Low Carbon Asia Research Network (LoCARNet) 6th Annual Meeting
1-3 November 2017, Bangkok, Thailand

Plenary keynote talk

Low Carbon Cities: Knowledge and Action Gaps

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ipcc — Intergovernmental Panel on Climate Change — WMO UNEP

UCLG United Cities and Local Governments

UN environment — United Nations Environment Programme

UN HABITAT — FOR A BETTER URBAN FUTURE

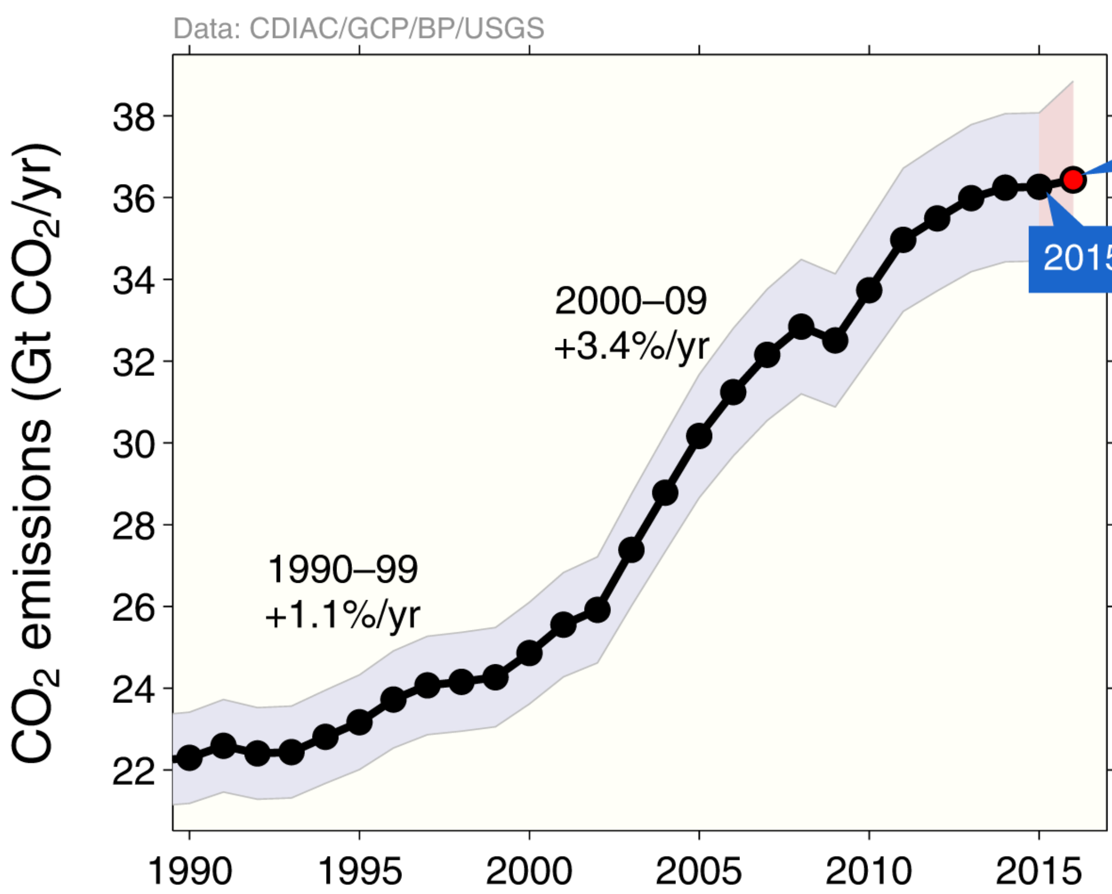
Sustainable Development Solutions Network — A Global Initiative for the United Nations

WCRP — World Climate Research Programme

Emissions from fossil fuel use and industry

Global emissions from fossil fuel and industry: 36.3 ± 1.8 GtCO_2 in 2015, 63% over 1990

- Projection for 2016: 36.4 ± 2.3 GtCO_2, 0.2% higher than 2015



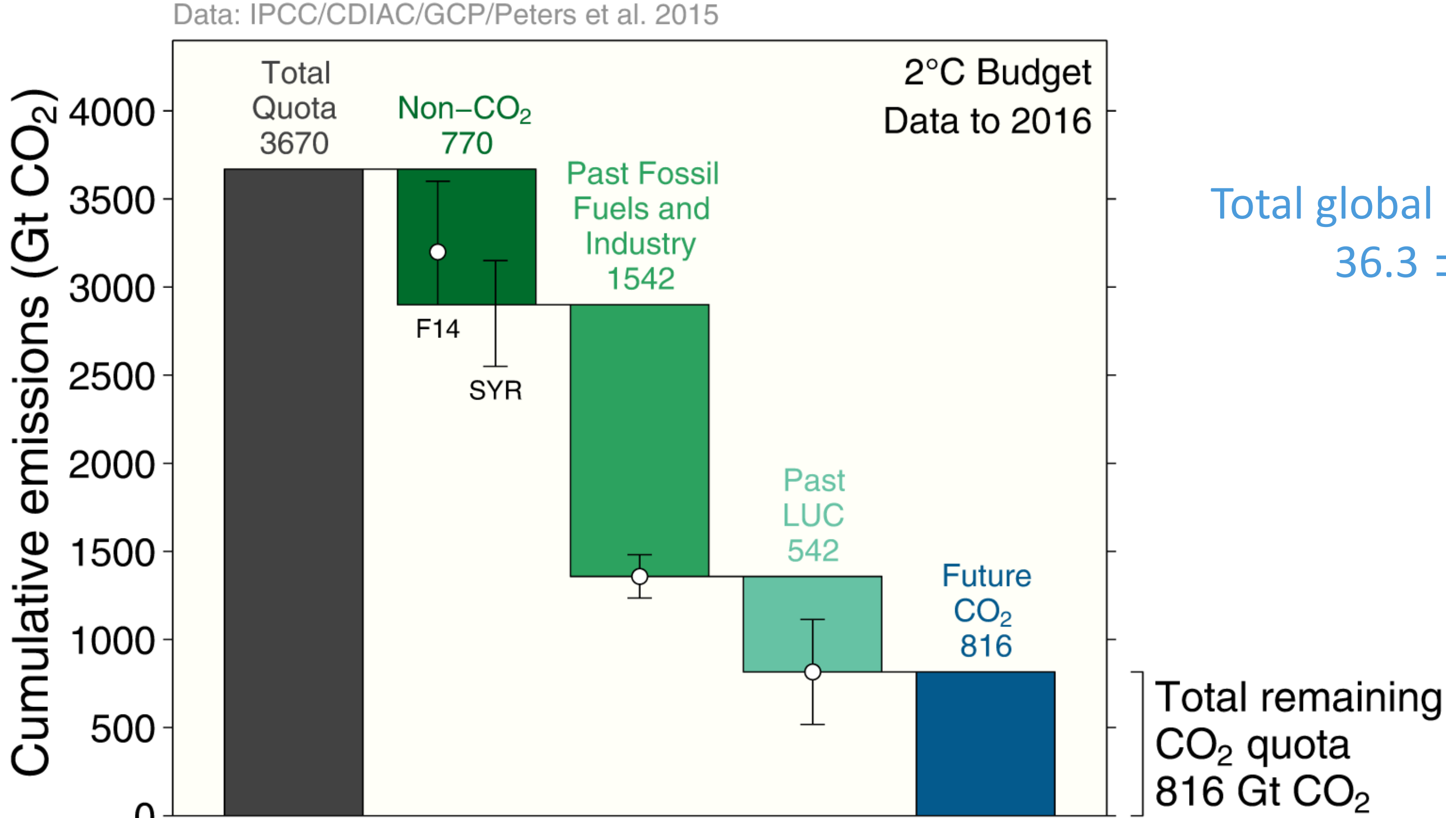
Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

Estimates for 2014 and 2015 are preliminary. Growth rate is adjusted for the leap year in 2016.

Source: CDIAC; Le Quéré et al 2016; Global Carbon Budget 2016

Carbon quota for a 66% chance to keep below 2°C

The total remaining emissions from 2017 to keep global average temperature below 2°C ($800GtCO_2$) will be used in around 20 years at current emission rates

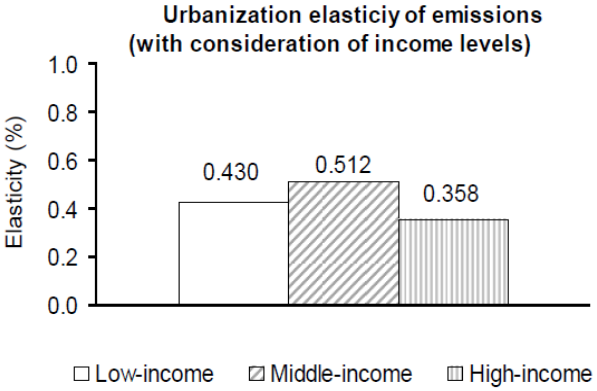


Total global emissions in 2015: $36.3 \pm 1.8\ GtCO_2$

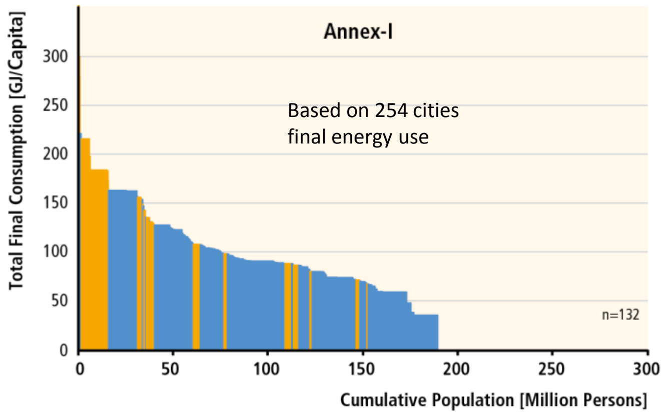
Grey: Total CO_2-only quota for 2°C with 66% chance. Green: Removed from CO_2 only quota. Blue: Remaining CO_2 quota.
The remaining quotas are indicative and vary depending on definition and methodology
Source: Peters et al 2015; Global Carbon Budget 2016

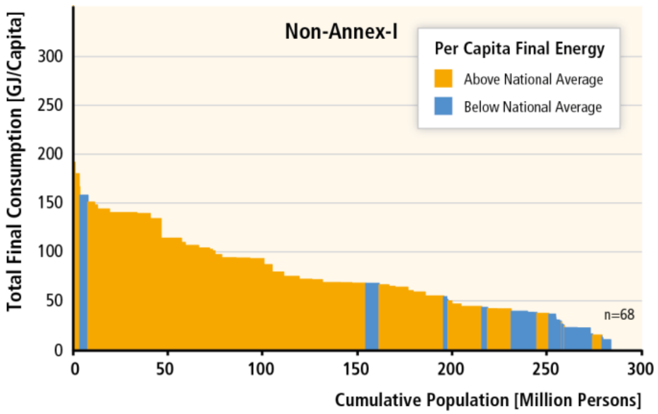
Role of cities in global GHG mitigation is enormous

- ➢Urbanization-income nexus → higher urban incomes correlated with higher energy and GHG emissions (Poumanyvong and Kaneko, 2010; IPCC 2014, GEA 2012)
- ➢Bottom up analyses show that Cities in developing countries have, generally, higher per capita final energy use and CO2 emissions than respective national averages – majority of new urbanization will be in these countries



Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model and a sample of 88 countries for the period 1975–2005 Poumanyvong and Kaneko, 2010, Ecological Economics.

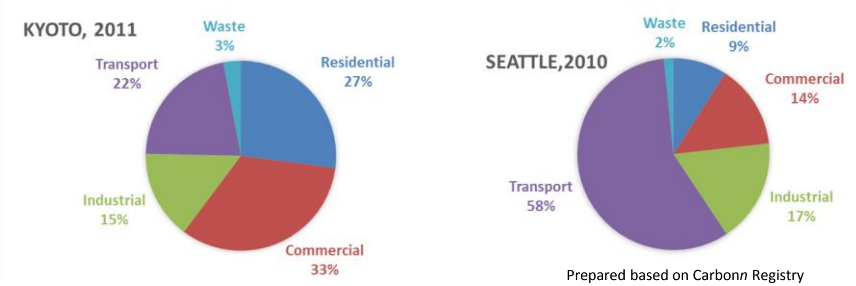




Source: GEA, 2012; Grubler et al., 2012; IPCC, 2014

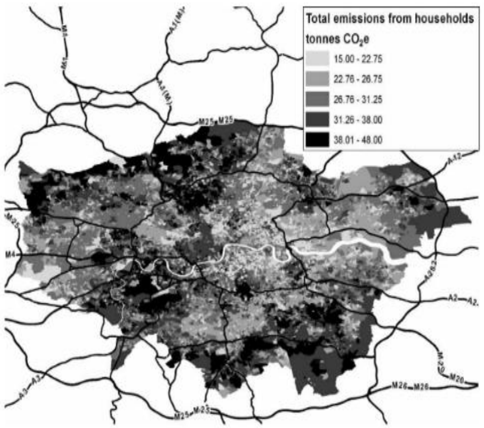
Role of cities in global GHG mitigation is enormous

- 71-76% of energy-related global CO_2 emissions are from energy use in cities (IPCC, 2014; GEA 2012; WEO 2008)
- Consumption driven upstream emissions makes cities even more important–e.g. over two-times in Tokyo and London
- Emissions and contribution of sources vary greatly across cities – direct comparison often does not tell us much - cities are different from nation states



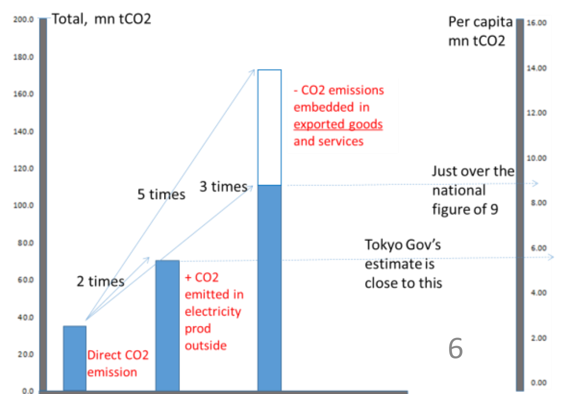
Prepared based on Carbonn Registry

LONDON, 2004
Consumption CO2



Minx et al. 2009, Economic Systems Research

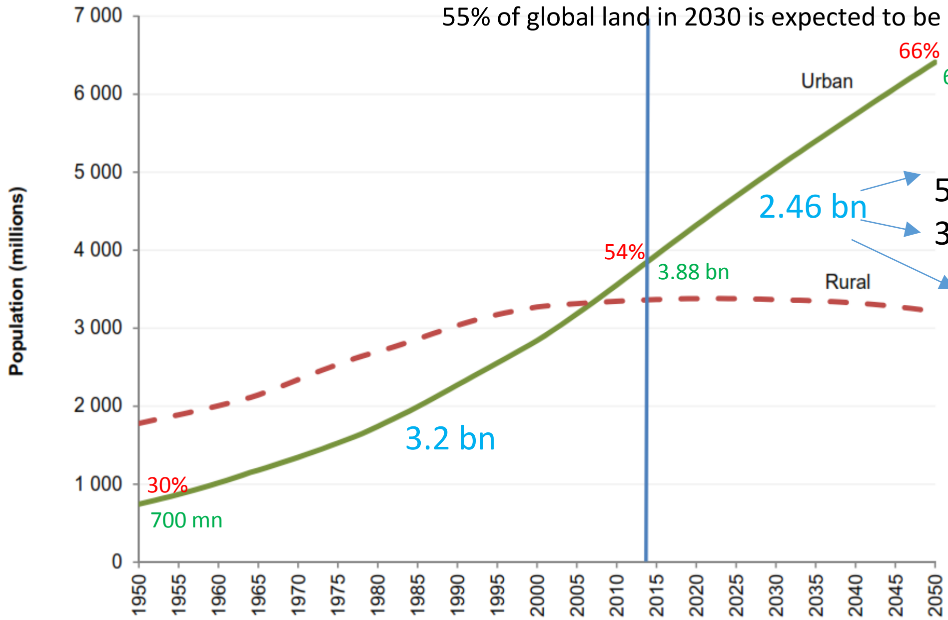
TOKYO



Kaneko & Dhakal (2012), donot quote, under publication

Global urbanization trends

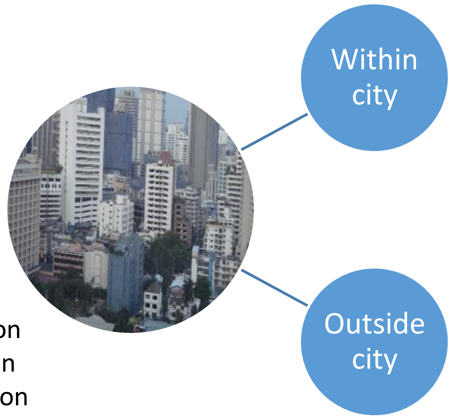
Urban land could expand up-to 3 time in 2000-30
55% of global land in 2030 is expected to be developed in 2000-30

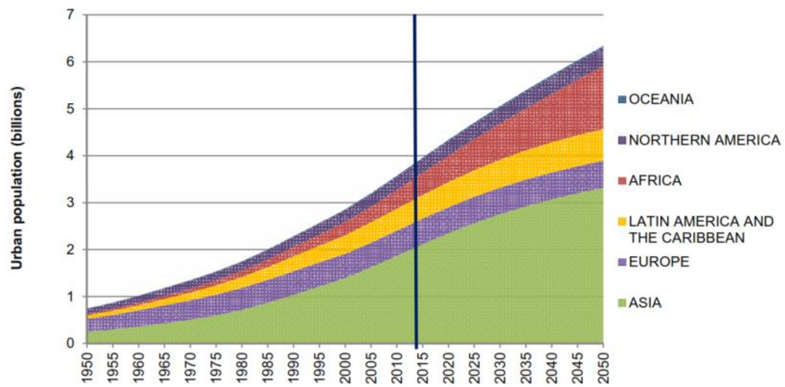


51% Asia
36% Africa

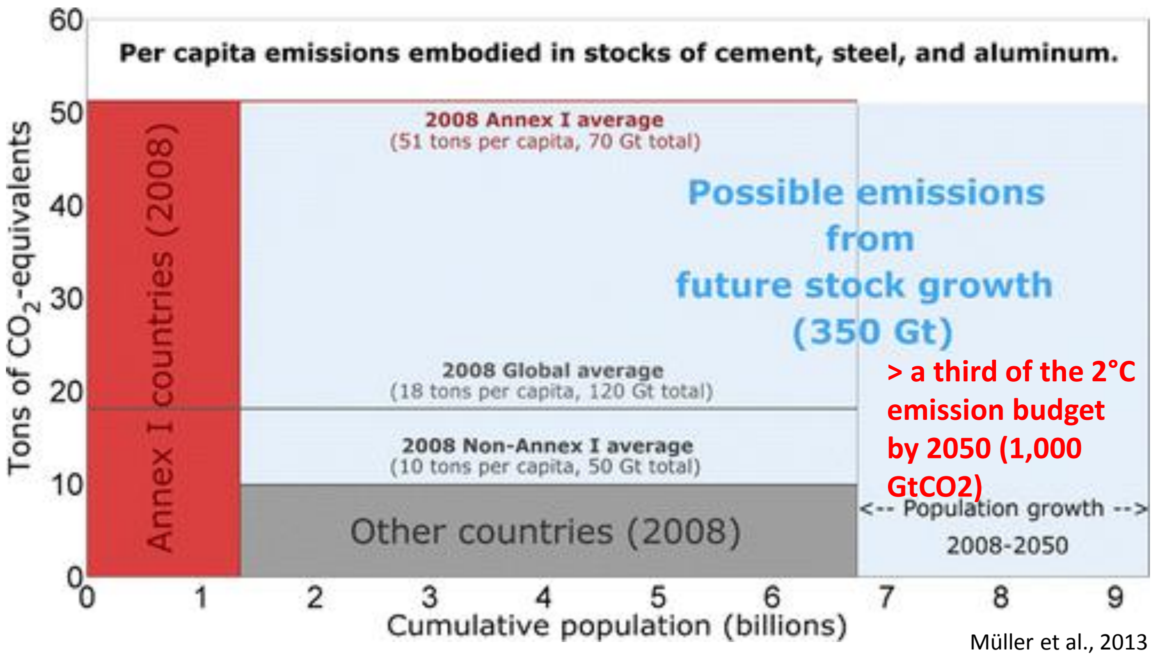
>10 mn city-agglomeration
1-5 mn city-agglomeration
< 300 th city-agglomeration

Source: UN DESA World Urbanization Prospects 2014
Schneider et al., 2009; Angel et al., 2011; Seto et al., 2011, 2012





Infrastructure demands large emissions



Müller et al., 2013

- The existing infrastructure stock
  - Average Annex-I resident is 3 times that of the world average
  - About 5 times higher than average non-Annex I resident

What drives cities’ emissions?

- No single factor explains per-capita emissions across cities
- Key factors include income, population dynamics, urban form, locational factors, development stage, economic structure, history, policies, and governance
- Key urban form related drivers of emissions are complex inter-mix of density, land use, connectivity and accessibility
- What combination of drivers leads into which city-emission trajectories are yet elusive

City emissions-data challenge !!

- Lack of bottom-up emissions and basic driving-factor data
- Methodological diversity- IPCC, GPC, and others
- Limited scope/boundaries of emissions
- Incomplete coverage- Gases, sectors

- Data-partnerships
    - ICLEI Carbon*n* Registry
    - C40/CDP self-reporting system
    - EU Covenant of Mayors

Effort to standardize: GPC 2.0 users -- expected GHG data- Not yet !!

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Endorsing Partners:

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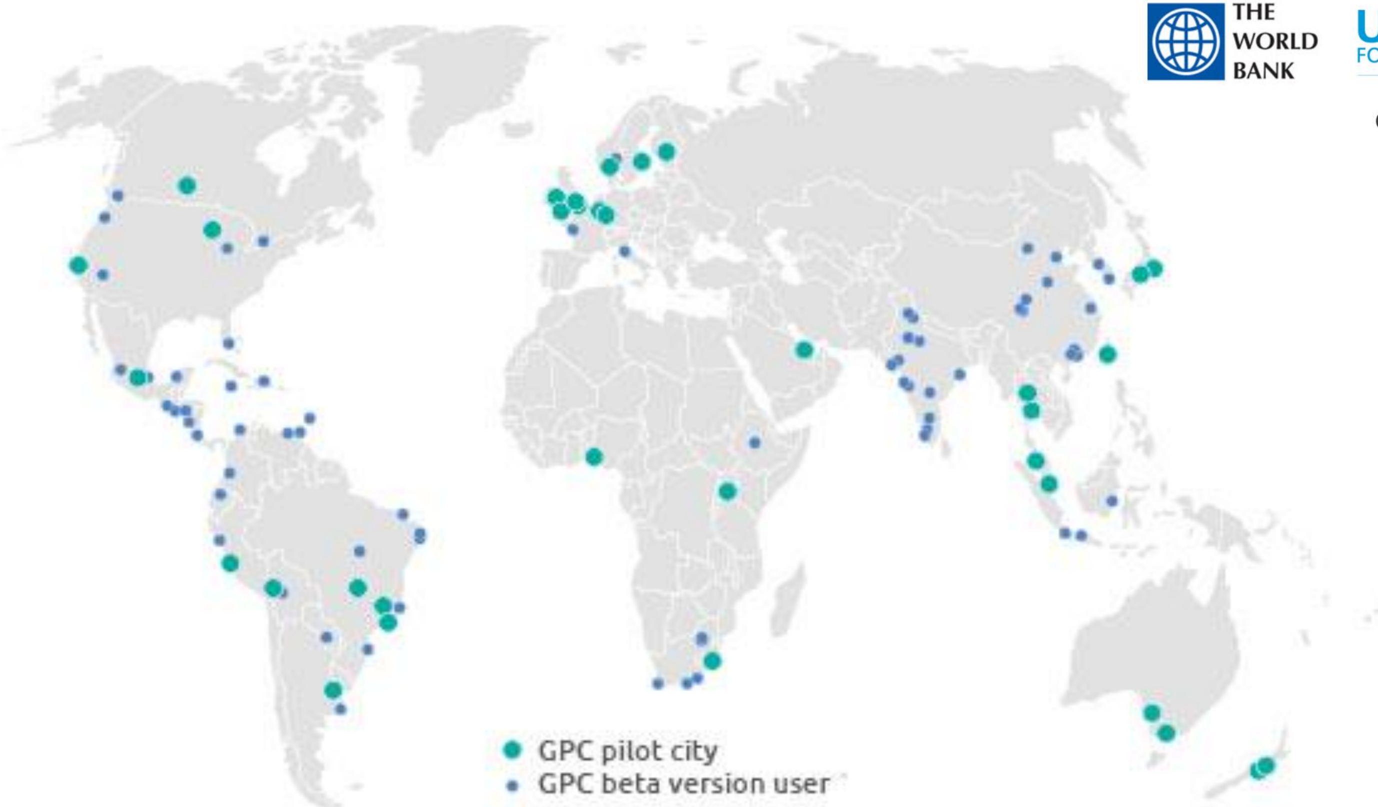
UNEP

Cities Alliance Joint Work Program



Benchmarking exercises

- Global Energy Assessment- Urban energy data
- 46 cities emissions benchmarking for World Bank (2010)
- Ongoing emission benchmarking – about 400 cities aimed – 224 global cities

Country	City Name	City definition	Year	Primary Protocol	CO2e (10^6 tons)	Year	GDP (10^9 USD)	Year	Population (10^6 person)	Area
Ethiopia	Addis Ababa	City Administration	2012	GPC	5.04	2014	4.00	2008	3.38	527.00
Jordan	Amman	Greater Amman Municipality	2013	2006 IPCC	7.22	2014	15.09	2015	3.60	700.00
Nigeria	Lagos	City/Municipality	2014	GPC	29.43	2015	136.60	2016	21.00	999.60

Different Accounting Methodologies

	GPC	ICLEI	2006 IPCC	OTHER	TOTAL
Africa	5	1	1.00		7.00
East Asia	2		3.00	21.00	26.00
Europe	8		4.00	89.00	101.00
Latin America	12		4.00		16.00
North America	16	35.00	3.00	10.00	64.00
South Asia and Oceania	6		10.00	1.00	17.00

Preliminary results- do not quote/cite

Benchmarking exercise

City/ Source	Energy	Electrical line losses	Gasoline Use from sales data	Gasoline use scaled	Gasolines use from model or traffic count	Aviation: all fuels loaded at airports	Aviation: all domestic; intl LTO only	Marine: all fuels loaded at port	Marine: inland or near-shore (12 mile) only	Railways	Biofuels	Industrial processes	AFOLU	WASTE	Landfill: scaled from national data	Landfill: EPA WARM model	Landfill: total yield gas	First Order Decay	Waste water	Upstream fuels	Embodied food or materials
Africa																					
Kennedy and others 2009																					
Cape Town	X	X	X			X		X													
Asia																					
T.V. Ramachandra and others 2015																					
Delhi	X	X			X								X	X					X		
Greater Mumbai					X			X					X	X					X		
Kolkata					X			X					X	X					X		
Chennai					X			X					X	X					X		
Greater Bangalore					X								X	X					X		
Hyderabad					X								X	X					X		
Ahmedabad					X								X	X					X		
Bangkok	X	X			X									X			X				
Dhakal 2009																					
Beijing	X	X	X																		
Shanghai	X	X	X																		

Preliminary results- do not quote/cite

Benchmarking exercise

Appendix D – Gases, Scopes and Sectors of CO2e Emissions Inventory

Mn tonsCO2e

Country	City Name	Gases Included	Scope 1	Scope 2	Scope 3	Stationary Energy	Transport	Waste	IPPU	AFOLU	TOTAL
Ethiopia	Addis Ababa	CO2, CH4, N2O	3.71	0.00	1.34	1.71	2.27	0.80	0.01	0.25	5.04
Jordan	Amman	CO2, CH4, N2O	3.32	3.89	0.00	4.75	2.27	0.19	0.00	0.00	7.22
Nigeria	Lagos	CO2, CH4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.43
South Africa	Cape Town	CO2, CH4, N2O	9.78	12.86	1.29	14.39	7.12	2.42	0.00	0.00	23.94
South Africa	Durban	CO2, CH4, N2O	7.32	2.44	4.77	2.88	11.27	0.29	0.00	0.09	14.53
South Africa	Johannesburg	CO2, CH4, N2O	6.99	8.56	0.00	8.34	7.21	0.00	0.00	0.00	15.54
South Africa	Pretoria - Tshwane	CO2, CH4, SF6, N2O	1.20	11.98	0.00	7.79	4.09	1.30	0.00	0.00	13.18
China	Beijing	CO2, CH4, N2O	105.40	49.60	0.00	0.00	0.00	0.00	0.00	0.00	155.00
China	Chongqing	CO2, CH4, N2O	125.28	18.72	0.00	0.00	0.00	0.00	0.00	0.00	144.00
China	Dalian		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.00
China	Hengshui		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00
China	Nanjing	CO2, CH4, N2O, CF4, C2F6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.43
China	Ningbo		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.00
China	Qingdao		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.00
China	Shanghai	CO2, CH4, N2O	209.28	8.72	0.00	0.00	0.00	0.00	0.00	0.00	218.00
China	Shenyang		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.00

Preliminary results- do not quote/cite

Data availability, methodology and gaps in city emissions in China

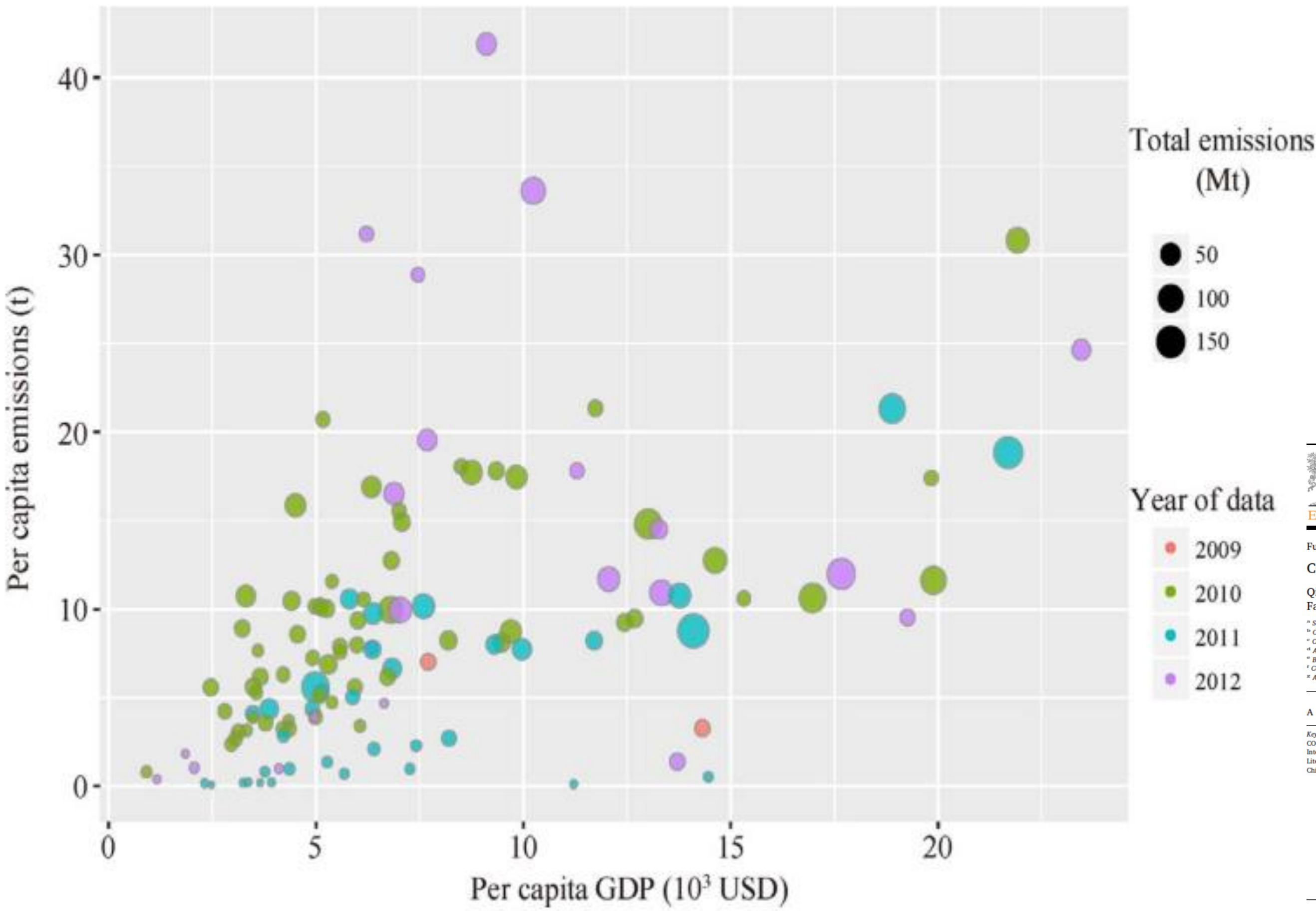
- 177 studies; 80 studies in English and 97 in Chinese
- 45% of prefecture-level cities (out of 283) have some emission estimates with different levels → More than half of the Chinese cities lack publicly available CO2 emissions data
- Varying level of sectoral data used in estimates and several different methodologies-used → mostly focused on city energy consumption data only

Sectoral coverage of data sources for different calculation methods.

Method type	Sectoral coverage of data sources						Scope			Proportion (%)
	Energy use	Industrial production	Land use	Waste disposal	Agricultural data	Others	Scope1	Scope2	Scope3	
Type1	√	√	√	√	√	√	√	√	√	13.56
Type2	√						√			49.25
Type3	√					√	√	√		37.19

Qianli Chen, Bofeng Cai, Shobhakar Dhakal, Sha Pei, Chunlan Liu, Xiaoping Shi, Fangfang Hu.(2017). CO2 emission data for Chinese cities. *Resources, Conservation and Recycling* 126: 98–208

Data availability, methodology and gaps in city emissions in China



- Energy-related Carbon emissions data for 122 cities
- Shanghai (273 mn t CO2) to Xiangxi Tujia and Miao Autonomous Prefecture (0.23 mn tCO2)

Resources, Conservation & Recycling 126 (2017) 198–208

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Full length article

CO_2 emission data for Chinese cities

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ARTICLE INFO

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Intensity of Concern (IC)
Literature
Chinese cities

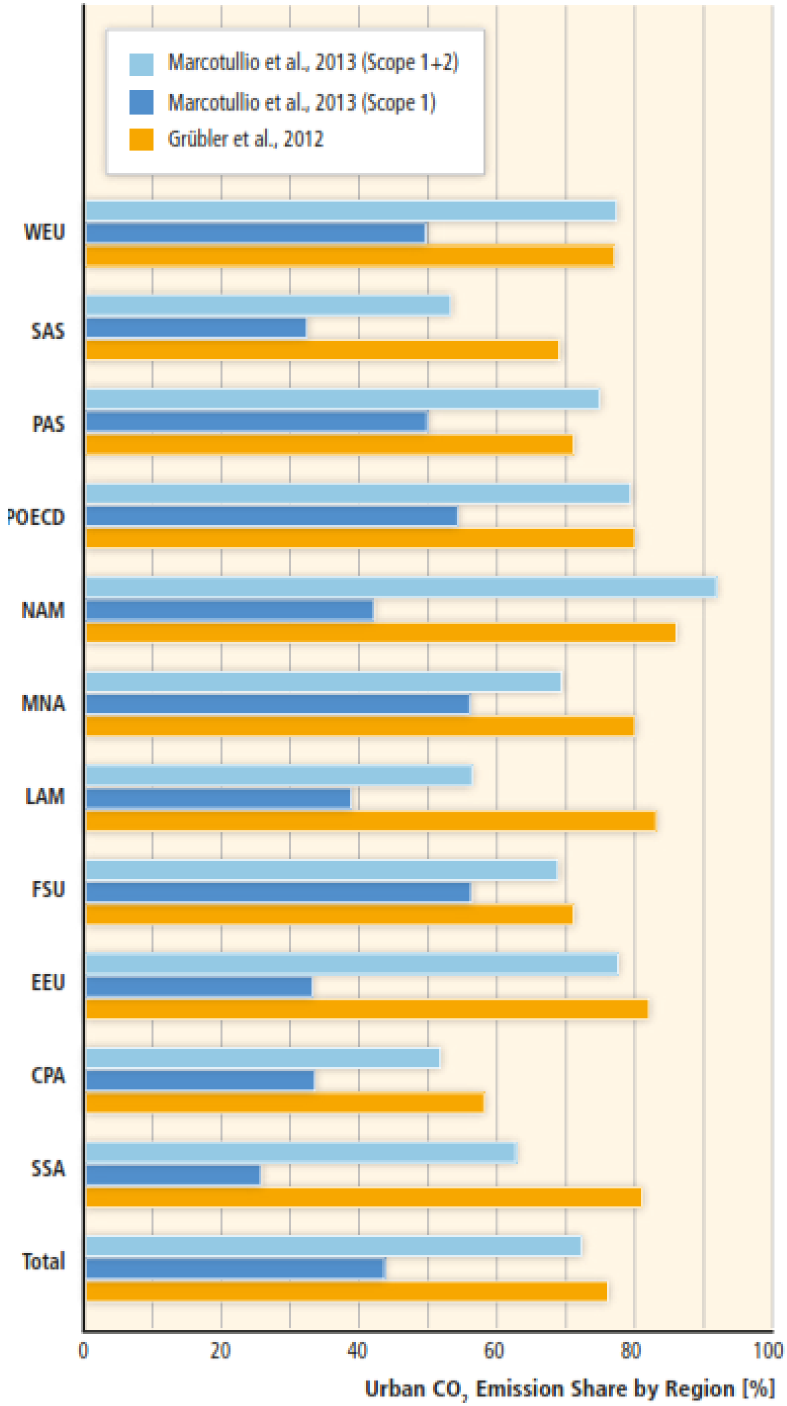
ABSTRACT

Greenhouse gas (GHG) emission inventories and basic data sources for energy consumption in cities are important for the mitigation of carbon emissions and the development of low-carbon strategies. However, recent IPCC reports and other studies have highlighted significant data gaps in the place-based literature for cities' carbon emissions and their drivers. In the last few years, literature related to cities' carbon emissions in China has grown rapidly. This study reviews the literature on city-level carbon emissions in China and examines the emission estimates. A detailed literature search, a regression analysis, and an inductive analysis of city carbon emission data were conducted. Our findings showed that approximately 45% of prefecture-level cities have emission estimates with different levels. The CO_2 emission data available for prefecture-level cities are scarce. The methodologies, sectoral coverage, and other aspects of the estimates are limited. The energy-related carbon emissions of the cities differ significantly across city typologies in China. The values of Intensity of Concern (IC) and Clustering Intensity (CI) are spatially aggregated, with the highest values in eastern China, middle values in the central area, and lowest values in western China. There are significant differences and gaps in the carbon emissions inventories and capabilities of low-carbon development in Chinese cities. A number of advanced cities could act as model cities for data collection, and reliable basic data sources could be provided for low-carbon development by perfecting the nation's carbon emissions accounting system, the statistical system, and shared mechanisms.

Qianli Chen, Bofeng Cai, Shobhakar Dhakal, Sha Pei, Chunlan Liu, Xiaoping Shi, Fangfang Hu.(2017). CO2 emission data for Chinese cities. *Resources, Conservation and Recycling* 126: 98–208

Top-down emissions estimations and limitations

- Attraction: Lack of place-based emissions can be complemented from top-down (?)
- EDGAR-based analysis overlaying urban extent (remote-sensing products), MESSAGE-Downscaled (IIASA), nightlight intensity based
- Lily Parshall (2010), Peter Marcotullio (2012)
- Fine-scale CO2 resolution images by several researchers at regional scale, incl (Kevin Gurney, Philippe Cias, Mike Raupach etc.)
- Few emerging work in China building-on multiple-bottom-up datasets
- Snap-shot only; allocation of imported electricity is problem (CARMA Database v. 3.0 (http://carma.org/) used in some case)
- Proxy-based downscaling has poor or no representation of local conditions
- 'Utility' of top-down analysis needs a careful look !! Difficult to use for local purpose



Two top-down studies compared

Seto, Dhakal et al. (2014), IPCC AR5 WGIII Chapter 12

Urbanization's wedge in future emissions/ mitigation- what exist?

- WEO (2008) by IEA – urban CO2 emissions 76% by 2030 (energy related)
- Brian O'Niels et al.'s limited work, IAM are not addressing urban
- Karen Seto et al.'s work from urban land expansion
- Daniel Mueller's work on infrastructure stock (2013)
- Felix et al 's PNAS work on urban typology (2013)
- Estimation by SEI-USA for Michael Bloomberg's initiative (2015)
- IEA (2016)
- Felix et al. (2016) work on 2040 mitigation potential

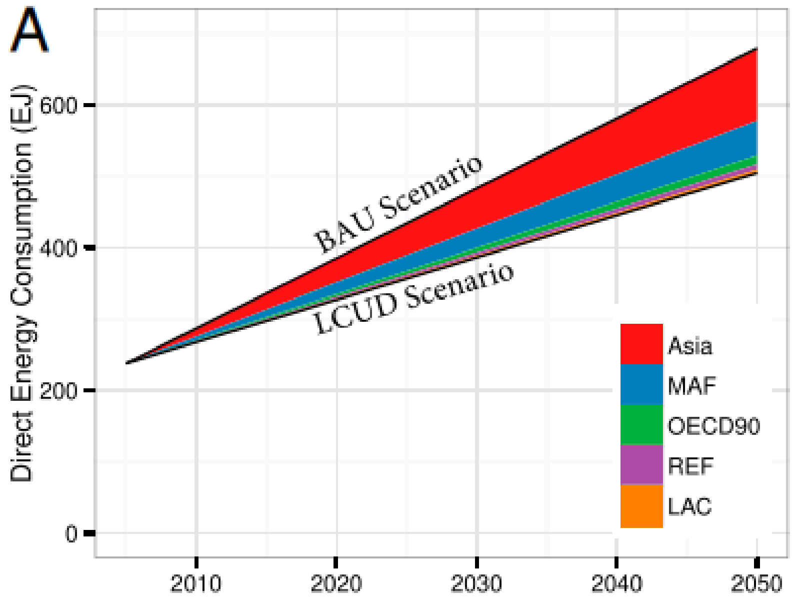
Large window of opportunity for mitigation from spatial planning in next 2-3 decades

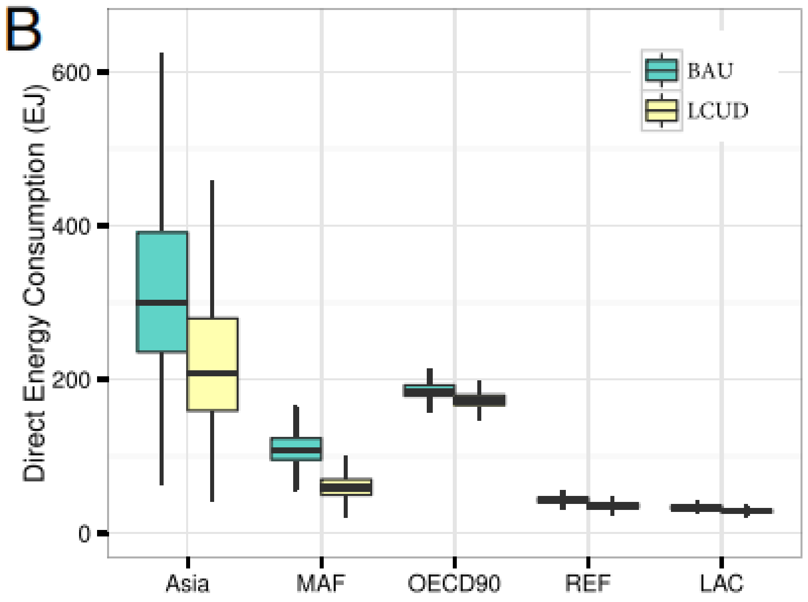
Study	Scenario	Projected Urban Expansion to 2030 (km²)								% of projected urban land in 2030 to be built between 2000–2030
		Urban Land 2000 (km²)	Africa	Asia	Europe	Latin America	North America	Oceania	Total (% increase from 2000)	
Seto et al. (2011)	SRES A1	726,943	107,551	1,354,001	296,638	407,214	73,176	16,996	2,255,576 (310)	76
	SRES A2	726,943	113,423	702,772	162,179	122,438	49,487	15,486	1,165,785 (160)	62
	SRES B1	726,943	107,551	1,238,267	232,625	230,559	86,165	18,106	1,913,273 (263)	72
	SRES B2	726,943	136,419	989,198	180,265	131,016	74,572	15,334	1,526,805 (210)	68
Seto et al. (2012)	> 75 % probability	652,825	244,475	585,475	77,575	175,075	118,175	9,700	1,210,475	65
		Urban Land 2000 (km²)	Africa	Asia	East Asia and the Pacific	Europe and Japan	Latin America and the Caribbean	Land Rich Developed Countries	Total (% increase from 2000)	
Angel et al. (2011)	0 % density decline	602,864	58,132	120,757	43,092	9,772	49,348	54,801	335,902 (56)	36
	1 % density decline	602,864	92,002	203,949	75,674	74,290	98,554	119,868	664,337 (110)	52
	2 % density decline	602,846	137,722	316,248	119,654	161,379	164,975	207,699	1,107,677 (184)	65

Seto, Dhakal et al. (2014), IPCC AR5 WGIII Chapter 12

Urbanization’s energy wedge

Role of Asia is Paramount





Potential of an urbanization wedge in energy use. (A) Urbanization wedge characterized by median business-as-usual (BAU) and low-carbon urban development (LCUD) scenarios. (B) Uncertainty in scenarios for the different world regions. *The centerline is the median, the top and bottom of the boxes are the 25th and 75th percentiles, and lines present overall range. OECD90, OECD countries in 1990; LAM, Latin America and the Caribbean; MAF, Middle East and Africa; REF, reforming economies of Eastern Europe and the former Soviet Union.*

Felix Creutigz et al., PNAS, 2013

- Dataset of 274 cities
- Based on the clustering and scaling sample cities statistically
- If current trends in urban expansion continue, urban energy use will increase more than threefold, from 240 EJ in 2005 to 730 EJ in 2050
- Urban planning and transport policies can limit the future increase in urban energy use to 540 EJ in 2050 and contribute to mitigating climate change

MICHAEL R. BLOOMBERG | UN Secretary-General's Special Envoy for Cities and Climate Change

C40 CITIES

A report to the UN Secretary-General from the UN Secretary General's Special Envoy for Cities and Climate Change, in partnership with the C40 Cities Climate Leadership Group

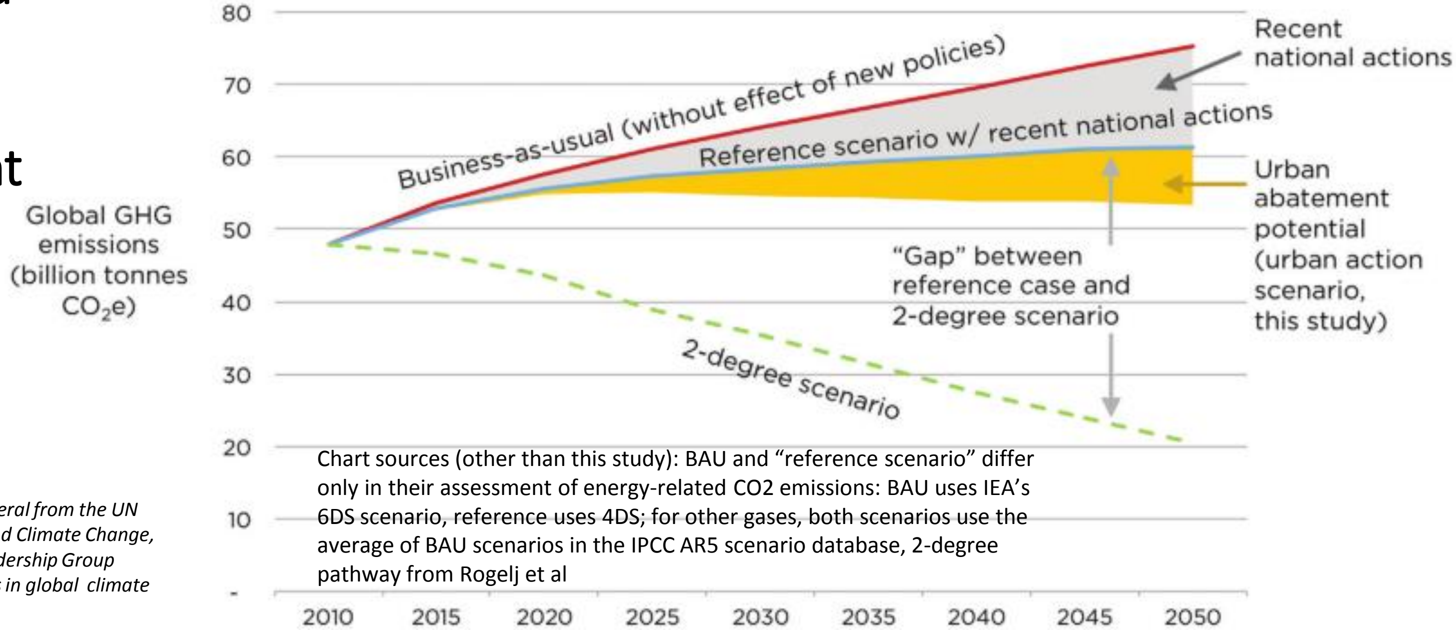
Advancing climate ambition: cities as partners in global climate action

Urban abatement by sector in the urban action scenario, 2030 and 2050

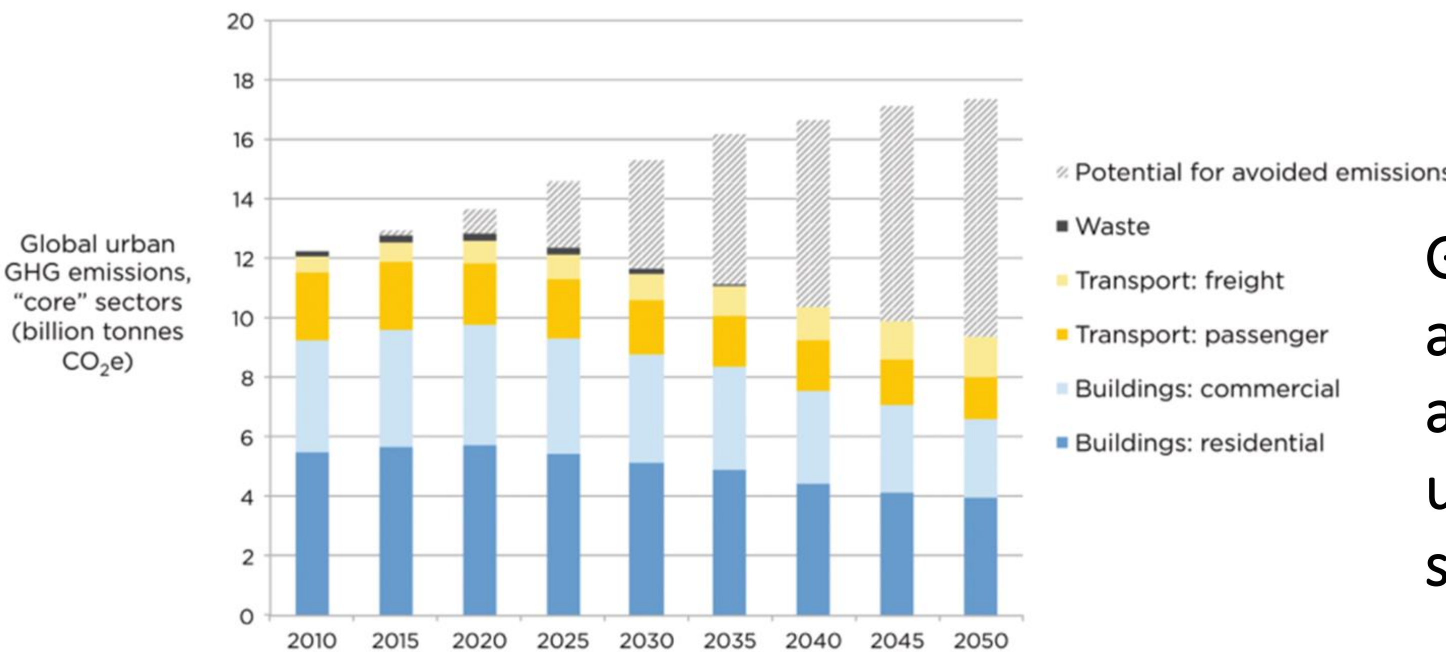
Sector	Action	Abatement, $GtCO_2e$ 2030	Abatement, $GtCO_2e$ 2050	Share of total Abatement, % 2030	Share of total Abatement, % 2050
Buildings, residential	New building heating efficiency	0.6	1.2	16%	15%
	Heating retrofits	0.4	0.5	12%	7%
	Appliances and lighting	0.4	0.9	12%	11%
	Fuel switching / solar PV	0.1	0.2	3%	3%
Buildings, commercial	New building heating efficiency	0.3	0.5	7%	7%
	Heating retrofits	0.2	0.2	6%	3%
	Appliances and lighting	0.3	0.7	8%	8%
	Fuel switching / solar PV	0.1	0.2	3%	3%
	Subtotal, buildings	2.4	4.5		
Transport, passenger	Urban planning–reduced travel demand	0.2	0.5	5%	6%
	Mode shift and transit efficiency	0.4	1.0	11%	12%
	Car efficiency and electrification	0.2	0.9	7%	11%
Transport, freight	Logistics improvements	0.1	0.2	2%	3%
	Vehicle efficiency	0.1	0.3	3%	4%
	Subtotal, transport	1.0	2.9		
Waste	Recycling	0.2	0.3	4%	4%
	Landfill methane capture	0.0	0.3	0%	4%
	Subtotal, waste	0.2	0.6		
Total		3.7	8.0		

Cities can contribute significantly to bridging the global emissions gap – with emissions reduction potential of up to two-thirds the impact of recent national policies and actions:
urban actions could decrease global greenhouse gas (GHG) emissions by 3.7 GtCO2e below what national actions are currently on track to achieve in 2030, and by 8.0 GtCO2e in 2050.

Urban action could help deepen the aggregate, global ambition of current national pledges

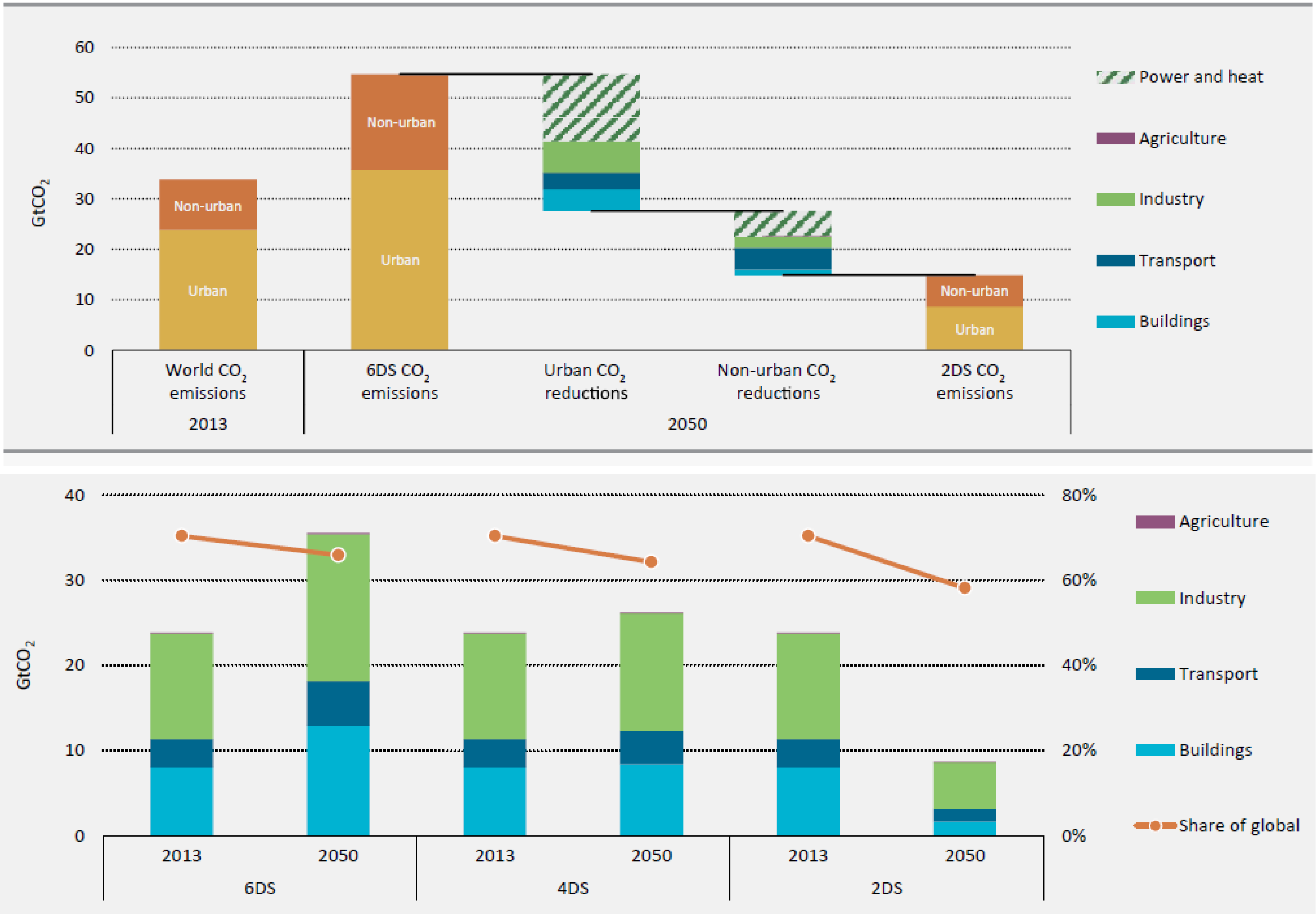


C40 (2015)- A report to the UN Secretary-General from the UN Secretary General's Special Envoy for Cities and Climate Change, in partnership with the C40 Cities Climate Leadership Group Advancing climate ambition: cities as partners in global climate action



GHG emissions and emissions avoided in the urban action scenario

Urban carbon emissions reduction potentials, 2013-50



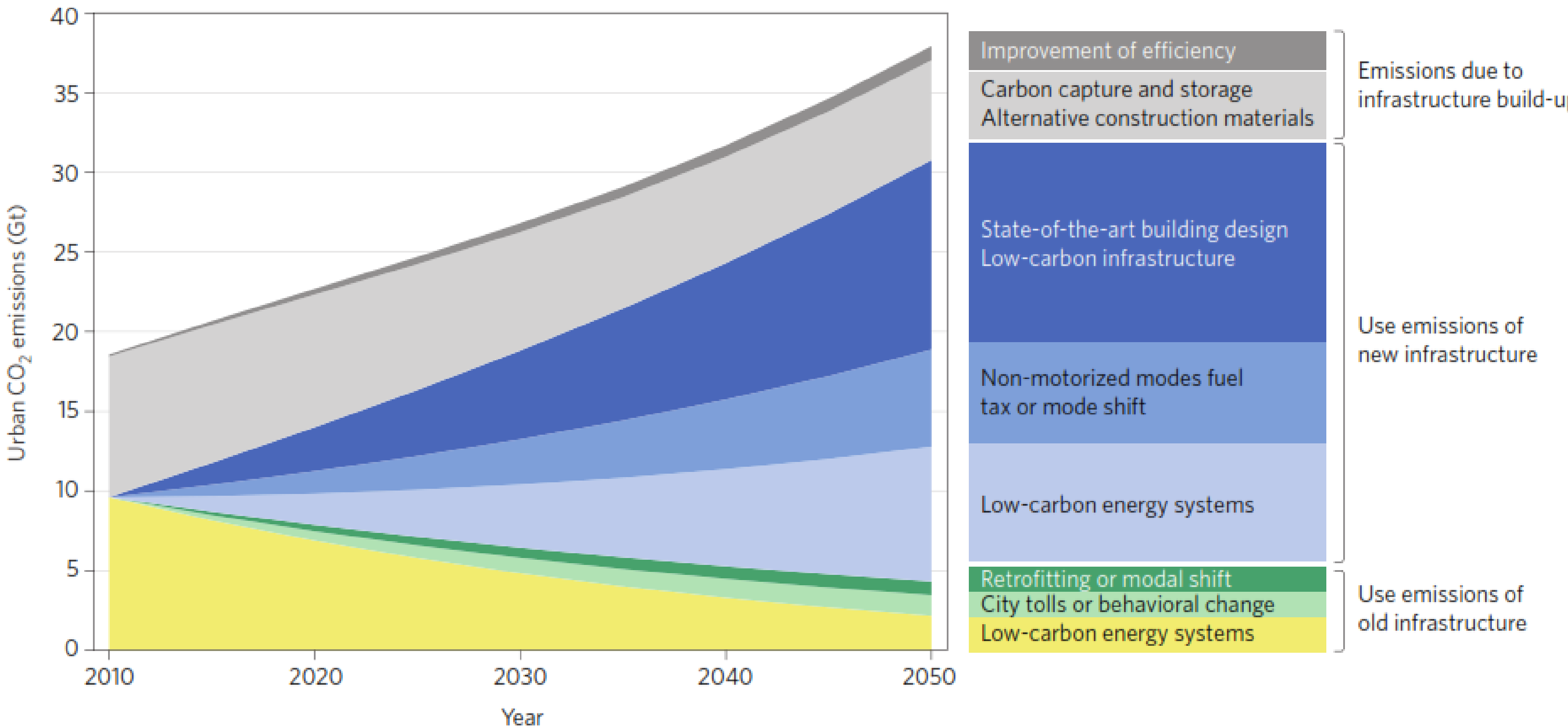
Note: CO_2 emissions from the power sector are distributed to the end-use sectors proportional to their use of electricity and heat.

Under the 2DS, global urban CO2 emissions can be reduced by around 75% in 2050 compared with the 6DS.

IEA, 2016

Urban infrastructure choices structure climate solutions

Felix Creutzig, Peter Agoston, Jan C. Minx, Josep G. Canadell, Robbie M. Andrew, Corinne Le Quéré, Glen P. Peters, Ayyoob Sharifi, Yoshiki Yamagata and Shobhakar Dhakal



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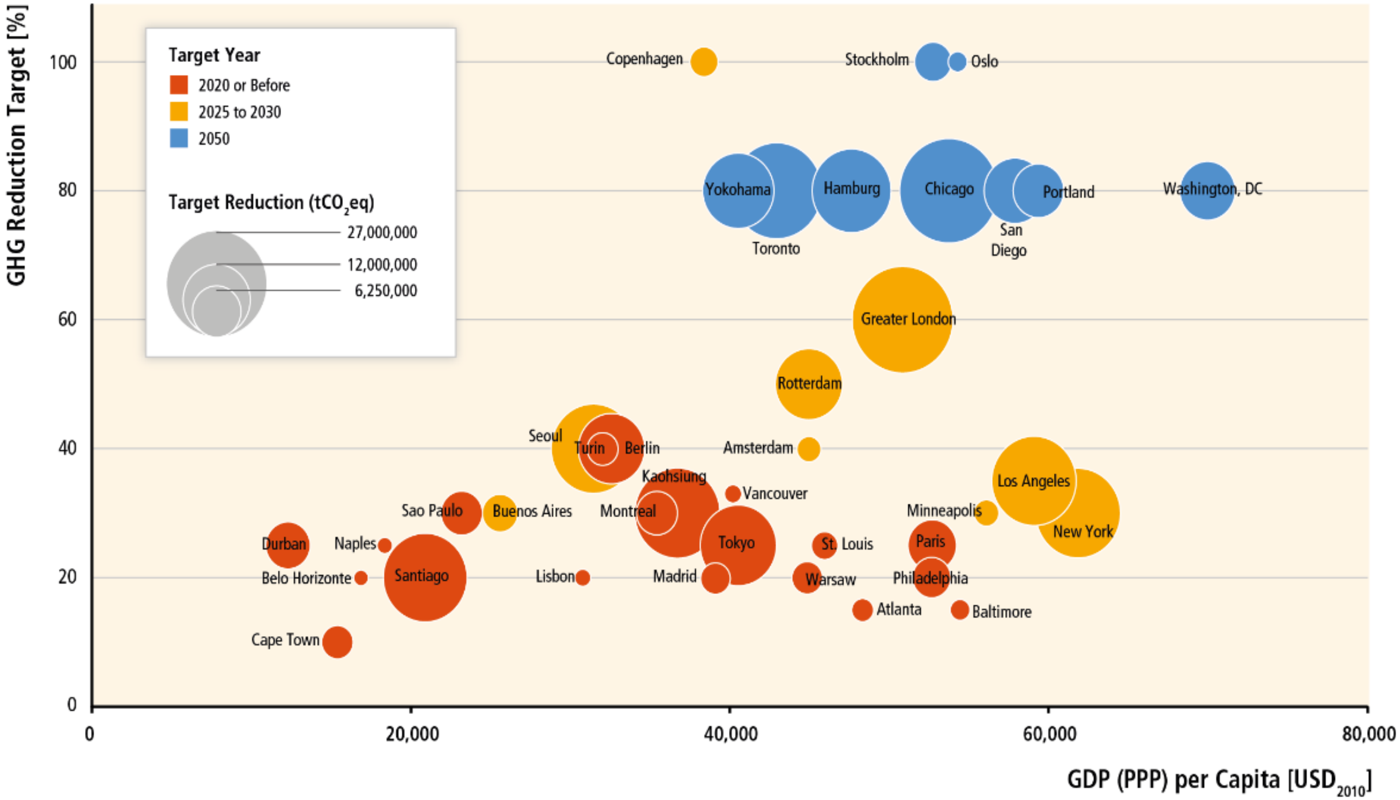
We can cut global emission by half by 2040 if we build smarter cities

Thousands of cities are undertaking Climate Action Plans and mitigation commitments



Sources: Baseline emissions, reduction targets, and population from self-reported data submitted to Carbon Disclosure Project (2013). GDP data from Istrate & Nadeau (2012). Note that the figure is illustrative only; data are not representative, and physical boundaries, emissions accounting methods and baseline years vary between cities. Many cities have targets for intermediate years (not shown).

- Little systematic assessment on their level of implementation & the extent to which reduction targets are being achieved
- Focused largely on energy efficiency
- Limited consideration to land-use planning strategies and other cross-sectoral, cross boundary measures

Yet, their aggregate impact on urban emissions is uncertain

Knowledge gaps (AR5)

1. Lack of consistent and comparable emissions data at local scales
2. Little scientific understanding of the magnitude of the emissions reduction from altering urban form, and the emissions savings from integrated infrastructure and land use planning.
3. Lack of consistency and thus comparability on local emissions accounting methods
4. Few evaluations of urban climate action plans and their effectiveness.
5. Lack of scientific understanding of how cities can prioritize climate change mitigation strategies, local actions, investments, and policy responses that are locally relevant
6. Large uncertainties as to how urban areas will develop in the future

What all these mean for Asia?

- Window of opportunities immense
- Science based action planning and tracking progress necessary
- Late-comer's advantage, large co-benefits
- Capacity/governance constraints – small and mid-size cities

In summary

- Cities are crucial elements of global deep de-carbonization- next 2-3 decades is ‘window of opportunities’
- Bottom-up city emissions inventories must be built, standardized and tracked despite having complexities – too few emission data
- ‘Within-cities’ and ‘outside cities’ emission implication are key, particularly infrastructure and cross-boundary emissions management
- Emission drivers and city-typology research must progress to inform climate solutions
- Future cities’ mitigation potential assessment are in infancy stage
- Mitigation-achieved from climate actions must be paid a close attentions – ambition vs. outcomes
- 1.5 Degree vision needs systemic ‘transformative pathways’ as opposed to ‘incremental’ one – new avenues must be explored for cities

IPCC WGIII AR6 Approved Chapter 8: Urban systems and other settlements

Drivers

- Demographic perspectives, migration, and urbanisation trends
- Consumption, lifestyle, and linkages between urban and rural areas

Emissions analyses

- Urbanisation wedge in future emissions and mitigation at global and national levels
- City emissions and drivers analysis, city typologies

Options analyses

- Urban emissions and infrastructure lock-in
- Urban mitigation options and strategies
- Low-carbon city scenarios, options and costs

IPCC WGIII AR6 Approved Chapter 8: Urban systems and other settlements

Options analyses

- Urban form, design, and role of spatial planning
- Urban technologies, including disruptive technologies, the use of information and communication technologies, involving use of data
- Waste and waste water management, material recycling

Experiences, lessons and how to do?

- Innovative strategies and climate actions, urban experimentation, city networks and coalitions
- Urban mitigation governance – levels, barriers, and opportunities
- Policy instruments and infrastructure investments
- Rural settlements: leapfrogging opportunities

Thank you

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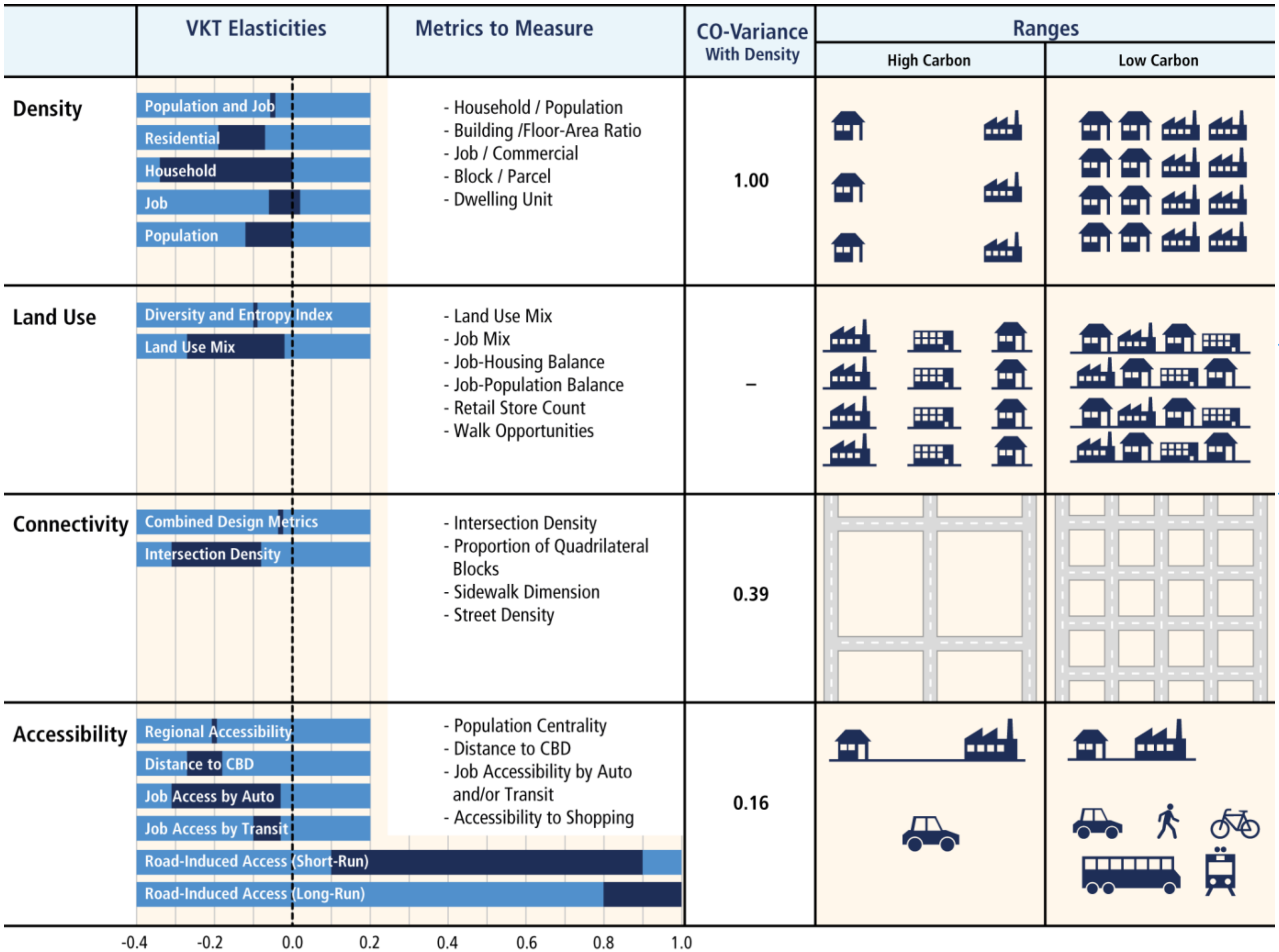
Key findings of AR5

Key drivers for emissions from urban form are density, land use, connectivity and accessibility



Higher density leads to less emissions (i.a. shorter distances travelled).

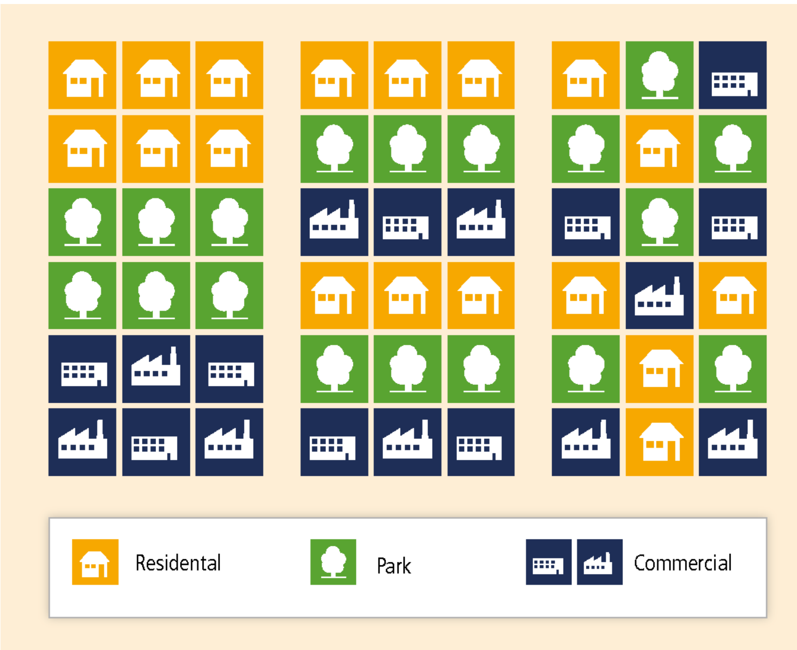
Mix of land-use reduces emissions.

Improved infrastructural density and design (e.g. streets) reduces emissions.

Accessibility to people and places (jobs, housing, services, shopping) reduces emissions.

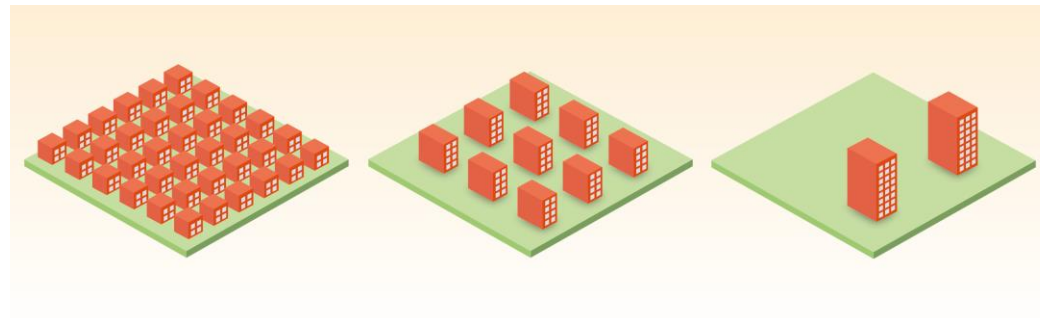
Numbers from Ewing and Cervero (2010), National Research Council (2009a), and Salon et al (2012) are based on the following original sources: Density (Schimek, 1996; Kockelman, 1997; Sun et al., 1998; Pickrell and Schimek, 1999; Ewing and Cervero, 2001; Holtzclaw et al., 2002; Bhatia, 2004; Boarnet et al., 2004; Bento et al., 2005; Zhou and Kockelman, 2008; Fang, 2008; Kuzmyak, 2009a; a; Brownstone and Golob, 2009; Ewing et al., 2009; Greenwald, 2009; Heres-Del-Valle and Niemeier, 2011); Land Use (Kockelman, 1997; Sun et al., 1998; Pushkar et al., 2000; Ewing and Cervero, 2001, 2010; Chapman and Frank, 2004; Frank and Engelke, 2005; Kuzmyak et al., 2006; Vance and Hedel, 2007; Brownstone and Golob, 2009; Kuzmyak, 2009b; Frank et al., 2009); Connectivity (Ewing and Cervero, 2001; Boarnet et al., 2004; Chapman and Frank, 2004; Frank and Engelke, 2005; Ewing et al., 2009; Greenwald, 2009; Frank et al., 2009); Accessibility (Goodwin, 1996; Ewing et al., 1996, 2009; Kockelman, 1997; Cervero and

Low carbon cities need to consider urban land use mix



Manaugh and Kreider, 2013

Density is necessary but not sufficient condition for lowering urban emissions



Adapted from (Cheng, 2009)

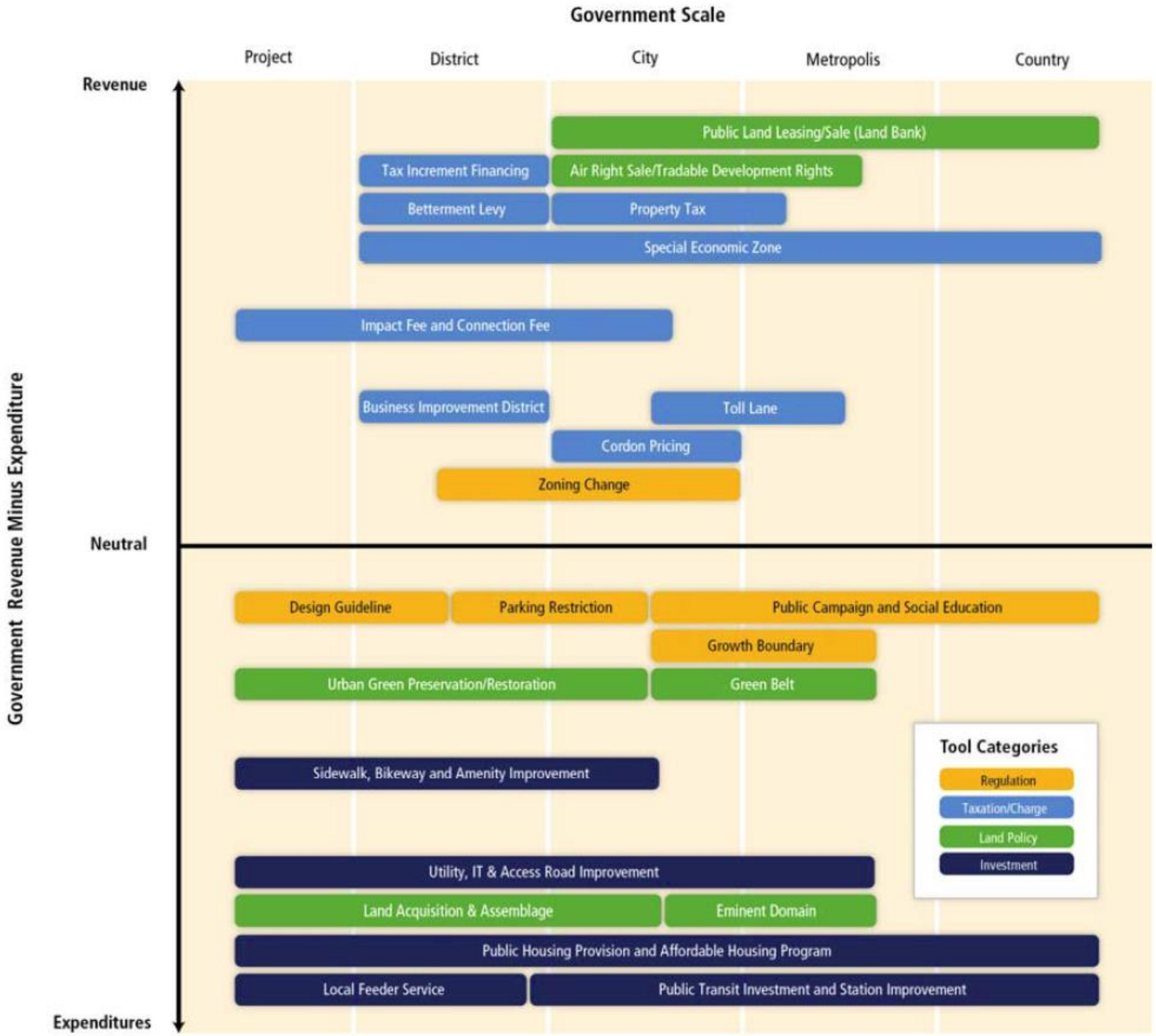
Mitigation options in urban areas vary by urbanization trajectories and are expected to be most effective when policy instruments are bundled

The largest mitigation opportunities with respect to human settlements are in rapidly urbanizing areas with

- **Small and mid-size cities**
- **Developing regions of the world**
- **Economical growing regions**
- **Infrastructure is being built and yet not locked-in**

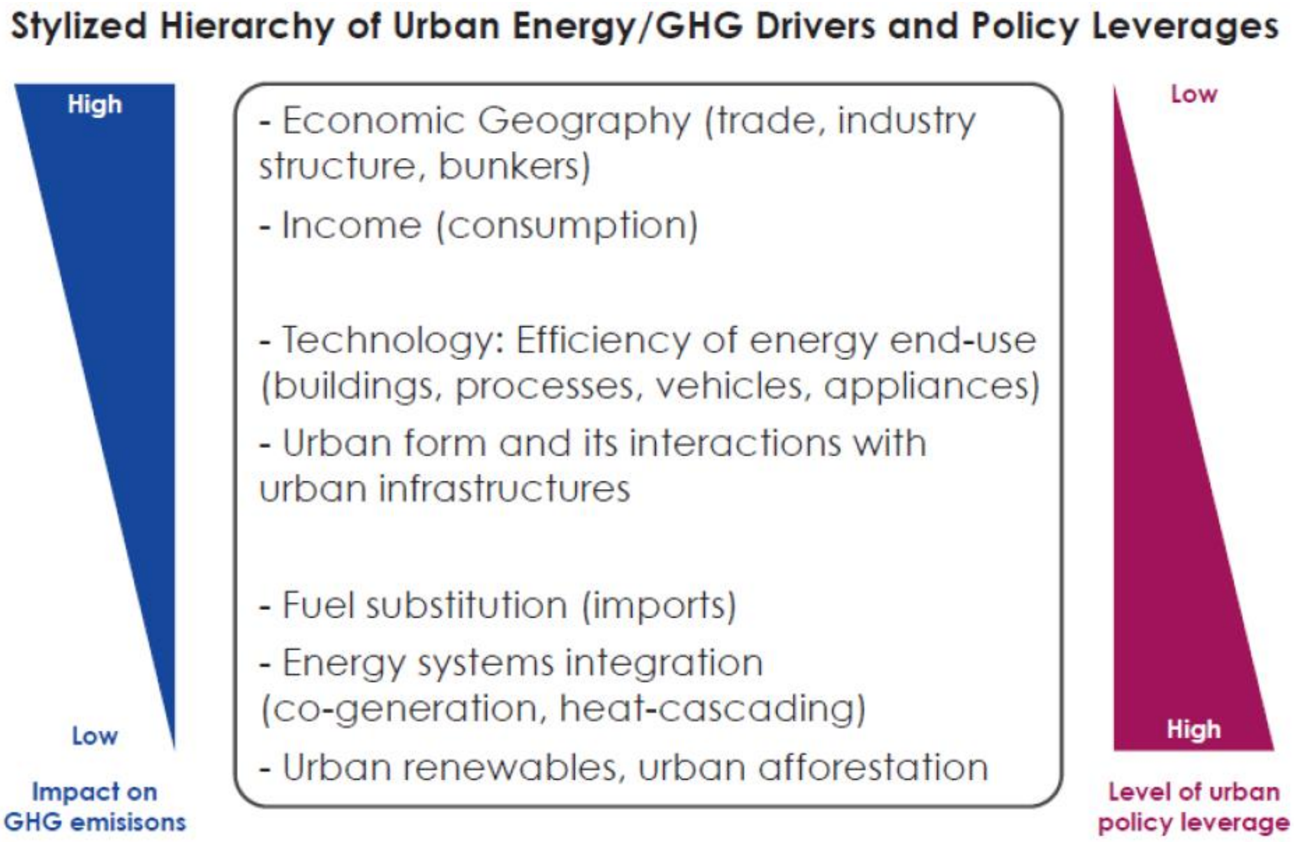
But these are often the places where limited financial and institutional capacities persist

The feasibility of spatial planning instruments for climate change mitigation is highly dependent on a city's financial and governance capability



Sources: Bahl and Linn (1998); Bhatt (2011); Cervero (2004); Deng (2005); Fekade (2000); Rogers (1999); Hong and Needham (2007); Peterson (2009); Peyroux (2012); Sandroni (2010); Suzuki et al. (2013); Urban LandMark (2012); U.S. EPA (2013); Weitz (2003).

In decisions making, the policy leverages do not often match with the largest mitigation opportunities



Systemic changes have more mitigation opportunities but hindered by policy fragmentation

Successful implementation of urban-scale climate change mitigation strategies can provide health, economic and air quality co-benefits

- Urban areas continue to struggle with challenges, including ensuring access to energy, limiting air and water pollution, and maintaining employment opportunities and competitiveness

- **Action on urban-scale mitigation often depends on the ability to relate climate change mitigation efforts to local co-benefits**

Mitigation measures	Effect on additional objectives/concerns		
	Economic	Social (including health)	Environmental
Compact development and infrastructure	↑ Innovation and productivity[1] ↑↑ Higher rents & residential property values[2] ↑ Efficient resource use and delivery[5]	↑ Health from physical activity[3]	↑ Preservation of open space[4]
Increased accessibility	↑ Commute savings[6]	↑ Health from increased physical activity[3] ↑ Social interaction & mental health[7]	↑ Air quality and reduced ecosystem/health impacts[8]
Mixed land use	↑ Commute savings[6] ↑↑ Higher rents & residential property values[2]	↑ Health from increased physical activity[3] ↑ Social interaction and mental health[7]	↑ Air quality and reduced ecosystem/health impacts[8]

‘Governance paradox’ and need for a comprehensive approach

- ‘Systemic changes’ in urban areas have large mitigation opportunities but hindered by current patterns of urban governance, policy leverages and persisting policy fragmentation
- Governance and institutional capacity are scale and income dependent, i.e., tend to be weaker in smaller scale cities and in low income/revenue settings
  - However, the bulk of urban growth momentum is expected to unfold in small- to medium-size cities in non-Annex-I countries
  - The largest opportunities for GHG emission reduction might be precisely in urban areas where governance and institutional capacities to address them are weakest
- The feasibility of spatial planning instruments for climate change mitigation is highly dependent on a city’s financial and governance capability
- For designing and implementing climate policies effectively, institutional arrangements, governance mechanisms, and financial resources all should be aligned with the goals of reducing urban GHG emissions