TOKYO METROPOLITAN UNIVERSITY
東京都立大学

9 Feb, 2023
The 11th Energy Management Action Network Workshop
Toward net-Zero Energy Building

Impact for GHG reduction by ZEB

Tokyo Metropolitan University
Department of Architecture
Associate Professor
Masayuki Ichinose, PhD.

Contents

1. History and scenario of energy consumption / CO_2 emission in Asia
2. Green Building and ZEB strategies
3. Actual status of IEQ / EUI at Asian Green Building
4. Impact for GHG reduction by ZEB

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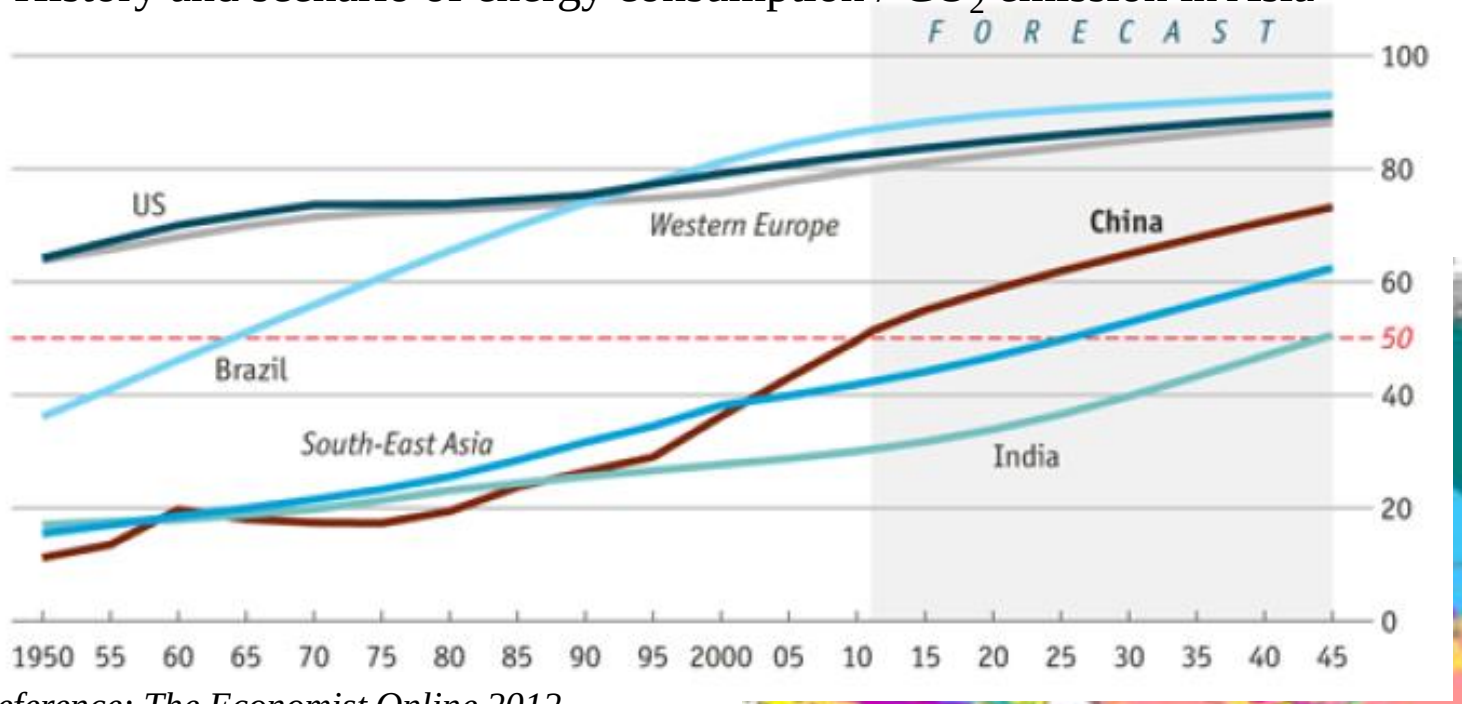
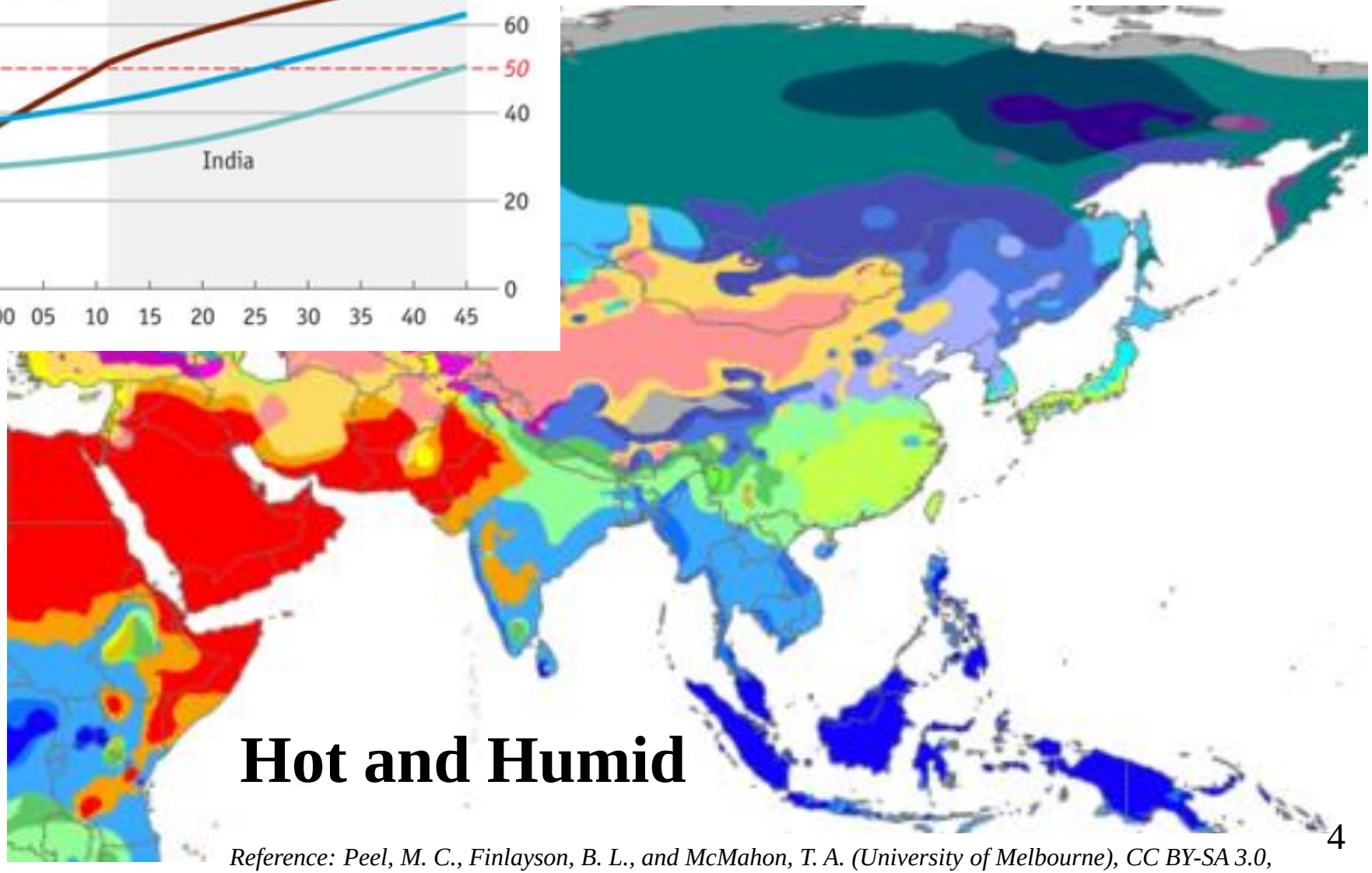
1. History and scenario of energy consumption / CO_2 emission in Asia



Reference: The Economist Online 2012

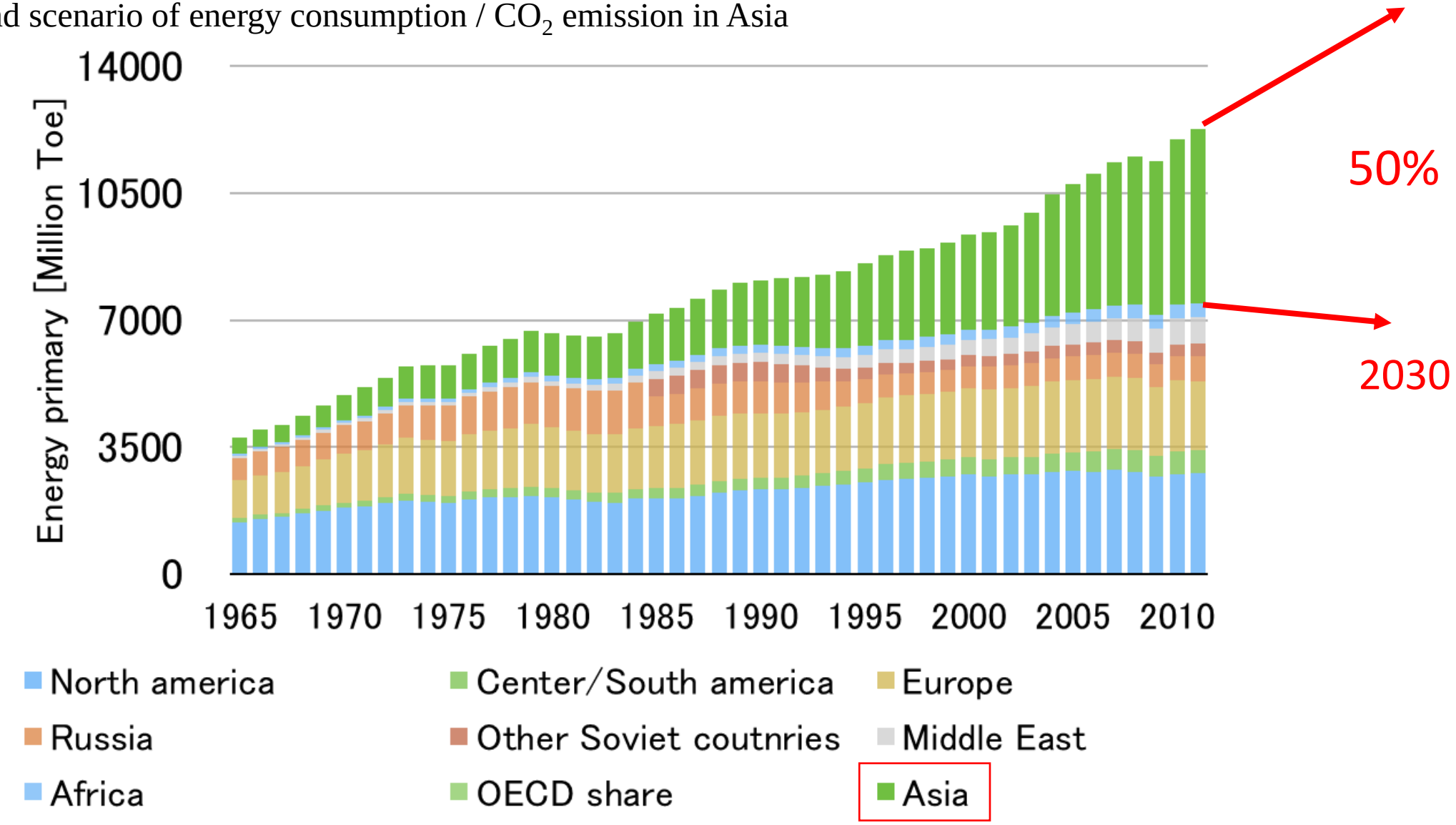
Urbanization



Hot and Humid

Reference: Peel, M. C., Finlayson, B. L., and McMahon, T. A. (University of Melbourne), CC BY-SA 3.0,

1. History and scenario of energy consumption / CO_2 emission in Asia



Breakout of historical global energy consumption

Reference: BP, Statistical review of world energy

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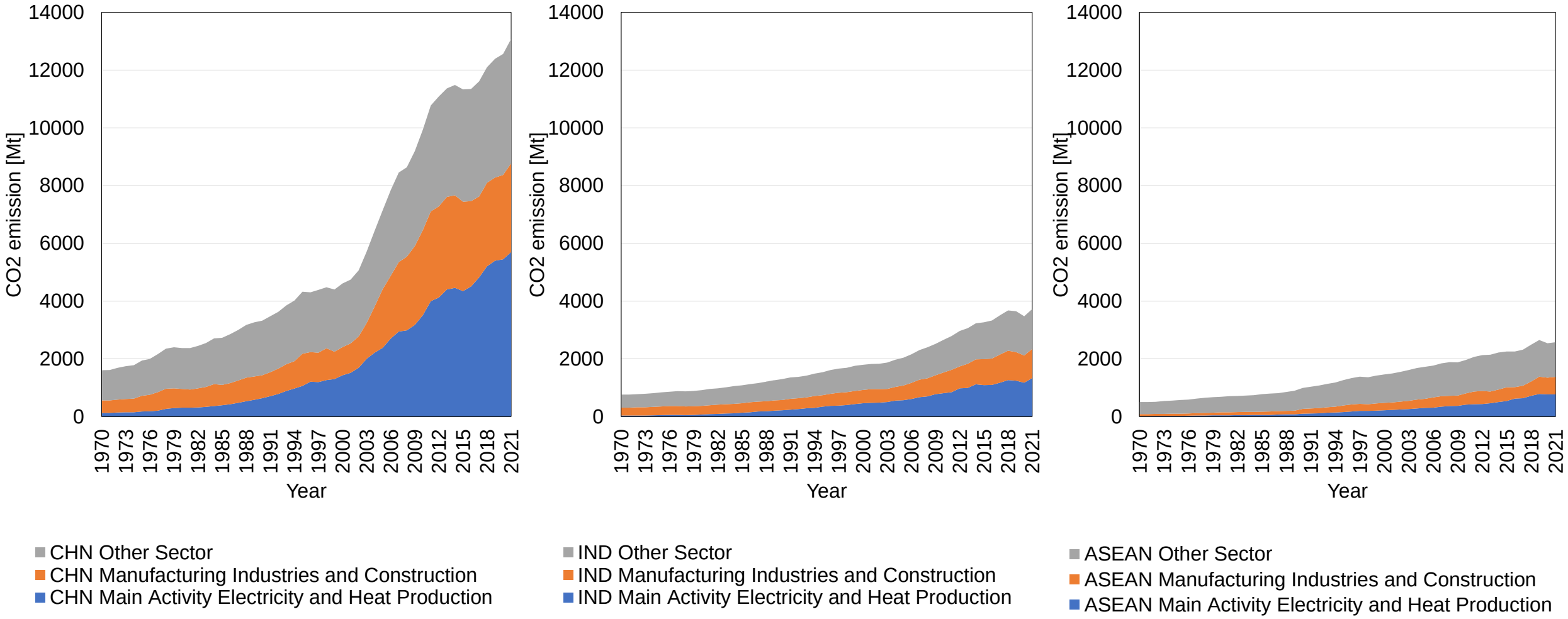

Historical CO_2 emission by sector in China, India and ASEAN

Reference: European Commission, Joint Research Centre (EC-JRC)/Netherlands Environmental Assessment Agency (PBL). Emissions Database for Global Atmospheric Research (EDGAR), release EDGAR v7.0_GHG (1970 - 2021) of September 2022. For the energy related sectors the activity data are mainly based on IEA data from IEA (2021) World Energy Balances, www.iea.org/statistics, All rights reserved, as modified by Joint Research Centre, European Commission.

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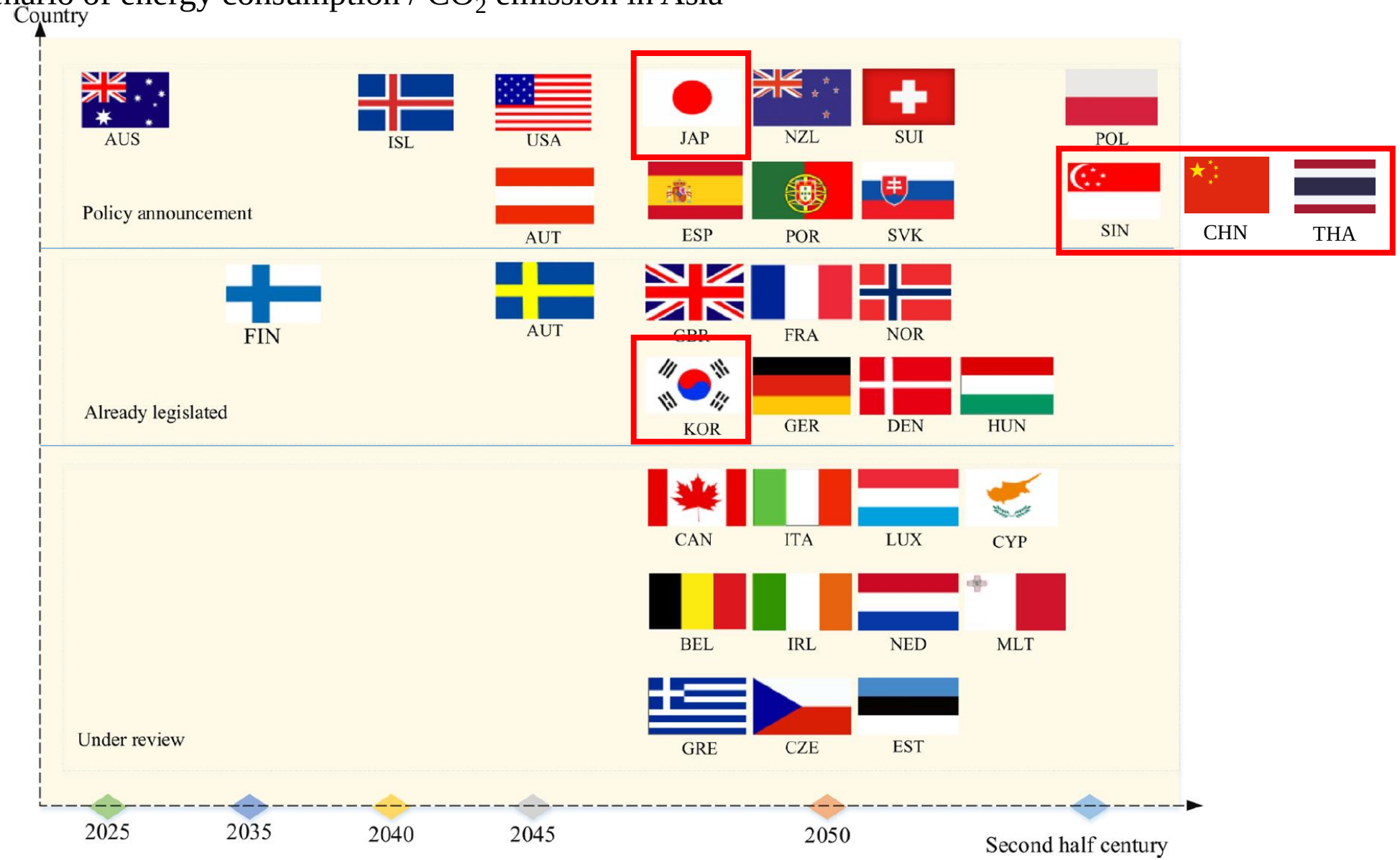

Expected year for carbon neutrality in 32 developed countries and Asia

Reference: Feng Dong, Yangfan Li, Yujin Gao, Jiao Zhu, Chang Qin, Xiaoyun Zhang, "Energy transition and carbon neutrality: Exploring the non-linear impact of renewable energy development on carbon emission efficiency in developed countries", Resources, Conservation and Recycling, Volume 177, 2022, 106002, ISSN 0921-3449, https://doi.org/10.1016/j.resconrec.2021.106002

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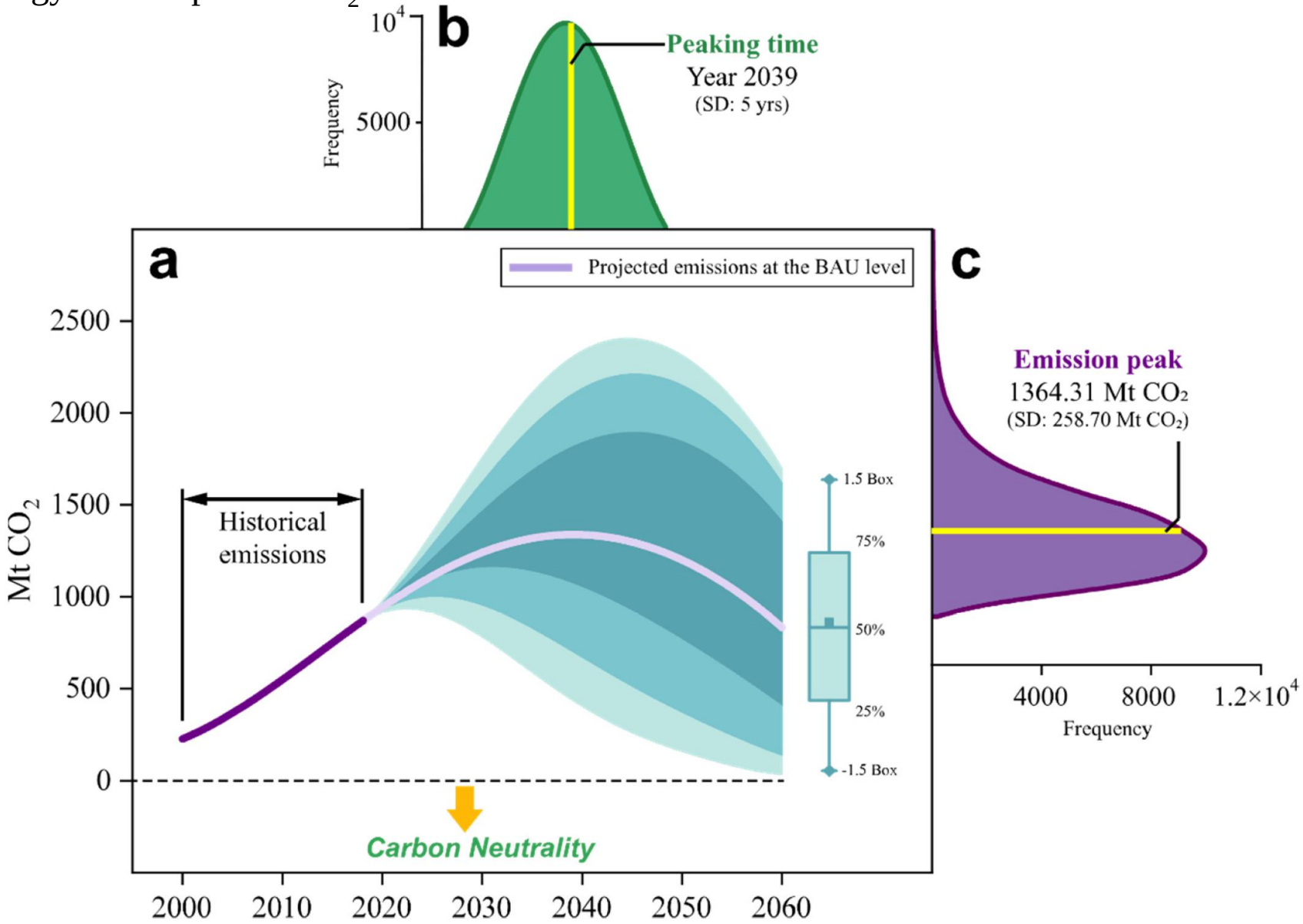

Static emissions scenario with the emission peak dynamic scenario simulation towards 2060 in China

Reference: Zhang, Shufan, Xiwang Xiang, Zhili Ma, Minda Ma, and Chenchen Zou. 2021. "Carbon Neutral Roadmap of Commercial Building Operations by Mid-Century: Lessons from China" Buildings 11, no. 11: 510. https://doi.org/10.3390/buildings11110510

Synopsis of energy scenarios (ASEAN)

Scenario		
Business as usual	BAU	The continuous trend of the developments from the past
AMS targets scenario	ATS	ASEAN Member States (AMS) have been using Renewable Energy (RE) Target as a policy instrument to set the energy development on the supply side
Advancing policy scenario	APS	Incorporates progressive policy and action plans from each AMS to achieve their official national target for energy efficiency and renewable energy
The least-cost optimization scenario	LCO	All of the technologies with the least cost are applied toward energy efficiency and renewable energy

Reference: ASEAN Centre for Energy (2022), The 7th ASEAN Energy Outlook, ASEAN Centre for Energy, 2022

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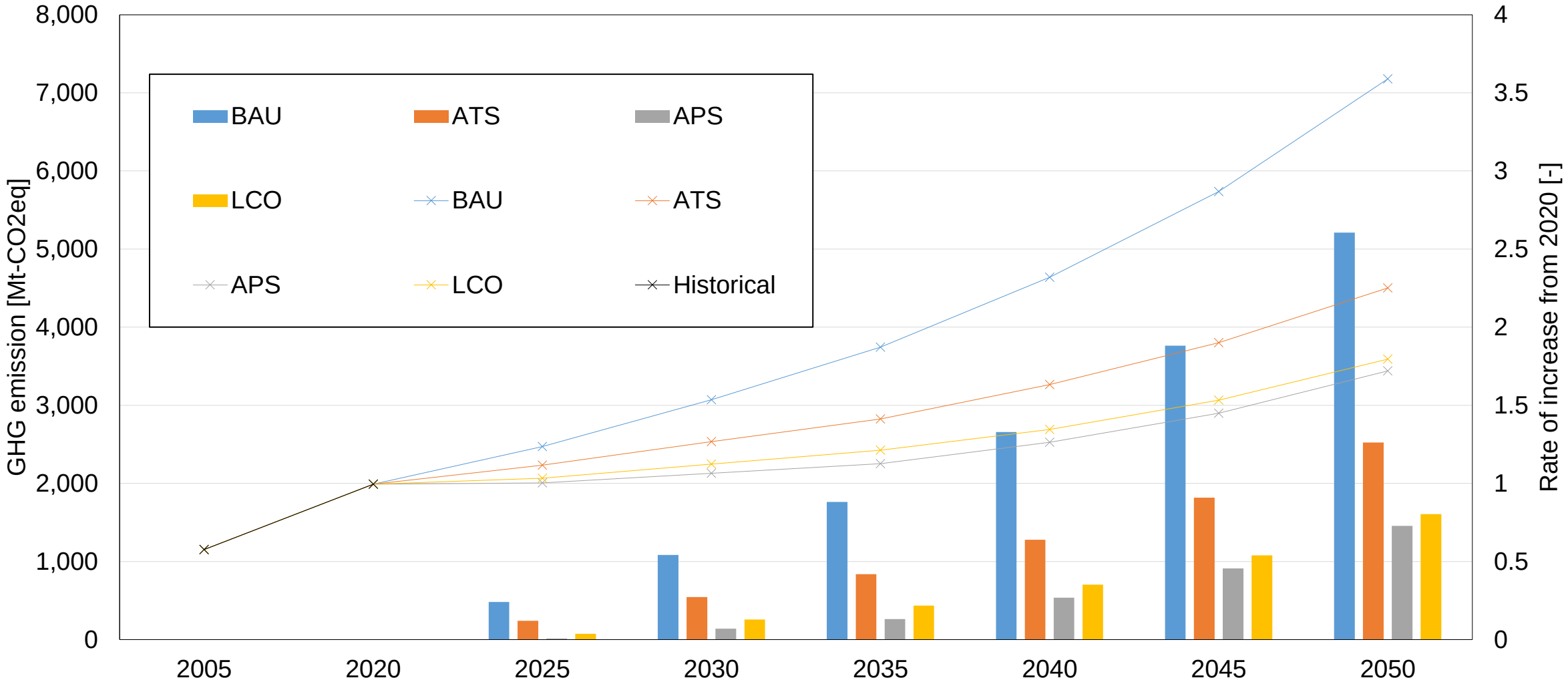

GHG emissions and rate of increase from 2020 for different scenario in ASEAN

Reference: ASEAN Centre for Energy. The 7th ASEAN Energy Outlook. 2022

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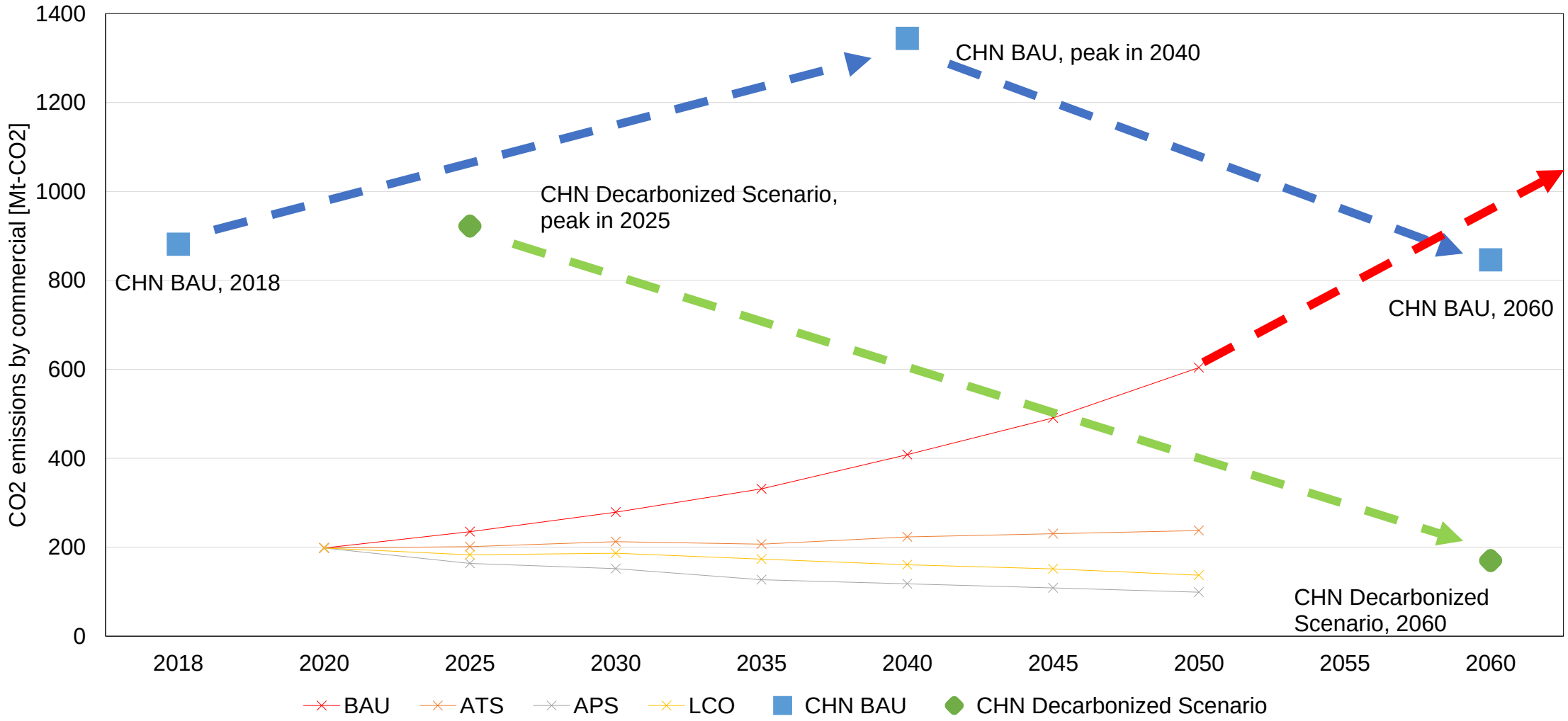

Comparison of estimated CO2 emissions by commercial sector in ASEAN and China

Reference: Shufan Zhang et al., Carbon Neutral Roadmap of Commercial Building Operations by Mid-Century: Lessons from China, Buildings 2021 11(11) 510, 2021.10

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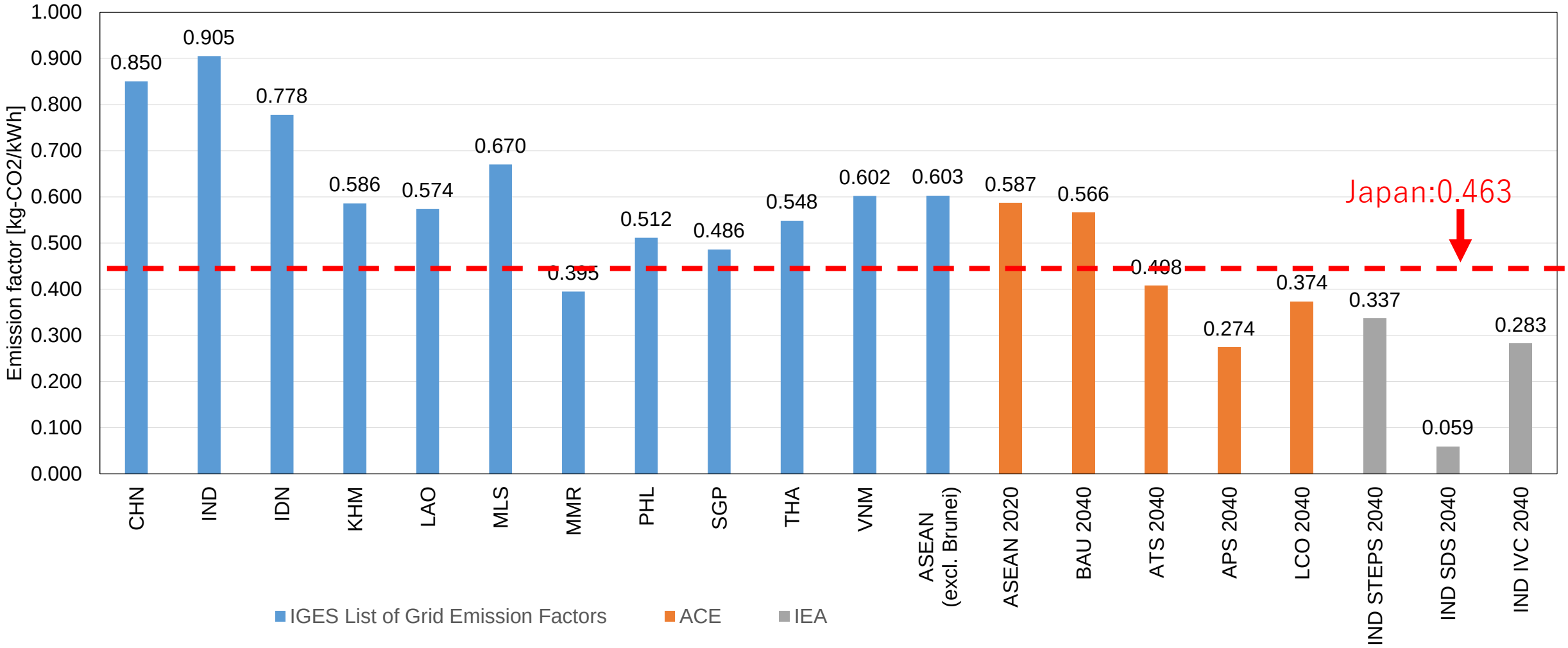

CO_2 emission factor in 2020 and scenario in Asia

Reference: ASEAN Centre for Energy. The 7th ASEAN Energy Outlook. 2022
Institute for Global Environmental Strategies (2022). List of Grid Emission Factors, version 11.0. Available at: https://pub.iges.or.jp/pub/iges-list-grid-emission-factors. 2022.11.25
IEA, India Energy Outlook 2021, 2021

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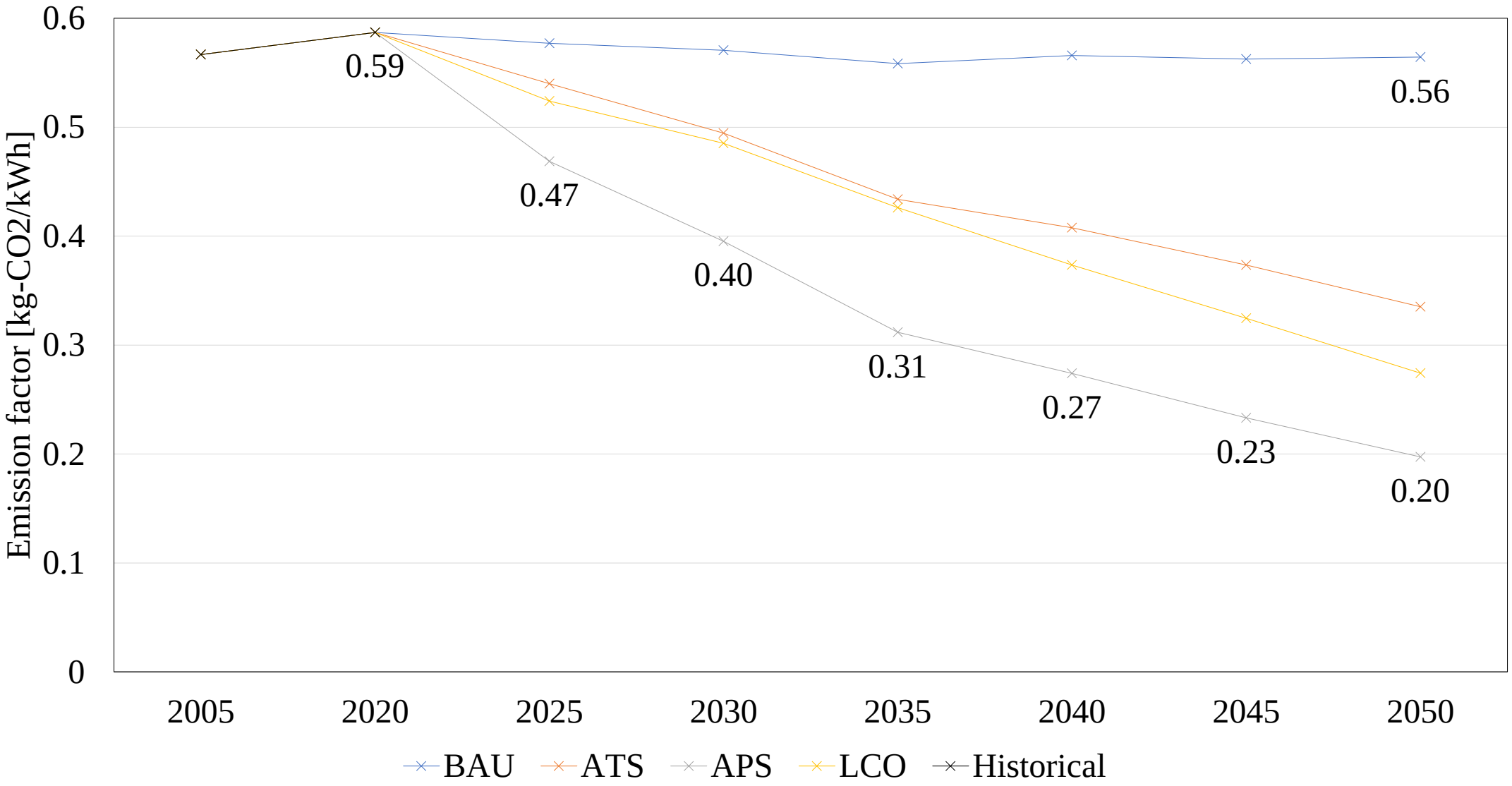

CO2 emission factor for each scenario

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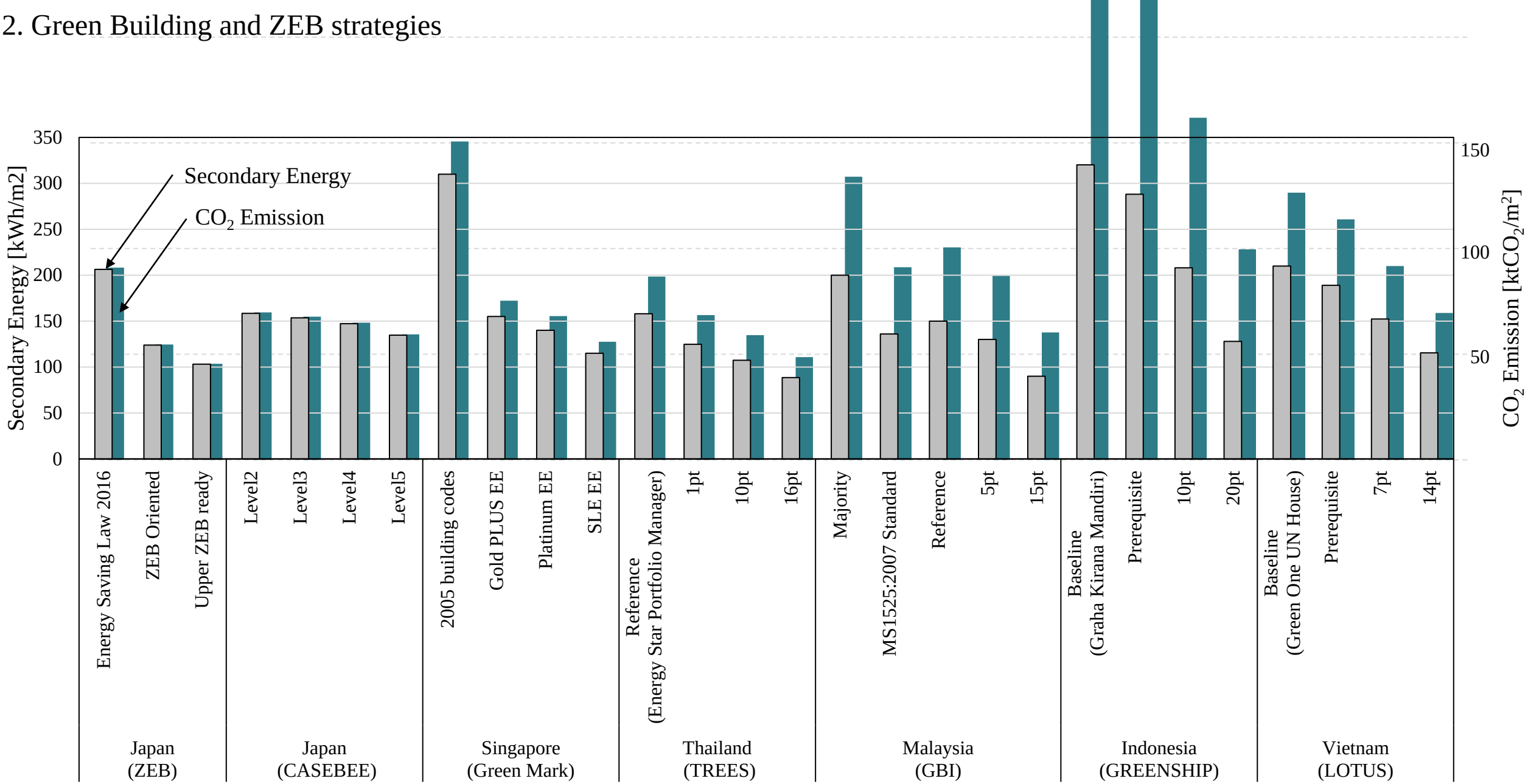
Green Building certified projects in Asia

Synopsis of criteria for Green Building and ZEB in Japan and ASEAN

Economy	Energy conservation standards	Evaluation method
Japan	CASBEE [1]	Evaluated by BEE = Environmental quality of building / Environmental load of building. Evaluated higher as BEE increases. There are many evaluation items. Energy consumption is evaluated in terms of **BPI** (ratio of standard PAL* to design PAL).
	ZEB [2]	Evaluated in terms of BEI (ratio of standard primary energy consumption to design primary energy consumption). Evaluated higher as BEI decreases.
Singapore	Green Mark [3]	Evaluated based on the score of 5 items related to an **energy consumption reduction rate compared with the energy conservation standard model enacted in 2005** and sustainability. Achieve GoldPLUS at 50% reduction of energy consumption, Platinam at 55%, and SLE at 60%, respectively.
Thailand	TREES [4]	Evaluated with the total score of 8 items related to sustainability. For energy consumption, points are added based on a **reduction rate compared with Energy Star Portfolio Manager**. Energy Star Portfolio Manager is the U.S. standards.
Malaysia	Green Building Index [5]	Evaluated based on the total score of 6 items related to sustainability. For energy consumption, points are added every time **secondary energy consumption** is reduced by 10 kWh/m^2・year **on the basis of 150 kWh/m^2・year**.
Indonesia	GREENSHIP [6]	Evaluated based on the total score of 6 items related to sustainability. For energy consumption, one point is acquired at every 2.5% reduction from the baseline model, assuming 10% reduction therefrom as a minimum requirement. **The baseline model shall be annual energy consumption of the model in line with the standards enacted by MoPW (Indonesian Ministry of Public Works)**.
Vietnam	LOTUS [7]	Evaluated based on the total score of 6 items related to sustainability. For energy consumption, one point is acquired at every 2.5% reduction from the baseline model, assuming 10% reduction therefrom as a minimum requirement. The baseline model shall be **annual energy consumption of the model designed based on LOTUS Guideline**.

References:
1) CASBEE for Building: New Construction 2016 Edition, Japan Sustainable Building Consortium
2) ZEB Portal / Definition of ZEB Ministry of the Environment, Japan
3) GREEN MARK 2021, Building and Construction Authority, Singapore
4) Thai's Rating of Energy and Environmental Sustainability 2017, Thai Green Building Institute
5) GREENBUILDINGINDEX SDN BHD: Green Building Index for NRNC (2009), Malaysia
6) GREENSHIP 2013, Green Building Council Indonesia
7) Lotus New Construction V3 Technical Manual 2019, Vietnam Green Building Council



Targeted secondary energy / CO2 Conservation Level in Japan and ASEAN

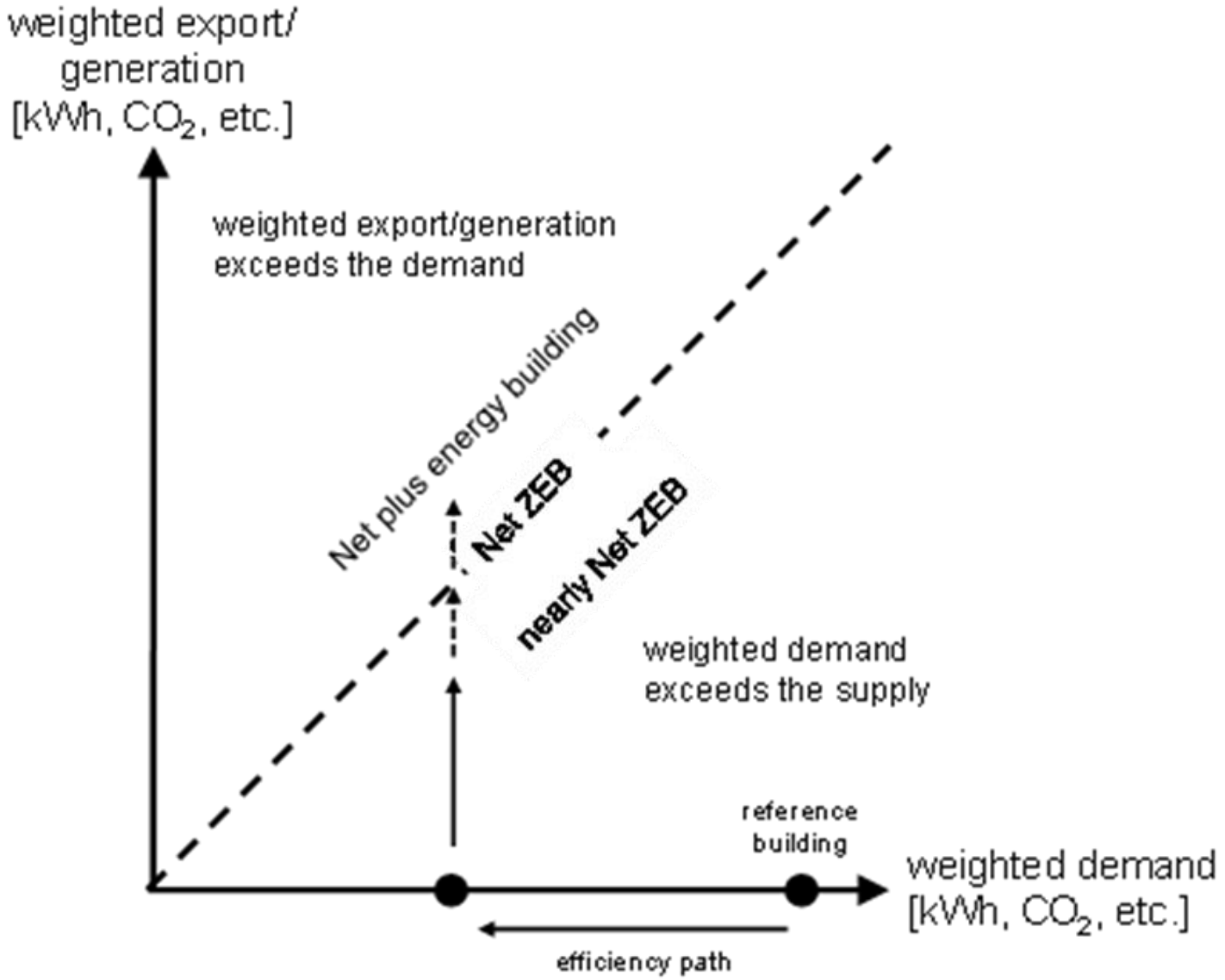
2. Green Building and ZEB strategies

JP

US

CN

ZEB projects in Asia and Pacific

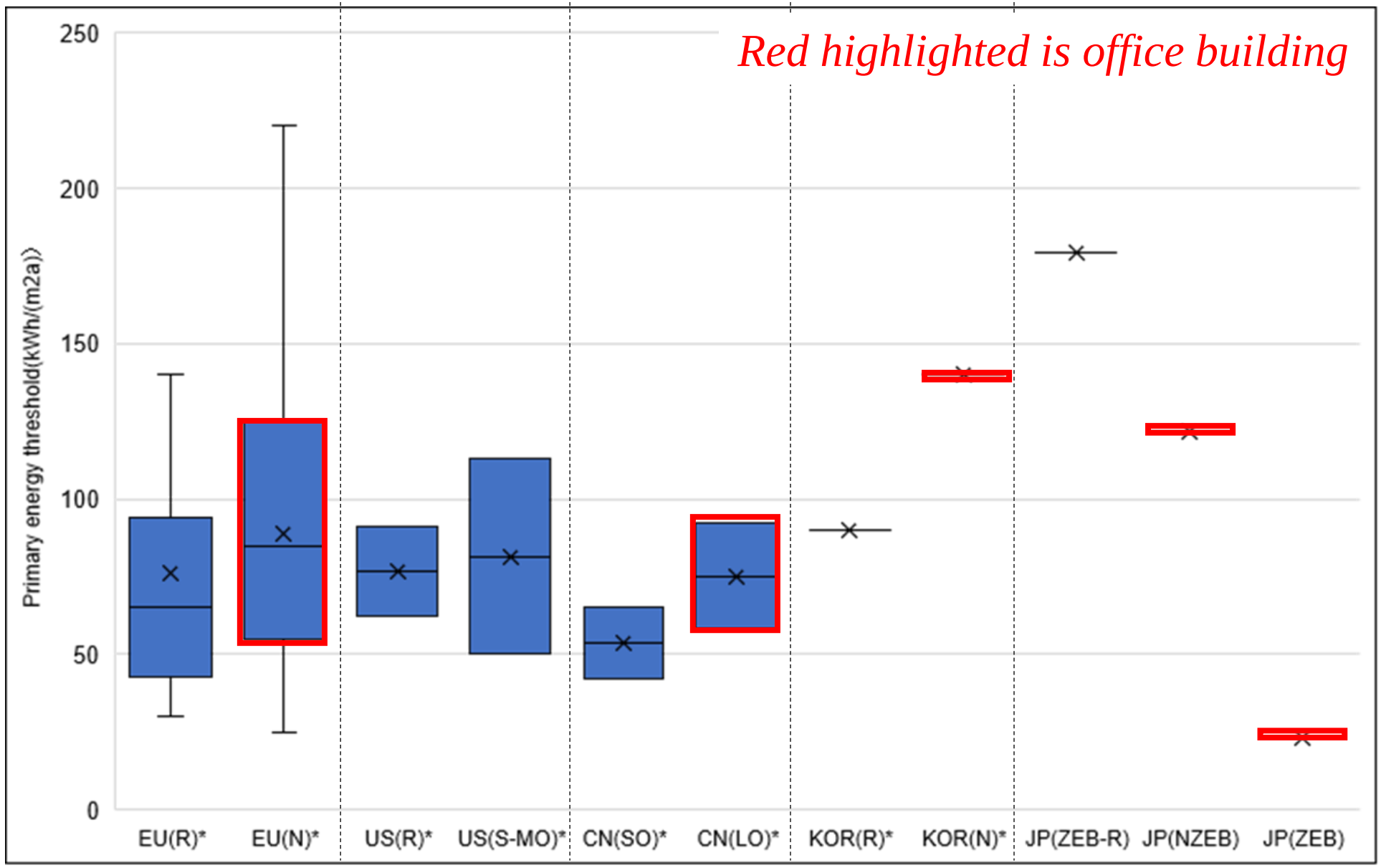


Definition of ZEB

References: Karsten Voss, Igor Sartori, Roberto Lollini. Nearly-zero, Net zero and Plus Energy Buildings – How definitions & regulations affect the solutions. REHVA Journal: June 2012

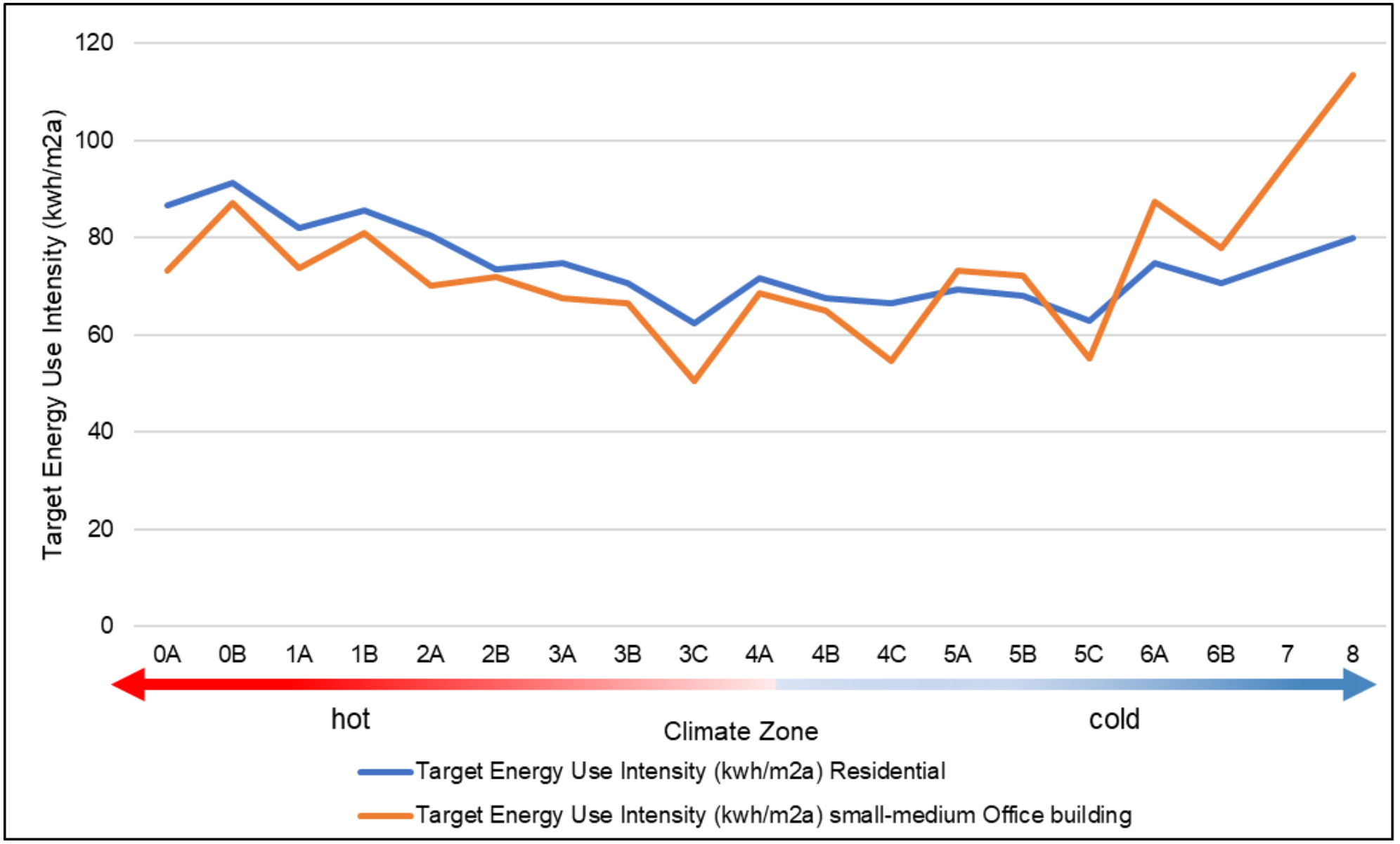
Target of ZEB in countries and regions

	Year	ZEB Policy
US	2030	All new buildings to be net ZEB
	2040	50% of commercial building to be zero energy
	2050	All commercial buildings to be zero energy
JP	2030	Achieve ZEB on average with regards to newly constructed buildings, Achieve ZEH for all newly constructed houses
CN	2030	30% of the new building and existing building will be ZEB, and 30% of new building energy consumption will be renewable
KOR	2030	All new buildings will achieve zero energy goal
EU	2027	All new public buildings are zero-emission
	2030	All new buildings are zero-emission

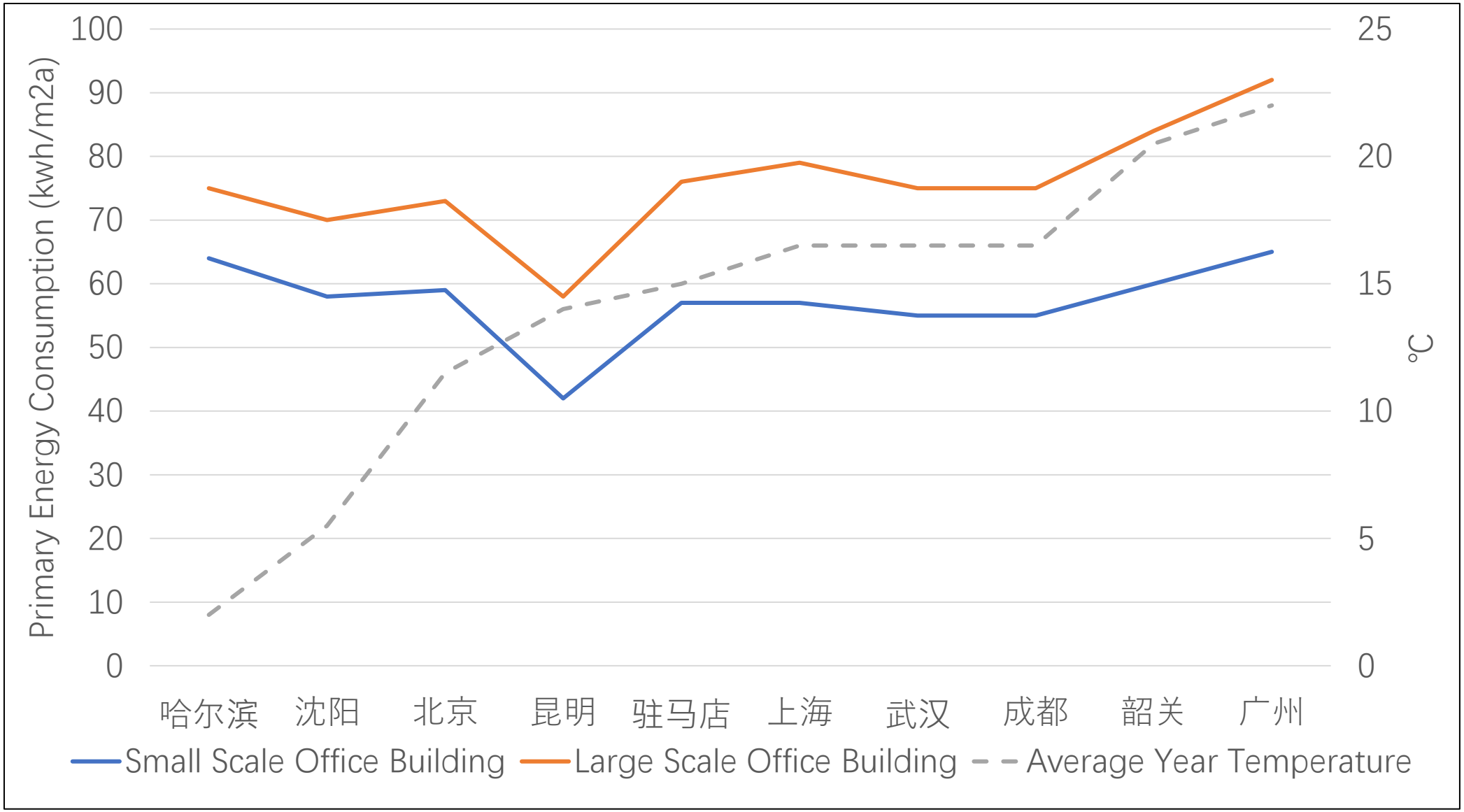


Target primary energy consumption for ZEB in each countries and regions

(N)*: Non-residential、(R)*: Residential、(S-MO)*: Small-Medium Office Building、(SO)*: Small Office、(LO)*: Large-Scale Office Building



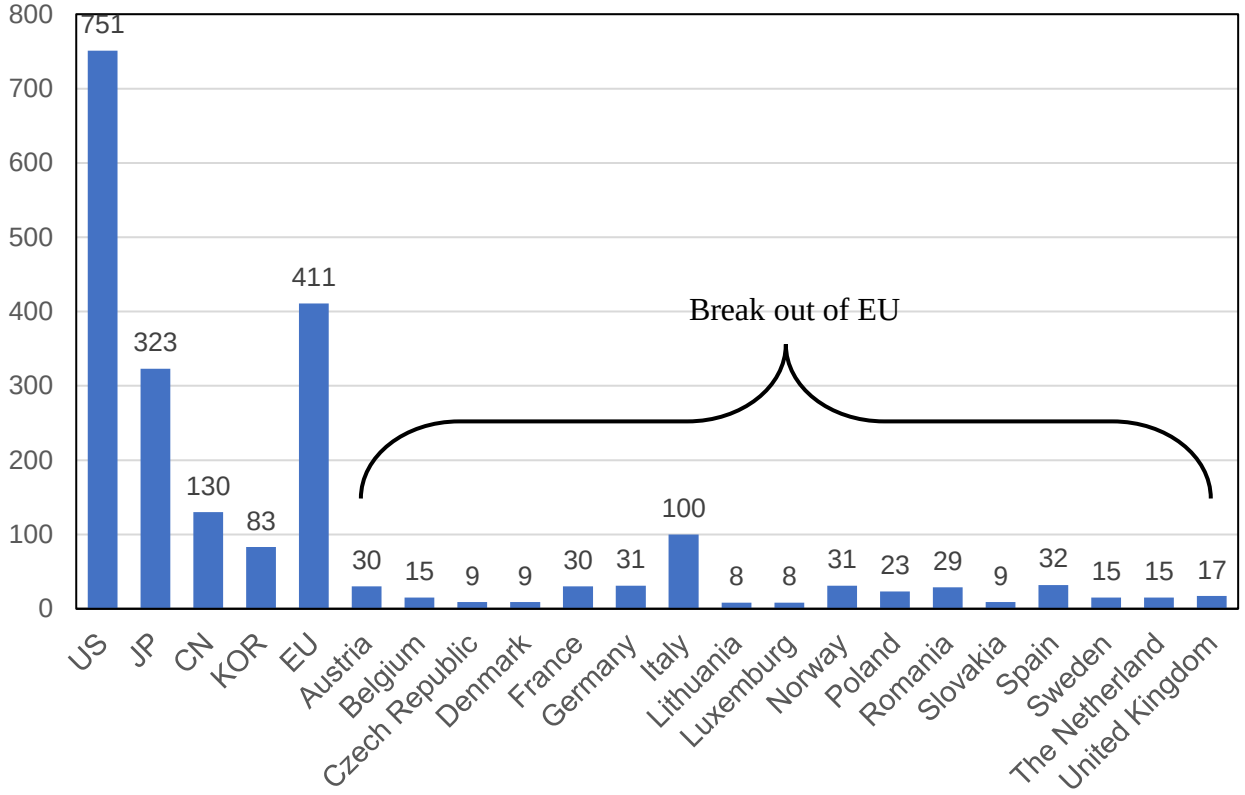
Relationship between Climate Zone and Target Energy Use Intensity in US

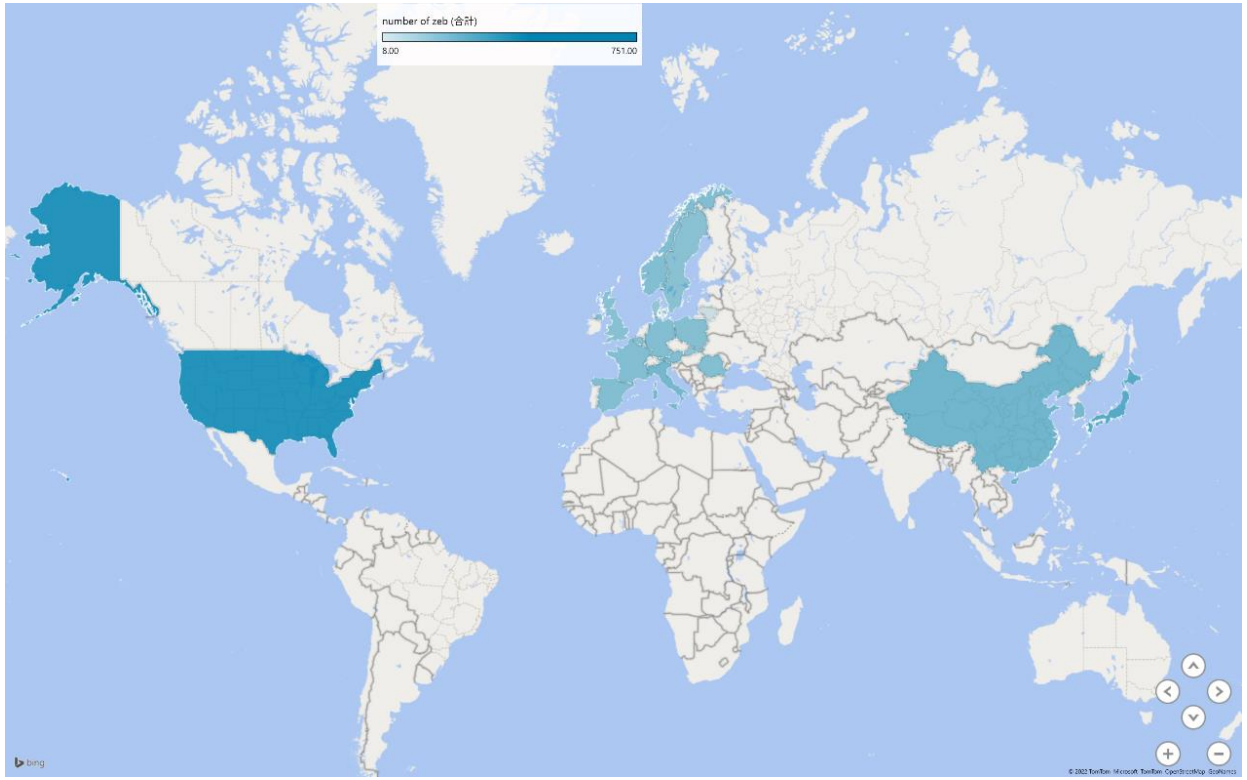


Relationship between Climate Zone and Target Energy Use Intensity in CN

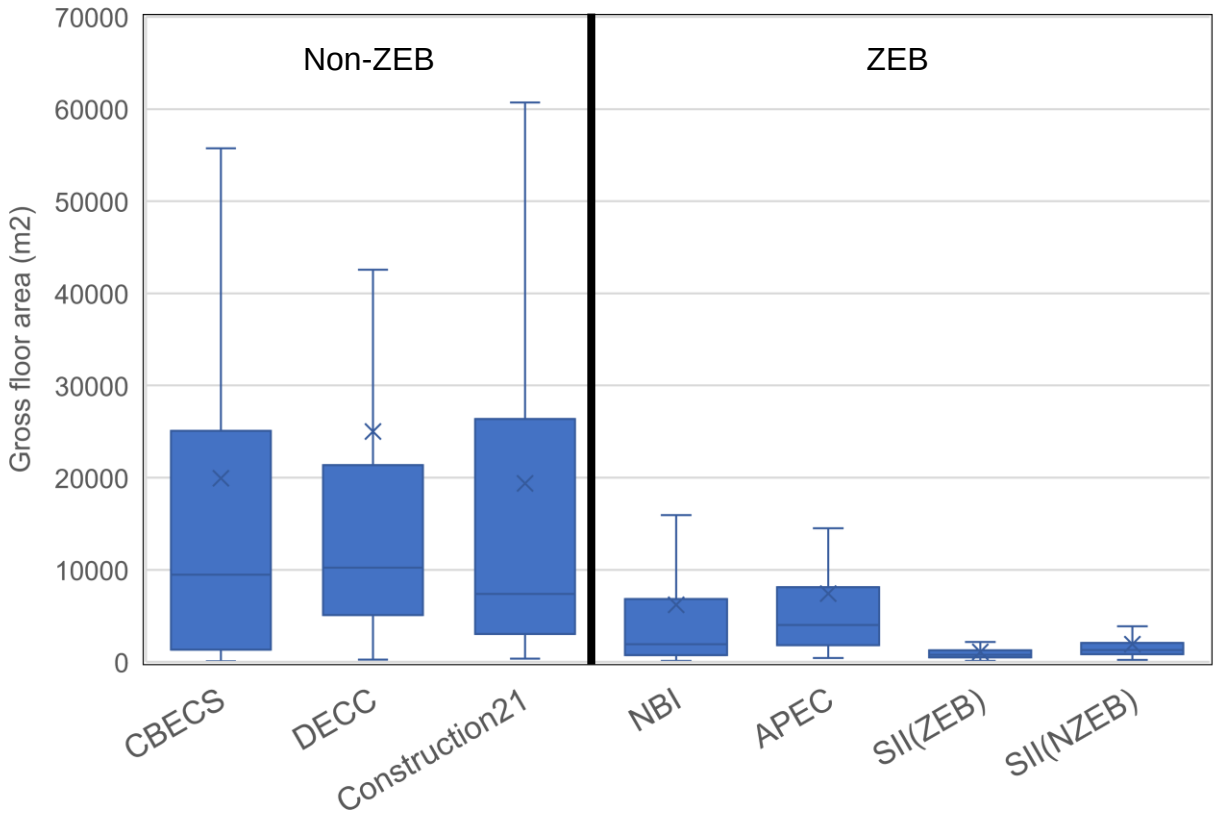
Target database for analysis on ZEB and non ZEB

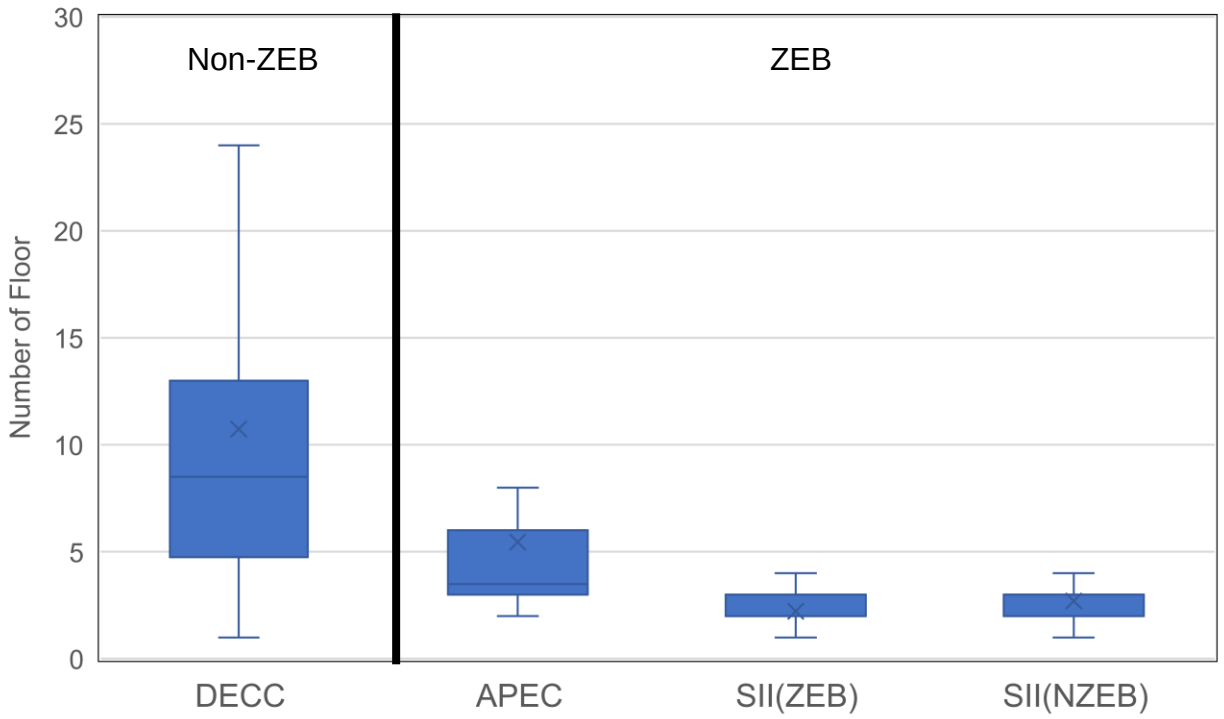
	Country	Number	Outline
CBECS	US	1329	A sample survey of information on commercial building stock across the United States, a database containing energy-related building characteristics and energy use data.
NBI	US	93	the statistical data of ZEB in the United States
Construction 21		60	Achieve ZEB on average with regards to newly constructed buildings, Achieve ZEH for all newly constructed houses
APEC		21	A database that extracts and organizes building information from 100 NZEB/ZEB case study reports in APEC member countries.
DECC	JP	140	Statistical data for commercial buildings in Japan managed by the Japan Sustainable Building Association.
SII	JP	120	A database of ZEB cases in Japan handled by the Environmental Co-Creation Initiative.



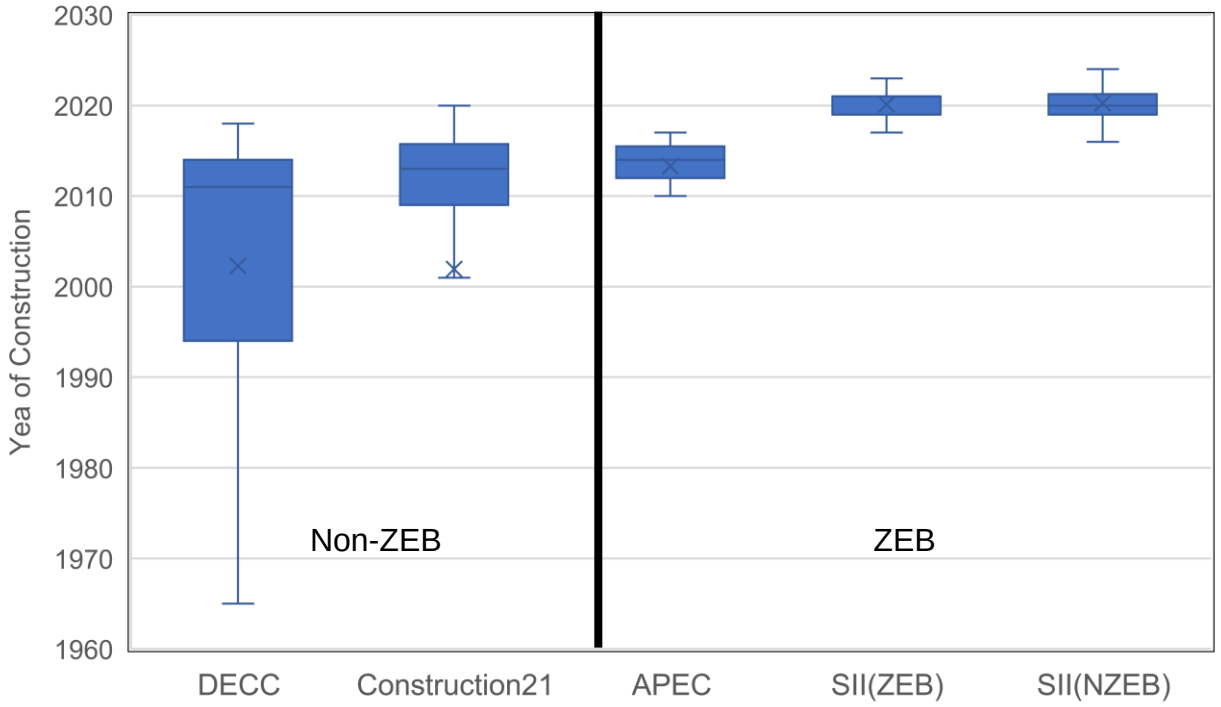


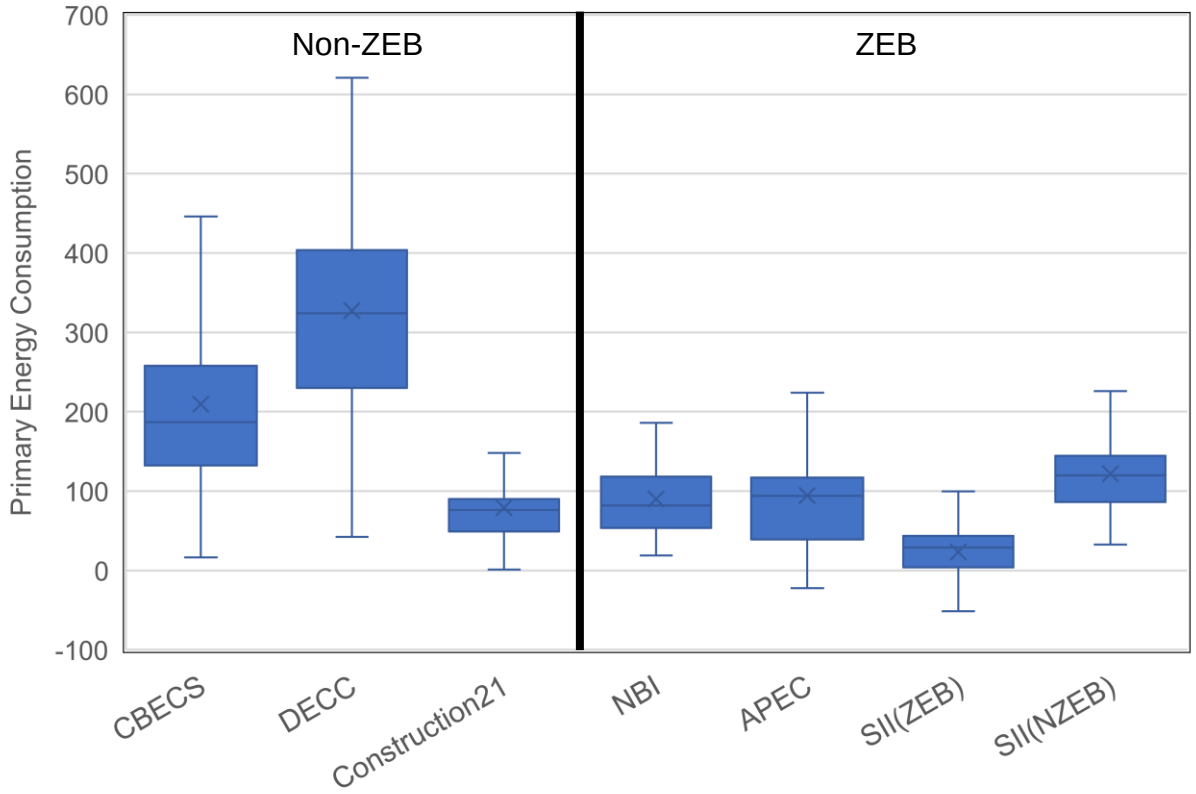
Number and distribution of ZEB





GFA and number of stories





Year of construction and Primary energy consumption

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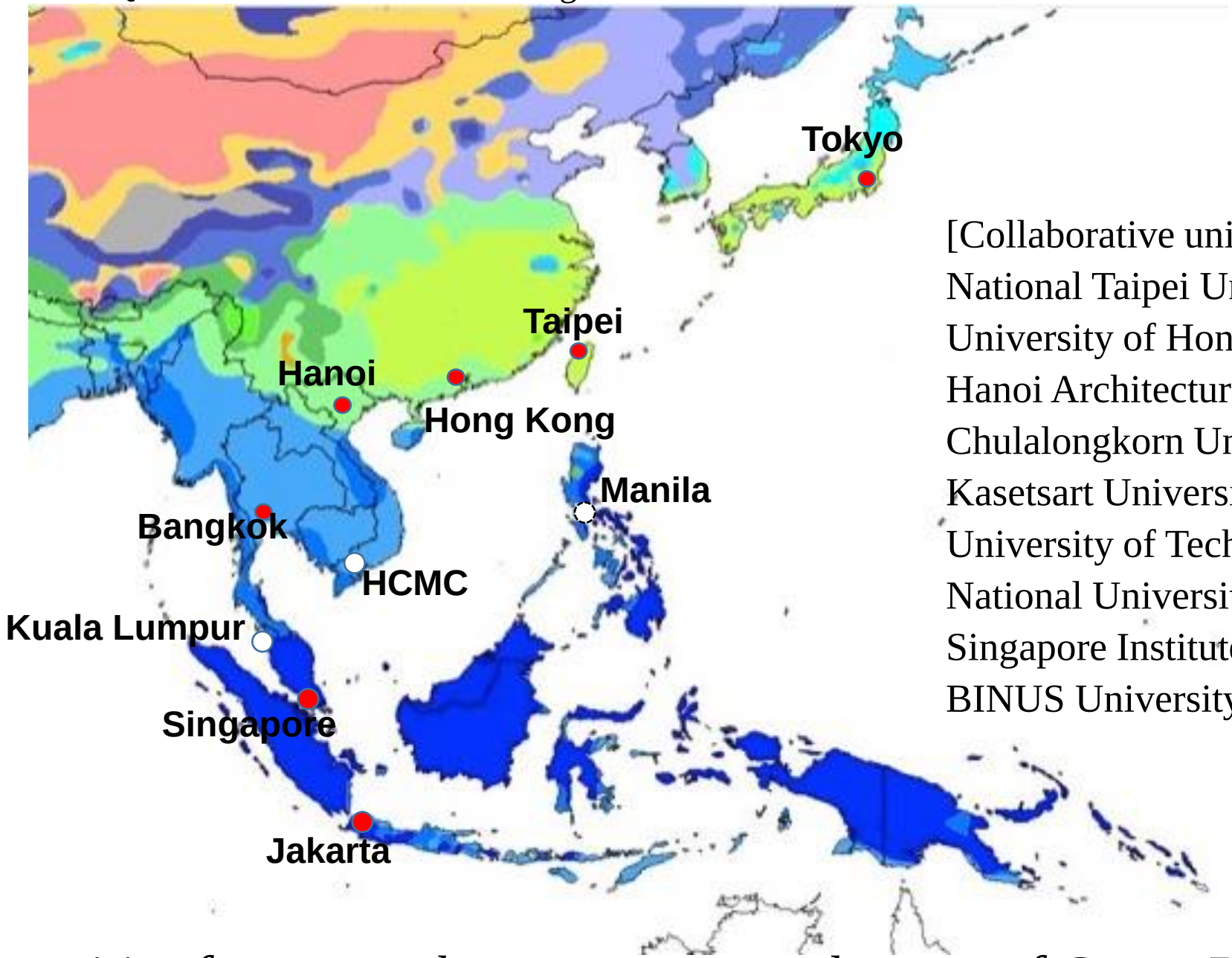


[Collaborative universities]
National Taipei University of Technology
University of Hong Kong
Hanoi Architectural University
Chulalongkorn University
Kasetsart University
University of Technology, Malaysia
National University of Singapore
Singapore Institute of Technology
BINUS University

Target cities for research survey on actual status of Green Building in Asia

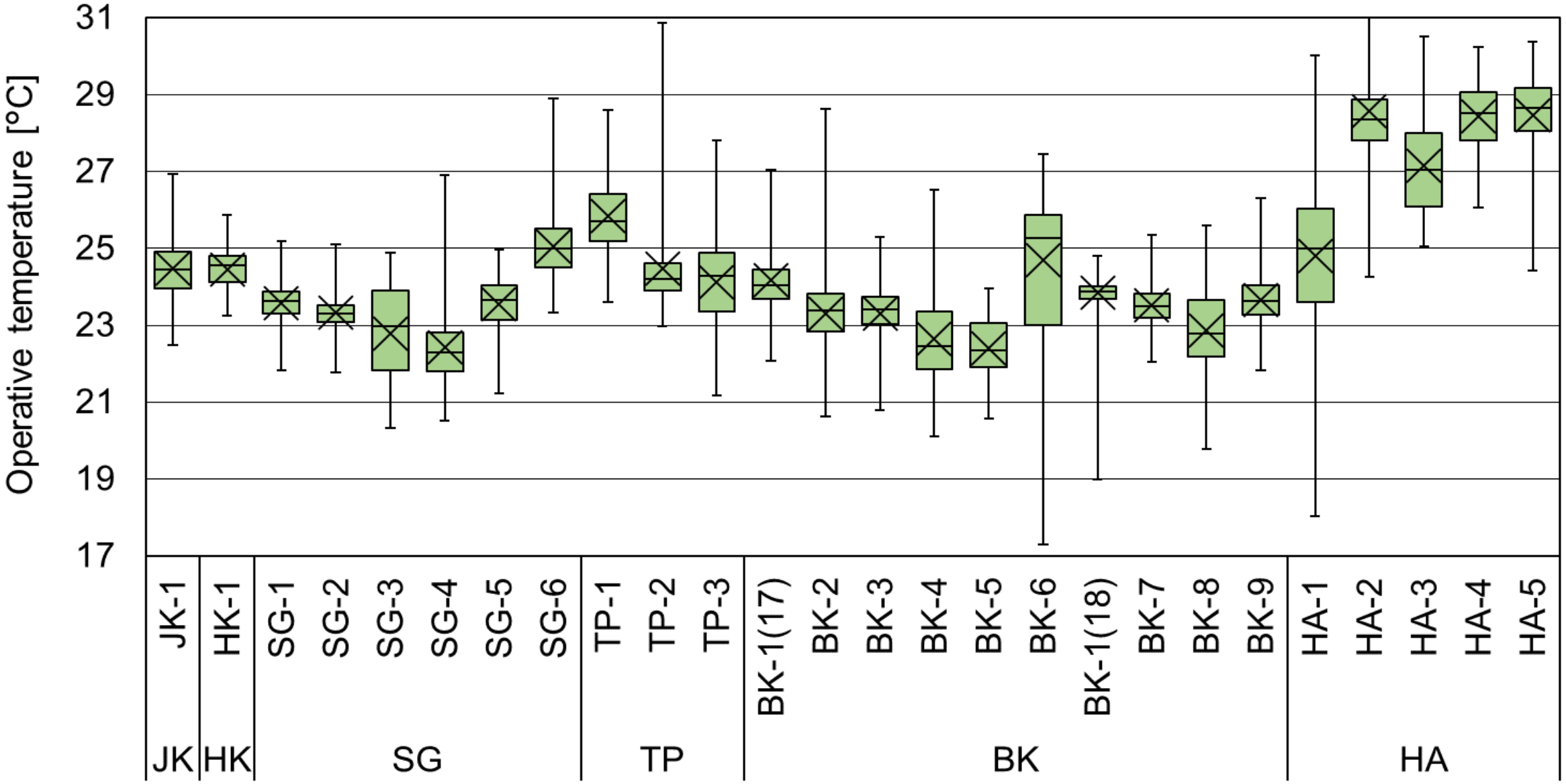
3. Actual status of IEQ / EUI at Asian Green Building

Target office building for investigation

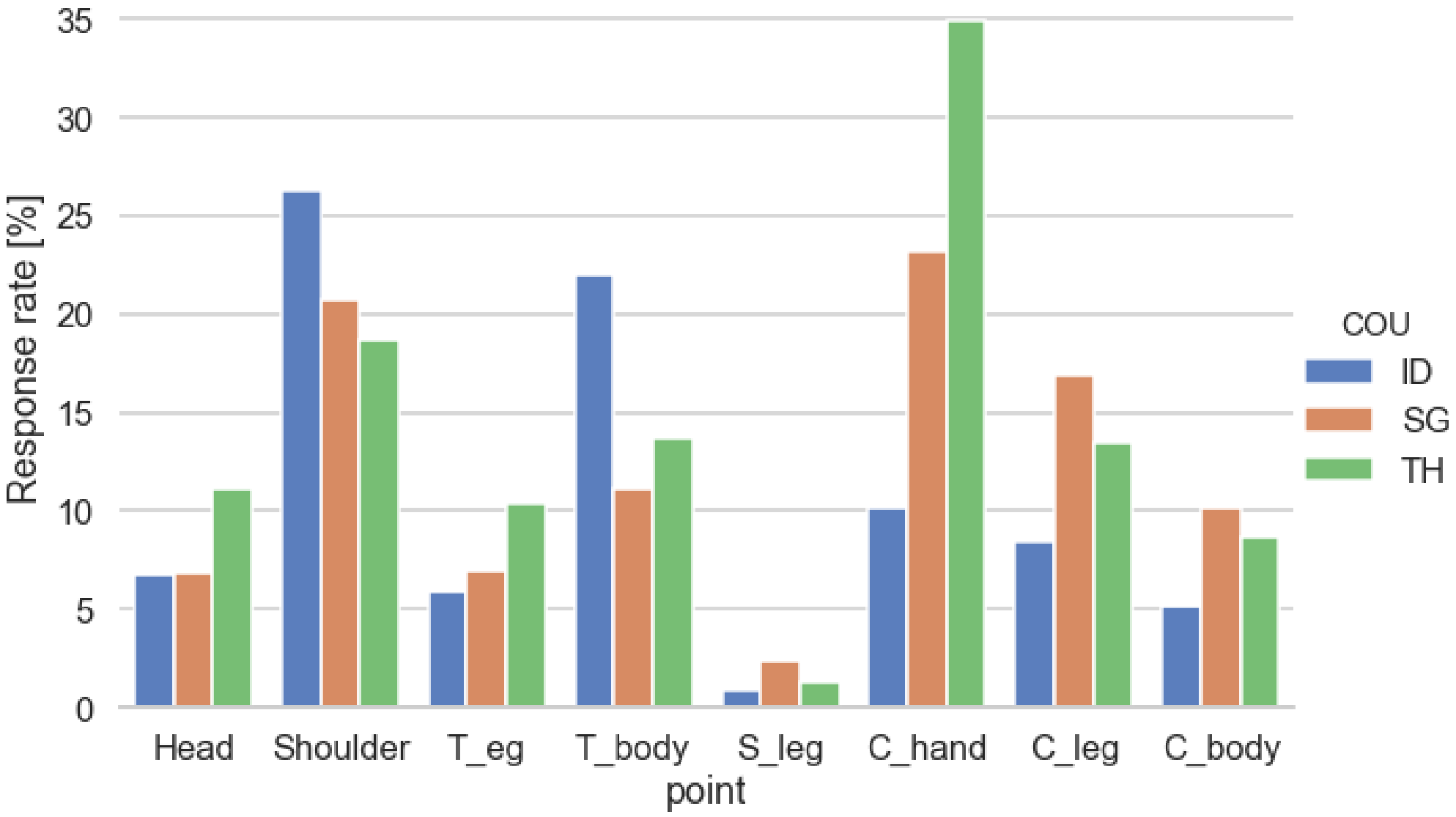
City	Jakarta	Hong Kong	Singapore						Hanoi				
													
Office	JK-1	HK-1	SG-1	SG-2	SG-3	SG-4	SG-5	SG-6	HA-1	HA-2	HA-3	HA-4	HA-5
Age	1993	2010	2014	1985	2014	2003	2014	2015	2010	2009	2002	2013	2009
Total stories	22	118	9	42	5	5	20	6	23	27	19	25	27
Measured floor	17	19	4	31	3	2	5	6	22	5	14	22	7
A/C type	Cent	Cent	Cent	Cent	Cent	Cent	Cent	Cent	Indi	Cent	Both	Both	Indi
GFA [m^2]	27000	260200	8667	81756	-	8408	31360	5516	28000	22518	34640	61400	40000
Measured area	843	484	550	879	360	1060	1761	565	981	436	1224.5	1684	840
Number of the occupants	74	41	31	88	22	38	186	51	36	40	54	152	35
Business time	9:00-17:00	9:00-18-00	8:30-17:00	8:30-17:30	8:30-17:30	8:30-17:30			8:00-18:00	8:00-18:00	8:00-18:00	8:00-18:00	8:00-18:00
Investigation	Sep2017	May2018	Oct2017	Nov2017	Mar2018	Mar2018	May2018	May2018	May2015	May2015	May2015	May2015	May2015

City	Taipei			Bangkok									
													
Office	TP-1	TP-2	TP-3	BK-1(17)	BK-2	BK-3	BK-4	BK-5	BK-6	BK-1(18)	BK-7	BK-8	BK-9
Age	-	2014	2014	2014	1992	2011	1985	1989	2016	2014	2011	2008	2015
Total stories	12	23	23	22	31	41	19	20	5	22	27	48	25
Measured floor	10	17	17	17	28	36	14	7	4	17	17	32	11
A/C type	Indi	Indi	Indi	Cent	Cent	Cent	Cent	Cent	Cent	Cent	Indi	Cent	Cent
GFA [m2]	9158	42712	42712	27720	194655	161285	24300	41500	6961	27720	64558	97094	56000
Measured area	544.7	967.7	1063	778	411	1090	1212	1100	1465	778	290	492	950
Number of the occupants	62	61	61	85	37	142	53	107	190	85	65	75	140
Business time	9:00-18:00			8:00-18:00	8:00-18:00	8:00-17:00	9.00-18.00	9.00-17.00	8:00-18:00	8:00-18:00	8:00-17:00	8:30-17:30	8.30-17.30
Investigation	Sep2016	Jun2018	Jun2018	Mar2017	Mar2017	Jul2017	Jun2018	Jun2018	Sep2018	Sep2018	Mar2019	Mar2019	May2019

3. Actual status of IEQ / EUI at Asian Green Building

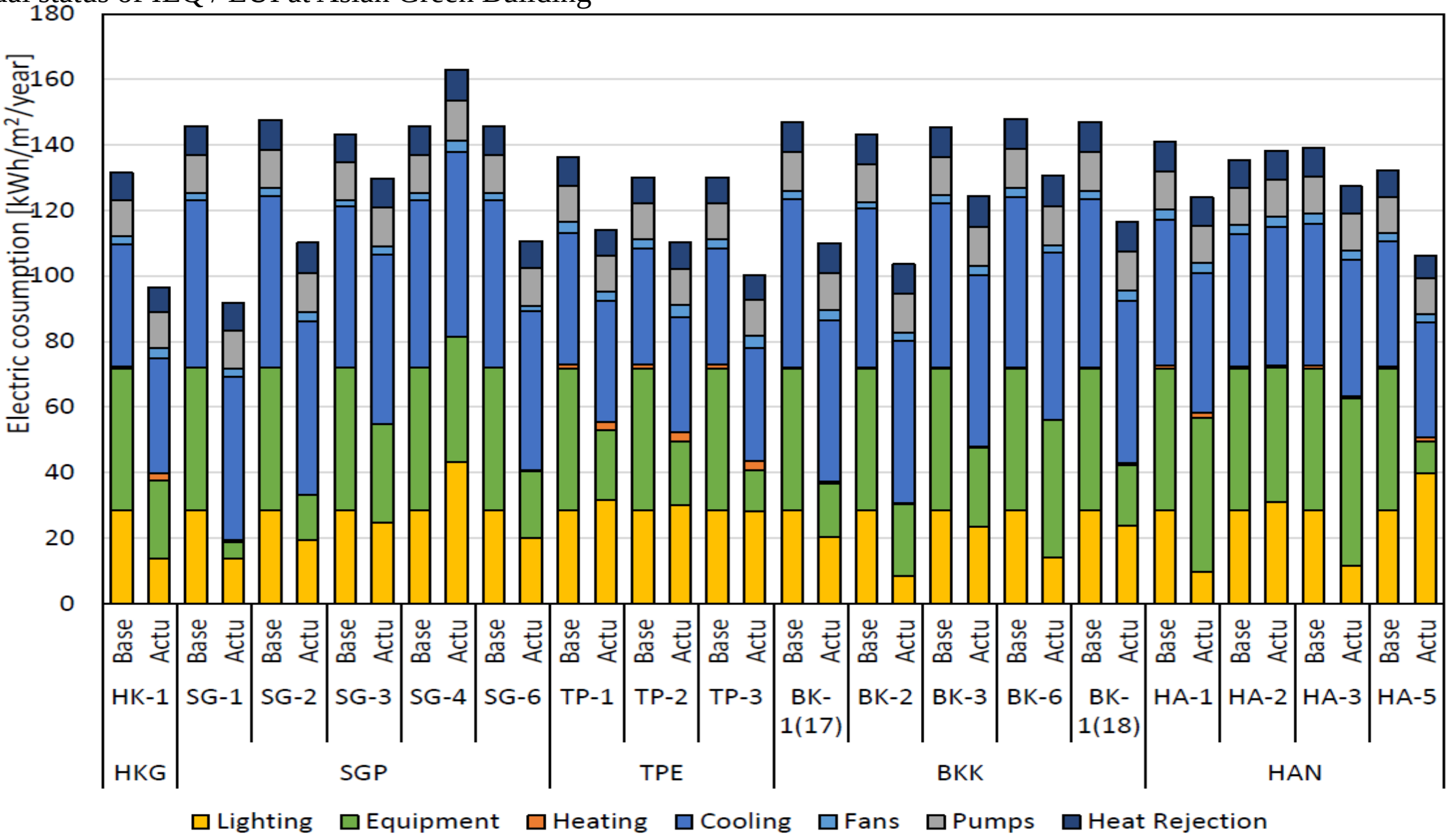


Operative temperature distribution during office hour



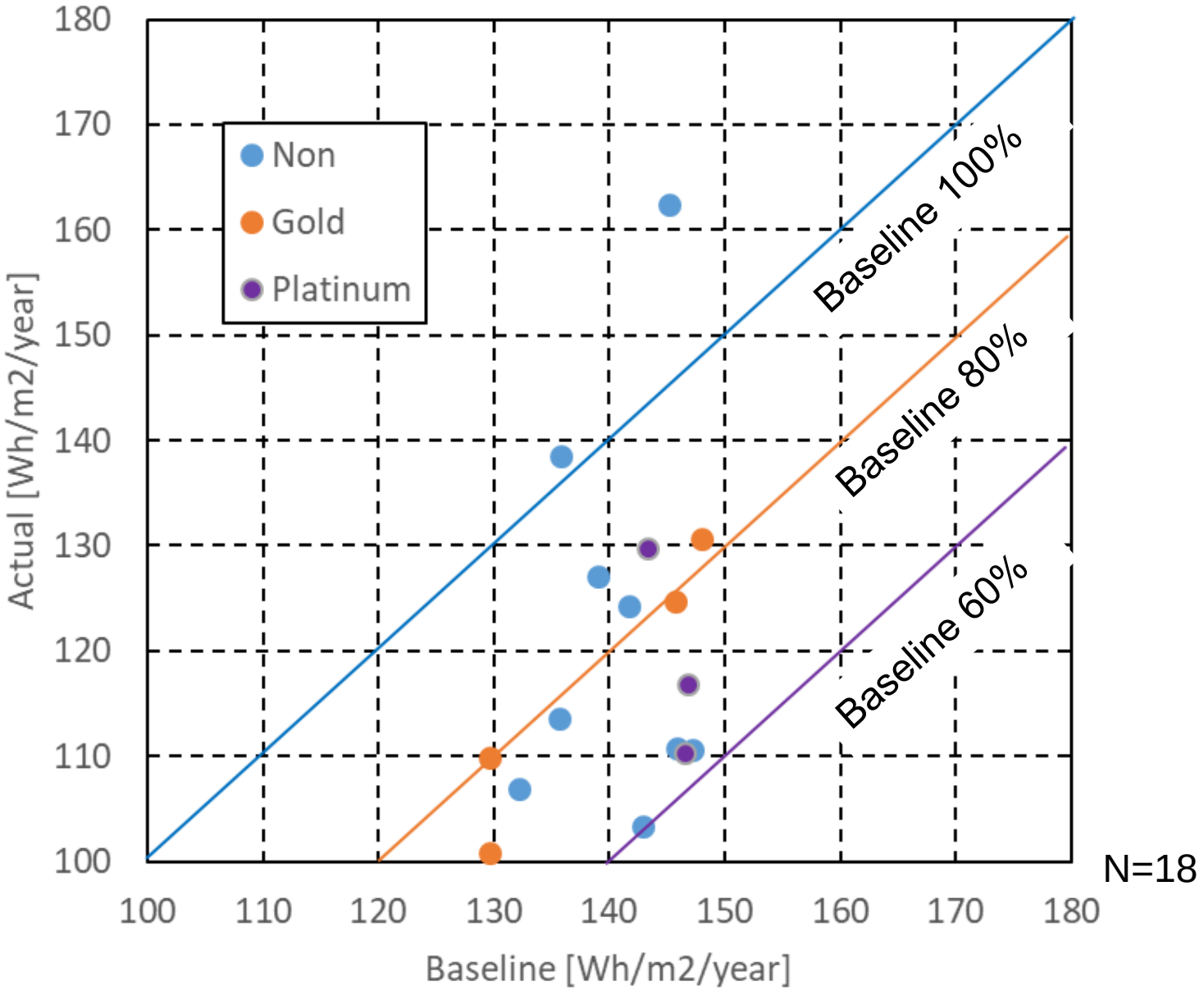
Frequency of symptom derived from excessive cooling

3. Actual status of IEQ / EUI at Asian Green Building



Yearly energy consumption of baseline and actual

3. Actual status of IEQ / EUI at Asian Green Building



Correlation between baseline and actual energy consumption

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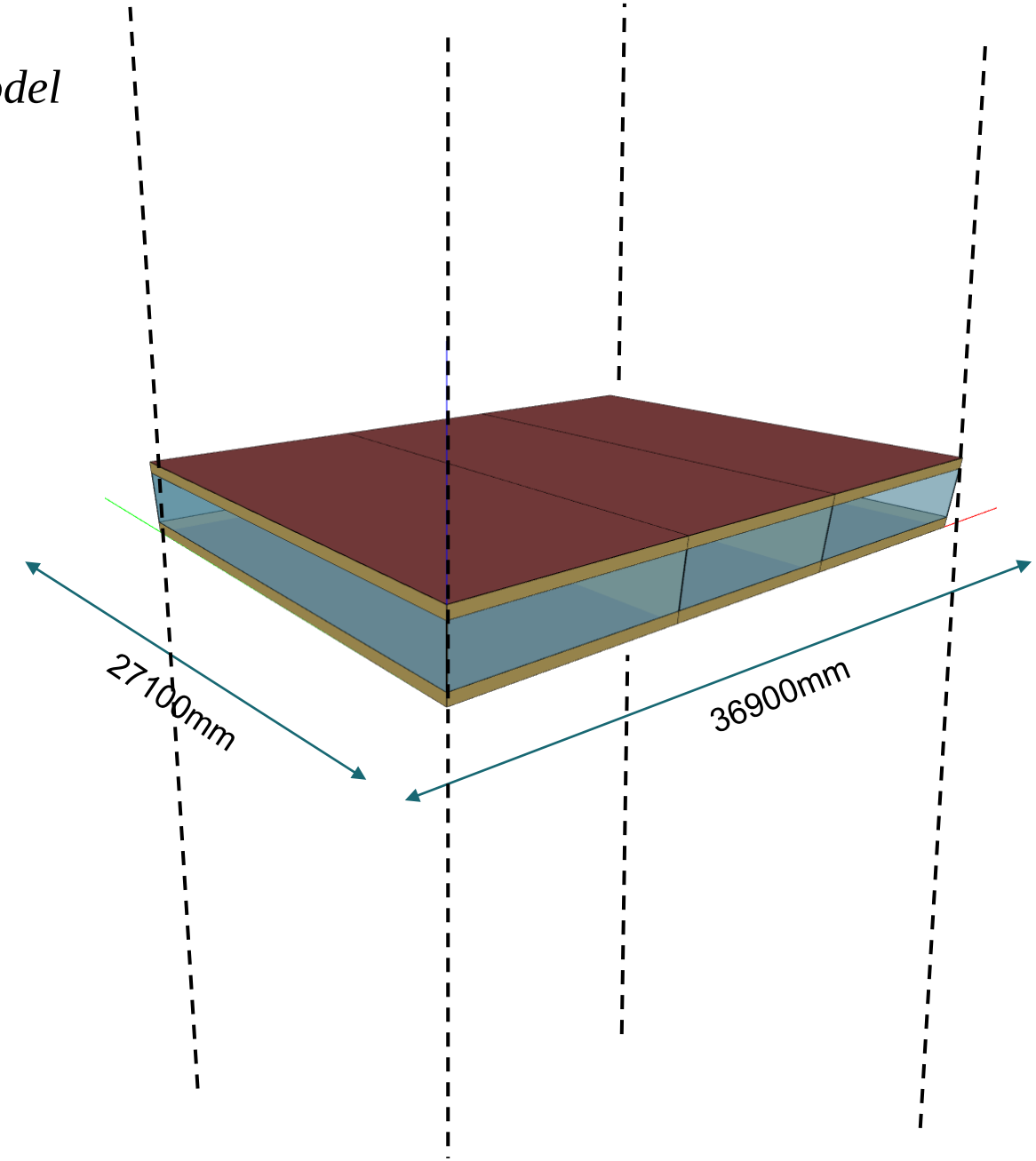
Parameters for reference, middle/high countermeasure model

	Reference	Middle	High
Wall insulation [mm]	25	50	75
Daylight [lx]	-	500	300
Eaves [mm]	-	500	1000
Glass U-value [W/(m2K)]	5	3	1
Glass SHGC [-]	0.35	0.25	0.15
Setponit temperature [°C]	22	24	26
Infiltration [/h]	10	5	1
Air conditioning schedule	8:00~22:00	8:00~21:00	8:00~20:00
Lighting load [W/m2]	8.5	6.5	4.5
Equipment load [W/m2]	8	6	4

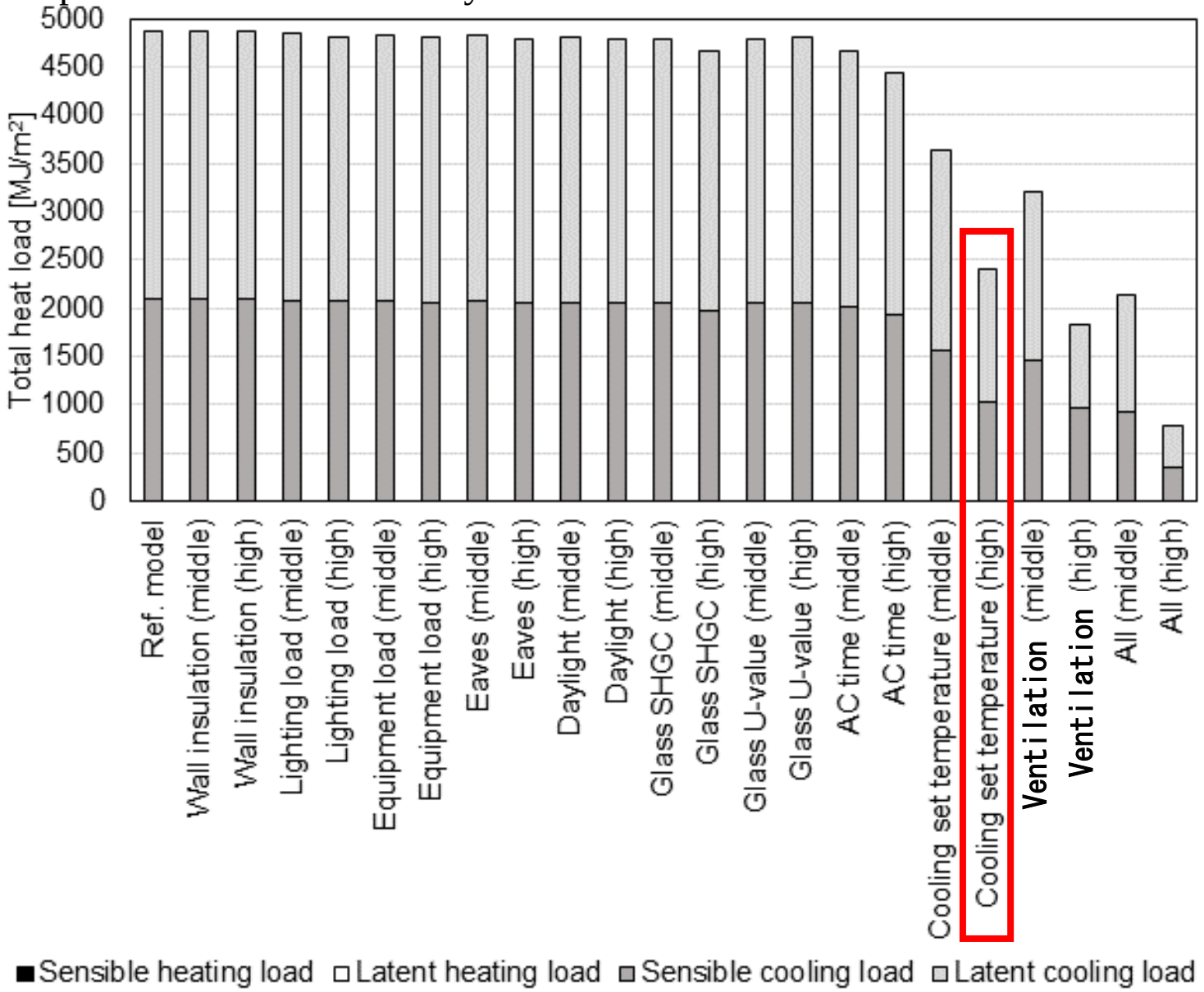
Parameters for combination application

	Setpoint	Infiltration	Other strategies
CASE 1	22°C	10/h	×
CASE 2	22°C	5/h	×
CASE 3	22°C	1/h	×
CASE 4	24°C	1/h	×
CASE 5	26°C	1/h	×
CASE 6	26°C	1/h	○

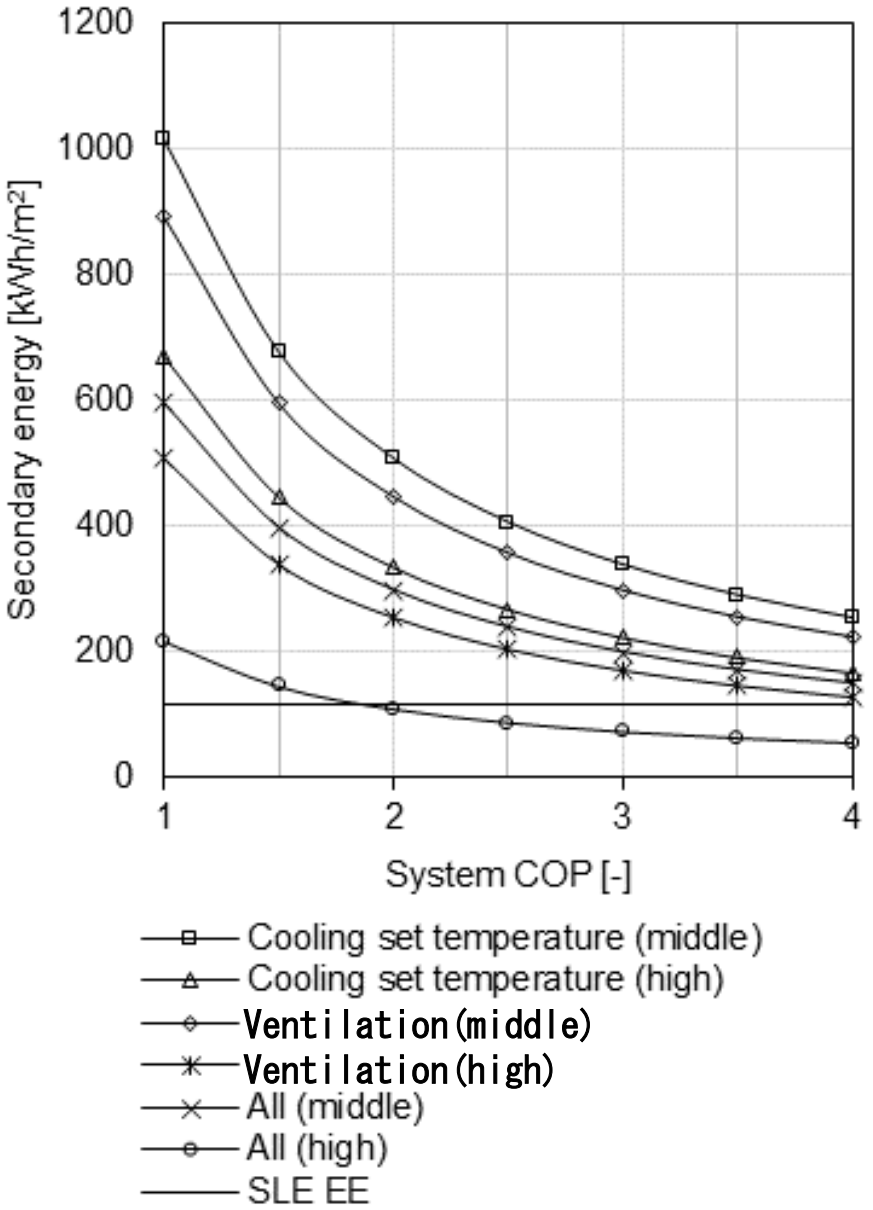


Heat load simulation model for EnergyPlus

4. Impact for GHG reduction by ZEB



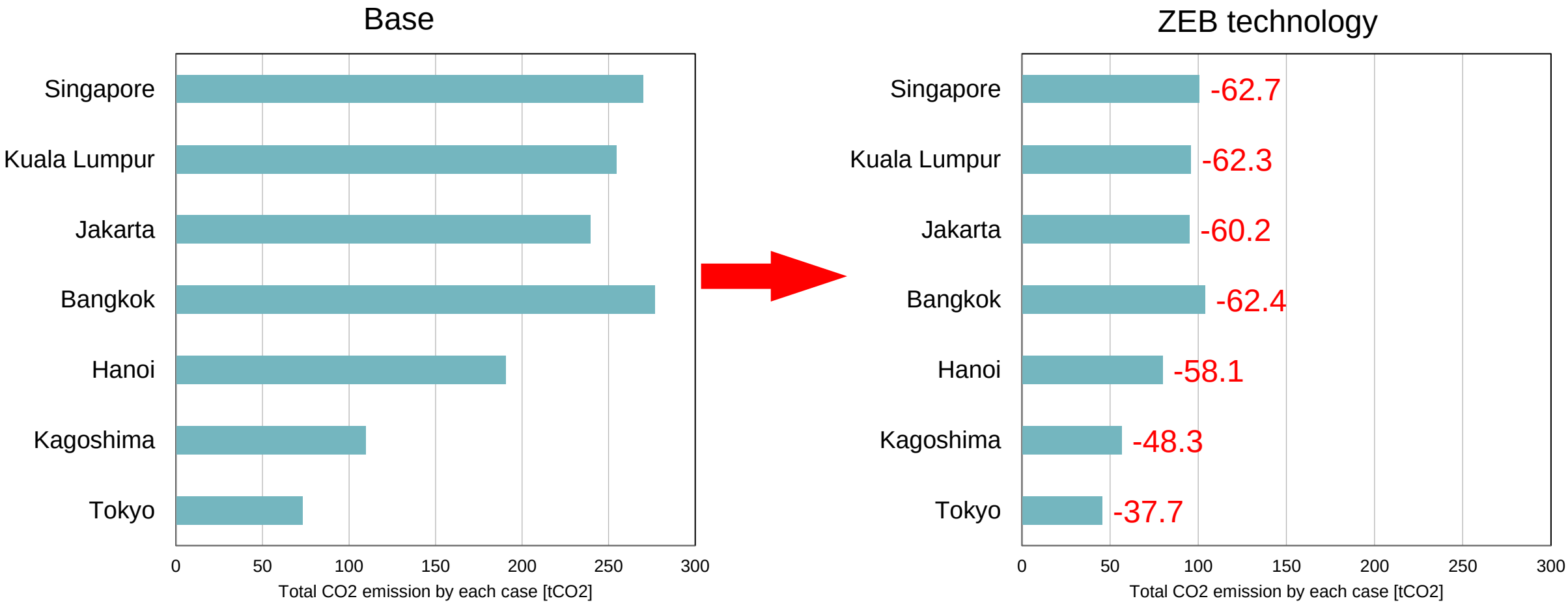
(a) Sensitive analysis on heat load of ZEB countermeasures



(b) Relationship between COP and secondary energy consumption

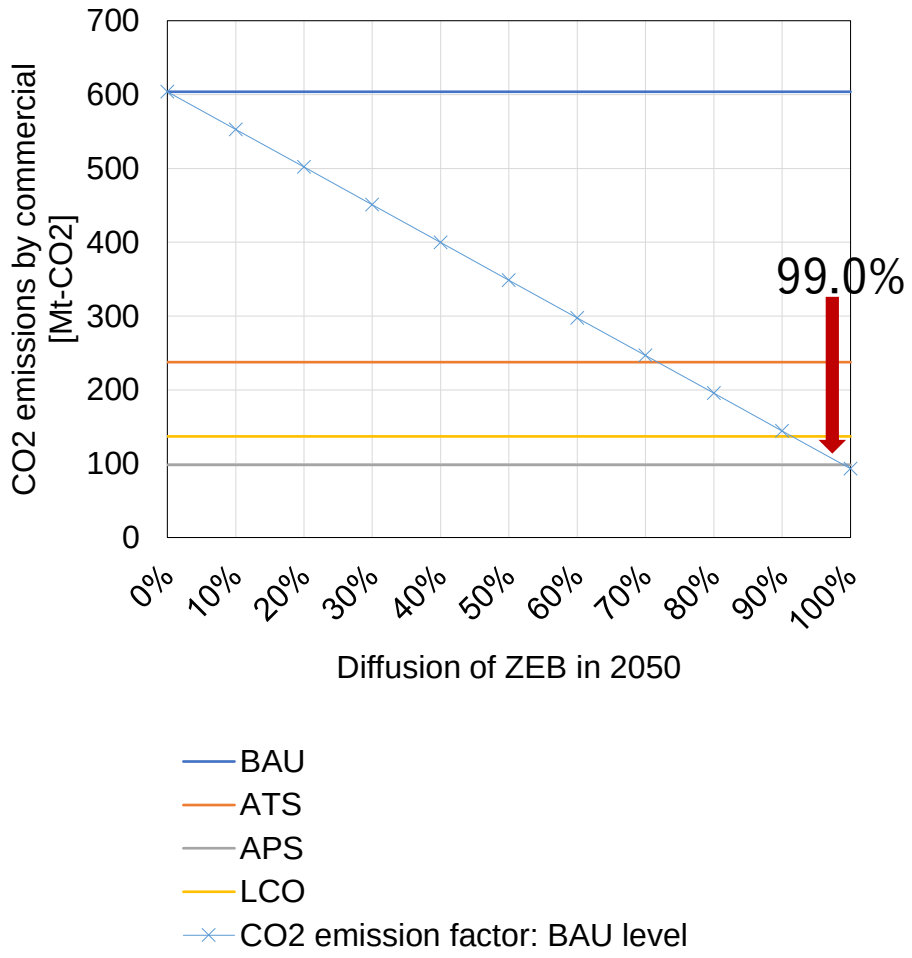
Annual heat load and energy consumption results at EPW Singapore

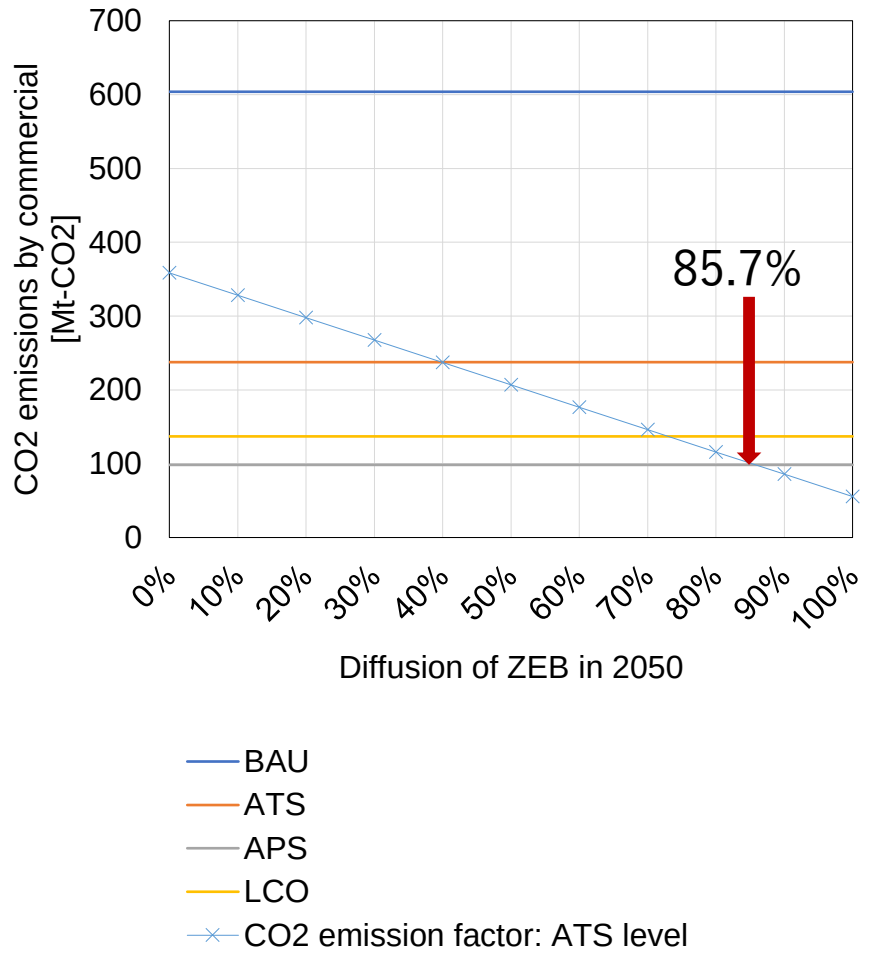
4. Impact for GHG reduction by ZEB



CO_2 emission reduction effect by ZEB measures for base model in different cities of Asia

4. Impact for GHG reduction by ZEB



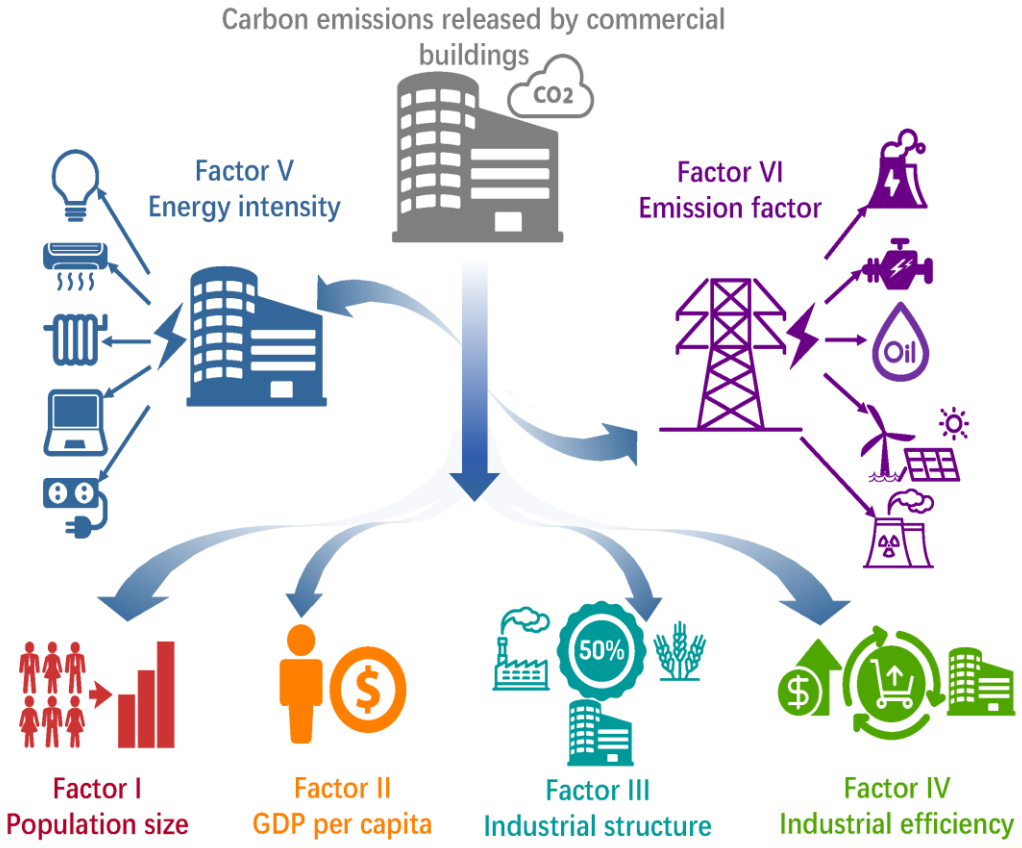


Relationship between diffusion of ZEB and Estimated CO2 emissions in 2050

Reference: International Energy Agency, Net Zero by 2050 A Roadmap for the Global Energy Sector, https://www.iea.org/reports/net-zero-by-2050, 2023.1.18

Importance of ZEB in Asia toward CN

- Energy consumption will accounts for 50% in 2030 and building sector accounts for 30%.
- Hot&Humid climate and urbanization are main factor of emission.
- China is the largest emission currently but approach CN by 2060.
- ASEAN will increase 4-5 times by 2050 compared to current.
- Green Building certification became widespread due to economic motivation but operation performance is inferior to designed one.
- One of the most efficient countermeasure is efficient ventilation.
- Guideline for local sustainable design/operation/metrics are needed for the urban building in Asia.



Six factors guided by the Kaya identity in an emissions model of a commercial building operation.

Reference:
Zhang, Shufan, Xiwang Xiang, Zhili Ma, Minda Ma, and Chenchen Zou. 2021. "Carbon Neutral Roadmap of Commercial Building Operations by Mid-Century: Lessons from China" *Buildings* 11, no. 11: 510.

Necessity of data collection and analysis

- Existing building code and assessment are not enough for evaluating building efficiency and realization of carbon neutrality.
- There are a lot of emerging data around the building that can be utilized.
- All of the data should be analyzed to display holistic building performance (indoor environmental quality, environmental load, disaster risk, etc.) for building owner, manager and user with transparency.