Cooling Energy:
Demand, Technology and Institution

Experts’ Group on R&D Priority-setting and Evaluation (EGRD)
IEA Committee on Energy Research and Technology (CERT)
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• Since 1978
• Non-profit organization
• Expertise - energy technology assessment
• Energy areas
• Visit http://www.iae.or.jp for further information
1. Building Energy Intensity Trend in Japan
   - Demand

2. Labels and Standards
   - Institution

3. Toward ZEB/ZEH
   - Technology and Institution

4. Summaries
1. Building Energy Intensity Trend in Japan

2. Labels and Standards

3. Toward ZEB/ZEH

4. Summaries
Commercial Energy Intensity and Activity Index

- Intensity
  (+: incr. factors
  -: decr. factors)
  - Equipment efficiency improvement (-)
  - Heat insulation (-)
  - Size and number of appliances (+)
  - Additional cooling demand from appliance heat (+)

- Floor space increase cancels out intensity effects

Source: IEEJ estimate

Commercial Energy Intensity by Category

- Appliance etc
- Cooking
- HotWater
- Cooling
- Heating
- Floor space

Commercial Energy Intensity by Source

- Thermal
- Coal
- Oil
- Gas
- Electricity

Notes
(#) Gas includes town gas and LPG.
(#) Thermal includes geothermal and solar thermal.

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Residential Energy Intensity and Activity Index

- Intensity
  (+: incr. factors
  -: dechr. factors)
  - Household size (-)
  - Equipment efficiency improvement (-)
  - Size and number of appliances (+)
  - Heat insulation (-)

- Household number increase cancels out intensity effects

Source: IEEJ estimate

Residential Energy Intensity by Category

Residential Energy Intensity by Source

Notes (#): Coal etc includes charcoal, fuelwood, heat.
Cooling Energy Intensity of Buildings

- Residential cooling energy intensity peaking
  - Equipment efficiency (-)
  - Conservation behavior in recent years (?)
  - Household size (-)

- Commercial cooling energy intensity peaking
  - Gas share is comparable to electricity
  - Equipment efficiency (-)
  - Conservation behavior in recent years (?)

Source: IEEJ estimate

Cooling Energy Intensity (Residential)

Cooling Energy Intensity (Commercial)
Cooling Degree Day in Urban Areas

- Large differences among regions.
- Urbanization would accelerate heat island effects.
- Inter-annual variability between peak years and off-peak years.

(Notes) * Cooling Degree Day (CDD) = Annual integration of daily average temperature above 24degC.
* Offset temperature is 22degC.
* Average numbers are population weighted by 9 regions.

Source: IEEJ estimate

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Outline

1. Building Energy Intensity Trend in Japan
2. Labels and Standards
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Top Runner Program

- Mandatory program from 1999. Encourages competition among companies by setting the efficiency targets for next 3 to 10 years.
- Program has contributed to the significant energy efficiency improvement.
- Building materials are added recently.

Top Runner Products (Directly related to cooling functions)


Source: METI, Japan
Energy Performance Labeling

- Labeling for manufacturers and retailers.

Source: METI, Japan
Category
- Floor space: large (2000m²-), medium (300m² - 2000m²), small (-300m²)
- Non-residential, residential

Enforceability as new law effective from April 2016, full operation from 2017
- Obligation, notification, efforts (category dependent)

BELS (Building-housing Energy-efficiency Labeling System)
- BEI (Building Energy Index)
  \[ BEI = \frac{\text{(design primary energy cons (*) )}}{\text{(reference primary energy cons (*))}} \]
  (*) excludes appliance energy consumption after completion of building

<table>
<thead>
<tr>
<th>Ratings</th>
<th>House BEI (office, school, factory, etc.)</th>
<th>Non-House BEI (hotel, hospital, department store, restaurant, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 stars</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>4 stars</td>
<td>0.85</td>
<td>0.7</td>
</tr>
<tr>
<td>3 stars</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>2 stars</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1 star</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Source: MLIT, Japan
International Collaboration – Working with Asia

- Capacity building of energy efficient equipment performance tests.
- Industrial standard with Asian countries. Energy efficiency performance evaluation in the product standards (i.e. ISO and IEC).
  - China, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand, Vietnam
  - Product coverage: air-conditioner, refrigerator, LED, building material, etc.
  - Air conditioner is one of important target products. Japan submitted ISO new work item proposal, and new ISO 16358 (#) published in 2013 includes testing and rating methods of high efficient inverter-type air conditioner.

Source: METI, Japan

ISO/TC 86/SC 6  Testing and rating of air-conditioners and heat pumps
ISO 16358  Air-cooled air conditioners and air-to-air heat pumps
  -- Testing and calculating methods for seasonal performance factors
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Outline

Source: METI, Japan

Advanced energy-saving buildings to achieve the ZEB status

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What is ZEB?

- ZEB = Net zero energy building
- ZEB is a building with considerably reduced annual energy consumption by saving as much energy as possible via better heat insulation, solar shading, natural energy and high-efficiency equipment as well as creating energy (e.g. photovoltaic power generation), while maintaining comfortable environments.

Source: METI, Japan

ZEB Definition and Categories

- **ZEB definition and categories**
  - ZEB ready: 50% or more energy saving wrt reference
  - Nearly ZEB: reduction of 75% or more
  - ZEB: reduction of 100% or more

*Source: METI, Japan*
## Promotion of ZEB Diffusion

- **Design guidelines, technology development, public outreach**
- **Standard and labeling**

### Energy-specific type vs. Comprehensive evaluation type

<table>
<thead>
<tr>
<th>Energy saving rate</th>
<th>Energy Star (US)</th>
<th>Energyausweis (DE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▲40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▲60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▲80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▲100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The 2013 Energy Saving Standard</th>
<th>BELS</th>
<th>Certified low-carbon building</th>
<th>ZEB</th>
<th>CASBEE</th>
<th>LEED</th>
<th>BREEAM (UK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent to the 2013 Energy Saving Standard</td>
<td>2 ★</td>
<td>Equivalent to the certified low-carbon building</td>
<td>ZEB</td>
<td>Level 3</td>
<td>Evaluation criteria for the energy performance of NC (new construction)</td>
<td>1 point added for each two additional energy saving</td>
</tr>
<tr>
<td>* Including renewable energy related to self-consumption and home electric appliances</td>
<td>3 ★</td>
<td>* Including renewable energy related to self-consumption and home electric appliances</td>
<td>ZEB Ready</td>
<td>Level 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 ★</td>
<td></td>
<td></td>
<td>Nearly ZEB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ZEB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 ★</td>
<td></td>
<td></td>
<td>Level 5</td>
<td>CASBEE</td>
<td>Evaluation criteria for buildings (newly-constructed)</td>
<td>Level 5-3</td>
</tr>
<tr>
<td>* Including renewable energy related to self-consumption and home electric appliances</td>
<td></td>
<td></td>
<td></td>
<td>19 out of 19 points</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** METI, Japan

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**Workshop on Space Cooling, Experts’ Group on R&D Priority-setting and Evaluation (EGRD)**
What is ZEH?

- ZEH = net zero energy house
- ZEH is a house with an annual net energy consumption around zero (or less) by saving as much energy as possible while maintaining comfortable living environment. This can be achieved through better heat insulation, high-efficiency equipment, and creating energy with photovoltaic power generation.

Source: METI, Japan

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### Require as little energy as possible
(Cool in summer and warm in winter)

### More efficient use of energy

- Heating
- Cooling
- Ventilation
- Lighting
- Hot water supply

### Create energy

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<table>
<thead>
<tr>
<th>Region category</th>
<th>Region 1 (Asahikawa, etc.)</th>
<th>Region 2 (Sapporo, etc.)</th>
<th>Region 3 (Morioka, etc.)</th>
<th>Region 4 (Sendai, etc.)</th>
<th>Region 5 (Tsukuba, etc.)</th>
<th>Region 6 (Tokyo, etc.)</th>
<th>Region 7 (Kagoshima, etc.)</th>
<th>Region 8 (Naha, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZEH Standard</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>–</td>
</tr>
<tr>
<td>Energy Saving Standard</td>
<td>0.46</td>
<td>0.46</td>
<td>0.56</td>
<td>0.75</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
<td>–</td>
</tr>
</tbody>
</table>

Table: Standards for the average heat transmission coefficient of the envelope (UA value)
ZEH Definition and Categories

- ZEH definition and categories
  - 20% or more energy saving wrt reference
  - Nearly ZEH: reduction of 75% or more
  - ZEH : reduction of 100% or more

Source: METI, Japan
Promotion of ZEH Diffusion

- Incentives, SME training, public outreach
- Standard and labeling

Source: METI, Japan

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R&D Example: Commercial Building Cooling

- Developed for ZEB HVAC prototype.
- Liquid cooling for energy conservation and comfort.

**Conventional System**

- Low temp. chilled water (7degC).
- Temp. distribution is not uniform.

**Liquid Cooling System**

- Chilled water temp. (21degC) is close to room temp.
- Uniform temp. distribution.

Source: NEDO, Japan
Concept of New Commercial Building Cooling

System Concept
Source: NEDO, Japan

- (6) ZEB energy management system
- (2) Desiccant air conditioning for outdoor latent heat exchange
- (3) Liquid cooling system for indoor sensible heat
- (1) Liquid cooling system for indoor heat source
- (4) Liquid cooling piping inside building
- (5) Heat recovery from indoor heat source
- (7) Desiccant air conditioning

Unit or Equipment

- Solar Heat Radiation panel
- Cooling tower
- Air source HP
- Absorption refrigerator
- Water source HP
- Heat exchange unit
- Heat exchange unit for LEDs
- Chilled Beam
- Heat recovery water
- Leakage breaker
- Chilled water outlet
- PC

Subsystem

- Hot Water
- Chilled Water

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Technological Challenges – We Need innovations

- **Passive technologies** such as:
  - Heat insulation: Thin materials (e.g. vacuum insulation)
  - Building shell: Radiative self-cooling material that reflects solar radiation during days and nights
  - Natural lighting and/or natural ventilation adjusted to local climate and urban design

- **Active technologies**: Cost down of high performance appliances, such as high performance heat pumps, CHP including fuel cells, and latent heat recovery water boilers

- **Energy management technologies**: Innovative energy management technologies such as individual air conditioning.

- **Renewable energy integration**: Renewable integration ready building such as built-in photovoltaic panels.
Social Challenges

- **Standards**: Standard of energy saving technologies for buildings to assist global diffusion of ZEBs/ZEHs.

- **Regulations and incentives**: Regulation and incentives for buildings to meet energy saving standard and to integrate renewable and unused energy. These regulations must take the needs and appropriateness into account.

- **Life style change**: Energy saving life styles and social-scientific approach for segmented customers including economic incentives.

- **Smart grid integration**: Integrate ZEBs/ZEHs to small-scale smart grid and heat exchange system among buildings to realize zero emission community.
ICEF 2016 – Save the Dates

- ICEF (Innovation for Cool Earth Forum)
  - Discussion of building sector and other energy issues
  - http://www.icef-forum.org/