Estimating Anthropogenic Heat Release from Megacities

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Setting the scene

Published estimates for anthropogenic heat release (Q_F) are available, but

- mostly for individual cities of wealthy or mid-latitude regions
- methods, scales, time periods, and data sources vary

Comparisons of Q_F are limited; generalisations are biased

Study objectives

Develop a multi-city (i.e., global) dataset of Q_F estimates using

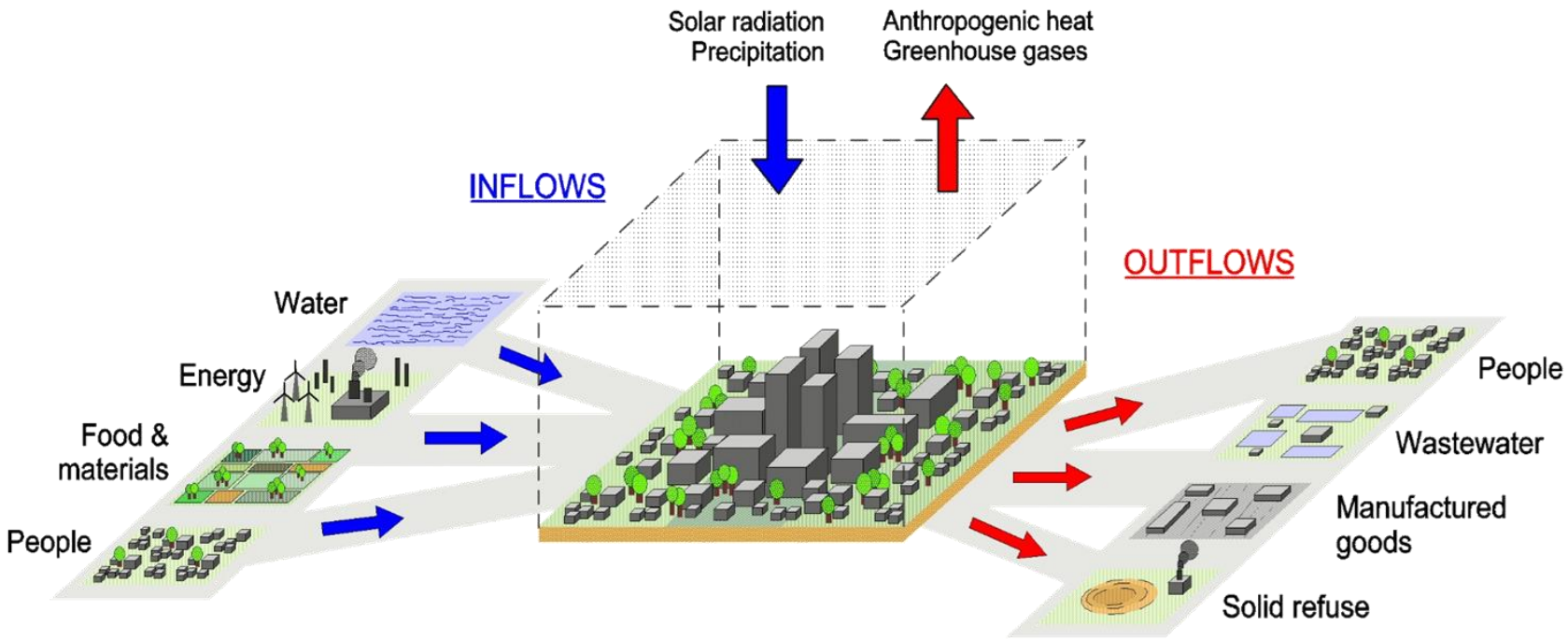
- common years and methods of derivation
- inventories of final energy consumption

Examine regional influences of economy, climate & demography on Q_F

- sectoral contributions from vehicles, buildings, humans, and animals

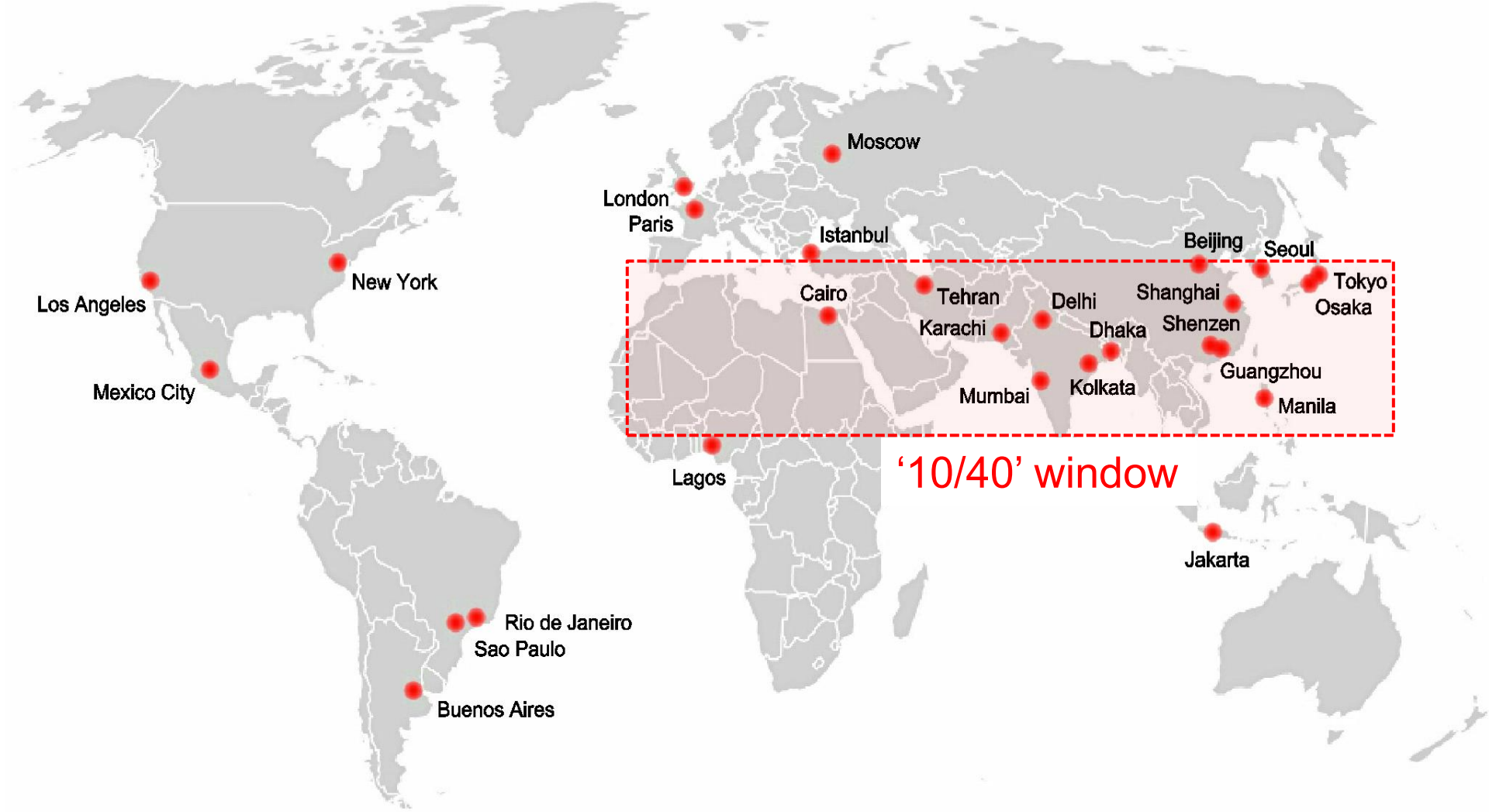
‘Metabolism of Megacities’

Major international study of energy, water, waste, and material flows through the world’s 27 megacities (as of 2010).

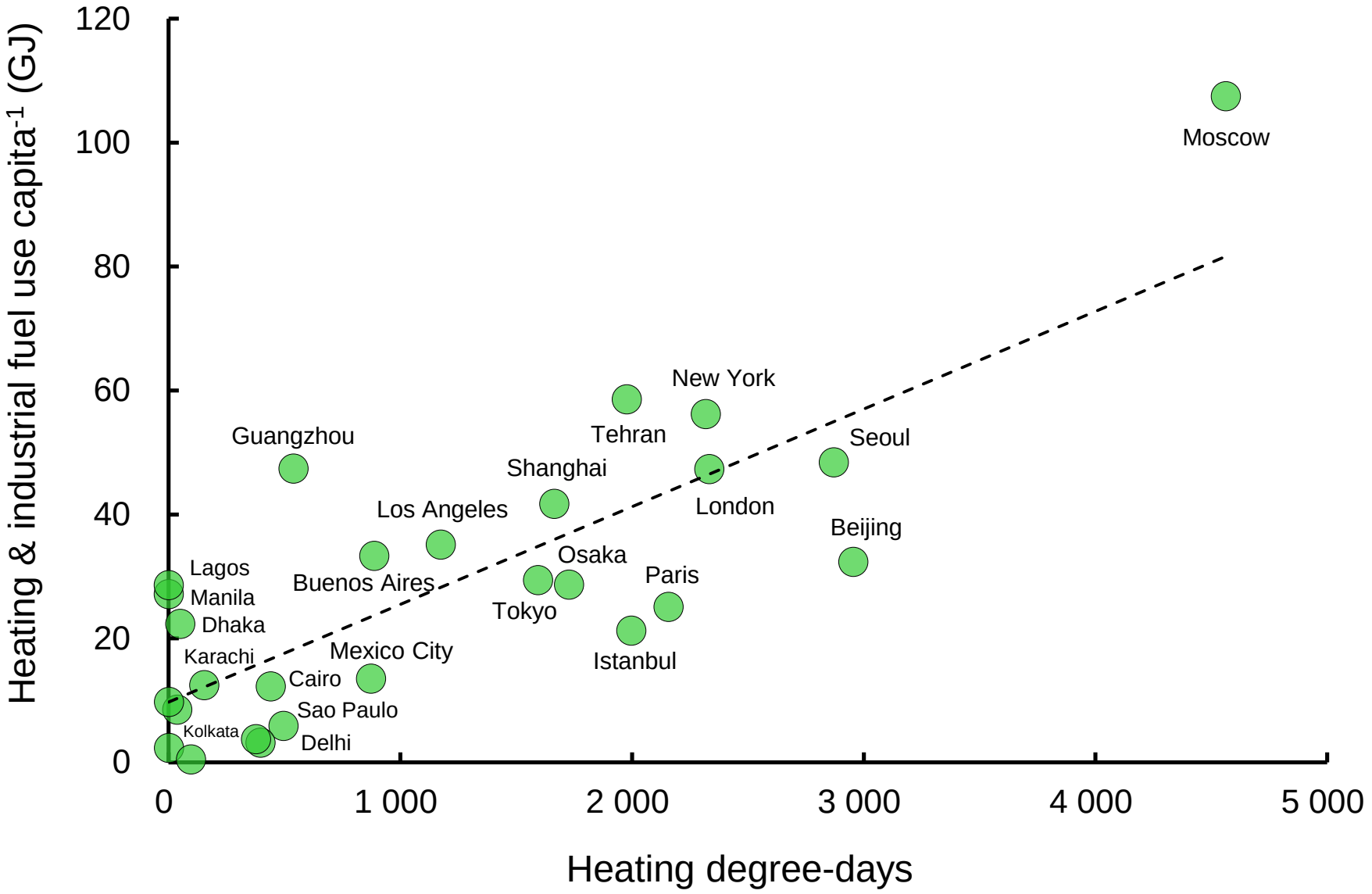


*Kennedy CA., Stewart ID, Facchini A., et al., 2015. Energy and material flows of megacities. *Proceedings of the National Academy of Sciences of the United States of America* 112, 5985–90.

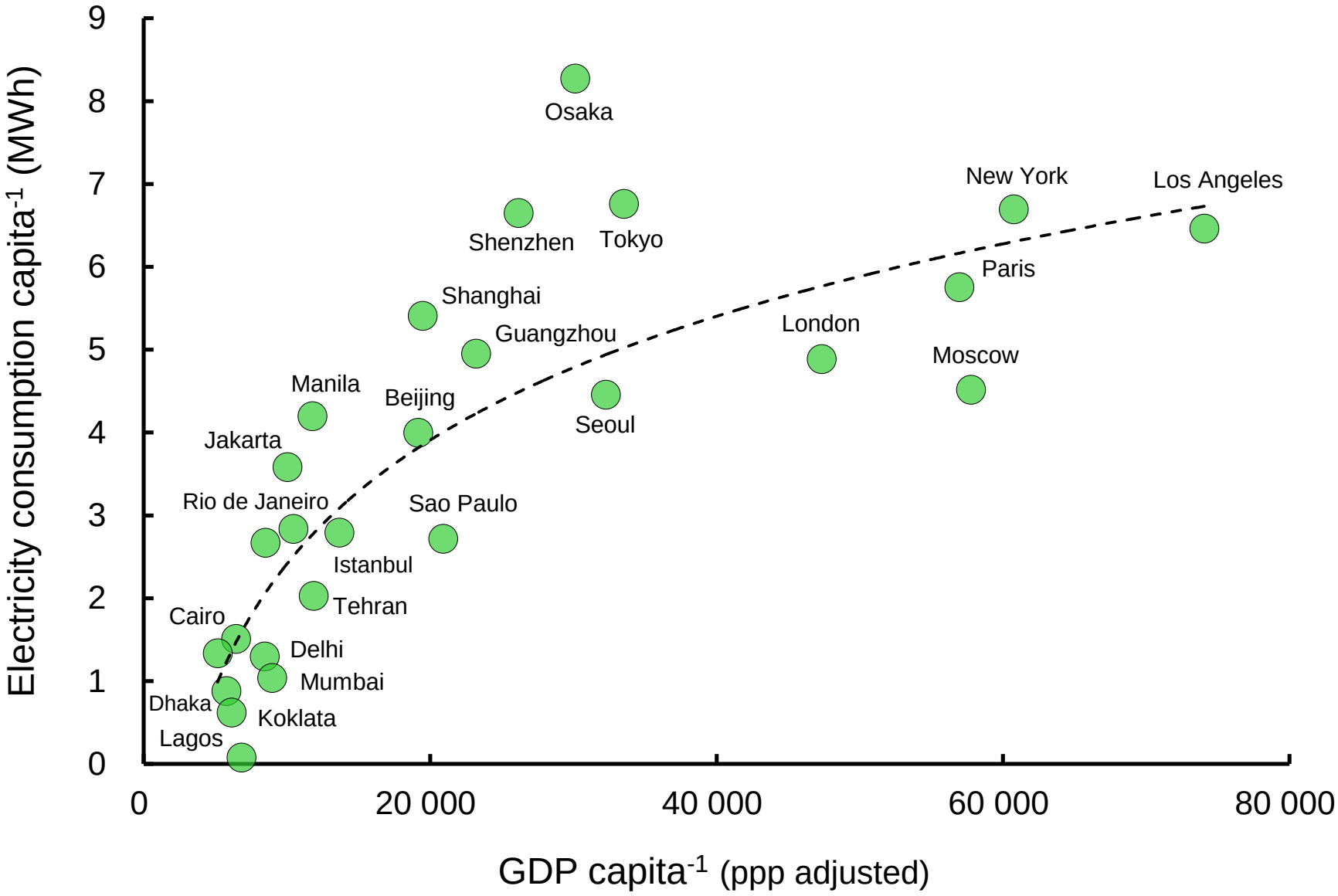
Global distribution of megacities



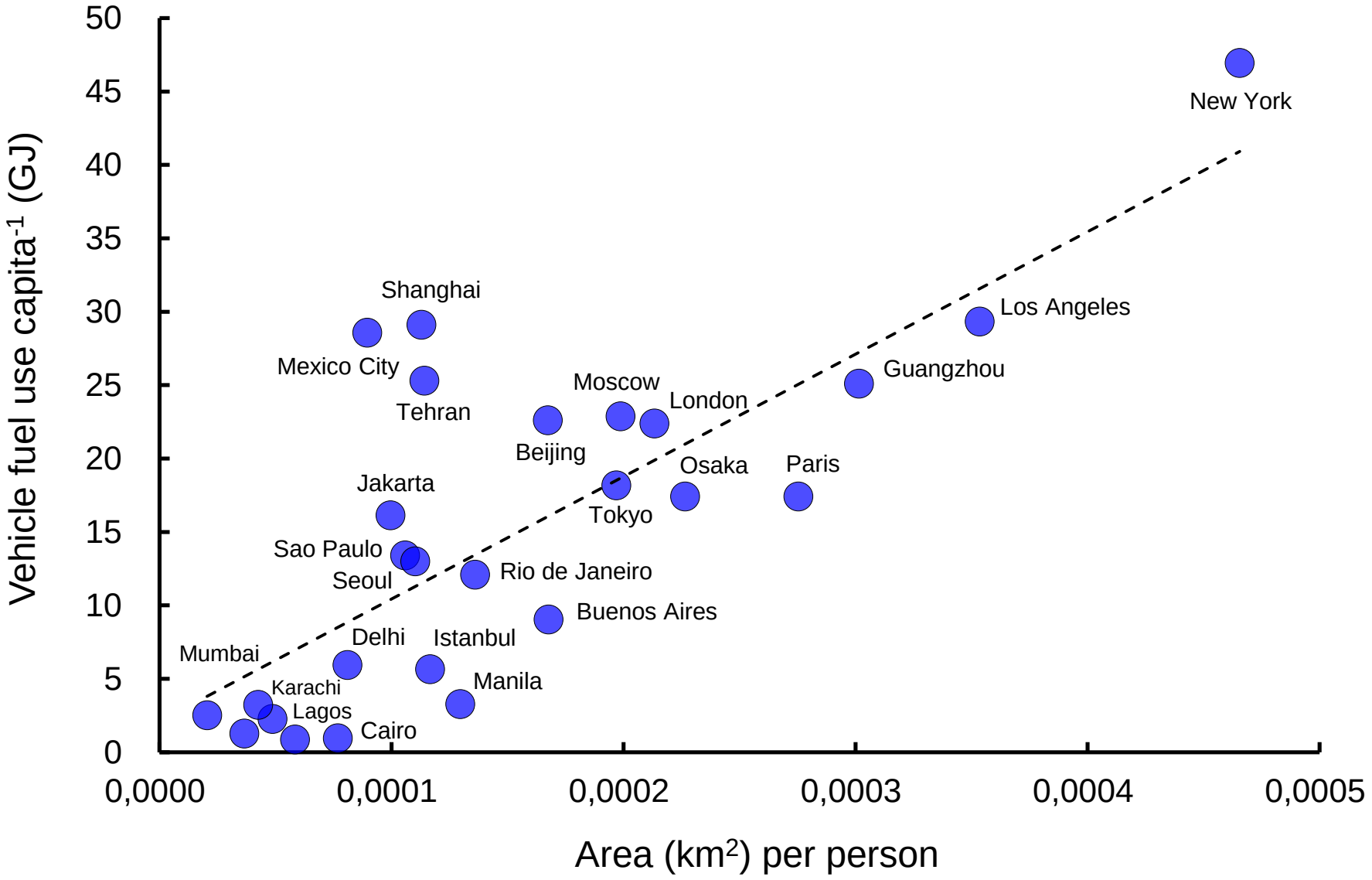
Building fuel use vs. heating degree-days



Electricity consumption versus GDP



Vehicle fuel use versus urban density



Calculating Q_F in megacities

Inventory approach: $\mathbf{Q_F = Q_{Fb} + Q_{Fv} + Q_{Fm}}$

Q_{Fb} building fuels for home and industry; electricity use for cooking, lighting, space heating/cooling

Q_{Fv} transportation fuels for cars, buses, and other ground vehicles

Q_{Fm} human and animal metabolism; ~150 Watts person^{-1}; 40 Watts animal^{-1}

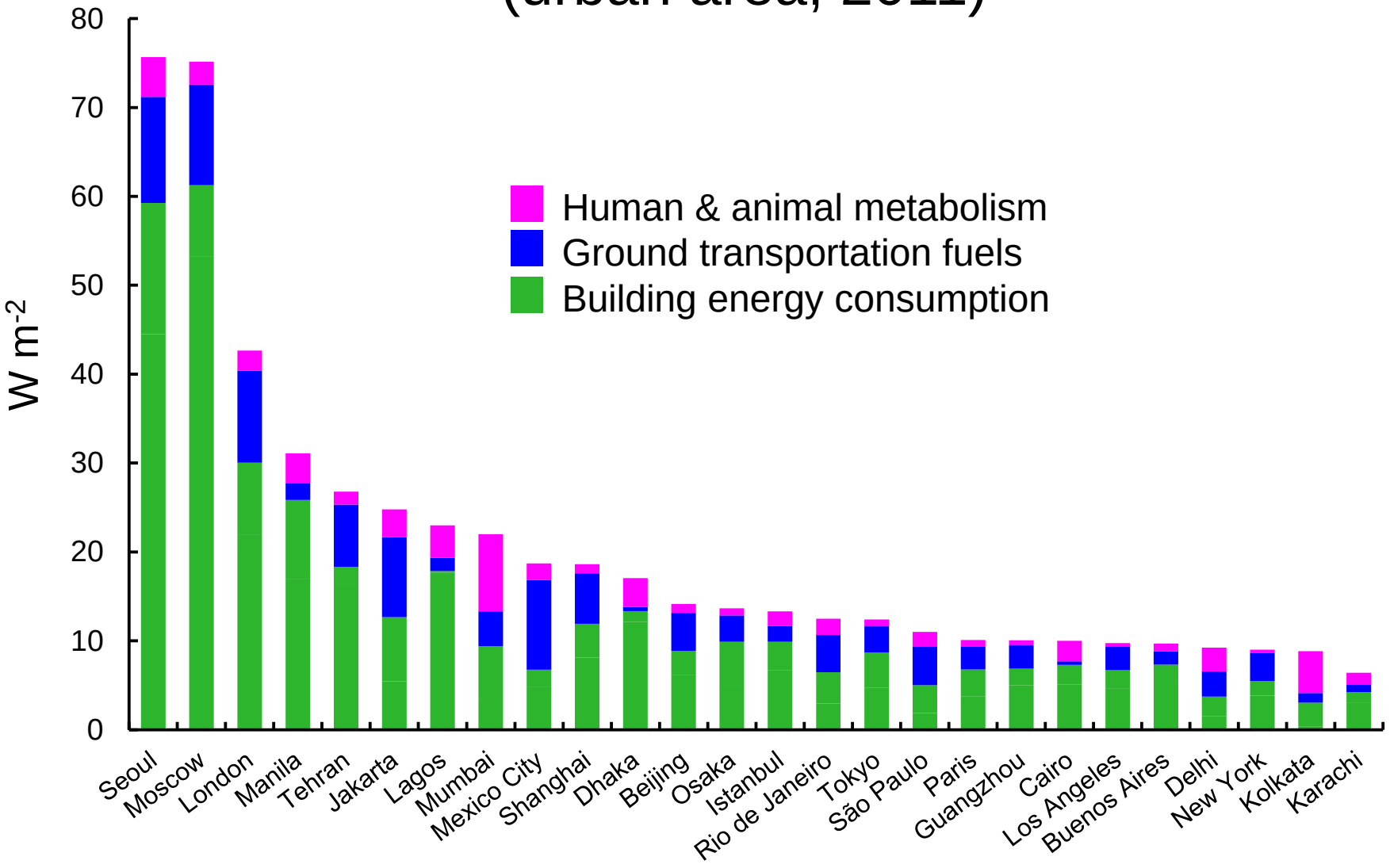
Estimating urban animal populations

- Livestock, companion pets, roaming dogs
- Populations vary with climate, economy & cultural practice (UN FAO, 1999)

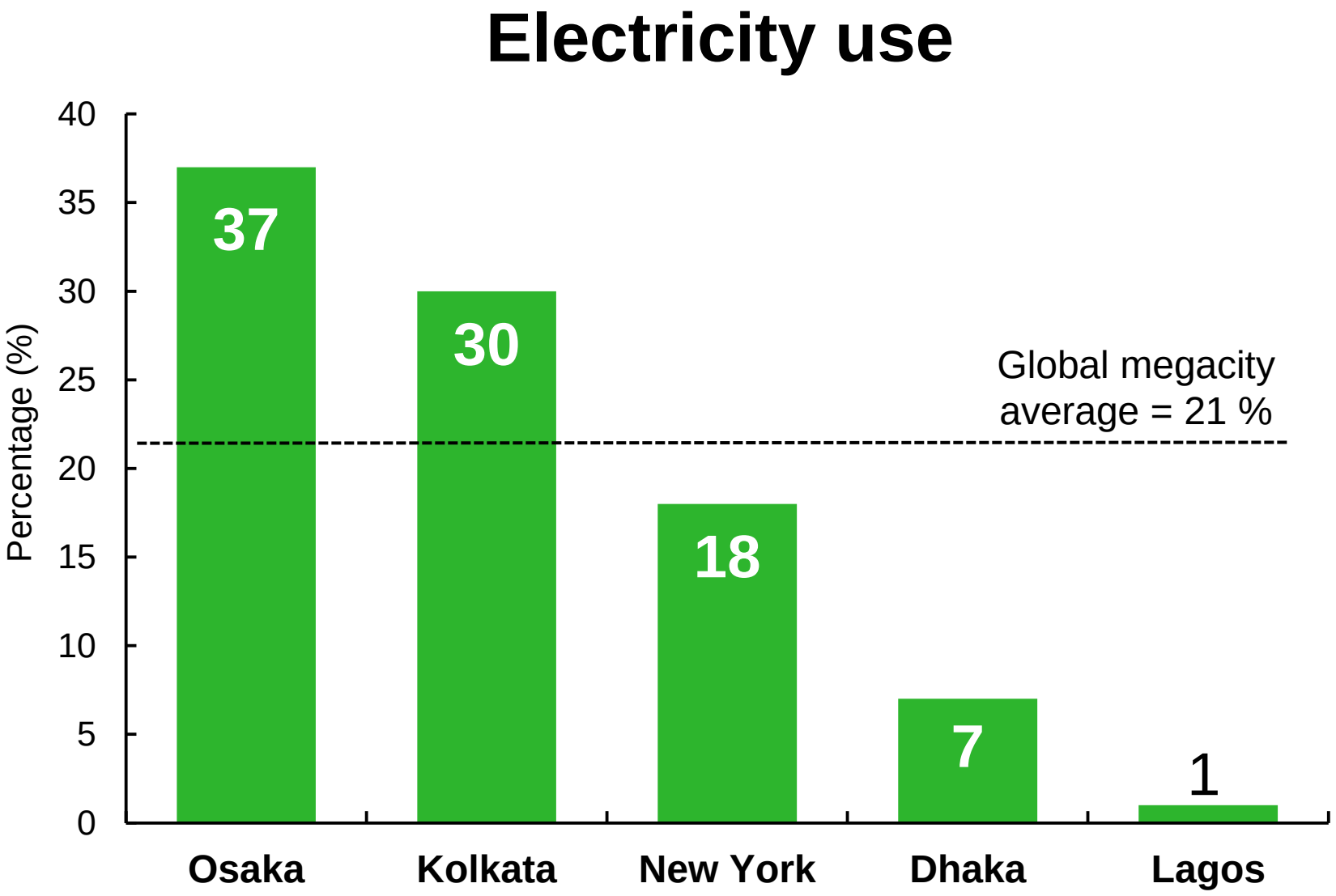
Country income group	Example cities	Animal-to-human ratio
Low	Dhaka	1:1
Lower-middle	Cairo, Karachi, Manila	7:10
Upper-middle	Moscow, Tehran, Buenos Aires	4:10
High	Paris, New York, Tokyo	1:10

Anthropogenic heat release

(urban area, 2011)

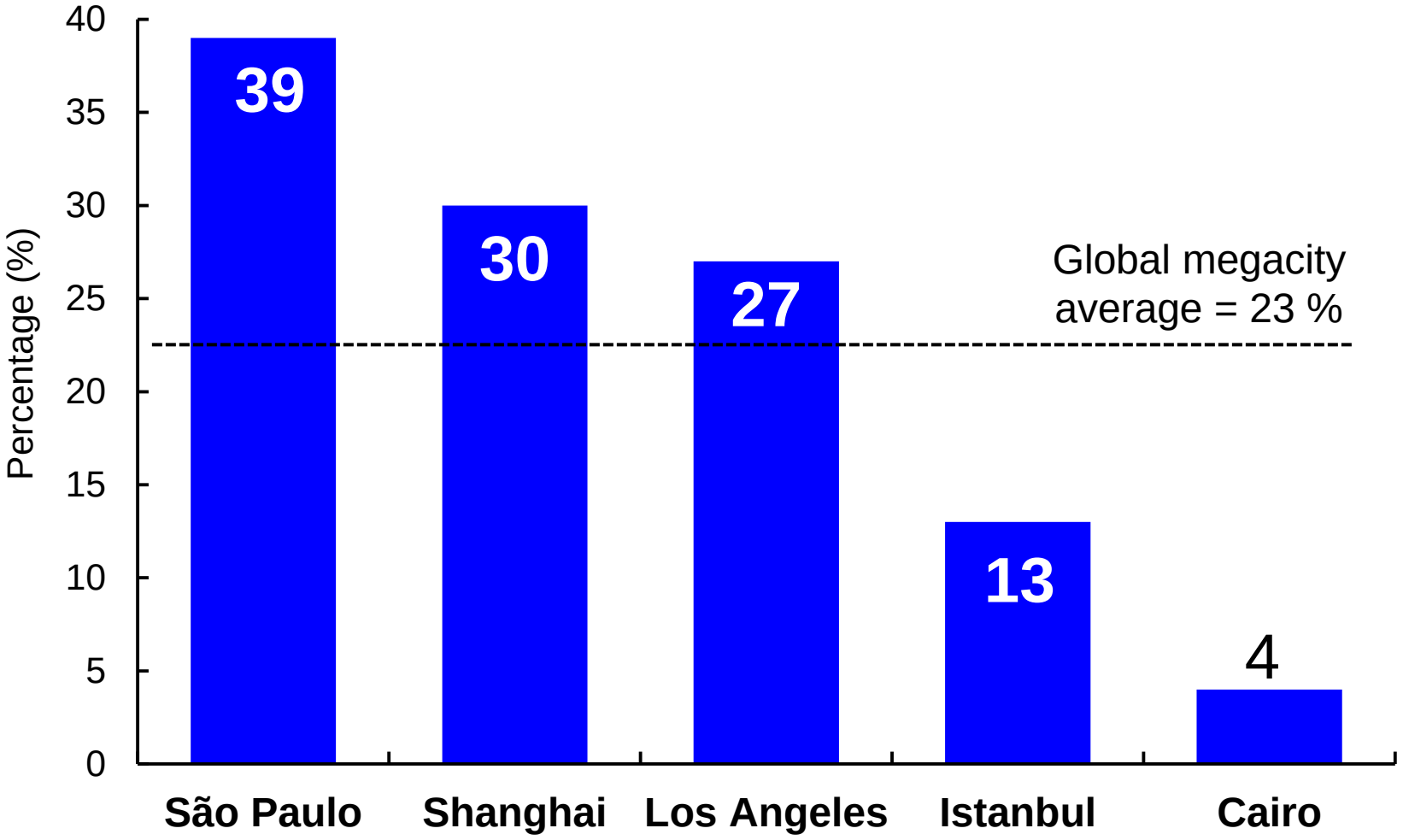


Percentage contribution to total Q_F



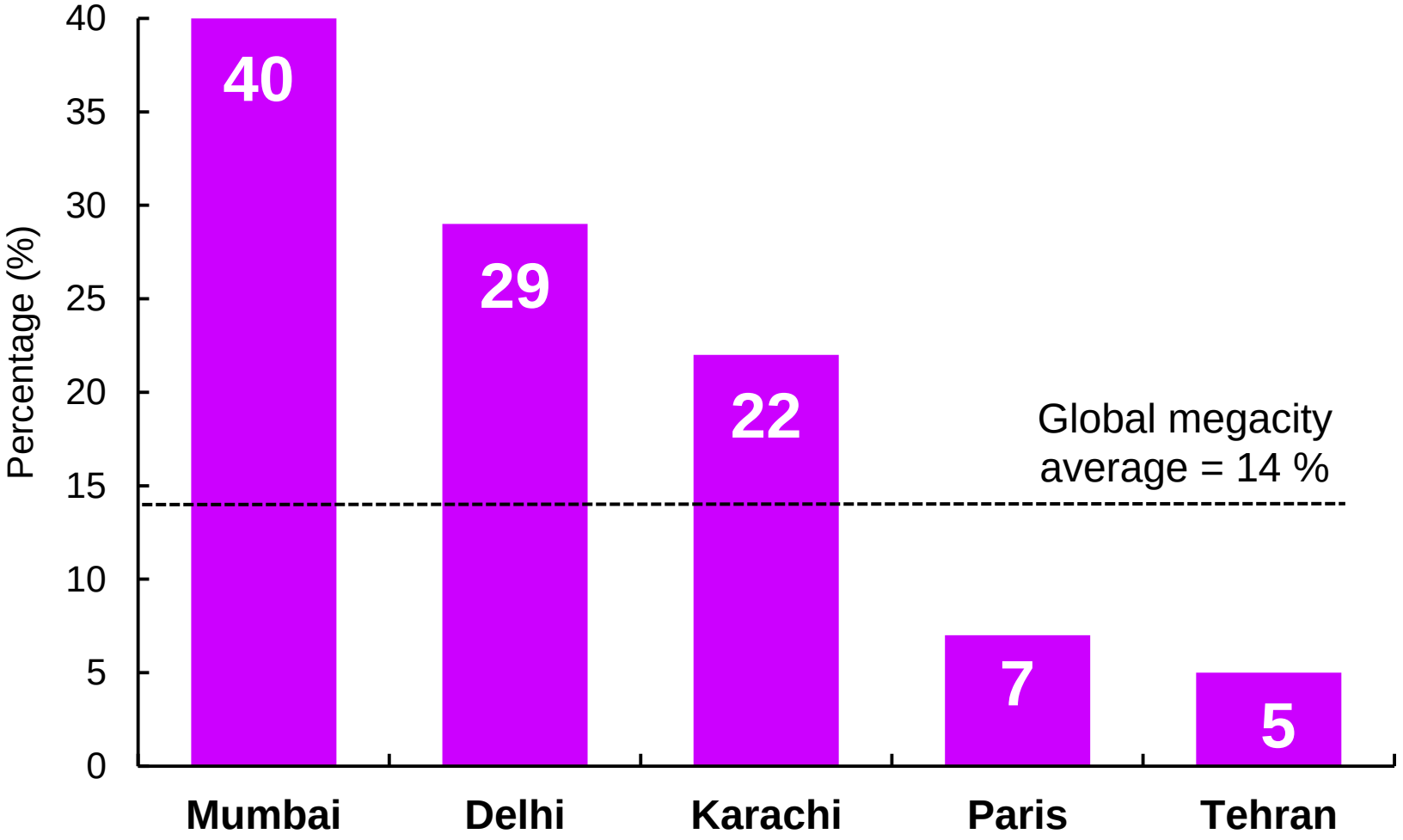
Percentage contribution to total Q_F

Transportation fuels



Percentage contribution to total Q_F

Human & animal metabolism



Cross-sector comparisons: Mumbai

Buildings & industry	Human & animal metabolism	Ground transportation
9 W m^{-2}	9 W m^{-2}	4 W m^{-2}

Cross-sector comparisons: Global

Kolkata

Human & animal metabolism

5 W m^{-2}

London

Building electricity

8 W m^{-2}

Mexico City

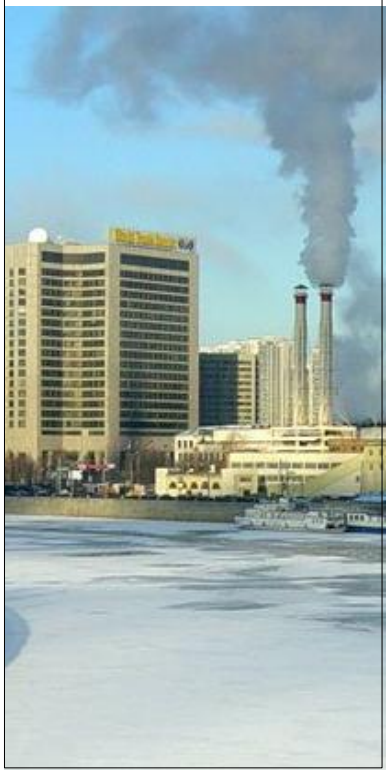
Ground transportation

10 W m^{-2}

Moscow

Building & industrial fuels

53 W m^{-2}



Final remarks

Estimates of Q_F for low-latitude, low-income cities

- Raw data are publicly available in Kennedy et al. (2015)
- Data are spatially and temporally coarse, but geographically and economically diverse

First exchange of data between researchers of urban metabolism & urban climatology

- Metabolism literature is a good source of city-scale data on energy & material flows