Contribution of APSEC and of the APEC Cooperative Network of Sustainable Cities to promoting green, digital and inclusive cities

Prof. Zhu LI, President, APEC Sustainable Energy Center (APSEC)
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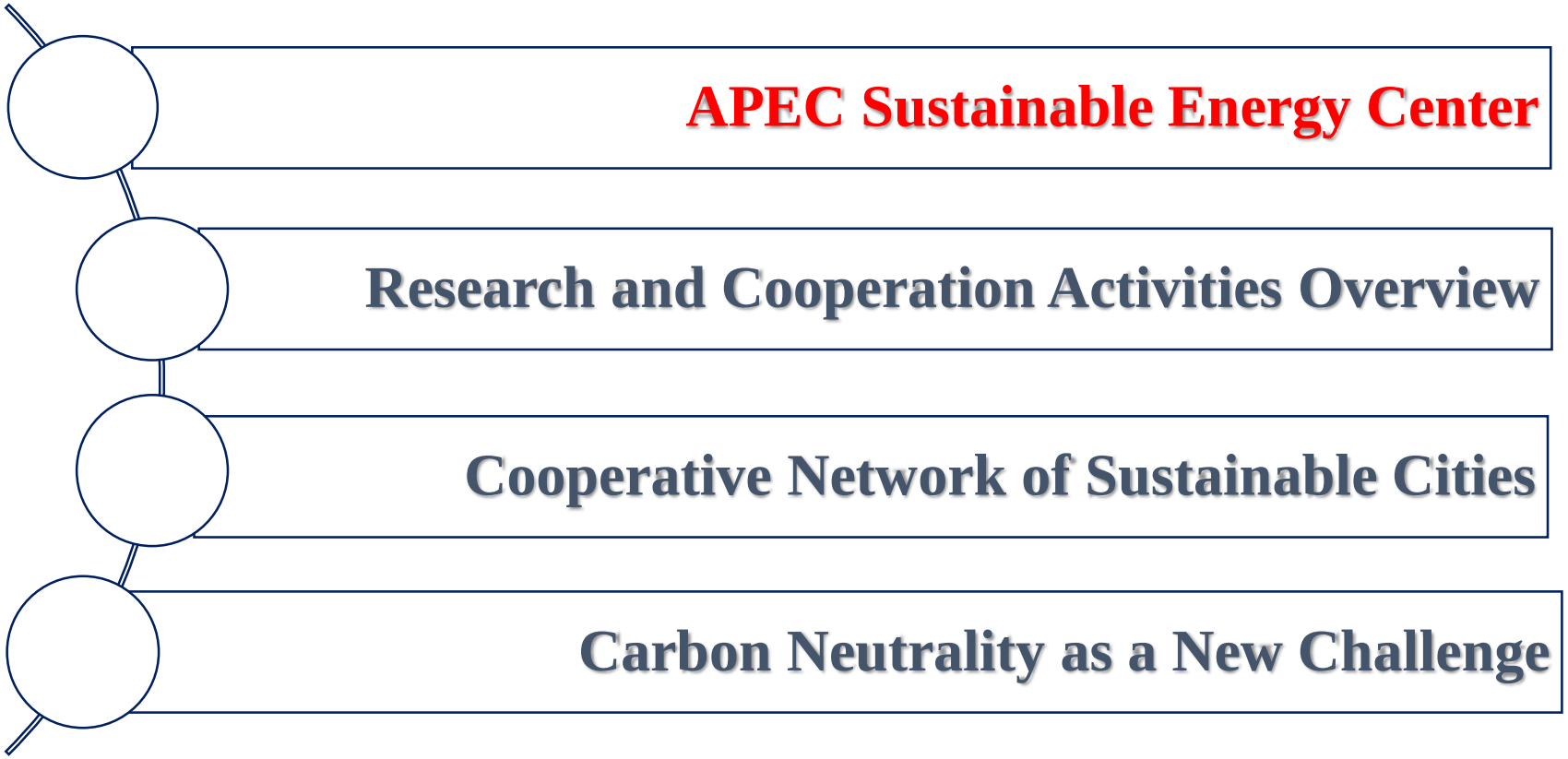
Building the Green, Digital and Inclusive City of the 21st Century. Online Conference, 11 – 12 January 2024


APEC Sustainable Energy Center
Research and Cooperation Activities Overview
Cooperative Network of Sustainable Cities
Carbon Neutrality as a New Challenge

APEC Sustainable Energy Center APSEC

APEC Sustainable Energy Center (APSEC) was established at the 11th APEC Energy Ministerial Meeting in 2014, and mentioned in the 22nd APEC Leaders‘ Declaration. It is a major achievement of the Chinese government responding positively to the initiative of APEC leaders to participate in energy cooperation in APEC region.

Sep. 2014	11th EMM, Beijing Declaration, China
Nov. 2014	22nd APEC Leaders’ Declaration
Oct. 2015	12th EMM, Cebu Declaration, Philippines
Nov. 2015	23rd APEC Leaders’ Declaration

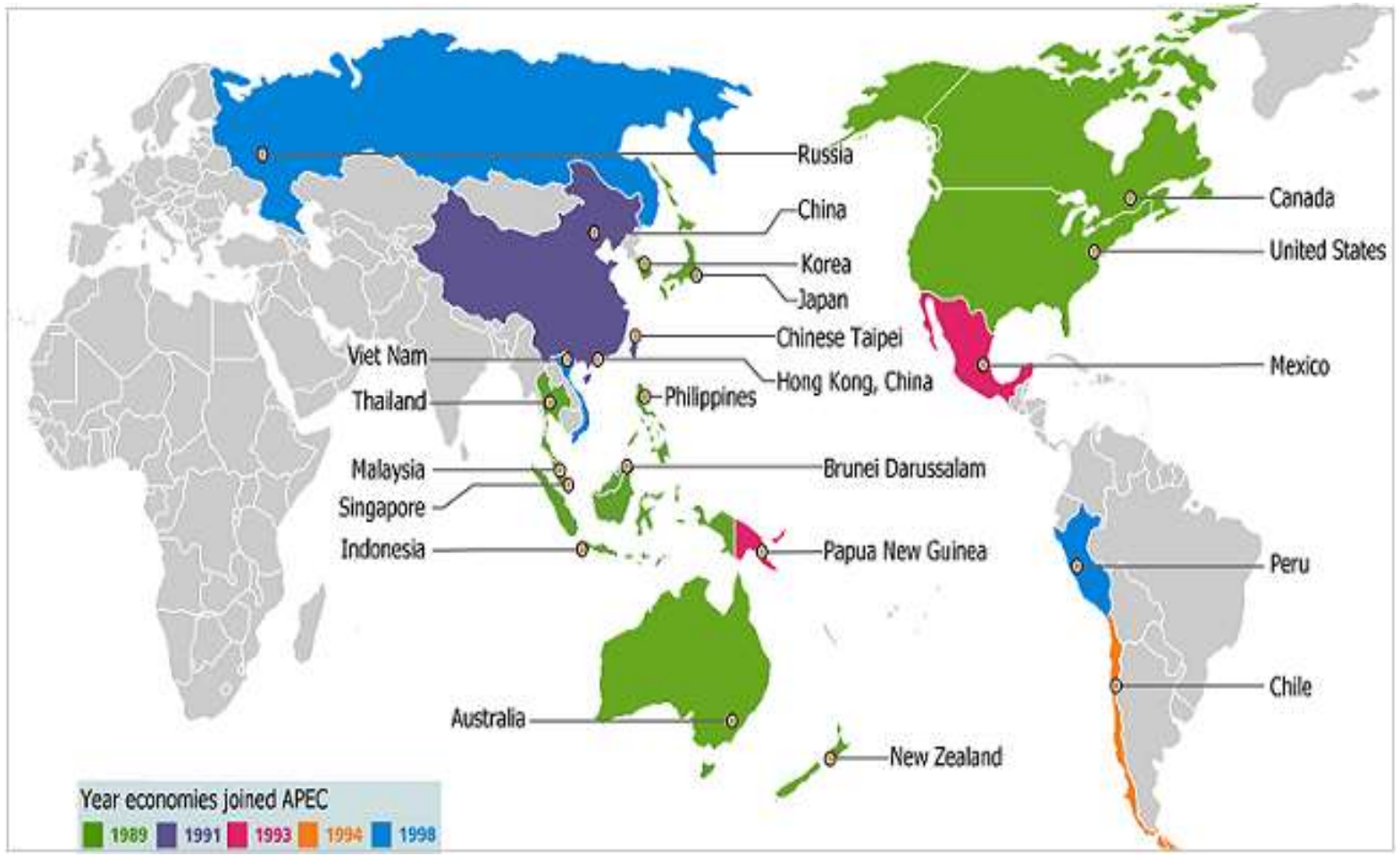
APSEC Mission

1. To promote pragmatic cooperation on sustainable energy development among APEC economics;

2. To act as National Energy Administration's think-tank on conducting strategic research and international cooperation in the field of sustainable energy development

CET Pillar Program Clean Energy Technologies for the Future	CNSC Pillar Program Cooperative Network of Sustainable Cities	ETS Pillar Program Energy Transition Solutions	Events: Two Workshops The Annual Forum

Asia Pacific Economic Cooperation (APEC)

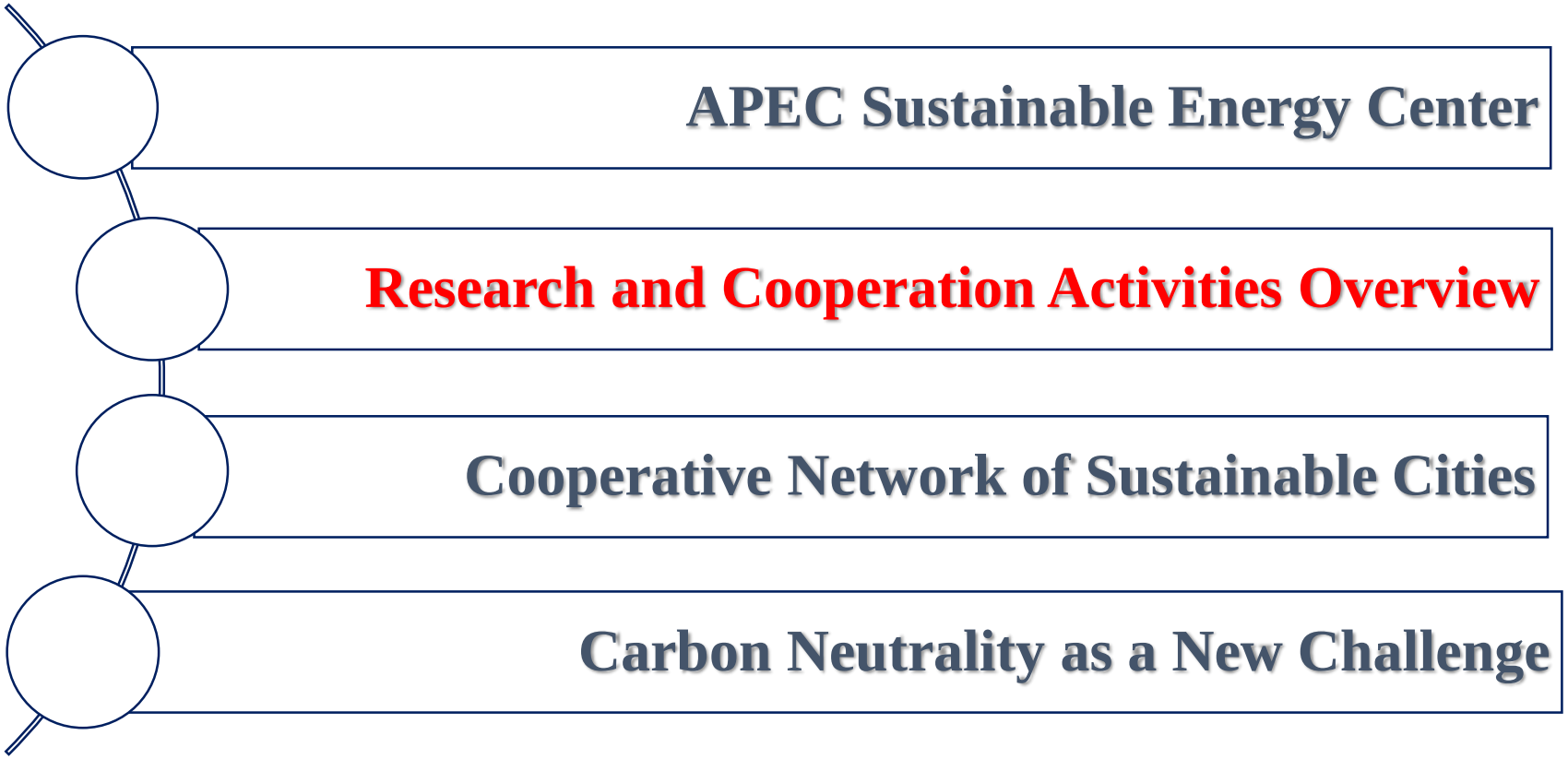


Created in 1989 in Canberra
21 member economies

38% of world population
42% of global terrestrial surface
47% of world trade
60% of global GDP
62% of global CO2 emissions

Rotating annual presidency
APEC-Secretariat in Singapore

Energy Working Group with several Sub-groups and two Research Centers: APSEC in China and APERC in Japan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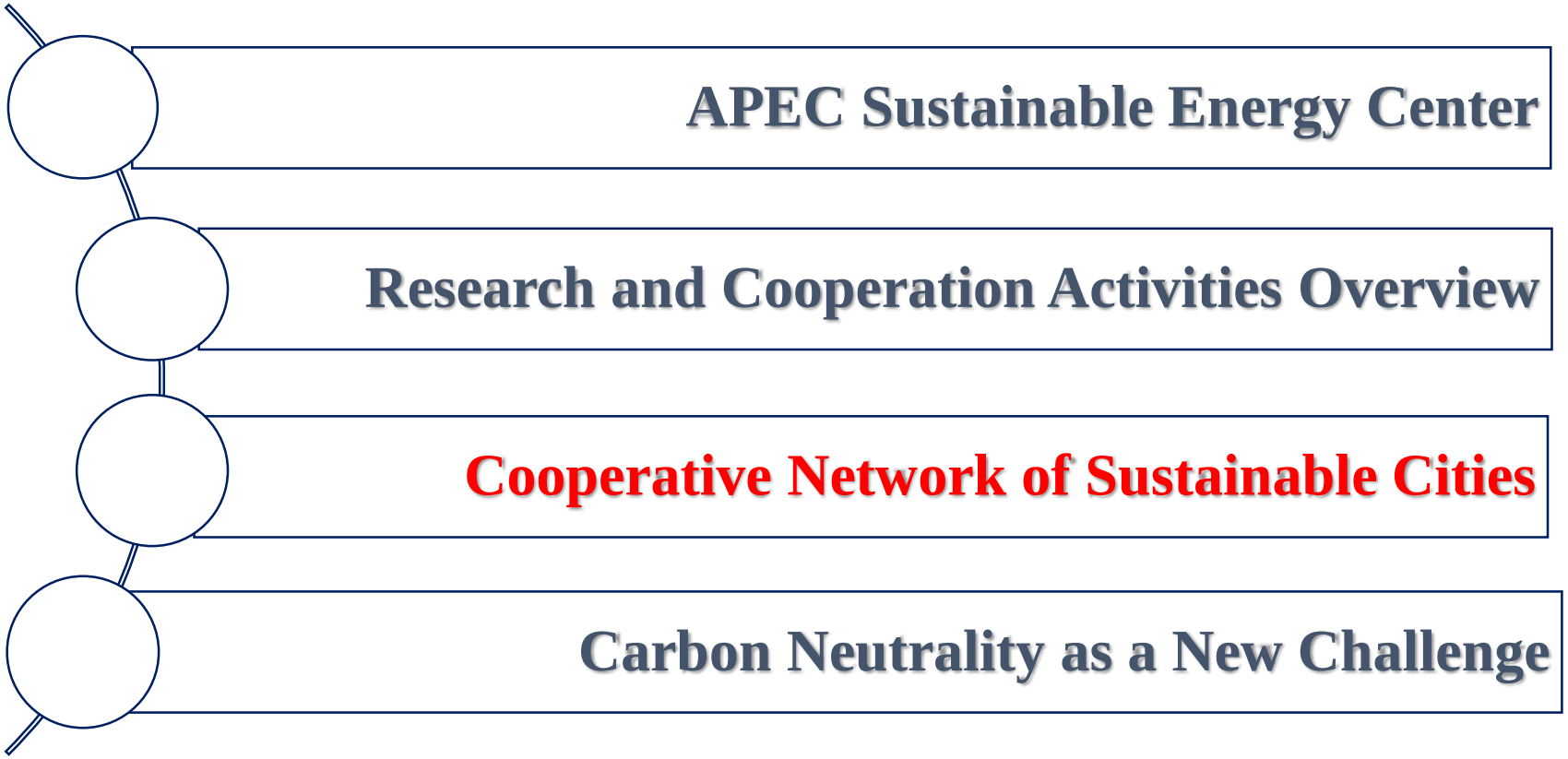
Research and Cooperation Activities Overview

ZHU Li, President, APEC Sustainable Energy Center (APSEC), Tianjin, China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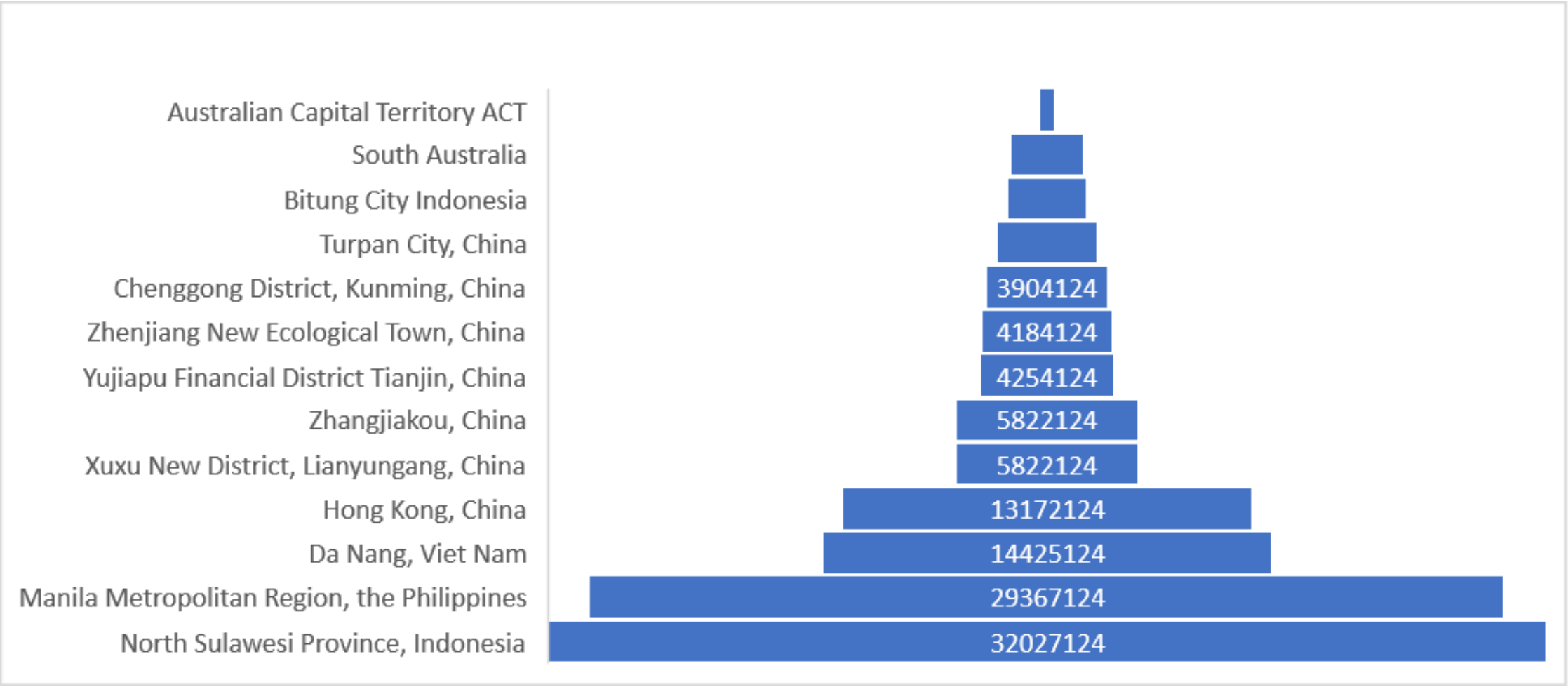
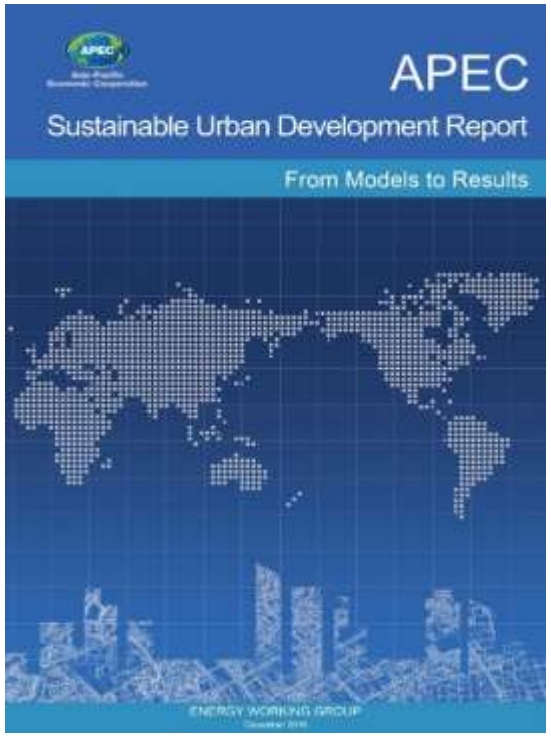
Cumulated population of CNSC cities 2016 - 2022

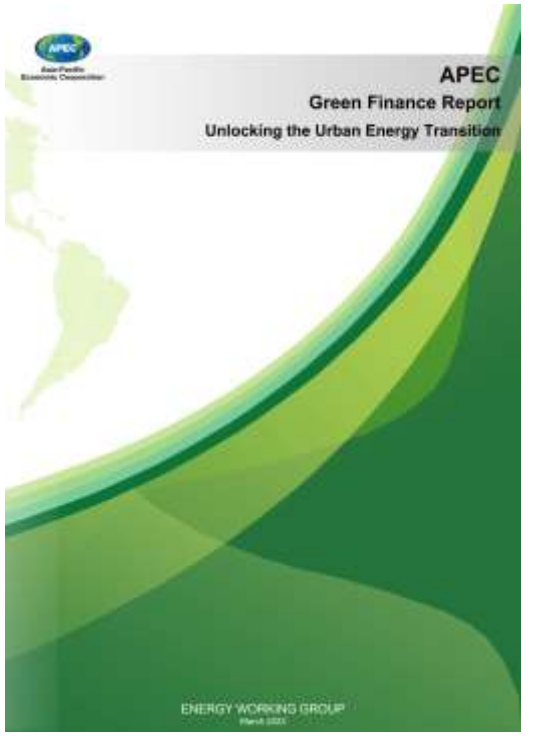


CNSC Research Reports (in English language)



APEC Sustainable Urban Development Report – From Models to Results
https://www.apec.org/Publications/2019/04/APEC-Sustainable-Urban-Development-Report---From-Models-to-Results

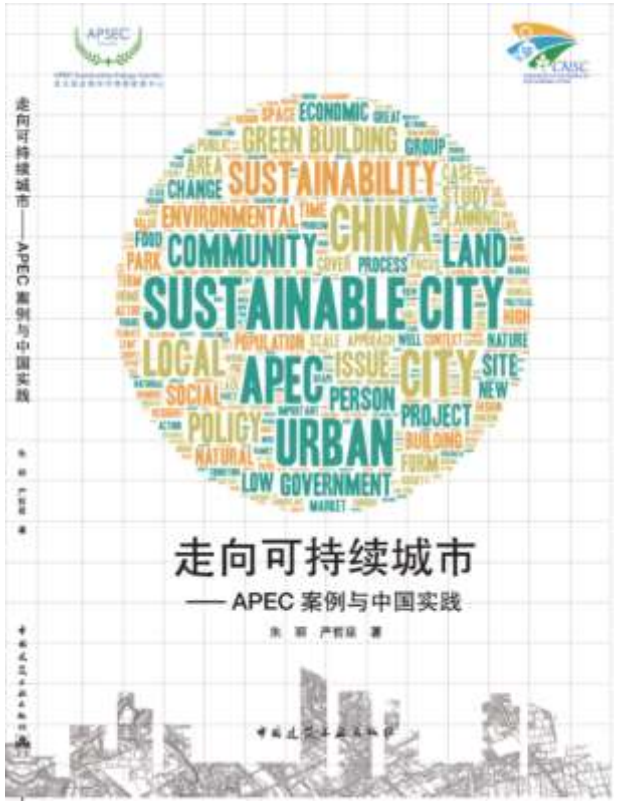
APEC Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability
https://www.apec.org/Publications/2021/03/APEC-Integrated-Urban-Planning-Report



APEC Green Finance Report – Unlocking the Urban Energy Transition
https://www.apec.org/publications/2023/03/apec-green-finance-report-unlocking-the-urban-energy-transition

Building the Green, Digital and Inclusive City of the 21st Century. Online Conference, 11 – 12 January 2024

CNSC Research Reports (Chinese Language)



Towards Sustainable Cities – APEC Cases and Chinese Practices

Chinese publication at China Architecture & Building Press（ISBN 978-7-112-23799-9）

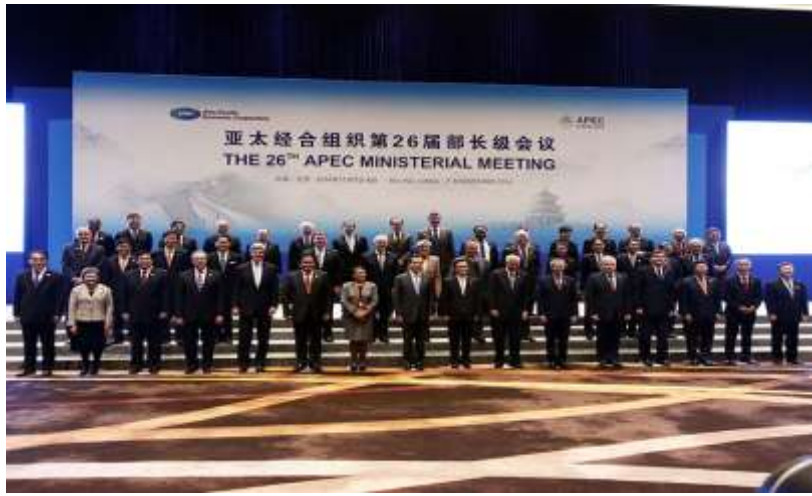
Research on Forms of Low-Carbon Energy System and Best Practices for APEC Sustainable Cities

The English version:
https://www.apec.org/publications/2020/09/research-on-forms-of-low-carbon-energy-system-and-best-practices

Research Report of APEC Urban Energy Transition Solutions and Implementation Path

Building the Green, Digital and Inclusive City of the 21st Century. Online Conference, 11 – 12 January 2024

Background: Relevant APEC Policy Guidelines



2014 AMM: "We endorse the APEC Cooperation Initiative for Jointly Establishing an Asia-Pacific Urbanization Partnership".

Two Quantitative Aspirational APEC Energy Goals

+ creation of the APEC Sustainable Energy Center (2014)

Relevant UN Frameworks 2015

March 2015

December 2015

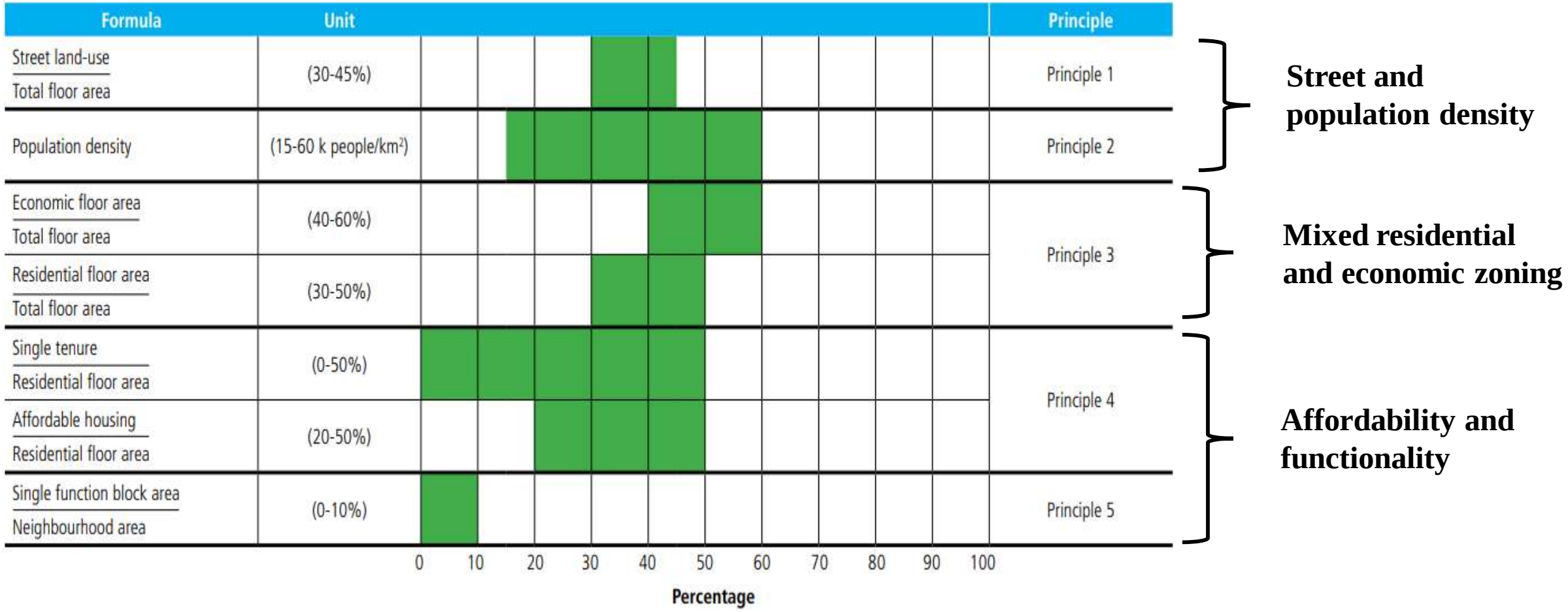
Included in

September 2015

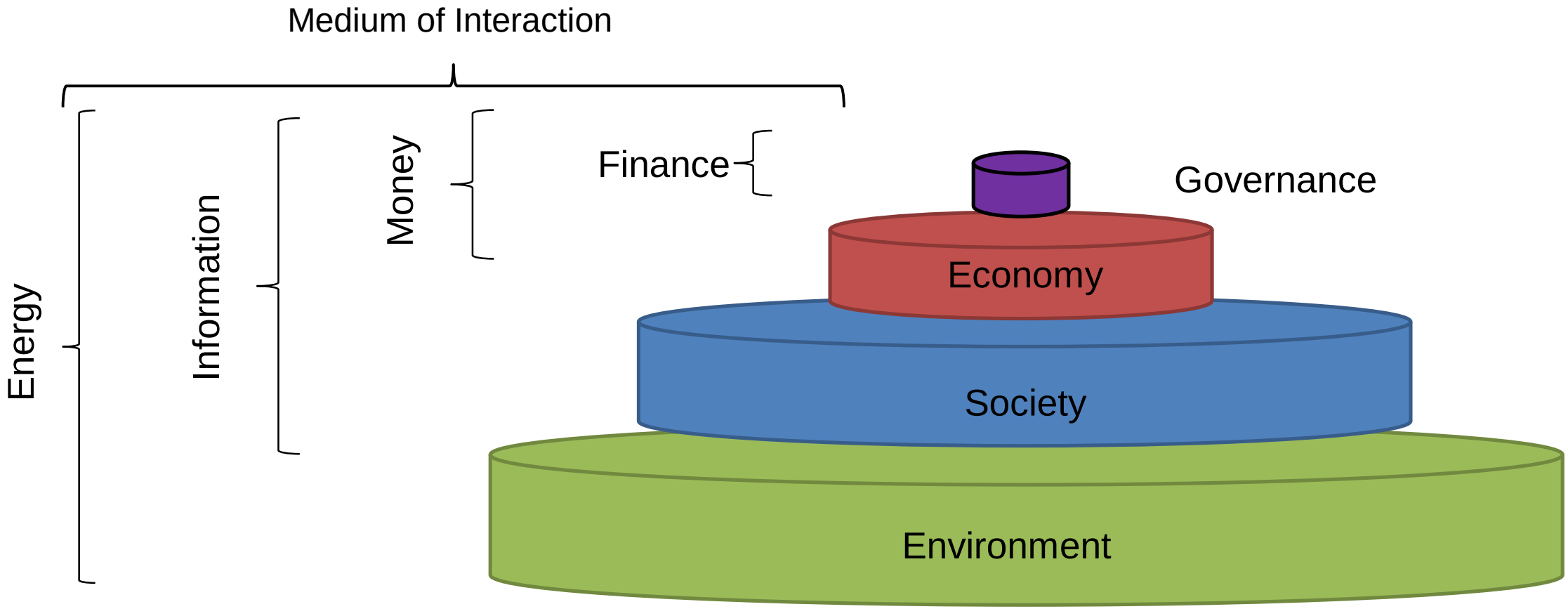
Concretized by

Five Principles of Urban Planning (UNHABITAT, 2015)

https://unhabitat.org/sites/default/files/download-manager-files/A%20New%20Strategy%20of%20Sustainable%20Neighbourhood%20Planning%20Five%20principles.pdf

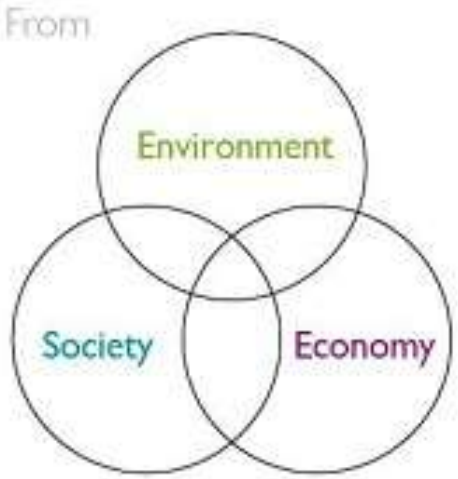


Defining Speres by means of their Medium of Interaction

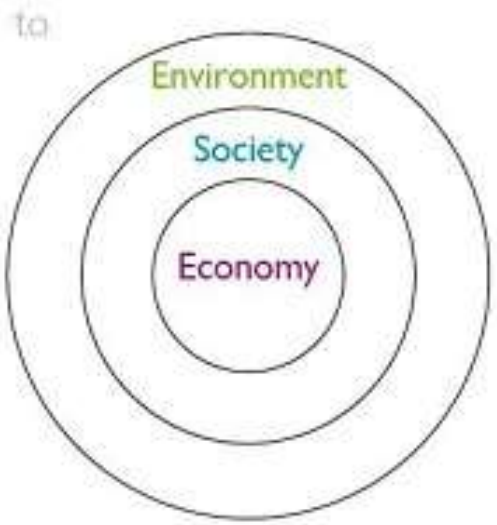


Shaping the Evolution of Sustainability Concepts

UNCED, Rio 1992

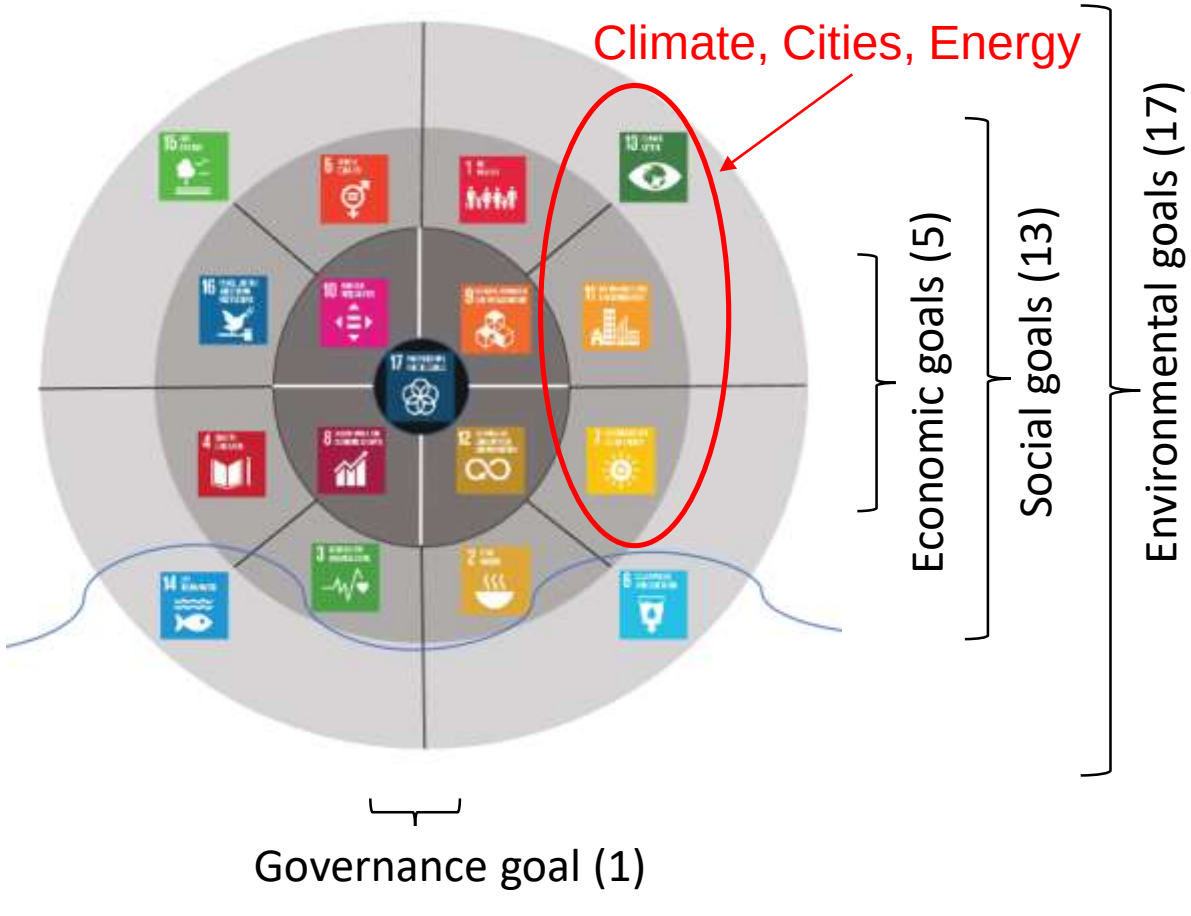


Giddings, Hopwood, O'Brien, 2002

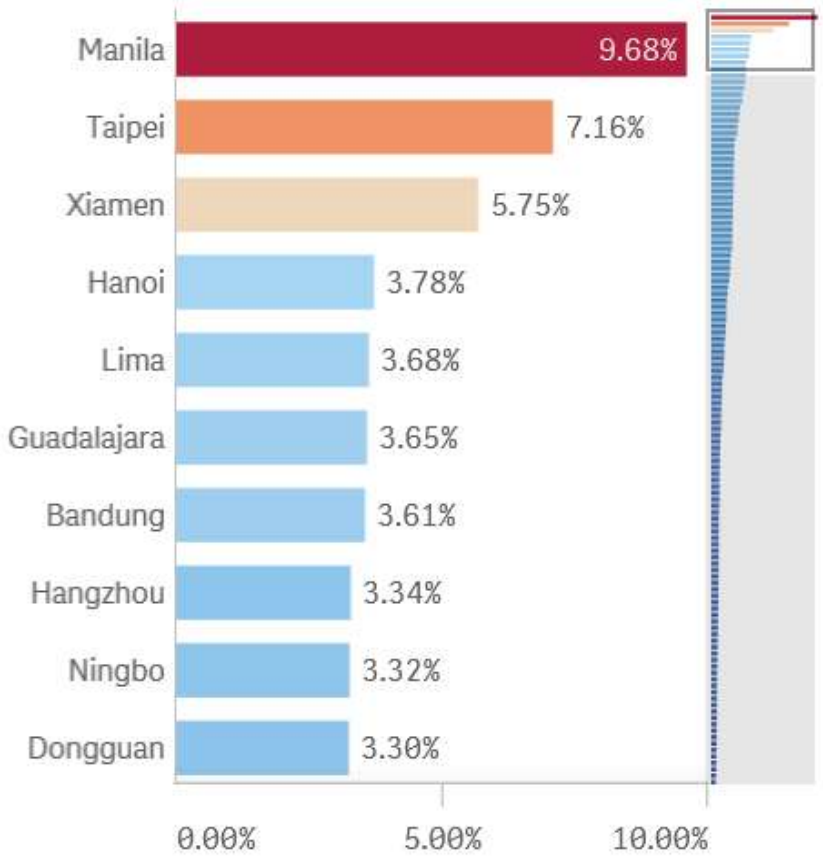


Source: B. Giddings, B. Hopwood, G. O'Brien, Environment, Economy and Society: fitting them together in Sustainable development, Wiley Interscience, 2002

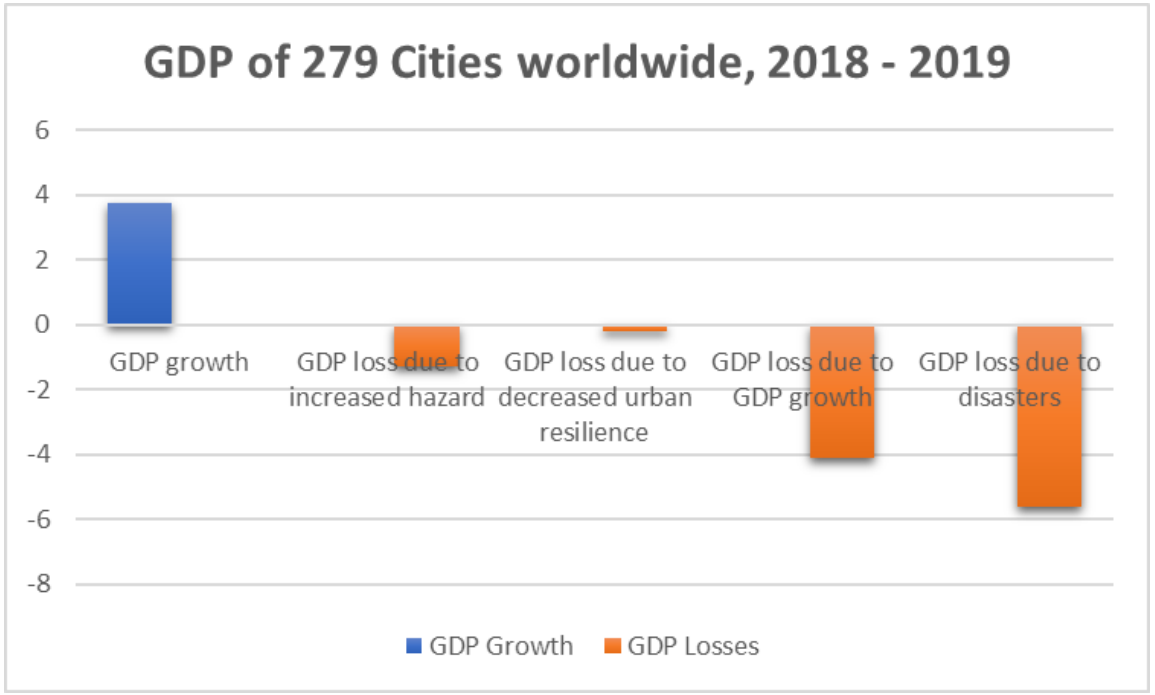
APSEC, 2019



Detailed Analysis of Disasters striking APEC Cities

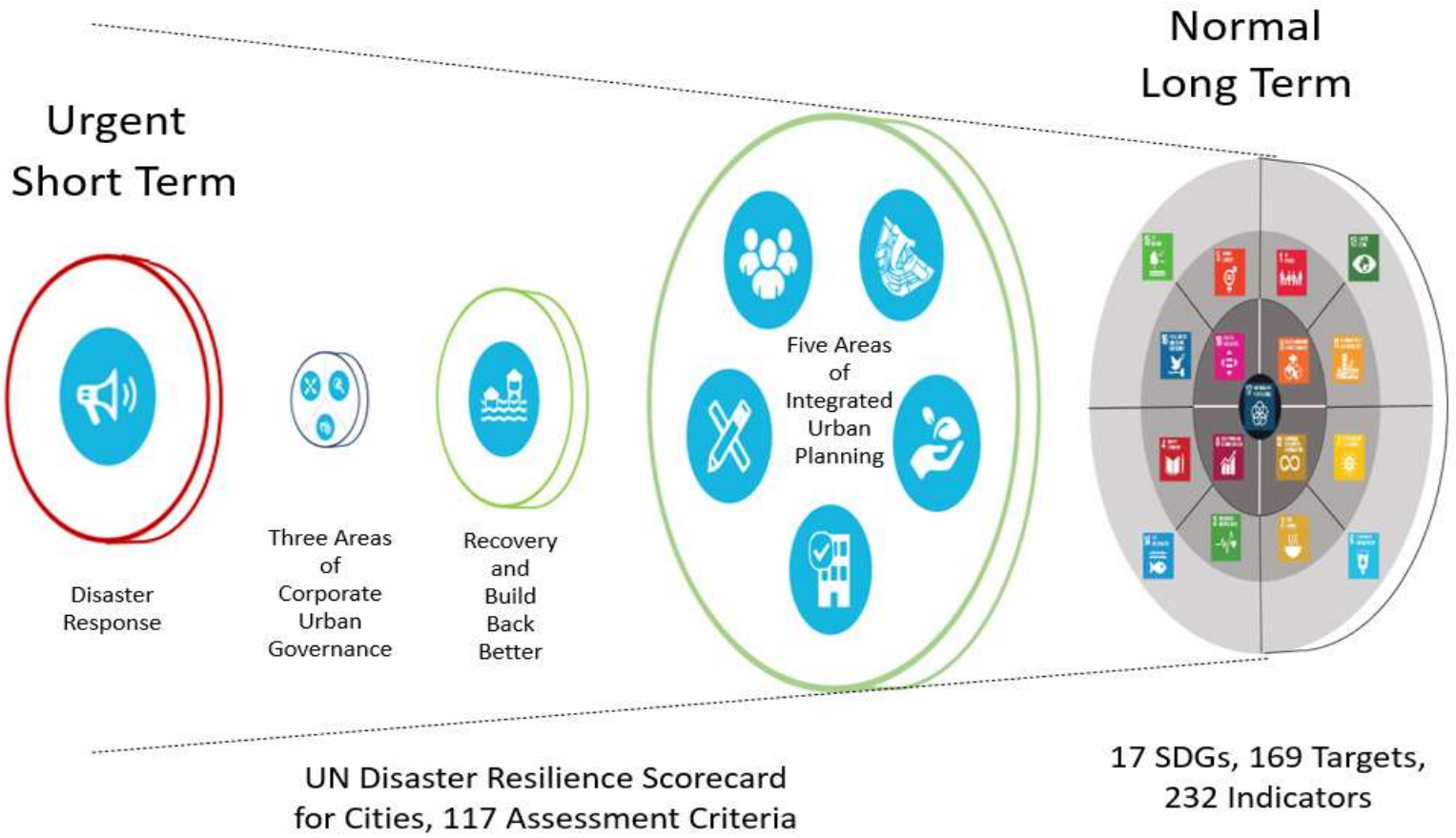


→ Manila, the most disaster-threatened APEC city, is losing 9.68% GDP per year to disasters.



Bearable risk level (all threats) < 1% GDP, e.g. Hong Kong: 0.93% GDP

Integrating Disaster Resilience (DR) with SDGs: DR takes the role of instrument to attain SDGs



Integrating Systems-theoretical elements:

SDGs = objectives or targets

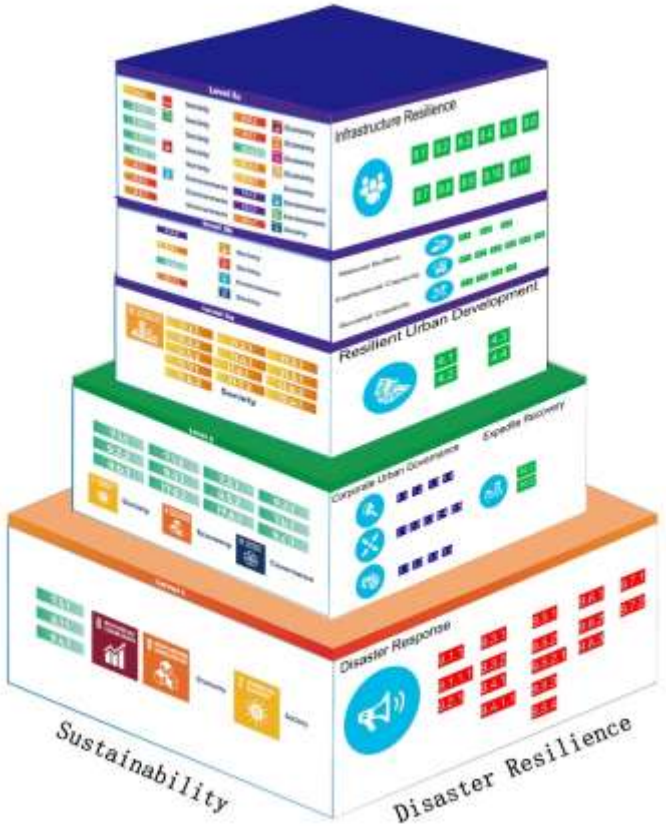
To reach n independent targets you need at least n independent instruments ("decision variables")

SDGs do not have more than 75 instruments for approx. 160 targets

Disaster Resilience provides for 117 instruments to attain the SDG targets

Helping Cities to improve Data Collection

APEC CityStats



Commitment level 3 (large cities): Implementing and evaluating local action plan

Objective: Allowing large APEC cities to make in-depth transformation towards integrated sustainable development and disaster resilience, using data from all major urban areas

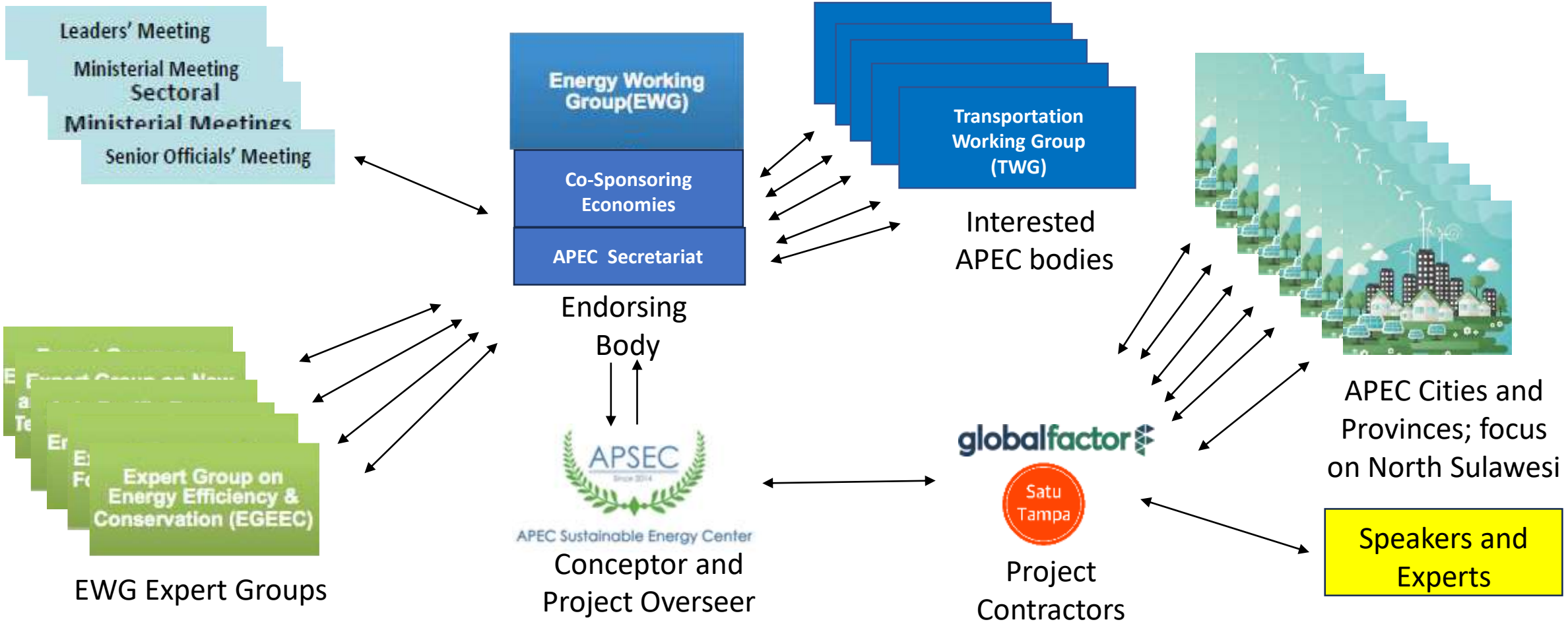
Commitment level 2 (medium-sized cities): Local 2050 vision, 2030 targets, elaborating integrated holistic (sustainability + disaster resilience) local action plan

Objective: Allowing middle-sized APEC cities to achieve rapid progress, driven by key areas: **Energy, Industrial Innovation, IT**

Commitment level 1 (small cities): Start improving elementary sustainable development and disaster response and showcase results

Objective: Allowing APEC communities of any size to participate in data collecting with little data requirement

APEC Project EWG 04 2022A
Data Driven Carbon Neutral Disaster Resilient Cities



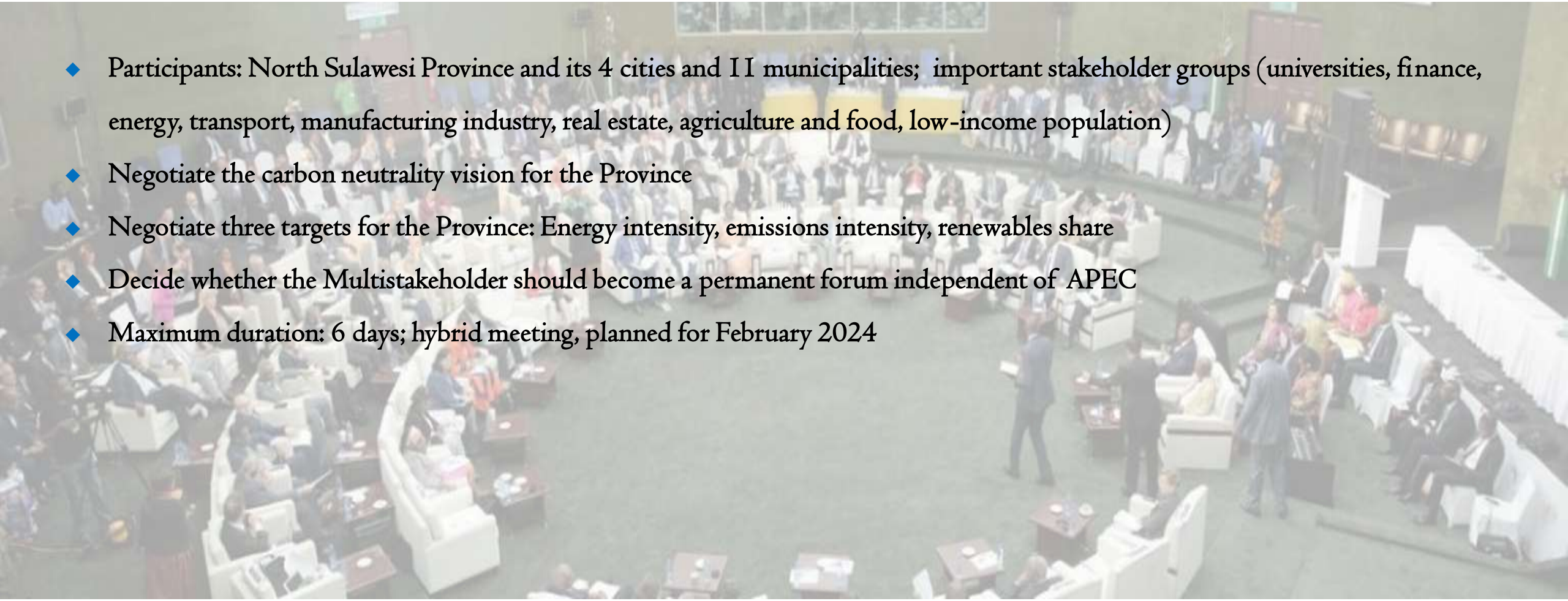
EWG 04 2022A: Developing a carbon-neutrality vision

- **Negotiated one-page document**
- **inspiring, energizing, hopeful, positive, clear**
- **The Member's overarching purpose and core values described in one sentence**
- **The Member's 3 to 5 biggest current sustainability challenges**
- **The Member's 3 to 5 biggest current disaster threats**
- **The Member's 3 to 5 most important measures addressing either of the above**
- **How the Member would react if it became certain that by mid-century the use of carbon-emitting fuels would be impossible without fully neutralizing their emissions.**

  - **The Member's strengths**
  - **The Member's weaknesses**
  - **The opportunities arising for the Member**
  - **The challenges the Member would have to face**

http://apsec.tju.edu.cn/index.php/En/Xiangmu/article/id/51.html

EWG 04 2022A: Convene a Multistakeholder Dialogue



- Participants: North Sulawesi Province and its 4 cities and 11 municipalities; important stakeholder groups (universities, finance, energy, transport, manufacturing industry, real estate, agriculture and food, low-income population)
- Negotiate the carbon neutrality vision for the Province
- Negotiate three targets for the Province: Energy intensity, emissions intensity, renewables share
- Decide whether the Multistakeholder should become a permanent forum independent of APEC
- Maximum duration: 6 days; hybrid meeting, planned for February 2024

Workshops held in the framework of the annual Asia-Pacific Forum

Sept. 2018: Workshop on Low-Carbon Energy Systems of Sustainable Cities
Sept. 2019: Workshop on Integrated Urban Planning and Low-Carbon Energy Systems
Sept. 2020: Workshop on Energy Resilience Through Urban Renewables (merged with WSC5 due to COVID-19)
Sept. 2021: Workshop on Defining Visions and Targets for Cities' Carbon Reduction
Sept. 2022: Workshop on Driving APEC Cities towards Carbon Neutrality

Workshops on Sustainable Cities WSC 4 – WSC7

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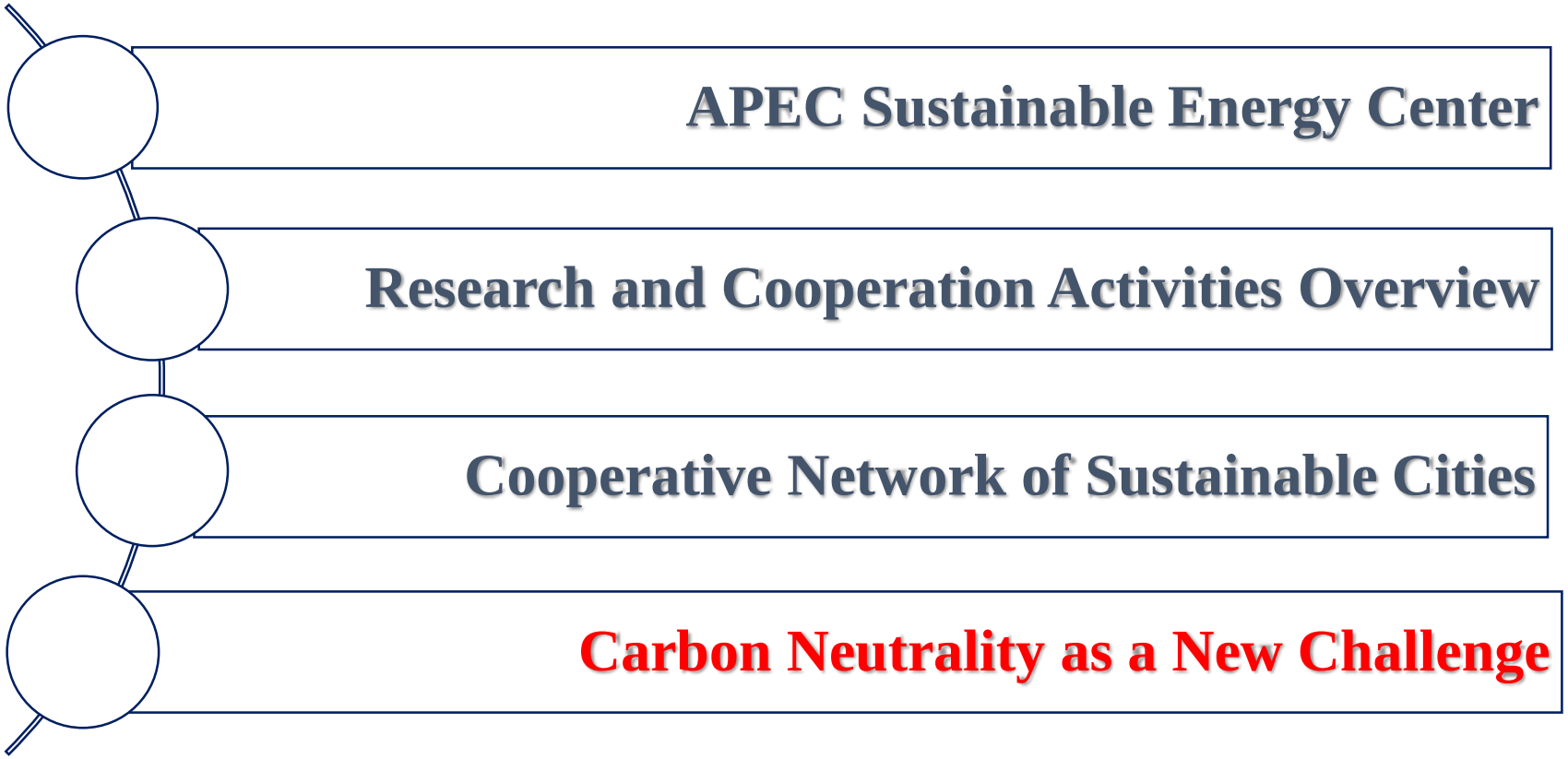
Networking

45 presentations at international conferences since 2018, of which
10 keynote speeches and 2 video-recordings.

2 interviews in Global Times

"As the Chinese national carbon trading starts today, this can be called a big milestone for China and the beginning of a new era. It shows to the world that China is working seriously toward carbon neutrality. Hopefully, other countries which do not yet have any carbon trading will be inspired to study and follow the Chinese example," Steivan Defilla, President Assistant at APEC Sustainable Energy Center, told the Global Times on Friday.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Computed global scenarios up to the year 2100

To be used by cities as global context during the 2020 – 2030 period

Series	2020 – 2030 step
Global Population (both scenarios)	9% increase
Global GDP at constant 2015 USD (both scenarios)	29% increase
Per capita GDP (both scenarios)	18% increase
Total Primary Energy Supply TPES (both scenarios)	10.6% increase
Per capita TPES (both scenarios)	1.5% increase
TPES/GDP (both scenarios)	-14% (decrease)
Total Final Energy Consumption TFC (both scenarios)	+9%
Per capita TFC (both scenarios)	stationary
TFC/GDP (both scenarios)	-15% (decrease)
CO2 emissions (unsustainable scenario)	9% increase
Per capita CO2 emissions (unsustainable scenario)	stationary
Installed renewable generation capacity (sustainable energy scenario)	Multiply by 3
Per capita installed RE capacity (sustainable energy scenario)	Multiply by 2.7
Renewable energy generation (sustainable energy scenario)	Multiply by 2.25
Renewable energy share in TPES (sustainable energy scenario)	Multiply by 2.375
Renewable energy share in TFC (sustainable energy scenario)	Multiply by 2.4
CO2 emissions (sustainable energy scenario)	-26% (decrease)
Per capita CO2 emissions (sustainable energy scenario)	-33% (decrease)
CO2 intensity of GDP (sustainable energy scenario)	-43% (decrease)
CO2/TPES intensity	-33% (decrease)

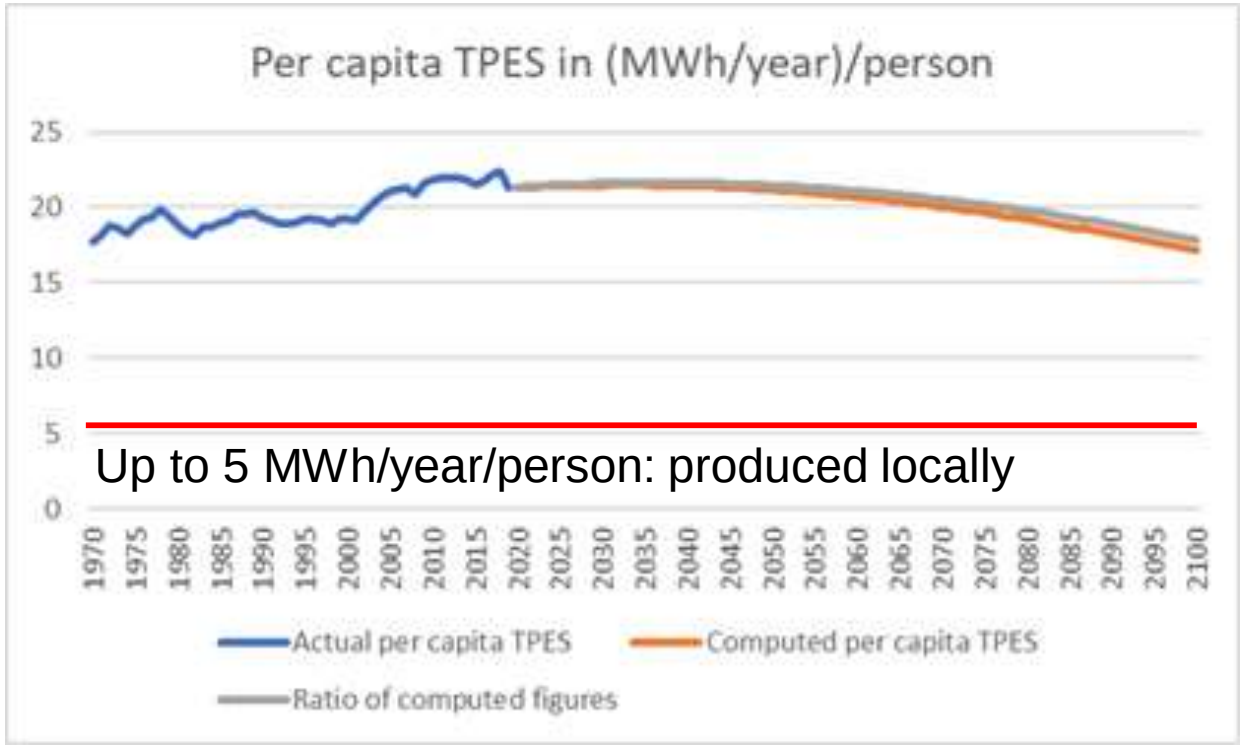
Unsustainable Scenario: Carbon neutrality after 2100; cumulated emissions 1810 Gt by 2100 and still increasing

Supported by APEC Leaders in 2023

Sustainable Energy Scenario: Carbon neutrality by mid-century
Cumulated emissions after 2020: 550 Gt by 2050

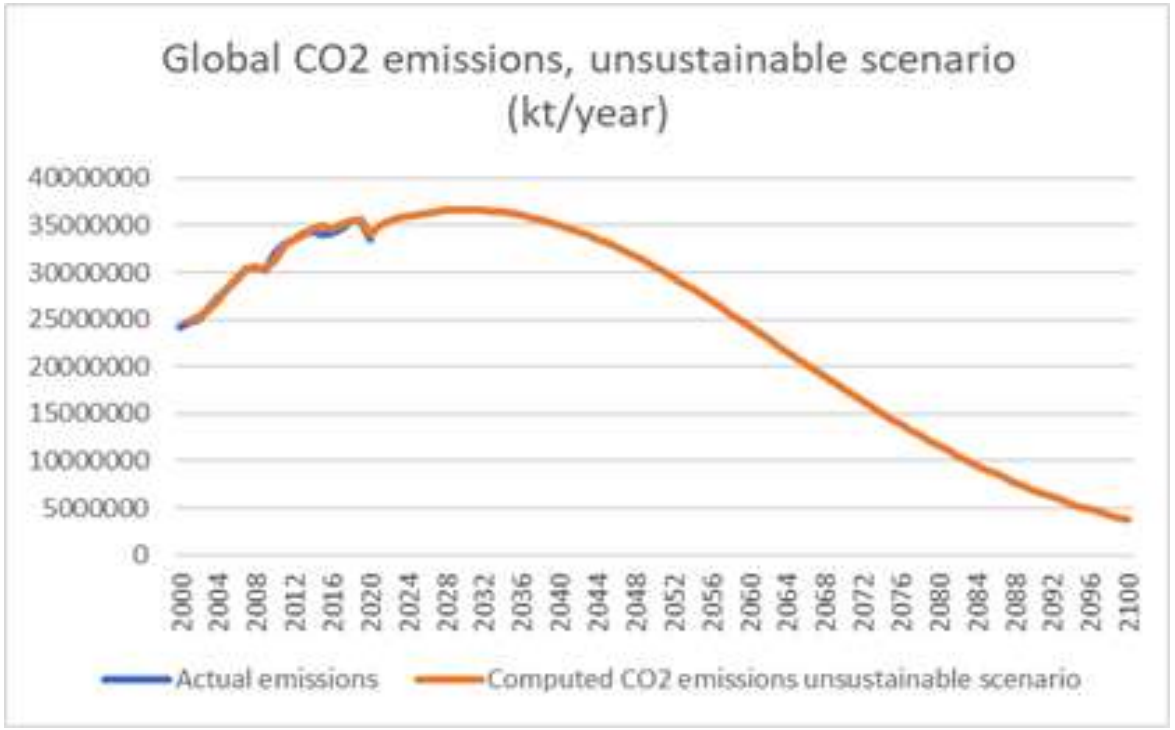
Scenario Variables: Two examples

Example 1: Global per capita TPES



Up to 5 MWh/year/person: produced locally

Example 2: Global CO2 emissions, unsustainable scenario



Land Area Requirement of Renewable Energies

Renewable energy type (electricity resp. biofuel)	Area [km2]
Thermal solar farm (empirical)	**12**
Photovoltaic solar farm (empirical)	**42**
Wind farm (empirical)	**167**
Wave farm (Pelamis prototype)	**168**
For comparison: Size of the City of Vienna, Austria	*414*
Marine current farm (prototype)	**2000**
For comparison: Tropical forest (biomass)	**2000**
Maize farm (biofuel, empirical)	**5000**
Average vegetation (biomass, empirical)	**12500**
Hydropower (Δh=400 m, river basin size)	**13500**
Osmotic power (prototype, river basin size)	**44000**
Geothermal power (drilling area size)	**45000**
For comparison: Land area of the City of Tianjin	*11610*

Global average figures

Land Area Requirement for replacing one large coal power plant of 1 GWe by renewable energy

Local conditions may be more favourable

Computed Required PV (m2/person) to satisfy per capita TFC

As a function of PV Potential (PVOUT, horizontal) and TFC (vertical)

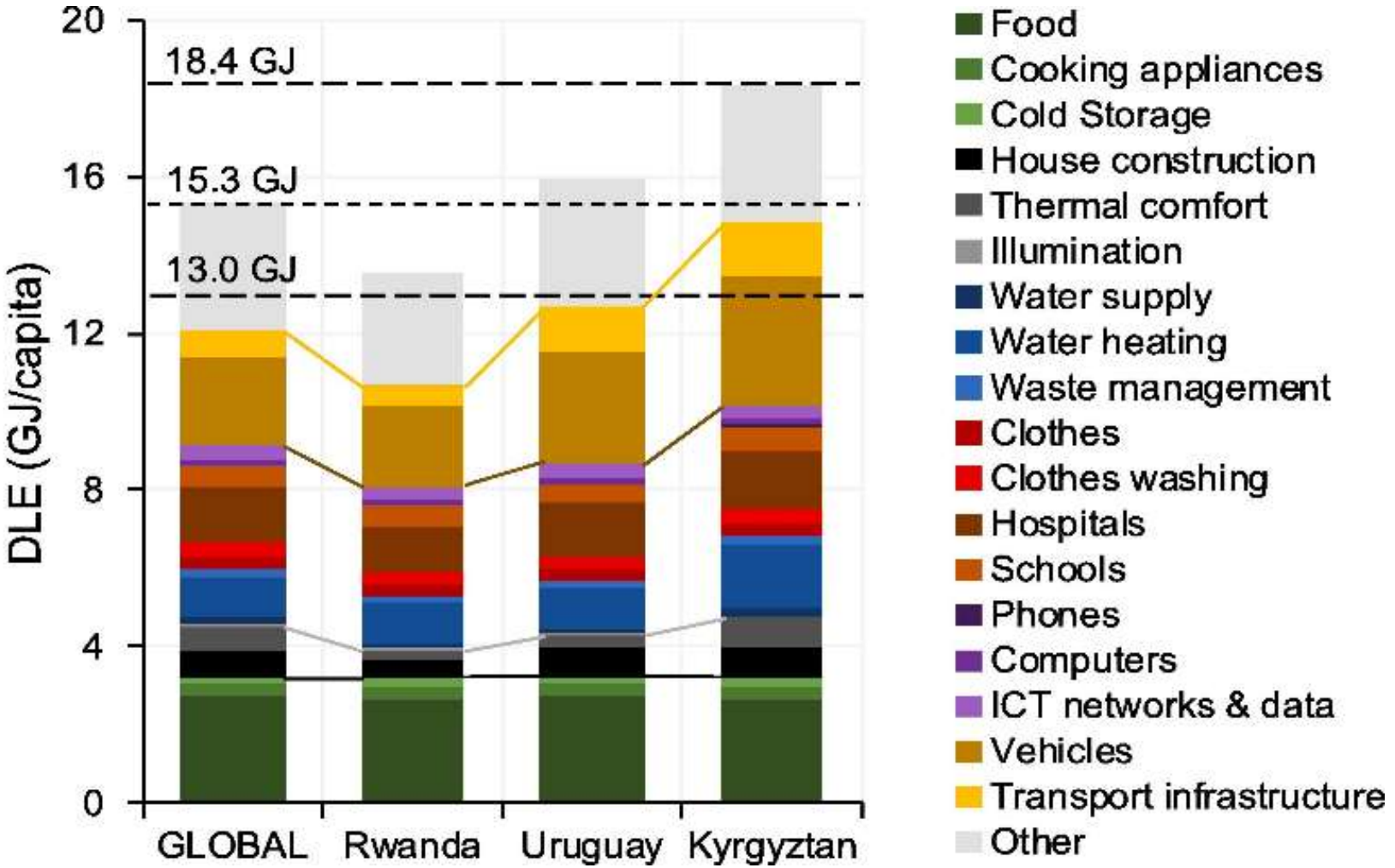
	Daily totals kWh/kWp	2	2.4	2.8	3.2	3.6	4	4.4	4.752	4.8	5.2	5.6	6	6.4
	Yearly totals kWh/kWp	731	877	1023	1169	1315	1461	1607	1736	1753	1899	2045	2192	2338
TFC	(MWh/person), year 2020													
3.226	The Philippines	23.41	19.51	16.72	14.63	13.00	11.70	10.64	9.85	9.75	9.00	8.36	7.80	7.31
4.017	Papua New Guinea	29.15	24.29	20.82	18.22	16.19	14.57	13.25	12.27	12.14	11.21	10.41	9.72	9.11
5.000	Decent Living Standard	36.28	30.23	25.91	22.67	20.15	18.14	16.49	15.27	15.12	13.95	12.96	12.09	11.34
6.172	Peru	44.78	37.32	31.99	27.99	24.88	22.39	20.35	18.85	18.66	17.22	15.99	14.93	13.99
6.425	Indonesia	46.61	38.85	33.30	29.13	25.90	23.31	21.19	19.62	19.42	17.93	16.65	15.54	14.57
7.464	Viet Nam	54.15	45.13	38.68	33.85	30.09	27.08	24.62	22.79	22.56	20.83	19.34	18.05	16.92
9.015	Mexico	65.40	54.50	46.72	40.88	36.34	32.70	29.73	27.53	27.25	25.16	23.36	21.80	20.44
9.951	Hong Kong, China	72.20	60.17	51.57	45.12	40.11	36.10	32.82	30.39	30.08	27.77	25.79	24.07	22.56
12.646	Thailand	91.75	76.46	65.54	57.34	50.97	45.88	41.71	38.62	38.23	35.29	32.77	30.58	28.67
14.538	China	105.48	87.90	75.34	65.92	58.60	52.74	47.94	44.39	43.95	40.57	37.67	35.16	32.96
15.115	World	109.66	91.38	78.33	68.54	60.92	54.83	49.85	46.15	45.69	42.18	39.16	36.55	34.27
15.645	Chile	113.51	94.59	81.08	70.94	63.06	56.75	51.59	47.77	47.29	43.66	40.54	37.84	35.47
15.889	Malaysia	115.28	96.06	82.34	72.05	64.04	57.64	52.40	48.52	48.03	44.34	41.17	38.43	36.02
18.505	APEC	134.26	111.88	95.90	83.91	74.59	67.13	61.03	56.51	55.94	51.64	47.95	44.75	41.96
21.543	Japan	156.30	130.25	111.64	97.69	86.83	78.15	71.04	65.78	65.12	60.11	55.82	52.10	48.84
21.740	Singapore	157.73	131.44	112.67	98.58	87.63	78.87	71.70	66.39	65.72	60.67	56.33	52.58	49.29
23.040	Chinese Taipei	167.16	139.30	119.40	104.48	92.87	83.58	75.98	70.35	69.65	64.29	59.70	55.72	52.24
26.412	Brunei Darussalam	191.62	159.69	136.87	119.77	106.46	95.81	87.10	80.65	79.84	73.70	68.44	63.87	59.88
27.613	New Zealand	200.34	166.95	143.10	125.21	111.30	100.17	91.06	84.32	83.48	77.05	71.55	66.78	62.61
28.069	Korea	203.65	169.71	145.46	127.28	113.14	101.83	92.57	85.71	84.85	78.33	72.73	67.88	63.64
33.283	Australia	241.48	201.23	172.49	150.92	134.16	120.74	109.76	101.63	100.62	92.88	86.24	80.49	75.46
34.061	Russia	247.12	205.93	176.51	154.45	137.29	123.56	112.33	104.01	102.97	95.05	88.26	82.37	77.23
46.145	United States	334.80	279.00	239.14	209.25	186.00	167.40	152.18	140.91	139.50	128.77	119.57	111.60	104.62
50.010	Canada	362.83	302.36	259.17	226.77	201.57	181.42	164.92	152.71	151.18	139.55	129.58	120.94	113.39

Required percentage of land area to satisfy per capita TFC

TFC/person (MWh/person)	City	Pop density (pers/km2)	Pop density (pers/ha)	PVOUT (kWh/kWp)	Required per capita PV area (m2/person)	Required PV area (m2/ha)	Percentage of land area required for PV (%)
7.000	Manila City	43064	431	1376	26.96	11611	116
7.000	Metro Manila	22000	220	1376	26.96	5932	59
9.951	Hong Kong	6400	64	1159	44.48	2847	28
21.740	Singapore	8592	86	1287	89.51	7691	77

The Density Challenge of Cities: beyond a certain population density (e.g. Manila city: 43’000 persons/km2), it requires more than 100% (116%) of the land area of the city to satisfy TFC by PV generation.

Proposed how to address the density challenge: Energy consumption for Decent Living Standards (DLS)



Either:
Total Energy Needs for DLS: to be satisfied by local renewable electricity production.

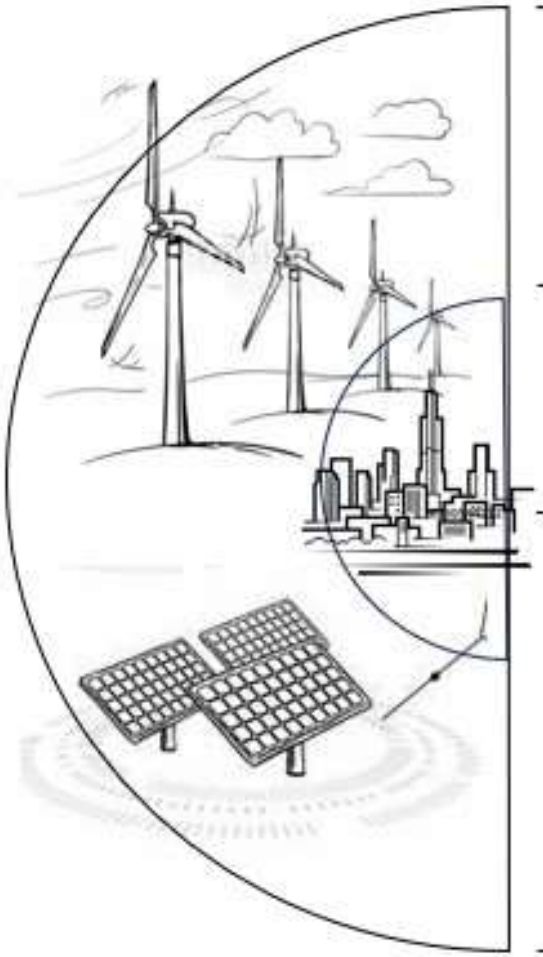
18 GJ/year/person=
5MWh/year/person =
570W/person
Hence, most APEC economies need 15 to 25 m2/person PV area within the city territory

Or 30% of total land area to be used for local renewable electricity production
NB: street network = 30% of area

https://www.sciencedirect.com/science/article/pii/S095937802030751 2?via%3Dihub#f0005

Monitoring system for cities

18 data series to monitor approx. 50 ratios related to: local, distant and total accessible renewable electricity generation; energy efficiency; green economy and green finance



$$\frac{DPPAREgeneration}{LPopulation} = \frac{DPPAREgeneration}{DPPARECapacity} \times \frac{DPPARECapacity}{DRECapacity} \times \frac{DRECapacity}{LTRMcapacity} \times \frac{LTRMcapacity}{LPopulation}$$

Distant (=outside city borders) renewable electricity generation

$$\frac{LREgeneration}{LPopulation} = \frac{LREgeneration}{LRECapacity} \times \frac{LRECapacity}{LPVnetarea} \times \frac{LPVnetarea}{LPVgrossarea} \times \frac{LPVgrossarea}{LPopulation}$$

$$\frac{LREgeneration}{LPopulation} = \frac{LREgeneration}{LGreenVA} \times \frac{LGreenVA}{LGreenEmpl} \times \frac{LGreenEmpl}{LGDP} \times \frac{LGDP}{LPopulation}$$

Local renewable electricity generation

$$\frac{APPAREgeneration}{LPopulation} = \frac{APPAREgeneration}{LTPES} \times \frac{LTPES}{LGDP} \times \frac{LGDP}{LPopulation}$$

$$\frac{APPAREgeneration}{LPopulation} = \frac{APPAREgeneration}{AREstorage} \times \frac{AREstorage}{Totalstorage} \times \frac{Totalstorage}{LTFC} \times \frac{LTFC}{LPopulation}$$

$$\frac{APPAREgeneration}{LPopulation} = \frac{APPAREgeneration}{APPARECapacity} \times \frac{APPARECapacity}{LGreenDebt} \times \frac{LGreenDebt}{LGreenEquity} \times \frac{LGreenEquity}{LPopulation}$$

Accessible (=local + distant) PPA contracted renewable electricity generation

THANK YOU FOR YOUR ATTENTION!

"Joining Hands Toward Sustainable Energy Development in the Asia-Pacific Region."