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XIII INTERNATIONAL WINTER ROAD CONGRESS

QUÉBEC, FEBRUARY 8 TO 11, 2010

WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE
AIPCR PIARC

Québec

SUSTAINABLE WINTER SERVICE FOR ROAD USERS

SNOW MELTING SYSTEM USING SHALLOW GROUND HEAT AT "MICHI-NO-EKI", HACHI-KITA

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" MICHI-NO-EKI"

About 1000 sites in Japan

A kind of public rest area

(Travel plaza, cafeteria, service sopt for road information)

In snowfall region

→Parking lots to put on/take off tire chains

"HACHIKITA " (construction in 2000y)

Thermal data measuring

OUTLINE

BACKGROUND

SNOW MELTING SYSTEM USING GROUND HEAT

SEASONAL PAVEMENT TEMPERATURE CONTROL

Cooling and heating of the pavement using ground heat

THERMAL TRANSFER OF “HACHI-KITA”

Monthly change of ...
- the water temperature in the tanks
- the ground temperature surrounding ground
- the heat fluxes across the pavement surface

Heat transfer budgets between the equipments

CONCLUSION

BACKGROUND

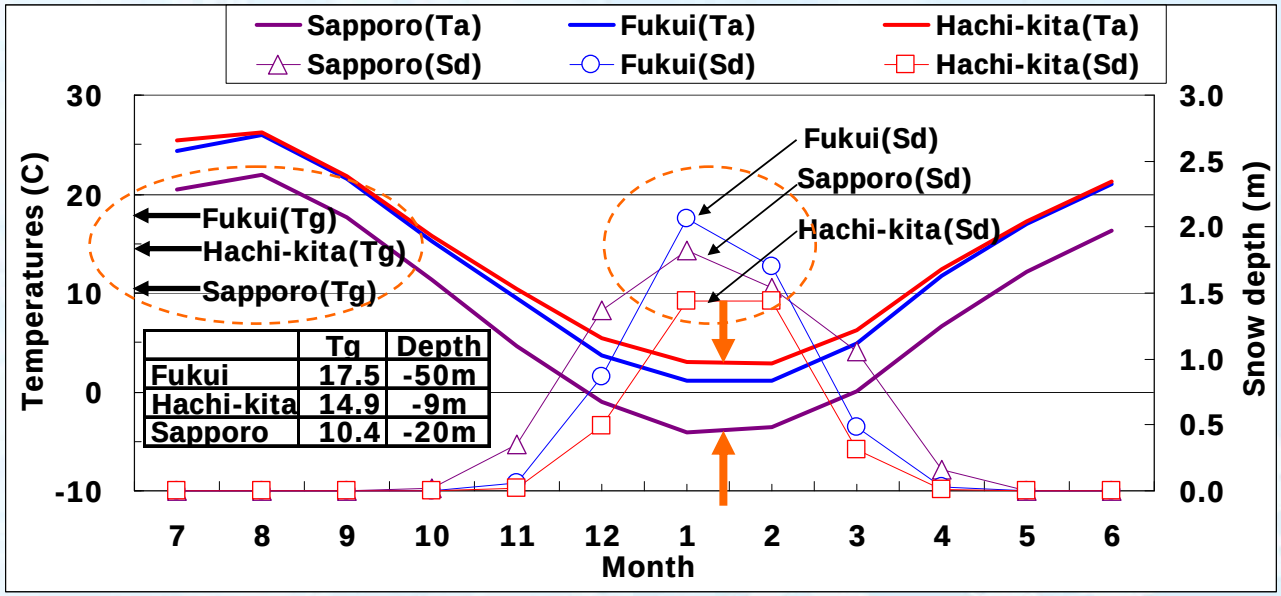
Climatic characteristics of Japan

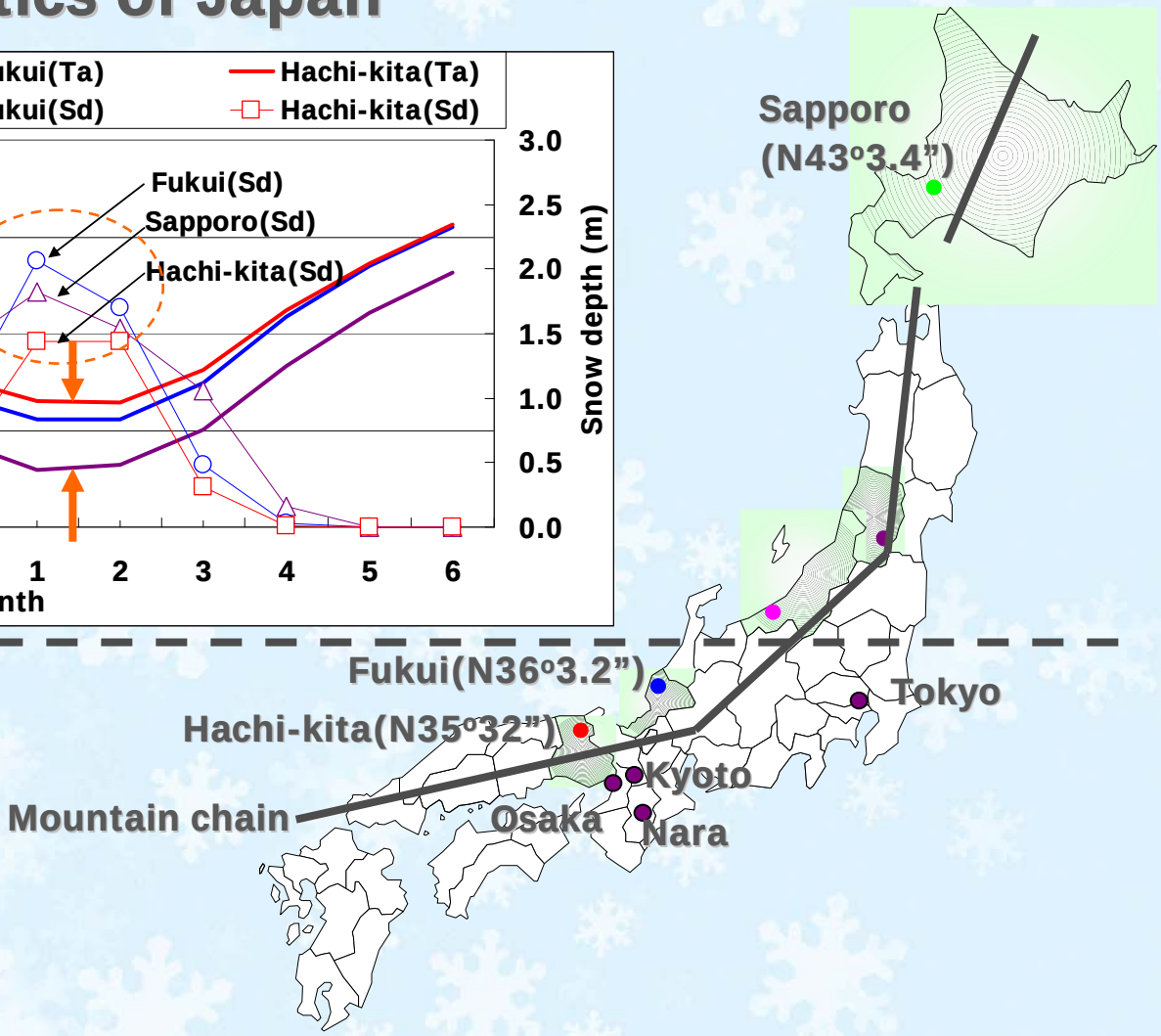
- Japanese land shape is slender
- Climatic variation depended on the altitude
- Cold region and warm region

- Mountain chain
- Heavy snowfall area and lightly snowfall area
- Warm snowfall region

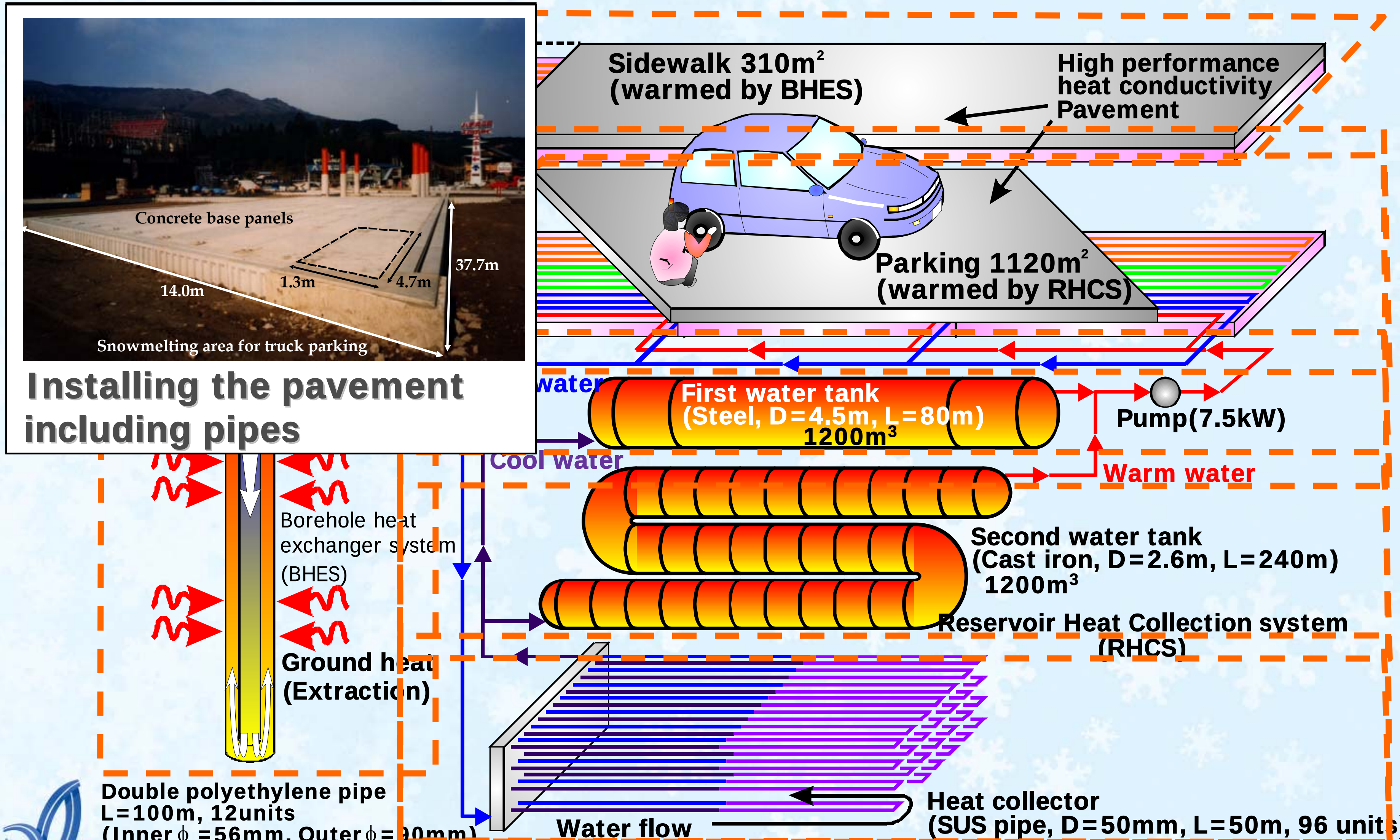
BACKGROUND

Climatic characteristics of Japan





SNOW MELTING SYSTEM USING GROUND HEAT



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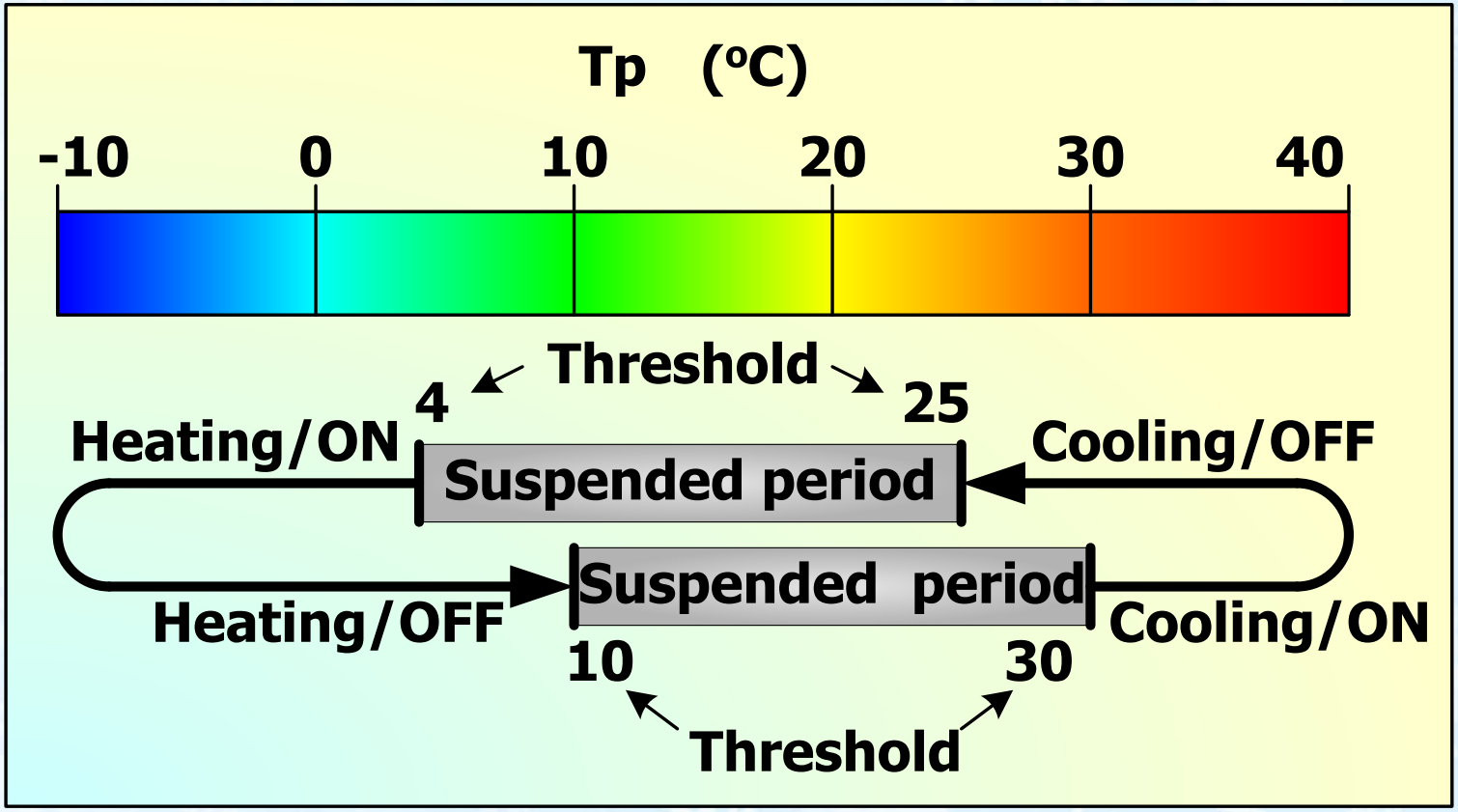
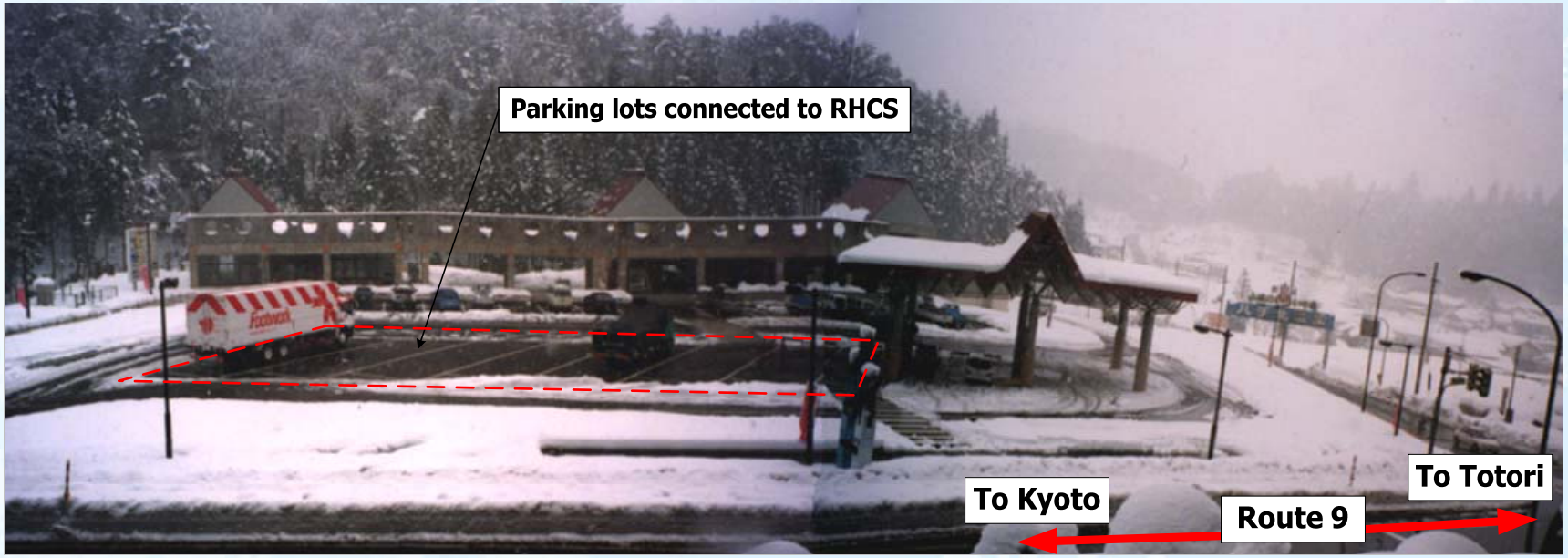
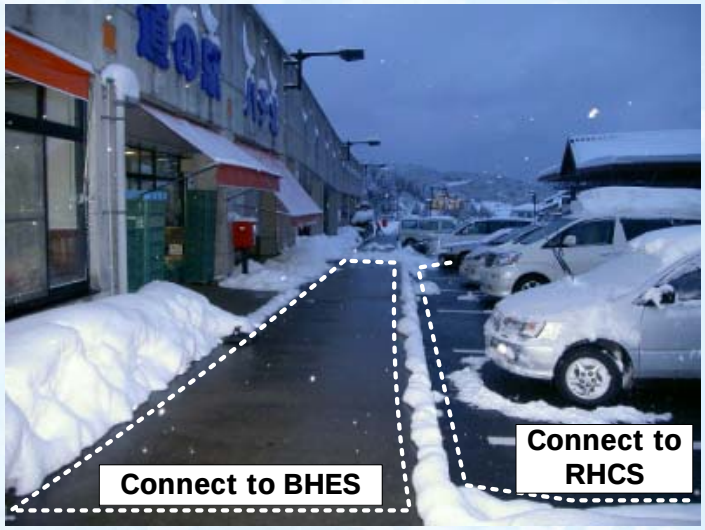
PAVEMENT TEMPERATURE CONTROL



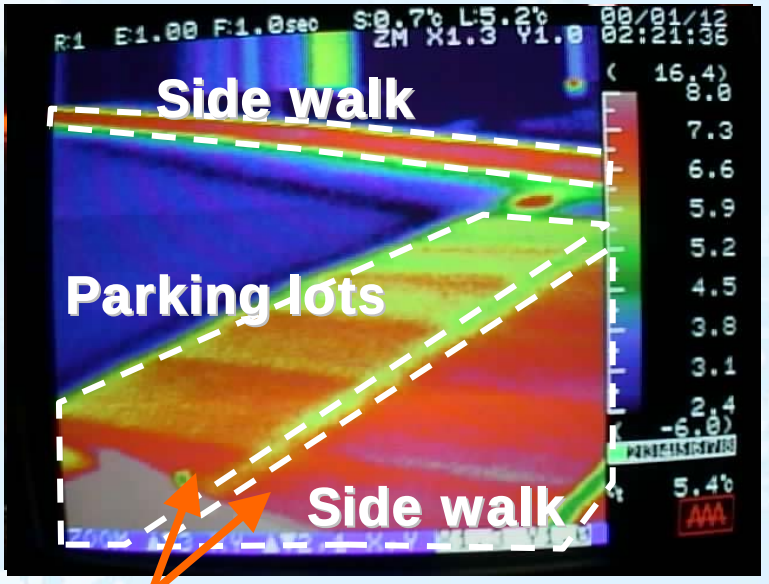
SNOW MELTING SYSTEM USING GROUND HEAT





SEASONAL PAVEMENT TEMPERATURE CONTROL

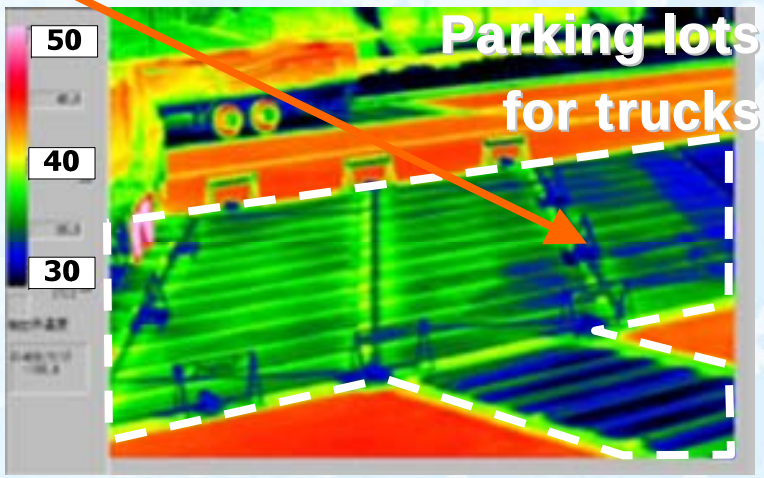
Summer period



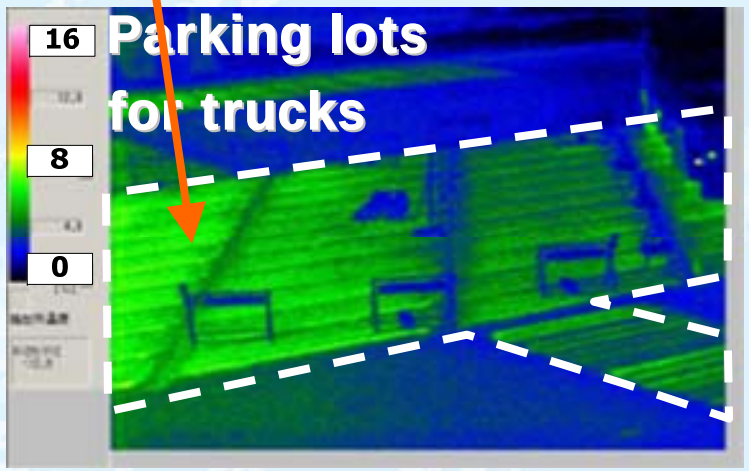
Winter period

Cooling area

Heating area



Summer period



Winter period

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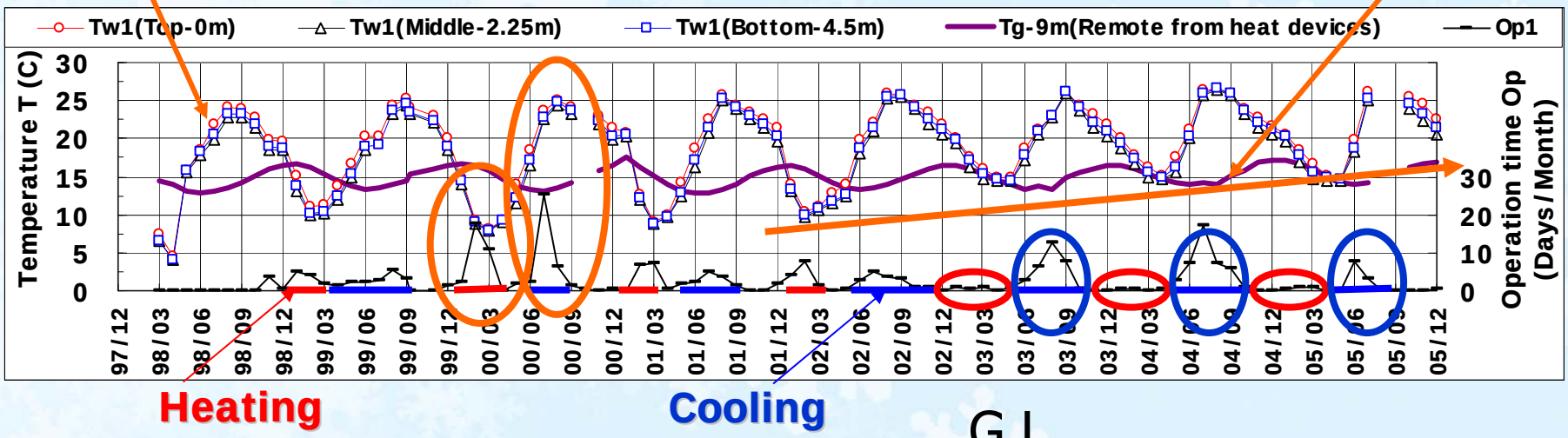
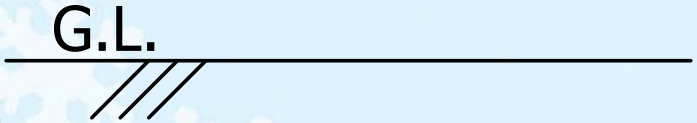
TIME SERIES OF WATER TEMPERATURE AND GROUND TEMPERATURE OF THE 1st WATER TANK



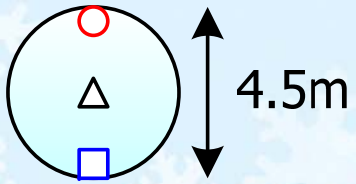


Increase of Op1→ Drop of Tw1 (Winter)

Increase of Op1→ Rise of Tw1 (Summer)

Op1 decrease (Winter)

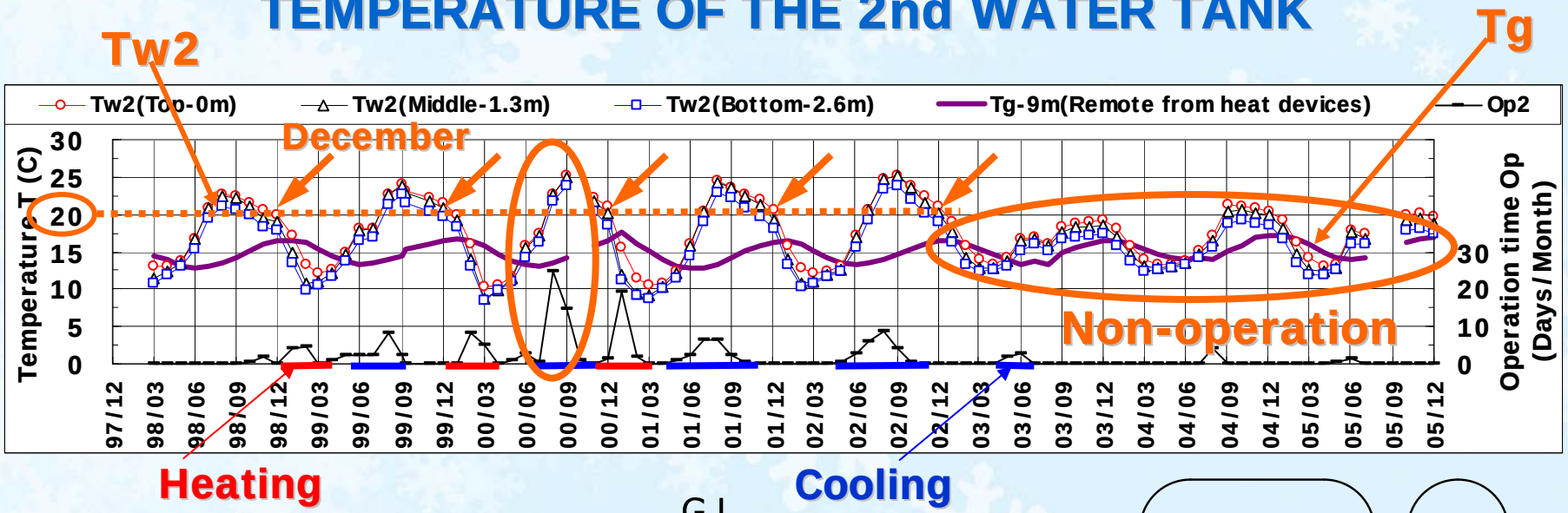
Op1 increse (Summer)



<Cross section of 1st water tank>

→ The Min. value of Tw1 in winter gradually rise

TIME SERIES OF WATER TEMPERATURE AND GROUND TEMPERATURE OF THE 2nd WATER TANK



Increase of Op1

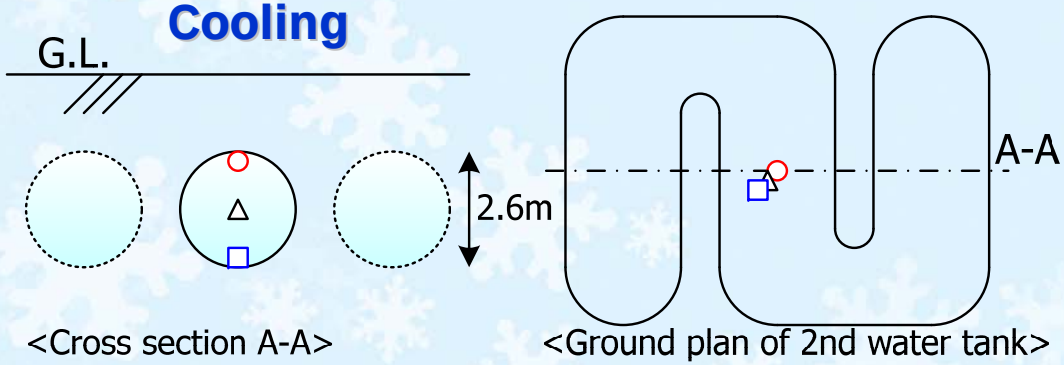
→ **Rise of Tw2 (Summer)**

Tw2 in December

→ **Tw2 kept at over 20C**

Suspended operation

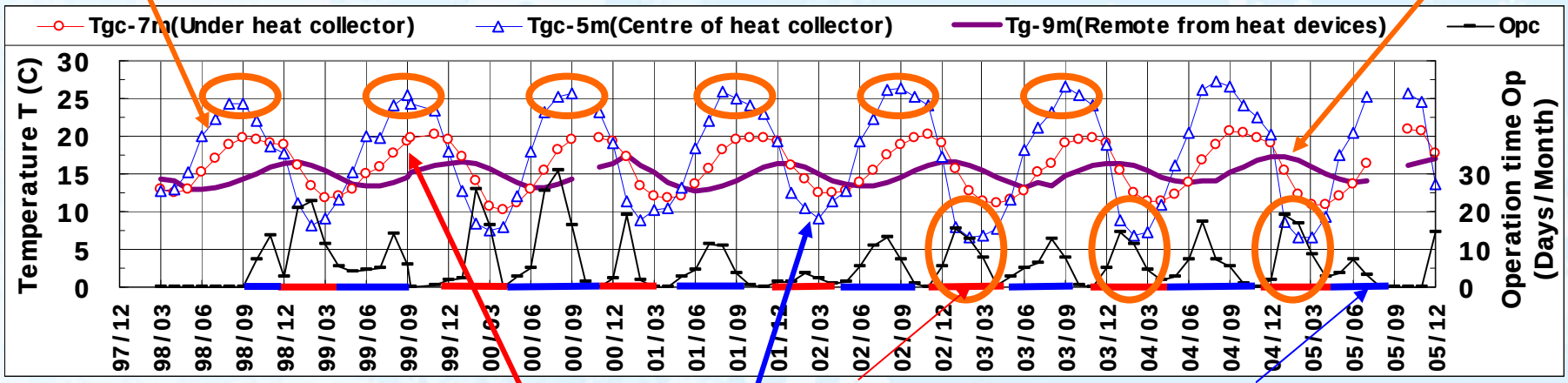
→ **Tw2 resembles the time change of Tg**

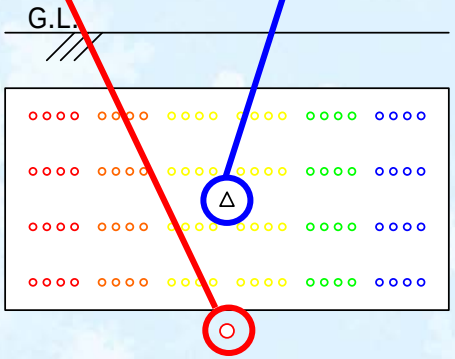


<Cross section A-A>

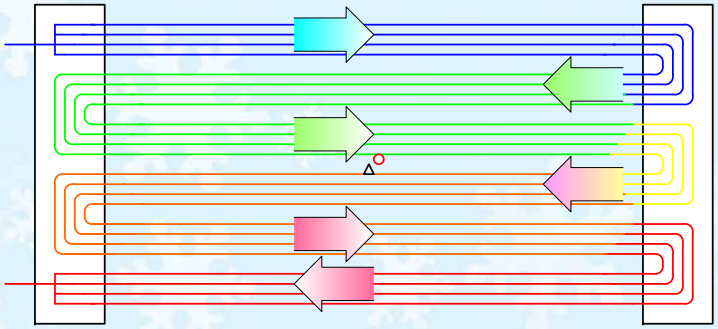
<Ground plan of 2nd water tank>

TIME SERIES OF GROUND TEMPERATURE AROUND THE HEAT COLLECTOR





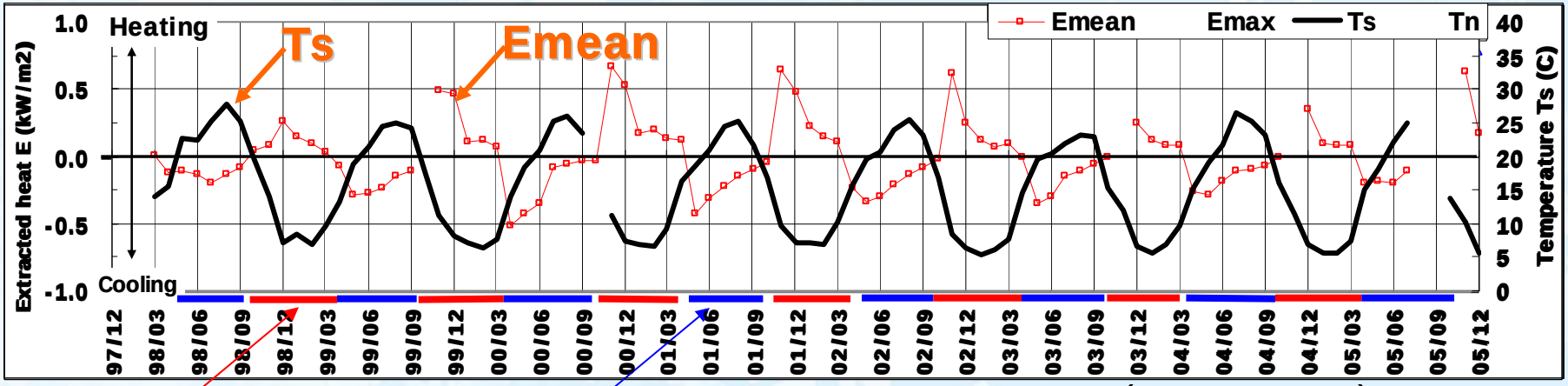
<Cross section of heat collector>



<Ground plan of heat collector>

- Tgc(blue) often reached 27C(summer)
- Opc rapidly increase
  →Tgc(blue) remarkably fell 6C(winter)

TIME SERIES OF THE HEAT FLUXES AND PAVEMENT TEMPERATURES



Heating **Cooling**

$$E = \rho c Q \left(T_{W\,out} - T_{W\,in}\right) / A$$

ρ : *Heat capacity* $[J / (m^3 K)]$

Q : *Flow rate* $[m^3 / s]$

A : *Snow melting area* $[m^2]$

T_W : *Fluid temperature*

- |E| rapidly increases at the beginning of heat usage period
  - → |E| gradually decreases
    - Negative correlation between Emean and Ts
    - Road heating…
      - Ts falls → Emean increases, Ts raises → Emean decreases
    - Road cooling…
      - Ts raises → Emean decreases, Ts falls → Emean increases

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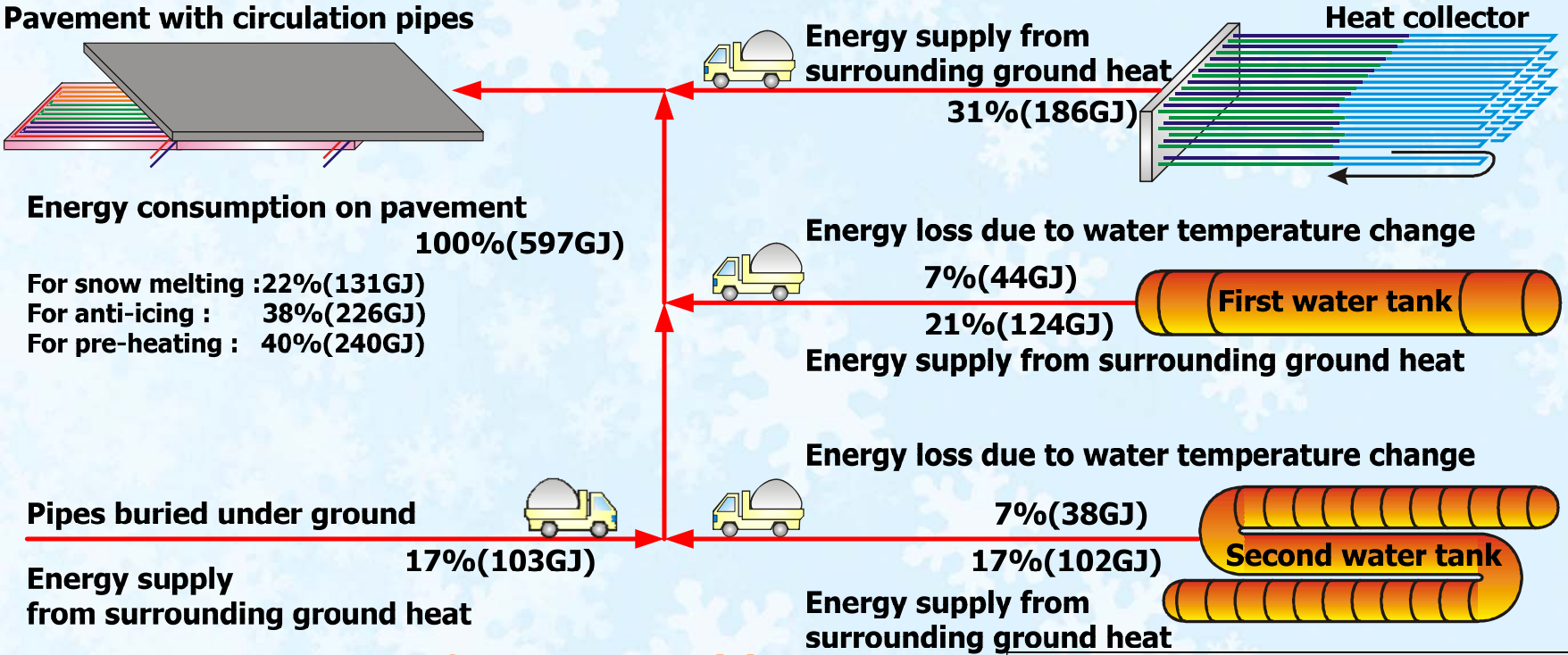
Heat balance of RHCS from Dec. 1998 to Mar. 1999



22 % for snow-melting

28 % from 1st water tank

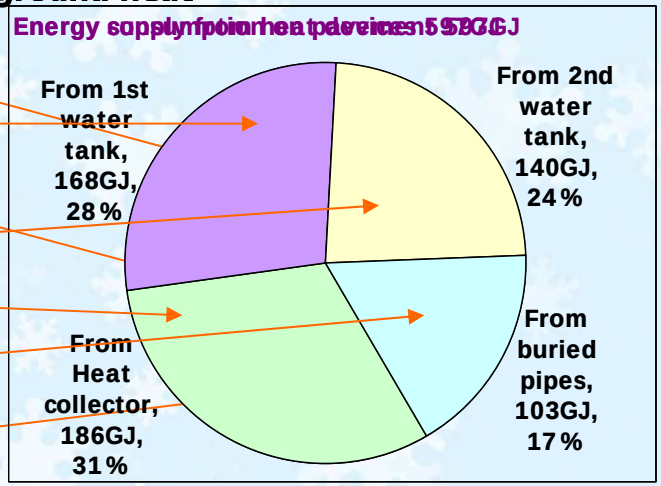
40 % for pre-heating

24 % from 2nd water tank

31 % for heat collector

17 % from heat transfer pipes

38 % for anti-icing



CONCLUSION

1. The snow-melting performance of the RHCS was satisfactory, except during occasional heavy snow fall.
2. The road cooling operations in the summer contribute to the rise in the tank water temperature and the surrounding ground temperature by injecting solar heat into the water tanks.
3. The RHCS has the self control function of saving the extraction of ground heat when both road heating/cooling operations are conducted.
4. The breakdown of the energy consumption in winter (597GJ) was 22% due to snow-melting, 38% to anti-freezing and 40% to the pre-heating of the pavement, respectively.
5. The contribution rate to the total thermal energy extracted from the shallow ground was 31% from the heat collector, 52% from the two water tanks, and 17% from the heat transportation pipes buried in the ground.