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Energy Transition Solutions Joint Operation Center

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Energy Transition Solutions Sub-forum

Energy Transition and Low Carbon Green Development

Beijing Time (GMT+8) 09:00-17:20, September 17, 2021

Interaction of urban energy system and infrastructure with climate change mitigation

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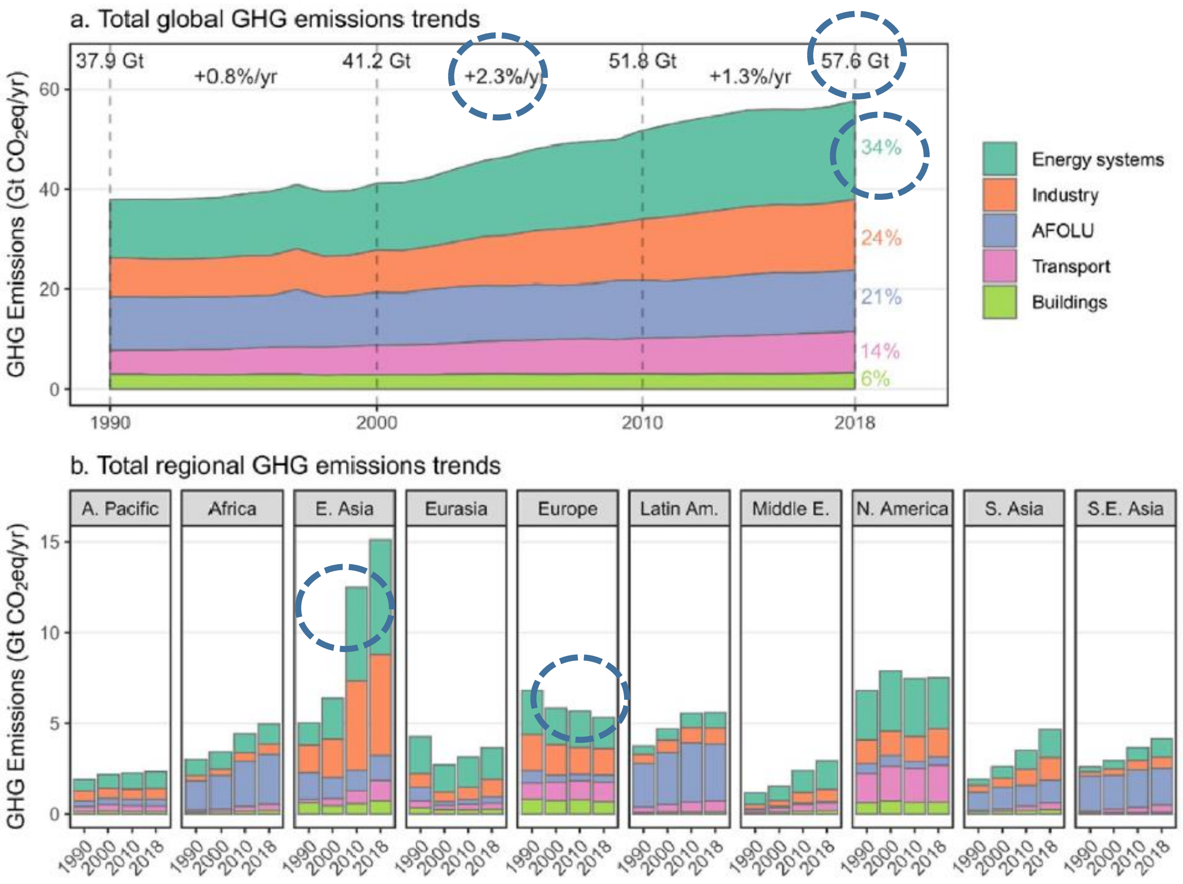
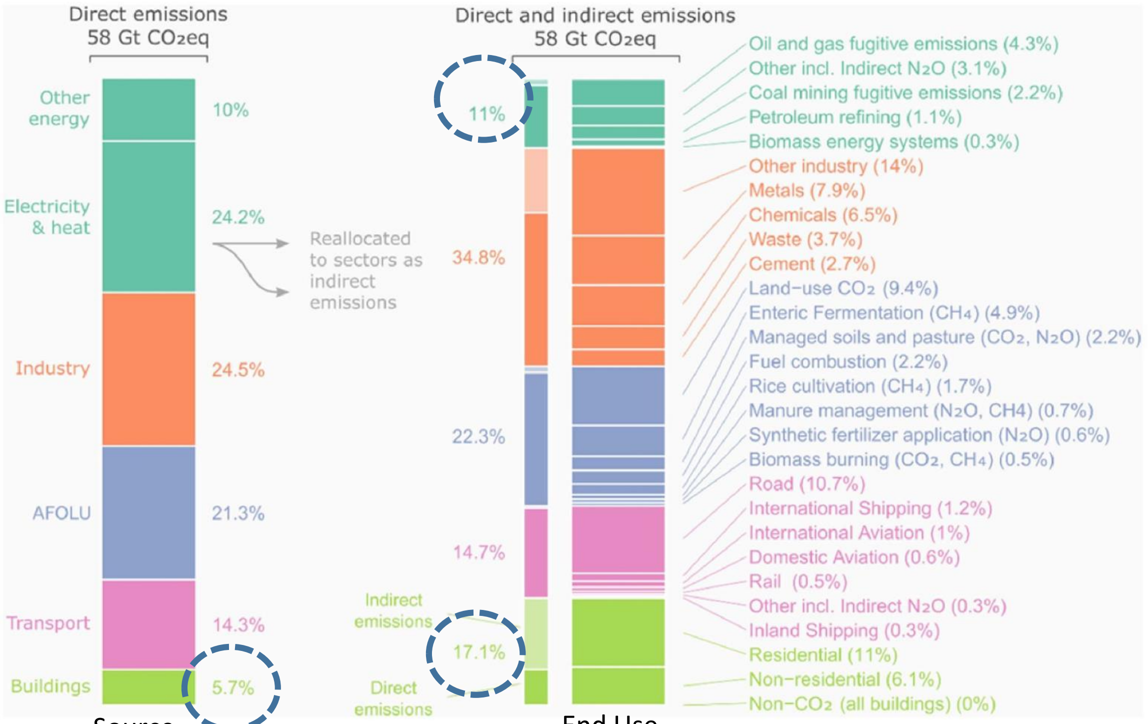
- Global emission trends from energy sector – key observations
- Expectations from energy sector in Net Zero Emission pathways
- Role of urban system and infrastructure in global emissions and future mitigation potentials
- Multi-dimentional ways of cities to influence local energy and emission
- Key opportunities for transformative change
- Key challenges to overcome

Global and regional GHG emissions trends



Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018, Environmental Research Letters 16, 073005

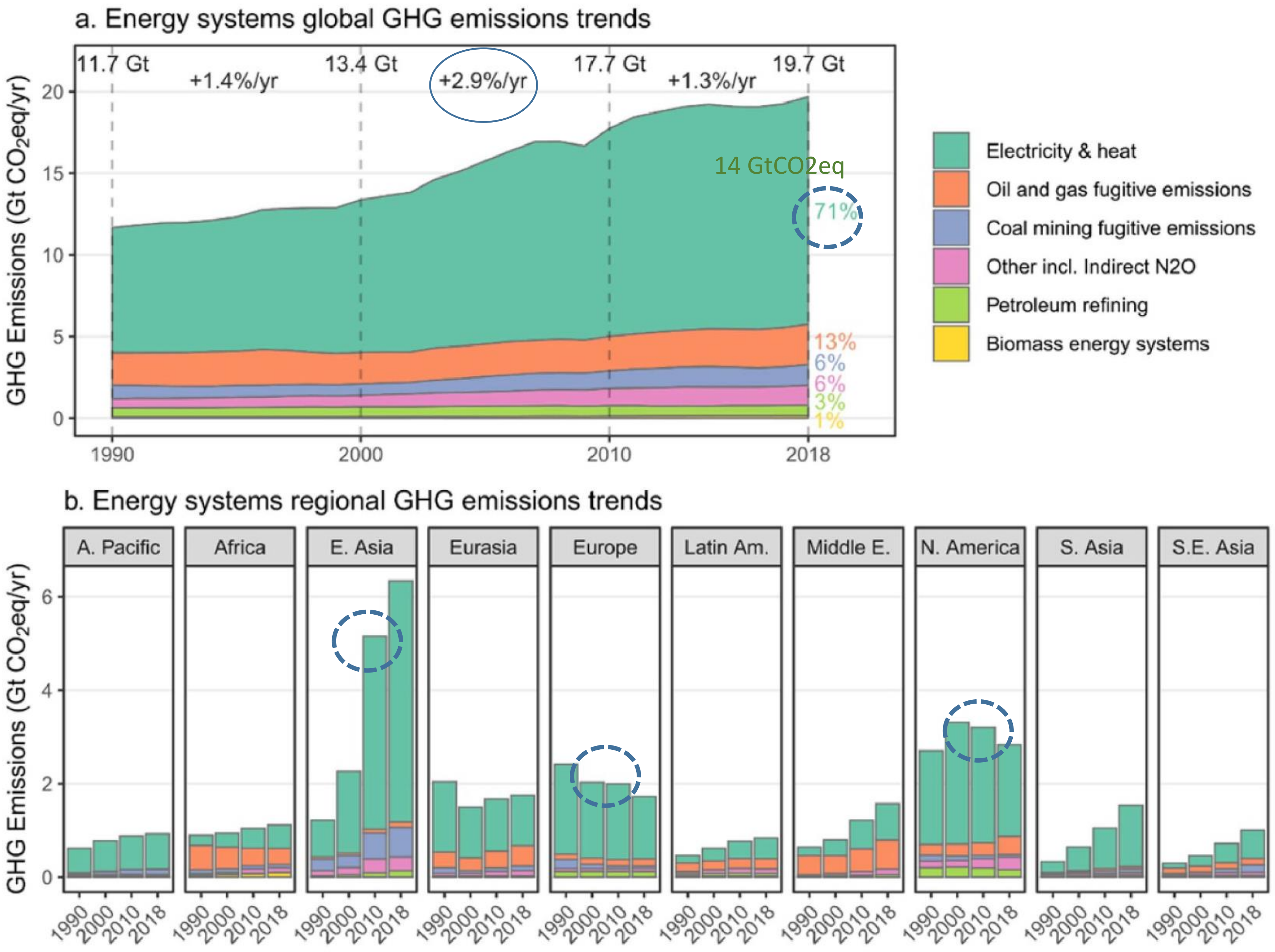


Source allocation

End Use allocation

- 2018 GHG emissions: 58 GtCO2eq → GHG emissions in 2010- 2018: 11% higher (5.8 GtCO2eq) from 2010 (52 GtCO2eq)
- Energy sector contribute the largest, 34% share (20 GtCO2eq)
- One third of ‘increase’ in GHG emissions in 2010-2018 is from energy sector (1.9 GtCO2eq)
- The only region with a decline in emissions is Europe (−0.3 GtCO2eq, −0.8%/yr) in 2010-18

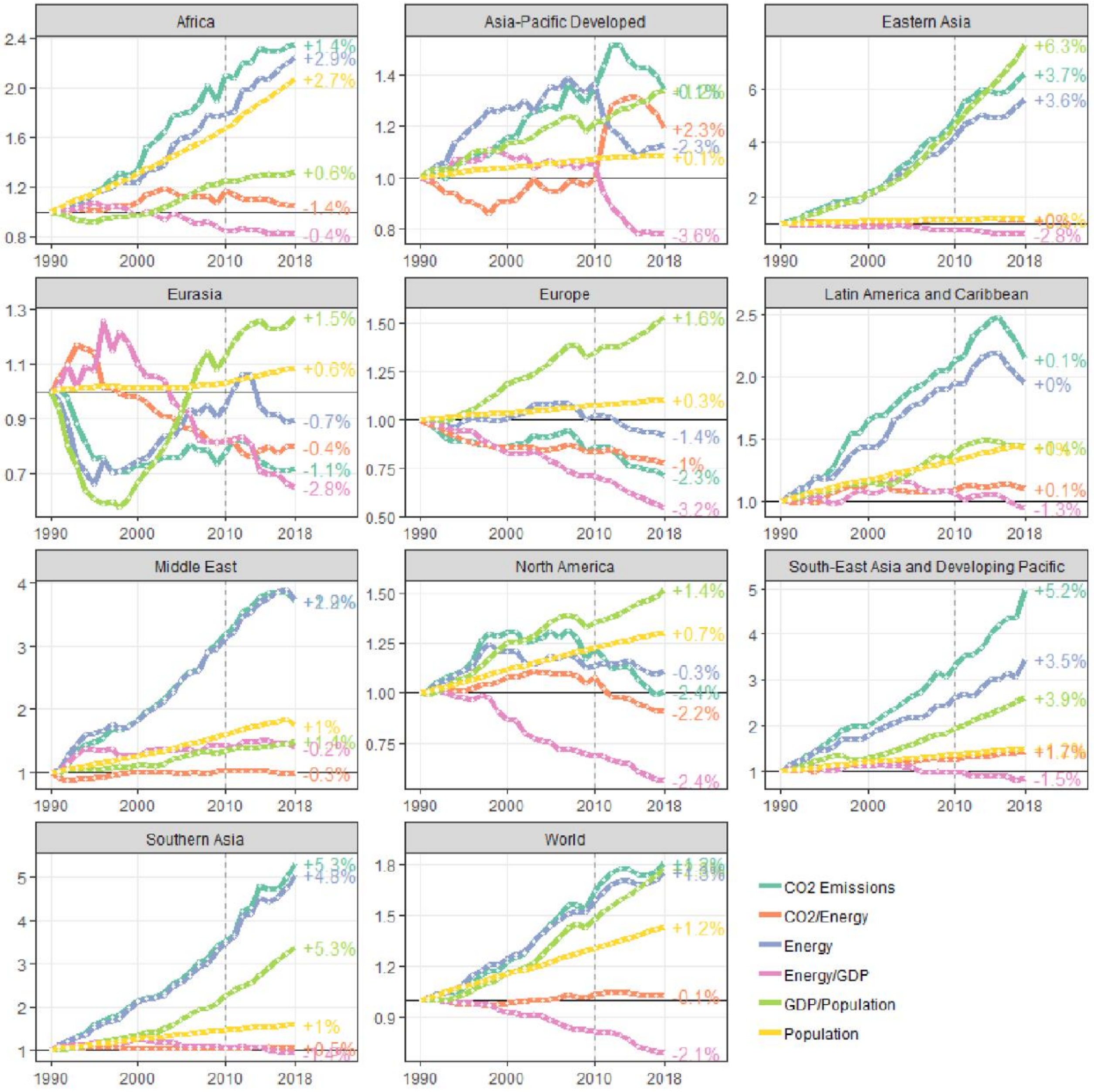
Global and regional GHG emissions trends **for the energy sector**



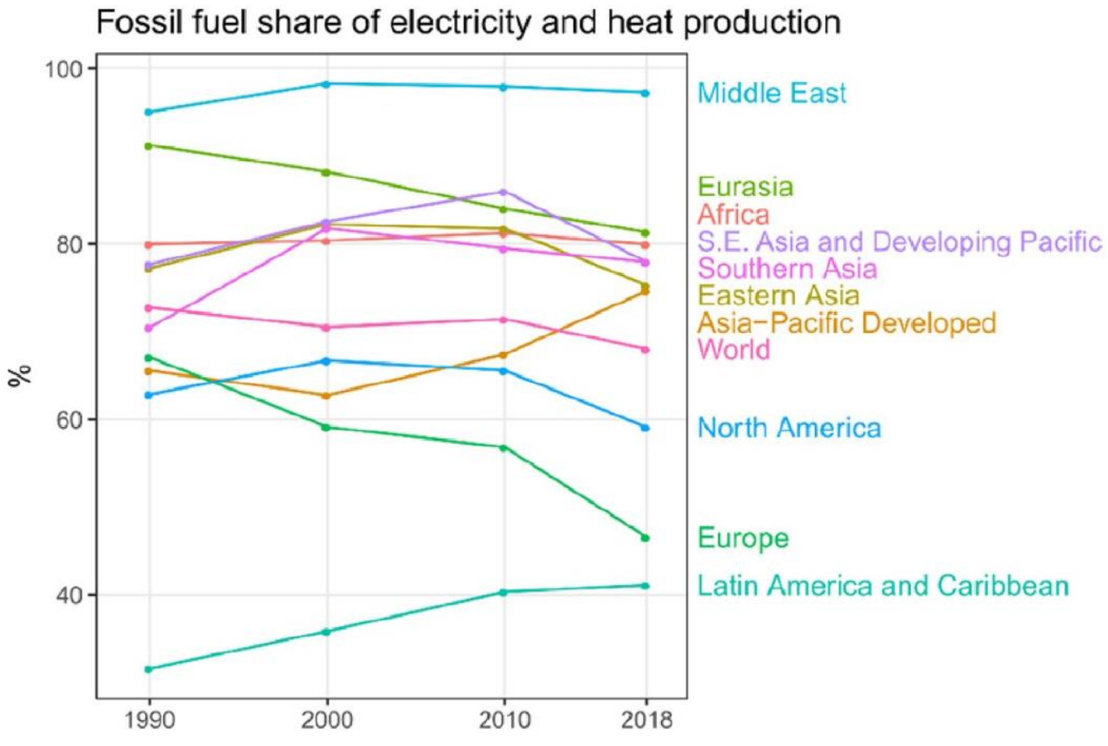
East Asia stands out as the largest contributor to energy systems emissions in 2018, 6.3 GtCO2eq

Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018, Environmental Research Letters 16, 073005

Kaya decomposition of CO2 emissions drivers for the energy systems sector



- At global level, growth in energy sector emissions have closely tracked rising GDP per capita
- Almost all regions have seen steady decreases in energy intensities



Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018, Environmental Research Letters 16, 073005

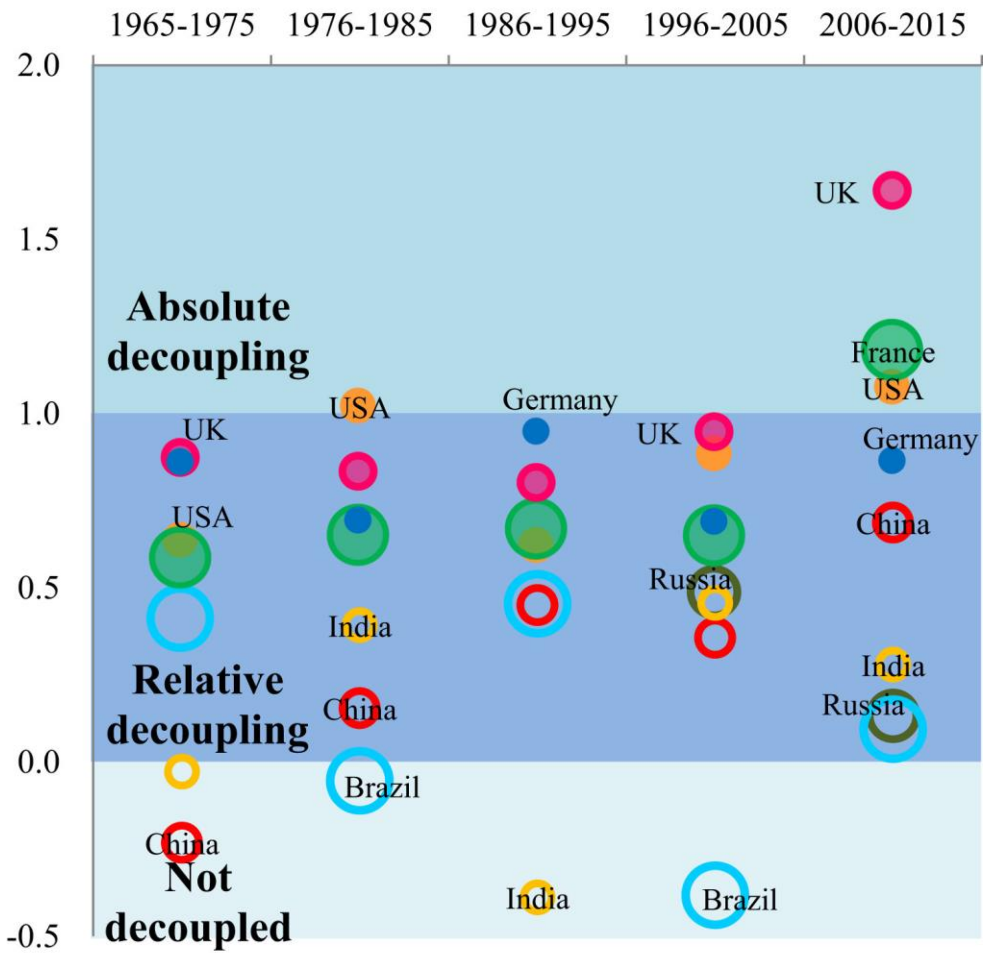
Key observations

- Global energy sector emissions growth has slowed in recent years
- Global share of fossil fuels down from 73% in 1990 to 68% in 2018
- A moderate decarbonisation of energy systems in Europe and North America is driven by fuel switching and the increasing penetration of renewables.
    - Reduction of fossil capacity additions in China
    - A structural shift to gas and renewables in the United States
    - The increasing penetration of renewables in Europe
- By contrast, in rapidly industrialising regions, fossil-based energy systems have continuously expanded, only very recently slowing down in their growth.
- Strong demand for materials, floor area, energy services and travel have driven emissions growth in the industry, buildings and transport sectors, particularly in Eastern Asia, Southern Asia and South-East Asia.

Lamb et al. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018, Environmental Research Letters 16, 073005

Silver-lining in the dark

- Three dozen countries have reduced CO_2 emissions consistently for a decade, by now – *sustaining and increasing rate is key for next decade*
- Several countries are decoupling their CO_2 emission from their GDP growth - *aggressive efforts needed*

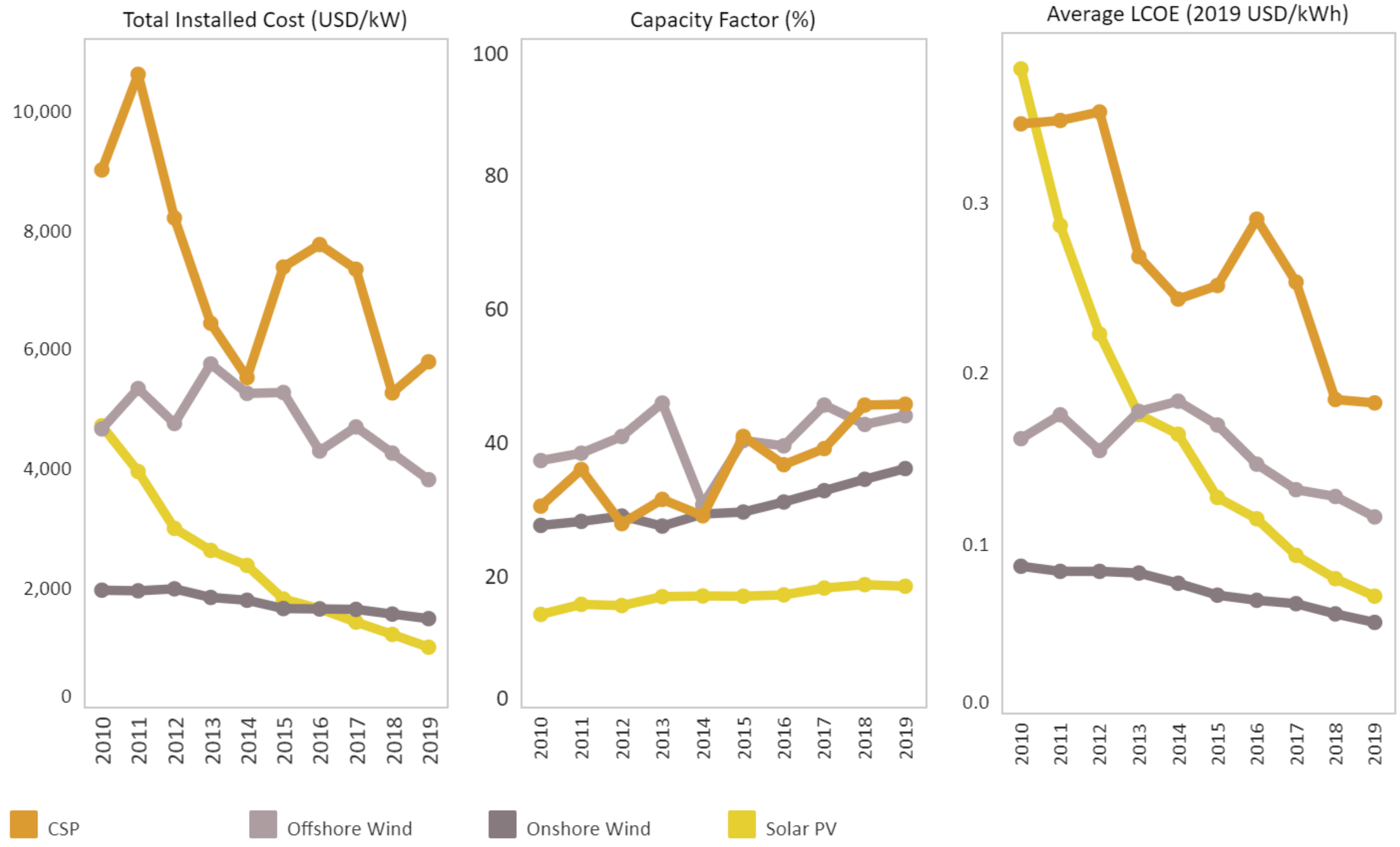


The decoupling state analysis in 1965–2015

Wu et al. (2018) Energy Policy

Absolute decoupling: Emissions reduction in absolute terms
Relative decoupling: emissions growth < GDP growth
No decoupling: Emissions growth is equal or > GDP growth

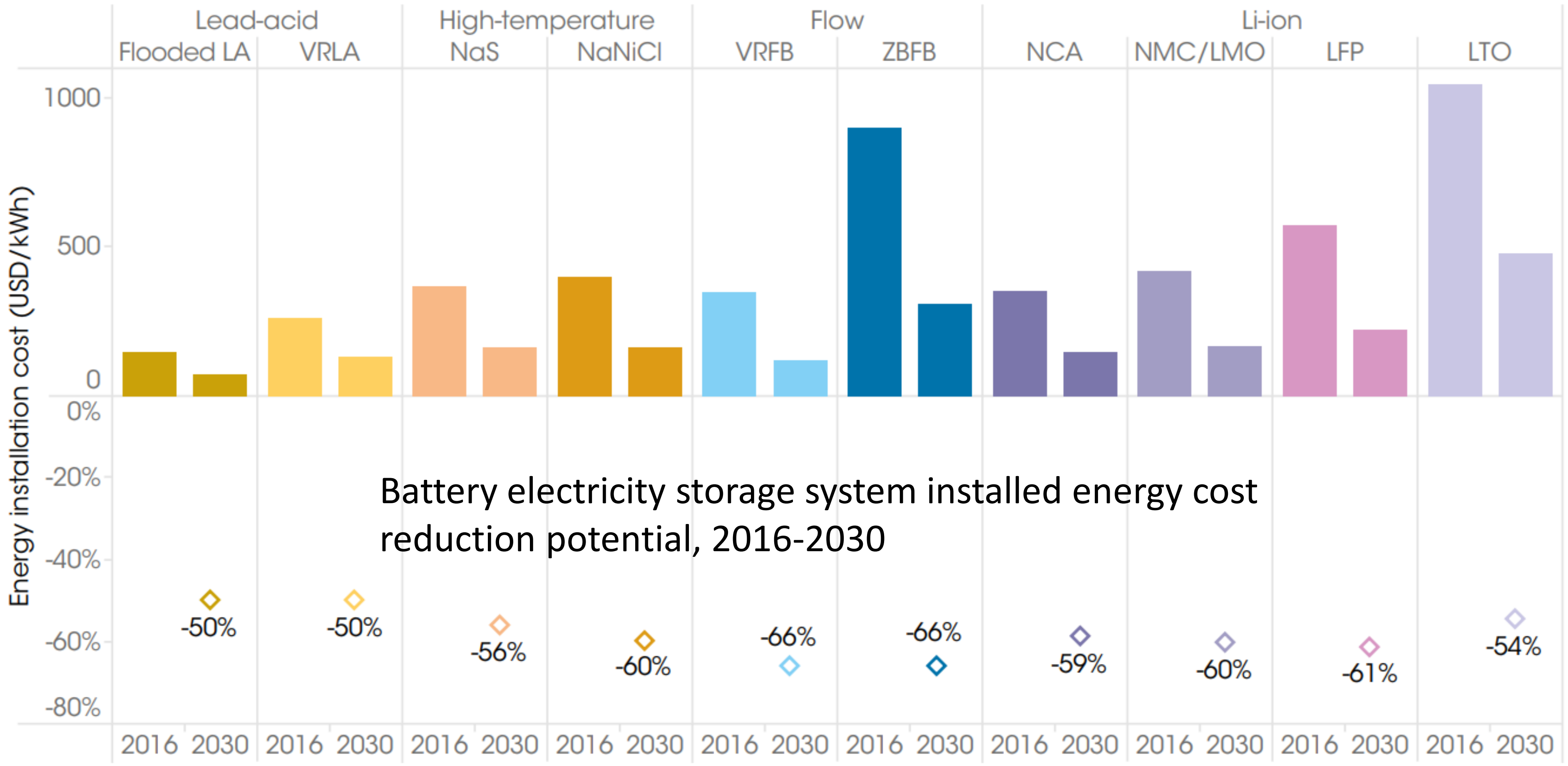
Cost reduction in key RE technologies happening



Note: All LCOE values are calculated based on project level data for total installed costs and capacity factors from the IRENA Renewable Cost Database, with other assumptions necessary for LCOE detailed in the source link below, notably an assumption of a weighted-average cost of capital of 7.5% real in the OECD and China and 10% elsewhere.

Source: IRENA (2020), Renewable Power Generation Costs in 2019, International Renewable Energy Agency, Abu Dhabi
https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019

Battery storage cost is reducing



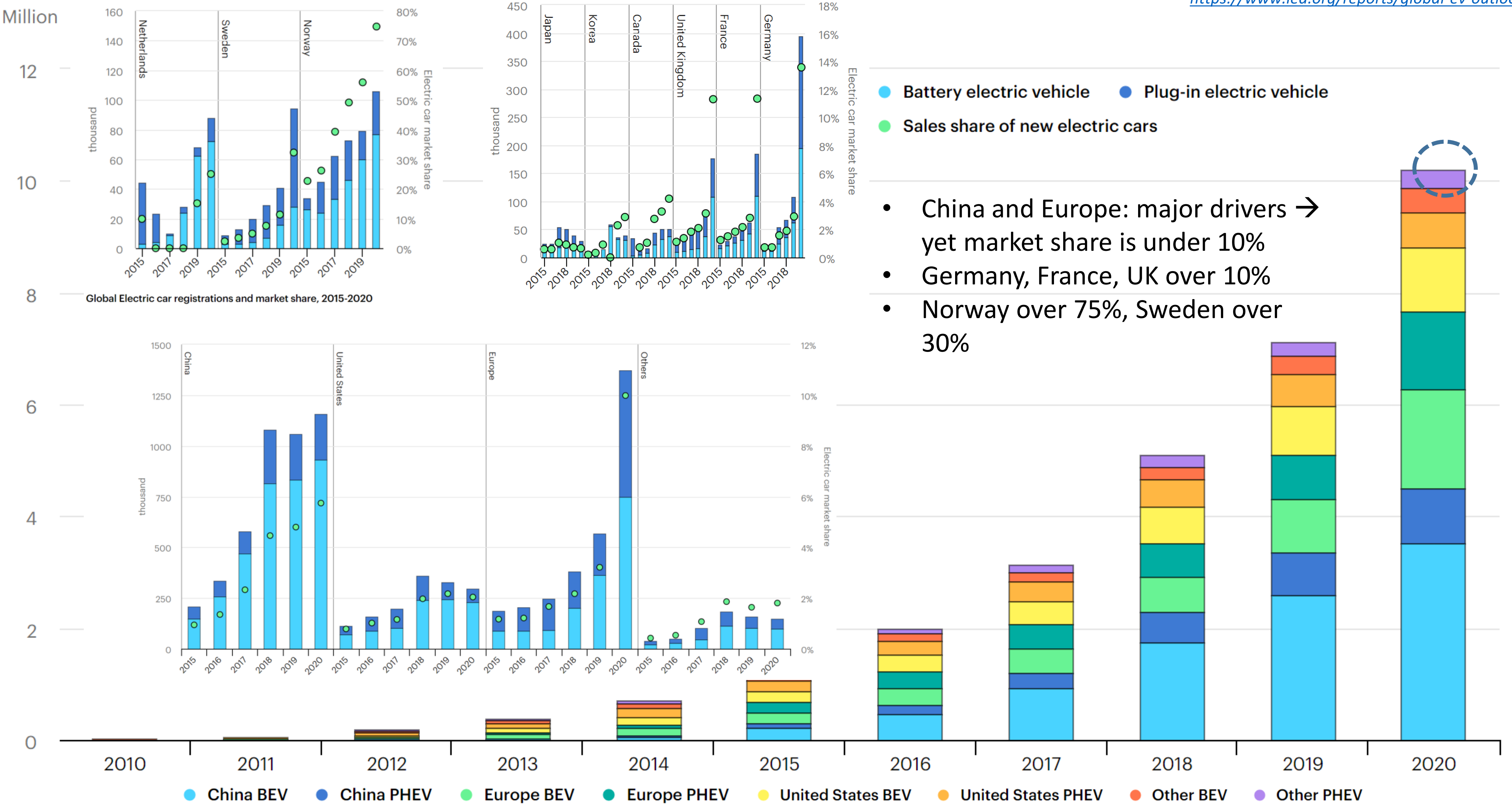
Battery electricity storage system installed energy cost reduction potential, 2016-2030

Note: LA = lead-acid; VRLA = valve-regulated lead-acid; NaS = sodium sulphur; NaNiCl = sodium nickel chloride; VRFB = vanadium redox flow battery; ZBFB = zinc bromine flow battery; NCA = nickel cobalt aluminium; NMC/LMO = nickel manganese cobalt oxide/lithium manganese oxide; LFP = lithium iron phosphate; LTO = lithium titanate.

IRENA (2017)
ELECTRICITY STORAGE AND RENEWABLES: COSTS AND MARKETS TO 2030

EVs are capturing more automobile segment as more RE is into the grids

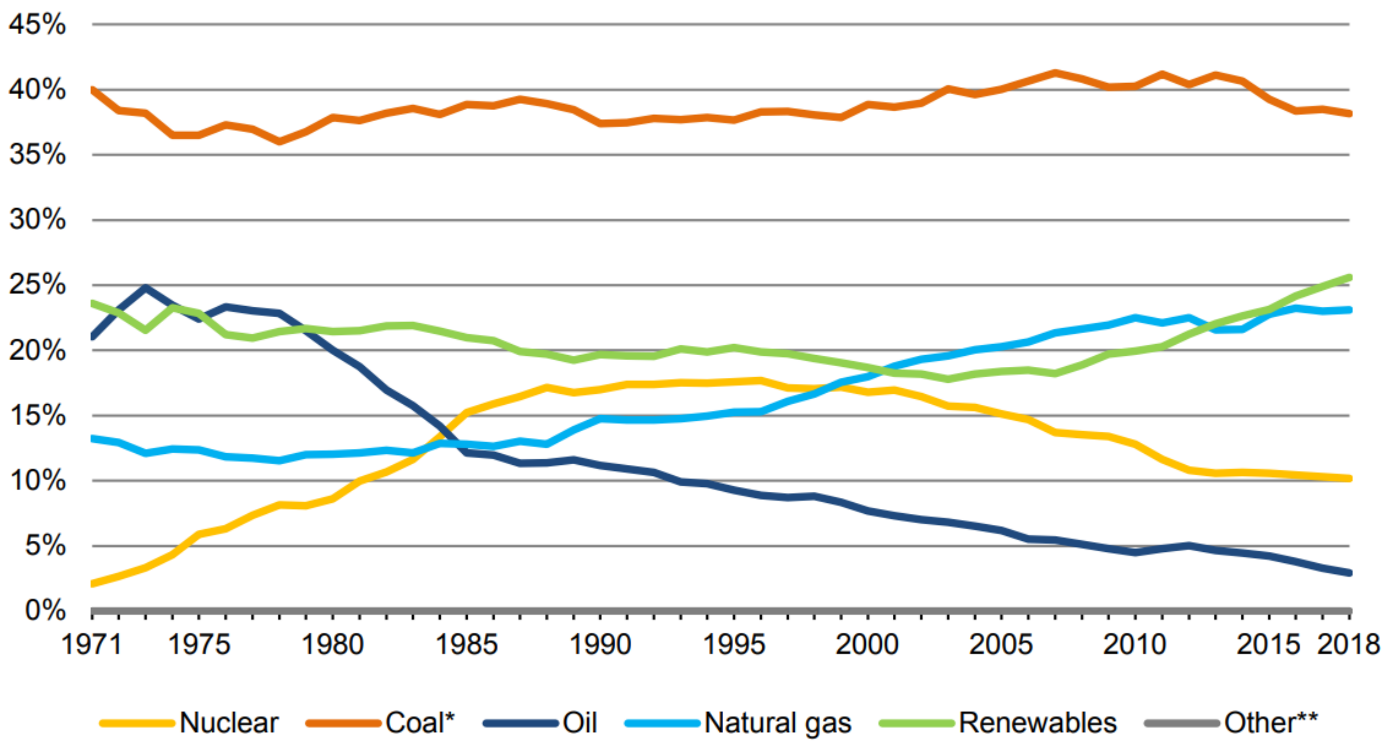
Global EV Outlook 2021, IEA
https://www.iea.org/reports/global-ev-outlook-2021



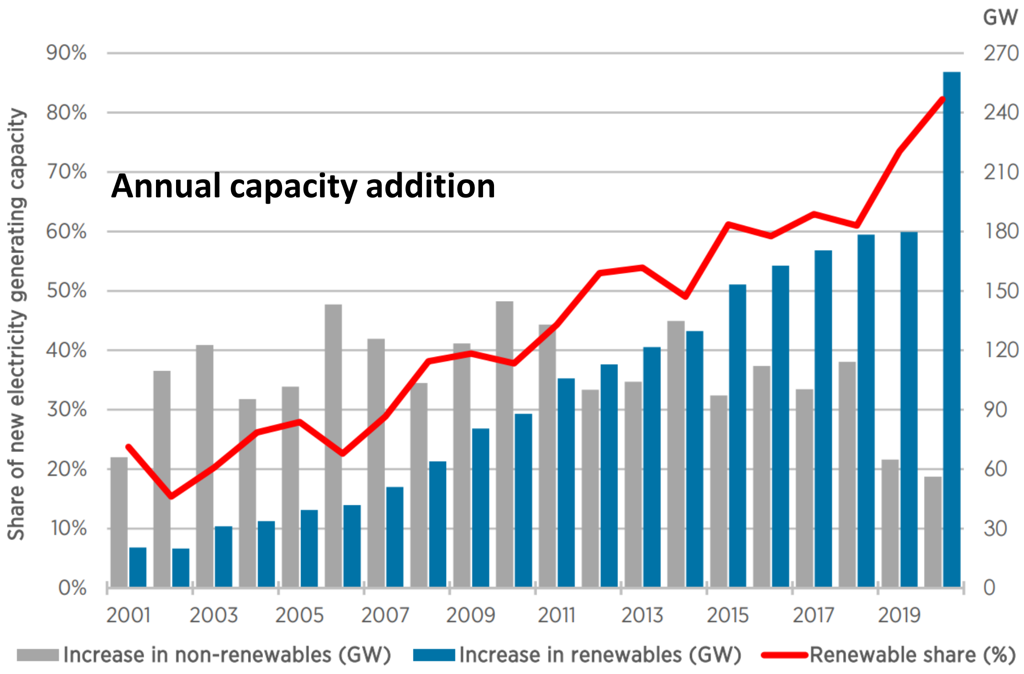
- China and Europe: major drivers → yet market share is under 10%
- Germany, France, UK over 10%
- Norway over 75%, Sweden over 30%

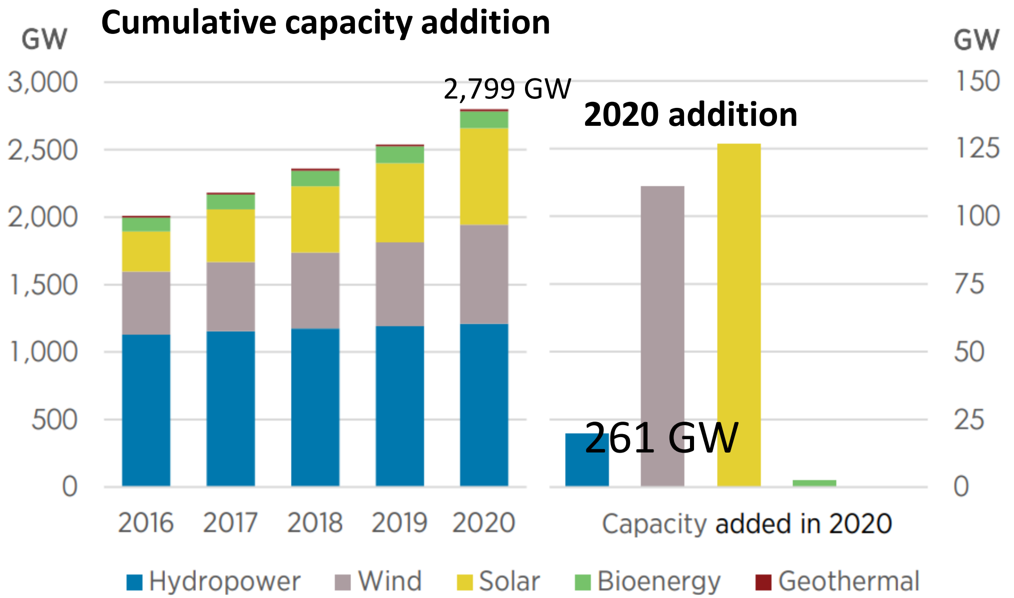
Greater RE is electricity - renewables contribute 82% of net **capacity** expansion in 2020

RE has 26% electricity generation mix globally (2018)



RE has 33.2% capacity mix in 2018; 36.6% in 2020





Renewable capacity highlights IRENA (2021)

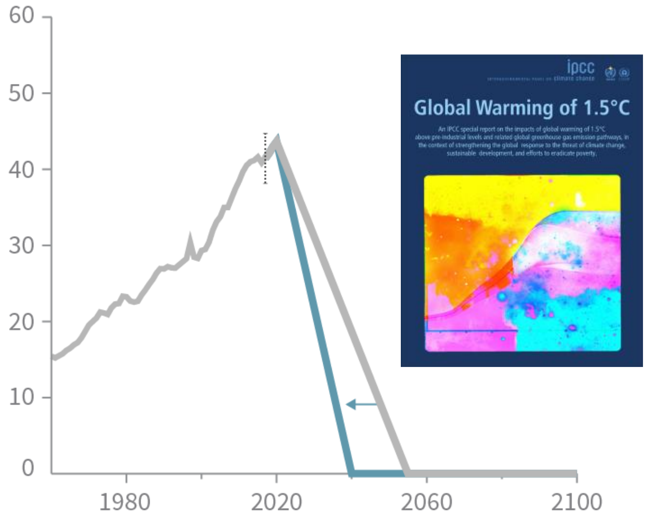
IEA World Energy Balances, 2020
IRENA Renewable capacity statistics 2021

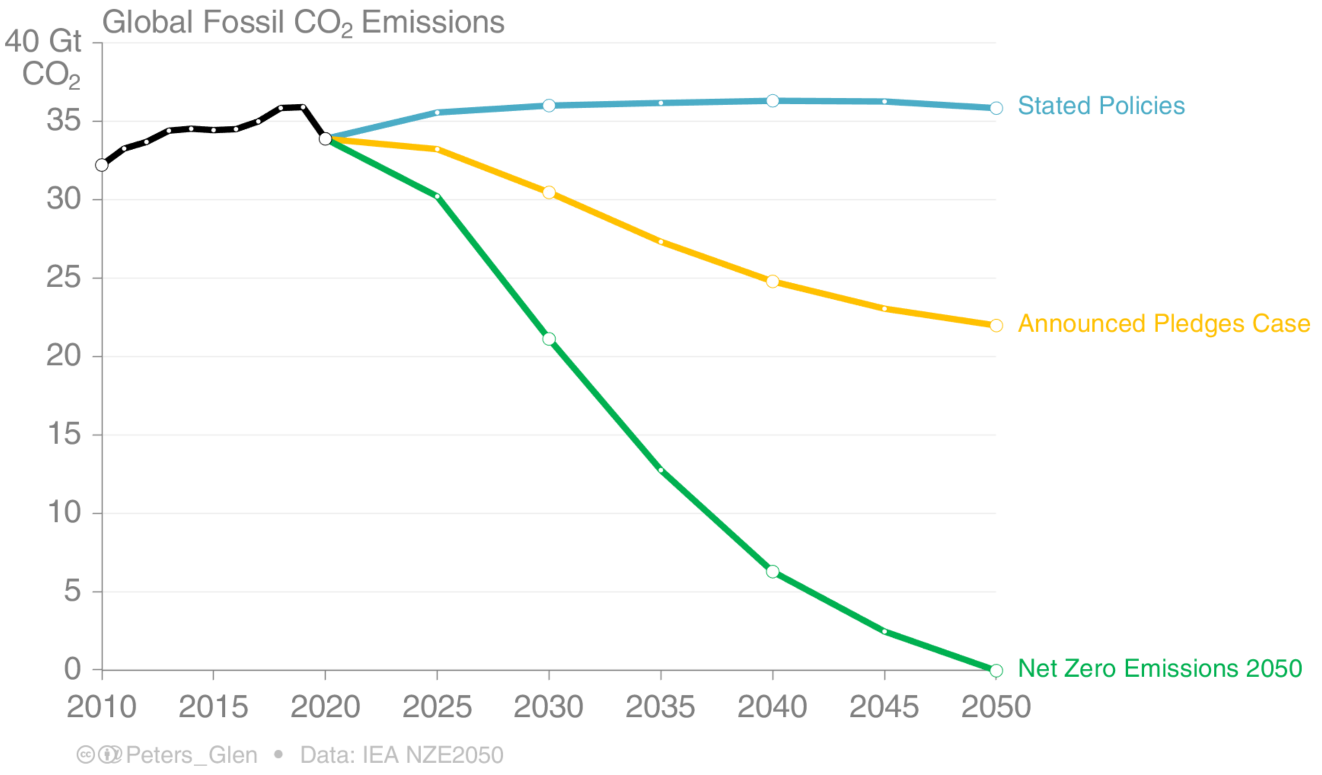
Are we acting enough for 1.5ºC pathways?

(IEA-NZE2050 Report, 2021 May)

Paris Agreement – for 1.5°C CO_2 emissions must fall by about 45% by 2030 (from 2010 levels) or "net zero' by 2050

b) Stylized net global CO_2 emission pathways
Billion tonnes CO_2 per year ($GtCO_2/yr$)





- The number of countries that have pledged to achieve net-zero emissions has grown rapidly over the last year & now covers around 70% of global emissions.
- However, most pledges are not yet underpinned by near-term policies & measures.

Based on: https://www.iea.org/reports/net-zero-by-2050

The 2050 pathways of achieving 1.5ºC target by 2100 varies

- Many technical options available in the roadmap
- Pathway is narrow but can be achieved
- Hinges on scaling up of clean technologies, clean energy, more electricity, fully renewable electricity, EVs, economic restructuring, technologies under development (innovation)

Key leader raise hands together after adoption of a historic global warming pact at the COP21 Climate Conference in Le Bourget, north of Paris, on Dec. 12, 2015. Anadolu Agency—Getty Images

Guardian Opinion cartoon, Ben Jennings on the Paris climate talks, Friday 11 December 2015

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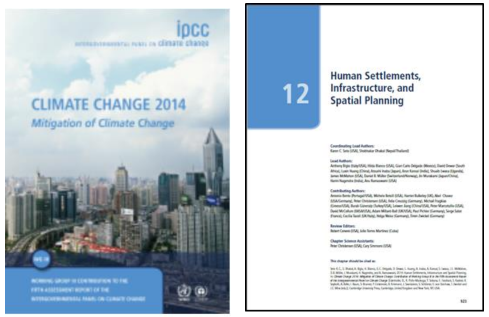
- Key challenges to overcome

Why urban energy system matters then?

- More than 50% of the global population; ~80% of global GDP; cities are global economic engine
- Two-thirds of global energy consumption and more than 70% of annual global carbon emissions (Seto et al, 2014) → Asian cities play a key part (IEA, 2008, 2016)
- By 2050 about 70% of the world's population live in cities
  - → massive growth in demand for direct urban energy - especially in the developing world where per capita energy tends to increase with urbanization
  - → massive growth in physical infrastructure → indirect/embodied energy use
- Cities are key to net-zero emission future → decarbonisation of cities is a global priority → they have special significance to achieving national commitments



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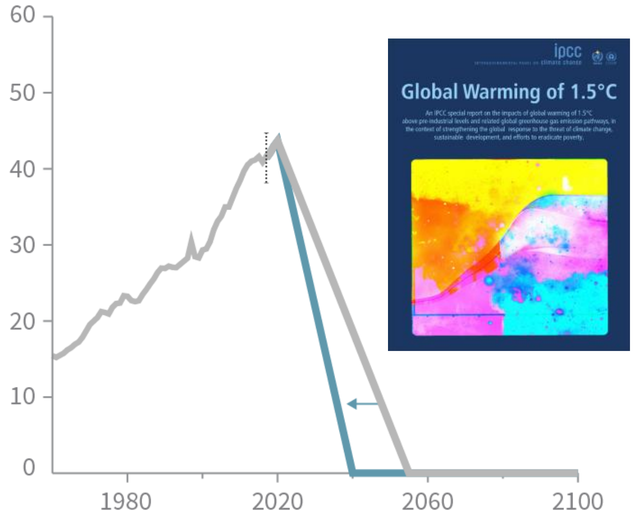
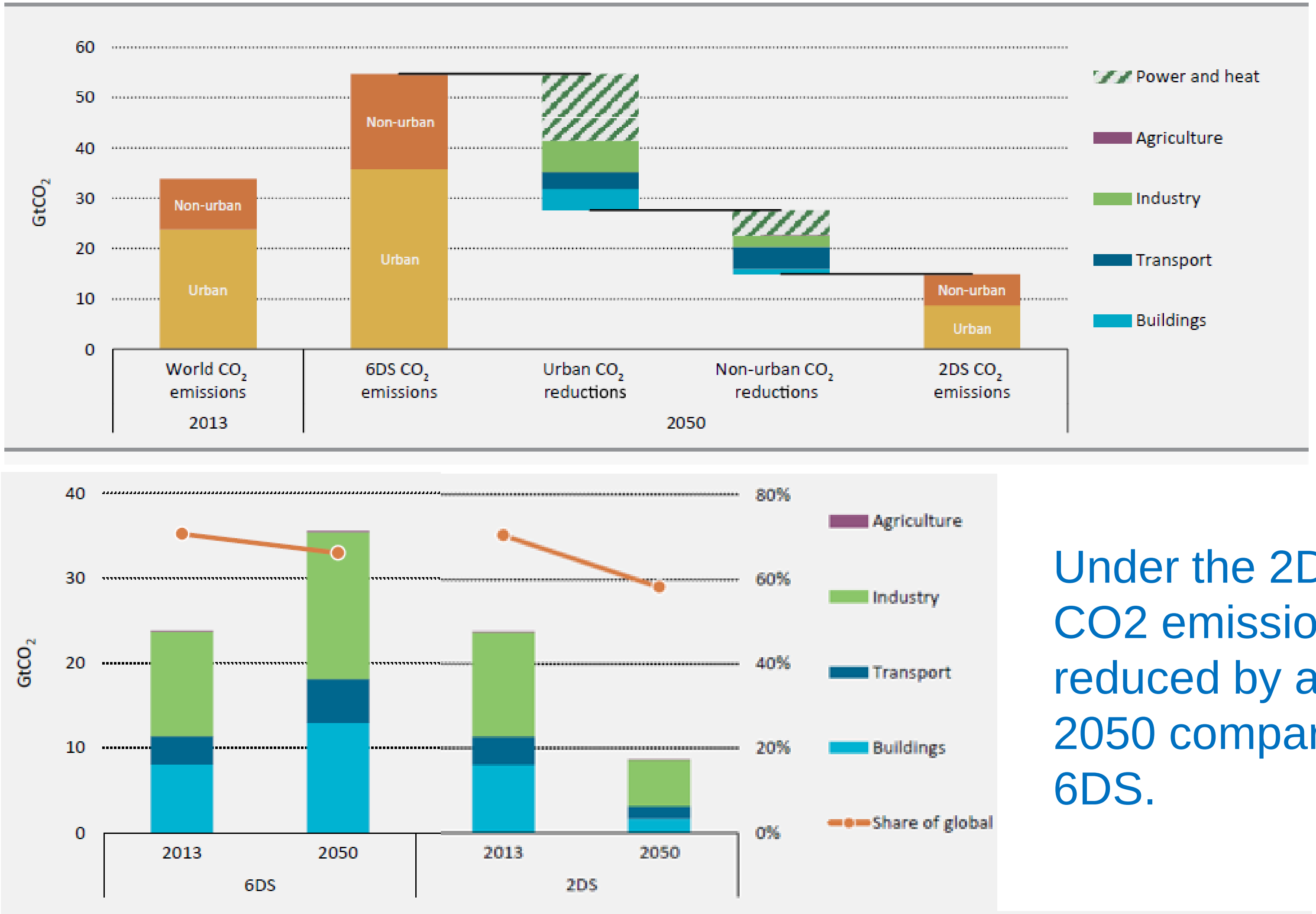
Billion tonnes CO_2 per year ($GtCO_2$/yr)



Urban CO2 emissions and 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 abatement potentials are high

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 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		

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

Urban actions could help deepen the global ambition of current national pledges

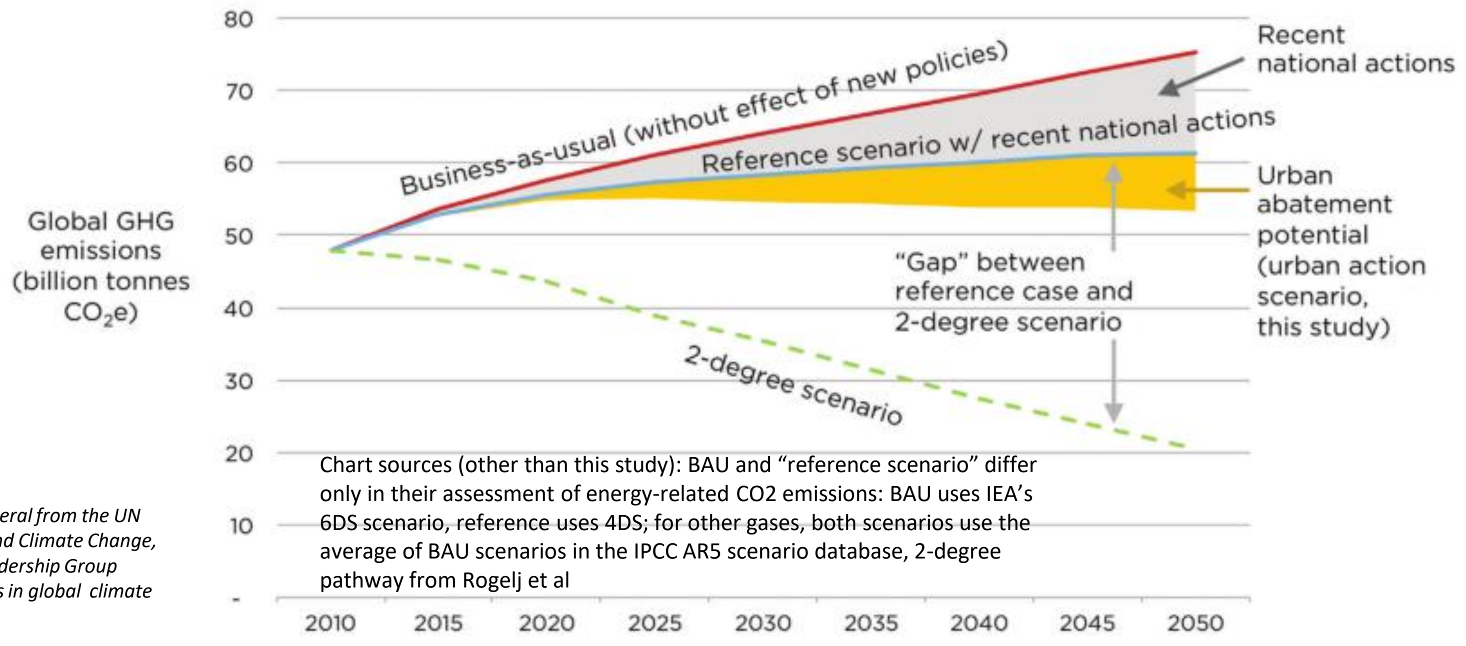
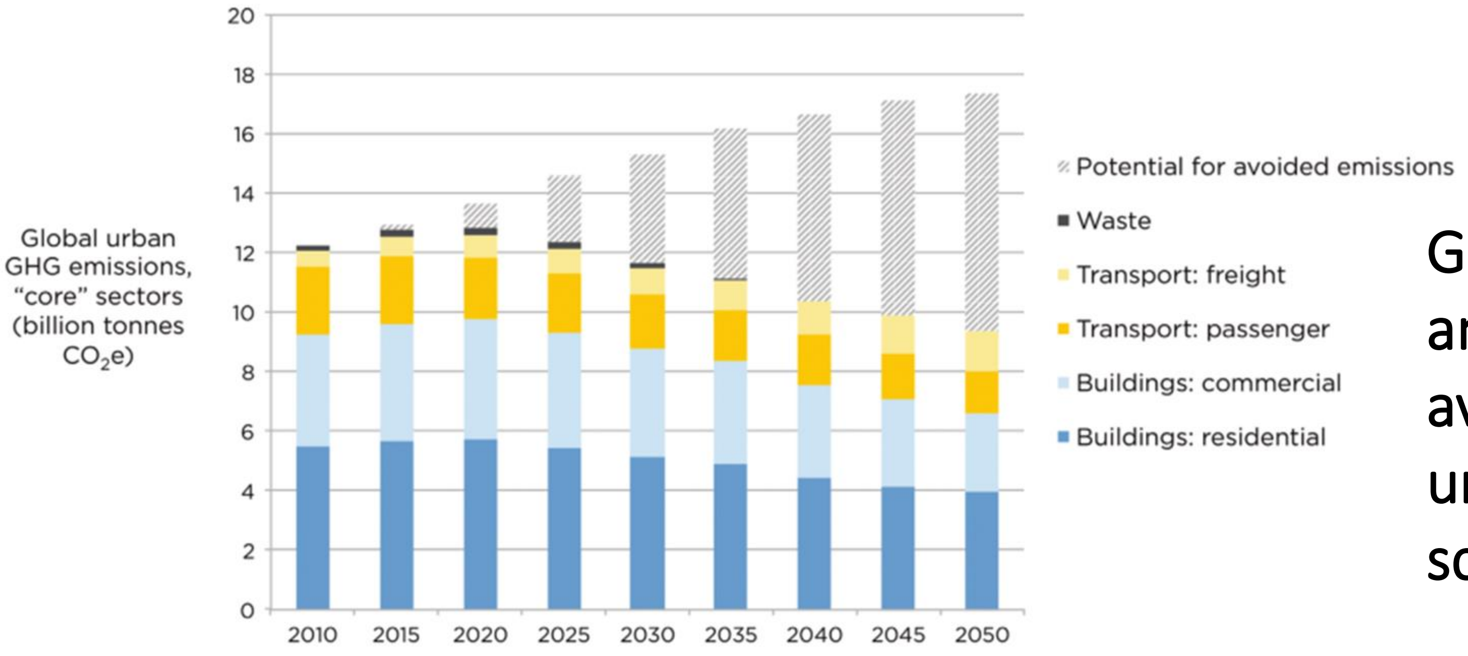


Chart sources (other than this study): BAU and "reference scenario" differ only in their assessment of energy-related CO2 emissions: BAU uses IEA's 6DS scenario, reference uses 4DS; for other gases, both scenarios use the average of BAU scenarios in the IPCC AR5 scenario database, 2-degree pathway from Rogelj et al

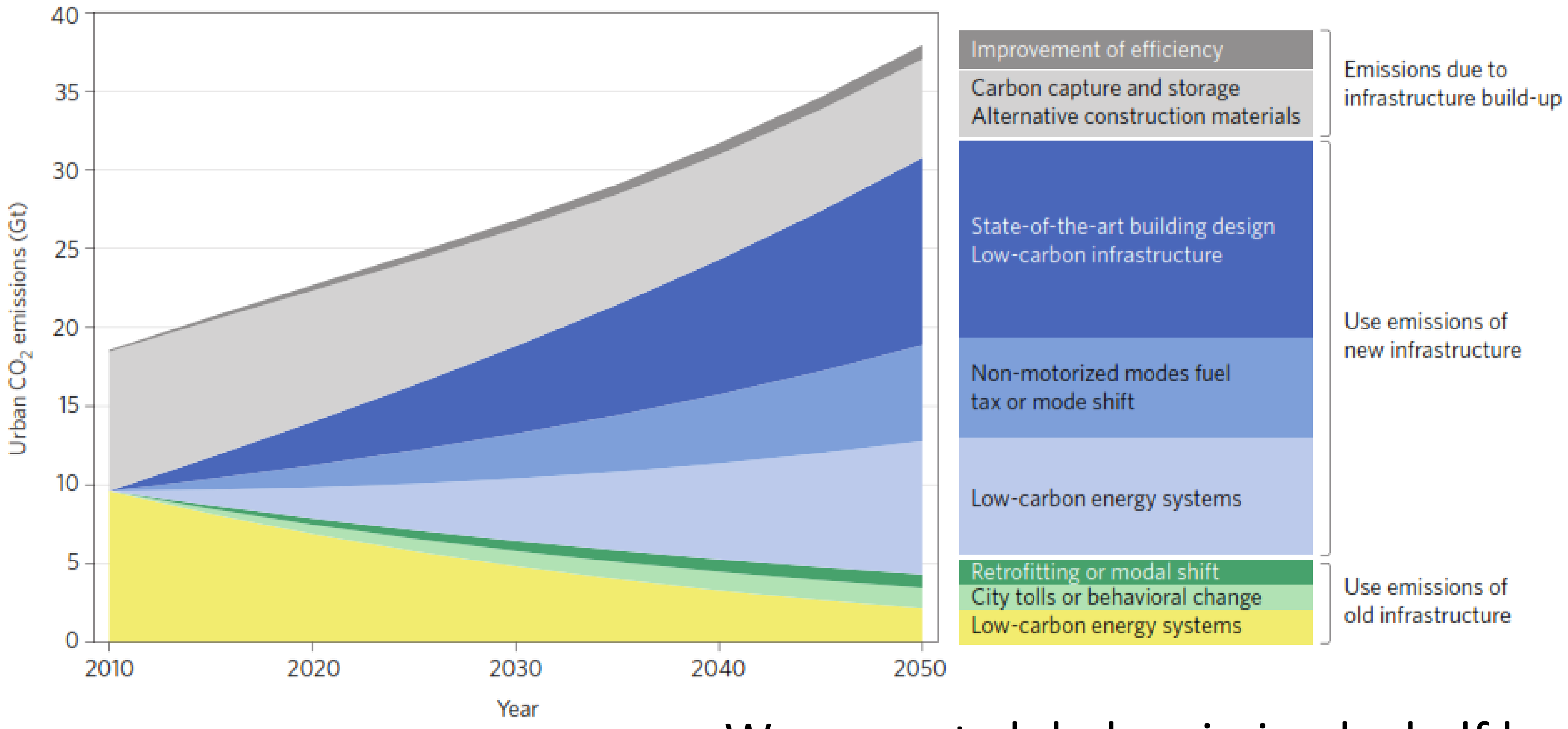
C40 (2015)- A report to the UN Secretary-General from the UN Secretary General's Special Envoy for Cities and Climate Change, in partnership with the C40 Cities Climate Leadership Group Advancing climate ambition: cities as partners in global climate action



GHG emissions and emissions avoided in the urban action scenario

Urban 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



NATURE CLIMATE CHANGE | VOL 6 | DECEMBER 2016 |

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

How cities can influence local energy systems

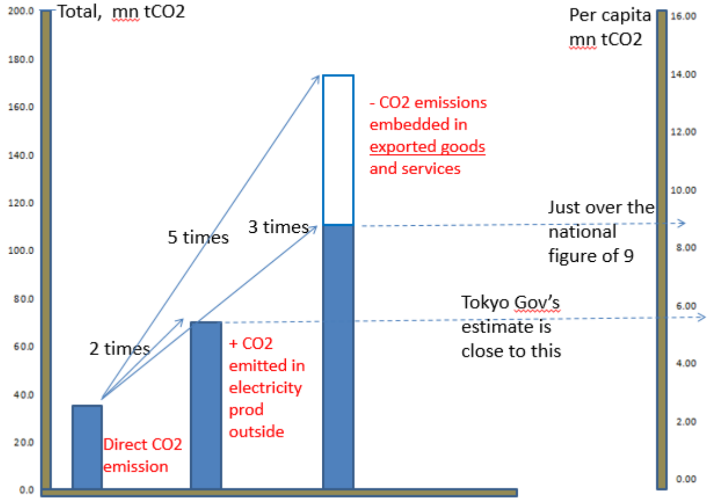
IEA (2021). Empowering Cities for a Net Zero Future: Unlocking resilient, smart, sustainable urban energy systems, IEA, July 2021

Why urban energy system matters then?

- Beyond traditional thinking
  - The urban as open system - the question of cross boundary energy and other infrastructure
  - The question of indirect implications

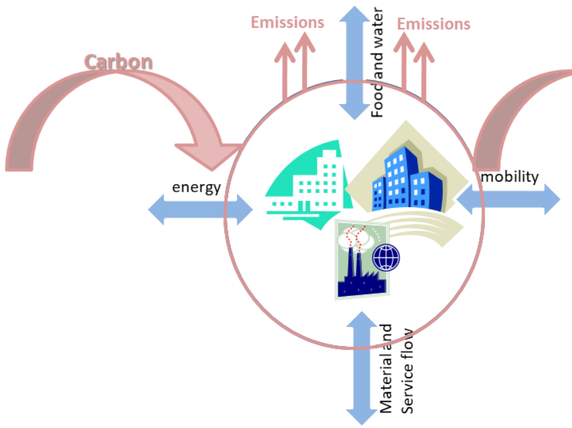
Tokyo for illustration

Tokyo direct + indirect CO2 emissions
Using Economic I-O analyses



Why consider out-of-boundary items?

- **Logic**: Electricity produced "outside" is already being counted; boundary is blurred
- **More holistic**: Per capita city-scale emissions from in boundary activities typically less than national per capita in developed countries
- **City comparison makes a better sense:** Can we otherwise compare Shanghai with London? Not to penalize industrial cities in low carbon debate !!!!
- **Avoid Perverse Incentives**: Avoid crediting emission shifts to the "outside": e.g., hydrogen fueled transport
- **Create win-win policies**: Incentivize cross-boundary, cross-sector policies: e.g., sustainable food diets, green concrete, ICT strategies (e.g., teleconferencing)
- **Communicate consistently with public**: Consistently include major human activities at all scales from personal-scale to city-scale to national-scale



- The catchment of urban activities goes beyond the administration or agglomeration boundary
- The indirect/embodied carbon emissions flows overwhelm total carbon emissons (direct + indirect carbon)

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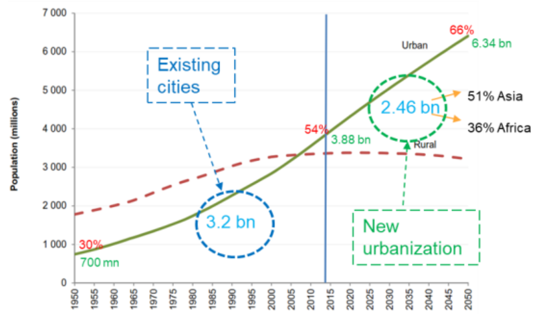
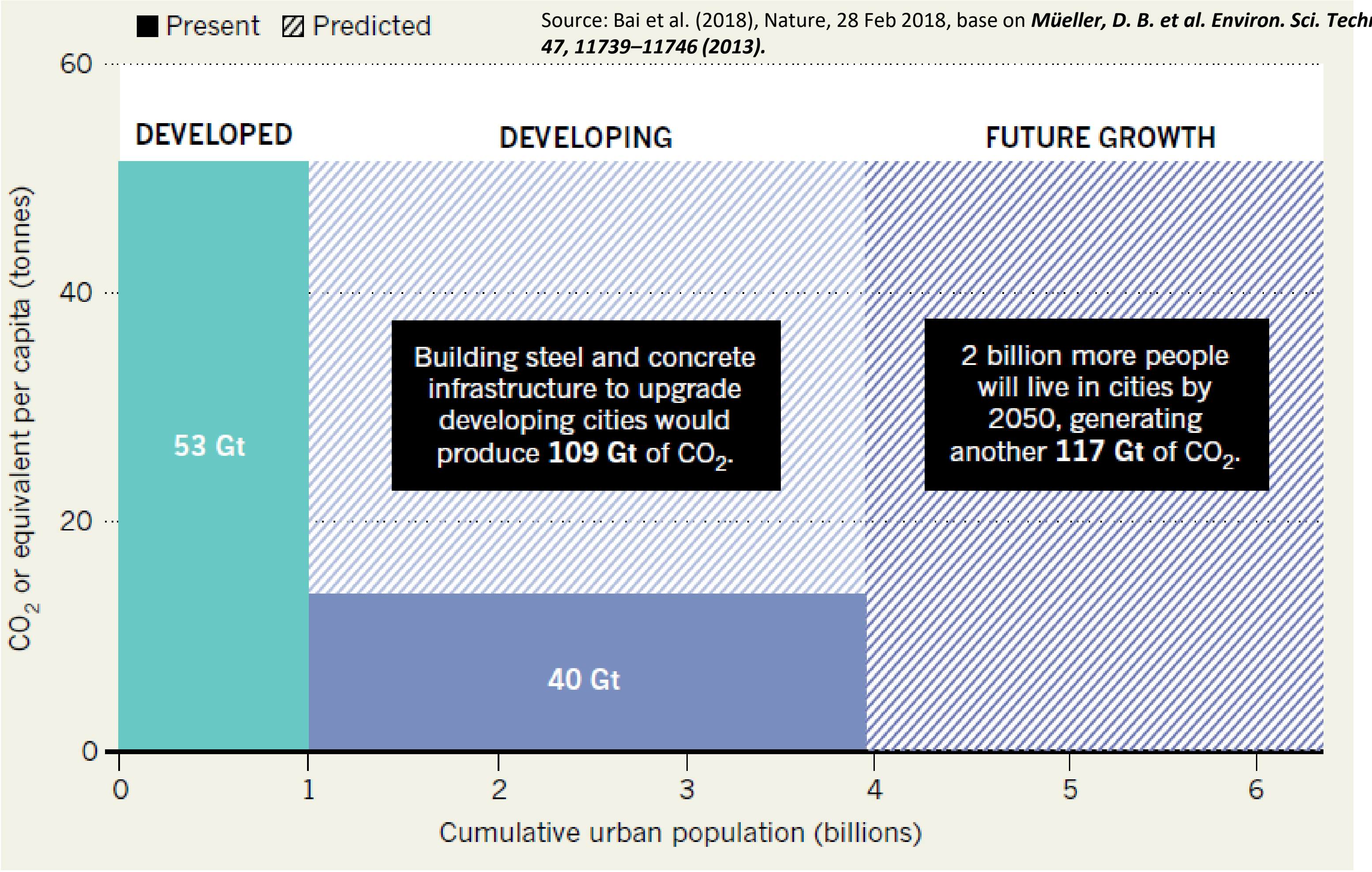
Key opportunities for transformative change



Avoiding 'lock-in' in rapidly urbanizing regions

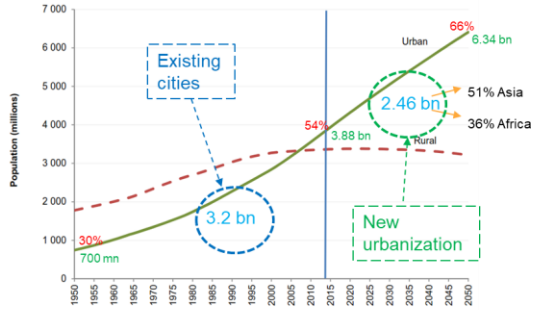
- Urban design and spatial planning
- Infrastructure
- Population density, mixed land-use, accessibility, and connectivity
- Large window of opportunity for next two decades



Source: Bai et al. (2018), Nature, 28 Feb 2018, base on ***Müeller, D. B. et al. Environ. Sci. Technol. 47, 11739–11746 (2013).***

Key opportunities for transformative change

Re-engineering the existing built cities



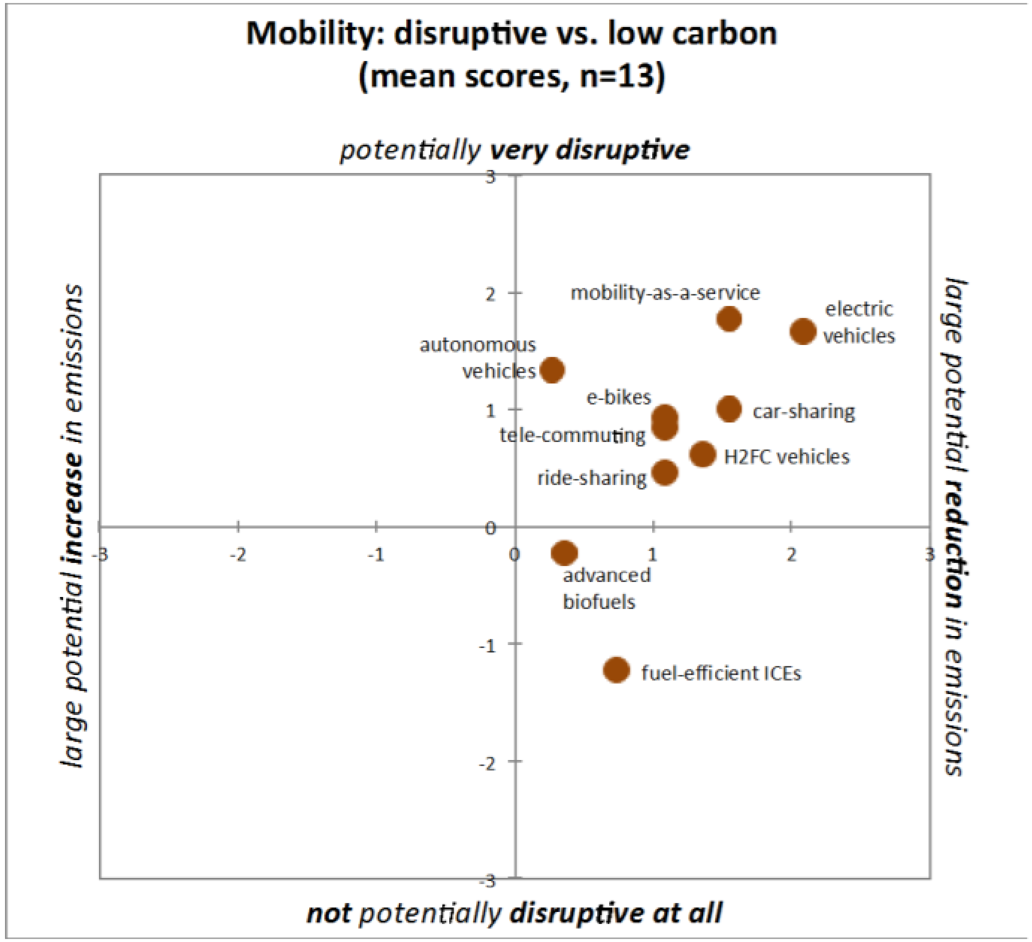
- Accelerated ‘green’ infrastructure replacement
- System efficiency, best practices, and new technologies
- Benefitting from Cost reduction in key RE technologies → greater RE in electricity → Reducing battery storage cost → Distributed energy and prosumer → EVs with more RE is into the grids
- Re-orienting public choices and consumption through sound incentives, policies and governance

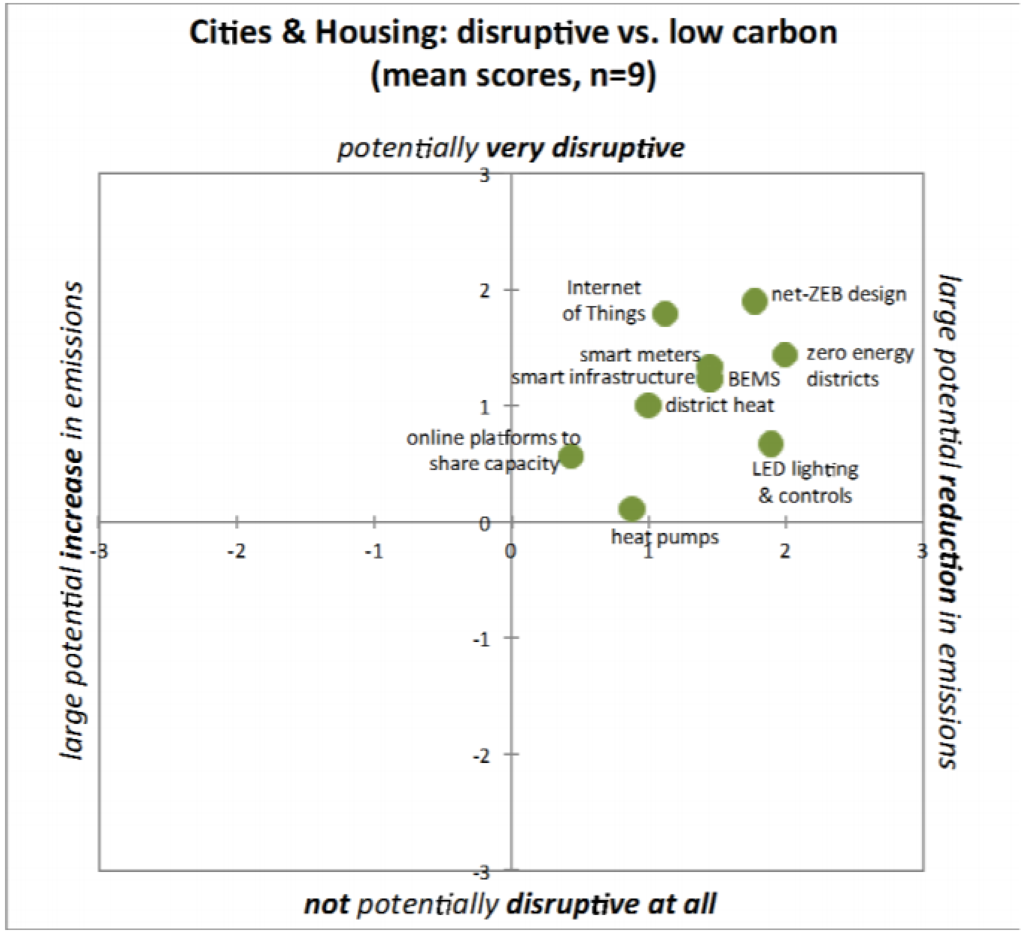
- Oslo’s pro-active attitude
- Tokyo’s efficiency

- ➢ Developing an effective Climate Action Plans in cities is urgent
  - ➢ Now, too focused on energy efficiency and end-of-pipe solutions only; aggregate impact of actions on urban emissions unclear

Key opportunities for transformative change

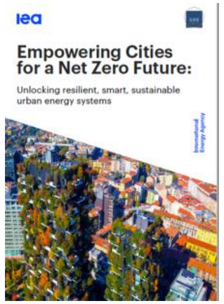
Disruptive innovations, technologies, and behaviour





Wilson, C. (2017). *Disruptive Low Carbon Innovation Workshops: Synthesis Report.* Tyndall Centre for Climate Change & Future Earth. Norwich, UK. April 2017. Tyndall Working Paper 164.

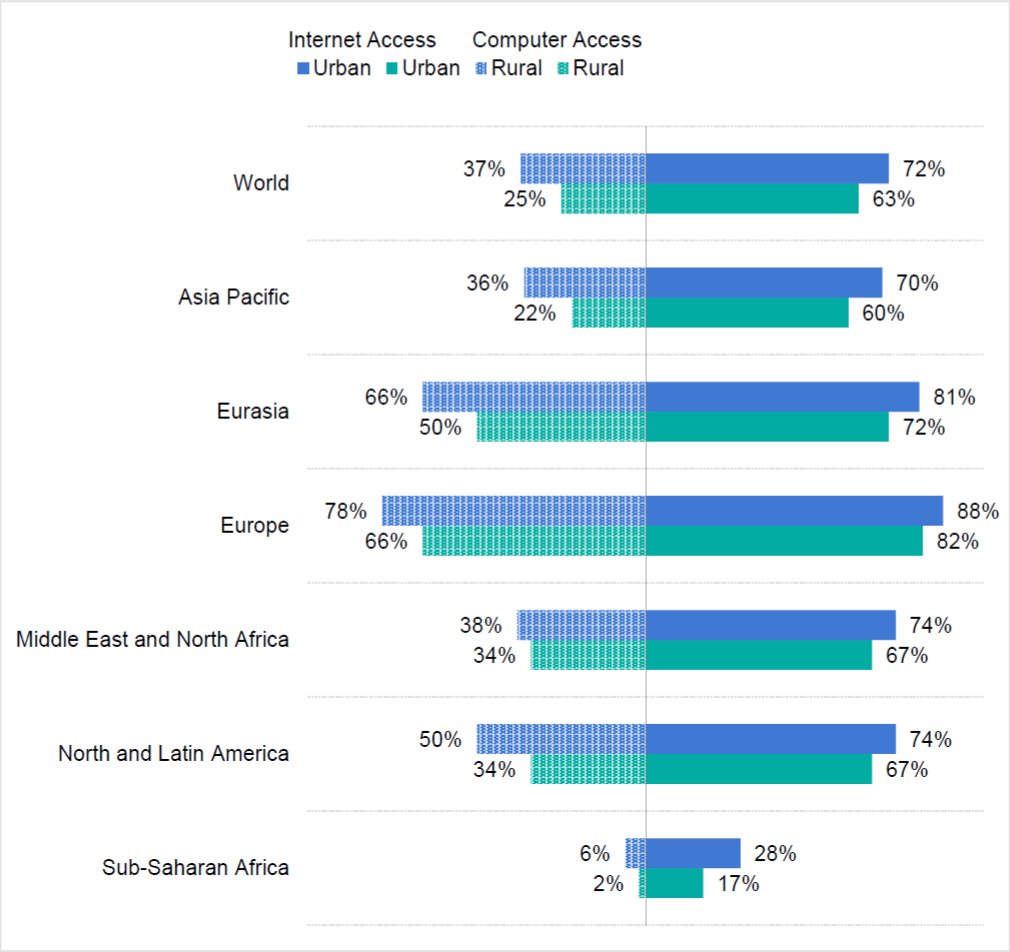
Key opportunities for transformative change



Digitalization as drivers for change

- Digitalization is driving sustainable energy transitions in cities

- Digitalization and smart controls can reduce emissions from buildings by 350 Mt CO_2 by 2050



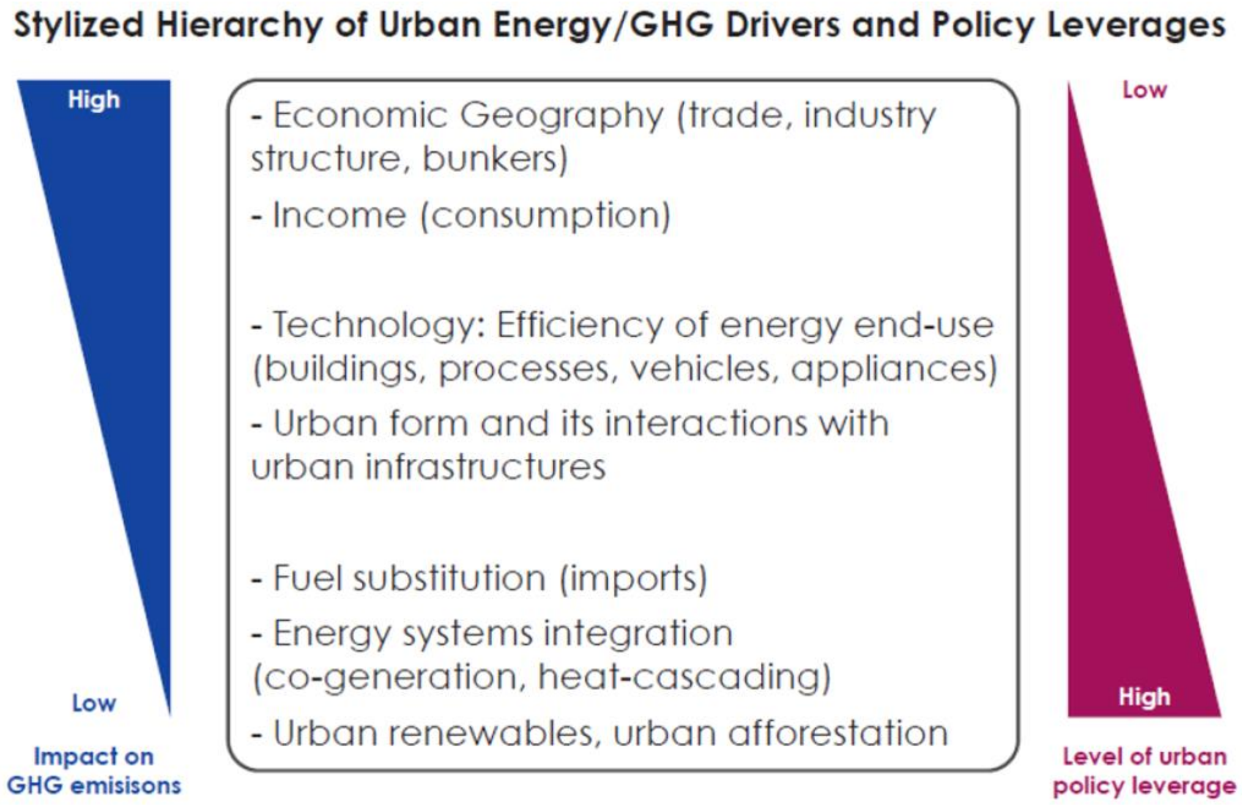
Source: Adapted from ITU World Telecommunication/ICT Indicators Database.
Note: Economic classifications of world regions might differ between the ITU (https://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx) and the IEA (https://www.iea.org/countries).

IEA (2021). Empowering Cities for a Net Zero Future: Unlocking resilient, smart, sustainable urban energy systems, IEA, July 2021

Key opportunities for transformative change

Bridging mitigation potential’s policy and governance paradox

Largest mitigation come from <u>systemic change</u>



But systemic change requires overcoming policy fragmentation and dispersed, uncoordinated decision making

Source: Global Energy Assessment, KM 18
Seto, Dhakal et al. (2014), IPCC AR5

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Many challenges to overcome

- ❑ Need to go beyond Incremental change → to transformative change
- ❑ System thinking looking urban as a holistic unit - instead of sectoral thinking
- ❑ Deploying far-reaching market-based solutions coupled with planning, such as pricing mechanism
- ❑ Overcoming the governance paradox and policy fragmentations
- ❑ Addressing energy and emission implications of cities to ‘outside’ its physical boundaries
- ❑ Smoothening the entry points: Demonstrating the best practice technologies and local co-benefits of urban-scale mitigation actions

Thank you

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