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# An Assessment of Unutilized Heat Sources and Distributed Energy Technologies by an Energy Network Model with 151 Subregions of Tokyo Koto Area

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## Overview

It is well understood that the energy conservation of the commercial buildings in the metropolitan area is one of the key issue under the environmental constraints. Especially in Tokyo, since Olympic is being held in 2020, distributed energy technologies including CGS, Photovoltaics, new heat-pumps etc., will play a main role to mitigate the inclusing energy demand and environmental issues. The unutilized heat sources such as the underground and the river are reconsidered because of the improvement of the heat pump (HP) technologies. The potential contribution of heat transportation among buildings should be also taken into account when we pursue the energy efficiency.

In this study, we investigate the contribution of new energy technologies for the commercial buildings by developping a energy flow model which explicitly deals with the potentials of unutilized energy sources and energy transportation among regions in the following manner: first, we divide Koto-area in Tokyo into 151 sub-regions in around 250m by 250m meshes specifying the building types, i.e. commercial buildings, office buildings, residential buildings, sport gymnasium, and hospital and hotels. Second, we estimate the energy demand by purpose and then apply an energy flow model shown in Figure 1. The potentials of unutilized energy sources such as underground heat, river heat sources, waste incineration heat, the possible contributions of these technologies and energy transportation among regions as well as the CGS are then evaluated. Third, the energy flow model modules are then connected with each other when considering the possibility of energy transportation among sub-regions. Our model with the unused energy sources and new technologies demonstrates the potential and the limit of these new sources.

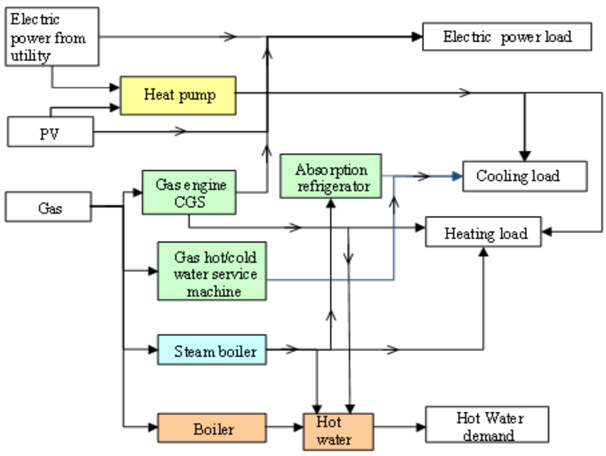


Figure 1 Energy flows for the commercial building

## Method

We extract the detailed building data for Koto-ku specifying the building floor area and commercial type described in the above based on the GIS data. We the estimate the energy demand by end-use, i.e. heating, cooling, hot water and other general electric demand according to Mori et.al (2013). We then aggregate the building data into 151 sub-regions which represent approximately 250m by 250m mesh, where each of sub-regions consists of seven building categories and corresponding four type energy demand. The energy flow model is applied to each building. Since 151 sub-regions are often separated by river, canal or highway, heat transportation possibility is limited. We draw a potential transportation network among sub-regions.

Next, based on the “Potential Underground Heat Utilization Map for Tokyo” provided by Tokyo Environmental

Division (Tokyo, 2016), as shown in Figure 2. According to the "Green Tokyo - Global Warming Mitigation Project" (Institute for Tokyo Municipal Research, 2014), we assume that the buildings within the 500m distance from the river side can utilize the river heat. We then expand the energy flow model in Figure.1 including the above two unutilized heat sources as well as conventional unutilized energy sources such as municipal waste incineration heat, municipal sewage heat and wind power. We also assume that each sub-region can implement district energy distribution center (DHC) if it is beneficial.

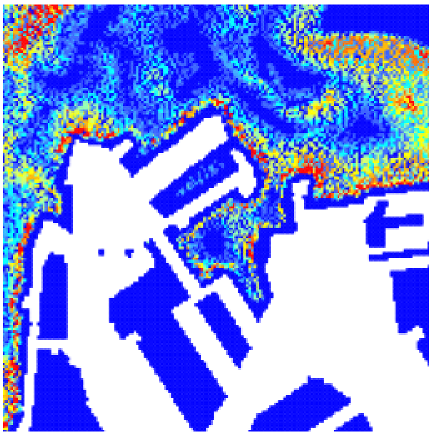

Figure 2 Example of potential underground heat of Tokyo-bay area (red:high blue:low potential)

The simulation cases are shown in Table.1. We also assume two cost-minimization cases: the one is minimizing total cost including all variable fixed costs and another is minimizing consumer costs only assuming that each consumer can purchase heat and chilled water from DHC at the certain price, i.e. 23 yen/MWh, 14.1 yen/MWh, and 33.6 yen/MWh for chilled water, heating heat and hot water, respectively based on the existing market data.

Table1 Simulation cases

| | Heat trans-portation | PV | CGS | DHC | Conventional unutilized sources | All unutilized heat sources |
|---|---|---|---|---|---|---|
| Baseline | no | no | no | no | no | no |
| Case-1 | no | Yes | no | no | no | no |
| Case-2 | no | Yes | Yes | no | no | no |
| Case-3 | no | Yes | Yes | Yes | Yes | no |
| Case-4 | no | Yes | Yes | Yes | Yes | Yes |
| Case-5 | Yes | Yes | Yes | Yes | Yes | Yes |

## Results

Figure 3 exhibits the results of CO2 emissions of total Koto-area showing that Case-2 to Case 4 show almost same CO2 emission while Case-5 provides additional CO2 emission reduction. This suggests that CGS and the new unutilized sources contribute to both economies and CO2 reduction at the same time.

Figure 4 shows the relationship between the heat pump installation capacity for the underground heat utilization and the heat price provided by the DHC. Here the price of heat from DHC is decreased from the baseline. It is shown that the underground heat utilization diminishes when heat price becomes 40% of the current average price.

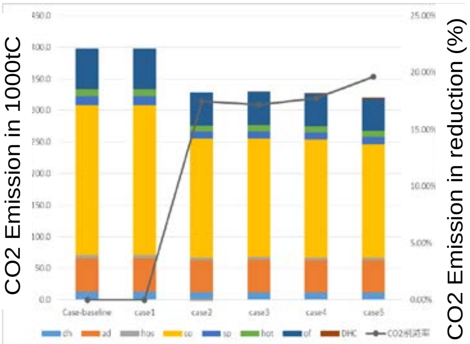


Figure 3 Total CO2 emissions and emission reduction rates

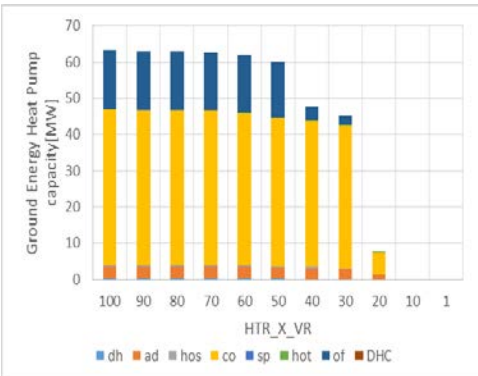


Figure 4 Relationship between implementation of HP capacity for underground heat utilization (MW) the price of DHC heat

## Conclusion

We developed a model for the evaluation of unutilized energy sources for Tokyo area dealing with the detailed building energy demand dividing the Koto-area into 151 subregions. Our current resutls show that thanks to the progress in the HP and the drilling technologies, such unutilized energy sources as underground heat and river heat have potential to improve both the economic and environmental efficiency. It is also suggested that the contribution potential varies siognifcantly among sub-regions. Thus, detailed potential survey is essential to evaluate them.

## REFERENCES

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