Home Electronics and Appliances for Environmentally Conscious Lifestyles

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OVERVIEW: Home electronics products are widely used around the world, providing users with convenience, comfort, and entertainment in their daily lives. Meanwhile, reducing power consumption in the home is becoming increasingly important as a part of various activities being undertaken in different countries to encourage an environmentally conscious society that includes measures for preventing global warming, the elimination of environmentally harmful chemicals, and recycling. Hitachi is seeking to reduce the environmental burden imposed by home appliances over their life cycle based on "DfE Assessment" which stipulates specific environmental criteria. Hitachi is also helping to improve energy efficiency further by working on new technologies for energy management and other systems that control equipment in the home to ensure that energy is used effectively.

INTRODUCTION

A range of activities are being undertaken in different countries to help establish an environmentally conscious society. For the home electronics products that provide users with convenience, comfort, and entertainment in their daily lives, there is a need for measures such as reducing power consumption, use of materials with a low impact on the environment, and recycling of resources. Accordingly, the manufacturers of these devices are developing products that comply with the environmental regulations (see Table 1) of each market while also pursuing enhancements and continuous improvement of their environmental performance. In Japan, meanwhile, the need for technologies that can achieve a better balance of electricity supply and demand has become greater by the sudden change in this balance following the Great East Japan Earthquake in March 2011.

Through its home appliances, Hitachi is contributing to improving the QoL (quality of life) of the people who use these products by commercially producing home electronics products including the refrigerators, air conditioners, and other home appliances made by Hitachi Appliances, Inc. and the digital televisions made by Hitachi Consumer Electronics Co., Ltd.

This article describes trends in the environmental regulation of home appliances together with the

TABLE 1. Main Environmental Regulations for Home Electronics in Various Countries
Environmental regulation is expanding around the world in response to global issues including energy efficiency, environmentally harmful chemicals, and the elimination of fluorocarbons.

Type of regulation	Japan	USA	Europe	China
Energy efficiency	• Act on the Rational Use of Energy (revised in 1999: Top Runner Program)	• Energy Independence and Security Act of 2007 (EISA 2007) • Energy Star	• Ecodesign Directive (ErP Directive) • Energy Labelling	• Measures for the Administration of Energy Efficiency Labels
Environmentally harmful chemicals	• J-Moss (Act on the Promotion of Effective Utilization of Resources)	• Toxic Substances Control Act (TSCA) H.R. 2420 amendment	• RoHS Directive • REACH Regulation	• Measures for the Control of Pollution from Electronic Information Products • Measures for Environmental Management of New Chemical Substances
Fluorocarbon elimination	• Act on the Protection of the Ozone Layer Through the Control of Specified Substances and Other Measures	• Clean Air Act (CAA)	• F-Gas Regulation	• Regulation on the Administration of Ozone Depleting Substances

J-Moss: abbreviated name of JIS C 0950 "The marking for presence of the specific chemical substances for electrical and electronic equipment"
H.R.2420: US version of RoHS law ErP: Energy-related Products RoHS: Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment
REACH: Registration, Evaluation, Authorization and Restriction of Chemicals

outlook for the distinctive technologies being used by Hitachi in its products to comply with these regulations and improve environmental performance. It also reviews the outlook for energy management systems, a technology for improving energy efficiency in the home that is expected to enter widespread use in future.

HOW DIFFERENT COUNTRIES ARE SEEKING TO BUILD ENVIRONMENTALLY CONSCIOUS SOCIETIES

The scale of worldwide demand for home appliances and home electronics is demonstrated by annual sales of 80 million refrigerators, 70 million washing machines, 60 million room air conditioners, and 200 million televisions. Looking at the environmental impact of these products over their life cycle, there is a need to reduce their energy consumption when in use as the associated CO_2 (carbon dioxide) emissions are a major factor in the effects of global warming[1]. Also in need of consideration are the effects that the chemicals used in these products have on the ecosystem and other parts of the natural environment and the issues associated with the recycling of these products at the end of their useful lives.

The following sections describe developments regarding the regulations that deal with these problems.

Prevention of Global Warming (Energy Efficiency)

The 1997 Kyoto Protocol based on the United Nations Framework Convention on Climate Change set targets for reducing the emission of greenhouse gases by developed nations. The actions undertaken by major nations with respect to the energy efficiency of electrical products have involved a two-fold approach to regulation, combining standards for energy use efficiency with ranking systems, and this has been driving improvements in the energy efficiency of the products themselves.

In many countries, standards for energy use efficiency have taken the form of MEPSs (minimum energy performance standards) like those in the USA and China which set minimum levels of performance that all products in a particular category must satisfy[2, 3].

Elsewhere, other countries have adopted “average standards” which require compliance with a weighted average (based on the number of products shipped) of product energy use efficiency. In Japan, the Top Runner method is used to determine the levels at which to set these standards. That is, standards are set based on the best-practice level of energy use efficiency at the time when the standard is formulated, an approach that is seen as accelerating improvements in product energy efficiency across the entire industry.

Countries like USA and China have also set standards for minimizing water use by washing machines within the framework of their energy efficiency standards[4, 5].

Regarding labeling regimes for power consumption, in conjunction with efficiency standards for use of electrical energy in different markets, different countries have adopted a range of different labeling practices intended to provide a clear visual indication of a product’s energy efficiency performance.

In the European Union, the Ecodesign Requirements for Energy-using Products (EuP) Directive that came into effect in 2005 was revised and replaced by the Ecodesign Requirements for Energy-related Products (ErP) Directive which not only requires manufacturers to reduce the power consumed by electrical products when in use or on standby but also to adopt ecodesign practices that consider the entire life cycle of the product.

Environmentally Harmful Chemicals (Reducing Burden on Environment)

Regulation of the use of lead in electrical products was first considered in the 1990s in response to a growing awareness of the environmental pollution caused by lead and other heavy metals. The European Union issued the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive in 2006 which limited the use in electrical and electronic equipment of six classes of substance: lead, mercury, cadmium, hexavalent chromium, and specific brominated flame retardants (polybrominated biphenyl and polybrominated diphenyl ether). Similar regulations are now being adopted by other nations around the world. In 2007, the European Union also supplemented this directive with the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Regulation, the scope of which includes the registration of the chemical substances contained in products.

Regarding substances that deplete the ozone layer, CFCs (chlorofluorocarbons) have been prohibited based on the 1987 Montreal Protocol and progress now is being made internationally on reducing use of HCFCs (hydrochlorofluorocarbons). While HFCs (hydrofluorocarbons) are currently used as a substitute for CFCs and HCFCs, the F-Gas Regulation is being introduced by the European Union and the outlook is that use of HFC too will need to be reduced.

Recycling of Resources

Product recycling schemes have been established in recognition of the pressure on sites used for final disposal after processing of waste material in Japan and the prevention of environmental pollution by toxic chemical substances in places like China and Europe. Additionally, Japan has passed the Act on the Promotion of Effective Utilization of Resources which requires use of design techniques that allow for recycling.

HITACHI'S CONTRIBUTION TO FIELD OF HOME ELECTRONICS

Home Appliances

Home appliances are an integral part of our lives and have evolved in response to lifestyle and other social changes as well as the universal need for greater convenience and comfort. On the other hand, household energy consumption continues a relentless rise driven by changes in the structure of society including these lifestyle changes in pursuit of convenience and comfort, the increase in the total number of households, and the rising proportion of elderly. In the fiscal year 2009, it accounted for approximately 14% of total national energy consumption in Japan (excluding transport-related use such as the family car)(6).

Given this situation, the growing environmental awareness at a global level discussed earlier has resulted in the energy efficiency performance of home appliances and the reduction of the burden on the environment becoming key indicators.

(1) Energy efficiency

In Japan, a breakdown of household energy consumption shows that air conditioning and water heating make up approximately 56% of the total with the remainder including kitchen appliances, motors, and lighting(7). Among energy sources, 2008 figures have electricity accounting for about 50% of the combined total for kerosene, electricity, and gas. The reasons for the increase in electricity use include the widespread adoption and increasing capacity of electrical home appliances such as heat-pump air conditioners. With the number of all-electric homes having also increased in recent years, the use of heat-pump water heaters is another factor behind higher electricity consumption.

The following section looks at what is being done to achieve energy efficiency in electrical home appliances from a number of perspectives.

Firstly, Hitachi has worked to improve the efficiency of the motors and motor drive systems at the heart of home appliances through measures that include innovations in inverter control and by achieving lower losses through the use of high-performance high-functional materials, electromagnetic field analysis, and other methods. This has supported improvements in the efficiency of products such as air conditioners, refrigerators, washing machines, and vacuum cleaners(8), (9). Hitachi has also used original cycle and sensing technologies to make progress on improving the energy efficiency of the heat pump technology used to operate refrigerators as well as the air conditioners and water heaters responsible for the majority of household power consumption(10), (11).

To improve efficiency by eliminating waste, Hitachi has also developed technologies for thermal insulation and waste heat utilization. For refrigerators, it is reducing annual electricity consumption by using vacuum insulation to reduce leakage of heat into refrigerator compartments and by developing a "frost recycling" technology that utilizes the cold energy of the frost that forms on the evaporator (see Fig. 1 and Fig. 2).

The same vacuum insulation is also used on the storage tanks for heat pump water heaters to improve

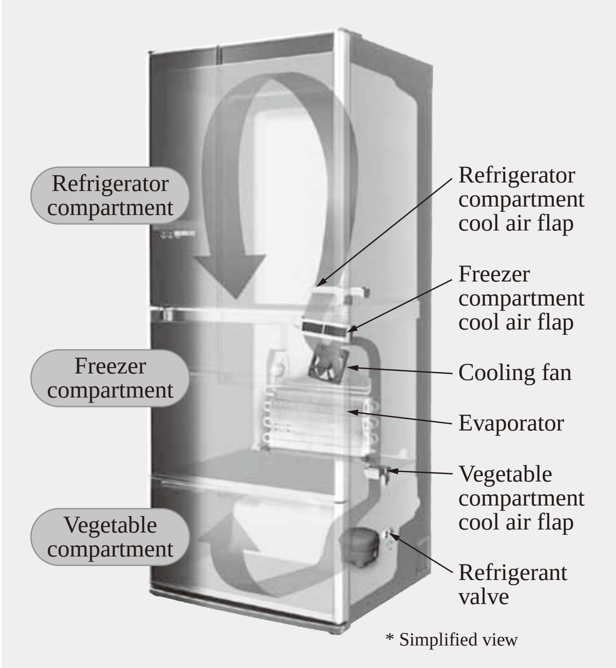

Fig. 1—Overview of Frost Recycling Technology.
Frost forming on the evaporator when it is operating reduces its cooling efficiency and in the past it was removed by melting with a heater. Hitachi Appliances, Inc. has adopted a design that directs air cooled by this frost to the refrigerator and vegetable compartments so that it can be utilized to continue providing a cooling effect even when the compressor is stopped.

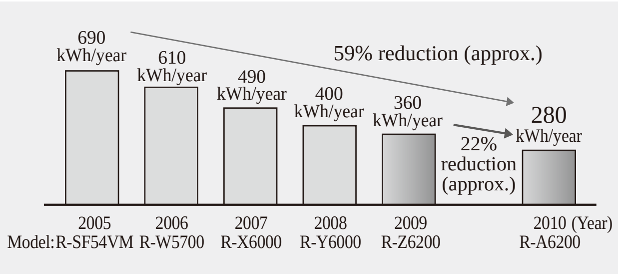

Fig. 2—Trend in Annual Refrigerator Electricity Consumption due to Energy Efficiency Improvement (Hitachi Models).
The annual electricity consumption is measured in accordance with the JIS C 9801 standard. The actual electricity consumption in use will vary depending on where and how the refrigerator is installed; the temperature setting in each compartment; ambient temperature, humidity, and other environmental factors; frequency of door opening; quantity, temperature, and other characteristics of new food placed in compartments; and how the refrigerator is used.

water heating efficiency by minimizing the leakage of heat from the hot water in the tank.

Hitachi has also improved the energy efficiency performance of a drum-type washer/dryer through the use of heat recycling technology which utilizes the waste heat in the machine(12).

Ways of minimizing water use by washing machines include the “beat wash” technique which recycles the washing water to achieve a high level of washing performance with a small quantity of water and the use of bath water for water-cooled dehumidification during drying.

As described above, most of the progress to date has been made by improving the energy efficiency or operational efficiency of individual home appliances. In the future, however, it is anticipated that integrated management and control across the entire house will become important in response to changes in the conditions inside houses such as higher levels of air tightness and insulation and changes in electricity supply and demand resulting from the use of photovoltaic power generation and other types of renewable energy.

(2) Reducing use of environmentally harmful chemicals

Hitachi Appliances started using lead-free solder in its refrigerators, washing machines, and room air conditioners from the 1999 models onwards and has since extended the practice to other home appliances. Subsequently, Hitachi Appliances has responded to the RoHS Directive issued by the European Union in July 2006 by making its products for both the Japanese and overseas markets RoHS-compliant.

Hitachi Appliances had been using HFC as a CFC-substitute in applications to the refrigerator such as the refrigerant used in refrigerating cycle and also as a foaming agent for insulation, and its products have been fluorocarbon-free since 2002 (excluding some compact models) with isobutane being used instead as a refrigerant and cyclopentane as a foaming agent. As both isobutane and cyclopentane are flammable and combustible hydrocarbons, ensuring their safety during transport, use, and maintenance is an important issue. Accordingly Hitachi Appliances has introduced a number of safety measures including reducing the amount of refrigerant used and the number of connectors in the cooling system piping, lowering the temperature of the frost-removal heater, use of a brushless fan motor, and use of explosion-proof electrical components(13).

Hitachi Appliances’s heat pump water heater uses a natural refrigerant (CO_2) in place of HFC.

(3) Resource recycling

In Japan, the Act on the Promotion of Effective Utilization of Resources designated refrigerators, air conditioners, washing machines, and other similar devices as “Specified Resources-Saved Products” and “Specified Reuse-Promoted Products.” In addition to encouraging the rationalization of raw material use, sharing of common parts, and improved durability to provide a longer operating life, the law obliged manufacturers to adopt designs that take account of things like resource recycling, ease of disassembly, and safety assurance. To comply with these rules, Hitachi has been using DfE (Design for Environment) Assessment in its product design process since 1999(14).

Digital Television

This section explains about digital televisions as an example how Hitachi is doing in response to environmental regulations.

(1) Energy efficiency

Japan’s Act on the Rational Use of Energy stipulates rules for the energy efficiency of televisions in terms of their annual electricity consumption. It also includes the Energy Saving Labeling Program which obliges manufacturers to list their achievement for the target fiscal year and the percentage to the target achieved by each product in their catalogs and other documents. The 2010 revisions to the Act on the Rational Use of Energy criteria (standards of judgment for manufacturers/importers with regard to the improvement of the performance for the TV sets) stipulated new stricter

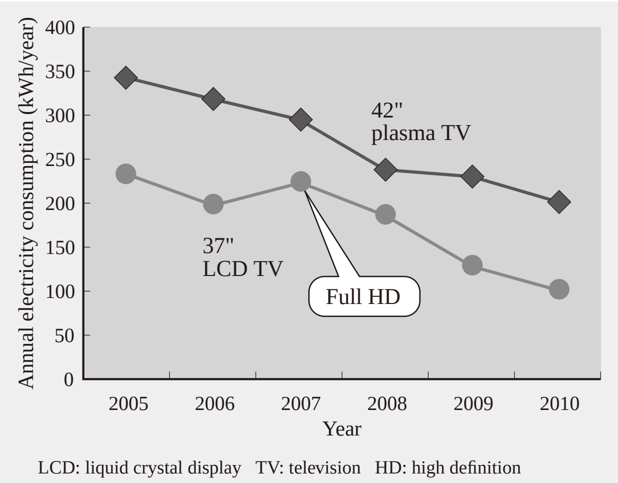

Fig. 3—Trend in Annual Electricity Consumption of Flat-panel Televisions due to Energy Efficiency Improvement.
The figures 2009 and 2010 are obtained using the new measurement procedure stipulated in the April 2010 revisions to the Act on the Rational Use of Energy criteria (standards of judgment for manufacturers/importers with regard to the improvement of the performance for the TV sets).

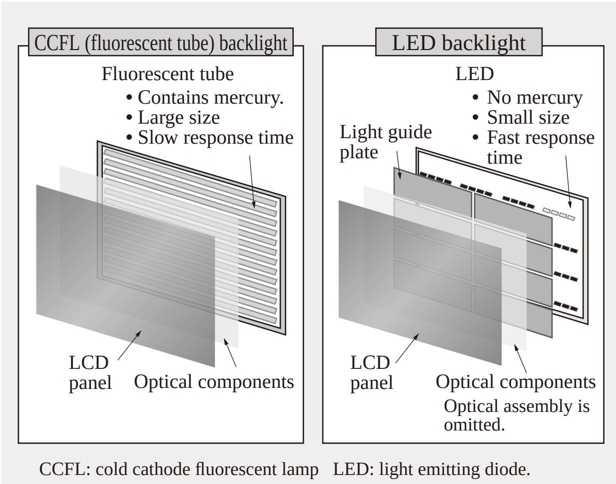

Fig. 4—Outline of CCFL and LED Backlight Structure.
Whereas a CCFL backlight operates continuously regardless of the input picture signal, an S-LED backlight consumes less power because its intensity is controlled area by area based on the input picture signal.

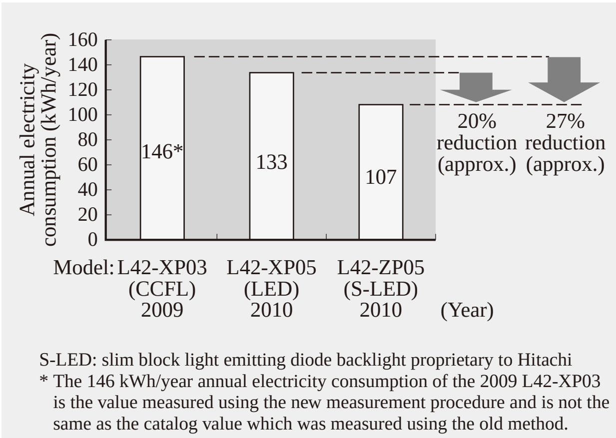

Fig. 5—Difference in Annual Electricity Consumption of 42” LCD Televisions with Different Types of Backlight (Measured Using Measurement Procedure Stipulated in April 2010 Revision of Act on the Rational Use of Energy Criteria).
The annual electricity consumption for a television is calculated in accordance with the Act on the Rational Use of Energy criteria based on an average household viewing time of 4.5 h/d and average standby time of 19.5 h/d.

standards to be achieved by the fiscal year 2012 along with changes in the measurement procedures for electricity consumption. Specifically, whereas the old procedure measured the electricity consumption during the display of four still pictures which was then converted using a mathematical formula to an equivalent value for motion pictures, the revised procedure stipulates a new measurement method using motion pictures which simulates the conditions when actual broadcast is received. Because using the new measurement method tends to give a higher value of annual electricity consumption for many televisions, it requires even higher energy efficiency performance.

Hitachi Consumer Electronics has been working hard to achieve both higher resolution of an image (higher definition) and greater saving of energy in its televisions (see Fig. 3).

To comply with the standards for the fiscal year 2012, Hitachi Consumer Electronics has changed the backlight system used in its televisions from CCFL (cold cathode fluorescent lamp) to LED (light emitting diode) backlight. It has also developed its own S-LED (slim block LED) backlight to achieve better energy efficiency and image quality. S-LED uses Hitachi own light guide plate technology together with a technology for performing area-by-area control of the light intensity and has succeeded in reducing the power consumption of the backlight unit by up to 45% (see Fig. 4)[15].

As an indication of how much difference the change of backlight system makes to an LCD (liquid crystal display) television, the annual electricity consumption of a 42” S-LED television of 2010 is approximately 27% lower than the equivalent CCFL model of 2009, and approximately 20% lower than a conventional LED model of 2010 (see Fig. 5).

A second generation of this technology with even better energy efficiency is currently under development to move Hitachi closer to its target of “helping reduce annual CO_2 emissions by 100 million tonnes by fiscal 2025 through Hitachi products and services."

(2) Reducing use of environmentally harmful chemicals

Information about the presence of environmentally harmful chemicals in digital televisions is obtained from the supplier of each purchased component and managed centrally on an in-house system. To deal with substances whose use is prohibited by regulations such as the European RoHS Directive, Hitachi Consumer Electronics ensures compliance through measures such as checking the submitted data and performing destructive measurements of component testing samples.

In order to deal with the communication of information stipulated by the REACH regulation and others, content substance data is totaled using the resources such as industry standarized search tools and intelligence infrastructure from the Joint Article Management Promotion-consortium (JAMP).

Whereas inert gas and mercury vapor are sealed inside the cold-cathode tubes used to produce light in CCFL backlights, the S-LED backlights described above do not use mercury in a light source by adopting the LED light sources.

Hitachi Consumer Electronics has adopted phosphorus frame retardants which do not use any chlorinated or brominated compounds in its housings, and the emission rate of VOCs (volatile organic compounds) from the product is within the guidelines set by the Japan Electronics and Information Technology Industries Association (JEITA)[16].

(3) Resource recycling

To take an environmentally conscious approach to product design which includes things like the 3Rs (reduce, reuse, and recycle) recommended by regulations such as Japan's Act on the Promotion of Effective Utilization of Resources and Europe's ErP Directive (Ecodesign Directive), Hitachi has incorporated DfE Assessment into its design and development processes since 1999. This has succeeded in making products slimmer and lighter by adopting measures from the design stage such as increasing the component density or reducing the number of screws.

To fulfill its recycling obligations as a manufacturer, Hitachi Consumer Electronics undertakes recycling of CRT (cathode ray tube), plasma, and LCD televisions through the joint recycling scheme set up by Japan's Act on Recycling of Specified Kinds of Home Appliances.

HOME ENERGY MANAGEMENT

As countries around the world take a variety of steps to bring about an environmentally conscious society, Japan is proceeding with work on demand-side control, electricity grid stabilization mechanisms, and installing renewable energy systems to achieve its goal of reducing CO_2 emissions by 25% (relative to 1990) by 2020. Meanwhile, the sudden change in the balance of electricity supply and demand following the Great East Japan Earthquake in March 2011 has increased the need for technologies that can appropriately regulate consumer electricity use in response to limited supply.

In addition to the improvements in the energy efficiency of individual products that manufacturers have been making over time, what will also be important for homes will be the management of energy across the entire home, with optimum control of household equipment based on factors such as ambient conditions and the quantity of power available. It is anticipated that HEMS (home energy management systems) able to make efficient use of limited energy will be widely adopted in future.

Hitachi has been building prototypes and undertaking a number of trials that aim to save energy in ways that include the control of household equipment and making energy use more "visible"[17]. The following section looks at the future outlook for integrated energy control systems that make effective use of energy in the home.

Use of photovoltaic power is growing rapidly in Japan and solar thermal energy is also attracting interest as a form of renewable energy which it is anticipated will become more widely used in future. In both cases, the quantity of energy harvested varies with factors such as the weather, seasons, and time of day. Accordingly, it is important that the system be designed to utilize energy effectively by the addition of electrical, heat, or other storage mechanisms that will allow the periods of energy production and use to be varied arbitrarily. This requires an integrated energy control system that can identify the applications, times, and amounts at which renewable energy can be used effectively and then control household equipment accordingly. Implementing such systems will require advances in techniques for predicting the characteristics of a range of different devices, sensing technologies, and optimum control techniques.

Fig. 6 shows an overview of a future household energy system. To expand the use of renewable energy, the system makes active use of heat recovery by using a

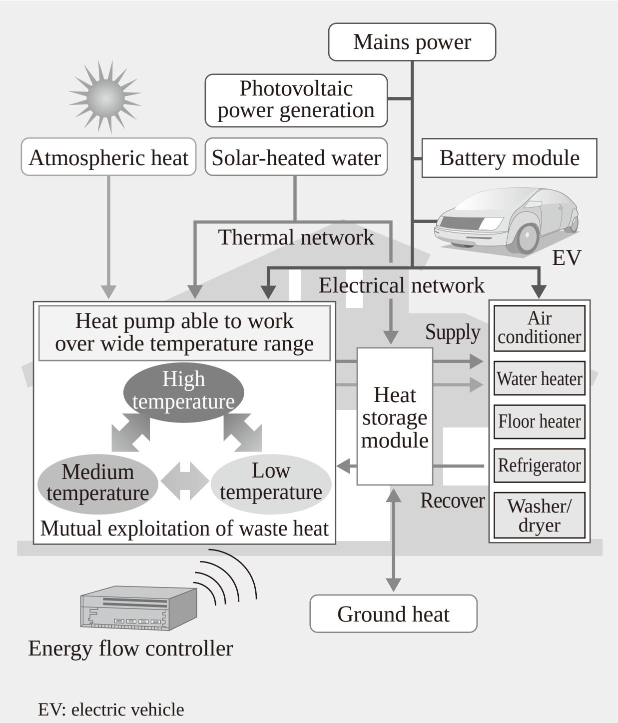

Fig. 6—Example Configuration of Future Home Energy System.
To expand the use of renewable energy, the system features a heat pump able to work over a wide temperature range and unforced refrigerant circulation, all of which is operated by an integrated energy control system.

heat pump that works over a wide temperature range and is managed and operated by an energy flow controller.

Implementing such a system helps protect the global environment by allowing the local production and consumption of energy in the home. Other expected benefits include minimizing the cost of energy to the consumer and providing a healthy and comfortable air-conditioned environment that suits the lifestyle of the home's occupants. It can also assist with balancing electricity supply and demand in the reconstruction of an earthquake disaster.

CONCLUSIONS

This article has described trends in the environmental regulation of home appliances together with the outlook for the distinctive technologies being used by Hitachi in its products to comply with these regulations and improve environmental performance. It has also reviewed the outlook for energy management systems, a technology for improving energy efficiency in the home that is expected to enter widespread use in future.

The sudden change in the balance of electricity supply and demand in Japan following the Great East Japan Earthquake has increased the need for technologies that can appropriately regulate consumer electricity use in response to limited supply. To help create an environmentally conscious society, achieve an appropriate balance between electricity supply and demand, and achieve other similar goals, Hitachi is working to reduce further the power consumption of home electronics products and to develop energy management systems and other new technologies.

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