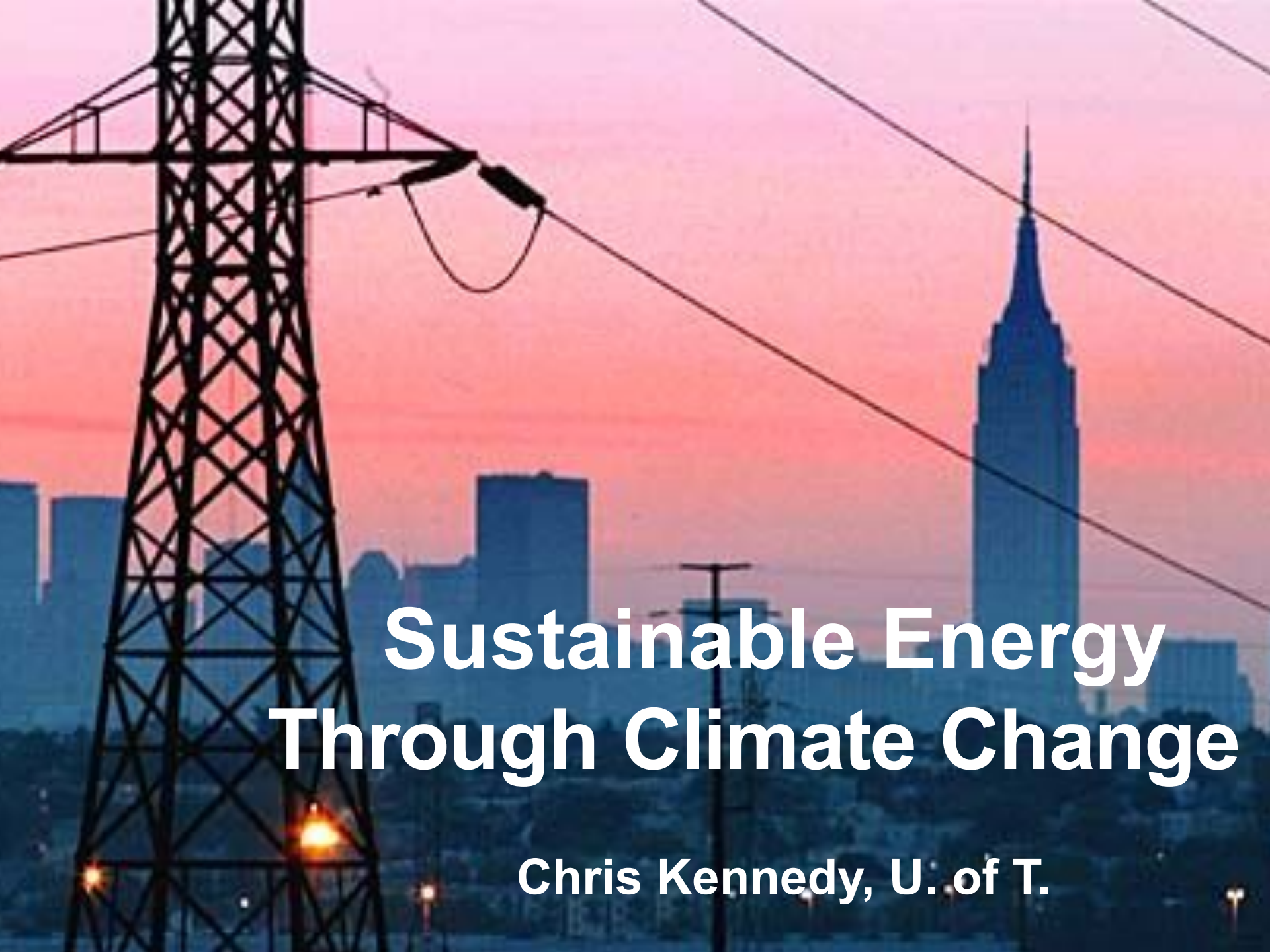


Sustainable Energy Through Climate Change

Chris Kennedy, U. of T.

Contents

Electrification (with decarbonization) as a key climate change mitigation strategy.

Can “electric” cities, provinces etc. be resilient to climate change?

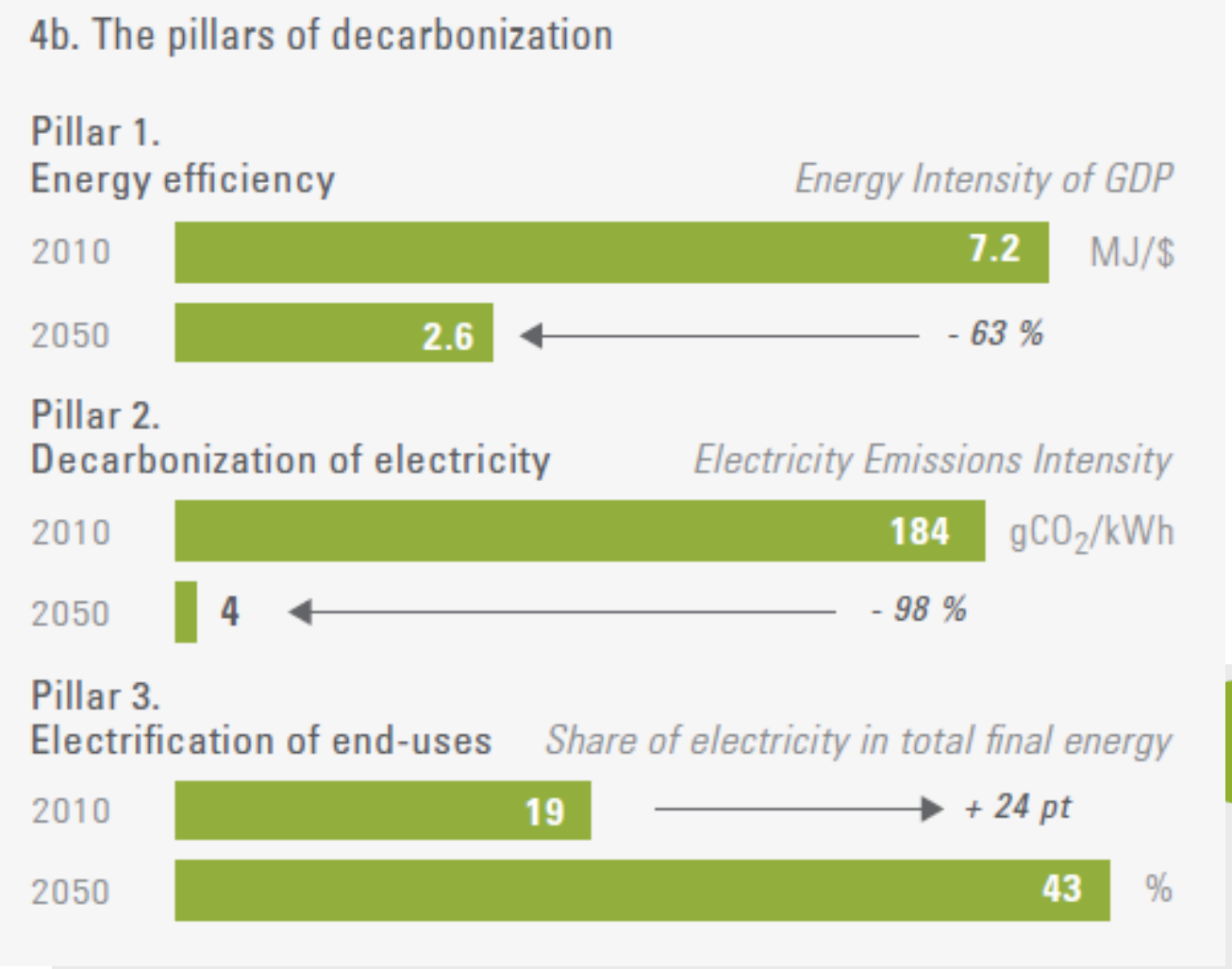
Importance of Electricity

Electricity generation causes ~30% of GHG emissions in Annex 1 countries.

Global electricity use will continue to rise, as it is strongly linked to economic growth

Electrification seems to be central to many (all?) envisaged plans for deep decarbonisation.

Low to medium income countries have less strong grounds for increasing carbon intensity of electricity.



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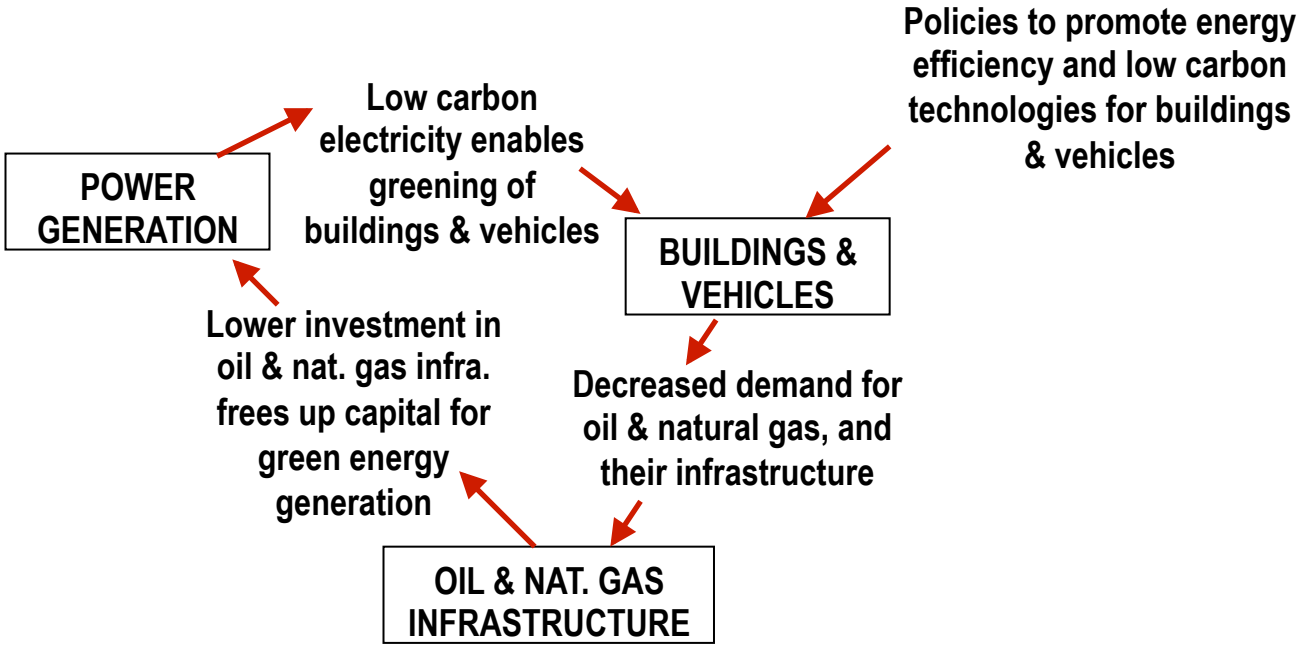
Canada Chapter

pathways to

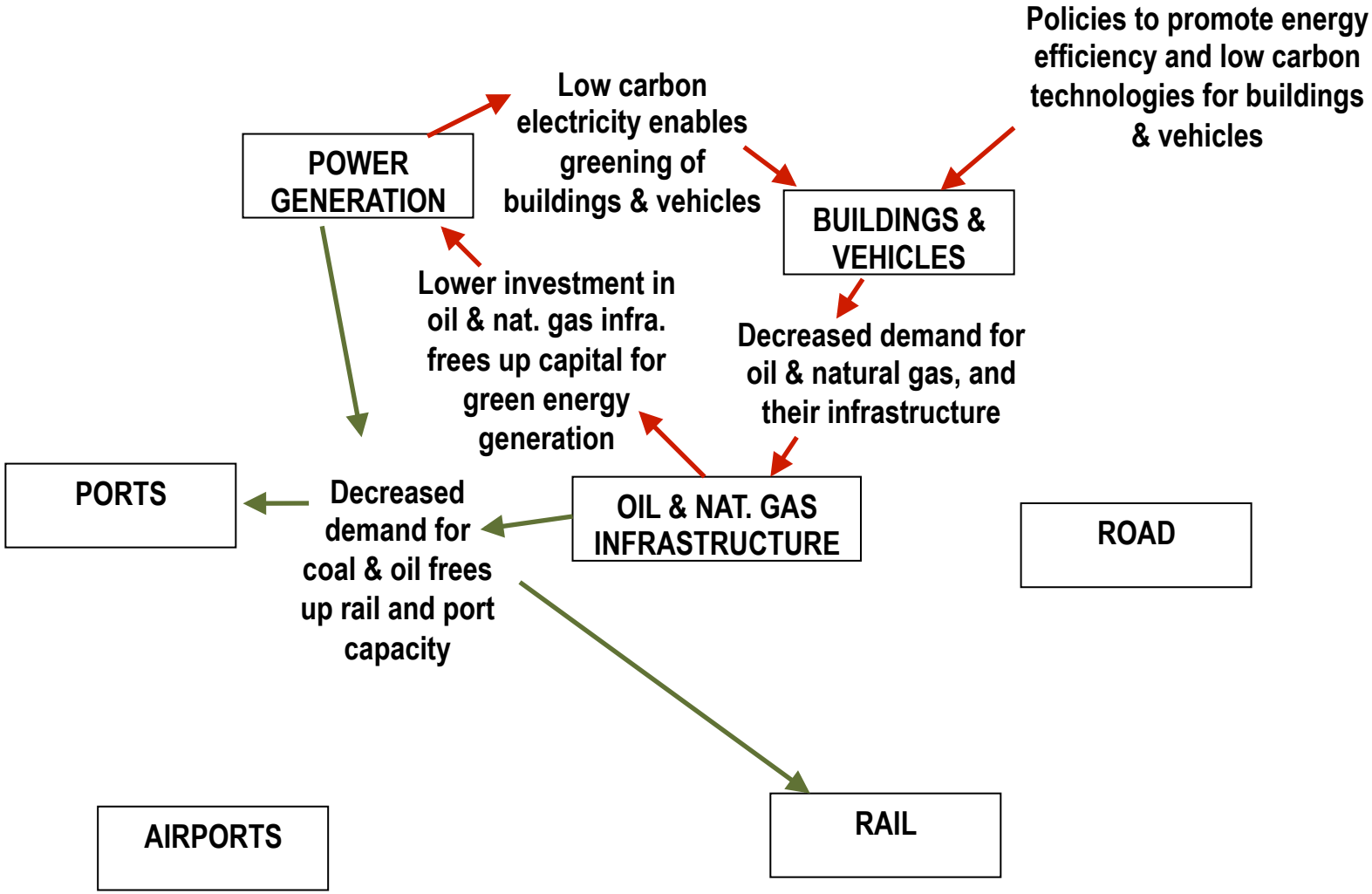
deep decarbonization

Infrastructure relationships in virtuous circles of low carbon growth



Source: Kennedy C. and J. Corfee-Morlot, 2012. Mobilising investment in low-carbon, climate resilient infrastructure, OECD.

Infrastructure relationships in virtuous circles of low carbon growth



Source: Kennedy C. and J. Corfee Morlot, 2012. Mobilising investment in low-carbon, climate resilient infrastructure, OECD.

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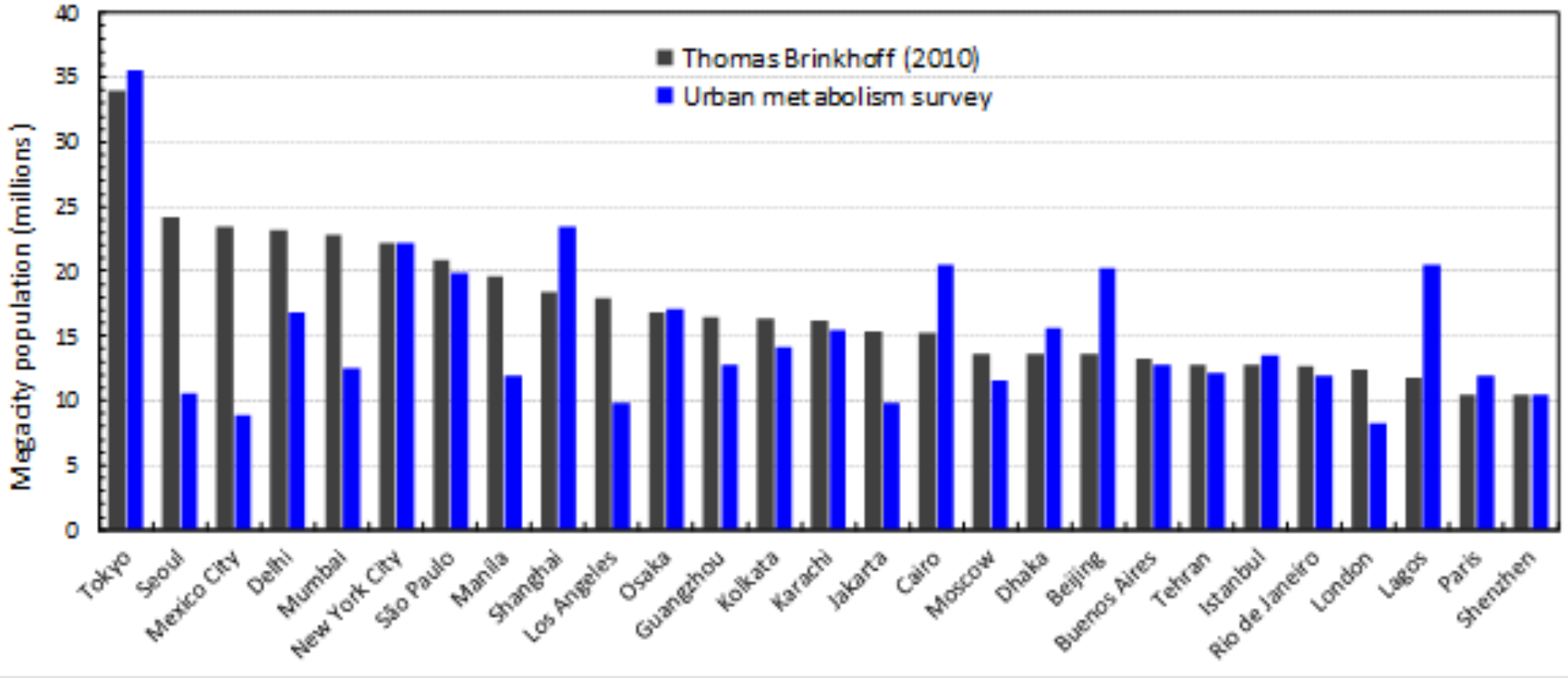
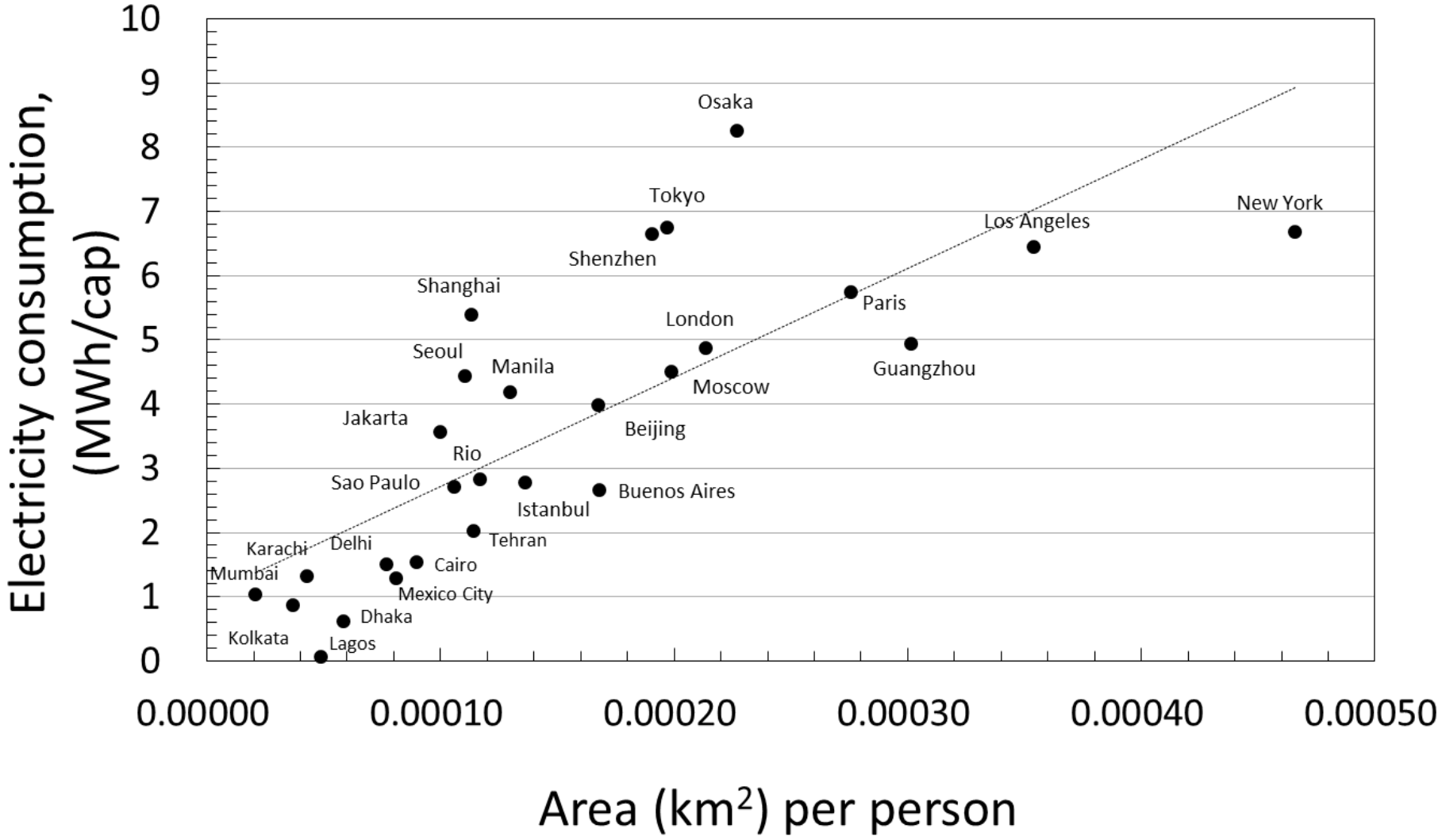
Energy for Knowledge

Metabolism of Megacities

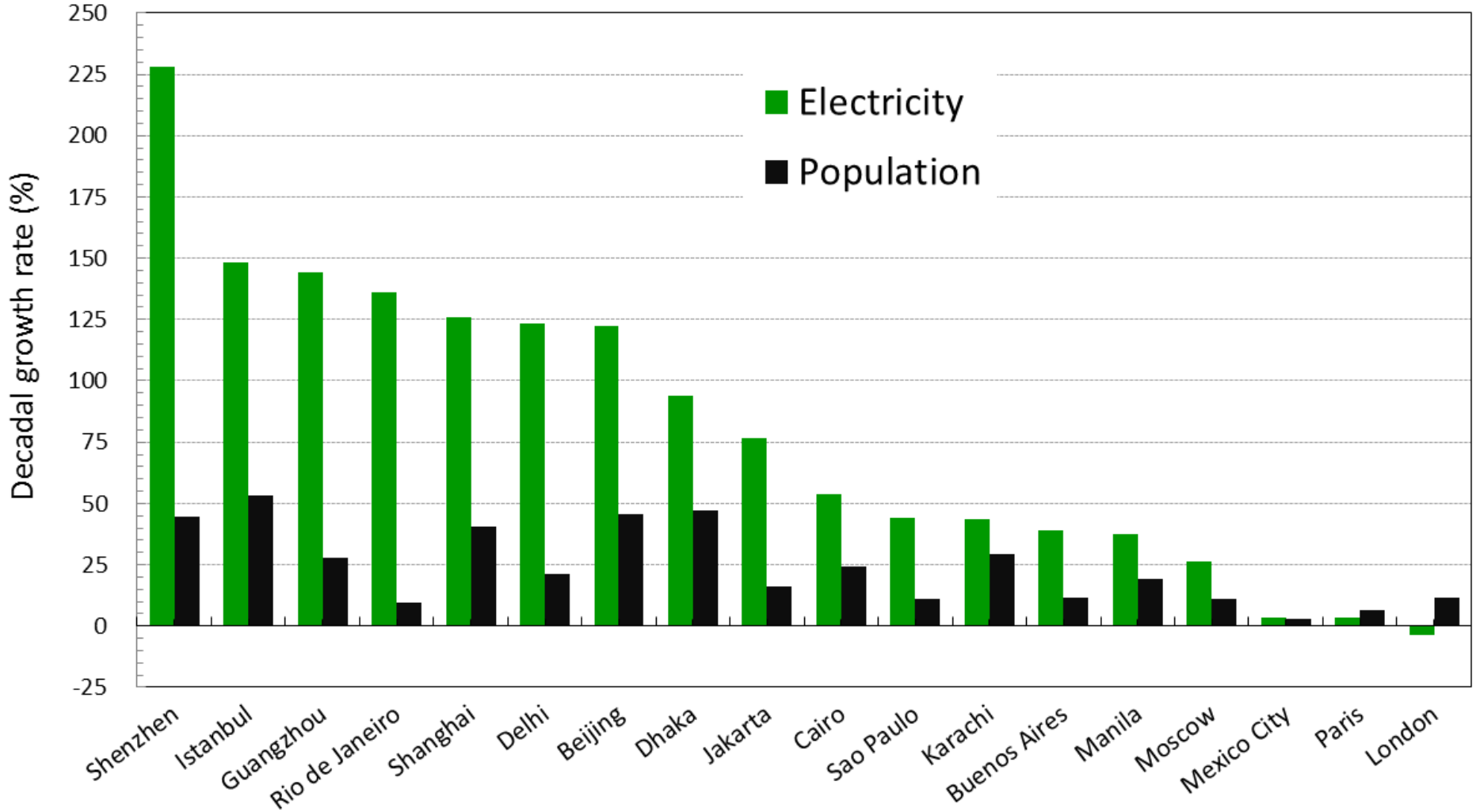
Populations



Electricity Use vs. Urbanized Area per capita



Growth in Electricity Use (2001-2011)

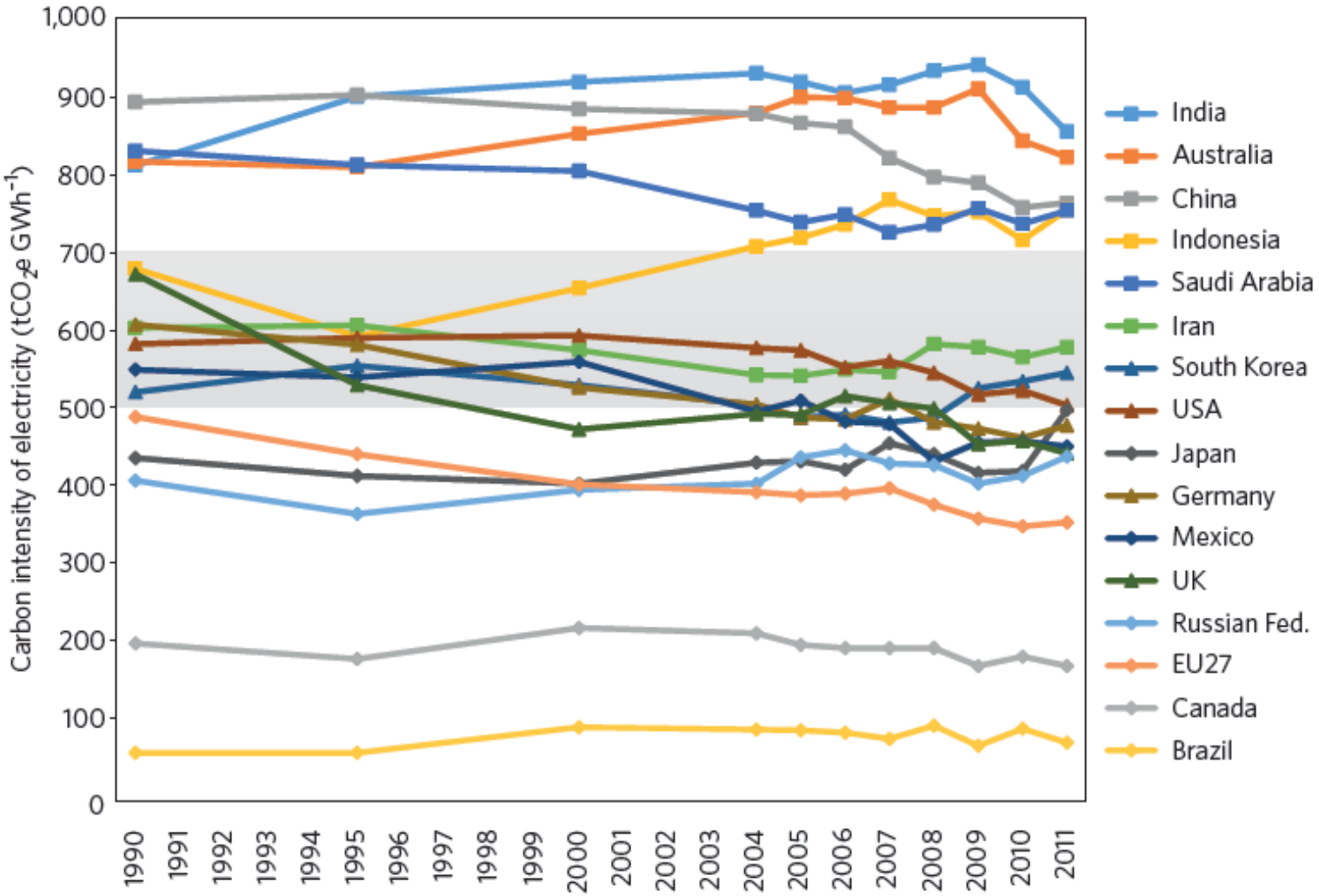


Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles

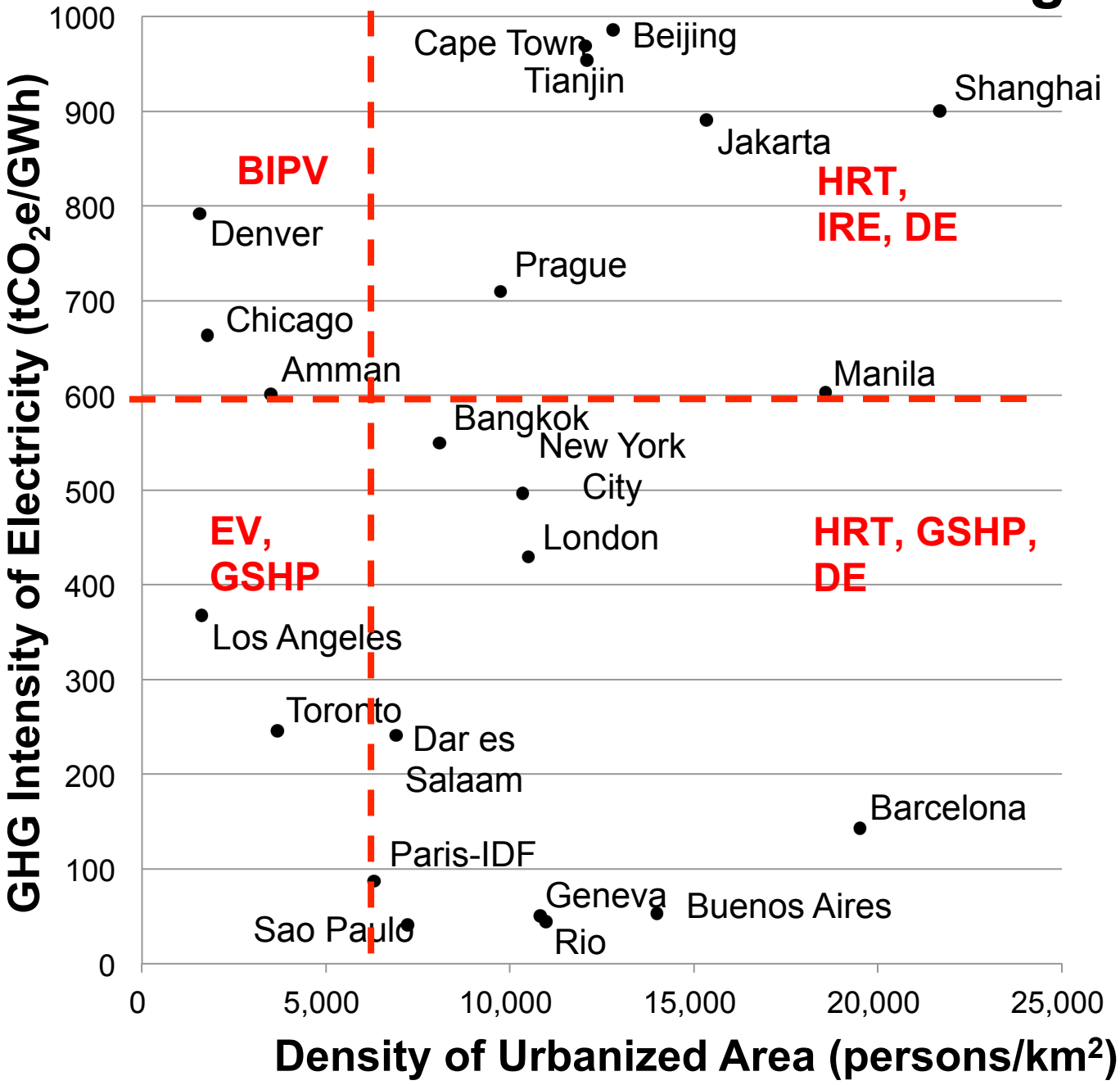
Troy R. Hawkins, Bhawna Singh, Guillaume Majeau-Bettez, and Anders Hammer Strømman

Key threshold for electricity emissions

Christopher Kennedy



Low Carbon Infrastructure Strategies for Cities



BIPV = building integrated photovoltaics,

DE= district energy,

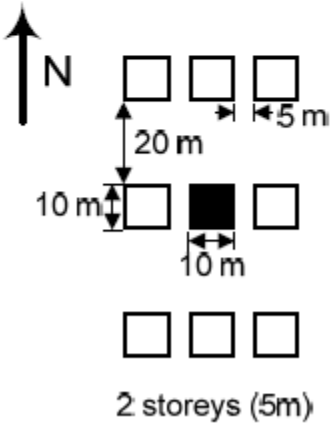
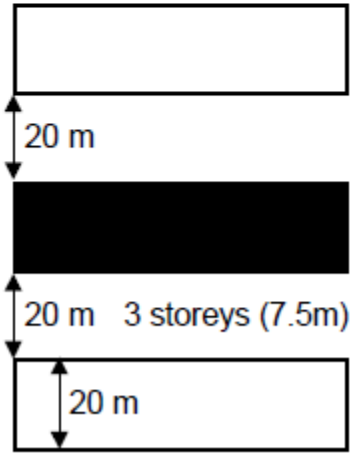
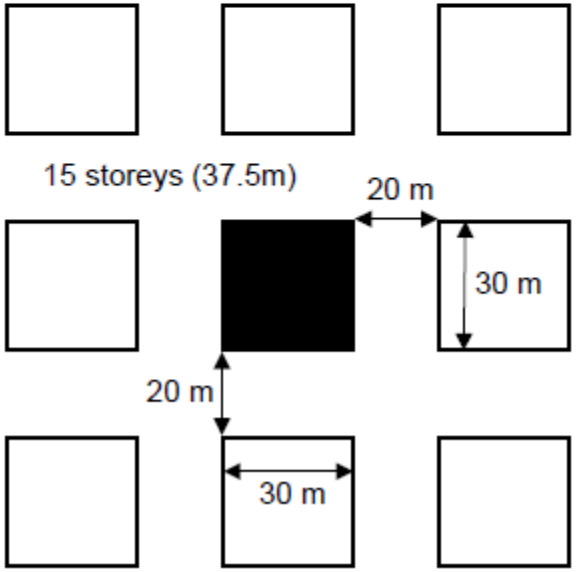
EV = electric vehicles,

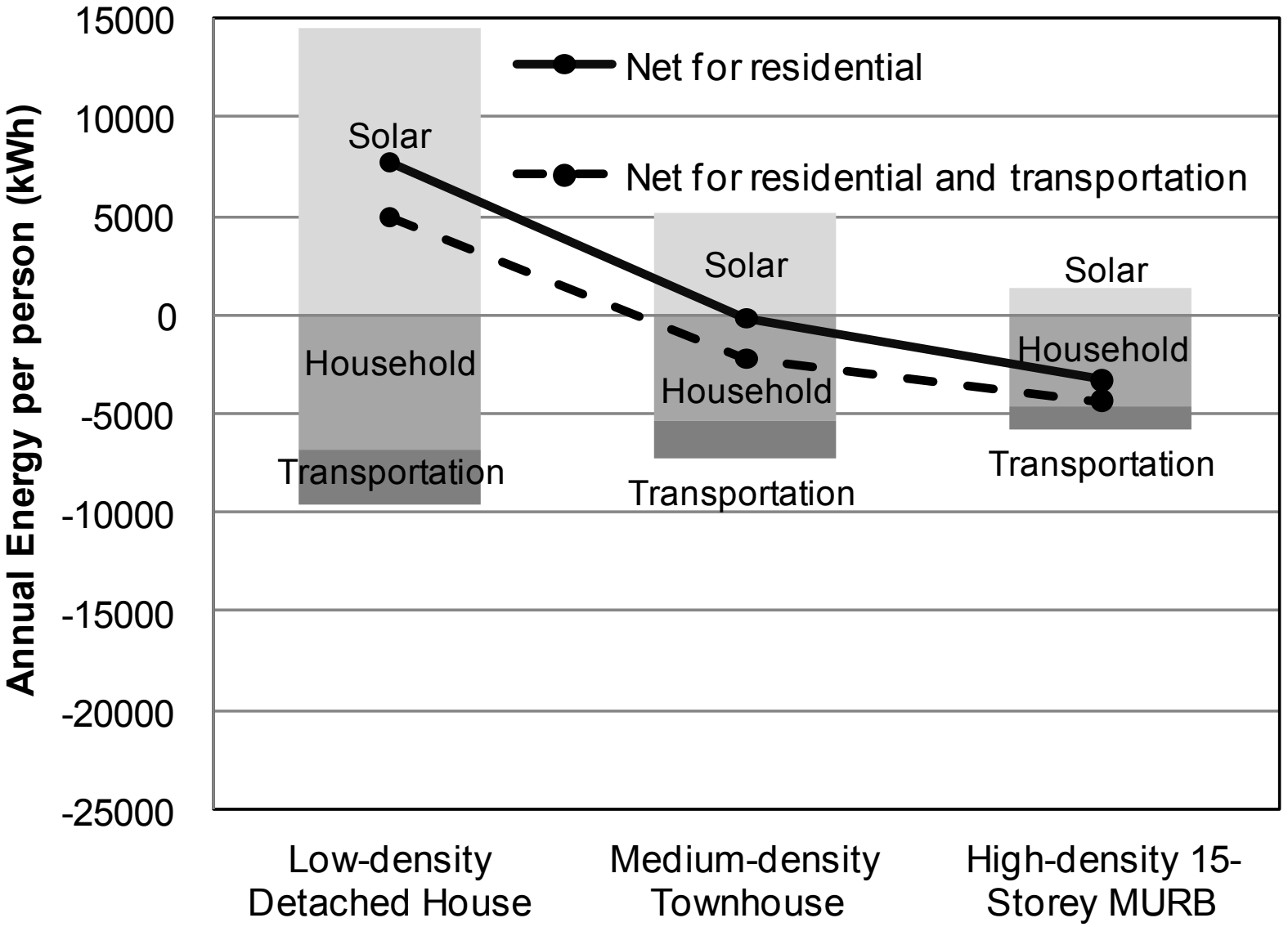
GSHP= ground source heat pumps,

HRT=heavy rapid transit,

IRE=import renewable electricity

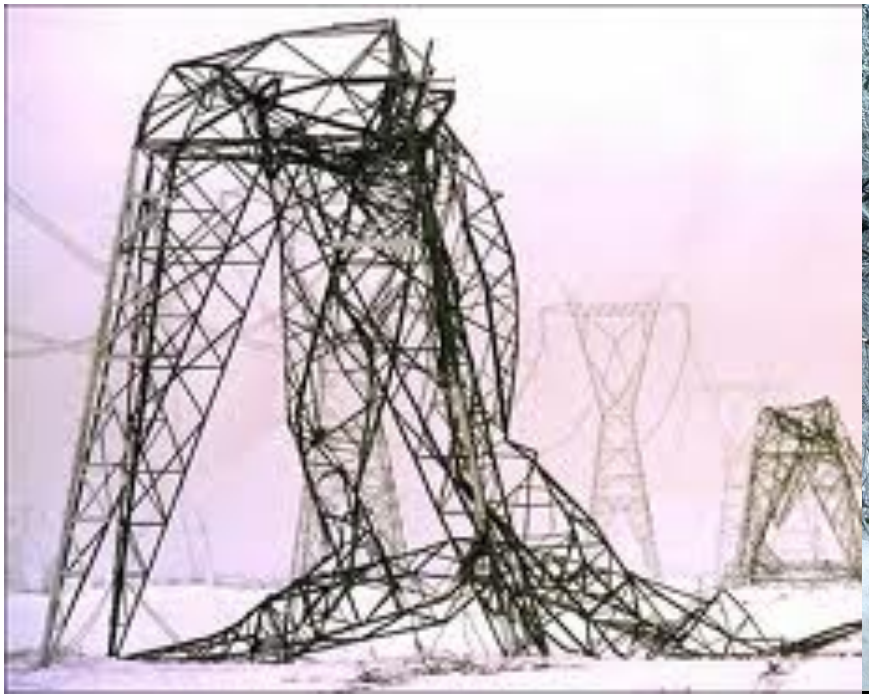
Net energy use and the urban density of solar buildings (O' Brien et al., 2010)

Low-density	Medium-density	High-density
		
		



Theoretical energy balances for three representative solar building developments in Toronto assuming energy efficient envelopes (30% below typical), 20% solar collector efficiency, and transportation by plug-in-hybrid electric vehicles (0.19 kWh per km driven). O'Brien et al. (2010).

Can “electric” cities, provinces etc. be resilient to climate change?

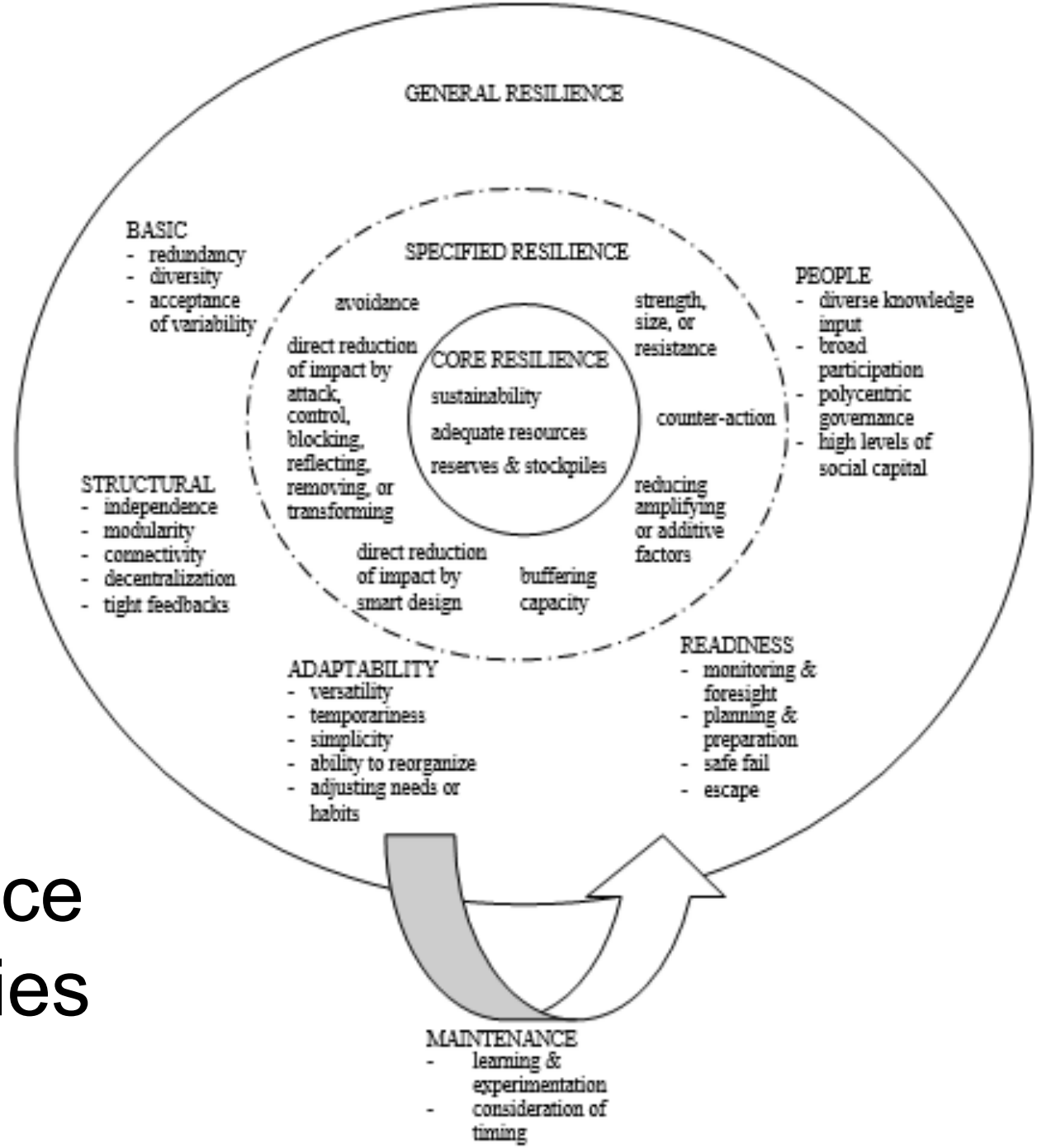


[1]

Examples of Interactions between adaptation and mitigation (Sugar et al.)

	Mitigation (-) **(increase GHG)**	**Mitigation (+)** **(decrease GHG)**
Adaptation (+) **(increase resilience)**	air-conditioning (conventional) desalination of water	urban greenery building insulation water efficiency & storage distributed and centralised renewable energy systems multi-modal transportation
Adaptation (-) **(decrease resilience)**		very high urban population density small hydropower (where competing with scarce water supplies)

Resilience Strategies (Uda)



Energy Stored in Cities as a Measure of Resilience

(Bristow & Kennedy)

Resiliency is associated with the time it takes for a system to return to operation after a shock.

When supply fails, internal buffer capacity becomes vital to meeting demand and hence is an important factor in resilience.

Toronto energy stocks and residence times
(Bristow & Kennedy)

Stock	Energy Content (TJ)	Days
Gasoline (total)	1,732	5.9
- Gas in Vehicle Tanks	1,190	4.1
- Gas at Stations	543	1.9
Diesel (total)	973	12
Food (total)	770	20
- Food in Residential Kitchens*	117	3
- Food in Grocery Stores	653	17
Local biomass for heating homes†	49,800	64

Key Questions

Is it possible for a near 100% electrified city or province to be resilient?

What other sources of low carbon energy might be used?

Can storage strategies simultaneously solve the “intermittency issue” and “resilience challenge”?

pathways to

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Figure 51. Sankey Diagram for 2050 Mixed Case U.S. Energy System