The geothermal heat pump experimental system

Associate Professor,
Graduate School of Advanced Science and Engineering
School of Engineering

KINDAICHI Sayaka

Research interests

Architectural environment, architectural equipment, unutilized energy

A heat pump for a healthy, comfortable, and environment-friendly living space

Is your home comfortable? It is said that many people in Japan live in an environment that is particularly cold in winter. This is partly due to the structural problems of Japanese housing but also because Japanese people have traditionally preferred methods of heating that involve warming themselves near a heat source, such as a sunken fireplace and a *kotatsu* (low, covered table), rather than heating the entire house. This leads to a great difference in temperature between different parts of a housing unit, which can cause heat shock, a health hazard, to its dwellers. Creating a healthy and comfortable living environment through an engineering approach and with minimum energy consumption is the basic theme of my research.

The pursuit of greater housing comfort usually requires larger quantities of energy. You have perhaps personally experienced this principle due to the COVID-19 crisis: you open the windows more frequently for ventilation, which lowers (or raises) the indoor temperature, which consequently necessitates greater use of AC units. In one of my ongoing research projects, I am developing a system that increases ventilation without increasing energy consumption. The key is the efficient use of a heat pump, and not relying on people's patience.

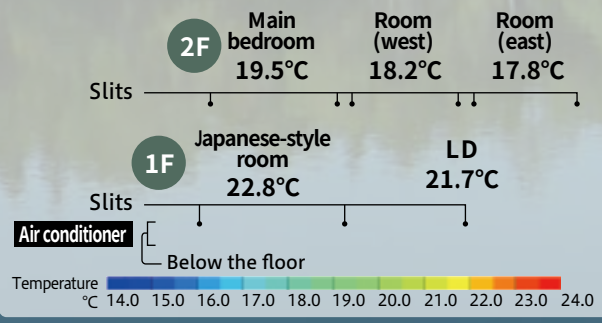
A heat pump operates on the same principle as air conditioners and refrigerators. The efficiency of the device itself has been increasing year after year, but its energy-saving efficiency largely varies, depending on how it is used. An air conditioner comprises outdoor and indoor units used in tandem, the former collecting heat from the atmosphere. Heat pump energy efficiency fluctuates, according to exterior temperatures: it saves more energy when the temperature is lower for cooling, and when the temperature is higher for heating. In general, however, cooling is more needed when the exterior temperature is higher, and heating is needed for lower exterior temperatures. A heat source that is more suitable for a heat pump may be able to solve this problem: unutilized energy in the ground, river and sea waters, etc. My research involves developing a system that uses heat collected from water in ponds dispersed around the Seto Inland Sea area. So far, I have found that pond water heat is suitable for a heat pump since its temperature is considerably low, around 15°C even in summer, at 5 meters below sea level or deeper toward the bottom. I hope to be able to produce a system unique to the region that cannot be realized in a big city.

In 2021, Hiroshima University issued a "Carbon Neutral x Smart Campus 5.0 Declaration," committing itself to actions to achieve carbon neutrality by 2030. With regard to "carbon neutrality," the use of solar panels to generate power and other such technologies seem to attract people's attention, but it is equally important to think of ways to reduce energy consumption in buildings. Introducing heat pumps using unutilized energy will be a major step in this direction. Energy conservation may sound like an outdated term, but its essential importance has not changed over the years.

What I find particularly significant about my research is its utility to society in improving spaces inside buildings that are indispensable for people's lives. I am hoping to communicate from Hiroshima University to society and to the whole world my research findings that can increase comfort in people's lives while caring for the environment.

Analysis of indoor temperature distribution during whole-house ductless heating by an air conditioner (example)

A single air conditioner, installed in the space underneath the floor, can heat the whole house by allowing heated air to spread throughout the house via slits.



"Engineering is an academic discipline for society and people. I want to create a housing environment that ensures people's health and comfort without increasing energy consumption," says Prof. Kindaichi.

Background photo: For its natural convection, water can release waste heat from a heat pump more efficiently than earth. Prof. Kindaichi is working toward the practical application of an unutilized energy-based heat pump that uses water stored in a retention basin as a heat source.

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*HiSIM (Hiroshima-University STARC IGFET Model) is a transistor model used in circuit design that has been developed by Hiroshima University in collaboration with the Semiconductor Technology Academic Research Center (STARC).

National Joint Usage Facilities

Hiroshima Synchrotron Radiation Center

Synchrotron radiation is generated when an electron traveling at the speed of light is forced to change direction by a magnetic field. Synchrotron radiation is called "dream light" because it is not only powerful but also includes light of various wavelengths. The center promotes advanced materials science and emerging interdisciplinary fields using synchrotron radiation.