The ideal of the low energy housing with validated effectiveness (LEHVE) is self-sufficiency that does not receive energy required for living from others. It aims to reduce energy consumption thereby controlling CO_2 emissions while maintaining the quality of the indoor environment.

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Chapter 1 : Low Energy Housing with Validated Effectiveness and Energy Conservation

1.1 What is Low Energy Housing with Validated Effectiveness?

As part of efforts to improve sanitary conditions, measures have been implemented to develop environment-friendly housing technology in Japan since the Meiji period (1868-1912) when even the causes of many diseases were unknown. For example, various efforts have been made to achieve houses that provide coolness in summer and warmth in winter, bright rooms, high-quality water and other functions such as being able to use hot water freely. Time passed, and in the 1970's, there was rising concern that the impact of society on the environment could not be ignored. Since the 1980's, man-made climate change such as global warming have been recognized as international issues. The Kyoto Protocol was created in 1997 and came into effect internationally in 2005. While the first commitment period of the Kyoto Protocol started in January 2008, proactive actions have been taken such as the review of Japan's Kyoto Protocol Target Achievement Plan and the international measures regarding the framework of steps taken after the Kyoto Protocol.

Since the 1990's, in the housing field, measures have been promoted to tackle the issue of environmental friendliness at different stages; construction, occupancy and demolition. Furthermore, recently, technology used for traditional housing in Japan has been re-evaluated, and methods for indoor climate control, which enable the realization of housing that is cool in summer and warm in winter, have been discussed in order to deal with the Japanese hot, humid climate with high solar radiation. Low energy housing with validated effectiveness (LEHVE) can be positioned as one such effort.

The ideal of LEHVE is to achieve housing with an established self-contained energy reception and consumption system that does not receive energy required for living from others. However, while considering this as a long-term goal, we firstly aim to develop and spread technology which contributes to the reduction of CO_2 emissions from the standpoint of housing by the deadline around 2010 adopted by the Kyoto Protocol.

Based on this, we define LEHVE as follows.

Low energy housing with validated effectiveness is housing that uses as much natural energy as possible according to the way of living and housing site conditions, such as climate and site characteristics, while increasing the standards of livability and convenience by carefully designing and selecting buildings, equipment and appliances. Thereby, such housing is able to reduce energy consumption (CO_2 emissions) during occupancy by up to 50% compared to housing that was common around 2000, and it will be able to be put to practical use by 2010.

In addition, various technologies used for LEHVE explained in this document are not the technologies that will be feasible in some distant future but the ones that are already in practical use and commercialized. They are mainly economical, highly valid and accessible technologies that should be updated and improved over time.

●International Trends and Efforts Made by Japan Regarding Global Environmental Issues

In the late 20th century, supplying a large amount of energy became possible thanks to low-priced oil and artificial environmental technology, as typified by heating and cooling technology, spread rapidly. However, the corresponding increase in energy consumption caused an increase in greenhouse gas emissions, which became recognized as the cause of environmental impact including global warming. Since the 1970's, the following measures have been implemented to reduce environmental impact

1972	"The Limits to Growth" by the Club of Rome presented the necessity for a change from growth to equilibrium. Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration) was adopted.
1978 onward	Specific measures for energy conservation accelerated due to soaring oil prices caused by oil crisis.
1979	Energy Conservation Law (Act on the Rational Use of Energy) took effect in Japan. Various standards for promoting the energy conservation for housing and other buildings were established.
1988	World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) Intergovernmental Panel on Climate Change (IPCC)
1992	Earth Summit was held. United Nations Framework Convention on Climate Change was adopted in order to control the emissions of greenhouse gas such as CO_2.
1997	Kyoto Protocol was created. Japan set target values for reducing greenhouse gas emissions by 6%, compared to those in 1990, by around 2010.
2002	Outline for Promotion Effects to Prevent Global Warming Japan declared target values for reducing greenhouse gas emissions in the private sector by 2%, by around 2010.
2005	Kyoto Protocol came into effect as 143 countries, which hold approximately 62% of the CO_2 emissions caused by developed countries, ratified it.
2007	The Prime Minister Abe proposed Cool Earth 50 (Beautiful Star 50). A long-term goal to reduce greenhouse gas in the entire world by half by 2050 was proposed. The 13th Conference of Parties (COP 13) of the United Nations Framework Convention on Climate Change was held in Bali, Indonesia. It was decided that the framework after the first commitment period of the Kyoto Protocol would be adopted with consent by 2009.
2008	The first commitment period of the Kyoto Protocol started as of January 1.

●Change in CO_2 Emissions in Japan

We will look at the change in CO_2 emissions in Japan by sector (Fig. 1). The increase in CO_2 emissions in the private sector (caused by energy consumption by businesses and homes) is remarkable. For example, the CO_2 emissions from the household energy consumption sector increased by 36.4% between 1990 and 2005. This shows that an approximately 22% reduction must be achieved during the first commitment period in order to control the emissions within the range of an 8.5% to 10.9% increase※, which is the goal set for the sector in question in the Kyoto Protocol Target Achievement Plan.

※ The Kyoto Protocol Target Achievement Plan created in March 2005 was revised in March 2008. Regarding the household sector, it is stated in the revision that the goal is to reduce rate of increase for CO_2 emissions by the year 2010 from the current level to an 8.5 – 10.9% increase compared to the year 1990.

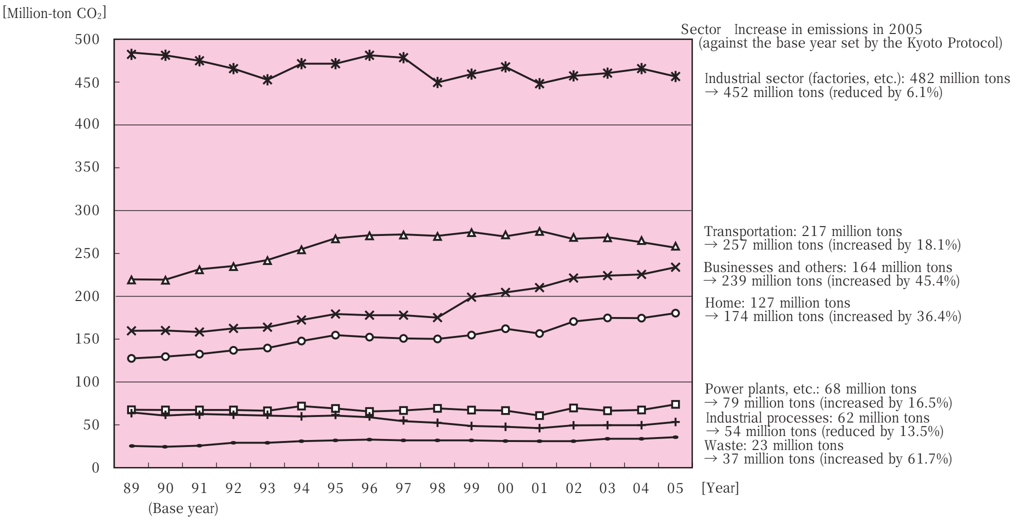

Fig. 1 Change in CO_2 emissions in each sector between 1990 and 2005

●Research Project on Low Energy Housing with Validated Effectiveness

The National Institute for Land and Infrastructure Management and the Building Research Institute implemented a research and development project on low energy housing with validated effectiveness for four years starting 2001. In June 2005, its results were summarized in the "Design Guidelines for Low Energy Housing with Validated Effectiveness" for detached houses in warm regions and are utilized by many people in the field. The project was followed by a subsequent project in and after 2005, which led to the creation of these guidelines for detached houses in hot humid regions.

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Chapter 1
Low Energy Housing with Validated Effectiveness and Energy Conservation

Glossary: GJ
GJ is pronounced as "gigajoule", and joule (J) is a unit of energy amount. Since giga means one billion, 1 GJ is 1 billion joules

1.2 Actual Situation of Energy Consumption during Occupancy and Tasks

The actual situation of energy consumption during occupancy of housing is shown roughly in Fig. 2. Weather conditions are reflected in the situation. In Hokkaido and the Tohoku district, heating energy consumption is high. In warm regions in Honshu and Kyushu, the ratio of domestic hot water energy and cooling energy tends to be high.

Fig. 2
Actual situation of energy consumption in housing: Comparison of detached houses in eight urban regions

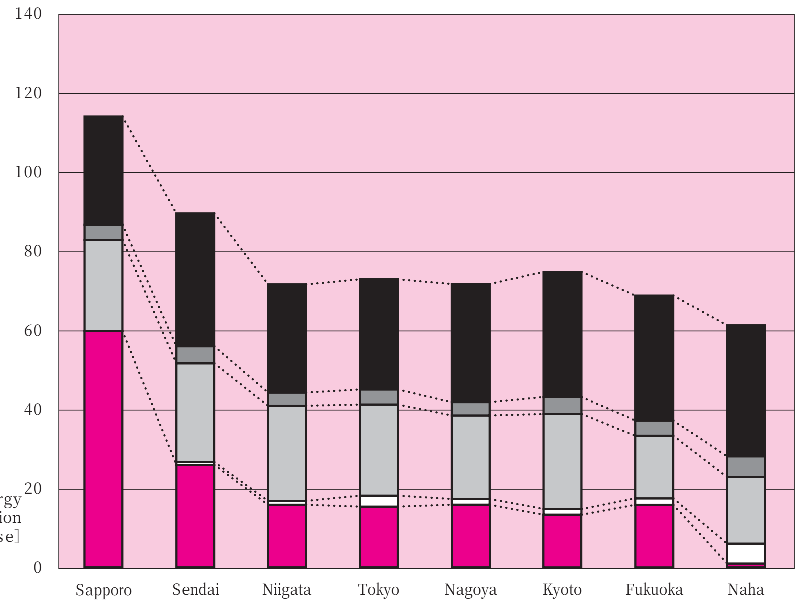
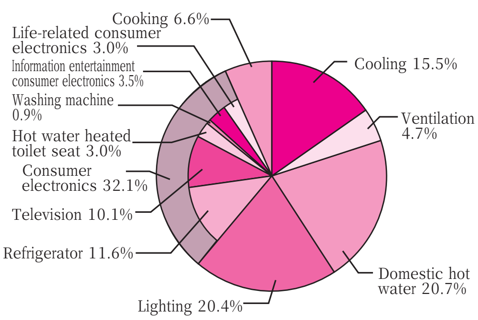
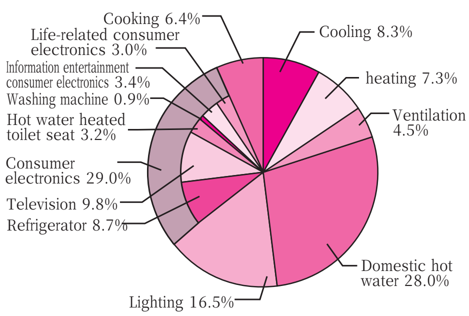


Fig. 3 shows the results of detailed analysis of the composition of energy consumption at detached houses in hot humid regions. In Naha located in Zone VI, its annual total consumption is: "16% for cooling", "5% for ventilation", "21% for domestic hot water", "20% for lighting", "32% for consumer electronics" and "7% for cooking" (0% for heating). In Kagoshima located in Zone V, the Fig. shows "8% for cooling", "7% for heating", "5% for ventilation", "28% for domestic hot water", "17% for lighting", "29% for consumer electronics" and "6% for cooking". As for the breakdown of consumer electronics, you can see that the ratios of refrigerators and televisions are high in both regions.

In order to achieve a great energy conservation effect as a whole, implementing a measure for a single use only is not sufficient. It is necessary to take measures for various uses of energy.



In the case of reinforced concrete house in Naha
Total primary energy consumption per year: 66.6 GJ



In the case of wooden house in Kagoshima
Total primary energy consumption per year: 68.6 GJ

Fig. 3
Ratio of annual primary energy consumption at detached houses in hot humid regions

1.3 Indoor Environment Performance that Low Energy Housing with Validated Effectiveness Aims for

While the goal of LEHVE is to reduce energy consumption during occupancy, we cannot forget that it should aim for creating a pleasant environment where occupants can feel “comfortable” at the same time. The quality of the environment that feels “comfortable” varies depending on the occupant’s living history, age and preferences. In addition, environmental quality that the same occupant seeks may be different depending on the housing site conditions. In other words, the “comfortable” environment that each occupant seeks is unique yet changes. Therefore, the complete removal of physiological stress (physiological unpleasantness caused by the gap between the quality that an occupant seeks and the actual quality), such as coldness, heat and darkness, is not necessarily the ultimate goal of LEHVE.

How much an occupant seeks environmental quality varies. Some occupants’ standards are flexible and they tolerate changes, while others have high standards and seek stability. Naturally, occupants have freedom to select the environment they seek. LEHVE secures such freedom for each occupant and accepts a wide range of ideas, aiming to realize the housing equipped with environmental quality suitable for the occupant.

Instead of relying only on machinery and equipment as well as commercial energy, LEHVE offers architectural ingenuity and natural energy application as preconditions. This is precisely why LEHVE does not always offer excessive standards for comfort by ignoring the occupant’s request. Instead, it values the active attitudes that occupants have toward creating environment. To achieve this, LEHVE is required to provide specifications and architectural arrangements that will accommodate the occupant’s creative ideas and measures. It is important to creatively design LEHVE in a way that allows the occupant to operate and adjust the following as he or she likes: finely-tuned operation of heating and cooling devices according to room temperature and outside air temperature; opening and closing of windows according to wind; adjusting solar radiation by installing solar shading devices; and turning on and off lighting fixtures according to places and actions.

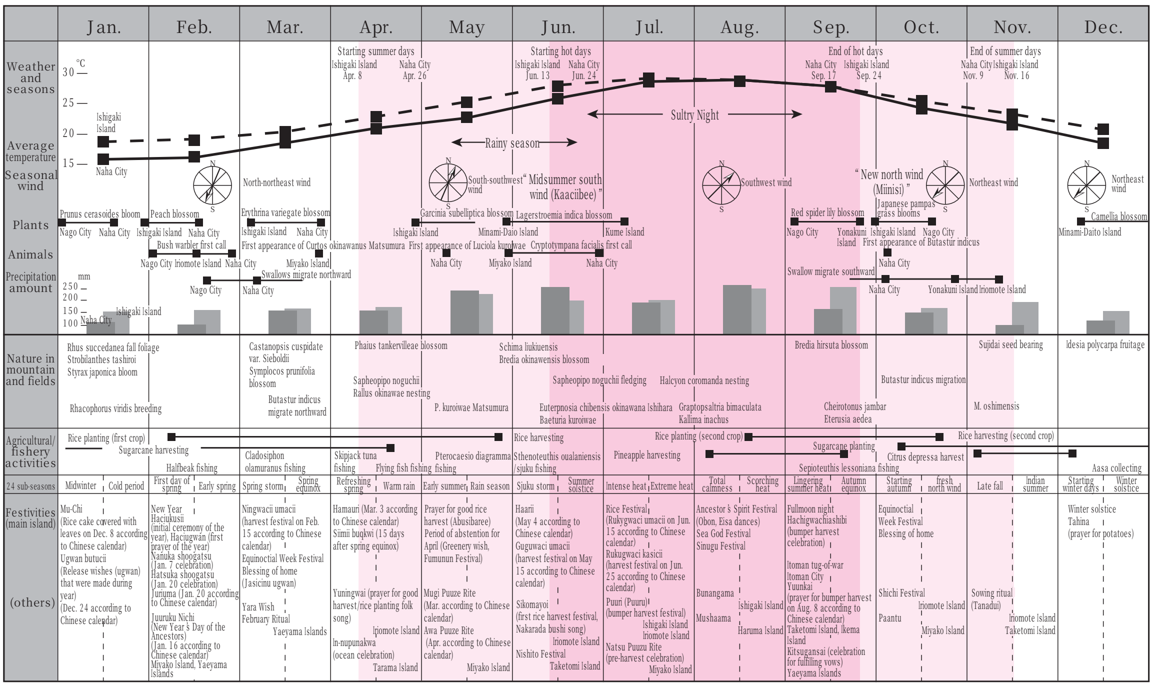


Fig. 4
Lifestyle in Okinawa that coexists with seasonal changes

Source: Okinawa Prefectural Basic Plan for Environmentally Symbiotic Housing, Housing Division, Department of Civil Engineering & Construction, Okinawa Prefectural Government

1.4 Climate and Housing Characteristics in Hot Humid Regions

1.4.1 Target Hot Humid Regions and Climate Characteristics

This document targets the following two regions. Zone VI is Okinawa Prefecture including the minor islands, and Zone V is the region along the Pacific coast west of Tokyo such as Southern Kyushu and the south of Shikoku (Table 1). The list of municipalities for each region is in "Supplement 1: Zone Classification Materials" (p.384).

The climate of each Zone varies, but general characteristics are described below (Table 2).

- Zone VI belongs to subtropical marine climate. It is hot and humid there with small temperature differences throughout the year. It is warm even in winter with a temperature around 16°C, and the temperature rarely falls below 10°C. In summer, on the other hand, it is rare for the temperature to significantly exceed 30°C. Although relative humidity is high, you may even feel cool thanks to high wind speed. In this region which gets hit by typhoons frequently, wind is strong throughout the year and rainfall is relatively high even when it is not the rainy season. Because this region is located at low latitudes, solar altitude is high with strong UV rays reaching the ground.
- Zone V covers a wide area. It is warm and humid throughout the year with high rainfall. In the rainy season and the typhoon season, concentrated heavy rain and extremely gusty winds occur in some areas. In general, sunshine hours are long in this region with high global solar radiation.

Table 1 Main hot humid regions

Zone VI	Okinawa (Okinawa Island and approximately 160 large and small islands including Miyako Island, Ishigaki Island, etc.)	
Zone V (16 prefectures)	Kagoshima (excluding the north mountain area) Miyazaki (excluding the west mountain area) Oita (part of the southwest coastal area) Kumamoto (the southwest plain area, large and small islands) Nagasaki (part of the east area, excluding Tsushima and Iki islands) Fukuoka (part of Fukuoka City) Kochi (most of the south coastal area) Ehime (part of the west coastal area)	Tokushima (part of the southwest coastal area) Yamaguchi (Shimonoseki City) Wakayama (part of the south area and west area) Mie (part of the south coastal area) Shizuoka (south area of Izu Peninsula) Tokyo (Izu Islands, Ogasawara Islands) Chiba (Choshi City) Ibaraki (Hasaki-machi)

Table 2 Weather data of major cities in hot humid regions (normal values)

Major cities		Temperature (°C) Annual average (January)	Precipitation amount (mm) Annual total	Relative humidity (%) Annual average	Wind speed (m/s) Annual average	Most frequent wind direction through the year (August)	Sunshine hours (h) Annual total	Global solar radiation (MJ/m^2) Average
Zone VI	Naha	22.7 (16.6)	2036.9	75	5.3	North-northeast (Southeast)	1820.9	13.9
	Miyako Island	23.3 (17.7)	2019.3	79	4.8	North-northeast (South)	1768.5	14.6
	Ishigaki Island	24.0 (18.3)	2061.0	77	4.7	North-northeast (South-southwest)	1852.6	15.0
Zone V	Kagoshima	18.3 (8.3)	2279.0	71	3.4	Northwest (Northeast)	1918.9	13.5
	Miyazaki	17.2 (7.6)	2457.0	75	3.2	Northwest (Northwest)	2108.4	13.9
	Kochi	16.6 (6.1)	2627.0	68	1.8	West (West)	2120.1	14.0
Zone IV (Reference)	Tokyo	15.9 (5.8)	1466.7	63	3.3	North-northwest (South)	1847.2	11.6

※Created based on Japan Meteorological Agency's website

1.4.2 Characteristics of Housing in Hot Humid Regions

The statistics of housing built in hot humid regions show that trends in terms of structure and construction differ between Zone VI and Zone V (Table 3).

- In Zone VI (Okinawa Prefecture), multi-family residential buildings account for more than half of the total number of housing, slightly exceeding the number of detached houses. As for the detached houses, more than 80% of them are reinforced concrete houses. While the ratios of one-story houses and two-story houses are almost the same, two-story houses have been on the increase in recent years. In addition, average total floor area is around 110 m^2.
- According to the data on the three Prefectures (Kagoshima, Miyazaki, and Kochi) in Zone V, detached houses account for 70% of the total number of housing. Among them, more than 90% are wooden houses. As for the number of stories, ratios are different in each prefecture. However, the ratio of houses with two or more stories has been increasing in recent years, accounting for 50% in Kagoshima and Miyazaki Prefectures and more than 80% in Kochi Prefecture. In addition, the average total floor area is between 100 m^2 and over 110 m^2.

Table 3 Construction and structure of housing in hot humid regions

Region/Prefecture		Total number of houses (household)	Construction (%)		Structure of detached house (%)		Number of stories (%)	
			Detached house	Multi-family residential building	Fire-retardant wood Wood	Reinforced/ Steel framed concrete	One-storied house	Two stories or more
Zone VI	Okinawa	465,000	45.9	50.3	13.7	82.4	48.6	51.4
			34.5	63.8	4.4	89.1	35.6	64.4
Zone V	Kagoshima	699,700	72.9	24.0	92.8	5.3	68.8	31.2
			59.9	38.5	90.0	6.0	53.9	46.1
	Miyazaki	435,300	72.7	24.0	95.7	2.7	62.1	37.9
			61.4	37.9	93.0	4.2	49.0	51.0
	Kochi	318,400	70.7	25.1	92.7	4.0	25.2	74.8
			55.7	41.2	88.9	5.6	14.7	85.3

※Created based on the data on 2003 housing/land statistical research by Statistics Bureau, Ministry of Internal Affairs and Communications
The upper rows show overall ratios and the lower rows show ratios of houses built between 1999 and 2003.
The number of stories for detached houses is that of the reinforced/steel framed concrete houses for Zone VI and wooden houses for Zone V.

Fig. 5
Average residential area in Naha City, Okinawa

Based on what has been described above, this document targets reinforced concrete house in Zone VI and wooden house in Zone V. Energy consumed during occupancy varies between houses in Zone VI and those in Zone V. With regard to elemental technologies effective in designing LEHVE, some are described in separate chapters for each region and others can be described in the same chapter for both regions without any problems. We will describe the details in Chapter 3 onward.