THE IMPORTANCE OF AIR SOURCE HEAT PUMPS FOR ZERO ENERGY BUILDINGS

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Abstract: Buildings and houses consume about 40% of global energy consumption. In order to achieve the stable level as called by IPCC, it is also reported by WBCSD (World Business Council for Sustainable Development) that carbon dioxide arising from the energy required by the buildings needs to be reduced by 77%. For that reason, the introduction of high-efficiency air-conditioning systems is extremely important. In Japan, astonishing progress is being made in the development of heat pump technology, which uses the heat in the air as a heat source. This writing aims to consider the possible role of air source heat pumps by examining the status of energy consumption by buildings in various countries.

ZEB (Zero Energy Building), Building Sector, Air Source Heat Pump

1. INTRODUCTION

In Japan, with the review of the new standard for office buildings that strengthened the 1999 standards, it is said that a new standard that consolidates overall energy consumption by buildings has been drawn up and will be enforced in two years time. That also includes “visualization” of energy saving performance in buildings, reviews of the labeling system that evaluates energy saving performance, strengthening of regulations and packaged costing and taxation incentives, generalization and popularization of lighting or air-conditioning control interfaces, data assessment for energy saving in small and medium sized buildings, and the development of the vision towards zero energy buildings (ZEB). Realization of ZEB (zero energy buildings) for new public buildings by the year 2020 or ZEB for all new buildings by the year 2030 within Japan has also been mentioned. ZEB and ZEH (zero emission housing) for the buildings and houses sectors have also been set as a high priority issue in the 2011 strategy for energy saving, as announced in March by The Ministry of Economy, Trade, and Industry.

2. TREENDS IN ENERGY CONSUMPTION BY BUILDINGS IN VARIOUS COUNTRIES

2.1 Situation in UK

With regulations, UK is the most advanced country. As the first step in a drastic strategy towards low carbon for the buildings announced by the British government, public consultation was initiated in December 2006 to target zero carbon for all new housing buildings by 2016. In March 2008, the British treasurer announced the ambitious target of zero carbon for all buildings by 2019. Setting a clear goal towards the realization of ZEH (zero emission housing) and ZEB (zero emission building), they will stick by their basic approach, recognized by UK’s strategy against warming in general where technology development progresses naturally with the market by first establishing a concrete schedule for overall toughened regulations. Stricter energy saving standards in stages towards ZEH are being considered.

In Britain, mandatory energy savings in buildings is stipulated in the Building Regulations. As

revised in 2006, the energy saving standard is unified by the use of the carbon dioxide emission rate (the amount of CO_2 emissions per unit of floor area). While there is a need for dramatic reduction from 2013 to 2016, the attention is on how this reduction is carried out. In enforcing ZEH, the problem is not only just cutting the amount of CO_2 emissions as restricted by energy saving regulations (in heating and cooling, ventilation, hot water, and lighting), but also the CO_2 emissions by home appliances, which are not governed by energy saving standards, thus indicated as a 50% reduction. Renewable energy has also become indispensable at this stage.
Well then, without improvements in insulation efficiency and energy savings through hot water and space heating, should we simply purchase solar batteries or off-site credit? In the event that the cost of energy saving becomes too expensive, it is quite possible that the purchase of credit becomes more economical.
To deal with such, we shall talk about a hierarchical concept that does not misplace priorities. First, energy saving performance for building services, such as thermal insulation for buildings, passive design, heating, and hot water, is the most important. In addition, the on-site use of solar or solar heat renewable energy, as well as low carbon district heating, such as biomass, is utilized. For the final stage, developing renewable energy or obtaining credit from renovating existing buildings nearby, and off-site low carbon energy development are recommended. In relation to ZEH, half or more of the necessary CO_2 emission reductions can be achieved through off-site measures, provided the measures apply to approximately 80% of all residents.

2.2 The Trend of EU

With the aim of improving building energy performance, a directive on building energy performance implemented in January 2003 by the EU (EPBD: Energy Performance of Buildings Directive) is progressing at a dramatic pace. This directive includes housing, and EU member countries are required to establish minimum requirements for energy performance standards, or assessment and certification systems for energy performance certificates (label). Those Japanese who are concerned have also been advised by real estate companies recently when they rent apartments in Europe. As there are standards applicable to imported items for air-conditioning equipment from Japan, it is necessary to be mindful of the trends from now on. From 2008, revisions to the EPBD are being examined, and reviews on zero energy for buildings are being carried out.

2.3 Revision By The European Committee

(November 2008) EU member countries were required to legislate national policies to develop and popularize zero carbon or zero energy buildings. In the revision by the European Parliament (April 2009), EU member countries were required to make all new buildings from 31 December 2018 onward to be ZEB. With additional amendments, the revision was established with the approval by the European Parliament in May 2010. The legislated contents were somewhat ambiguous. All new buildings from 31 December 2020 are to be “nearly zero energy.” The term “nearly” is used. Parallel to meeting high energy saving standards, it is also indicated that renewable energy is to be actively utilized. For public buildings, this is pushed two years forward, with all new work to achieve “nearly zero energy” from 2018 yearend onward. The provision of energy saving performance labels are made mandatory not just at the time of selling and buying of buildings, but also applicable in advertisements for selling, buying, and renting.

2.4 Situation in The USA

The number one topic within ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) recently is net zero energy buildings. The making of a new industry within the air-conditioning services sector is also highly anticipated. Based on the Energy

Independence and Security Act of 2007, the Department of Energy (DOE) announced the Net-Zero Energy Commercial Buildings Initiative in August 2008. In America the stance is not to impose ZEB as a regulation but to develop and standardize technologies and policies for achieving ZEB. Technological development and research is conducted to achieve cost-effective ZEB technologies, to achieve ZEB for all new buildings by 2030, 50% of all existing buildings by 2040, and all buildings by 2050 within America. The target for ZEH is set at 2020. In order to achieve that target, it is considered that research development by the government and regulating controls need to progress hand-in-hand in balance.
As important technologies towards ZEB, the DOE focuses on the research and development of lighting (LED), windows, insulation, air-conditioning equipment and systems, and hot water integrating the design with integrated control. In parallel, with the development of smart grids from now on, the focus is on air-conditioning technologies. NREL evaluated the ZEB feasibility of various building types in the case of utilizing the latest building technologies as of 2025. Based on floor area, the ZEB feasibility is 47% overall. Feasibility varies according to functions with 60% for schools, 22% for office buildings, and 89% for warehouses. Compared to the current standards, the aforementioned feasibilities are calculated on the assumption when the following are introduced: roughly 30% improved structure insulation performance, 50% reduced lighting electricity consumption, use of natural daylight, 25% reduction in electricity consumption through power points by using high efficiency equipment, 30% improved COP for heat pump, 20% improved boiler efficiency, reduced power for air conditioning (varies from the type by 17%–20%), 30% improved refrigeration equipment efficiency, and 50% improved solar power system with twice the cell efficiency of roof area.

3. IMPROVING AIR SOURCE HEAT PUMP EFFICIENCY

With building energy consumption and debates around ZEB both on the raise globally, air source heat pumps can be considered as an important elemental technology. From here, I would like to give an overview of heat pump technology that is evolving greatly in Japan, one of the elemental technologies for the realization of ZEB.
First of all, I would like to look at the efficiency and popularizing status of air source heat pumps that have been widely popular in Japan. First, let's consider the home appliances that are closest to us. For home air conditioning, air source heat pumps are taking over as the mainstream. In parallel, in terms of hot water supply, family heat-pump hot water units (EcoCute) are also becoming dramatically popular.
Following the adoption of the top runner program in the second half of the 1990s, the family heat pump air-conditioning technology developed at great speed, and products exceeding a COP score of 6 are being sold now, and their efficiency has actually improved by 70% compared to that of 1997. For EcoCute, products with an intermediate score of over 5 are being made, and efficiency can be considered to have improved by 40% compared to that from 2001, right after it released.
In recent years, with rising awareness over economy and the environment even at home, by end of 2010, EcoCute for home use was used by more than 2.6 million families in Japan.
Meanwhile, not only family heat pumps but also with the commercial heat pumps various measures have been exercised to improve efficiency. Especially for office buildings, although the coefficient of performance under full load is important, it is necessary to improve the coefficient of performance under partial loading in order to achieve annual energy savings.
In order to improve the characteristics under a partial load, a module chiller developed by a certain manufacturer allows better efficiency under partial loading than full loading by controlling the number of operating heat pump units installed in each modular system according to the overall size of the load.
In Japan, heat storage systems that contribute to electrical load-leveling are becoming increasingly popular; however, ice thermal storage chillers have also achieved major improvements in COP. In the past, the COP for chillers was quite low when ice was made. However there are examples where performance under partial loading would improve

substantially by controlling the number of operating heat pump units and controlling the inverters. According to the products by a certain manufacturer, there are examples where the improvement in COP increased by approximately 20% under roughly 50% partial loading.
Also, while heating in very cold regions used to rely on the direct burning of fossil fuels, it is now possible to achieve efficient comfortable heating with heat pumps even under low outside temperatures. The latest models allow heating by heat pumps even when the outside temperature is –25 degrees. Meanwhile, even at low outside temperatures, efficiency has improved substantially compared to those units in the past. In cold regions, comfort would be compromised if the heating stopped temporarily for defrosting in order to remove the frost from the outdoor unit under low outside temperatures. Recently, some models available for sale where the time for defrosting is greatly reduced and thus comfort is improved. Like this, heat pumps for commercial use for hot water purposes are improved, and many restaurants, geriatric health services facilities and business hotels quickly are adopting them.

4. CONCLUSION

With the use of heat pumps, it is possible to bring heat from a low temperature area to a high temperature area. It is a technology that extracts the heat in the air at room temperature, “relocates” and uses it as a form of useable heat energy. The heat in the air used by air source heat pump originates from “solar energy,” which is then collected by the heat pump as a form of renewable energy. Thus for heating and hot water through heat pumps, renewable energy is utilized. Fortunately, since air is available anywhere on this planet, put simply with heat pump technology, heat can be used without burning fossil fuels. Since without burning fossil fuel, many times the amount of input energy is available for use in heat energy, it is put under the spotlight as a trump card for global warming countermeasures. While it was used only for refrigeration in the past, heat pumps can now be used in an increasingly large area for heating and cooling, hot water, or even for steam generation. Through the use of high efficiency heat pumps domestically, commercially, and industrially, we shall look forward to achieving energy savings and a low carbon world where ZEB is put into practice.