Osaka Gas Experimental Housing “NEXT 21”
Introduction of Phase-4 Residential Experiment
Outline of NEXT 21
Architectural outline of NEXT 21

Experimental residence where the ideal style of urban multifamily housing for the near-future society is sought and verified

Completion: October 1993
Address: 6-16, Shimizudani-cho, Tennoji-ku, Osaka City
Site: 1,543 m²
Building size: Six stories above ground and one story underground
Dwellings & size: 18 units
(32 m² to 166 m²; Average 115 m²)
Total floor area: 4,577 m²
Green area: 934 m²
Architectural system

Testing state-of-the-art systems possible at that time

Skeleton-infill construction

Skeleton of NEXT 21 (Base building)
Architectural system

Testing state-of-the-art systems possible at that time
Testing state-of-the-art systems possible at that time

Flexible piping system
Symbiosis with nature

Testing the restoration of the natural ecosystem in an urban area
Seeking to simultaneously realize amenity as well as energy-saving, environmentally friendly living

Phase-1 Residential Experiment (FY1994 - 1998)

About 80% of outer walls are recycled.
Phase-2 Residential Experiment (FY2000 - 2004)

Special consideration to the global environment and comfortable daily living
Phase-3 Residential Experiment (FY2007 - 2011)

Housing and energy systems to support sustainable urban living

<table>
<thead>
<tr>
<th>MJ/30 days</th>
<th>FY2007</th>
<th>FY2008</th>
<th>FY2009</th>
<th>FY2010</th>
<th>FY2011</th>
<th>Goal</th>
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<tr>
<td>Baseline</td>
<td>38.9</td>
<td>31.9</td>
<td>30.2</td>
<td>30.1</td>
<td>26.8</td>
<td>25</td>
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</table>

* Cold start-up time: 5 minutes or less
History of NEXT 21 Residential Experiments

**Phase 1**
- 16 dwelling units
- Seeking to simultaneously realize “amenity” and “energy-saving, environmentally-friendly living”

**Phase 2**
- 16 dwelling units
- Special consideration of global environment and comfortable daily living

**Phase 3**
- 16 dwelling units
- Housing and energy systems to support sustainable urban living

**Phase 4**
- 2013
- Environmentally friendly, spiritually rich living
- Urban multi-unit housing encouraging close relationships among people, nature and energy

**Timeline**
- 1994: Phase 1
- 2000: Phase 2
- 2007: Phase 3
- 2013: Phase 4
The significance of NEXT 21 and the results of the residential experiments:

1. The demonstration model of environmentally symbiotic housing

2. The demonstration model of sustainable housing (= social assets) characterized by a long lasting “skeleton” (base building and utility systems) and “infill” (interior fit-out – “everything behind your front door”)

3. To provide the opportunity for testing, monitoring and evaluating home appliances and housing facilities/systems
The significance of NEXT 21 and the results of the residential experiments:

1. The demonstration model of environmentally symbiotic housing
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The significance of NEXT 21 and the results of the residential experiments:

3. To provide the opportunity for testing, monitoring and evaluating home appliances and housing facilities/systems
NEXT21 Phase-4 Residential Experiment
NEXT21 Phase-4 Residential Experiment

Concept

Environmentally friendly, spiritually rich living

Urban multi-unit housing encouraging close relationships among people, nature and energy.
The Concept of Phase 4

Environmentally friendly, spiritually rich living
Urban multi-unit housing encouraging close relationships among people, nature and energy
The Concept of Phase 4

Environmentally friendly, spiritually rich living

Urban multi-unit housing encouraging close relationships among people, nature and energy

The nature networks
Reconstructing the relationship between people and nature
The Concept of Phase 4

Environmentally friendly, spiritually rich living
Urban multi-unit housing encouraging close relationships among people, nature and energy

Reconstructing the relationship between people and nature

Creating people’s networks

The nature networks
The Concept of Phase 4

Environmentally friendly, spiritually rich living
Urban multi-unit housing encouraging close relationships among people, nature and energy

The nature networks
Reconstructing the relationship between people and nature

People’s networks
Creating people’s networks

Energy networks
Realizing a smart, energy-saving style of living
The Concept of Phase 4

Environmentally friendly, spiritually rich living

Urban multi-unit housing encouraging close relationships among people, nature and energy

Reconstructing the relationship between people and nature

The nature networks

Creating people's networks

Energy networks

Realizing a smart, energy-saving style of living

Housing
Experiments in Phase 4

1. Experiments on housing and living
   Verifying and proposing housing and manners of living responding to diverse lifestyles in the future

2. Experiments on energy systems
   Verifying the next-generation energy system to realize smart condominiums

The Concept of Phase 4

Environmentally friendly, spiritually rich living
Urban multi-unit housing encouraging close relationships among people, nature and energy

Creating people’s networks
Realizing a smart, energy-saving style of living

Reconstructing the relationship between people and nature
The nature networks

Housing

People’s networks
Energy networks

NEXT21 Phase-4 Residential Experiment

Experiments on Housing and Living
Residence evaluation through lifestyle surveys

Evaluating residences by surveying lifestyles in individual residences
Experiments on housing and living

1. Housing that creates a people’s network, while responding to lifestyles in an aging society with a declining birthrate

2. Housing that is environmentally friendly and symbiotic with nature, while inheriting the local residential culture
Proposals and experiments on environment-conditioning spaces

Traditional house design in temperate regions in Japan

House design with a focus on summer

Houses should be designed with a focus on summer.

From the 55th passage of Tsurezuregusa by Yoshida Kenko
Proposals and experiments on environment-conditioning spaces

The use of multiple layers helps optimize indoor thermal environment.
The use of multiple layers helps optimize indoor thermal environment.

Proposals and experiments on environment-conditioning spaces
You can appreciate a sense of the season, even on a hot (or chilly) day.

Cherry-blossom viewing, moon viewing, watermelon splitting, water play, barbecues, the Star Festival, fireworks, etc.
You can enjoy the comfortable fresh air of the outdoor environment. Child’s play, basking in the sun, enjoying the cool evening breeze, playing go, reading, working, studying, napping, enjoying meals, etc.
Proposals and experiments on environment-conditioning spaces

- Improving the efficiency of air conditioning by limiting heating and cooling in smaller spaces
Proposals and experiments on intermediate spaces

Creating private exchange spaces open to a shared zone and intermediate spaces to the local community to facilitate people’s close relationships

A private space inside a dwelling unit open to a shared zone

Suitable for children’s activities

A shared space in NEXT21 open to the outside

Suitable for gatherings of local residents and community activities
Unit #305: House with “blank” spaces
Unit #403: Resilient House

Entrance, food storage and a toilet/washbasin for students. Basin located outside the window. This basin can be used as a foot-bath or a sink.

65-year-old husband: retiree
- Enjoys a part-time job and hobbies
- Former cooking instructor
- Holds a cooking class at home, by making the spacious kitchen directly accessible from outside.

Visitors often enter this kitchen to participate in cooking classes.

This table is used as a work desk for the wife (as a cooking instructor), and also as a dining table or a food tasting counter for cooking classes.

This space can be used as an extension to the dining room, and is convenient when inviting neighbors.

This space is used for a "table-manners class" and Japanese-style etiquette class.

62-year-old husband: Retiree who enjoys a part-time job and plays guitar as a hobby.
- Housewife who is a gourmet and often goes out for lunch or dinner.
- She sometimes holds home parties. Their grown-up child already left home, and their niece is living as a tenant, using the child’s room.

Traditional Japanese-style garden with stepping-stones and a veranda, through which visitors can walk to reach the terrace entrance.

Visitors often enter this kitchen to participate in cooking classes.
Proposals and experiments on intermediate spaces

Creating private exchange spaces open to a shared zone and intermediate spaces to the local community to facilitate people’s close relationships

A private space inside a dwelling unit open to a shared zone

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A shared space in NEXT21 open to the outside

Suitable for gatherings of local residents and community activities
Promotion of people’s interaction through the use of an activity space

Creating an activity space made open to the nearby community to conduct various activities

To be used by NEXT 21 residents to create communication opportunities

To be used by NEXT 21 residents and local residents together to promote their exchanges

To be used by U-CoRo members for their activities to discover, share and utilize the understanding of the nearby community.
Demonstration experiments on nature and greenery

Creating “green corridors” within the residential building site to help provide a nature-rich urban living environment

- **Nectar plants**
- **Food plants** (Plants for caterpillars to eat)
- **Routes on which wild birds fly**
- **Feeding and resting places for wild birds**
- **Food plants** (Plants and trees with fruits or nuts for wild birds and butterflies to eat)
- **Nectar plants for wild birds to eat in winter**

![Diagram showing the layout of nectar plants and food plants within a residential building site.](image-url)
Redevelopment of a residential environment where people can enjoy the blessings of plants, breeze and sunlight in the urban area

Improving and rebuilding “green corridors”

Redevelopment of an ecological garden

Development situation of greenery on the rooftop
Creating greenery designed to be connected with plants on each floor so that wild birds and butterflies can fly around from the basement to the rooftop

Designing dwelling units so that residents can feel the changes of nature through the five physical senses, observing plants growing and wild birds flying around from the basement to the rooftop in their daily lives
NEXT21 Phase-4 Residential Experiment

Experiments on Energy Systems
Decentralized installation of SOFCs and energy interchanges

Demand response scheme and the adverse current mechanism

Independent power supply system

Introduction of the HEMS

Renewable energy in combination with conventional energy

Experimental items for energy systems

- Solar heat
- Solar power generation
- Storage cell
- Interchange of heat
- Interchange of electricity
- Utilization of cold and hot water
- ECOWILL
- ECOJOZU
- (Winter)
- Pretreatment unit
- Gas-powered unit
- Hot water tank
- Absorption heater-chillers
- Air conditioners installed in individual dwelling units
- Biogas generator
- Kitchen refuse

- Independent power supply to survive power outage (emergency situation)
- Use of desiccant (dehumidifier)
- Utilization of discharged heat
- Use of the "adverse current" electricity for residential zones
- Air conditioners
- Heater-chillers
- Kitchen refuse
- Biogas generator
- Pretreatment unit
- Gas-powered unit
- Hot water tank
- Absorption heater-chillers
- Air conditioners installed in individual dwelling units
- Heater-chillers
Experimental items for energy systems

A. Decentralized installation of SOFCs and energy interchanges
B. Demand response scheme and the adverse current mechanism
C. Independent power supply system
D. Introduction of the HEMS
E. Renewable energy in combination with conventional energy

Diagram:
- Solar heat
- Solar power generation
- Storage cell
- Interchange of heat
- Interchange of electricity
- Utilization of cold and hot water
- Biogas generator
- Pretreatment unit
- Gas-powered unit
- Hot water tank
- Absorption heater-chillers
- Air conditioners installed in individual dwelling units
- Storage cell
- Use of desiccant (dehumidifier)
- Interchange areas on the first basement to the 2nd floor
- Independent power supply to survive power outage (emergency situation)
A. Decentralized installation of SOFCs and energy interchanges

Solid Oxide Fuel Cell (SOFC) cogeneration system

ENE-FARM Type S (launched in April 2012)

Higher power generation efficiency than grid power

<table>
<thead>
<tr>
<th></th>
<th>ECOWILL</th>
<th>ENE-FARM PEFC</th>
<th>ENE-FARM type S SOFC</th>
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<tr>
<td>Power generation efficiency</td>
<td>26.3%</td>
<td>38.5%</td>
<td>46.5%</td>
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<tr>
<td>Exhaust heat recovery efficiency</td>
<td>65.7%</td>
<td>55.5%</td>
<td>43.5%</td>
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<tr>
<td>Heat output</td>
<td>2.6</td>
<td>1.4</td>
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<td>Electrical output</td>
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* LHV efficiency (as of April 2013)
A. Decentralized installation of SOFCs and energy interchanges

(1) Dwelling units share the capacity of SOFCs.

Taking full advantage of the power energy of highly efficient SOFCs

- Maintaining the rated-power high-efficiency operation of SOFCs in 4th-floor dwelling units as far as possible
- Promoting interchanges of surplus electricity or charging with storage cells
- Collecting surplus heat discharge from SOFCs to be used by dehumidifiers installed in shared zones
A. Decentralized installation of SOFCs and energy interchanges

(2) Effective heat utilization through the combined use of SOFCs and solar heat

Forecasting the improvement of power generation efficiency of SOFCs and the decline of heat output and compensating for the lack of discharged heat by using solar heat in winter

- Operating SOFCs in 5th-floor dwelling units in accordance with the electricity demand of each dwelling unit
- Using hot water generated through solar heat panels to save energy in winter
- Sending surplus waste heat to another dwelling unit in need
Aiming for higher power generation efficiency and small-size SOFCs

### A. Decentralized installation of SOFCs and energy interchanges

#### (3) Test operation of the next-generation, high-efficiency SOFC prototype

Aiming for higher power generation efficiency and small-size SOFCs

<table>
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<tr>
<th></th>
<th>2012 model</th>
<th>Next-generation model (goal)</th>
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<tr>
<td>Power generation efficiency(*)</td>
<td>46.5%</td>
<td>55%</td>
</tr>
<tr>
<td>Exhaust heat recovery rate(*)</td>
<td>43.5%</td>
<td>30%</td>
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<tr>
<td>Capacity of hot water tank</td>
<td>90L</td>
<td>10 ~ 30L</td>
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(*) in LHV

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The backup water heater units are of a conventional type.
Experimental items for energy systems

- **Decentralized installation of SOFCs and energy interchanges**
- **Demand response scheme and the adverse current mechanism**
- **Independent power supply system**
- **Introduction of the HEMS**
- **Renewable energy in combination with conventional energy**

**Diagram:**
- Solar heat
- Solar power generation
- Storage cell
- Interchange of heat
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- Utilization of cold and hot water
- Biogas generator
- Pretreatment unit
- Gas-powered unit
- Hot water tank
- Absorption heater-chillers
- Kitchen refuse
- Air conditioners
- Shared areas on the first basement to the 2nd floor

**Notations:**
- ECOWILL
- ECOJOZU
- Winter
- Next-generation
- Utilization of discharged heat
- Use of desiccant (dehumidifier)
B. Demand response scheme and the adverse current mechanism

(1) Demand response scheme

(1) Residents make energy-saving efforts.

(2) Home CHP systems increase power generation. (Operation control)

- ENE-FARM Type S (SOFC)
- ENE-FARM (PEFC)
- ECOWILL
- GENELITE (31 kW)

(3) CHP systems for shared areas increase power generation. (Operation control)
B. Demand response scheme and the adverse current mechanism

(2) Adverse current mechanism with home CHP systems

If the adverse current mechanism works with home CHP systems ..., the performance of CHP systems can be maximized to save energy. Stable supply of surplus electricity to an electrical grid is ensured.

Image of the “adverse current” mechanism (with SOFC)

Surplus electricity, created through the 24-hour rated-power operation, will be repurchased to a power company. Reduction in peak-time electricity purchases as a result of increased utilization of SOFC. Reduction in peak-time electricity purchases as a result of the effective utilization of surplus energy through the “adverse current” mechanism.
Experimental items for energy systems

- **Decentralized installation of SOFCs and energy interchanges**
- **Demand response scheme and the adverse current mechanism**
- **Independent power supply system**
- **Renewable energy in combination with conventional energy**

**A** Decentralized installation of SOFCs and energy interchanges

**B** Demand response scheme and the adverse current mechanism

**C** Independent power supply system

**D** Introduction of the HEMS

**E** Renewable energy in combination with conventional energy
C. Independent power supply system to survive power outage

Making use of CHP systems to establish an independent power supply system to survive power outage, while contributing energy saving at the same time.

At the time of power outage:
Gas-powered CHP units (GENELITE) can be turned on to run in self-operation mode.

- Electricity is supplied to dwelling units.
- SOFCs on the 3rd to 5th floors can supply electricity.
Experimental items for energy systems

- Decentralized installation of SOFCs and energy interchanges
- Demand response scheme and the adverse current mechanism
- Independent power supply system
- Introduction of the HEMS
- Renewable energy in combination with conventional energy
D. Introduction of the HEMS

(1) Visualization of energy and community services

- Estimated utility costs for this month
- Updates on consumptions of electricity, gas and water
- Information on actual internal power generation and energy interchanges
- Visualization of energy
- Communication among residents
- Customized calendar for family
- Internet supermarket
- Community services
Demonstrating the functions of the HEMS attractive to end users through residential experiments

D. Introduction of the HEMS

(2) Demonstration of the next-generation HEMS (Unit #601)

Demonstrating the functions of the HEMS attractive to end users through residential experiments

- **Tablet**
  - 10 kinds of operations
  - Visualization of energy consumption by room and by energy system/Operation screen display

- **Wall display**
  - Understanding of utility costs and the status of energy consumption can be shared by family members who can see the wall display at any time.

- **Table display**
  - The tablet terminal can promote family communications regarding the status of their energy consumption and saving needs.
Experimental items for energy systems

- Decentralized installation of SOFCs and energy interchanges
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- Renewable energy in combination with conventional energy

Diagram:
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- Solar power generation
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- Interchange of heat
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- Utilization of cold and hot water
- Biogas generator
- Pretreatment unit
- Gas-powered unit
- Hot water tank
- Absorption heater-chillers

Legend:
- Kitchen waste
- Air conditioners installed in individual dwelling units
- Heater-chillers
- Storage cell
- Use of dehydrant (dehumidifier)
E. Renewable energy in combination with conventional energy

Combining gas systems designed for multifamily housing with renewable energy

**Solar thermal energy**
Through the utilization of solar thermal energy together with the recycling of waste heat discharged from CHP units, seeking to promote energy saving of the centralized air conditioning system for the residential building.

**Biogas**
- Collecting kitchen refuse to generate biogas
- Blending biogas with city gas to feed into CHP units as fuel

Diagram:
- City gas
  - Equipment for the generation of biogas
  - Equipment for pretreatment and blending
  - Gas-powered system
  - Solar panel
  - Heat-powered absorption heater-chiller
  - Gas-powered absorption heater-chiller
  - Air conditioners inside dwelling units and in shared areas
E. Renewable energy in combination with conventional energy

Combining gas systems designed for multifamily housing with renewable energy

Solar power generation
- Realizing the Smart Energy House with a 3-way power system consisting of SOFCs, storage cells and solar cells (Unit #603)
- Conducting a second demonstration experiment on the Smart Energy House, using a dwelling unit in multifamily housing, following our previous experimental project with an independent house

Concepts of the Smart Energy House
- Simultaneous realization of energy saving and comfortable living
  - Comfortable energy saving through the use of a 3-way power system
  - Total management of heat and electricity

“Smart Energy House” Live-in experimental house (Oji-cho in Nara Prefecture)
Experimental items for energy systems

A. Decentralized installation of SOFCs and energy interchanges
B. Demand response scheme and the adverse current mechanism
C. Independent power supply system
D. Introduction of the HEMS
E. Renewable energy in combination with conventional energy
Aiming at the realization of environmentally friendly and spiritually rich living