



ZEB/ZEH Roadmap - Technology and Institution -



ICEF Roadmap Launch Event
Japan Pavilion, COP22, Marrakech, Morocco,
November 16, 2016

Atsushi Kurosawa
The Institute of Applied Energy (IAE), JAPAN

I would like to express thanks to IAE colleagues for compiling efforts
and experts from various organizations for their useful information and comments.

Outline

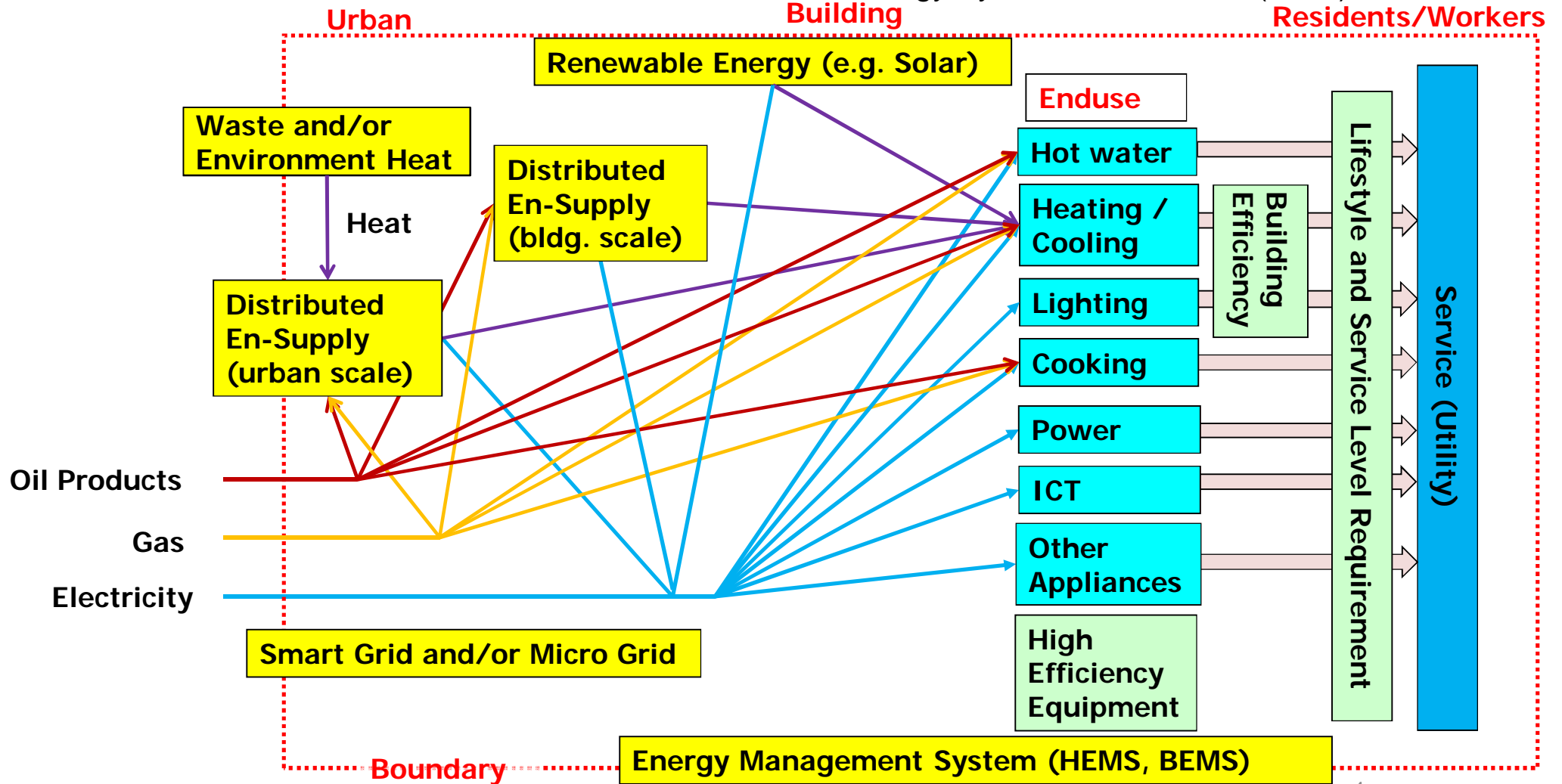
- 1. Energy System in Building Sector**
- 2. Toward ZEB/ZEH**
- Technology and Institution
- 3. Summaries**

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Energy System in Building Sector

Source: Modified from 'Urban Energy System', Y. Shimoda (2014)

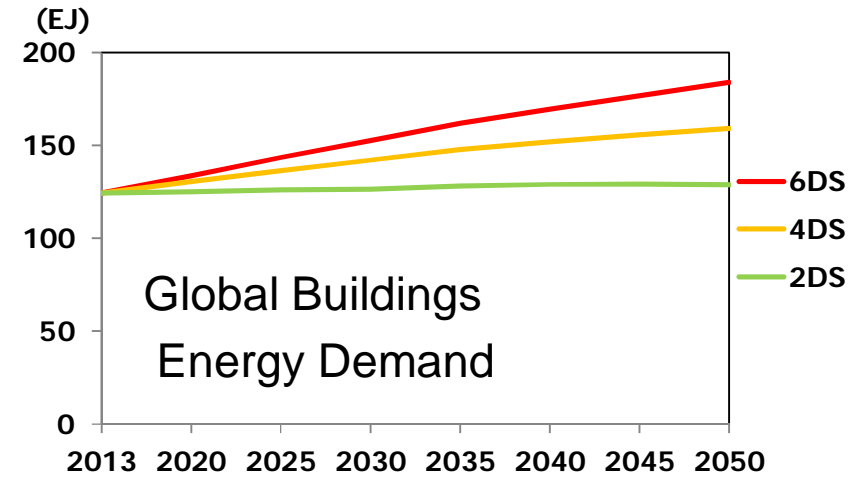


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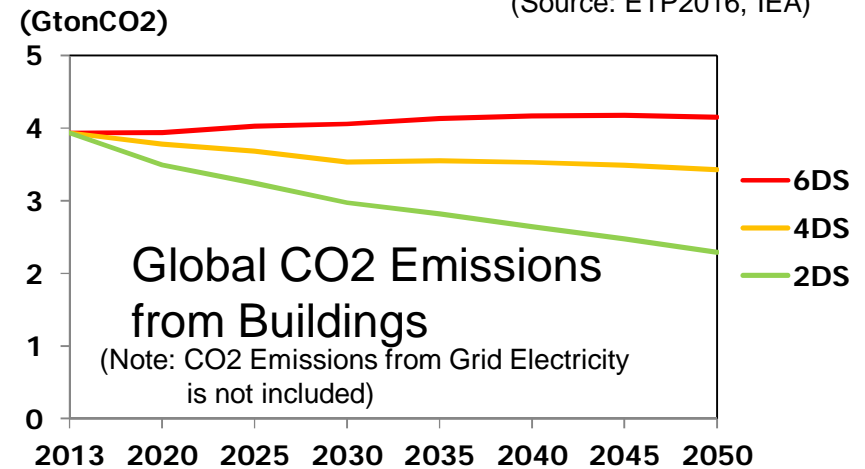
1. Energy System in Building Sector
2. **Toward ZEB/ZEH**
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Buildings - Energy Demand and CO2 emissions

- Global bldg. energy demand
 - 31% of total demand in 2013, 40% in 2050 (6DS)
 - Most of future growth expected in developing regions
- Bldg. energy demand drivers
 - Numbers of household
 - Floor space
 - Appliances
 - type, size and numbers
- Deep cut of CO2 emissions
 - Efficiency (end-use, envelope)
 - Low CO2 energy carriers
- The ZEB/ZEH roadmap as a guide for international cooperation and stakeholder involvement to assist deep cut



(Source: ETP2016, IEA)



(Source: ETP2016, IEA)

ZEB/ZEH – Definition and Goal

□ Definition

- Annual **net** energy consumption is nearly zero.

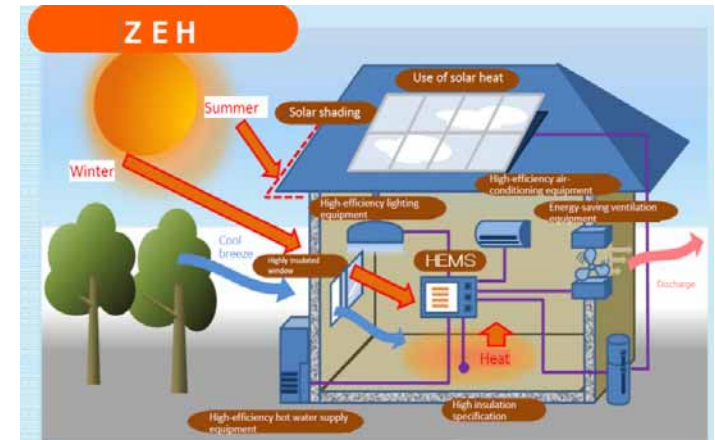
□ Goal

- Net zero energy consumption in buildings around mid-century to prepare long-term zero emission target

□ Achieved by energy conservation and renewable energy integration

- **Energy conservation FIRST** -energy efficient appliances and structure, energy management
- **Renewable energy** integration to assist net zero energy consumption

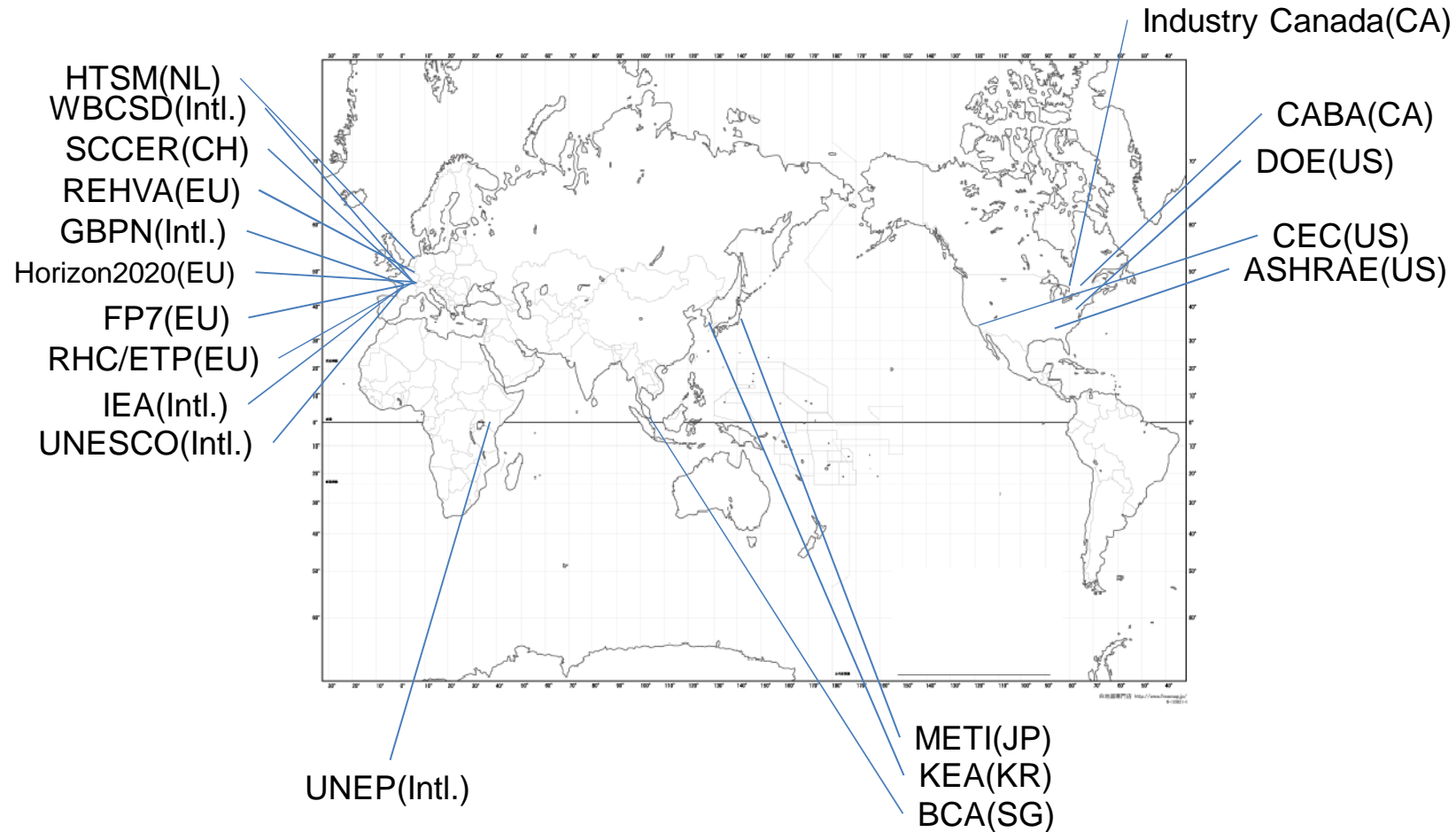
* ZEB/ZEH: Net Zero Energy Building / House



Example of ZEH & ZEB (Source: METI, Japan)

Existing ZEB/ZEH Roadmaps - Survey

- International organizations, national/local governments, industrial associations, etc.



ZEB/ZEH Definitions

(source) ZEB/ZEH roadmap committee report, Dec.2015 (in Japanese)

	DOE, USA	NREL, USA	REHVA, Europe	Japan
Year	2015	2006/2010	2013	2015
Design or Operation	Operation	Design/ Operation	Design	Design
Target Devices	HVAC*, Water heating, Lighting, Power outlet, Energy exchanged and transformed in building	HVAC, Water heating, Lighting, Power outlet, Energy exchanged and transformed in building	HVAC, Water heating, Lighting	HVAC, Water heating, Lighting, Elevators and moving stairs
Renewable Energy Integration	On-site, On-site + Off-site (for small houses)	Categorized On-site On-site + Off-site	Only On-site	Only On-site

DOE: Department of Energy

NREL: National Renewable energy Laboratory

REHVA: Federation of European Heating, Ventilation and Air Conditioning Associations

*HVAC: Heating, Ventilation and Air Conditioning

**AnREU: Annual non-Renewable Energy Use

ZEB/ZEH Definitions (cont.)

(source) ZEB/ZEH roadmap committee report, Dec.2015 (in Japanese)

	DOE, USA	NREL, USA	REHVA, Europe	Japan
Category of ZEBs	ZEB: annual primary energy use is recovered by on-site renewable energy	ZEB: annual energy use is recovered by renewable energy Near ZEB: built as ZEB, but does not met because of weather and operation etc.	PEB: net AnREU** < 0kWh/m ² yr ZEB: AnREU < 0kWh/m ² yr, self sufficient nZEB: net AnREU = 0kWh/m ² yr nnZEB: 0kWh/m ² yr < net AnREU < limit of individual country	ZEB/ZEH: Primary energy consumption (PEC) is less than 100% from the standards Nearly ZEB/ZEH: PEC is less than 75% from the standards ZEB ready: PEC is less than 50% form the standards
Building types	Building, Campus, Portfolio, Community	Building	Building	ZEB: Building ZEH: Detached house

DOE: Department of Energy

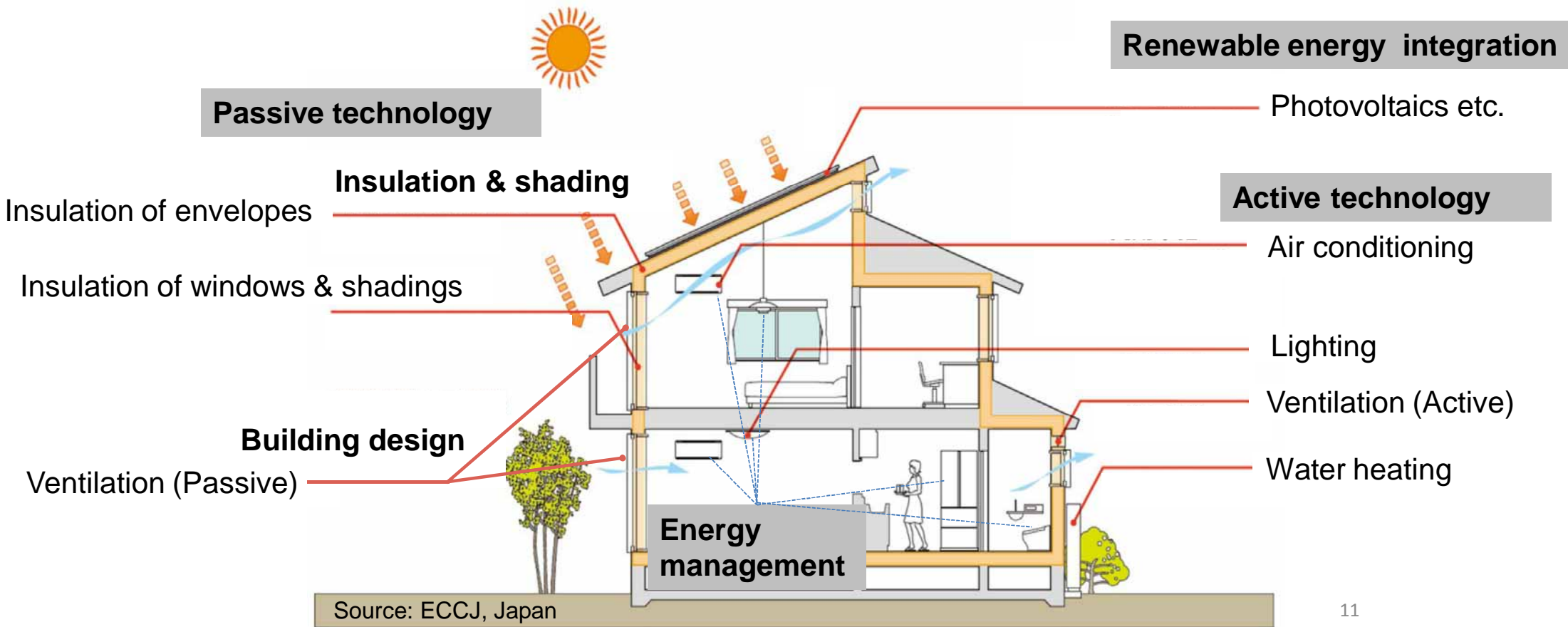
NREL: National Renewable energy Laboratory

REHVA: Federation of European Heating, Ventilation and Air Conditioning Associations

**AnREU: Annual non-Renewable Energy Use

ZEB/ZEH Technologies

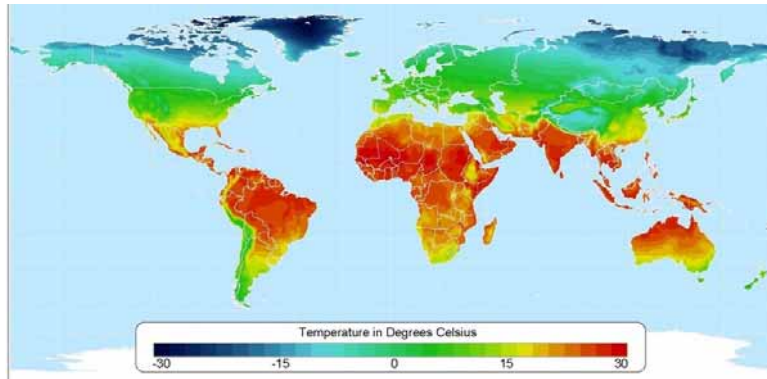
Four Technology Categories



11

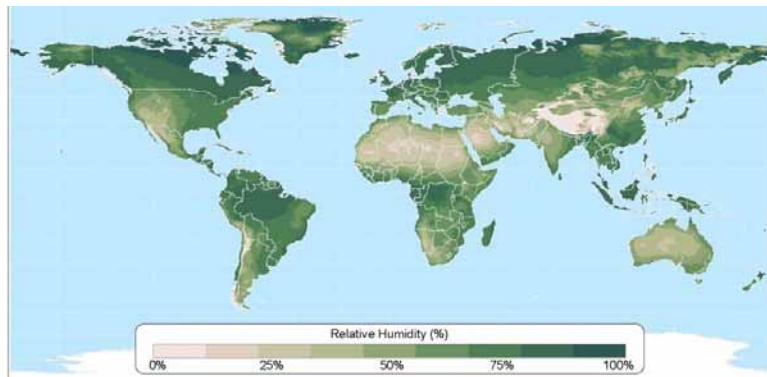
Roadmap Variations - Climate and Air Conditioning

□ Average Temperature



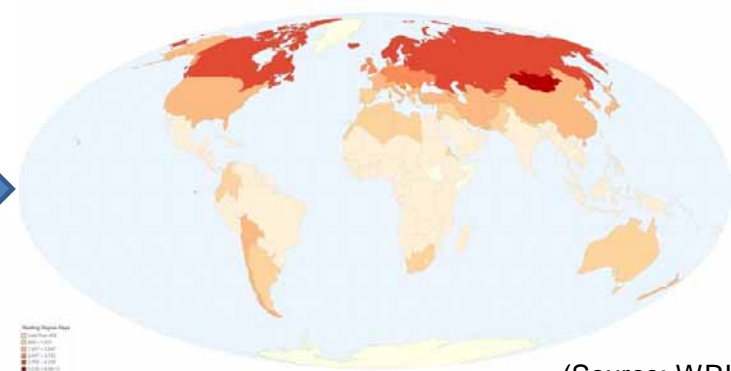
(Source: Wisconsin U. original data from CRU, U. East Anglia)

□ Relative Humidity / Dehumidification Demand



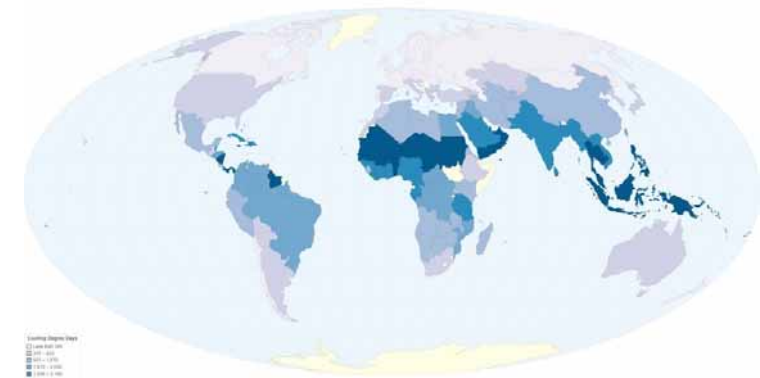
(Source: Wisconsin U. original data from CRU, U. East Anglia)

□ HDD / Heating Demand



(Source: WRI)

□ CDD / Cooling Demand



(Source: WRI)

Roadmap Variations - Climate and Air Conditioning

Source : Best Practice Policies for Low Carbon & Energy Buildings
Based on Scenario Analysis May 2012 (Global Building Performance Network)

□ Climate variation

● Three types of roadmap

➤ Moderate & humid

Heating, cooling & dehumidification

➤ Cold

High heating demand
- Only heating

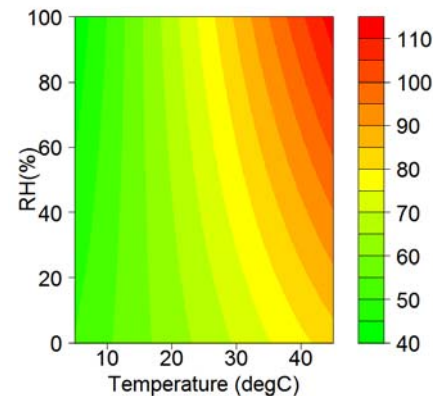
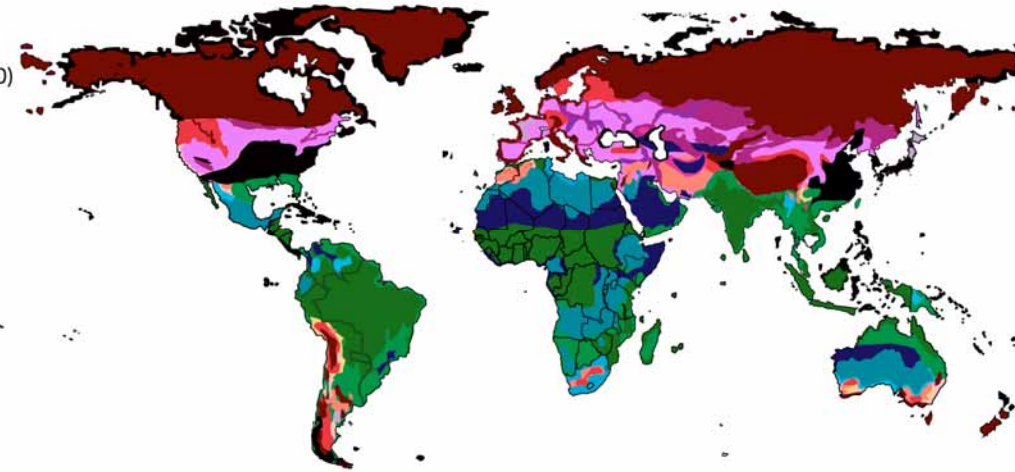
➤ Hot

High Cooling Demand (with
Dehumidification)
- Only cooling

□ Discomfort index

● Function of ambient temperature and relative humidity

- 1. Only Heating(very HHD)
- 2. Only Heating(HHD)
- 3. Only Heating(MHD+HHD)
- 4. Heating and Cooling(very HHD+LCD)
- 5. Heating and Cooling(HHD+MCD)
- 6. Heating and Cooling(HHD+LCD)
- 7. Heating and Cooling(MHD+MCD)
- 8. Heating and Cooling(MHD+LCD)
- 9. Heating and Cooling(LHD+MCD)
- 10. Heating and Cooling(LHD+LCD)
- 11. Only Cooling(very HCD)
- 12. Only Cooling(HCD)
- 13. Only Cooling(LCD+MCD)
- 14. Cooling and Dehum(very HCD)
- 15. Cooling and Dehum(HCD)
- 16. Cooling and Dehum(LCD+MCD)
- 17. Heating, Cooling, Dehum

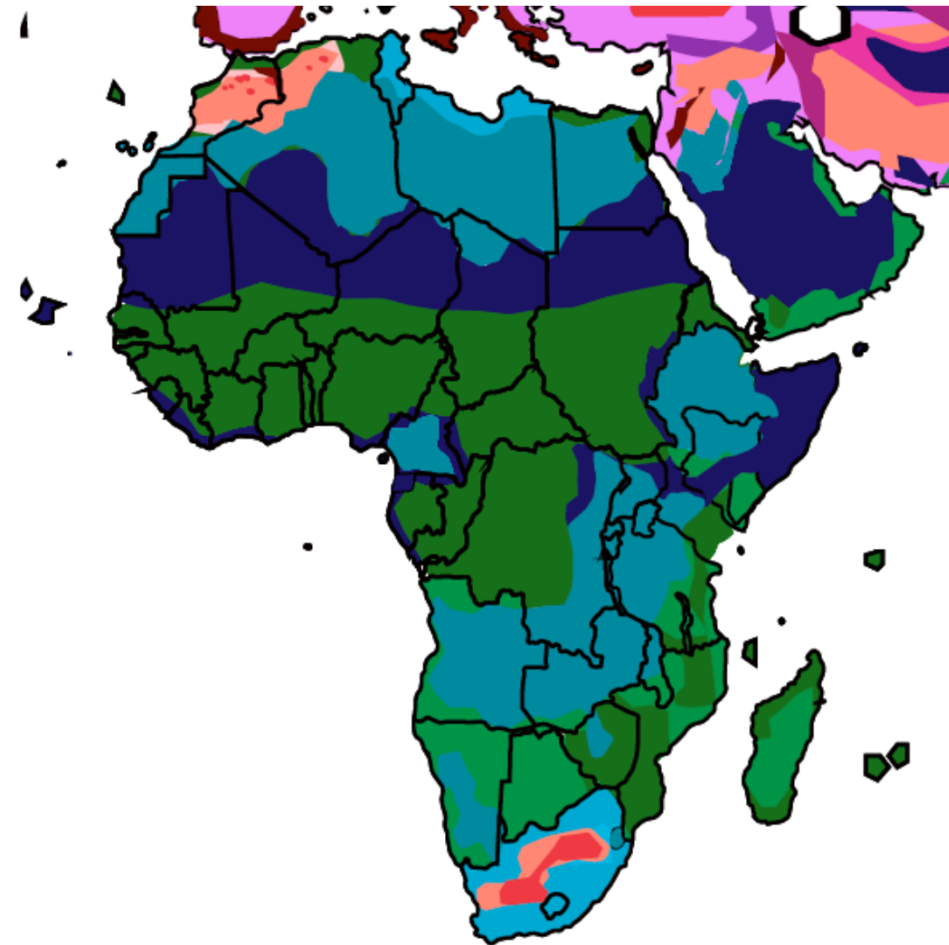


Discomfort Index

Climate and Air Conditioning in Africa

Source : Best Practice Policies for Low Carbon & Energy Buildings
Based on Scenario Analysis May 2012 (Global Building Performance Network)

- ❑ Cooling demand
 - Very high
 - High
 - Low and moderate
- ❑ Both cooling and heating
 - Morocco and others
- ❑ Dehumidification demand
 - Yes – green (right figure)
/ No – other colors
- ❑ Estimated economic losses from by heat stress
 - Dissemination of high-efficiency indoor and outdoor air-conditioning supports sustainable growth of Africa to avoid estimated losses.



(Source: WRI)



(Source: WRI)



(Source: Wisconsin U.
original data from
CRU, U. East Anglia)

ZEB/ZEH Technology Roadmap - Concept

- ❑ Climate zones
 - Moderate & humid, cold, hot
 - Energy demand of moderate-high temperature and humid regions will increase drastically.
- ❑ Technology categories
 - Active - Air conditioning, hot water, lighting
 - Passive - Envelope, aperture
 - Management
 - Renewable energy integration
- ❑ Technology indicators
 - Efficiency, cost, fuel, maturity
 - Climate zone – Moderate & humid, cold, hot
- ❑ Building vintage
 - New, retrofit
- ❑ Common technological elements for ZEB and ZEH. However, realization of ZEH could be faster than ZEB, because of its relatively low energy density.
- ❑ References
 - IEA roadmaps, METI, NEDO etc.

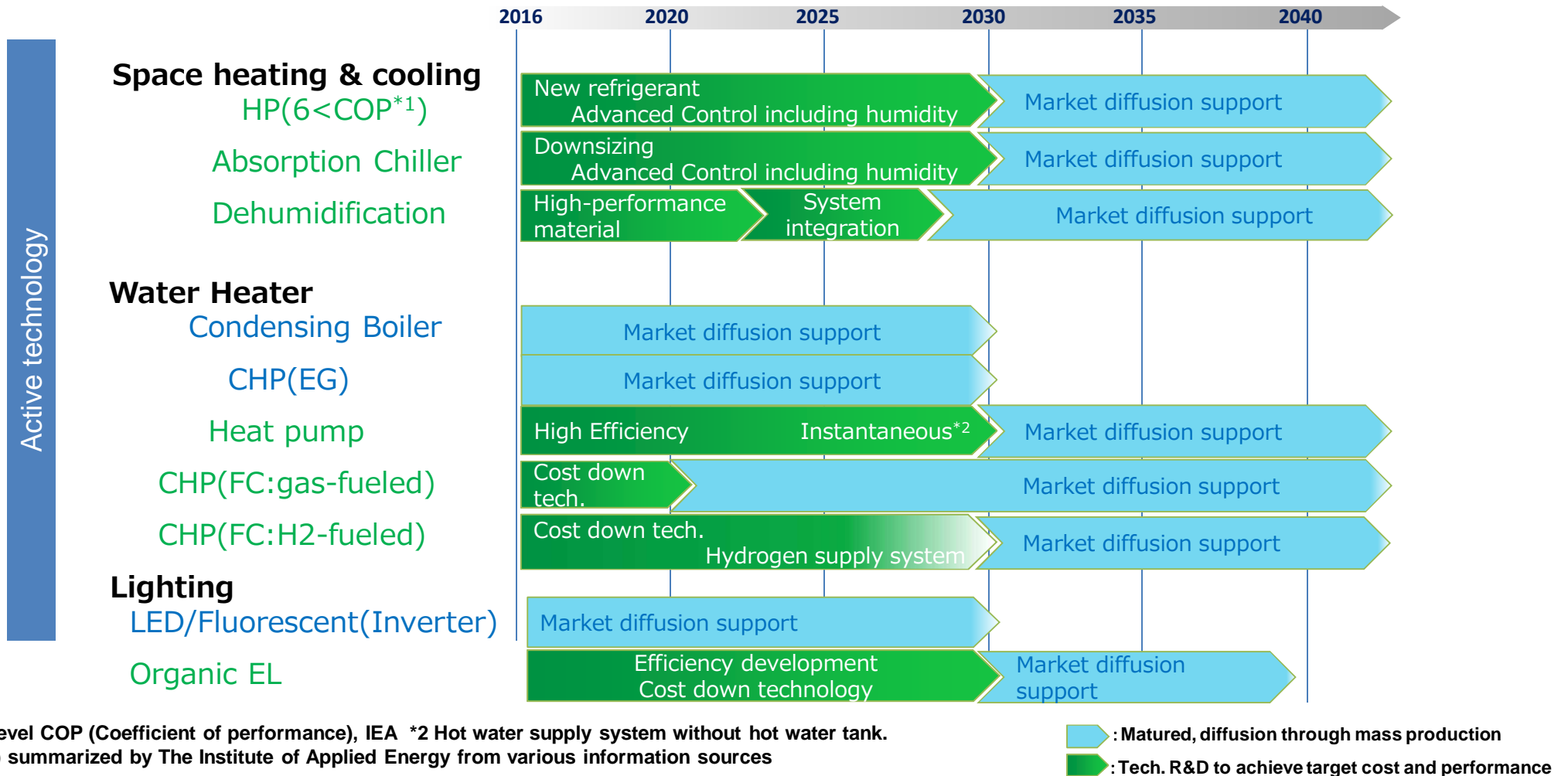
Example : Active technology Status (Air Conditioning)

(source) summarized by The Institute of Applied Energy from various information sources

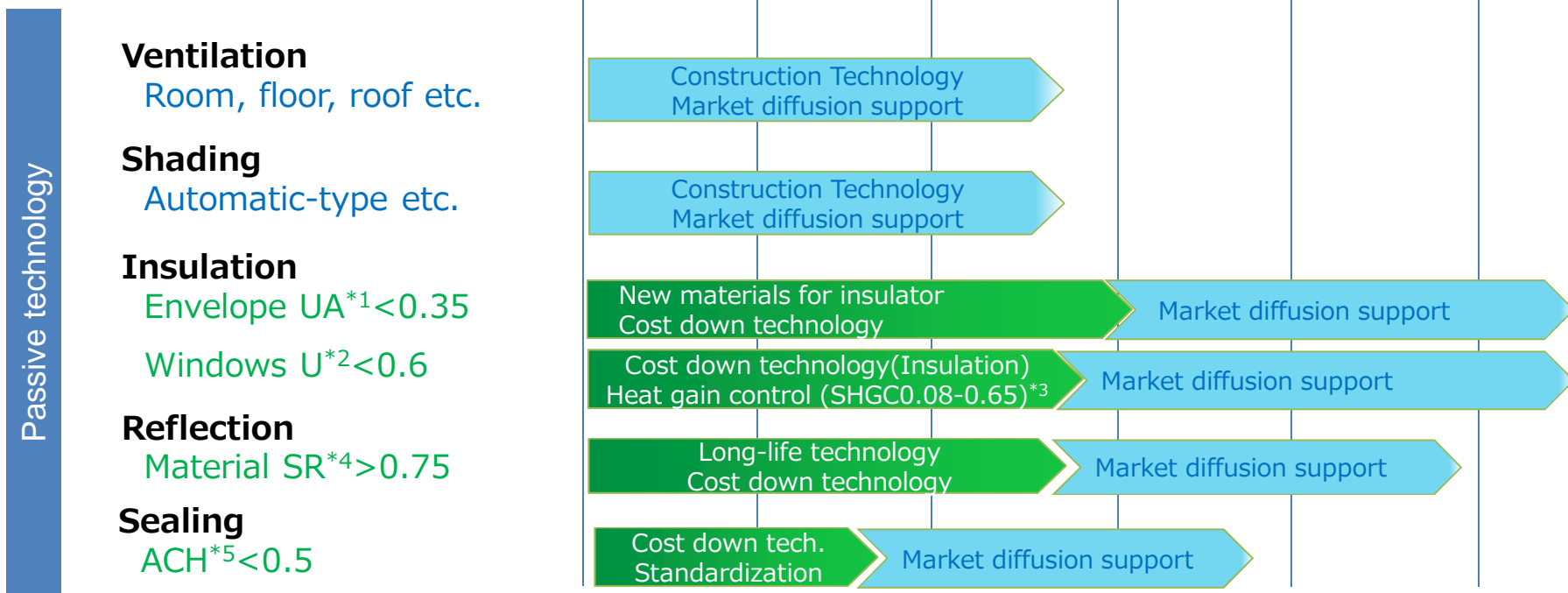
Technology	Efficiency %	Equipment cost*	Fuel type**	Fuel cost*	Maturity*	Climate***	Other Information
Boiler	70-88	L	G/O/B	M-H	H	C,M	Floor, Panel heating
Absorption air conditioner	70-120	M	G/O/B	M-H	H	M,H	
Heat Pump (Electricity)	200-600	L-M	E	M-H	H	All	
Heat Pump (Engine)	120-200	L-M	G/O/B	L-M	H	All	
CHP (Engine)	70-90	M-H	G/O/B	L-M	H	All	with Elec. supply
CHP (FC)	80-90	H	G/H	L-H	M	All	with Elec. supply
Dehumidifier	n.a.	H	E	H	M-H	M,H	heat pump, desiccant, compressor, wet
Humidifier	n.a.	L-H	G/E/O	L-H	H		evaporation, steam, ultrasonic

(notes) * L:Low, M:Medium, H:High / ** G:gas, O:Oil, B:Biomass, S:Solar, E:Electricity, H:Hydrogen / *** C:Cold, M:Moderate & Humid, H:Hot

Roadmap for Moderate & Humid Regions - Active Technology



Roadmap for Moderate & Humid Regions - Passive Technology



*1 Average U value (overall heat transfer coefficient) for wall and roof, IEA

*2 U value of whole window for ZEB, IEA

*3 Solar Heat Gain Coefficient, IEA

*4 SR (Solar reflectance), Long lasting white, in case of colored material $SR > 0.40$, IEA

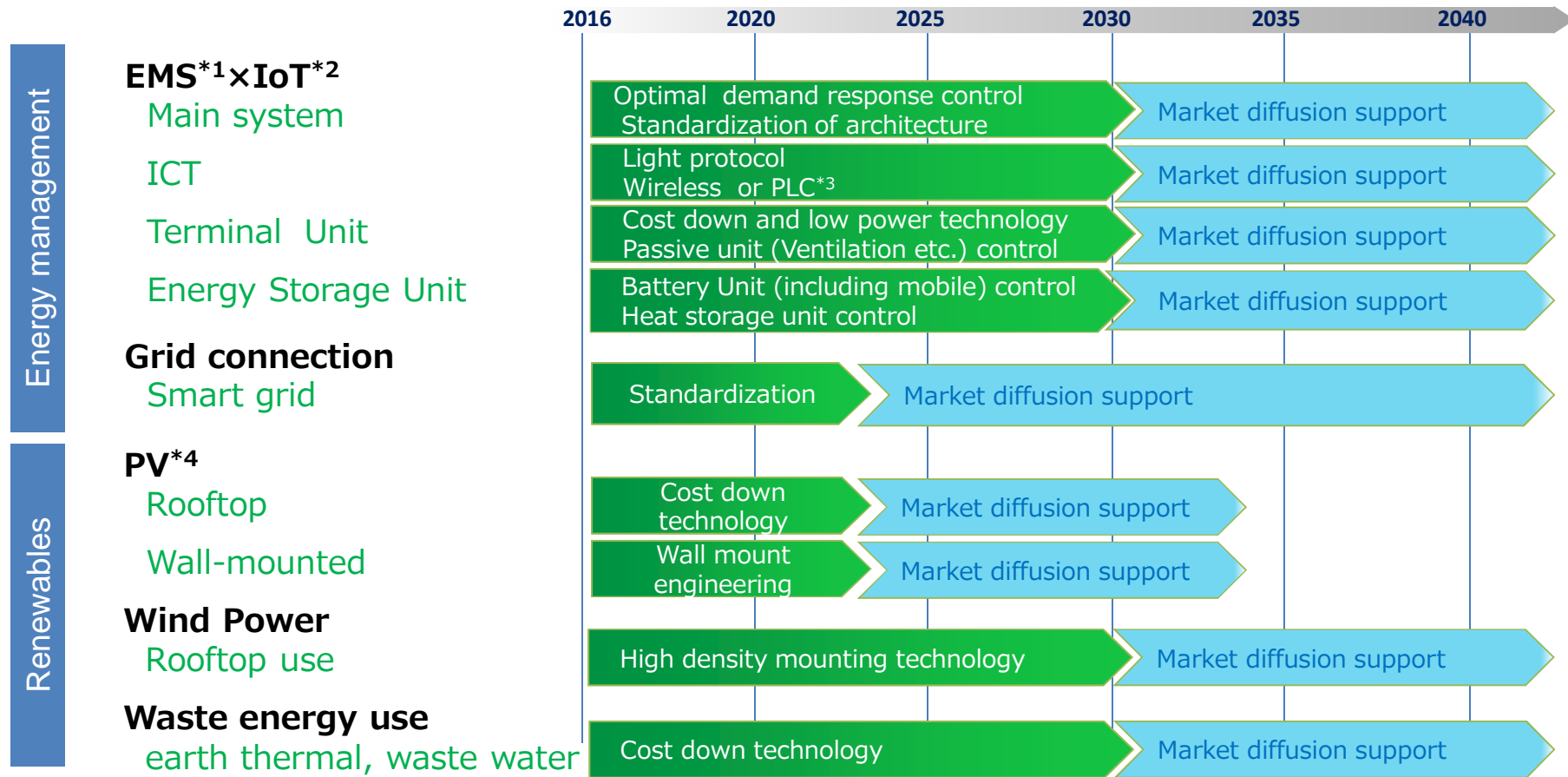
*5 ACH (Air change per hour), IEA

Light blue arrow: Matured, diffusion through mass production

Green arrow: Tech. R&D to achieve target cost and performance

(source) summarized by The Institute of Applied Energy from various information sources

Roadmap for Moderate & Humid Regions - Energy Management and Renewable Integration



*1 Energy management system *2 Internet of things *3 Power line communication

*4 Photovoltaics

(source) summarized by The Institute of Applied Energy from various information sources

Blue arrow: Matured, diffusion through mass production

Green arrow: Tech. R&D to achieve target cost and performance

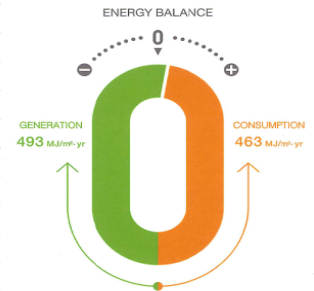
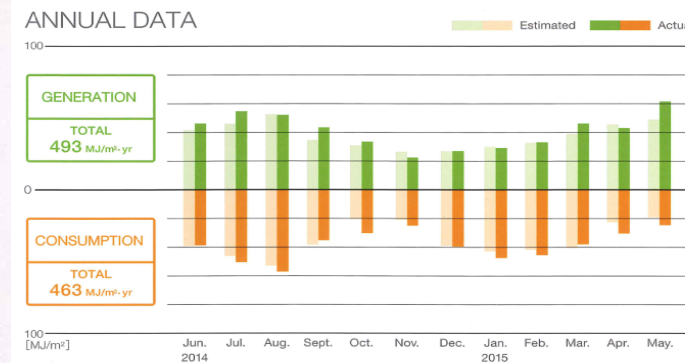
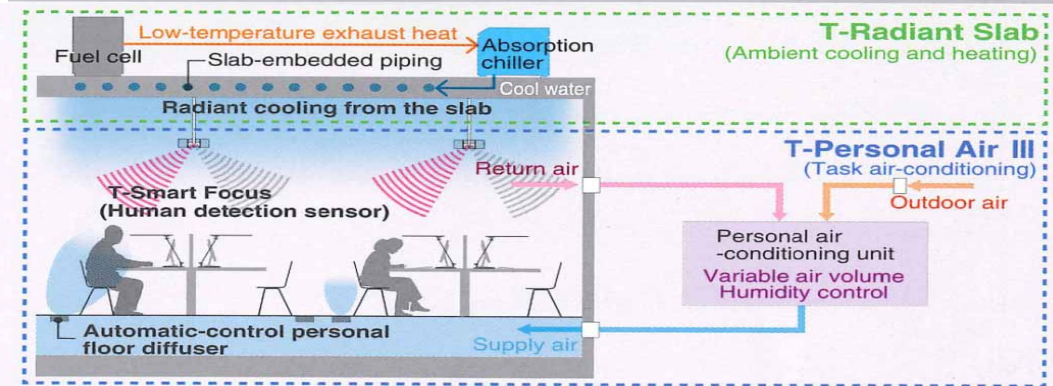
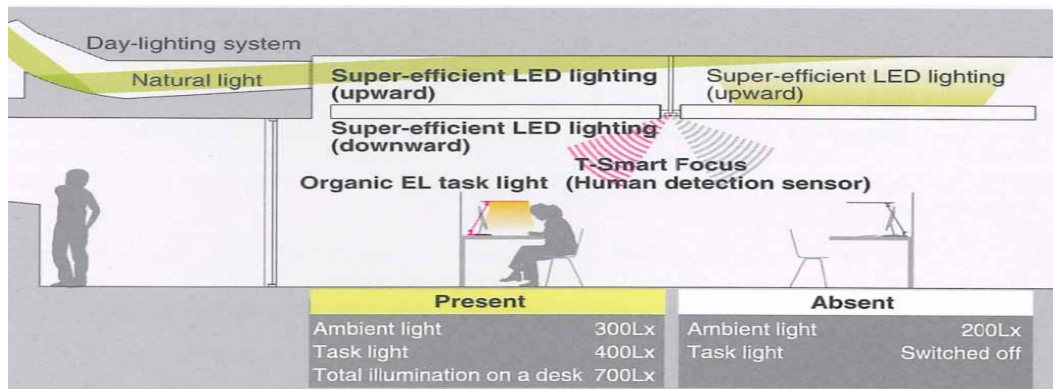
ZEB/ZEH Market Creation: Technology and Institution

(source) summarized by The Institute of Applied Energy from various information sources

Categories	Actions (examples)
Stakeholder Involvement	<ul style="list-style-type: none"> ● Public <ul style="list-style-type: none"> - Policy coordination among national ministries - National/regional/local coordination - Capacity building assistance ● Private <ul style="list-style-type: none"> - Design guidelines as knowledge base
Research, Development and Deployment (RD&D)	<ul style="list-style-type: none"> ● Beyond BAT (best available technology) <ul style="list-style-type: none"> - High performance, low cost ● Demonstration of building systems and elemental technologies ● Production at scale
Diffusion	<ul style="list-style-type: none"> ● Building code mandate ● Economic incentive (e.g. subsidy, tax reduction) ● Non-energy benefits (e.g. BCP (business continuity planning), indoor-health, real-estate value)

R&D Example(1): ZEB demonstration example in Japan

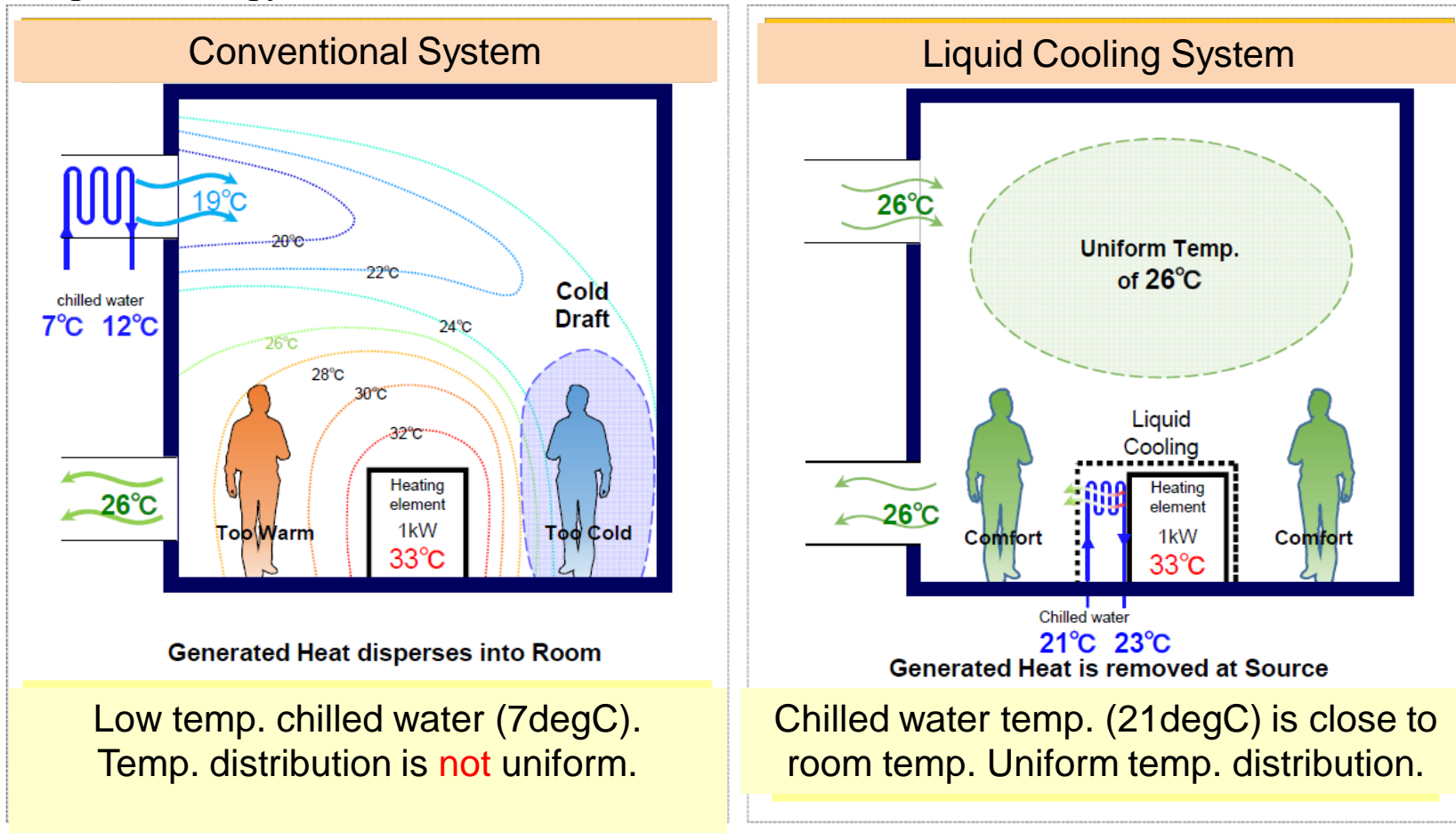
- ❑ ZEB demonstration building, Taisei Corp. Research Center (Yokohama, Japan, 2014-)
 - First urban building in Japan achieved annual zero energy balance. BELS five-star (Building Energy Labeling System)
 - Photovoltaics (crystalline - roof, organic thin film - external wall) Source: Taisei Corporation
 - Lighting conservation (-86%) Natural light, LED, organic EL, illumination control
 - Air-conditioning conservation (-75%) Task (sensor & personal), Ambient (radiation from slab)



R&D Example(2): Commercial Building Cooling

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

Source: NEDO, Japan

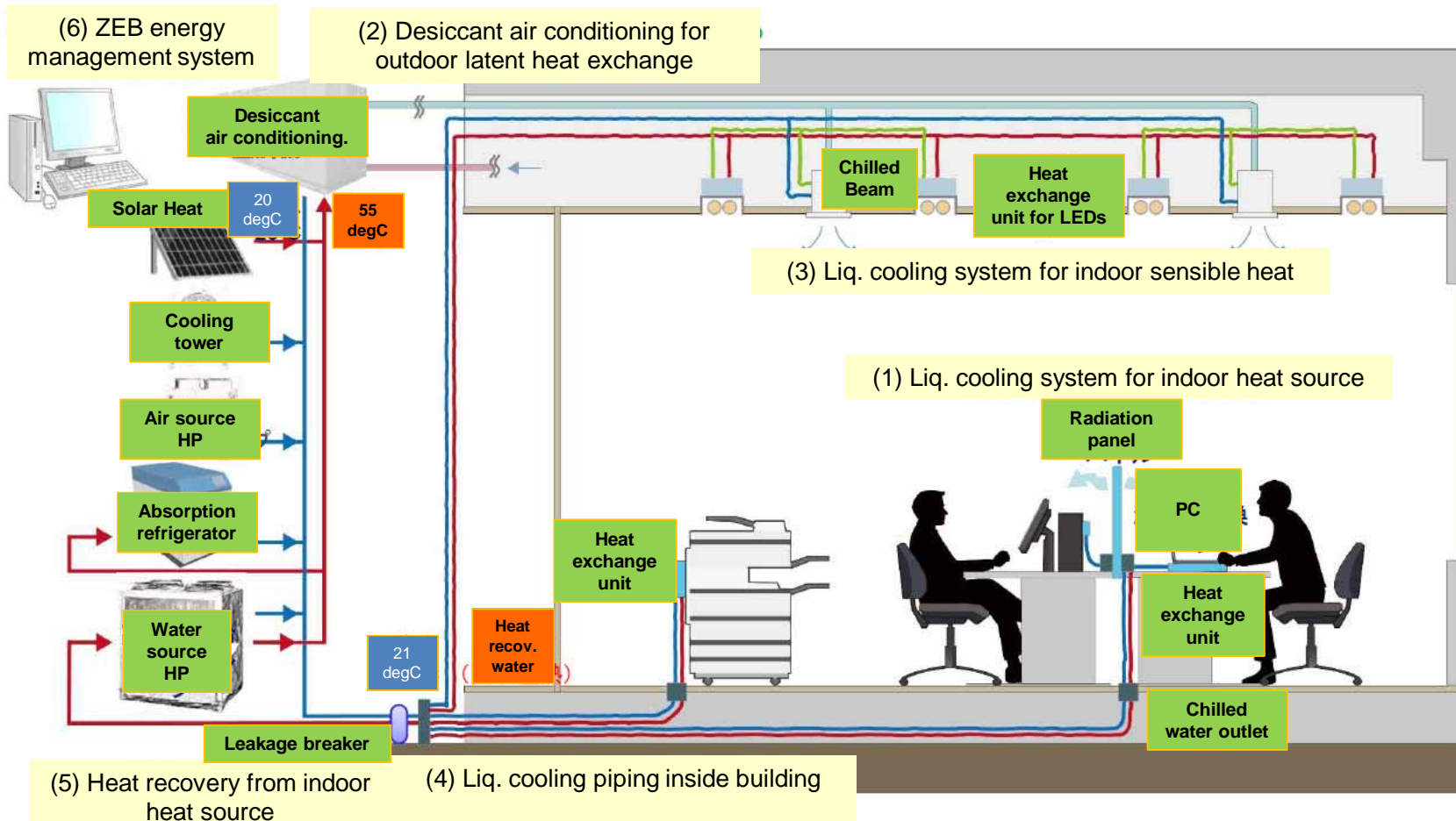


Concept of New Commercial Building Cooling

System Concept

Subsystem	Hot Water
Unit or Equipment	Chilled Water

Source: NEDO, Japan



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3. **Summaries**

Summaries – Proposals (1)

□ Sharing net zero energy building as a concept

- ZEB/ZEH concept in newly constructed buildings and houses
- Renovation to ZEB/ZEH at retrofitting timings
- Achievement of net-zero energy building stocks in the long-run

□ Immediate action via stakeholder involvement

- Challenges for ZEB/ZEH market creation (especially for retrofit)
- Some elemental technologies have been available already.
- Equipment and envelope
 - Retrofit of envelope – expensive
- Life of building is long and stakeholders are diverse.

Summaries – Proposals (2)

□ International technology collaboration and roadmap

- Collaboration measures on ZEB/ZEH
 - Technology collaboration network outreach
 - Diffusion policy comparison
 - Harmonization with urban policies
 - Establishment of international standards
- Roadmap sharing
 - Transparent approach for all global regions
 - ZEB/ZEH roadmap reflection to climate policy
 - ✓ Huge benefits through good practices and capacity building of stakeholders

