Natural energy utilization, building envelope performance and system efficiency should be taken into account when aiming to design LEHVE. Architects are required to proficiently combine these three elements according to the given design conditions including the building site and lifestyle of occupants, enhancing these elements rather than impairing them.

2

Chapter 2 : Design Process of Low Energy Housing with Validated Effectiveness and Outline of Elemental Technologies

2

Chapter 2
Design Process of Low Energy Housing with Validated Effectiveness and Outline of Elemental Technologies

2.1 Design Flow of Low Energy Housing with Validated Effectiveness

In order to “reduce energy consumption during occupancy” and “create a comfortable indoor environment”, which is the goal of low energy housing with validated effectiveness (LEHVE), it is necessary to combine “architectural techniques” through the use of natural energy and heat control of building envelopes with “mechanical techniques” by introducing high-efficiency mechanical systems, according to the characteristics of the home to be designed. It is important for architects to reach an appropriate and comprehensive design solution by combining different methods and to proceed with design work by taking into consideration the priorities of items to be studied and the context of design procedures. **Fig. 1** illustrates the design procedures for LEHVE as well as the essential stages and items to be studied in order to reduce as many design changes as possible and achieve the goal of LEHVE.

The design procedures of LEHVE are based on the standard design procedures for housing. This document views the standard design procedures for housing in four stages: “understanding given conditions and requirements”, “setting design goals and principles”, “developing design models”, and “analyzing design models and verifying their effectiveness”. **Fig. 1** presents the design flow of LEHVE according to these four stages, including the design and details to be studied for LEHVE and specific items to be studied.

The outline of the design procedures for LEHVE is explained below:

◆ Procedure 1　Understanding design requirements of LEHVE (i. Understanding given conditions and requirements)

This stage focuses on and identifies the “possibility of natural energy utilization at the building site” and “lifestyle orientation” which determines the feasible characteristics of LEHVE among the given design conditions.

◆ Procedure 2　Setting target design model for LEHVE (ii. Setting design goals and principles)

Based on Procedure 1, this stage sets the target design model for LEHVE. It is effective to study the possibility of applying elemental technologies and their levels in relation to the target design model. See Section 2.3.2 on p.029 for the types of houses that are considered typical target design models.

◆ Procedure 3　Basic items to be considered for designing LEHVE (iii. Developing design models – 1)

This stage refers to the early planning and design stage, such as building layout planning, floor planning, sectional and elevation planning, and examines the basic items to be considered for designing LEHVE. Please confirm and examine these basic items listed in Section 2.3.3 on p.034 prior to determining design specifics.

◆ Procedure 4　Examining the application of elemental technologies (iii. Developing design models – 2)

This stage studies in detail the application of elemental technologies, which determine the specifics of LEHVE, and integrates the design model. As shown in Table 1, this document covers 13 elemental technologies related to the thermal, air, light and other environmental planning fields, which are classified into the three categories of “natural energy application technology”, “heat control technology of building envelopes”, and “energy-efficient equipment technology”.

Table 1　Elemental technologies discussed in this document

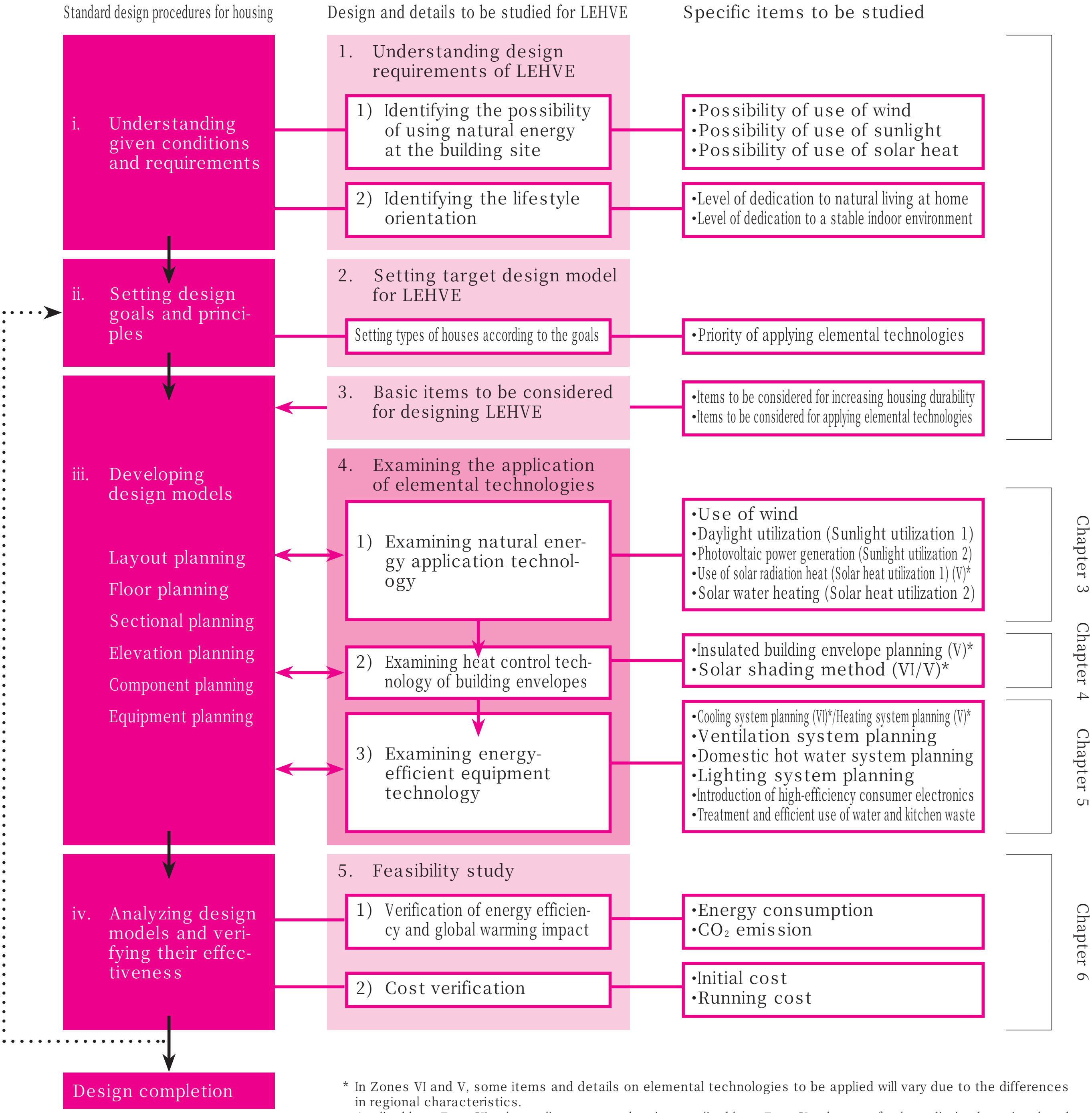
		Field of thermal environment	Field of air environment	Field of light environment	Other
Natural energy application technology	Technology that replaces fuel energy with natural energy such as wind, solar heat, sunlight	Use of solar radiation heat (Solar heat utilization 1) Solar water heating (Solar heat utilization 2)	Use/control of wind	Daylight utilization (Sunlight utilization 1) Photovoltaic power generation (Sunlight utilization 2)	
Heat control technology of building envelopes	Technology that controls heat transfer and maintains an appropriate indoor environment using architectural solutions for building envelopes including insulation and solar shading	Insulated building envelope planning Solar shading method			
Energy-efficient equipment technology	Technology that uses select energy efficient equipment and systems, reduces energy, and increases comfort	Cooling/heating system planning Domestic hot water system planning	Ventilation system planning	Lighting system planning	Introduction of high-efficiency consumer electronics Treatment and efficient use of water and kitchen waste

The prerequisite of LEHVE is to make optimum use of the natural potential of the building site. It is recommended to first examine the "natural energy application technology" and "heat control technology of building envelopes" as the priority before studying the "energy-efficient equipment technology". In order to create a "pleasant" indoor environment while reducing energy consumption, it is important to select elemental technologies that meet the design conditions from the various ones available, as well as to properly combine those technologies.

◆ Procedure 5 Feasibility study (iv. Analyzing design models and verifying their effectiveness)

This stage verifies the energy consumption (CO_2 emission) and cost of the design model that has been studied.

If the goal has not been achieved, go back to Procedure 2 and re-examine the design model.



* In Zones VI and V, some items and details on elemental technologies to be applied will vary due to the differences in regional characteristics.
Applicable to Zone VI only: cooling system planning; applicable to Zone V only: use of solar radiation heat, insulated building envelope planning, heating and cooling system planning; details are different between Zones VI and V: solar shading method. Other elemental technologies are applicable to both zones.

Fig. 1 Design flow of low energy housing with validated effectiveness

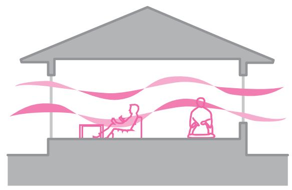
2

Chapter 2
Design Process of Low Energy Housing with Validated Effectiveness and Outline of Elemental Technologies

2.2 Outline of Elemental Technologies

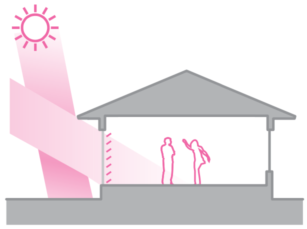
Natural energy application technology

01 Use and control of wind (3.1)



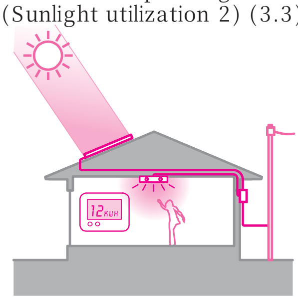
Method 1 Securing the opening area for the cross ventilation route
Method 2 Positioning the opening area according to the prevailing wind direction
Method 3 Use of high windows

02 Daylight utilization (Sunlight utilization 1) (3.2)



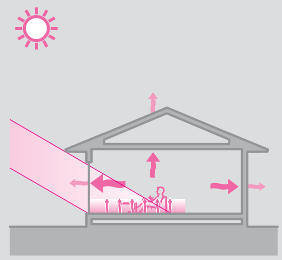
Method 1 Direct daylight utilization method (day-lighting method)
Method 2 Indirect daylight utilization method (day-light guiding method)

03 Photovoltaic power generation (Sunlight utilization 2) (3.3)



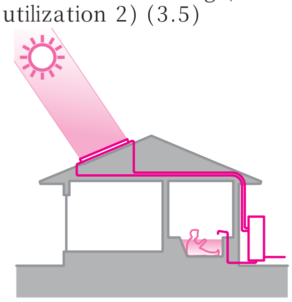
(Covers whether or not to install a photovoltaic power generation system and its capacity, etc. Methods have not been specified.)

04 Solar radiation heat utilization (Solar heat utilization 1) (3.4)



Method 1 Method for insulating openings
Method 2 Method for collecting heat from openings
Method 3 Heat storage method

05 Solar water heating (Solar heat utilization 2) (3.5)



Method 1 Securing heat collection area, etc.
Method 2 Proper connection to the auxiliary heat source
Method 3 Adoption of energy-efficient circulating pump

Key

- Elemental technologies effective for both Zones VI and V
- Elemental technologies effective for Zone VI
- Elemental technologies effective for Zone V

Numbers in parentheses refer to the section numbers in Chapters 3 and 5 in which the elemental technologies are explained.

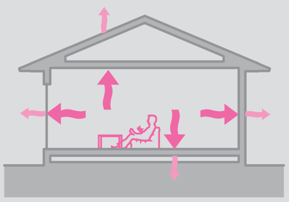
2.2.1 List of Elemental Technologies and Methods

There are 13 elemental technologies covered in this document for designing LEHVE: five types of “natural energy application technology”; two types of “heat control technology of building envelopes”; and six types of “energy-efficient equipment technology”. Please note that some items and details of elemental technologies to be applied vary in the hot humid zones VI and V due to the differences in regional characteristics.

Recommended design methods (hereinafter referred to as “methods”) that offer energy saving effects are specified for the elemental technologies. (Methods are not specified for some elemental technologies.)

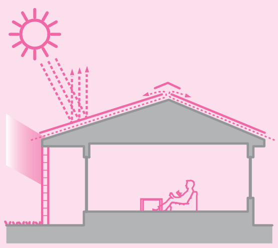
Heat control technology of building envelopes

06 Insulated building envelope planning (Zone V) (4.1)



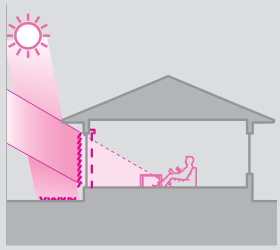
(It covers the insulation material thickness, opening specifications, airflow blocking for junction areas, condensation control, etc. Methods have not been specified.)

07-1 Solar shading method (Zone VI) (4.2)



Method 1 Solar shading method using outside shading device
Method 2 Solar shading method using building envelope

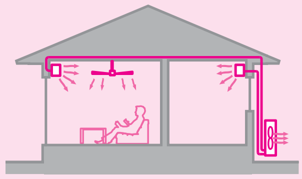
07-2 Solar shading method (Zone V) (4.3)



Method 1 Solar shading method of opening areas
Method 2 Solar shading method of roofs
Method 3 Solar shading method of exterior walls
Method 4 Other solar shading methods

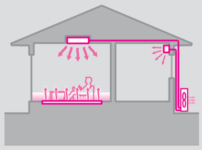
Energy-efficient equipment technology

08-1 Cooling system planning (Zone VI) (5.1)



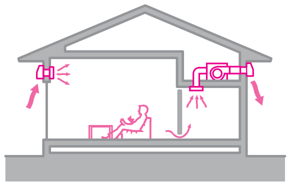
Method 1 Introduction of high-efficiency air-conditioner
Method 2 Adoption of electric and ceiling fans

08-2 Heating and cooling system planning (Zone V) (5.2)



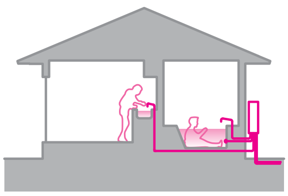
Type 1 Individual heating and cooling
Type 2 Gas/oil hot water heating
Type 3 Forced flue (FF) heating
Type 4 Duct central heating and cooling

09 Ventilation system planning (5.3)



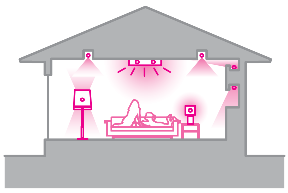
Type 1 Duct ventilation system
Method 1 Reduction of pressure loss of ducts, etc.
Method 2 Introduction of high-efficiency devices
Type 2 Through-the-wall ventilation system
Method 1 Proper combination of fan and outside air terminal

10 Domestic hot water system planning (5.4)



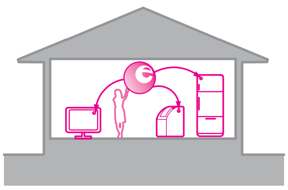
Method 1 Solar heat utilization
Method 2 Introduction of high-efficiency water heater
Method 3 Energy saving design/construction methods, etc., for each component of domestic hot water system

11 Lighting system planning (5.5)



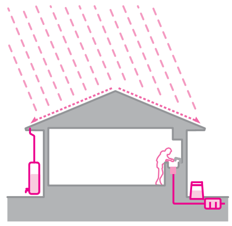
Method 1 Method using devices
Method 2 Method by lighting operation and control
Method 3 Method by design

12 Introduction of high-efficiency consumer electronics (5.6)



(Covers high-efficiency prime consumer electronics and priority consumer electronics, etc. Methods have not been specified.)

13 Treatment and efficient use of water and kitchen waste (5.7)



Method 1 Use of water saving devices
Method 2 Adoption of rainwater and wastewater reuse system
Method 3 Adoption of rainwater seepage pit, etc.
Method 4 Adoption of advanced wastewater treatment technology
Method 5 Adoption of efficient kitchen waste disposal technology

2.2.2 Uses of Energy to be Reduced

1. Uses of energy to be reduced by means of elemental technologies

This document classifies uses of energy that are consumed by occupants of a house into eight categories, which are cooling, heating, ventilation, domestic hot water, lighting, home electronics, cooking and water. The table below shows the uses of energy that can be reduced by using elemental technologies, and factors such as cooling and heating energy are influenced by multiple elemental technologies (Table 2).

Table 2 Relationship between uses of energy at houses and elemental technologies

Elemental technologies	Uses of energy to be reduced (marked with a circle)							
	Cooling	Heating	Ventilation	Domestic hot water	Lighting	Home electronics	Cooking	Water
1) Use/control of wind	○		○					
2) Daylight utilization					○			
3) Photovoltaic power generation								
4) Use of solar radiation heat (V)		○						
5) Solar water heating				○				
6) Insulated building envelope planning (V)	○	○						
7) Solar shading method (VI/V)	○							
8) Cooling system (VI)/ Heating and cooling system planning (V)	○	○						
9) Ventilation system planning			○					
10) Domestic hot water system planning				○				
11) Lighting system planning					○			
12) Introduction of high-efficiency consumer electronics						○		
13) Treatment and efficient use of water and kitchen waste								○

The following section focuses on the cooling, heating, domestic hot water and lighting energy and explains its relation with the elemental technologies.

1) Cooling energy

Related elemental technologies: Use and control of wind, insulated building envelope planning, solar shading method, cooling system/heating and cooling system planning (cooling)

- **In order to maintain a cool indoor environment without relying solely on the cooling system in the summer and in-between seasons, it is critical to achieve both cross ventilation and solar shading (including insulated building envelope planning for Zone V). These are all related to the provision of windows, overhangs and other features. When using accessories for solar shading the windows such as louvers and curtains, it is necessary to arrange them so that they will not hinder cross ventilation. On the other hand, it is possible not only to shade solar radiation but also to protect windows from heavy wind and rain by choosing the right sizes and shapes of overhangs and side walls (See Sections 3.1, 4.2 and 4.3).**

2) Heating energy

Related elemental technologies: Use of solar radiation heat, insulated building envelope planning, heating and cooling system planning (heating)

- **Energy that can be reduced by using solar radiation heat and planning the heating system is largely affected by the insulation level. In order to control the heating load by effectively using the solar radiation heat obtained indoors from windows in winter, it is necessary to increase the insulation performance of the openings, in particular, to reduce heat loss from the windows (See Sections 3.4 and 4.1).**
- **Low insulation levels lead to a significant temperature difference between the heated and unheated rooms and require a long heating operation time for maintaining a certain room temperature. In particular, if the lifestyle requires an extensive, long-hour heating operation system, as represented by a central heating system, it is critical to reduce running costs by enhancing the insulation level (See Sections 4.1 and 5.2).**

3) Domestic hot water energy

Related elemental technologies: solar water heating, domestic hot water system planning

- **Solar water heating and domestic hot water system planning involve different domestic hot water system heat sources. The former uses solar heat and the latter uses gas, oil or electricity as a heat source. When solar water heating is used, its planning generally incorporates a water heater as an auxiliary heat source. It is necessary to consider which combination of solar water heating system to be used and auxiliary heat source type is appropriate (See Sections 3.5 and 5.4).**

4) Lighting energy

Related elemental technologies: daylight utilization, lighting system planning

- **It is desirable to make an integrated examination of the daylight utilization and lighting system planning, which are related to lighting energy consumption. For example, if you want to actively introduce daylight utilization, use light fixtures with controlled lighting in the specific areas so that the lighting can be easily switched on and off during the daytime according to the availability of natural daylight. This will further increase the effect of lighting energy reduction (See Sections 3.2 and 5.5).**

2. Interaction of elemental technologies

Some elemental technologies are influenced by other elemental technologies and show different energy efficiencies when they are evaluated alone. In order to fully demonstrate the anticipated energy efficiency, it is necessary to examine individual elemental technologies as well as reviewing them as a group.

For example, even under the same living and environmental conditions, the cooling energy reduction effect obtained by the "use and control of wind" varies depending on the level of solar shading measures and the fluctuations of the internal heat generation caused by the use of lighting systems and devices as well as home electronics.

The influence of one elemental technology on the energy efficiency of another elemental technology is referred to as "interaction" in this document. Interactions are classified into synergic action, which increases the effect, and antagonistic action, which decreases the effect, in relation to other elemental technologies.

When estimating the overall energy efficiency of a house, we need to consider these interactions so that we can evaluate the energy saving effect more accurately.

2.3 Outline of Design Procedures

2.3.1 Understanding Design Requirements of Low Energy Housing with Validated Effectiveness

1. Possibility of natural energy utilization at the building site

The target design model of LEHVE varies depending on how much of nature's potential, such as solar heat and light energy and wind, can be utilized at building site. For this reason, architects need to confirm the local weather conditions and site conditions (building density and other surrounding conditions of the building site) and identify the possibility of natural energy utilization.

When discussing the overall natural potential the building site possesses, two points can be understood; a suburban location in which natural energy can be relatively easily utilized and an urban location in which natural energy can be utilized with some effort or is hard to utilize (Table 3).

Based on these points, specific site conditions need to be evaluated, particularly when adopting natural energy application technology (See Table 5 on p.027).

Table 3 Classification of location and possibility of natural energy utilization

Classification of location	Possibility of natural energy utilization
Suburban location	Building site in which natural energy can be easily utilized It is desirable to actively adopt natural energy application technology as its expected effects are high.
	Building site in which natural energy can be utilized with some effort Design ingenuity is required for adopting natural energy application technology.
Urban location	Building site in which natural energy is hard to utilize Effects of adopting natural energy application technology are considered low.

The following outlines the influences of weather and site conditions.

1) Influences of weather conditions

There is a relationship between the possibility of wind utilization and the outside wind characteristics in in-between seasons and summer, between the possibility of sunlight utilization and the solar radiation level, and between the possibility of solar heat utilization and the solar radiation level and outside air temperature particularly in winter. These relationships are summarized below according to each elemental technology with natural energy application (Table 4).

Table 4 Factors influencing possibility of natural energy utilization 1 (Weather conditions)

Elemental technologies	Major influential factors	Common influences
Use/control of wind	Outside wind speed	The higher the outside wind speed, the greater the possibility of wind utilization.
	Outside wind direction	Outside wind direction varies widely, but wind can be effectively utilized by taking into account the relationship between the direction which is frequently windward during the day or night and the openings.
Photovoltaic power generation	Annual solar radiation level	The higher the solar radiation level, the higher the photovoltaic power generation level (However, regional differences are not very significant in Japan).
Use of solar radiation heat	Solar radiation level in winter Outside air temperature in winter (PSP classification)	The higher the solar radiation level and outside air temperature in winter, the greater the possibility of utilizing solar radiation heat.
Solar water heating	Solar radiation level Outside air temperature in winter Snowfall and snow cover	The higher the solar radiation level in general, the higher the outside air temperature in winter and the lower the snowfall and snow cover, the greater the possibility of solar heat utilization for water heating (However, differences within the hot humid region are small).

Chapter 3 explains the details of how weather conditions influence each elemental technology and how to understand weather conditions.

2) Influences of site conditions

Major factors that influence site conditions include the density of buildings around the building site, height of adjacent buildings, and noise and other factors that impair the environment of the building site. These influential factors are categorized by elemental technologies related to natural energy application as shown in the table below (Table 5). Since it is desirable to quantitatively evaluate these site conditions when verifying the energy saving effects of applied elemental technology, simple evaluation methods are recommended for some elemental technologies (See Chapter 3 for details).

Moreover, in the hot humid region where solar shading is particularly important in the summer and in-between seasons, buildings around the building site may be effective for solar shading. The "solar shading method" in Zone VI takes into account the solar shading effect of buildings around the building site when evaluating the site conditions.

Table 5 Factors influencing possibility of natural energy utilization 2 (Site conditions)

Elemental technologies	Major influential factors	Common influences	Evaluation index (Classification of location for evaluation, etc.)
Use/control of wind	Building density around the site	The lower the density of buildings around the building site, the higher the possibility of wind utilization.	Building coverage ratio of adjacent area (Locations 1 – 2)
Daylight utilization	Level of obstruction of sunlight	The smaller the influence of the shade caused by buildings around the building site, the higher the possibility of daylight utilization.	— (Locations 1 – 3)
Photovoltaic power generation	Level of obstruction of sunlight	The smaller the influence of the shade caused by the topography of the building site and buildings around the building site, the larger the amount of photovoltaic power generation.	—
Use of solar radiation heat	Level of obstruction of sunlight	The smaller the influence of the shade caused by buildings around the building site in winter, the higher the possibility of utilizing solar radiation heat.	Sunshine hours in winter (Locations 1 – 3)
Solar water heating	Level of obstruction of sunlight (mainly on the roof)	The smaller the influence of buildings that obstruct solar radiation mainly on the roof, the higher the possibility of solar heat utilization for water heating.	—
Solar shading method (reference)	Building density around the site	The higher the density of buildings around the building site, the higher the solar shading effect expected from this.	Horizontal distance from surrounding buildings (Locations 1 – 3) * Zone VI

* The locations in the evaluation index column indicate that natural energy utilization is easier in the order of Locations 1, 2 and 3 (with 3 as easiest).

Chapter 3 explains the details of how site conditions influence each elemental technology.

2. Lifestyle orientation

The target design model of LEHVE varies according to how much the occupants are involved with nature in their everyday life as well as how they value environmental stability. Therefore, it is necessary to understand their awareness of natural energy utilization and equipment technology introduction in their lifestyle.

This section focuses on the "level of dedication to natural living" as the awareness of natural energy utilization and the "level of dedication to a stable indoor environment free of unpleasantness" as the awareness of equipment introduction. As shown in Table 6, these two types of awareness are classified into three levels.

Table 6
Items to be confirmed regarding lifestyle orientation

Items to be confirmed	Description	Level of awarenes
Level of dedication to natural living	Level of awareness of enjoying the changing environment such as strong /weak wind, moderate coldness/hotness, and brightness/darkness	High Moderate Low
Level of dedication to a stable indoor environment free of unpleasantness	Level of seeking a stable indoor environment that is free of unpleasantness or physiological stress, such as hotness, coldness and darkness, as much as possible	High Moderate Low

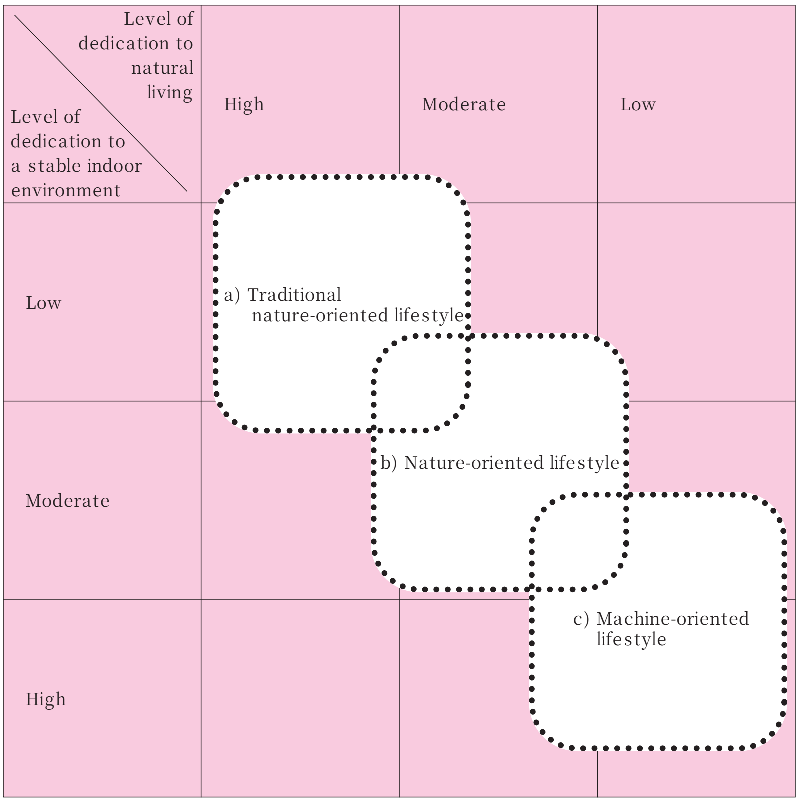
By combining the level of dedication to natural living and level of dedication to an indoor environment, we can identify the lifestyle orientation of the occupants. Here are three possible typical types of lifestyle orientation for reference (Table 7).

a) Traditional nature-oriented lifestyle: ...... **Values the enjoyment of the changing environment and optimizes the utilization of natural energy.**

b) Nature-oriented lifestyle: .... **Utilizes energy efficient equipment while utilizing natural energy.**

c) Machine-oriented lifestyle: .... **Seeks a stable indoor environment and uses energy saving equipment as a priority.**

Table 7 Classification of lifestyle orientation



2.3.2 Setting Target Design Model of Low Energy Housing with Validated Effectiveness

Set the target design models of LEHVE after identifying the "possibility of natural energy utilization at the building site" and "lifestyle orientation" shown in Section 2.3.1.

There are three possible typical housing types for the target design models of LEHVE, Types I, II and III, as illustrated in the design example in Table 8 and the following pages. These types of housing correspond to the three lifestyle orientation types and are listed for reference purposes. Since which elemental technologies should be used as a priority will depend on the housing type, architects can effectively set the target design model by referring to these types and consider the priority of elemental technology application when examining specific architectural techniques.

We can assume various housing models within the three housing types. Set the appropriate target design model according to the site conditions and the way of living.

Table 8 Target design models of LEHVE (typical types) and examples of elemental technology application

Design requirements of LEHVE		Target design models of LEHVE (Typical types)	Examples of elemental technology application		
Possibility of natural energy utilization at the building site	Lifestyle orientation		Classification of elemental technologies	Priority of application	Overview
Suburban location Location in which natural energy can be relatively easily utilized	Traditional nature-oriented lifestyle Optimizing the utilization of natural energy	Housing type I House that mainly uses natural energy to achieve comfort	Natural energy application technology	◎	Make maximum use of wind, daylight, etc. Take sufficient architectural measures to control the indoor environment according to hotness, coldness, etc.
			Heat control technology of building envelope	◎	Take sufficient measures to prevent penetration of solar radiation heat and install insulation to maintain constant temperatures according to regional climate characteristics, etc., in an effort to reduce cooling and heating loads.
			Energy-efficient equipment technology	△	Introduce mechanical measures such as cooling and heating systems and lighting systems as needed. Introduce as much energy-efficient equipment as possible.
	Nature-oriented lifestyle Utilizing energy efficient equipment while utilizing natural energy	Housing type II House that uses natural energy as well as equipment to achieve comfort	Natural energy application technology	○	Use as much wind and daylight as possible through design ingenuity, etc. Take as many architectural measures as possible to control the indoor environment according to hotness, coldness, etc.
			Heat control technology of building envelope	◎	Take sufficient measures to prevent penetration of solar radiation heat and install insulation to maintain constant temperatures according to regional climate characteristics, etc., in an effort to reduce cooling and heating loads.
			Energy-efficient equipment technology	○	Use mechanical measures such as cooling and heating systems and lighting systems to control the indoor environment. Introduce as much energy-efficient equipment as possible.
Urban location Location in which natural energy can be utilized with some effort (or is hard to utilize)	Machine-oriented lifestyle Using energy saving equipment as a priority	Housing type III House that mainly uses equipment to achieve comfort	Natural energy application technology	△	Use as much wind and daylight as possible as an auxiliary energy source.
			Heat control technology of building envelope	◎	Take sufficient measures to prevent penetration of solar radiation heat and install insulation to maintain constant temperatures according to regional climate characteristics, etc., in an effort to reduce cooling and heating loads.
			Energy-efficient equipment technology	◎	Use mechanical measures such as cooling and heating systems and lighting systems as a priority to control the indoor environment. Actively introduce energy-efficient equipment.

Priority of elemental technology application: ◎ high, ○ moderate, △ low

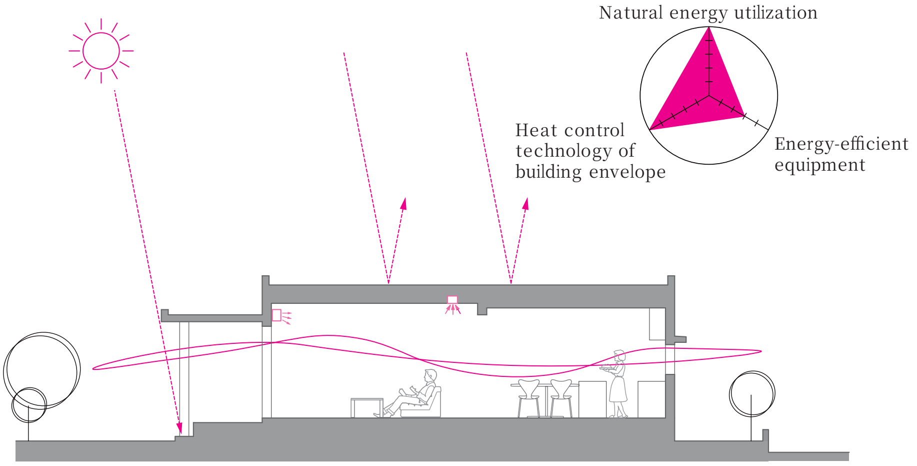
Design example of LEHVE (reinforced concrete house) in Zone VI

■Housing type I　Traditional nature-oriented lifestyle

Example of house and lifestyle

A single-storey house for a four-person family built on a large suburban site.
It has a wide frontage and an open layout with a series of rooms surrounding the living and dining rooms at the center. *Amahaji* (semi-outdoor space with a deep overhang) is installed along the south east corner of the house.
The bathroom, washing room and laundry area are located on the west side where it has a cloth drying area built with blocks with decorative openings to increase the solar shading effect.
The outdoor spot garden is in the shaded area, contributing to improved cross ventilation and heat exhaust of the rooms facing it.

- **Lot area: 432.0 m² (4,650.0 ft²)**
- **Building area: 185.5 m² (1,996.7 ft²)**
- **Total floor area: 145.3 m² (1,564.0 ft²)**



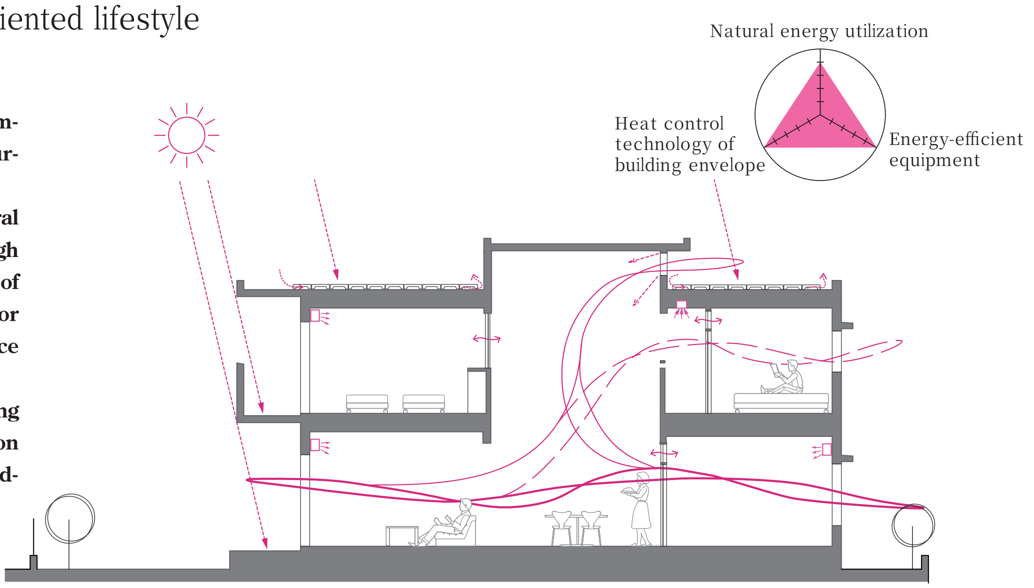
■Conceptual section rendering

■Housing type II　Nature-oriented lifestyle

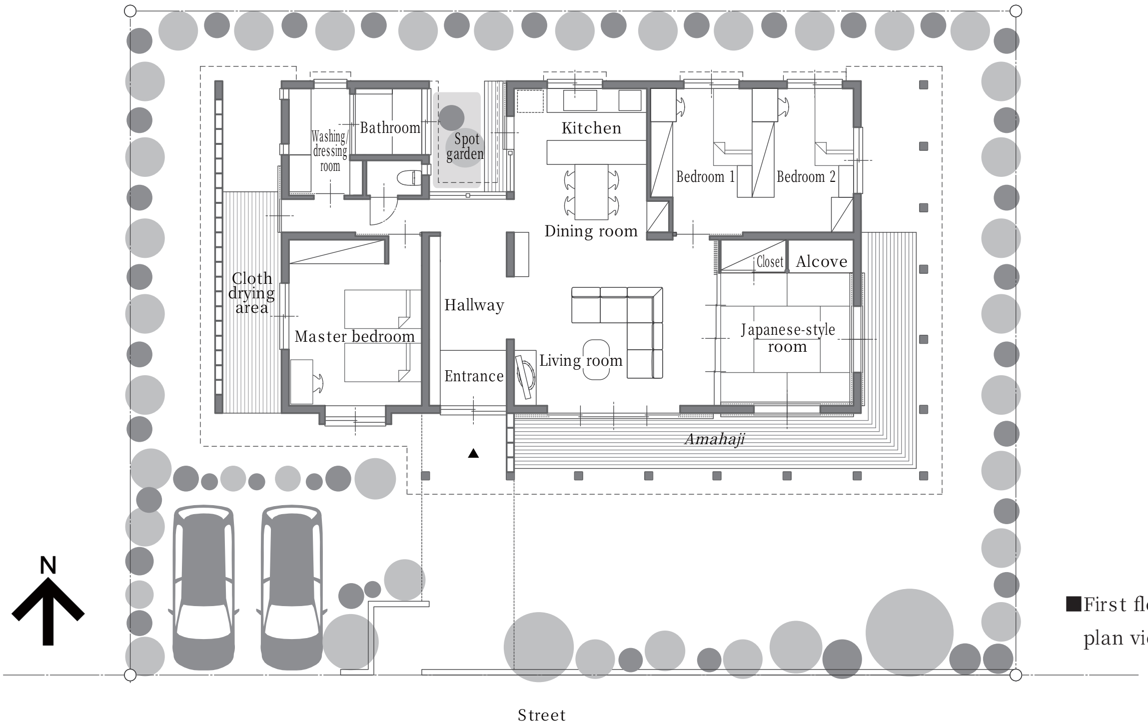
Example of house and lifestyle

A two-storey house for a four-person family built on a relatively small, yet long urban site stretching south and north.
It has an open structure with a central void space surrounded by rooms. A high window is installed in the upper area of the void space to release indoor air for better cross ventilation. The void space also secures the privacy of each room.
The bathroom, laundry area, washing room and cloth drying area are located on the west side to increase the solar shading effect.

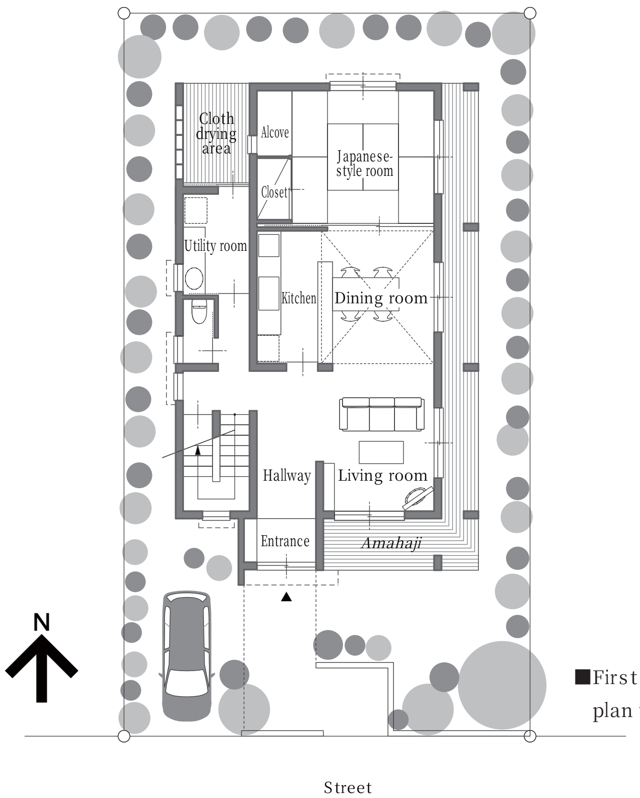
- **Lot area: 215.6 m² (2,320.7 ft²)**
- **Building area: 102.3 m² (1,101.1 ft²)**
- **Total floor area: 147.8 m² (1,590.9 ft²)**



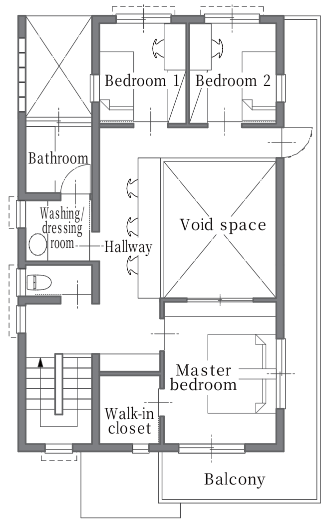
■Conceptual section rendering



■First floor plan view



■First floor plan view



■Second floor plan view

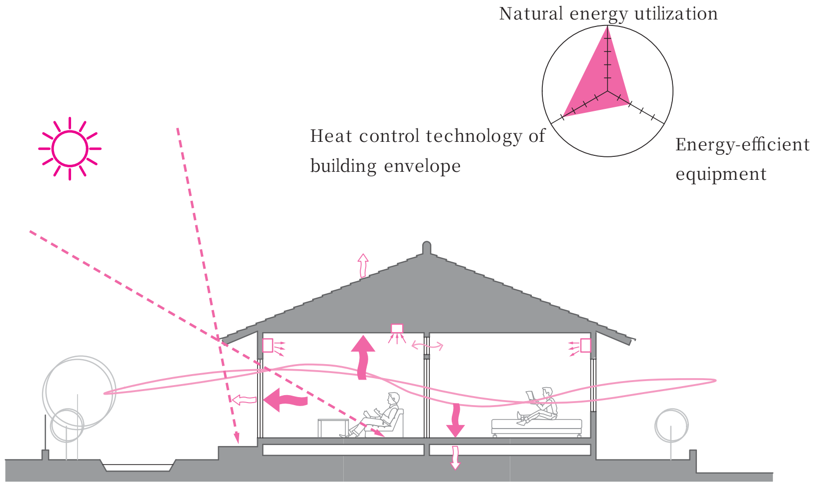
Design example of LEHVE (wooden house) in Zone V

■Housing type I　Traditional nature-oriented lifestyle

Example of house and lifestyle

A single-storey house built on a large suburban site in a medium-sized city.
It has an open layout with a series of rooms surrounding the living and dining rooms at the center. It is designed to efficiently utilize wind and solar radiation heat.
The deck and long overhangs on the south east corner are intended to increase the solar shading effect in summer.

- **Lot area: 274.5 m² (2,954.7 ft²)**
- **Building area: 94.8 m² (1,020.4 ft²)**
- **Total floor area: 73.7 m² (793.3 ft²)**



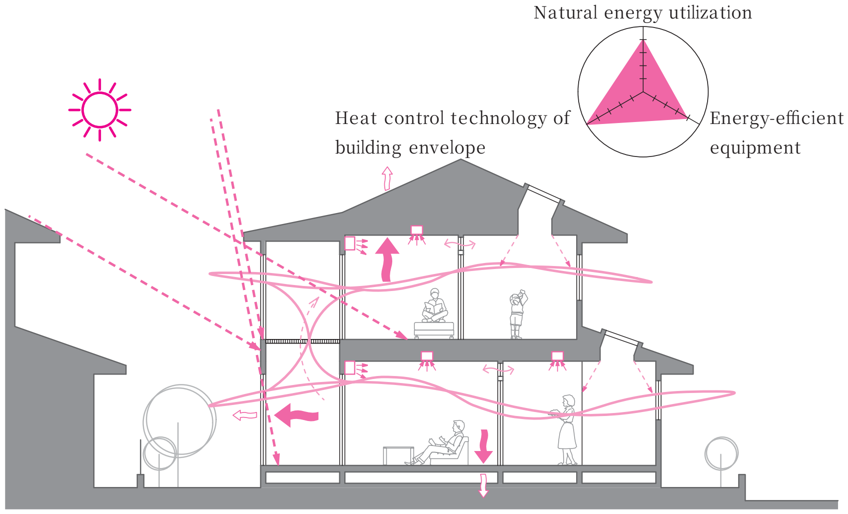
■Conceptual section rendering

■Housing type II　Nature-oriented lifestyle

Example of house and lifestyle

A two-storey house for a four-person family built on a relatively large site close to a city.
The terrace on the first and second floors, a family room located in the shared area in front of each room, and sliding doors are designed to promote wind in summer and solar heat gain and its active utilization in winter. The skylight on the north side of the roof facilitates daylight utilization.

- **Lot area: 210.0 m² (2,260.4 ft²)**
- **Building area: 77.8 m² (837.4 ft²)**
- **Total floor area: 128.3 m² (1,381.0 ft²)**



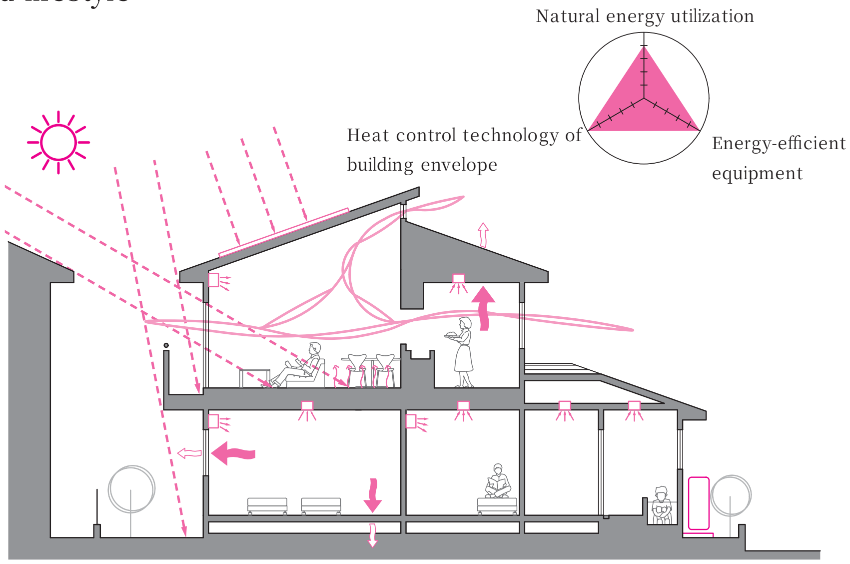
■Conceptual section rendering

■Housing type III　Machine-oriented lifestyle

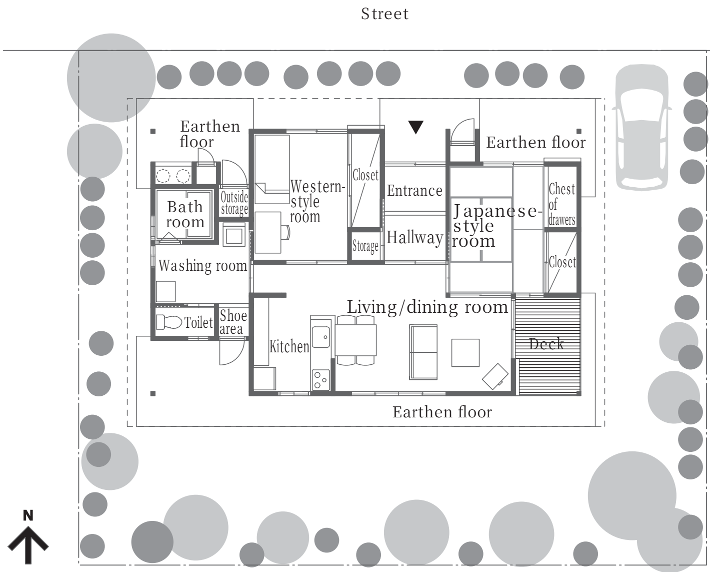
Example of house and lifestyle

A two-storey house for a four-person family built on a relatively large urban site.
The second floor living room and high windows are designed to promote as much as possible the utilization of the wind in summer and solar radiation heat and daylight in winter.
Rooms on the first floor are intended to control and maintain the indoor thermal environment using equipment during the night.

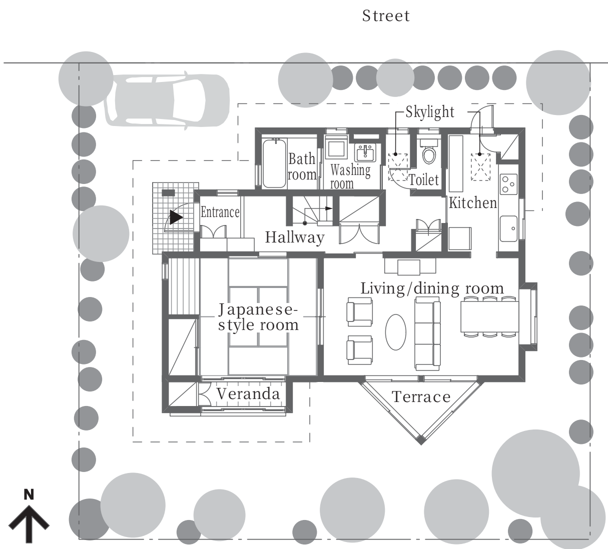
- **Lot area: 135.0 m² (1,453.1 ft²)**
- **Building area: 71.2 m² (766.39 ft²)**
- **Total floor area: 122.1 m² (1,314.3 ft²)**



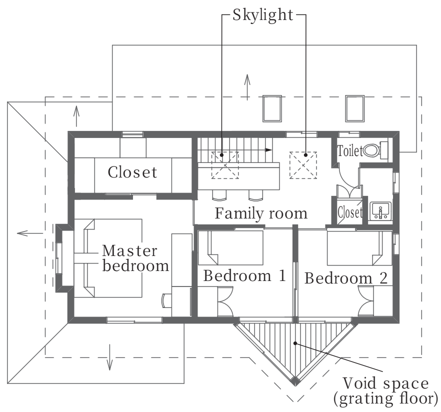
■Conceptual section rendering



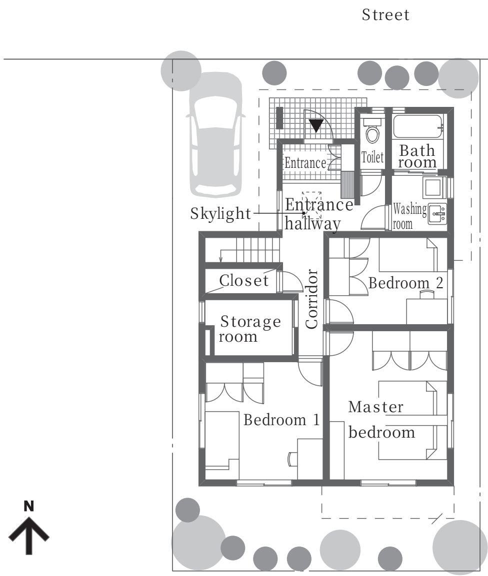
■First floor plan view



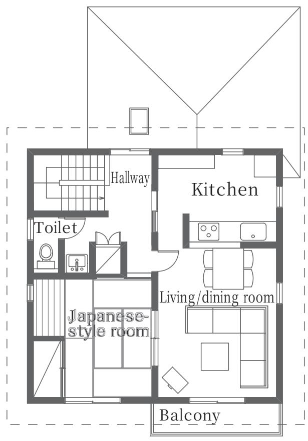
■First floor plan view



■Second floor plan view



■First floor plan view



■Second floor plan view

2.3.3 Basic Items to be Considered for Designing Low Energy Housing with Validated Effectiveness

1. Items to be considered for increasing housing durability

The hot humid region faces harsh natural environmental conditions such as high temperature and humidity, frequent typhoons, etc. In order to maintain long-term livability of housing in this region, it is essential to take countermeasures for the challenges brought by Mother Nature including heavy wind and rain, termites and salt damage. LEHVE aims to maintain long-term comfort and energy efficiency. Its fundamental principle is to plan for ensuring long-term livability and durability of housing by taking proper countermeasures to cope with these challenges.

The following shows examples of the possible factors influencing the durability of housing which are related to the natural environmental conditions of the hot humid region and their countermeasures for reference purposes (Table 9).

Table 9 Factors influencing housing durability and countermeasures

Influential factors	Description	Examples of countermeasures
Heavy wind and rain	The region faces frequent typhoons which often bring extremely heavy wind and rain. This may cause deterioration and water damage to the exterior of the house and broken windows due to flying objects.	• Install deep eaves, overhangs and flashing. • Use water-tight materials on the exterior openings. • Install storm doors, shutters or window bars on the exterior openings. • Make sure that roofing materials are securely fastened and fixed to the roof. • Bolt equipment frames to the envelope and securely fasten the main unit to the frame. • Install an evergreen hedge and plant trees (Choose varieties that are resistant to salt damage).
Termites	It is a warm humid region where termites are prevalent.	• Maintain good cross ventilation in the crawl space, attic, etc., to avoid retention of heat and humidity. • Place the right inspection spots in the crawl space, attic, etc., for easy inspection. • Ensure the concrete envelope and concrete slabs on earth or scarcement are cast as a single structure to prevent cracks and gaps. • Use lumber of termite resistant species. • Apply preservative and termite repellent to all the wooden components such as the timber frame. • Moisture control in the crawl space (adoption of slab on grade foundation or soil treatment, insulated foundation construction, etc.)
Salt damage	Places near the beach are influenced by the sea breeze throughout the year. During the typhoon season, seawater is fanned by a strong wind and mixed in the air. This can result in salt damage, causing the concrete envelope to crack or break away. Additionally, metal products used outside, such as sashes, railings and outside units, tend to rust.	• Finish the concrete surface with a paint, tiles, etc. • Make sure that there is a sufficient thickness of concrete covering. • Lay concrete with a low water-cement ratio to ensure solidity. • Apply surface treatment to metal components to increase corrosion resistance (hot dip galvanizing, etc.). • Apply weatherproof coating to metal components to increase corrosion resistance (fluorocarbon resin coating, etc.). • Rigorously inspect metal products. If rust is found remove it as early as possible and apply rust-proofing. • After typhoons have passed, wash the exterior walls and metal components with water.
UV light	Because of being located in the low latitude, the solar altitude is high and the UV light is intense. As such, paint work on the exterior finish, water proofing, sealants and other materials tend to deteriorate.	• Regularly reapply the coating of the exterior finish. • Cover the waterproofing material with top coating or a concrete or other protective layer. • Apply coating to the surface of the sealant and replace it regularly.

2. Items to be considered for applying elemental technologies

Lack of consideration in the early planning and design stage may lead to difficulty in applying elemental technologies or prevent the expected effects even if elemental technologies are applied. To avoid this, it is necessary to pay attention to the relationship between the planning and design items to be examined and the elemental technologies discussed in this document in the relatively early planning and design stage. Although there are various items to be examined in each stage of planning and design examination, the table below explains examples of major items to be discussed related to the layout, floor, sectional and component planning (material/specifications planning) and their relevance to the elemental technologies for reference purposes (Table 10).

Table 10 Relationship between planning and design items to be examined and elemental technologies

Type of planning/design	Items to be examined	Elemental technology							
		Use/control of wind	Daylight utili-zation	Photo-voltaic gener-ation	Use of solar radiation heat	Solar water heating	Insu-lated building envelope planning	Solar shading method	Energy-efficient equipment technologies (Commonly applicable)
Layout planning	Building position (distance from adjacent buildings, etc.)	◎	◎	○	◎	○		◎	
	Layout of major garden	◎	○		◎				
	Design of outer perimeter of the site	○	○						
	Planting layout	○						○	
	Outside equipment spacing								◎
Floor planning	Layout of major rooms	◎	○				○	○	○
	Kitchen and bathroom layout					○	○	○	○
	Layout/style of exterior openings	◎	◎		◎		◎		
	Layout/style of interior openings	◎	○						
	Exterior wall perimeter (overhangs, exterior floors, etc.)	○	◎		○		○	◎	
	Service yard layout					○			○
Sectional planning	Basic layer composition	○							○
	Roof composition			◎		◎	○		
	Ceiling composition		○				○		○
	Crawl space composition						○		
	Position/height of exterior openings	◎	◎		○		○		
	Exterior wall perimeter (overhangs, exterior floors, etc.)	○	◎		○		○	◎	
	Height of interior openings	○							
Component planning (materials/specifica-tions)	Building envelope materials/construction methods				○	○	◎	◎	
	Roof materials/construction methods			○	○	○	○	◎	
	Exterior wall materials/construction methods				○		○	◎	
	Specifications of exterior openings				◎		◎	◎	
	Interior materials		○		◎				
	Exterior materials		○					○	

Note: ◎ Particularly highly related, ○ Highly related
Items to be examined include those which are considered to be related to elemental technologies.

2.3.4 Examining Application of Elemental Technologies

As described above, it is considered desirable to examine the priority of the elemental technologies and decide the possibility and level of application after conceiving the target design model of LEHVE based on the site conditions and lifestyle orientations. Moreover, when deciding to adopt a certain elemental technology, it is necessary to verify both initial and running costs in addition to energy saving effects.

Details of the 13 elemental technologies are explained respectively in Chapters 3 to 5. The key information is as follows:

- **Purposes of elemental technology application and key points for design**
- **Energy saving effects of applied elemental technologies and how to achieve them**
- **Steps for examining elemental technology application**
- **Specific methods and details for applying elemental technologies**

2.3.5 Feasibility Study

Glossary:
Feasibility study
It refers to the process of verifying in advance the effectiveness and feasibility of the elemental technologies adopted.

It is beneficial to estimate the overall energy saving effects and costs of the house once the design work of LEHVE has progressed and the adoption of elemental technologies has been finalized to some extent.

It is difficult to set a general calculation method for energy saving effects and costs, however, Chapter 6 of this document evaluates under certain given conditions the energy efficiency (reduction level of primary energy consumption), global warming impact (CO_2 emissions reductions), and costs (initial and running costs) for reference purposes (See Sections 6.1 and 6.2).

Chapter 6 also shows simplified estimation methods for energy consumption based on this evaluation result. Use this information for estimating the energy consumption of LEHVE you design (See Section 6.3).

If the energy consumption reduction target has not been reached after completing the estimation, it is necessary to review the design (reexamine the details of elemental technology application) to the extent possible under given design conditions.

2.4 Energy Efficiency Indication Method

2.4.1 Meaning of Levels

Several energy conservation target levels (hereinafter referred to as the "level") are set for elemental technologies to show the differences in the level of energy saving measures.

- **Level 0 or design details not discussed in this document refer to the conventional design method (reference level of energy efficiency) that does not reach the standard of LEHVE.**
- **Level 1 or higher refers to the design details suitable for LEHVE. Countermeasures are set for each elemental technology according to the target level. The higher the number of the level, the higher the level of measures, indicating that higher energy saving effects can be achieved.**

The relationship between the uses of energy consumed during occupancy and the elemental technologies that can reduce them is shown in Table 2 of Section 2.2.2 on p.024. The explanation section of elemental technologies in Chapters 3 – 5 sets target levels and clearly illustrates the measures (e.g. methods) for achieving each level. It also shows how much energy saving effect (reduction ratio of primary energy consumption) can be expected using specific values regarding the uses of energy that can be reduced by implementing the measures for each level.

If the target design model of LEHVE is set and the priority of applying elemental technologies is considered, it is possible to efficiently increase energy efficiency by introducing the high level methods to the high priority elemental technologies.

2.4.2 Energy Saving Effects and Levels of Elemental Technologies

The uses of energy that can be reduced by applying elemental technologies and their energy saving effects and levels are summarized in Tables 11 and 12. See each section of Chapters 3 – 5 for details.

Table 11 Energy saving effects and levels of elemental technologies (Zone VI, reinforced concrete house)

Elemental technology		Uses of energy to be reduced	Energy saving effects and levels
Natural energy application technology	Use/control of wind	Cooling	4 – 12% reduction (Levels 1 – 3)
	Daylight utilization	Lighting	2 – 10% reduction (Levels 1 – 3)
	Photovoltaic power generation	Electricity	33.7 – 45.0 GJ reduction (Levels 1 – 2)
	Solar water heating	Domestic hot water	10 – 70% or higher reduction (Levels 1 – 4)
Heat control technology of building envelopes	Solar shading method	Cooling	10 – 30% reduction (Levels 1 – 4)
Energy-efficient equipment technology	Cooling system planning	Cooling	Individual cooling 10 – 35% reduction (Levels 1 – 3)
	Ventilation system planning	Ventilation	Duct ventilation 30 – 50% reduction (Levels 1 – 2) Through-the-wall ventilation 20% reduction (Level 1)
	Domestic hot water system planning	Domestic hot water	10 – 40% or higher reduction (Levels 1 – 4)
	Lighting system planning	Lighting	30 – 50% (Levels 1 – 3)
	Introduction of high-efficiency consumer electronics	Consumer electronics	20 – 40% reduction (Levels 1 – 2)
	Treatment and efficient use of water and kitchen waste	Water	Water saving device 10 – 40% reduction (Levels 1 – 2)

Table 12 Energy saving effects and levels of elemental technologies (Zone V, wooden house)

Elemental technology		Uses of energy to be reduced	Energy saving effects and levels
Natural energy application technology	Use/control of wind	Cooling	5 – 18% reduction (Levels 1 – 3)
	Daylight utilization	Lighting	2 – 10% reduction (Levels 1 – 3)
	Photovoltaic power generation	Electricity	32.7 – 43.6 GJ reduction (Levels 1 – 2)
	Use of solar radiation heat	Heating	5 – 35% reduction (Levels 1 – 4)
	Solar water heating	Domestic hot water	10 – 70% or higher reduction (Levels 1 – 4)
Heat control technology of building envelopes	Insulated building envelope planning	Heating	Partial intermittent heating 20 – 55% reduction (Levels 1 – 4)
			Whole-building continuous heating 40 – 70% reduction (Levels 1 – 4)
	Solar shading method	Cooling	15 – 45% reduction (Levels 1 – 3)
Energy-efficient equipment technology	Heating and cooling system planning	Cooling	Individual cooling 5 – 35% reduction (Levels 1 – 4)
			Central cooling 25 – 40% reduction (Levels 1 – 2)
		Heating	Individual heating 5 – 30% reduction (Levels 1 – 4)
			Central heating 20 – 45% reduction (Levels 1 – 2)
	Ventilation system planning	Ventilation	Duct ventilation 30 – 50% reduction (Levels 1 – 2)
			Through-the-wall ventilation 20% reduction (Level 1)
	Domestic hot water system planning	Domestic hot water	10 – 40% or higher reduction (Levels 1 – 4)
	Lighting system planning	Lighting	30 – 50% reduction (Levels 1 – 3)
	Introduction of high-efficiency consumer electronics	Consumer electronics	20 – 40% reduction (Levels 1 – 2)
	Treatment and efficient use of water and kitchen waste	Water	Water saving device 10 – 40% reduction (Levels 1 – 2)

There are various regional characteristics and types of houses in Zones VI and V, and a universal method for calculating the overall energy efficiency of housing has yet to be established. For this reason, this document calculates energy consumption using specific regions, family structures and housing conditions that are considered generic. Based on the calculation results, it illustrates energy saving effects and their estimation methods. Therefore, the values of energy saving effects shown in this document should be treated as a reference only. The energy consumption calculation was performed using the prerequisites of a detached reinforced concrete house in the suburb of Naha City, Okinawa for Zone VI and a detached wooden house in the suburb of Kagoshima City, Kagoshima for Zone V, in addition to a four-person family with standard lifestyle for both zones (Details will be explained in Chapter 6).

Methods described in this document and their energy saving effects are endorsed by reliable evaluation methods and validation experiments. Nevertheless, the development of method for more accurately estimating energy saving effects will continue to be a critical task.