ECEEE 2007 Summer Study
La Colle sur Loup

New challenge for residential building energy efficiency standards in Japan

- unify energy efficiency of envelope and housing appliances -

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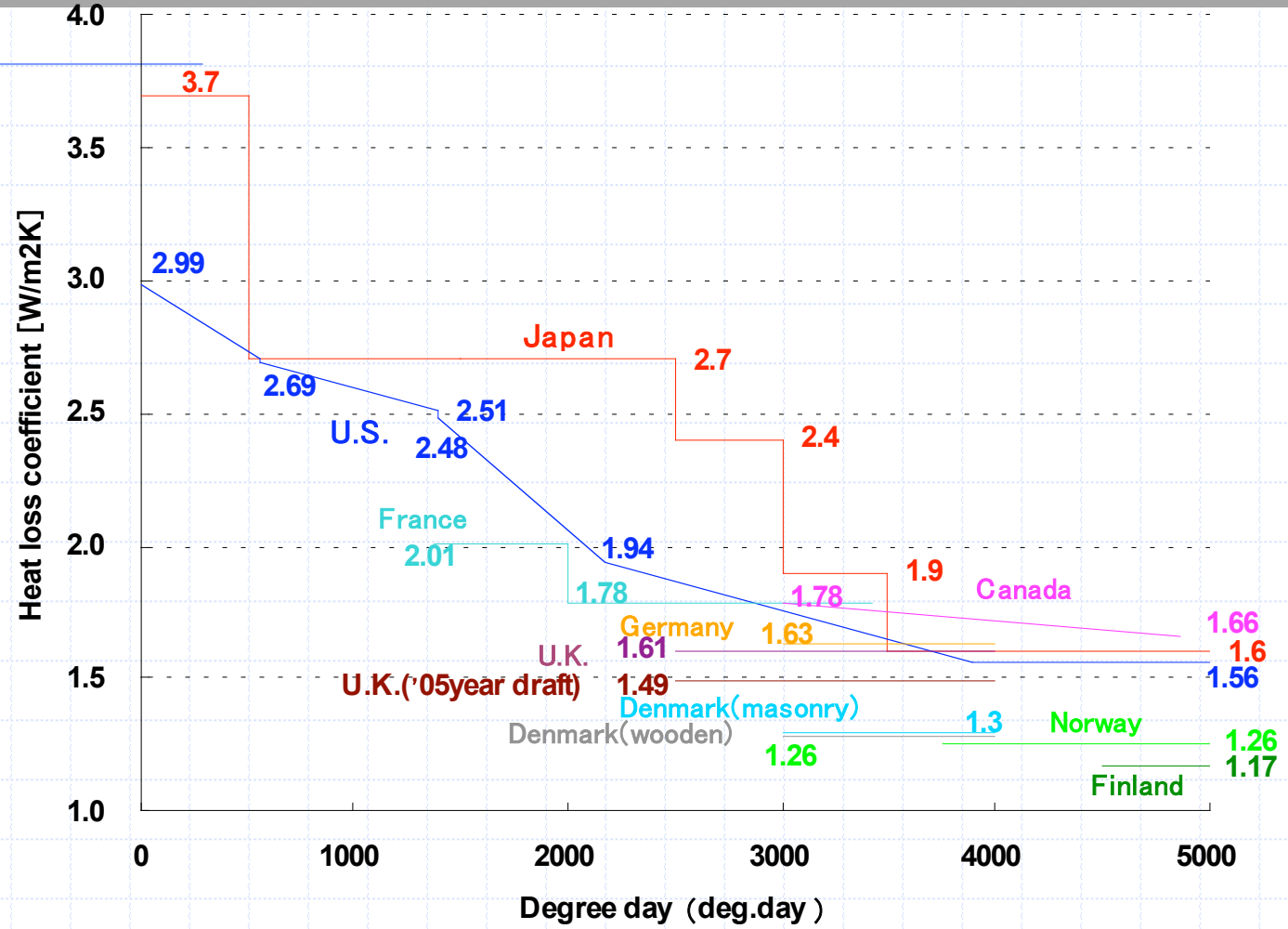
Overview of Presentation

- Composition of housing EE Standard
- Development of a new method to evaluate EE performance
  - ✓ Framework for evaluation of appliance EE
  - ✓ Evaluation method for space heating
  - ✓ Evaluation method for water heater
- Results of Energy Consumption Calculation
- Conclusion

Composition of housing EE Standard

- **Performance standard**
  - ✓ **Standard of annual heating and cooling load**
  - ✓ **Standard of heat loss coefficient**
  - ✓ **Standard of coefficient of solar heat gain**
  - ✓ Standard of equivalent leakage area per unit floor area
  - ✓ Proper ventilation
  - ✓ Ventilation, elevators, and lighting energy consumption in common areas of buildings with floor area 2000 m2 or greater
- **Prescriptive standards**
  - ✓ Thermal transmittance of envelope & shading measure & airtight measure
  - ✓ Specification of insulation elements

Comparison standards by estimated heat loss coefficient



Source: Tomoyuki Karatsu, 2006, Comparison of world housing energy efficiency standards, The Kenchiku Gijutsu, No.679, August 2006

Note: estimated from U value standards of each parts based on 120 m2, general housing plan in Japan.

New method of evaluate EE performance

- Present standard
  - ✓ Evaluate energy efficiency of envelope.
  - ✓ TRS evaluate energy consumption or EE for a fixed condition.
- New method of evaluate EE performance
  - ✓ Evaluate every end-use together, comprehensively.
  - ✓ For space conditioning, evaluate energy efficiency of the envelope and appliances at the same time.
  - ✓ Evaluate the efficiency during actual operation.

Develop a method of calculating energy consumption

- Subdivide some regions.
- Calculate annual heating, cooling and water heating load based on standard usage patterns by region.
- Perform measurements in the laboratory for air conditioners and floor heating, to analyse the relation between load and efficiency.
- Perform laboratory measurements of energy consumption for water heating boilers, heat pump water heaters, and co-generation,to analyse the efficiency of each appliance.
- From the set heat load and the results of analyses of equipment efficiency characteristics, we obtain a model for calculating whole house energy consumption.

Framework for evaluation of appliance energy efficiency

$E <= E_0$

- ✓ E: calculated results of energy consumption for an actual house
- ✓ E_0: calculated results of energy consumption for a standard house or appliance

$E = Eh + Ec + Ew + Ev + El - Es$

$E_0 = Eh_0 + Ec_0 + Ew_0 + Ev_0 + El_0$

- ✓ Eh: heating energy consumption
- ✓ Ec: cooling energy consumption
- ✓ Ew: water heating energy consumption
- ✓ Ev: ventilation energy consumption
- ✓ El: lighting energy consumption
- ✓ Es: reduction in energy consumption from solar electric power generation and others

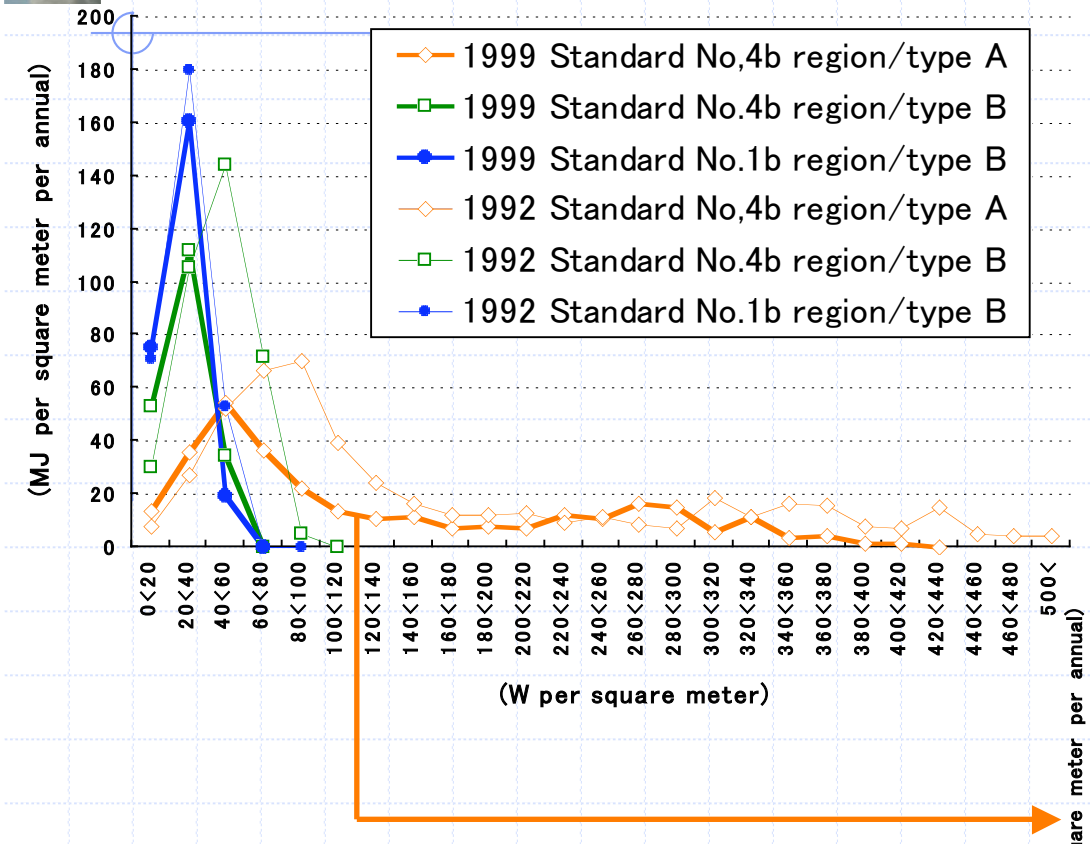
Setting space conditioning loads

Performing heat load simulations for standardized living conditions : we calculated 64 cases

- ✓ Regional divisions: 8 cases
- ✓ Housing types: detached and multifamily; 2 cases
- ✓ Space conditioning mode: whole house continuous operation, and room by room (called partial) intermittent operation; 2 cases; for partial, intermittent operation we calculate loads for the living room (LDK, or living, dining and kitchen), and for each other room
- ✓ envelope energy efficiency: meets 1999 standards and meets 1992 standards; 2 cases

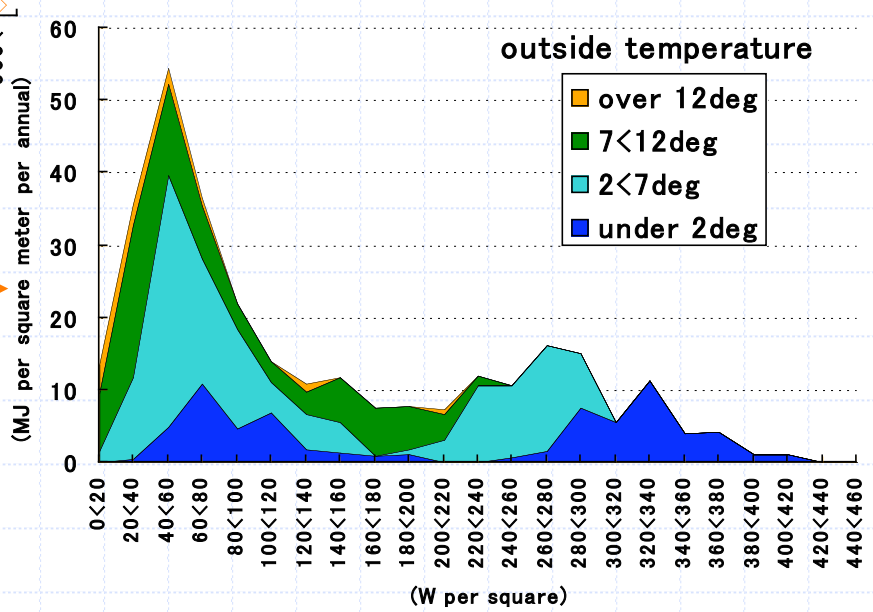
We estimated frequency distribution for space conditioning load.

Frequency distributions for heat load for living room of a wooden, detached house



type A=intermittent heating of the living area

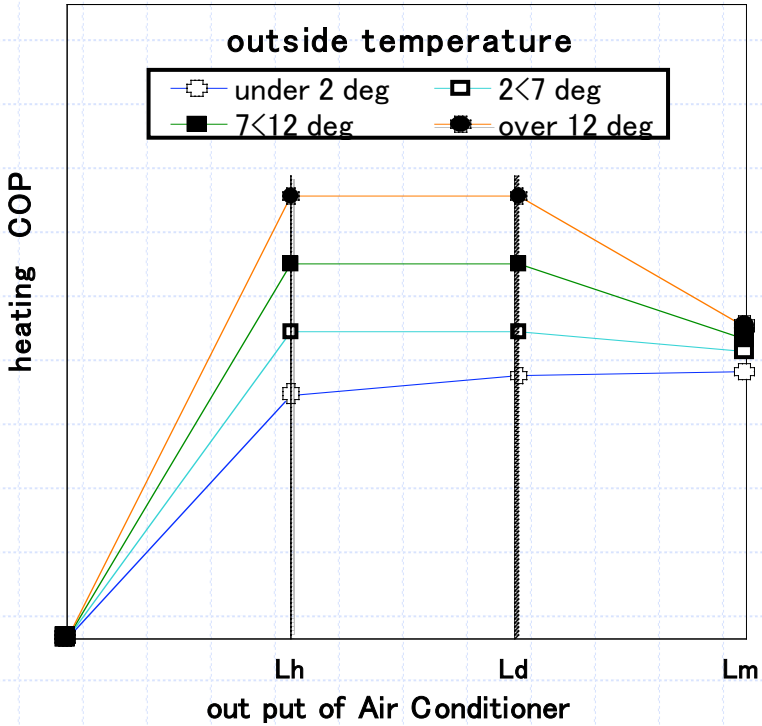
type B=whole house, continuous heating



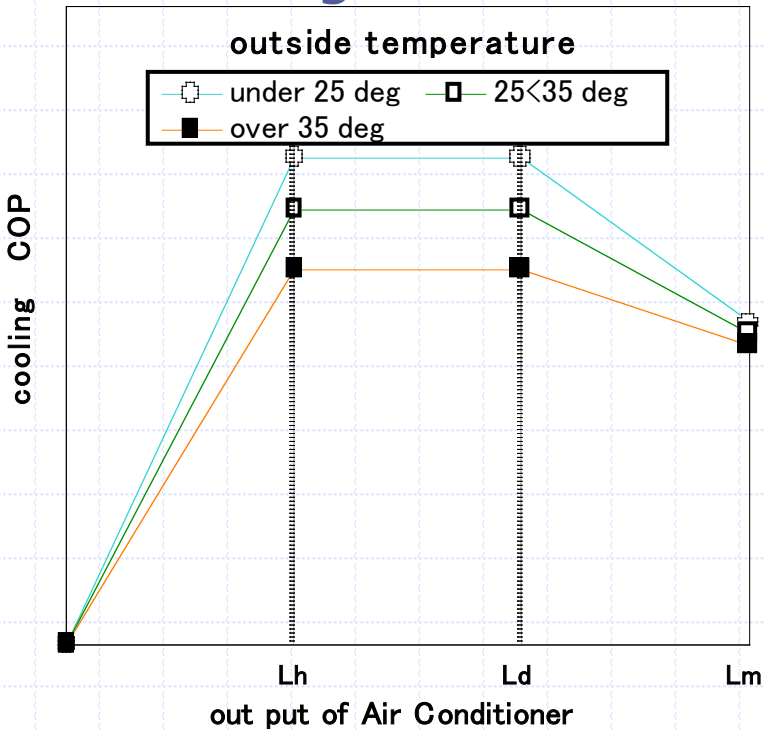
Region No. 4b: The envelope efficiency meets 1999 standards, and the heating mode is partial, intermittent.

Characteristics of air-conditioner efficiencies

<Heating>



<Cooling>

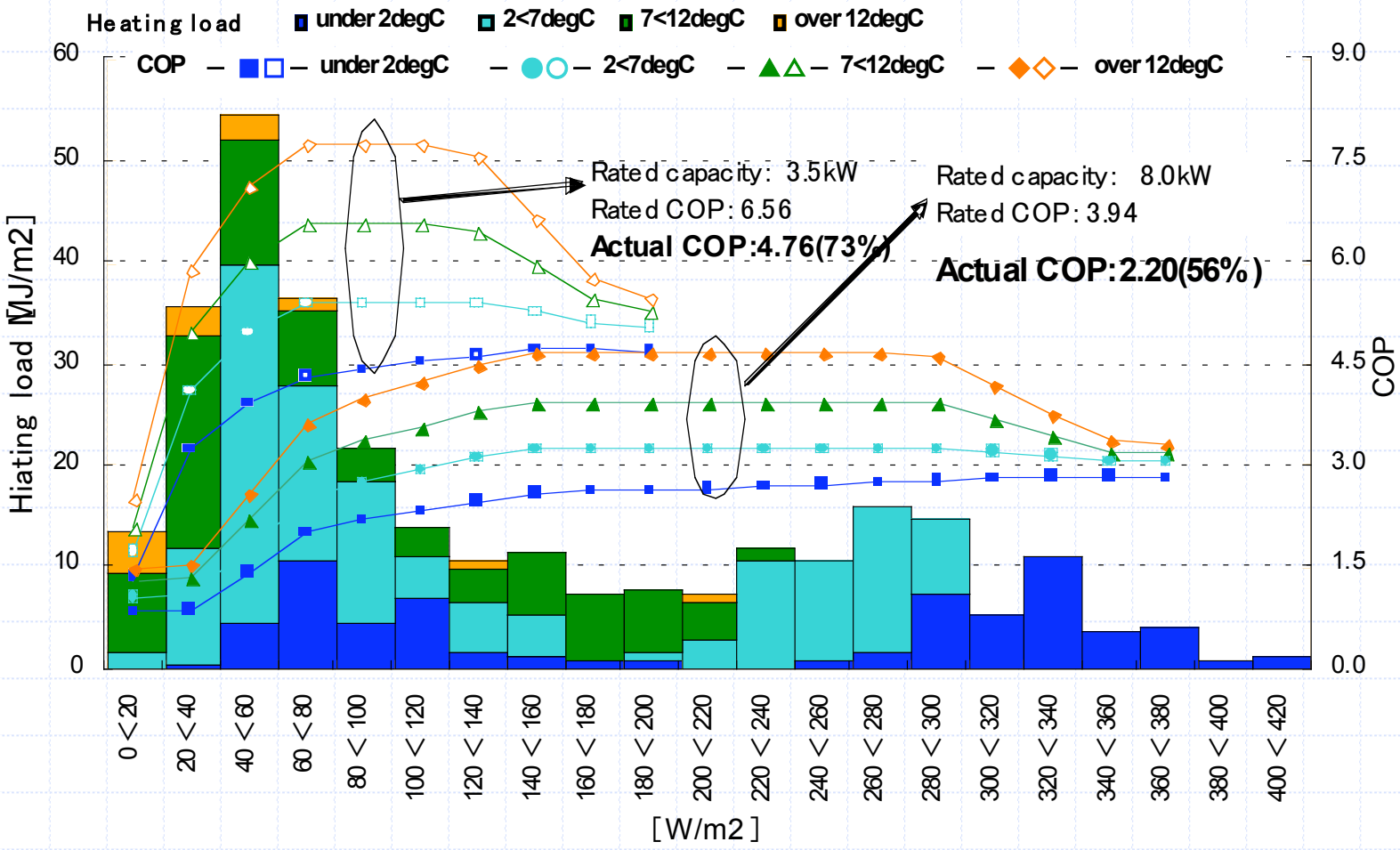


Lh: half of rated output

Ld: the design, or rated output

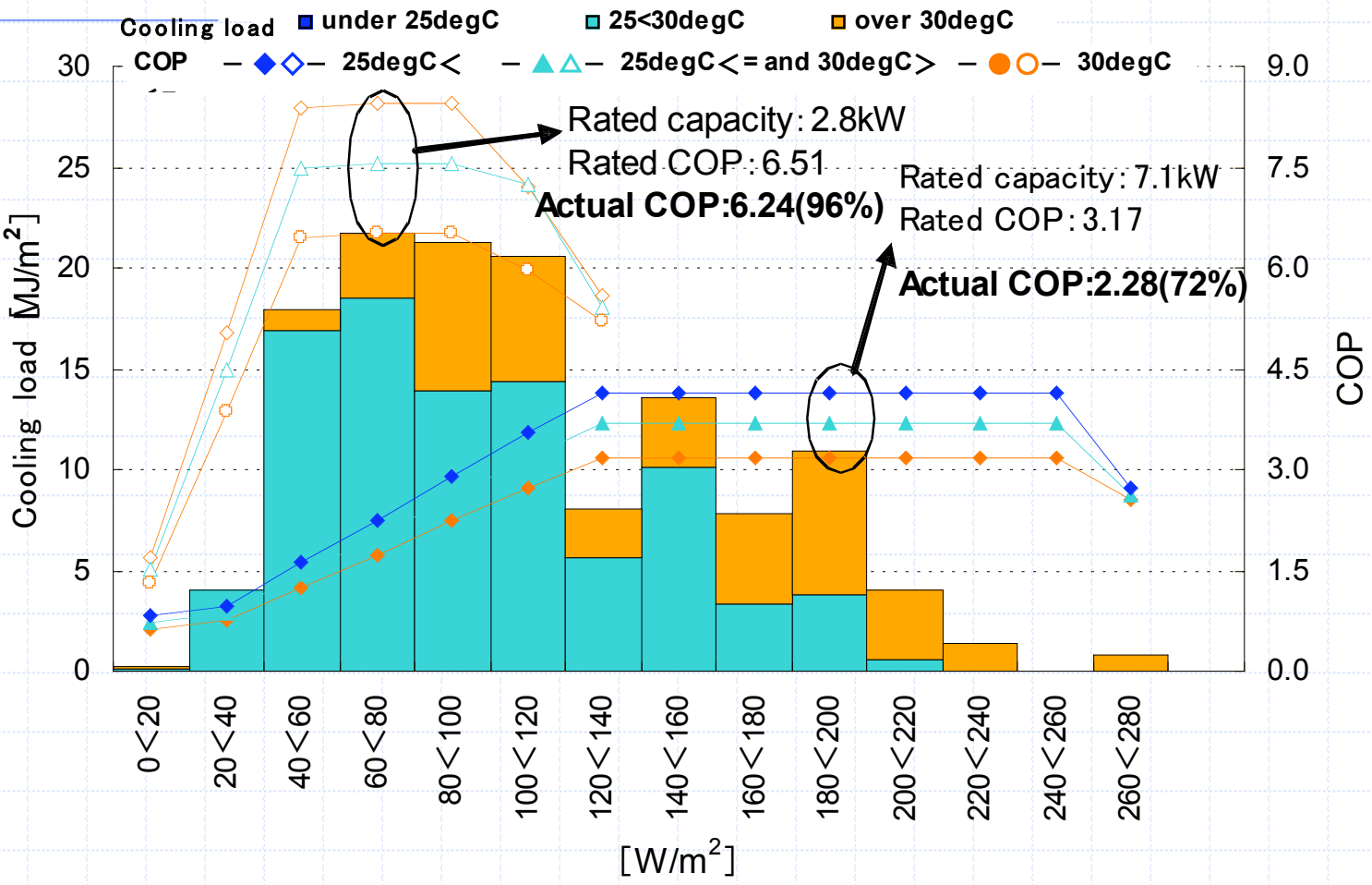
Lm: the maximum output

Relation between heating load and air conditioner heating efficiency



Living room:27.7m^2 / Region: No.4b(Tokyo)

Relation between cooling load and air conditioner cooling efficiency



Living room:27.7m^2 / Region: No.4b(Tokyo)

Annual water heater load & water heater efficiencies in region No.4b(Tokyo)

Annual water heater loads(MJ/year):17.0

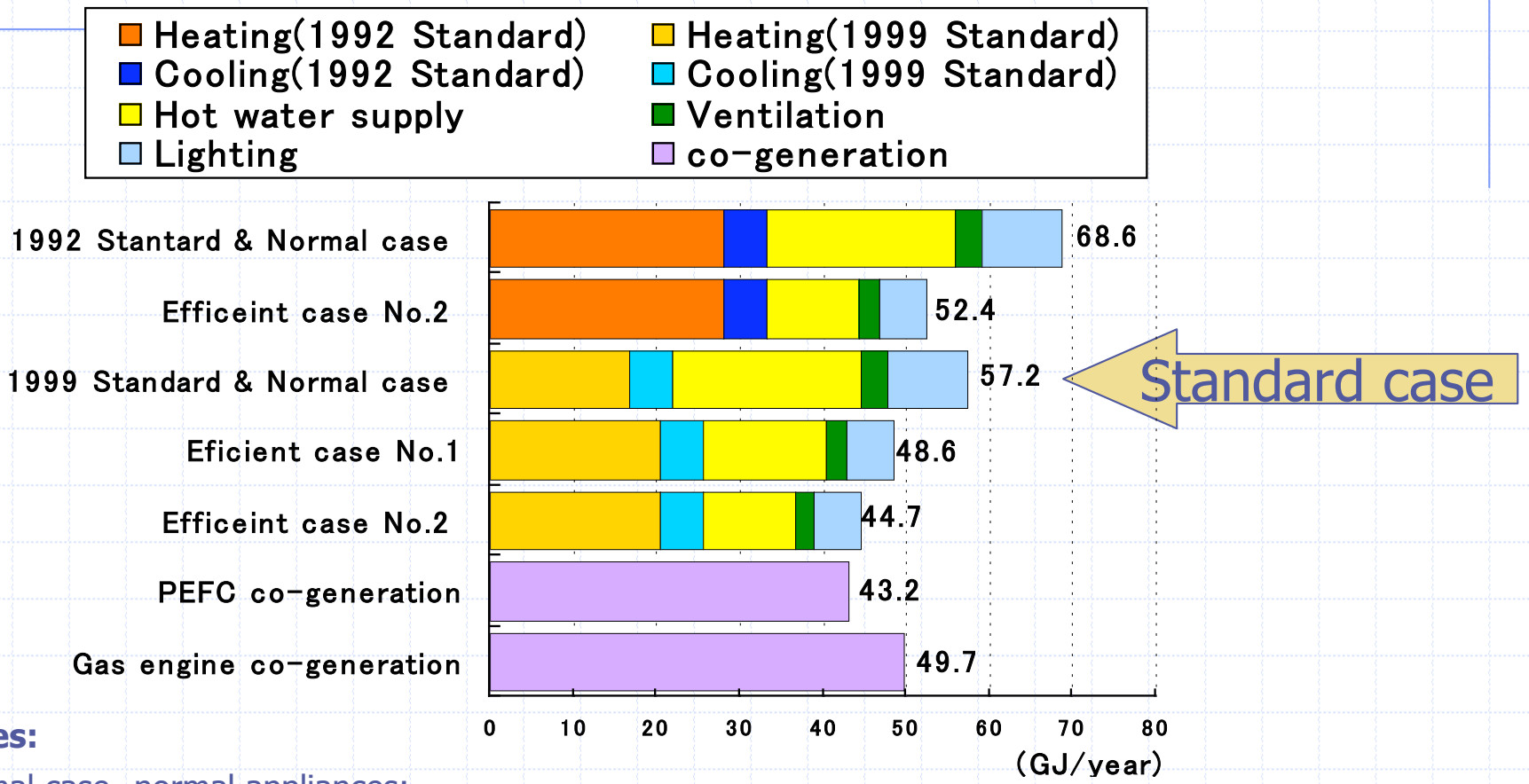
Water heater efficiencies

- gas on-demand water heater:0.73
- latent heat recovery gas on-demand water heater:0.86
- kerosene on-demand water heater:0.79
- kerosene tank water heater:0.77
- electric water heater:0.74
- CO_2 heat pump water heater:3.12

Energy saving rate for water heating energy efficiency measures

- kitchen, sprayer water column:4%
- bath room,water-conserving showerhead:4%
- piping, small diameter piping:5%

Results of Energy Consumption Calculations



Notes:

Normal case=normal appliances;

Efficient case No.1=most efficient air-conditioner + condensing boiler + efficient ventilation and lighting;

Efficient case No.2=most efficient air-conditioner + CO2 heat pump hot water supply + efficient ventilation and lighting;

Electricity conversion rate=9,760kJ/kWh.

Conclusion

- Energy efficiency standards of many countries address a house's envelope and appliances with separate standards.
- Japanese building energy efficiency standards were not made mandatory, construction of housing meeting the standards has not progressed.
- Many experts proposed Government to change the standard as mandatory. And Government began to examine it.
- Because residential energy efficiency varies greatly depending on the performance of appliances, we developed a method to evaluate performance of both the envelope and the appliances.
- The evaluation method we developed will have a major impact on future Japanese standards for residential energy efficiency.

Thank you!!

For more information

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Back ground slides

Examination process of the energy efficiency codes

Performance codes

Perscriptive codes

Case A

Standards of annual heating and cooling load

Case B

Standards of heat loss coefficient

Case C

correction factor for solar heat gain(passive solar)

Case D

Specific codes of design and construction

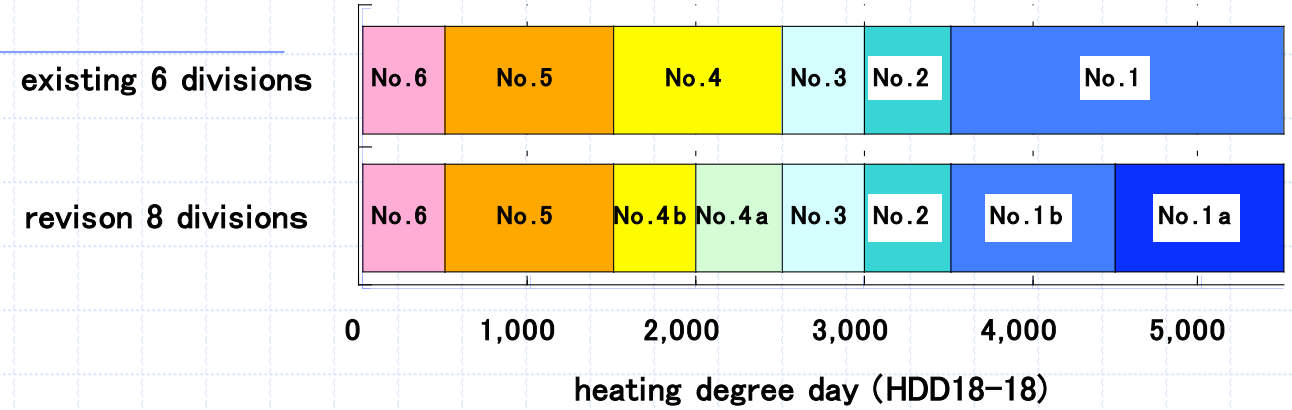
Standard of equivalent leakage area per unit floor area

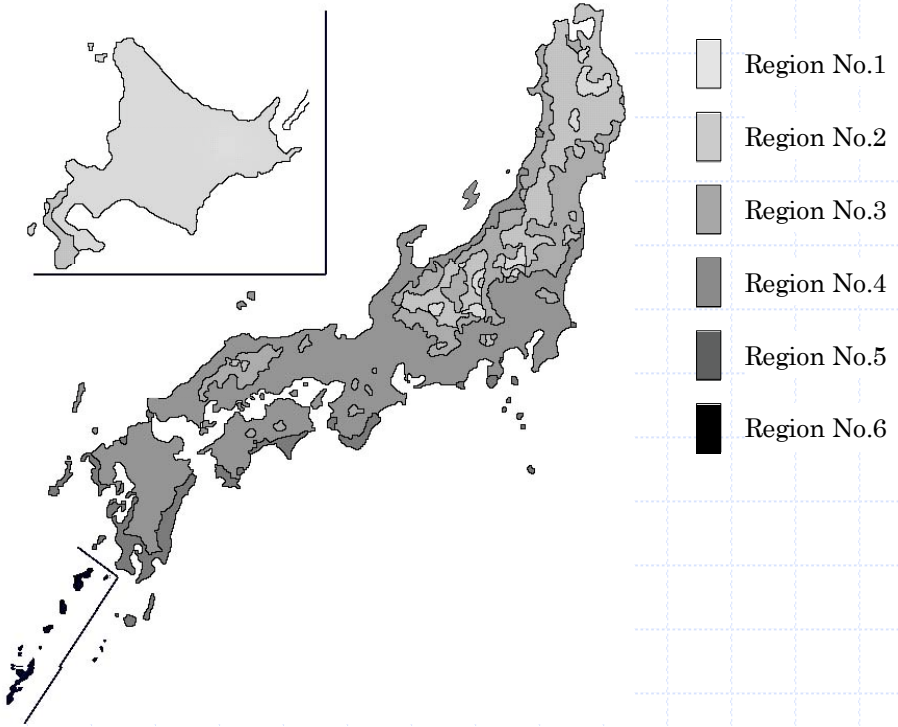
Other aspects (condensation prevention, protection, ventilation, air conditioning and cross ventilation)

Standard of energy consumption in common areas of buildings with area over 2000 m2

Division of regions

Regional divisions





Efficiency of radiant heating & other heating appliances

<Efficiency of radiant heating>

E=1/eb*(Qr/ep+Cp*Lp)

E: radiant heating rate of energy consumption (W)

eb: heat source efficiency

Qr: radiation from the radiant panel to the room (W)

ep: ratio of panel radiation up and down (for floor heating this depends on the insulation properties beneath the panel)

Cp: rate of heat loss by distribution pipes (W/m)

Lp: length of distribution pipes (m)

Qr=L*A*0.9 L: heat load per unit area (W/m2) A: living room area (m2)

<Efficiency of other heating appliances>

Heating appliance	Efficiency of appliance	Top Runner Standard
Gas Forced Draught Balanced Flue	0.8	0.82
Oil Forced Draught Balanced Flue	0.85	0.86
Oil Balanced Flue	0.83	0.83
Oil Conventional Flue	0.67	0.69
Other Oil Heater	0.67	0.67

Annual water heater load & water heater efficiencies by region

	No.1a	No.1b	No.2	No.3	No.4a	No.4b	No.5	No.6
Annual water heater loads(MJ/year)	22.5	22.0	20.8	19.8	18.8	17.0	14.5	12.4
gas on-demand water heater	0.71	0.71	0.72	0.72	0.72	0.73	0.73	0.75
latent heat recovery gas on-demand water heater	0.88	0.88	0.87	0.88	0.87	0.86	0.86	0.85
kerosene on-demand water heater	0.76	0.77	0.78	0.78	0.78	0.79	0.79	0.82
kerosene tank water heater	0.74	0.75	0.76	0.76	0.76	0.77	0.76	0.79
electric water heater	0.76	0.76	0.75	0.75	0.75	0.74	0.74	0.72
CO2 heat pump water heater	-	-	-	2.85	2.92	3.12	3.15	3.41

Evaluation method for co-generation

Et=C1Ee+C2Lw+C3

- ✓ Et: energy consumption of the co-generation system (GJ/year)
- ✓ Ee: electricity supplied by the co-generation system for heating , cooling, lighting, and ventilation (GJ/year)
- ✓ Lw: heat load supplied by the co-generation system for water and space heating (GJ/year)
- ✓ C1, C2, C3: coefficients shown below

	gas engine co-generation/	fuel cell co-generation
C1	0.999	0.995
C2	1.098	0.261
C3	0.70	5.35