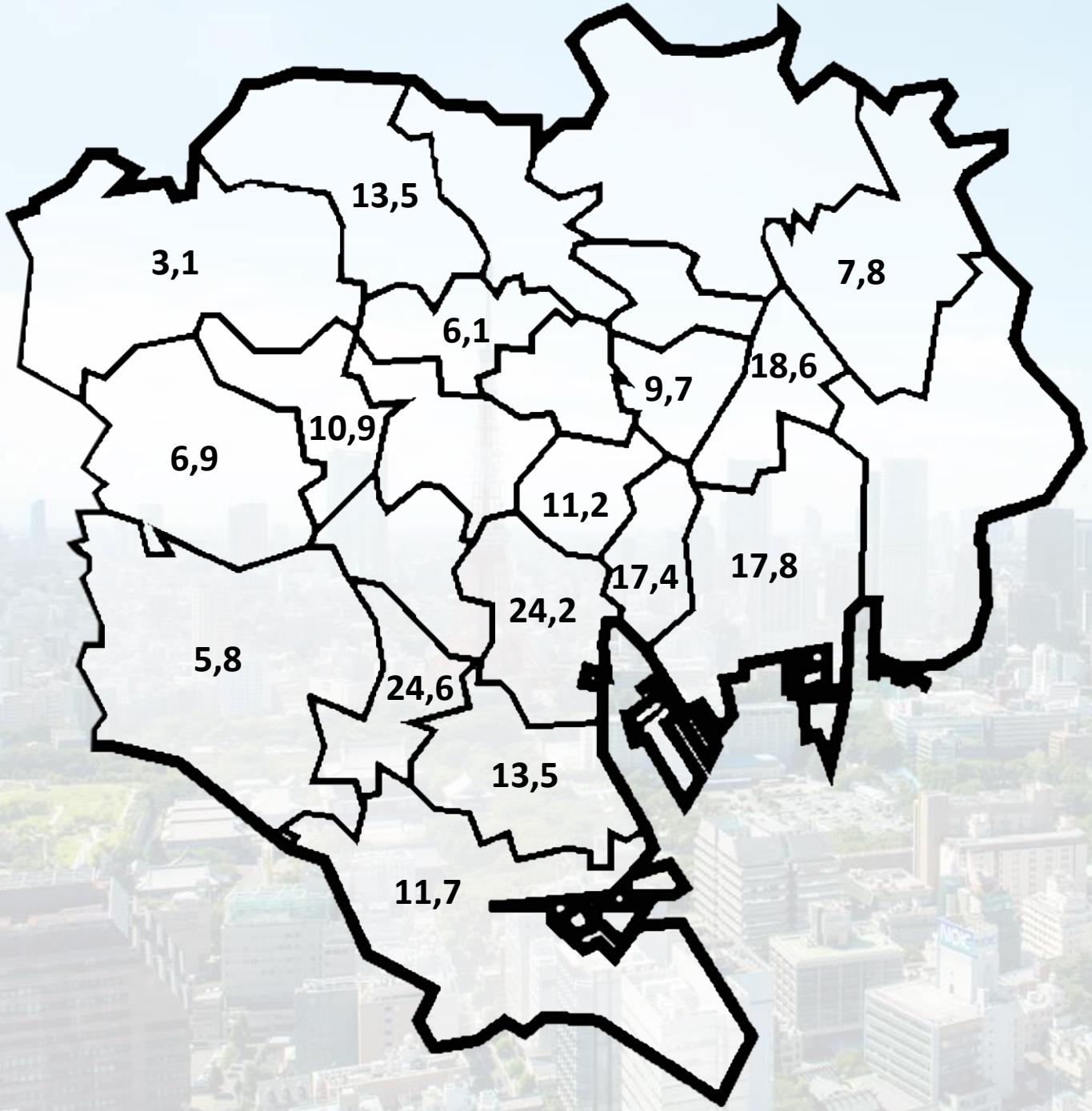
A cooperation of KTH and Gadelius

September 5, 2018



PRIMARY RENEWABLE ENERGY FRACTION

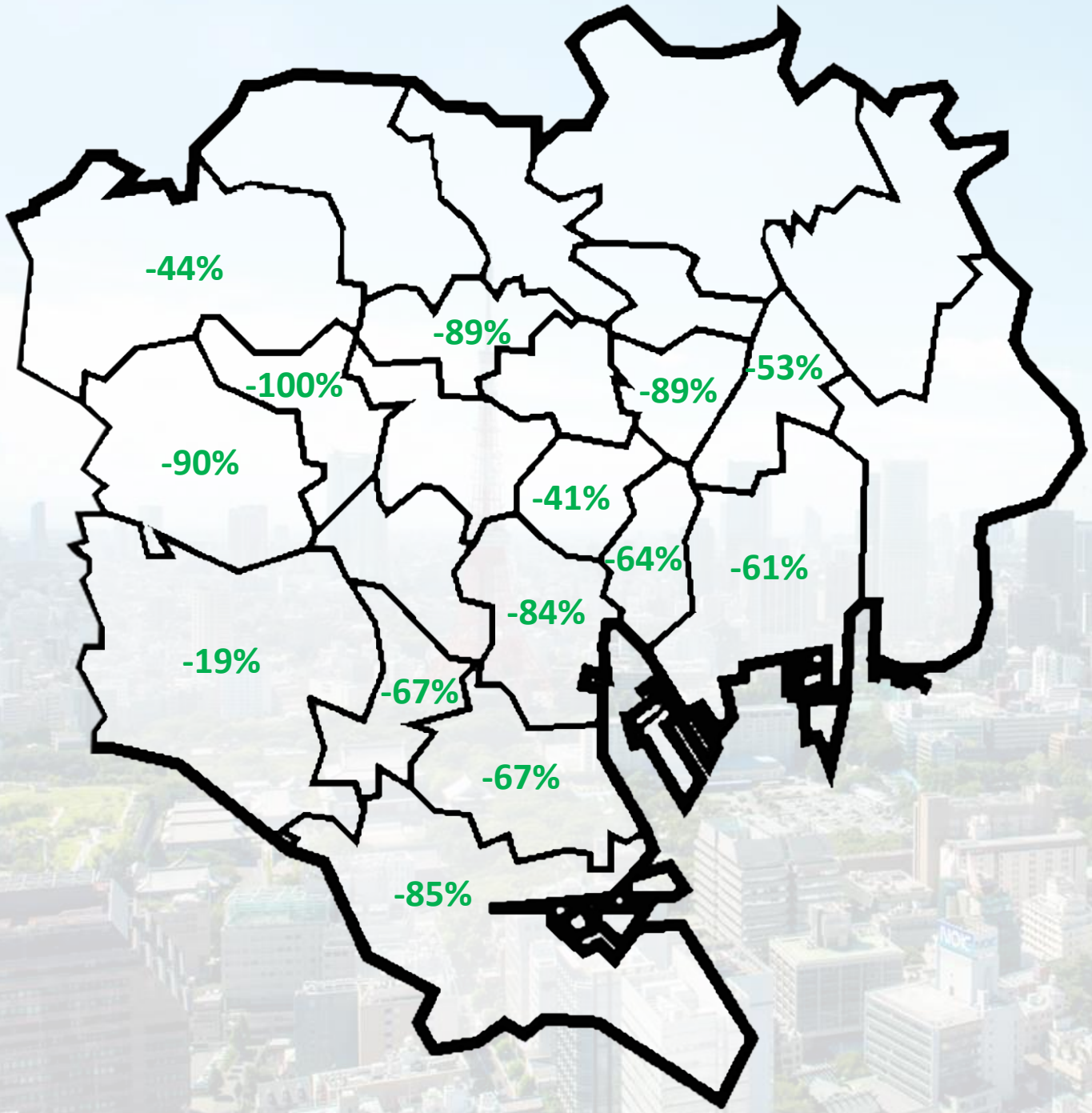
56%



PRIMARY ENERGY CONSUMPTION PER CAPITA

-36%

REDUCTION



NET CO2 EMISSIONS

-60%

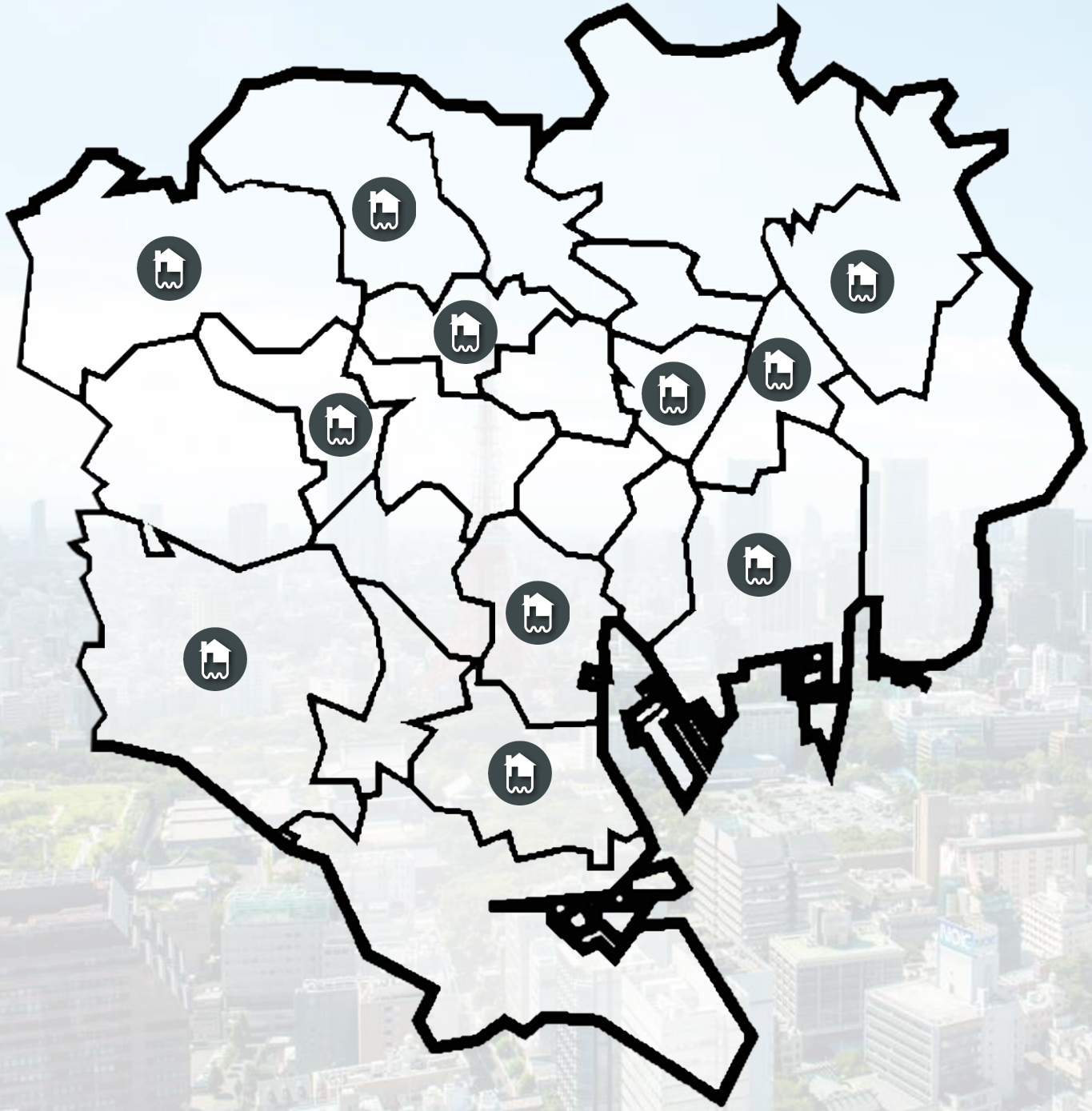
REDUCTION

If compared to a Business as Usual Scenario

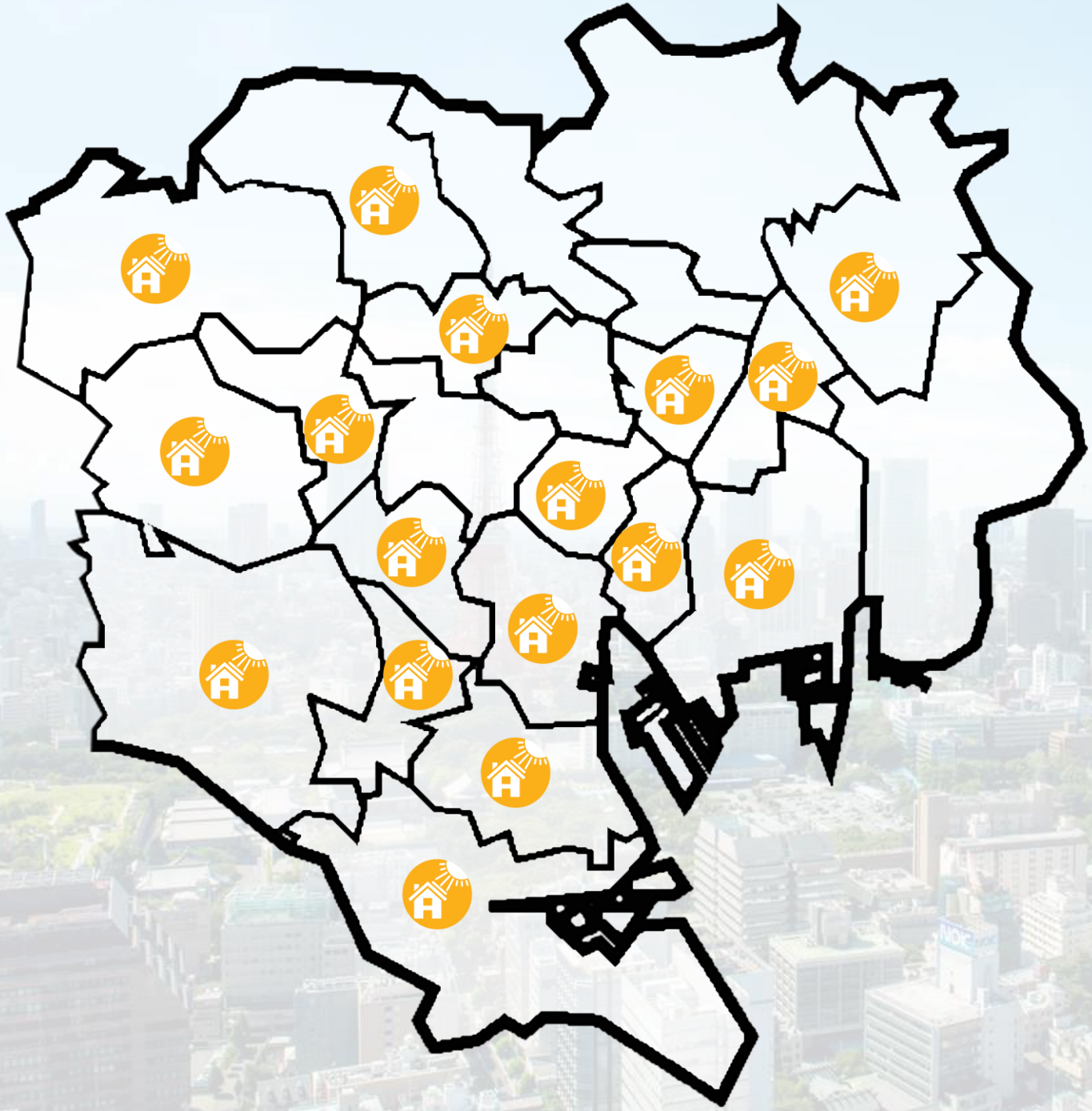
PROPOSALS AND RESULTS FOR 3 MAIN SECTORS:

- Building
- Transportation
- Waste Management and Environment

BUILDING SECTOR

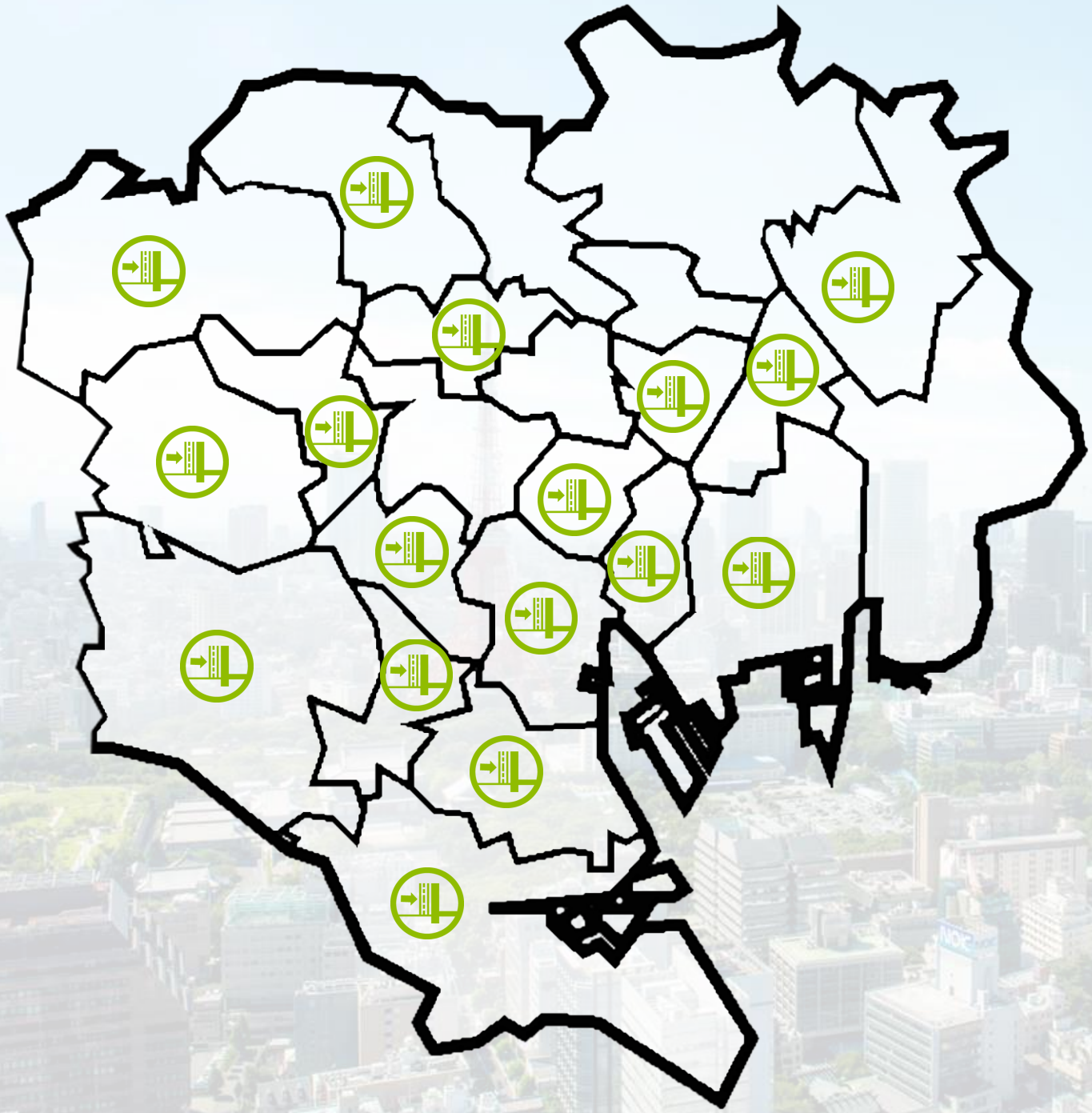


Heat Pumps (65%)



Heat Pumps (65%)

Rooftop PVs (100%)



Heat Pumps (65%)

Rooftop PVs (100%)

Improved Insulation (100%)

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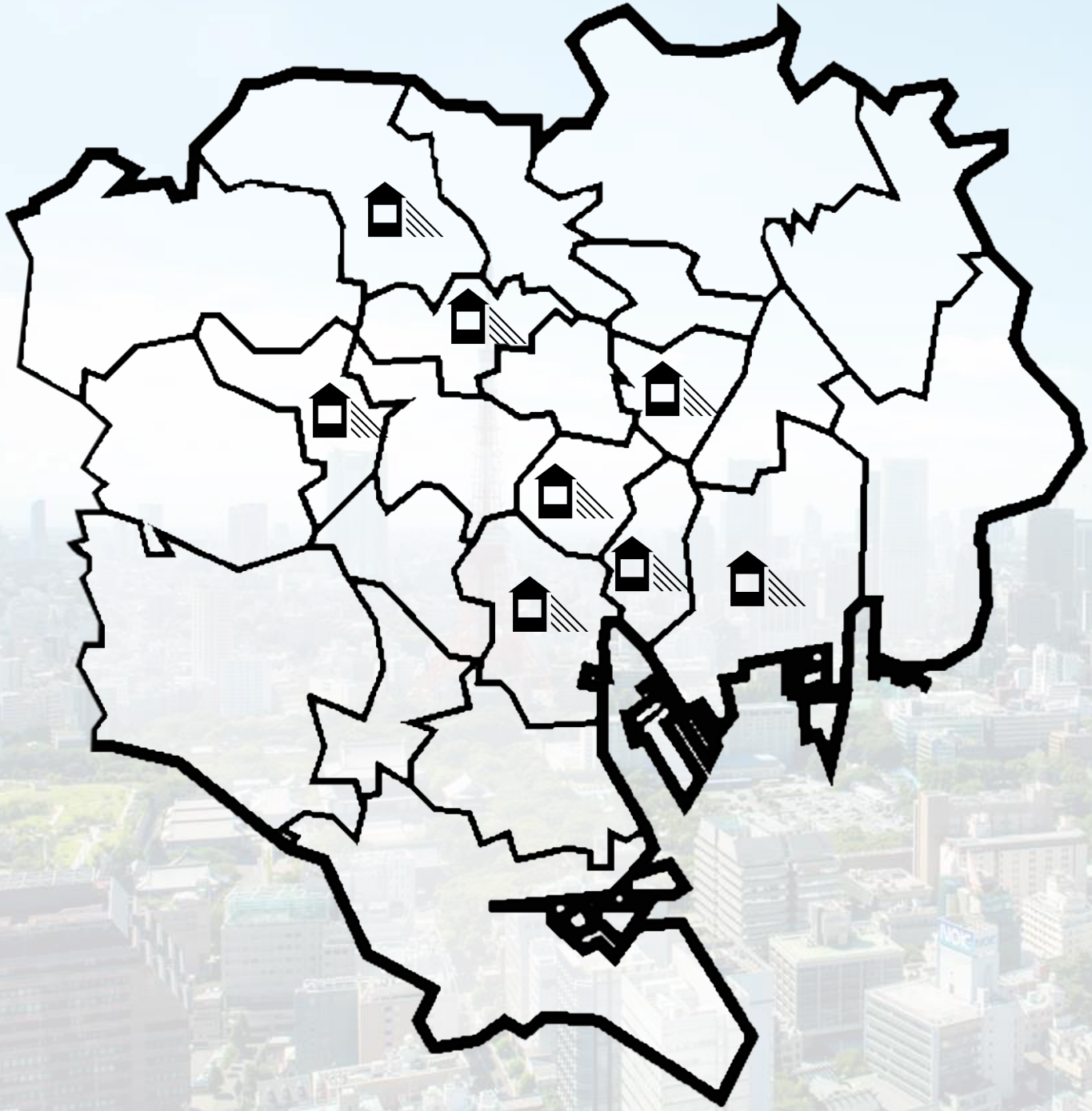
Rooftop PVs (100%)

Improved Insulation (100%)

Other Efficiencies (71%)



Heat Pumps (65%)

Rooftop PVs (100%)

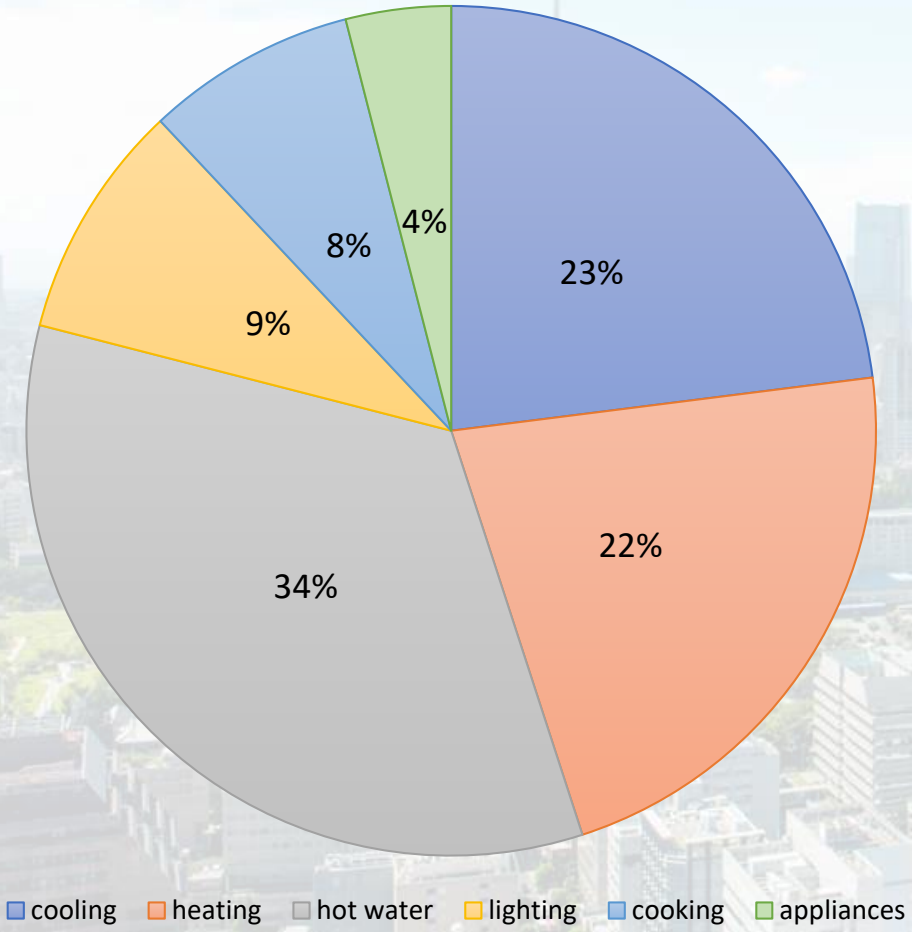
Improved Insulation (100%)

Other Efficiencies (71%)

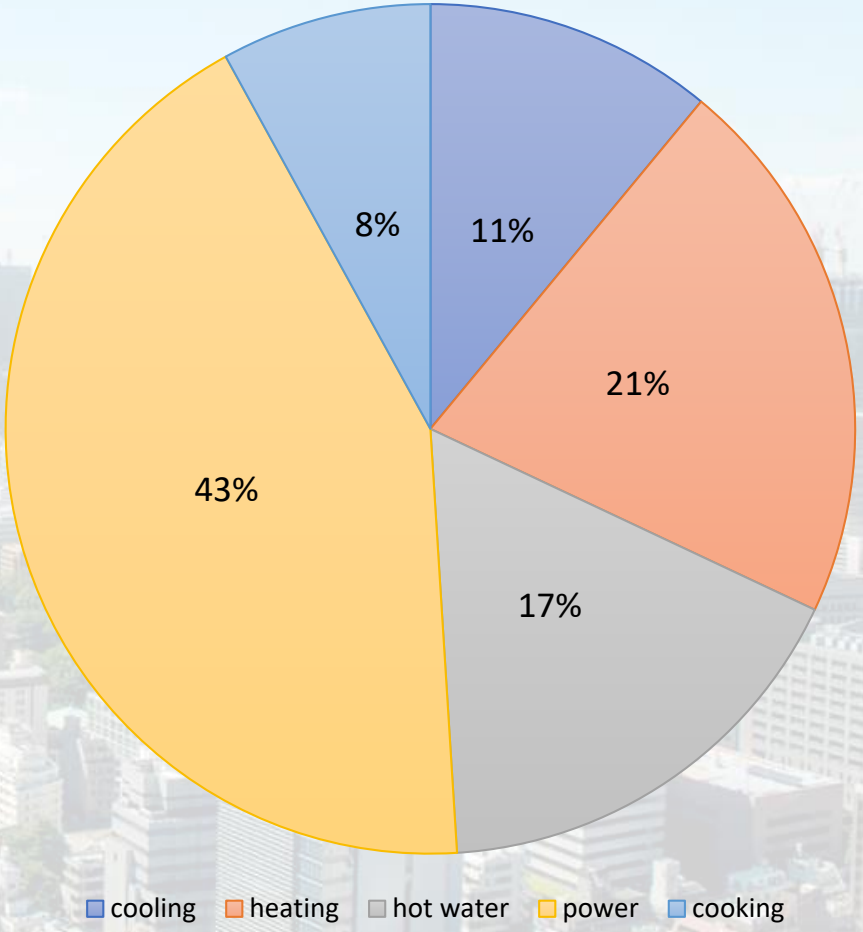
Shading Devices (47%)

The Tokyo of today

Residential energy end-use now



Commercial energy end-use now



Building sector measures

Better insulation

- Allows for better and safer living conditions
- Up to 30% savings on heating consumption

Efficiency changes

- Switch to electric cooking
- LED lighting
- Electrical appliances 15% more efficient

Shading devices

- Up to 30% savings on the cooling load

Rooftop PVs

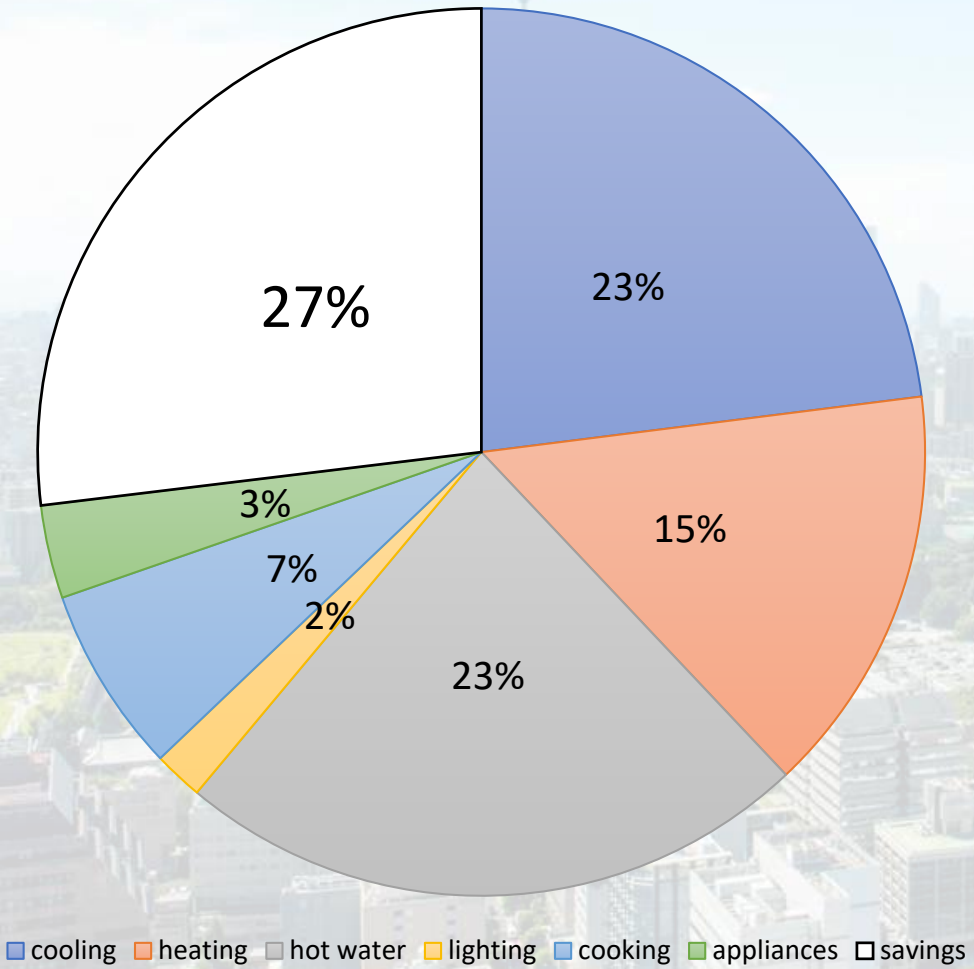
- Helps achieve the self-sufficiency in the sector
- Increases the renewable energy fraction

Heat pump systems

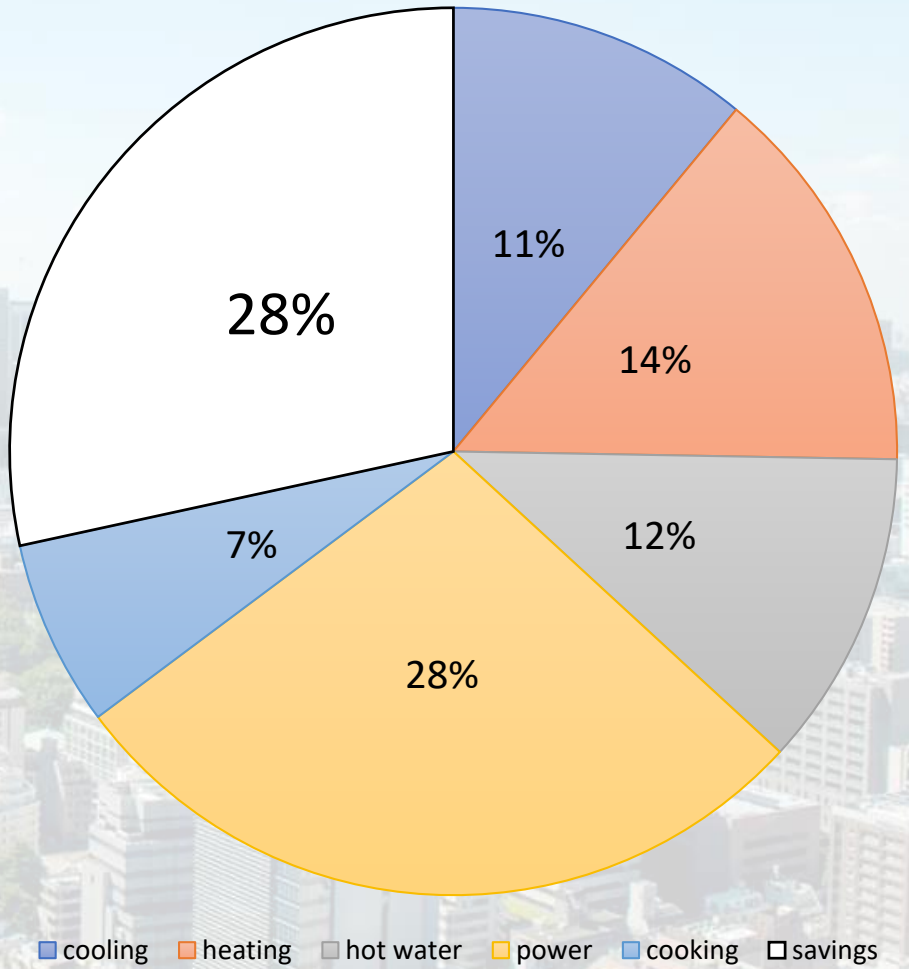
- Reduces the energy demand up to 60% and lowers CO2 emissions

Refurbished scenario

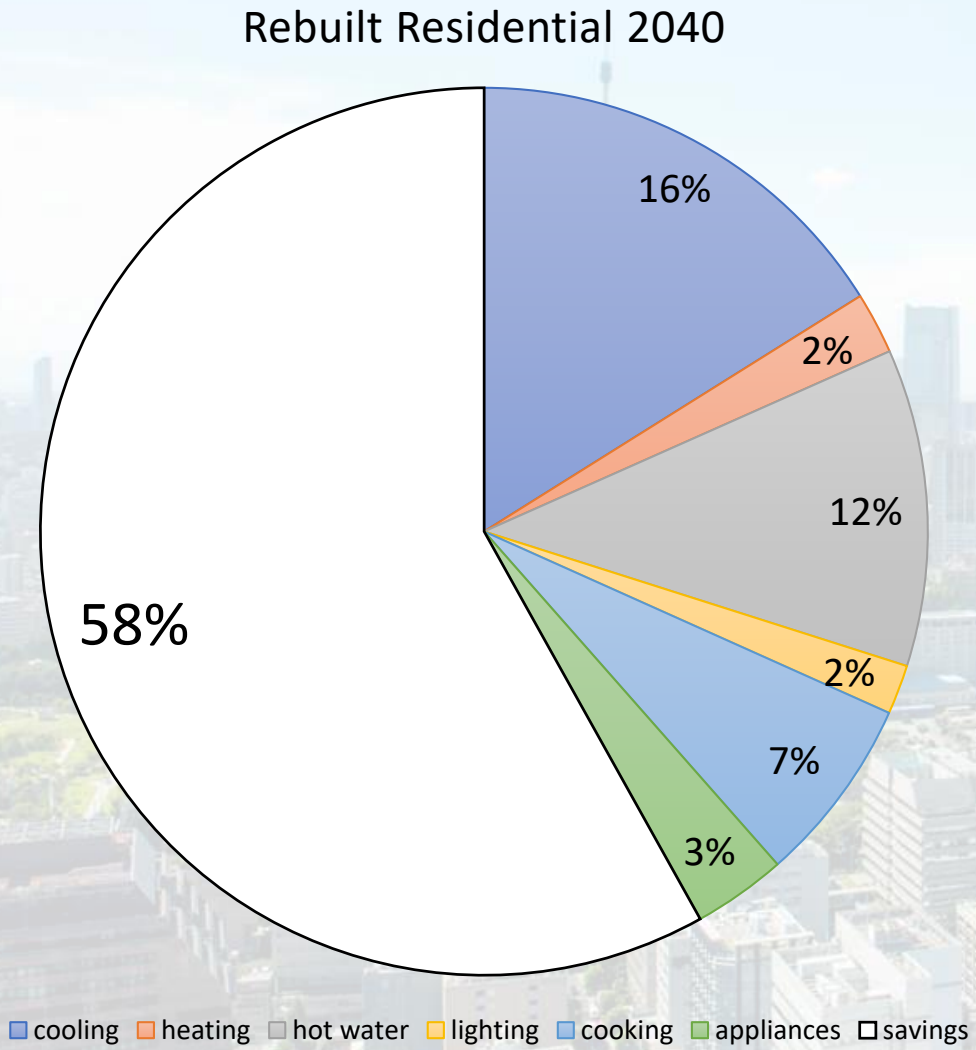
Refurbished Residential 2040

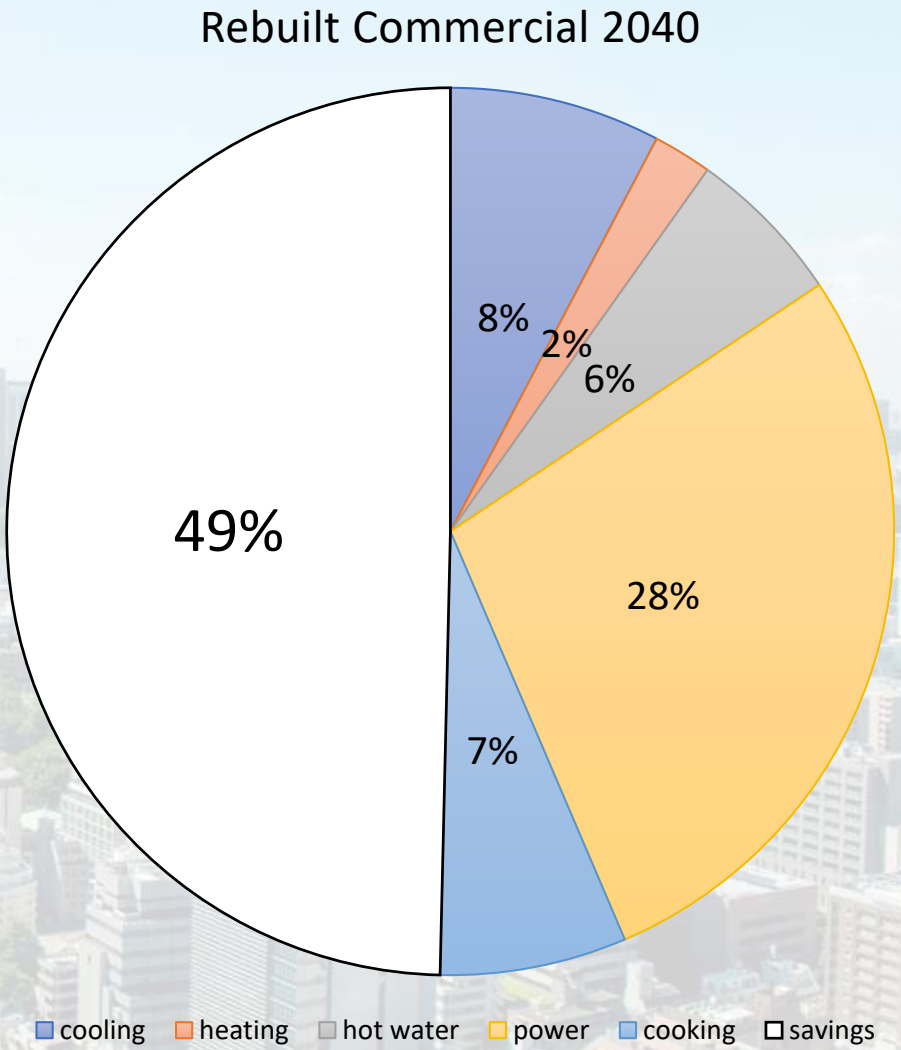


Refurbished Commercial 2040



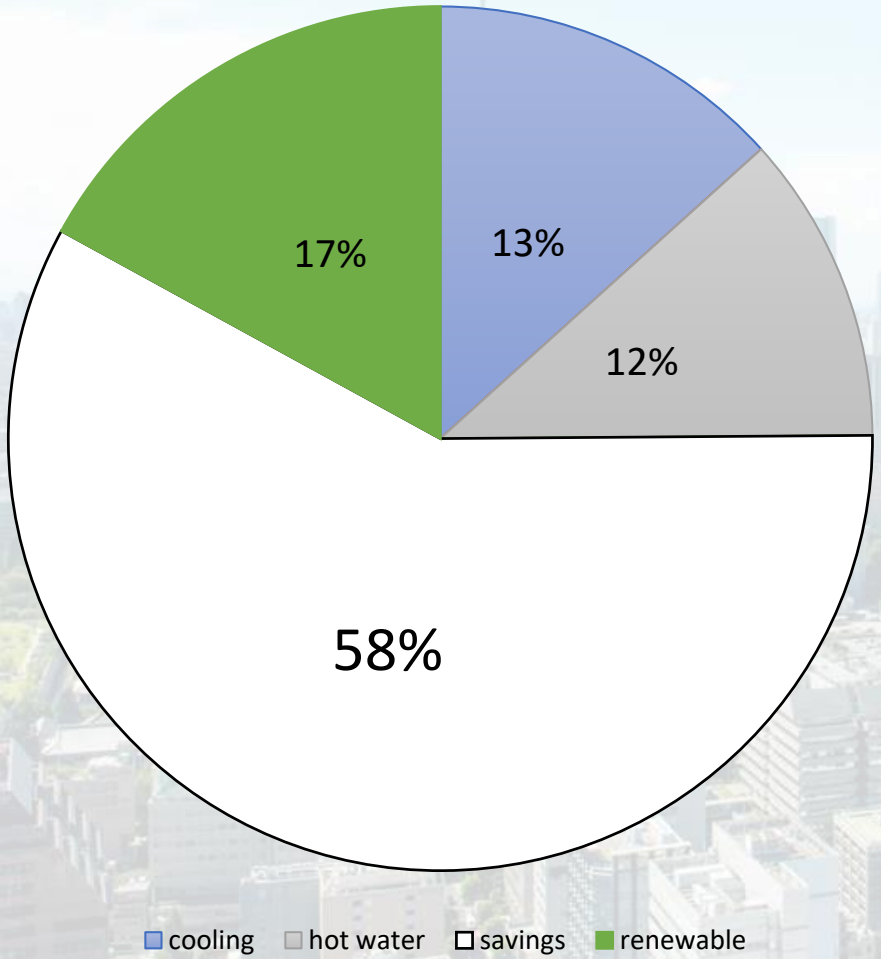
Rebuilt scenario



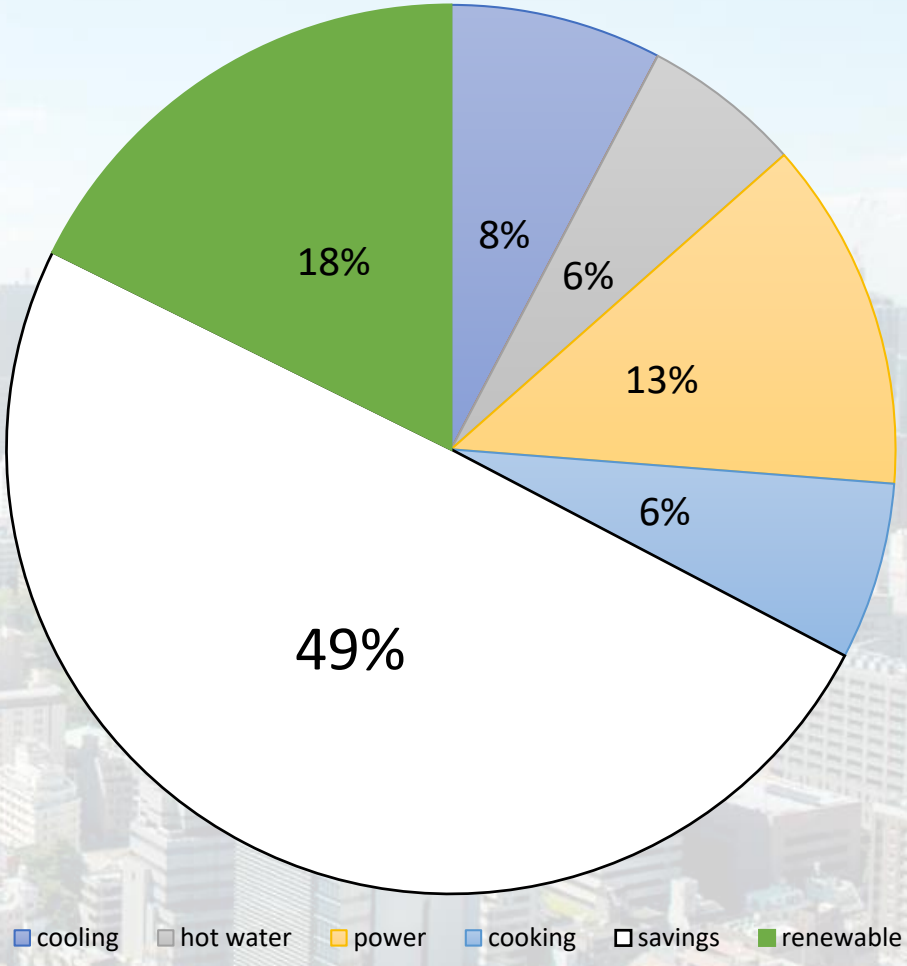


Green building scenario

Green building Residential 2040



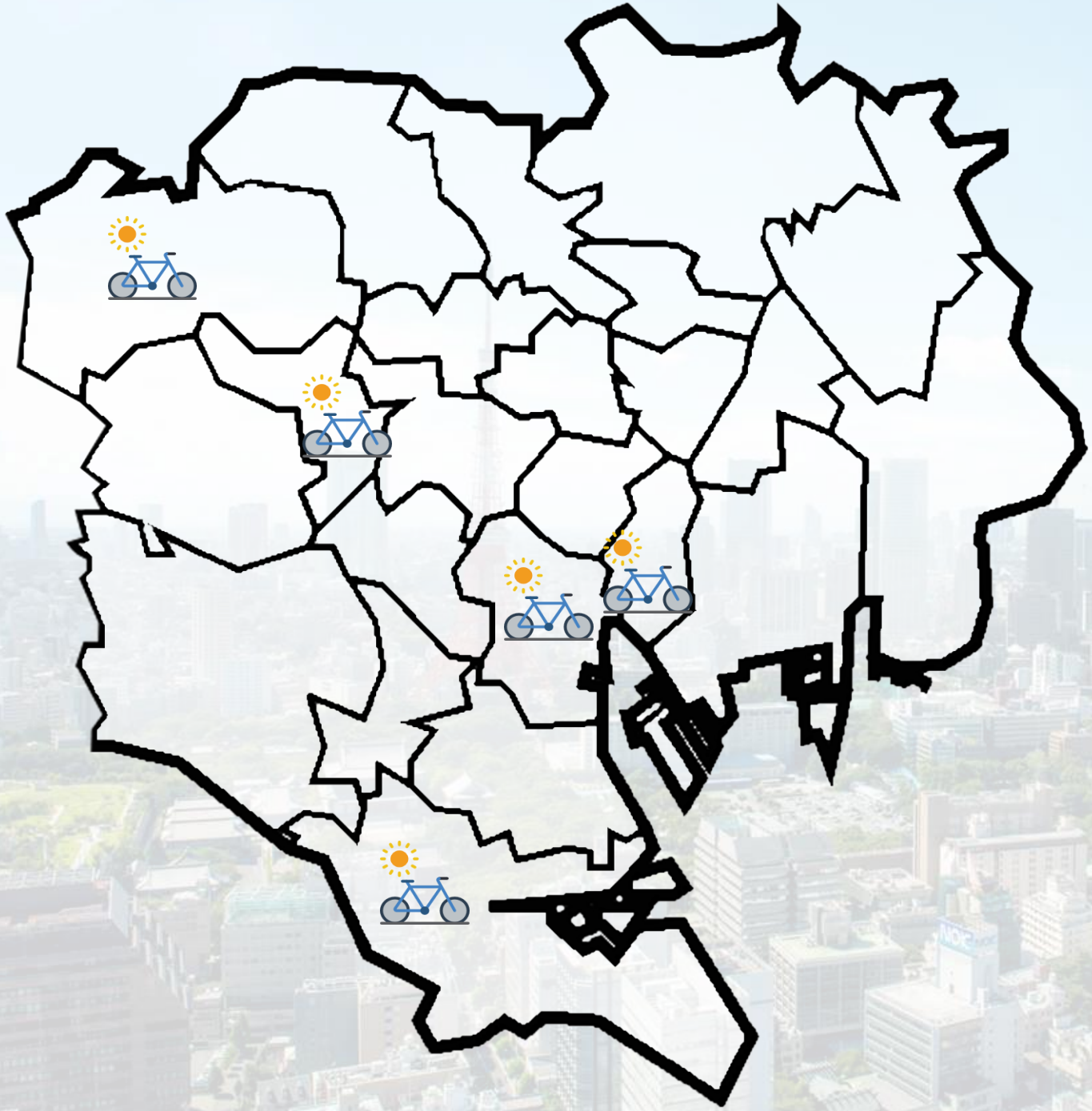
Green building Commercial 2040



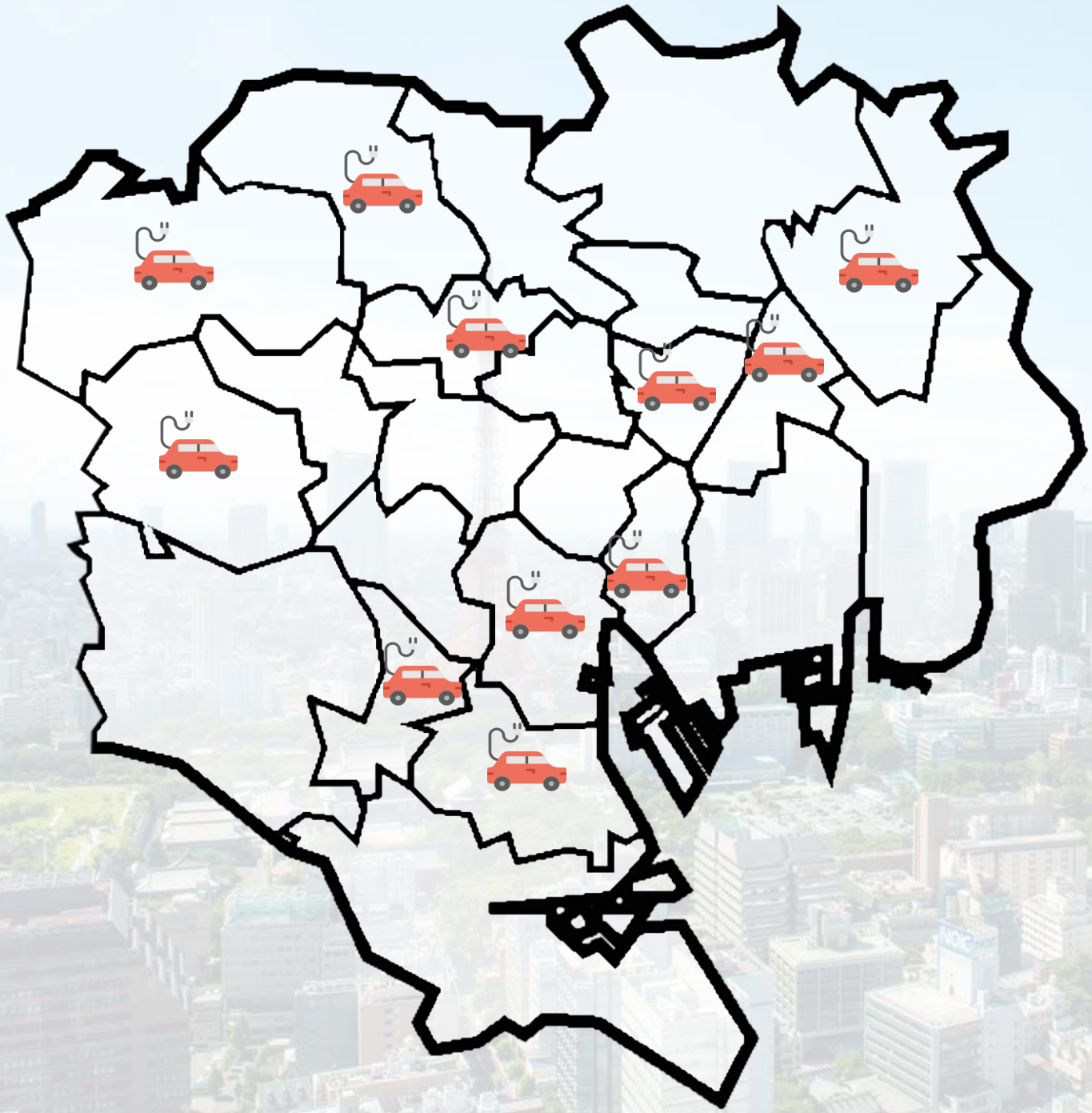
Building consumption changes

	Refurbished	Rebuilt	Green buildings
Residential now $[\frac{KWh}{m^2}]$	118		
Residential 2040 $[\frac{KWh}{m^2}]$	86.2 (27% savings)	49.6 (58% savings)	19.3 (84% savings)
Commercial now $[\frac{KWh}{m^2}]$	332		
Commercial 2040 $[\frac{KWh}{m^2}]$	239 (28% savings)	169.3 (49% savings)	139 (58% savings)

TRANSPORTATION SECTOR

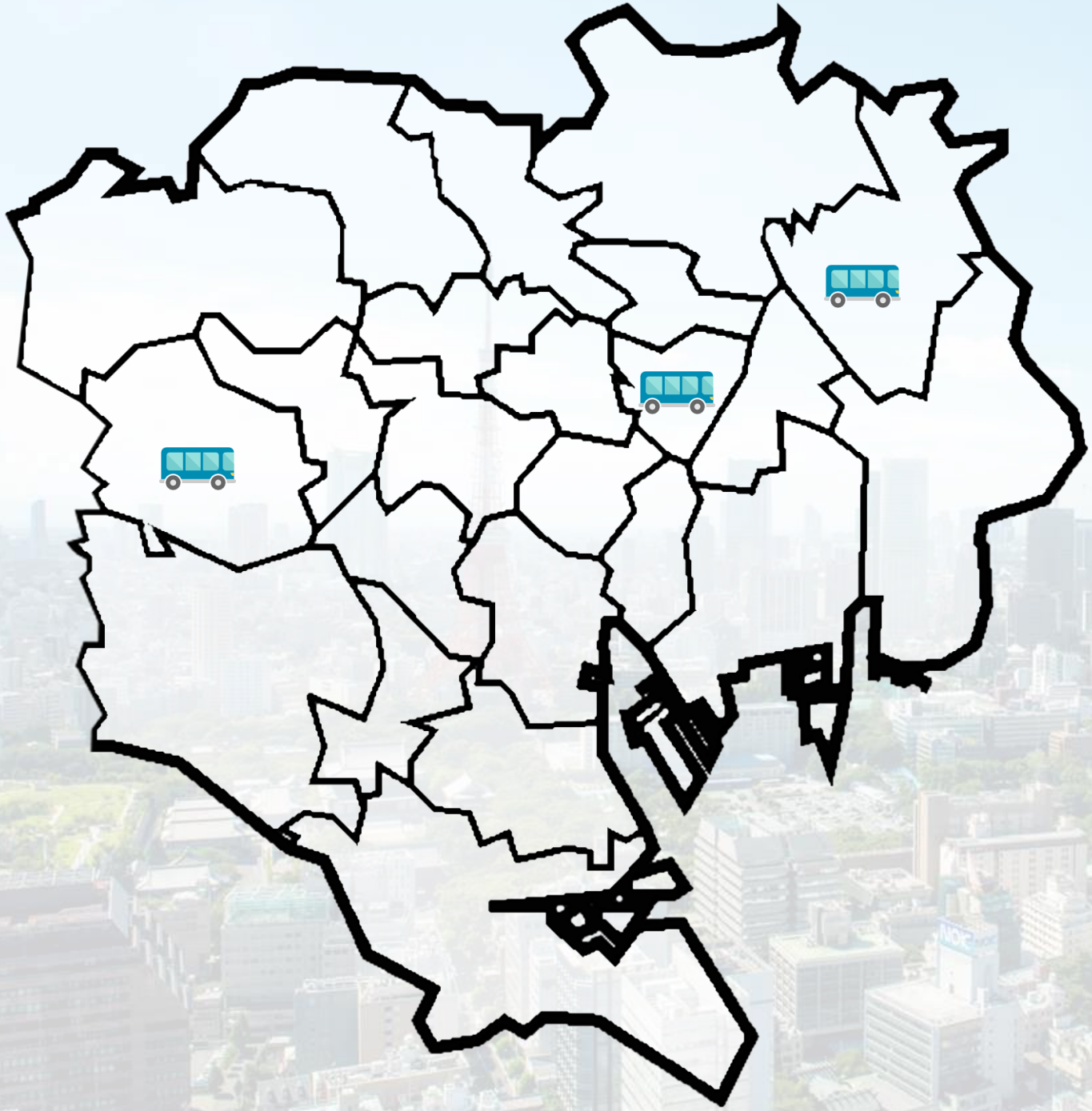


Bicycle Highway (29%)



Bicycle Highway (29%)

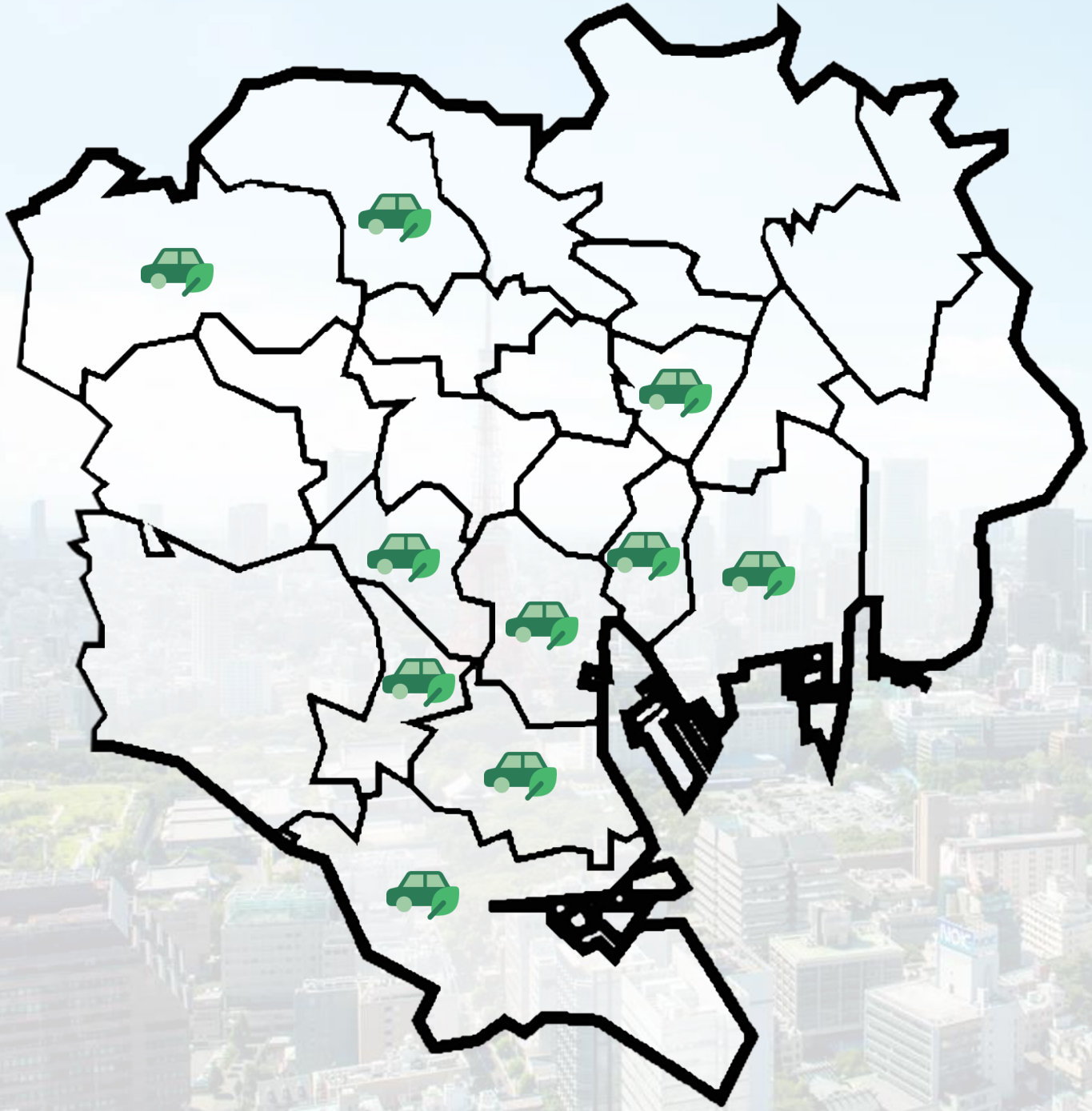
Electric Vehicles (65%)



Bicycle Highway (29%)

Electric Vehicles (65%)

Biogas Public Bus (18%)

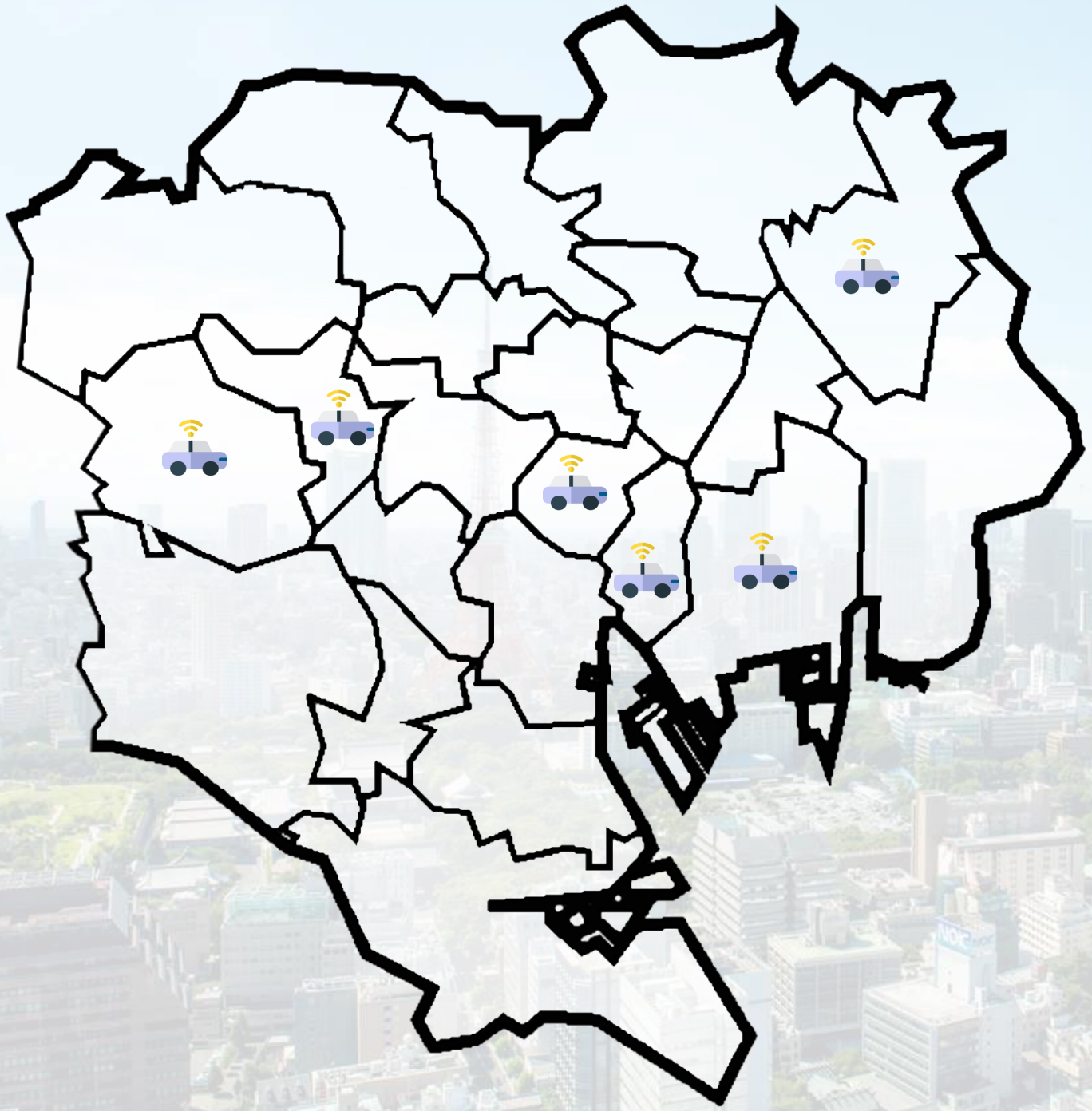


Bicycle Highway (29%)

Electric Vehicles (65%)

Biogas Public Bus (18%)

Hydrogen Vehicle (59%)



Bicycle Highway (29%)

Electric Vehicles (65%)

Biogas Public Bus (18%)

Hydrogen Vehicle (59%)

Tokyo iFleet (35%)

How would these ideas affect Tokyo?

- **Hydrogen Vehicles (FCV)**
  - One of the hot topics in Japan
  - H2 consumption: 1 kg/100 km
  - CO2 savings (KPI)

- **Electric Vehicles (EV)**
  - Consumption 10 kWh/100 km
  - It will affect the grid load, T&D systems
  - Increased electricity demand (KPI)
  - CO2 savings (KPI)

- **iFleet and Biogas Bus**

  - Variety of fully autonomous electric vehicles
  - In the case of Nakano, iFleet resulted in a 46,2% reduction in privately travelled pkm

  - New biogas consumption: 2 kWh/km
- **Bicycle Highway**
  - Unobstructed network for cyclists and pedestrians
  - Possibility to install PV-shading
  - 4 MW with 50% PV-shaded lanes

Assumptions and scenarios

General assumptions:

- Number of cars:
  23/100 people
- Average distance by car in Tokyo:
  16 km/day
- Specific CO2 emission of a car:
  70g/km
- Current biogas bus consumption:
  5 kWh/km
- Current gasoline bus consumption:
  4 kWh/km

Scenarios:

- **Full electrification (FE):**

95% electric / 3% H2 / 2% biogas and fossil fuel

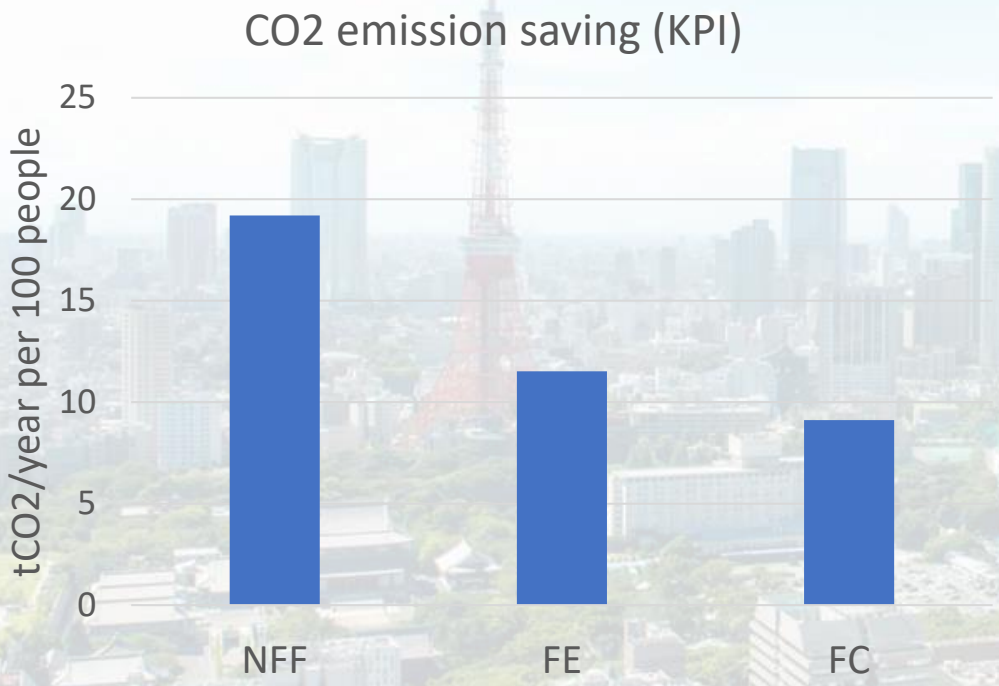
- **Fuel cell scenario (FC):**

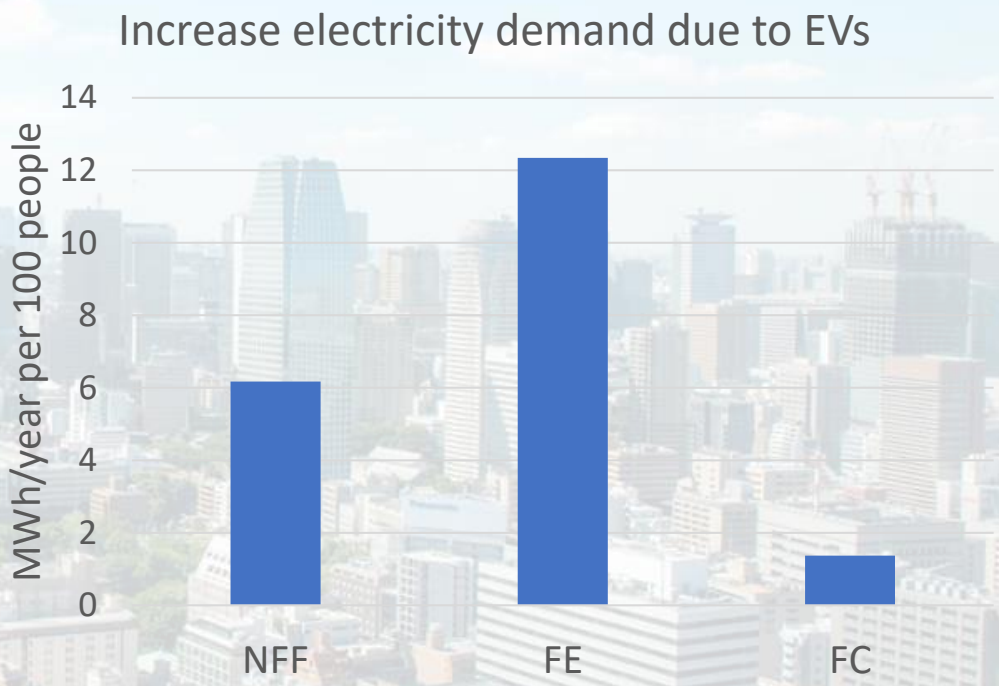
85% H2 / 10% electric / 5 % biogas and fossil fuel

- **No fossil fuel (NFF):**

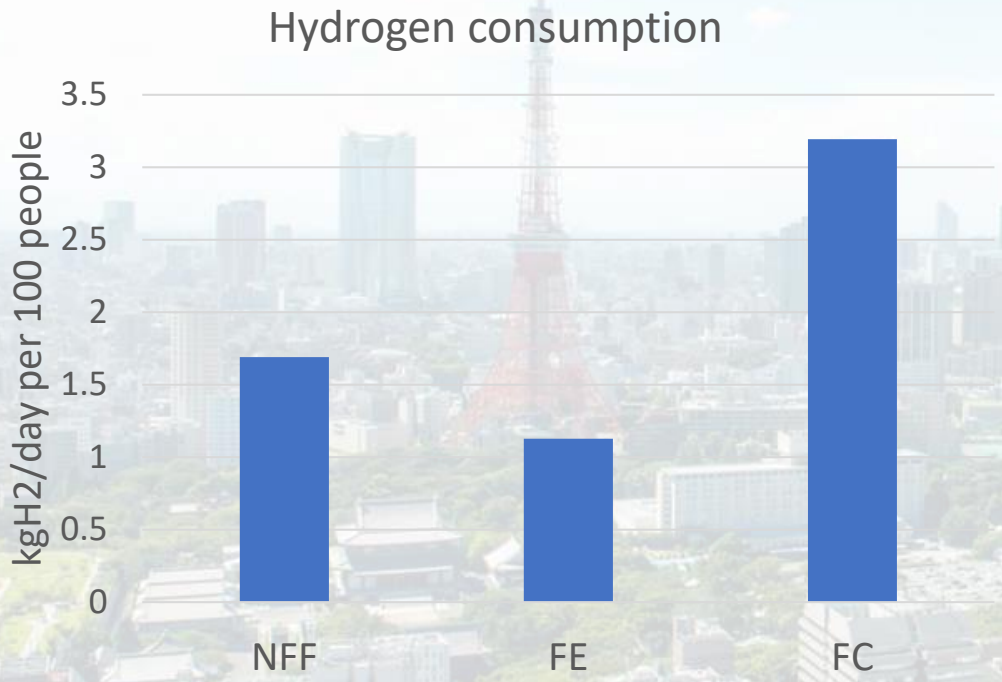
45% H2 / 45% electric / 10% biogas

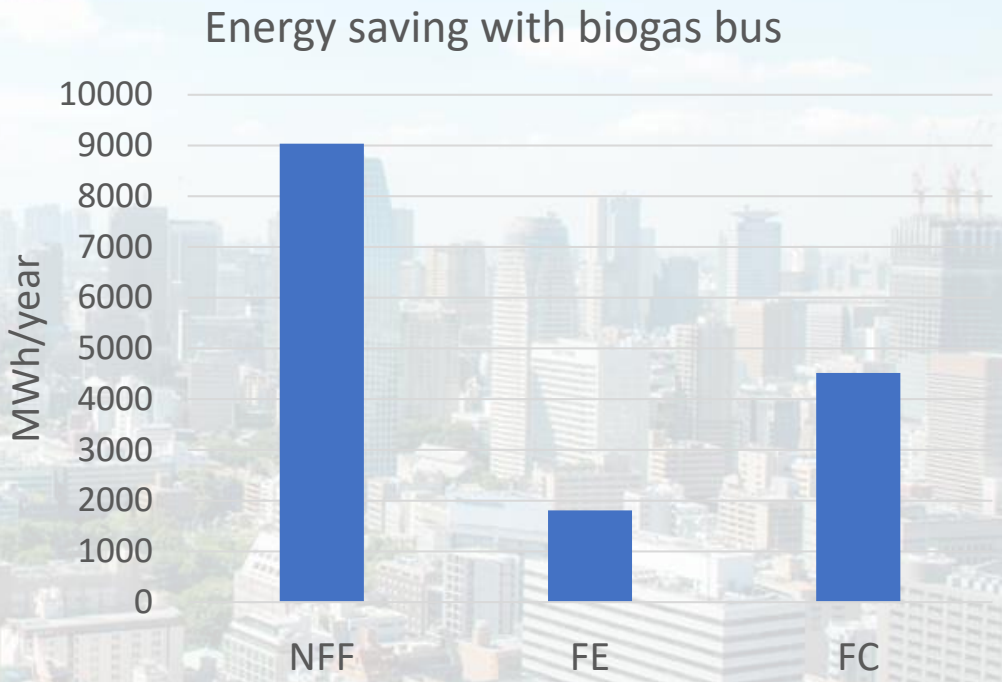
How would these ideas affect Tokyo?



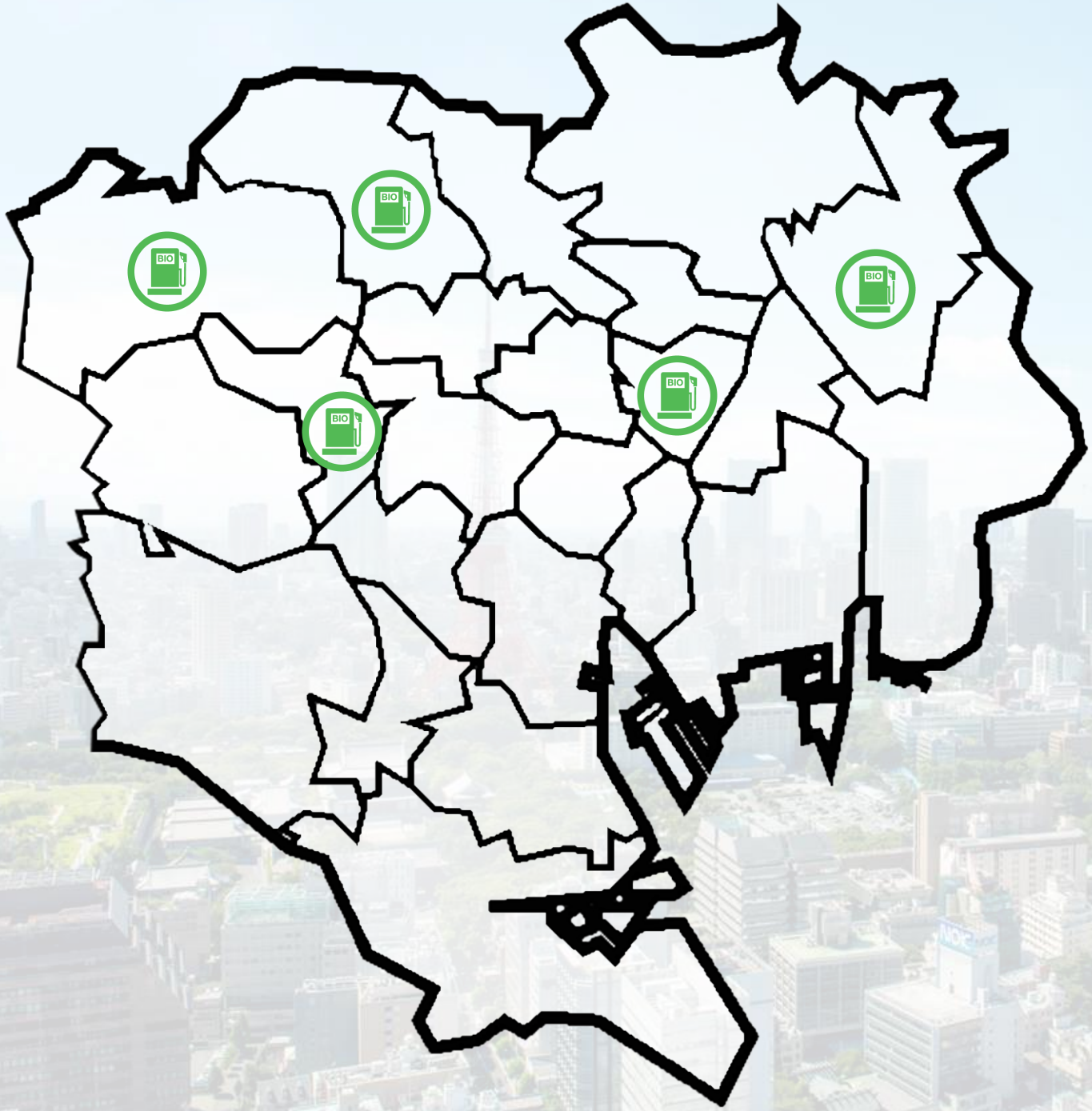


How would these ideas affect Tokyo?



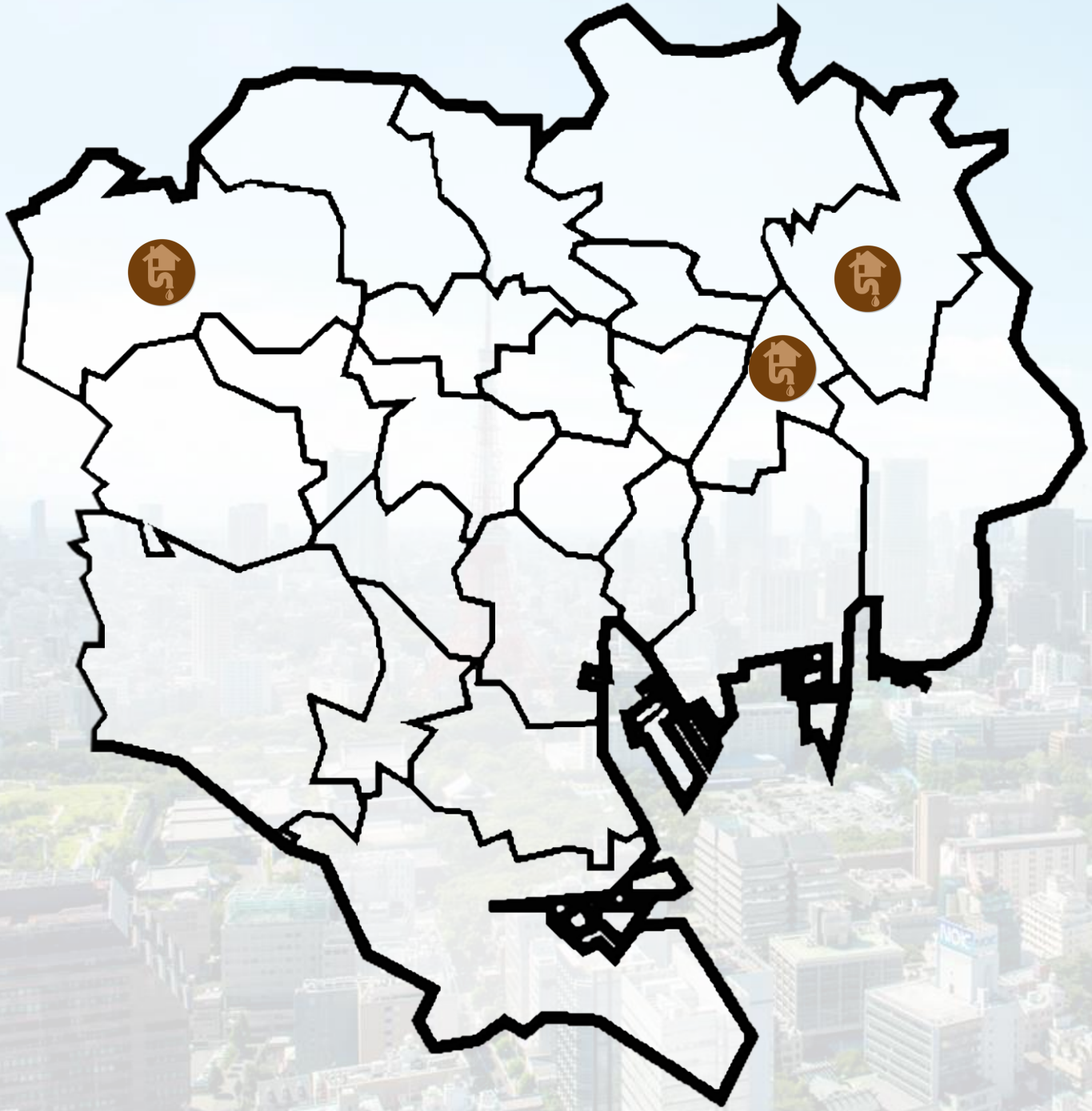


WASTE & ENVIRONMENT SECTOR



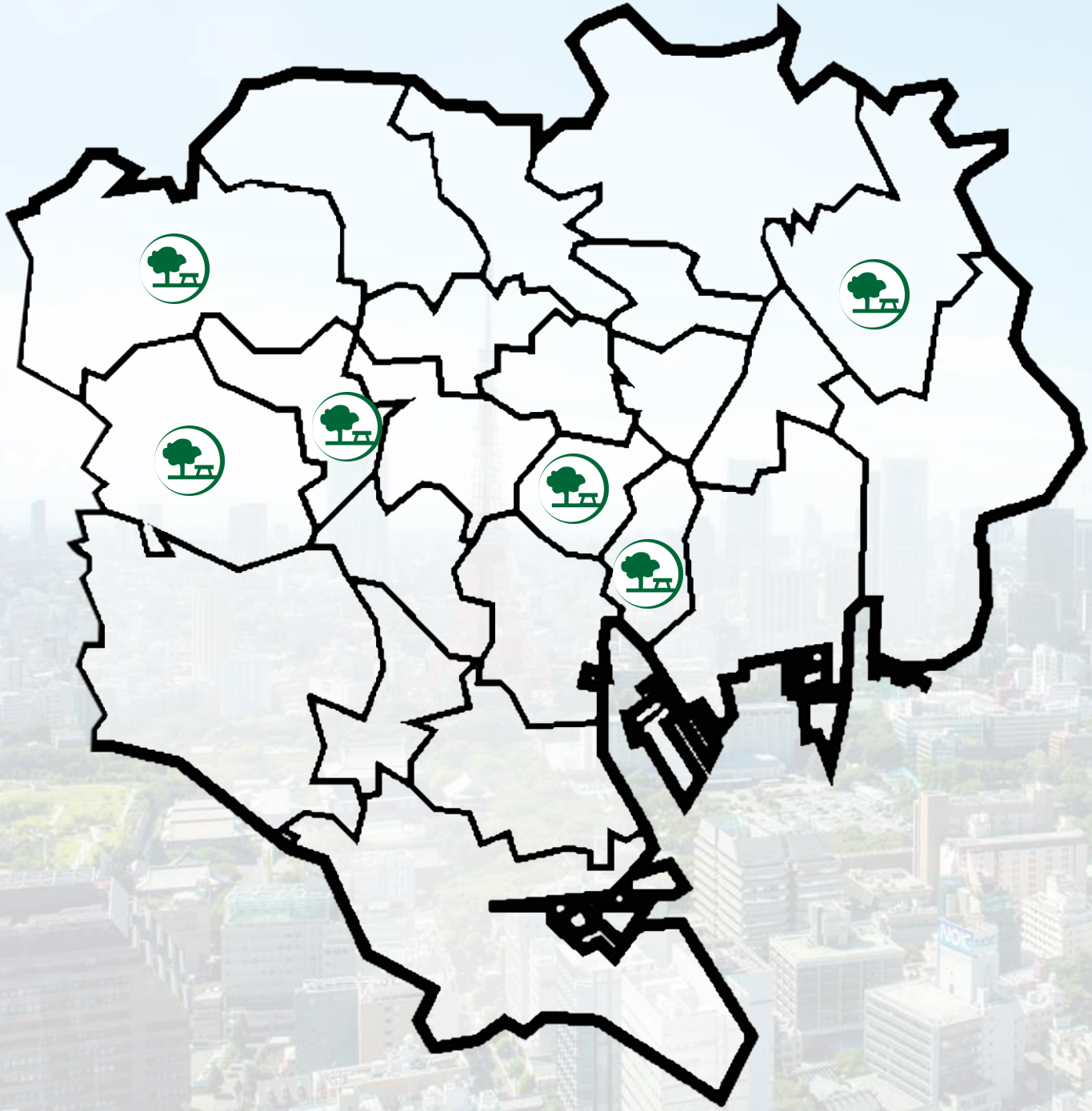
BIO

Biogas from food waste (29%)



Biogas from food waste (29%)

Biogas from sewage sludge (18%)



Biogas from food waste (29%)

Biogas from sewage sludge (18%)

Green areas (35%)

Biogas from food waste (29%)

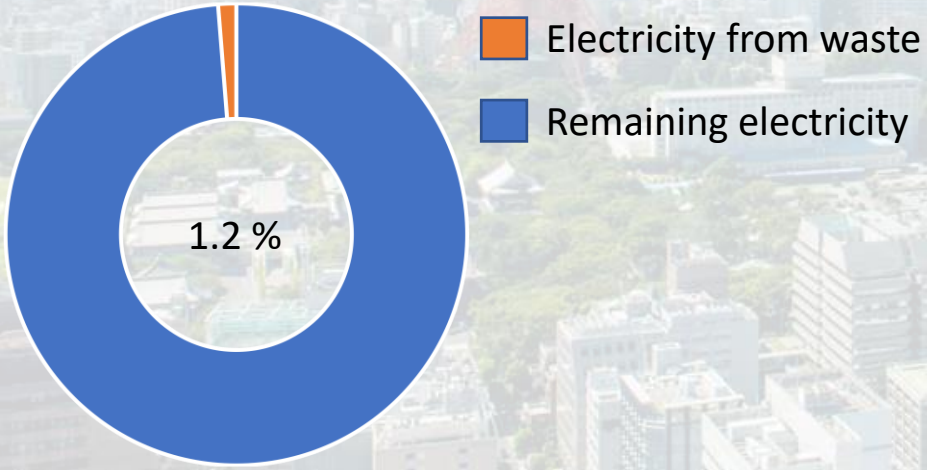
Biogas from sewage sludge (18%)

Green areas (35%)

Urban Heat Island Moderation (12%)

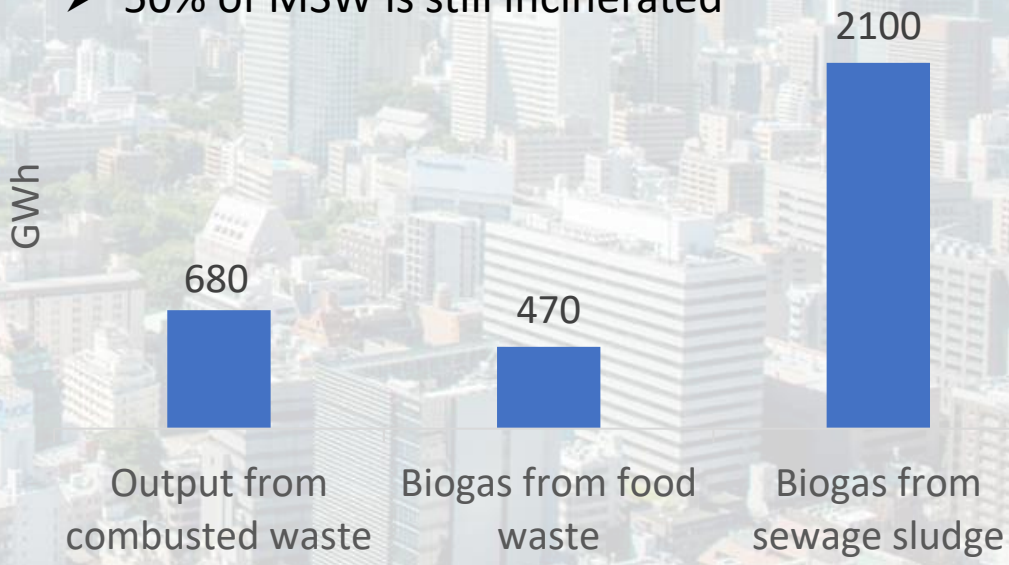
Current Situation

- 2.6 million ton of MSW
- 70% of MSW is incinerated
- 1000 GWh of output per year

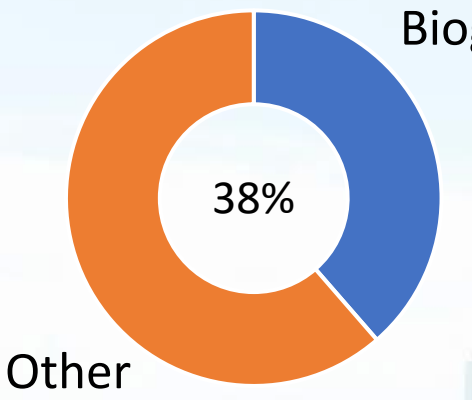


Our vision for 2040

- 2.4 million ton of MSW
- 20% of MSW is food waste
- All the food waste is turned into biogas
- All the collected sewage sludge is turned into Biogas
- 50% of MSW is still incinerated

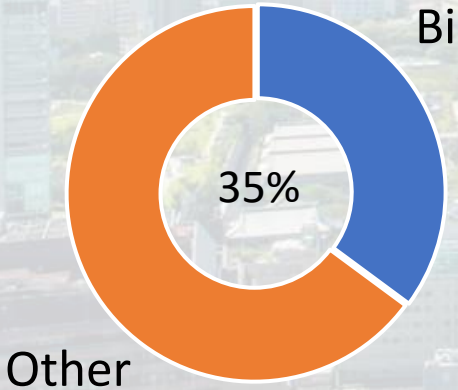


1° scenario: Heating



-470 Kt of CO_{2eq}

2° scenario: Heating + transportation



1500 Biogas Buses

-560 Kt of CO_{2eq}

Urban heat island effect in Tokyo

- +3 K in the last 100 years
- +1 K in inner Tokyo during summer months

Actions to counteract the UHI effect

- Expansion of green areas
- Green rooftops and green facades
- High albedo pavement areas
- Expansion of water spaces

Additional green surface

- Chiyoda: +8.4%
- Chuo: +28 %
- Katsushika: +10.3 %
- Nakano: +10.3 %

$+9.1\ Km^2 = -\ 2.7\ Kton\ of\ CO_2$

FINAL REMARKS

- Self sufficiency is not reachable, but large improvements, YES
- Biogas as the fuel for public transportation
- Energy efficiency measures should be the 1st step
- Reshaping of buildings for better neighbourhoods
- Incentives and policies towards innovation business models

THANK YOU!

ありがとうございました