**Introduction**

Except for lighting and electric appliances, most of the residential energy can be classified into the so-called low temperature level energy ranging from 5 to 60°C. For example, space heating, cooling, and domestic hot water supply are categorized into this range.

For this reason, it is possible to provide these energies with natural energy including solar thermal, photovoltaic, sky radiation cooling, wind, rainwater,1 and underground coolness.

About 20 years ago, one of the authors proposed an energy-efficient house incorporating solar thermal and sky radiation and the fundamental experiments have been conducted by using facilities at the Tohoku university.

The HARBEMAN house has two major features; one is a large heat/cool storage tank (30–60 m3) which makes it possible to store energy seasonally. From a standpoint of storing solar energy, the storage capacity can be minimized if one allows a relative large temperature fluctuation and an increase of auxiliary heating need. However, in case of this long-term storage over 3 months, the storage capacity should be large enough.

Another feature is to utilize seasonal sky radiation cooling. As is well known, sky radiation cooling appears most significantly under a clear weather condition in low relative humidity and low wind speeds.

The present energy-efficient house will give a promising concept for reducing CO2 emissions, and will contribute to mitigate global warming.

The development of on-site renewable energy production and demand management in buildings calls for a deeper understanding of the interaction between building operation and the electricity grid. Electricity consumption in buildings varies in terms of seasons (heating and cooling), day of the week (professional activities) and hour of the day, which is also the case of on-site electricity production (e.g. photovoltaic systems). Centralised electricity production varies as well according to the demand (e.g. during peak hours).

In 2010, the residential and service sector accounted for around half of the world global electricity consumption, according to the IEA (2011). In countries with a high penetration of electrical heating, such as France, this share can go up to 68% (INSEE, 2012). Electricity-related impacts are important in the environmental assessment of buildings. The electricity consumption in buildings is highly variable, with seasonal variation due to space heating or cooling, weekly variation due to economic activities and daily variation due to home appliances and lighting. As a direct consequence, the electricity production mix is also variable because power generation technologies modulate in order to comply with the demand.

The algorithms for energy efficient control of an electric technological complex with a frequency-controlled electric drive for autonomous heat and hot water supply based on hydrodynamic heaters have been developed. The complex is designed to carry out experimental studies of the problem of reducing energy consumption by hydrodynamic heaters. The functional and process flow sheet of the complex is given. The results of experimental studies confirming the effectiveness of the developed algorithms are presented. Power consumption reducing by 8% was achieved owing to the cyclic operation, and up to 45% due to capacity control of the pump unit.

Energy conservation is a priority for most of the nation states. Its relevance in modern world energy industry is growing every year. This problem acquires particular importance when a country is characterized by a lack of fuel and energy resources or adverse climatic conditions. The most effective way to reduce heat losses from heat network pipelines to environment is the use of heat insulation.

The main task of energy-efficient heat supply is to ensure full compliance between the produced and consumed thermal power, subject to a minimum of reduced costs. To achieve this goal, various methods of central and local regulation are applied. Analysis of the thermal schemes of some cities in Russia showed that most of the heat sources of centralized heat supply systems are not able to support the design hightemperature graphs with central regulation. Therefore, the area of centralized qualitative method of regulation of heat load has decreased substantially. A perspective direction for the further development of heat supply systems is to appeal to the experience of foreign countries, i.e. the use of qualitative-quantitative and quantitative methods of central regulation and low-temperature heat supply. There is also an acute problem of the complete use of heat by consumers, since overstating of the temperature of the return water substantially reduces the efficiency of heat sources. A new formula has been obtained which makes it possible to predict the temperature of the return network water in variable operating modes of heating points. The resulting formula can be used to set up programmable regulators and will allow correcting irrational modes of operation of heat supply systems.