STUDY ON THE INTRODUCTION OF ROAD HEATING SYSTEMS USING RENEWABLE ENERGY IN HOKKAIDO

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1. INTRODUCTION-STUDY AREA

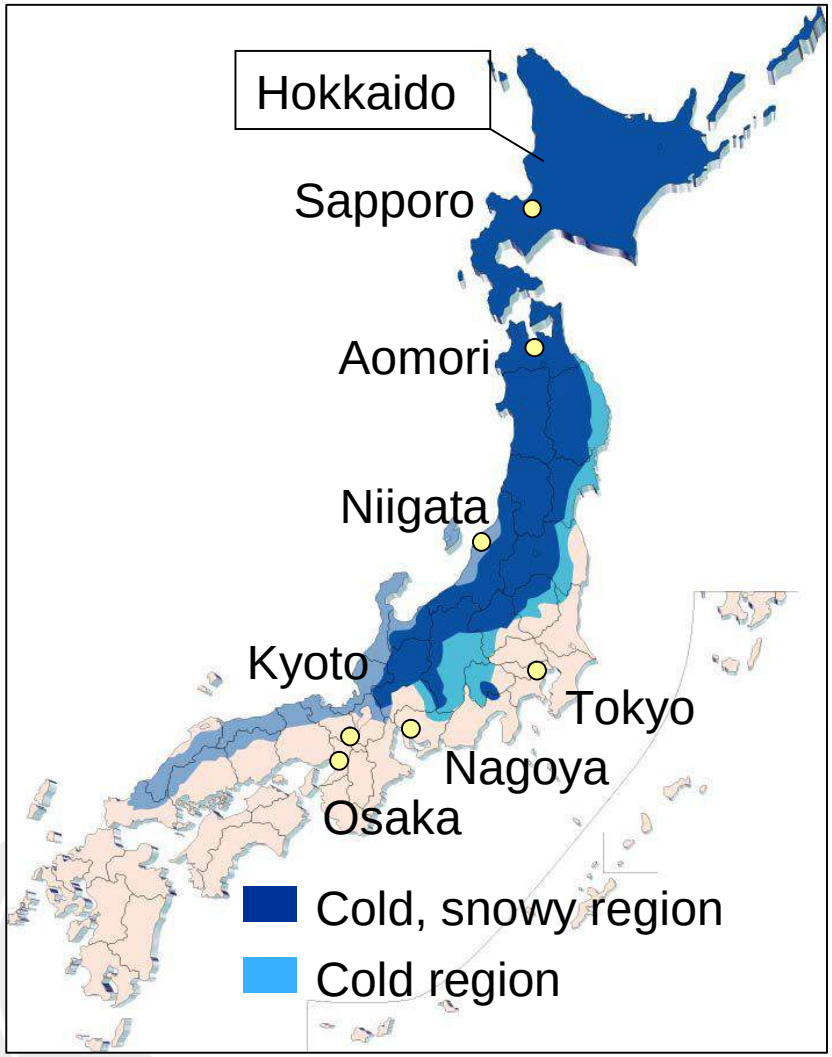
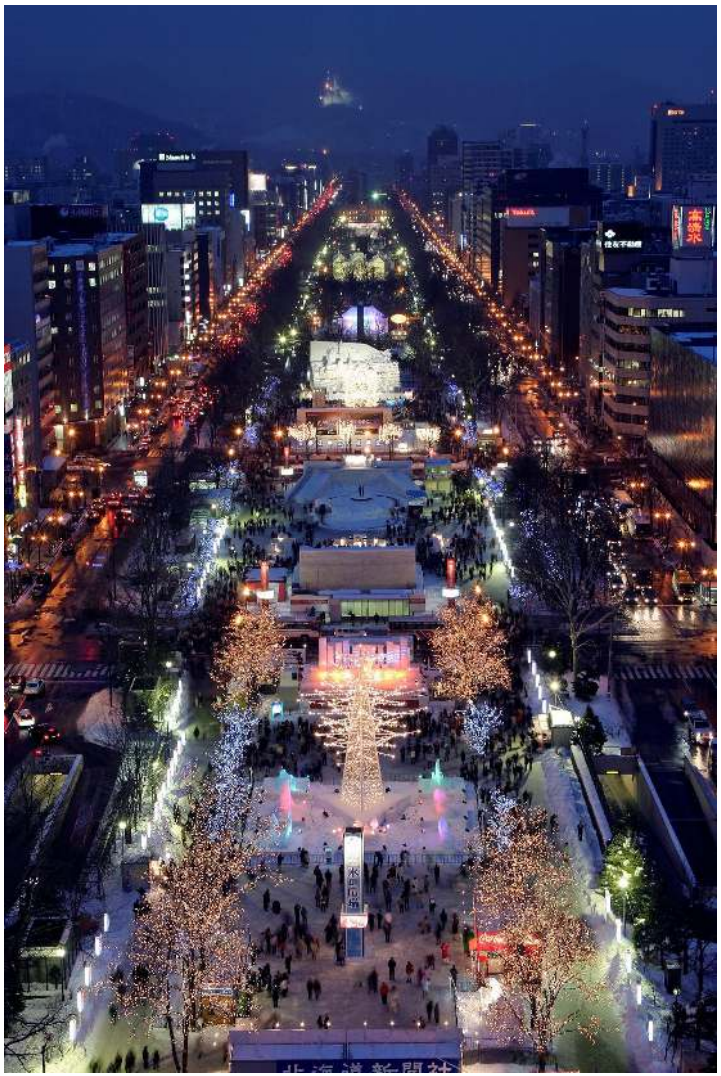


Fig.1 The cold, snowy regions of Japan



Sapporo City

1. INTRODUCTION

- In 1990, studded tire use was banned in Japan. After that, extremely icy road surfaces emerged in Hokkaido.
- To counter such icy road surfaces, road heating systems were rapidly introduced.
- In Sapporo, electric road heating systems were intensively installed to secure smooth traffic.
- However, the intensive introduction of road heating systems has resulted in financial difficulties for the City of Sapporo.
- This study discusses if recent temperature rise due to global warming would enable the introduction of renewable-energy-based road heating systems.

2. CHANGES IN WINTER WEATHER IN NORTHERN JAPAN, HOKKAIDO ISLAND AND SAPPORO CITY

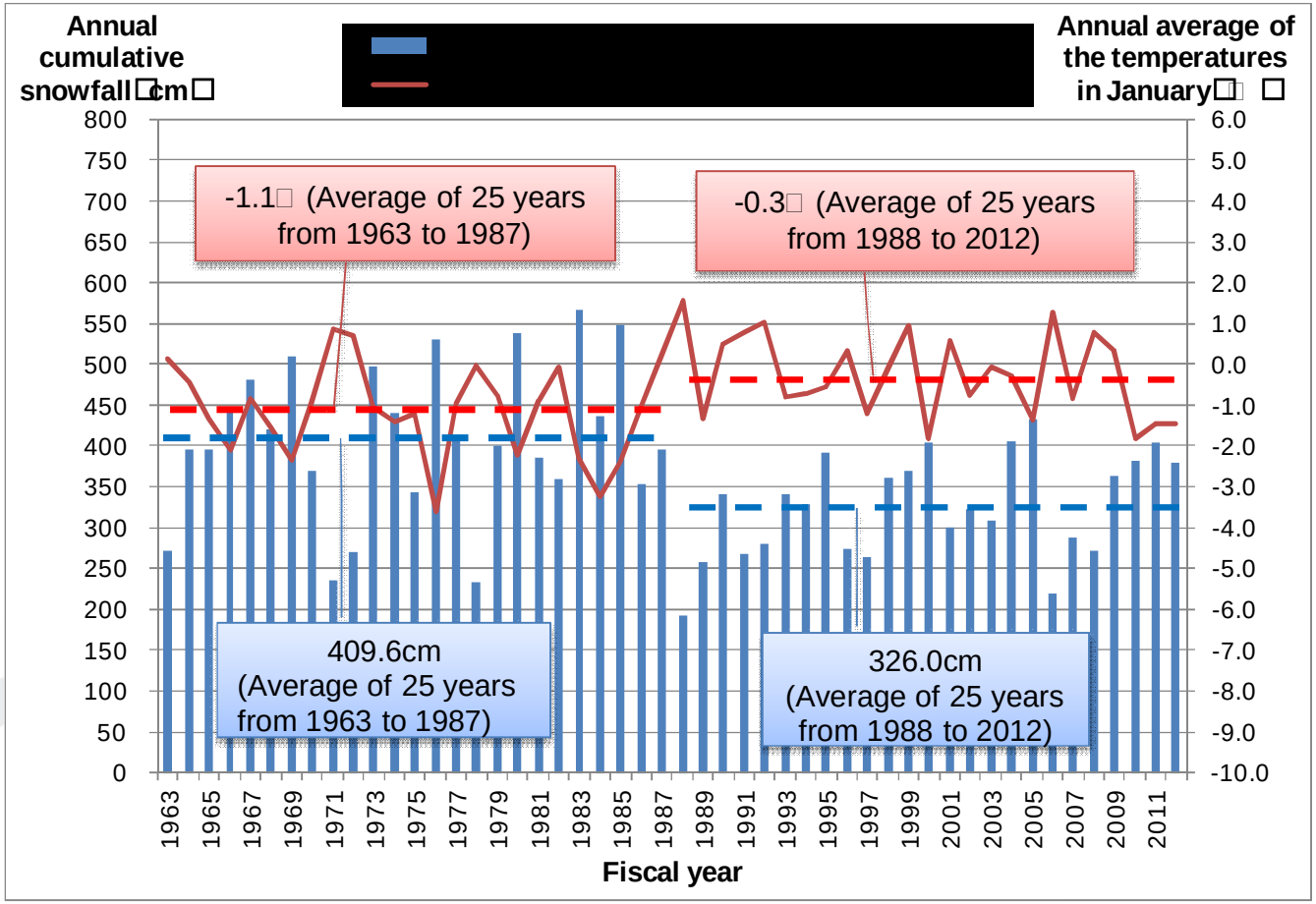


Fig.2 Changes in the average temperature in January and cumulative snowfall in Japan's cold, snowy regions

2. CHANGES IN WINTER WEATHER IN NORTHERN JAPAN, HOKKAIDO ISLAND AND SAPPORO CITY

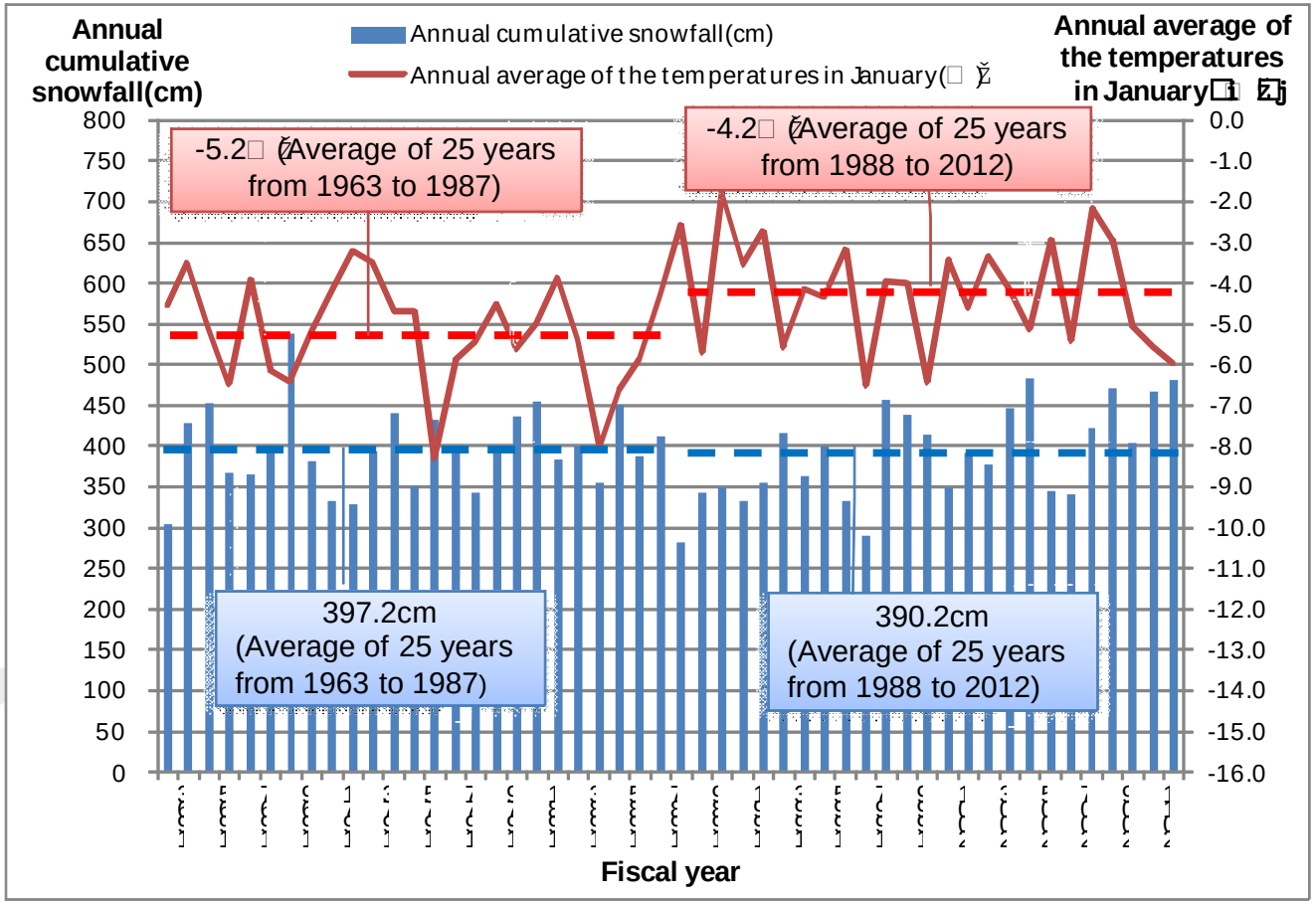


Fig.3 Changes in average temperature in January and cumulative snowfall in Hokkaido

2. CHANGES IN WINTER WEATHER IN NORTHERN JAPAN, HOKKAIDO ISLAND AND SAPPORO CITY

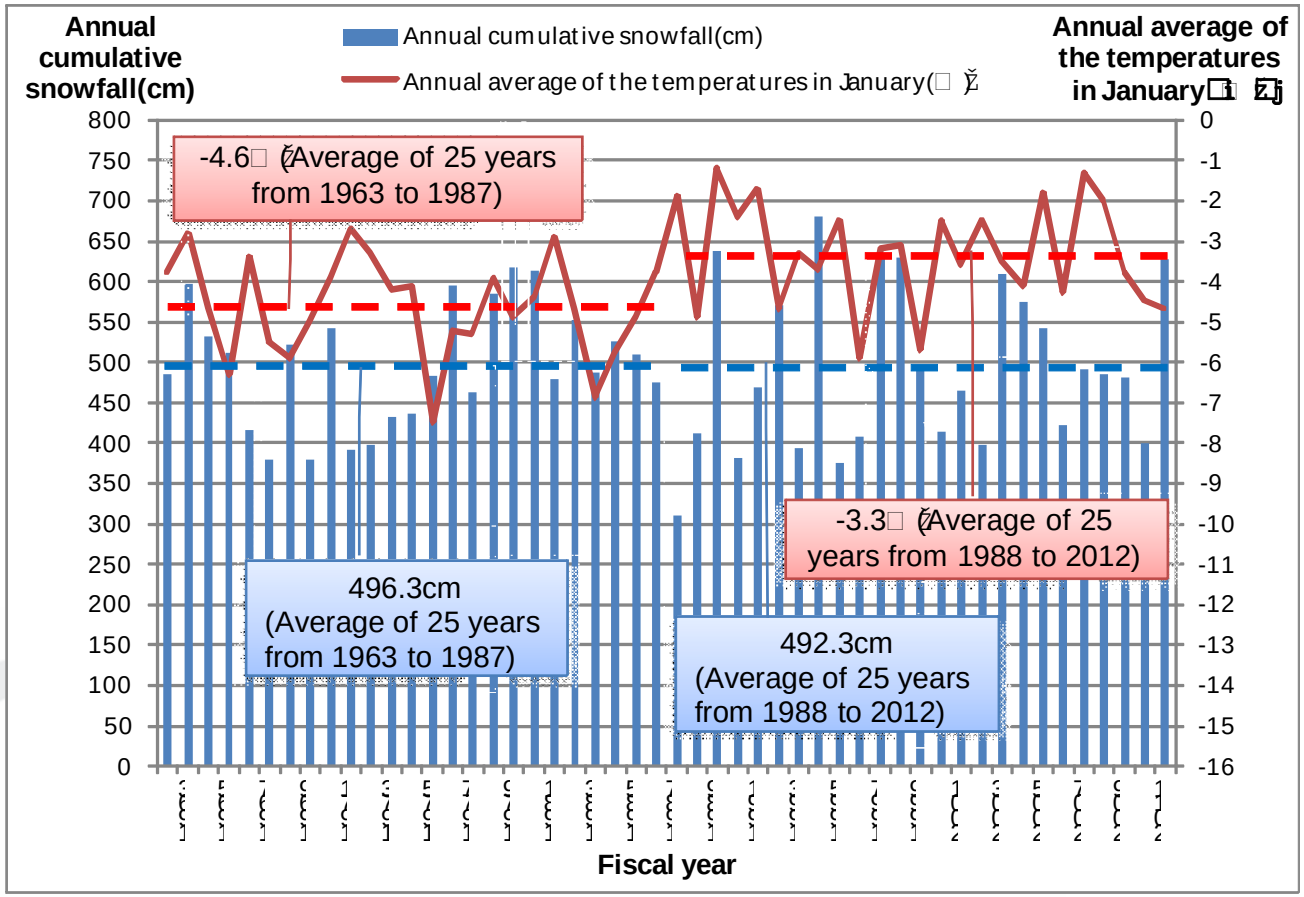


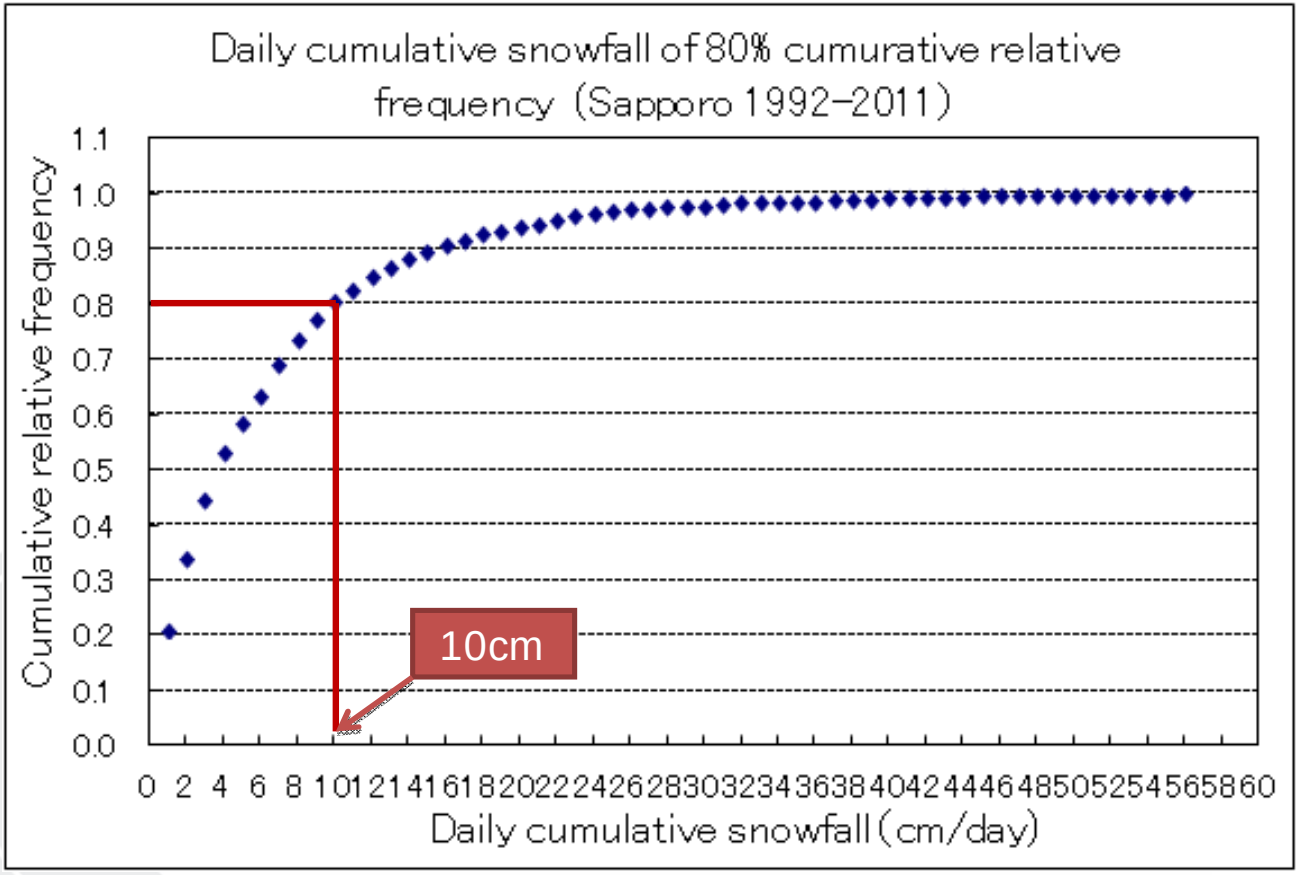
Fig.4 Changes in average temperature in February and cumulative snowfall in Sapporo

3. HEAT REQUIRED FOR A ROAD HEATING SYSTEM

- How to determine the heat (calories) required for road heating systems to effectively operate.
- The heat necessary for snow melting and that necessary to prevent road surface freezing are calculated.
- Comparing the two, the larger value is adopted to design road heating systems.

3. HEAT REQUIRED FOR A ROAD HEATING SYSTEM

The heat required for a road heating system to melt snow is calculated by Equations 1 to 4.



3. HEAT REQUIRED TO PREVENT ROAD SURFACE FREEZING

The heat required to prevent road surface freezing is calculated by Equations 5

$$q_2 = 1/\eta \cdot Ar \cdot (q_e + q_i) \quad \square\square\square\square\square \text{Equation 5}$$

q_2 : Heat required to prevent road surface freezing (W/m^2)

q_e : Heat of evaporation (W/m^2)

q_i : Convective radiant heat (W/m^2)

η: Heat efficiency (0.65~0.9)

Ar : Ratio of road surface without snow to total road surface area

3. HEAT REQUIRED FOR A ROAD HEATING SYSTEM TO EFFECTIVELY PERFORM IN SAPPORO

Changes in 10-Year-Period Heat required for road heating systems

		Period of time(FY)		
		1982 - 1991	1992 - 2001	2002 - 2011
Daily cumulative snowfall of 80% cumulative relative frequency		12cm	11cm	9cm
Heat required for snow melting		110.6W/m^2	103.6W/m^2	89.8W/m^2
Avg. lowest temp in Jan.		-7.5 ^{o}C	-7.0 ^{o}C	-6.2 ^{o}C
Avg. wind speeds in Jan.	Observed	2.0m/s	2.6m/s	3.3m/s
	Applied	3.0m/s	3.0m/s	3.3m/s
Heat required to prevent road surface freezing		234.3W/m^2	220.6W/m^2	209.5W/m^2

4. POTENTIAL RENEWABLE ENERGY SOURCES FOR ROAD HEATING SYSTEMS

Heat required by road heating systems using renewable energy sources

Energy Type	Technology to utilize the energy	Heat (w/m^2) 100 200 300
Groundwater or spring	Direct use	
	Heat pump	
Hot spring	Direct use/ heat pipe	
Geothermal energy	Heat pipe	
	Direct heat exchange	
	Heat pump	
Air	Heat pump	
Solar energy	Thermal storage	
Wind power	Electric heat	

5. COMPARISON OF ROAD HEATING SYSTEMS' OPERATING COSTS BY ENERGY SOURCE

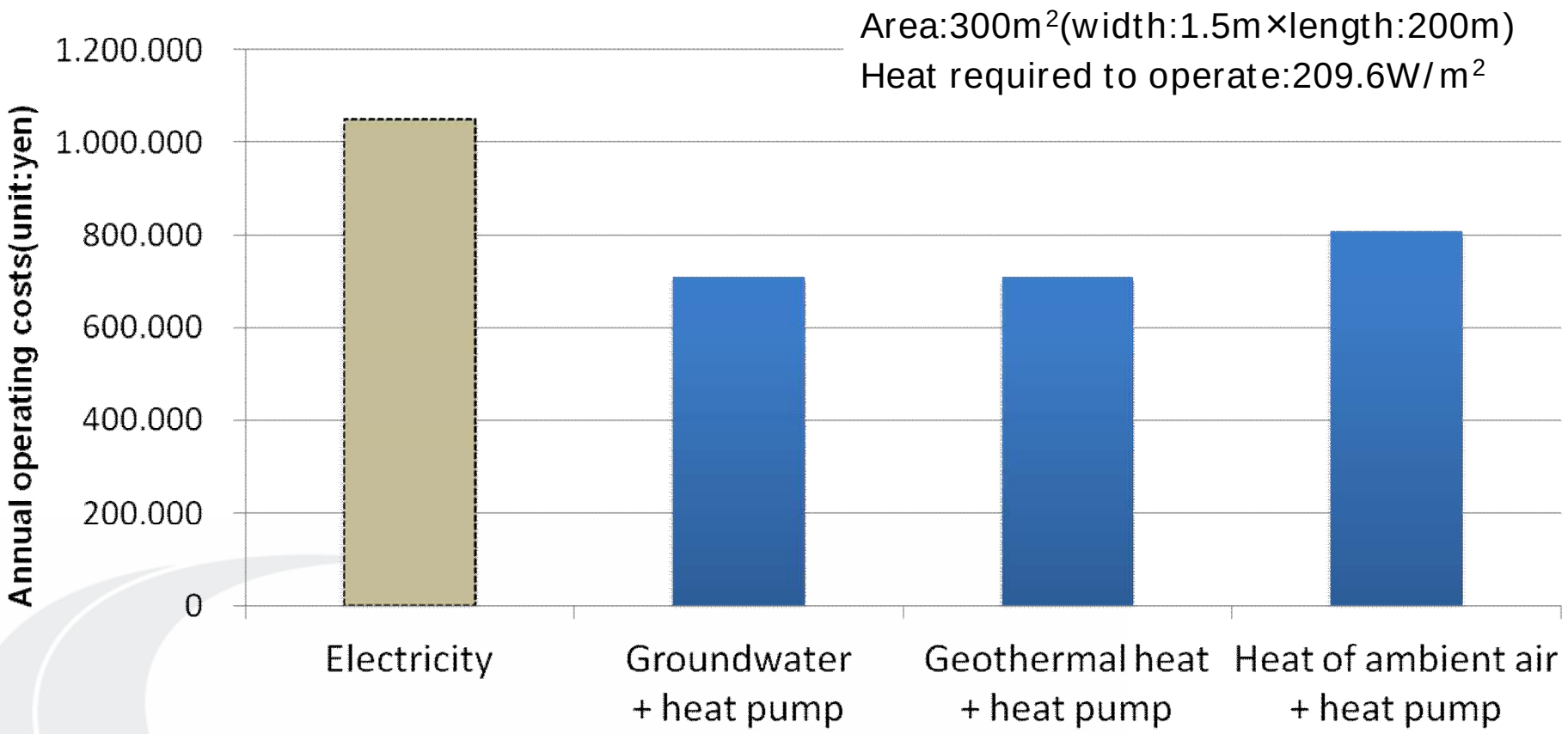


Figure 5 Operating costs of road heating systems by energy source

5. COMPARISON OF ROAD HEATING SYSTEMS' TOTAL COSTS BY ENERGY SOURCE

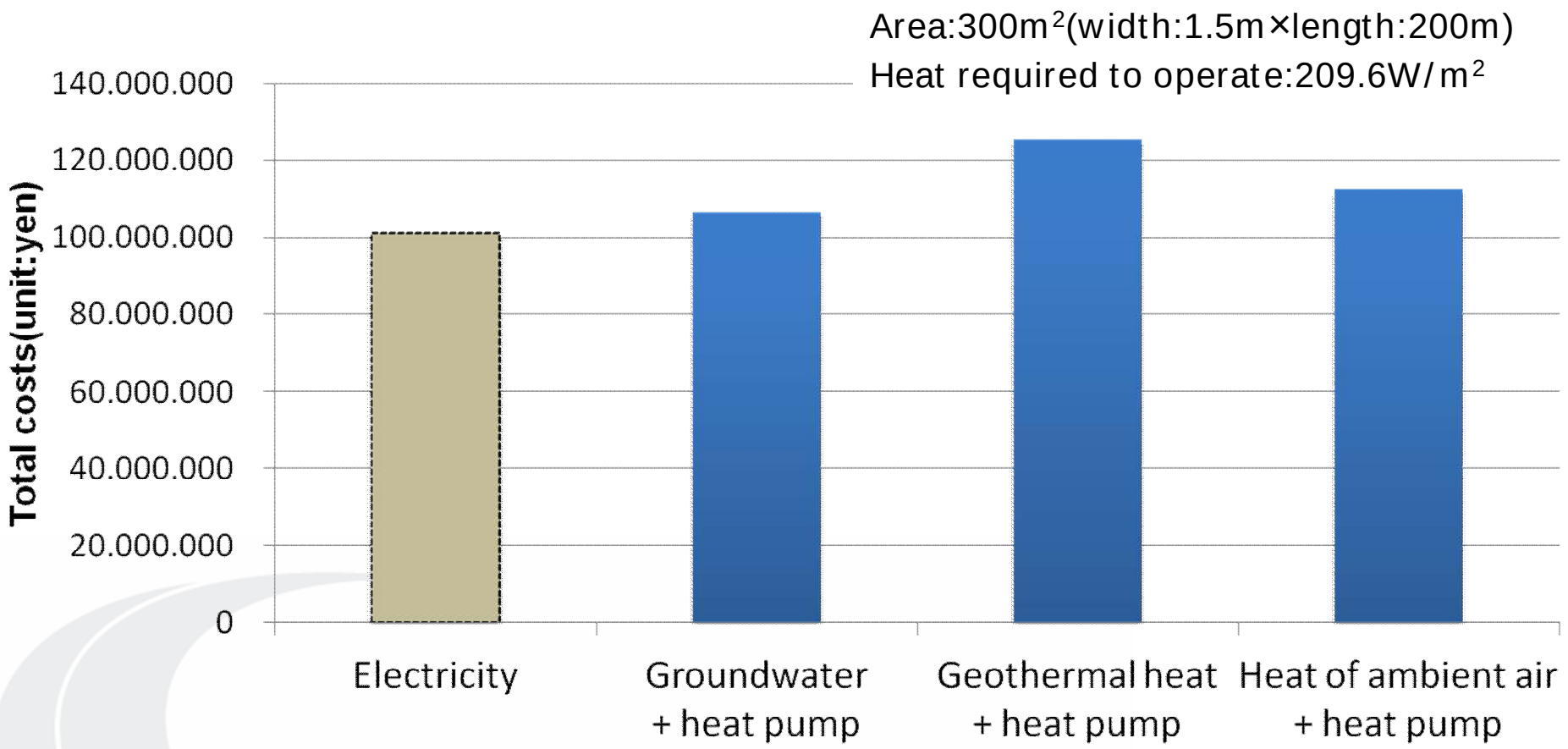


Figure 6 Total costs of road heating systems by energy source for 25 years

6. CONCLUSION

1. Probably because of global warming, average temperatures in winter tend to be increasing in Sapporo, thereby the heat required for road heating systems has lowered by about 25W/ m 2 (from 234.3W/m2 to 209.6W/m2).

2. This study examined if such changes would enable Sapporo to use road heating systems using renewable energy in light of the performance and costs.

3. Analyzing operating and installation costs and performance, this study has found that introducing road heating systems using renewable energy would be possible in Sapporo.

4. Using renewable energy as energy source for road heating systems is cost efficient and eco friendly. Improvement of facilities and design of such systems should be sought.

Thank you for your attention !