Opportunities and Challenges of Zero Carbon Buildings

Working Towards Zero Carbon Buildings

Construction Industry Council (CIC)

Centre for Innovation in Construction and Infrastructure Development (CICID), The University of Hong Kong

September 29, 2014 2:00pm-5:30pm

Dr Jimmy Tong

Associate | Building Sustainability Team

Hong Kong

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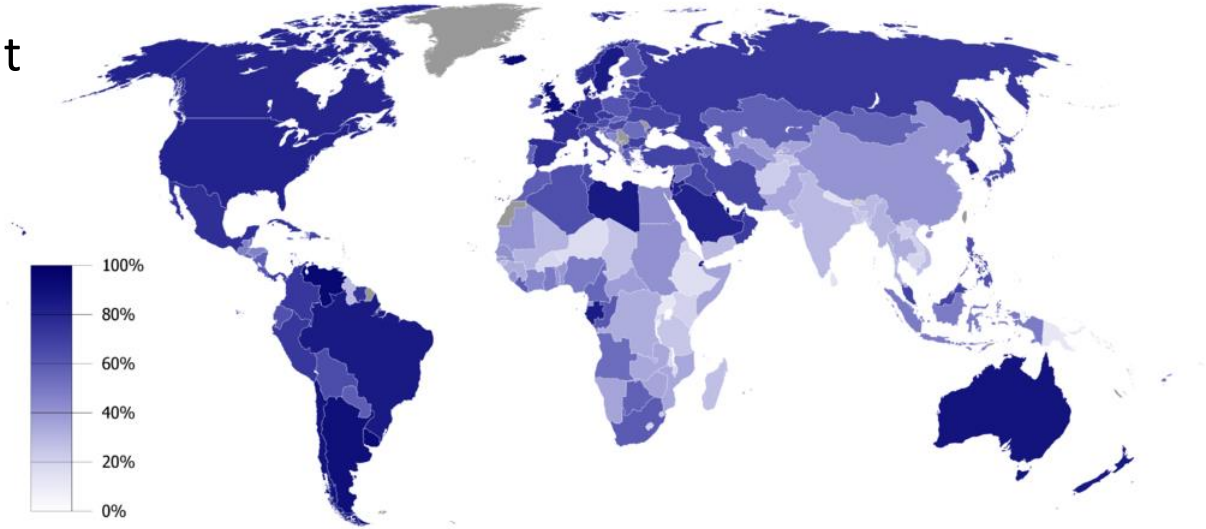
Agenda

We shape a better world

Arup focuses on design to take better decisions, create better solutions and deliver better results.

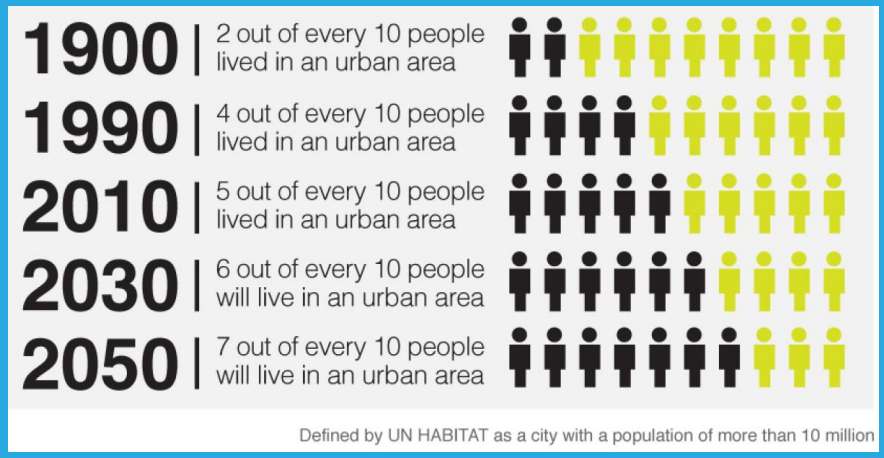
1. Urbanization
2. Design Strategies
3. Beyond Built Environment



Source: http://en.wikipedia.org/wiki/Urbanization_by_country

Urbanization

How each of us is using the energy?



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Urbanization – Developed Countries

UK (80% @ 2011)

City of London

USA (82% @ 2011)

City of Washington, DC

Urbanization – Developed Countries

Japan (91% @ 2011)

City of Tokyo

Singapore (100% @ 2011)

City of Singapore

Urbanization –Developing Countries

China (51% @ 2011)

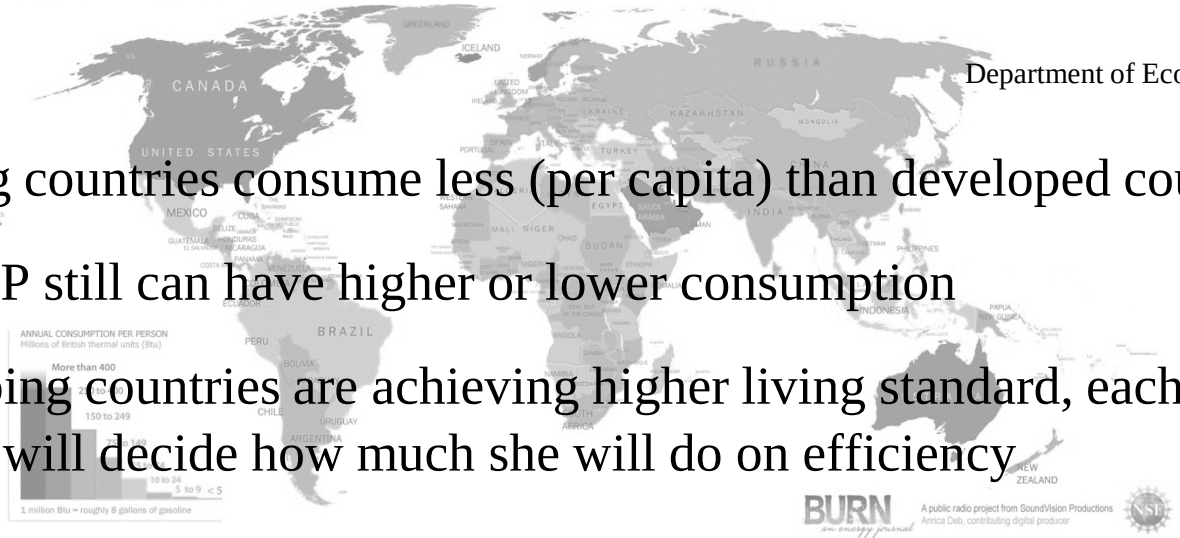
City of Beijing

Vietnam (31% @ 2011)

Ho Chi Minh City

Urbanization and Electricity Consumption

Country Name	Region	Total Population (in thousands)*	Urbanization Percentage *	GDP per capita, PPP (international $) *	Electricity consumption (kWh per capita) *
United States of America	America	313085	82%	49854	13246
Australia	Australasia	22606	89%	41588	10712
Republic of Korea	Asia	48391	83%	29035	10162
Singapore	Asia	5188	100%	72296	8404
Japan	Asia	126497	91%	34266	7848
Germany	Europe	82163	74%	40980	7081
United Kingdom	Europe	62417	80%	34800	5472
China	Asia	1347565	51%	10041	3298
Thailand	Asia	69519	34%	12798	2316
Viet Nam	Asia	88792	31%	4717	1073
India	Asia	1241492	31%	4883	684
China, Hong Kong SAR		7122	100%	50129	5949



* Data for 2011,
Department of Economic and Social Affairs,
United Nations.

- Developing countries consume less (per capita) than developed countries
- Higher GDP still can have higher or lower consumption
- As developing countries are achieving higher living standard, each of economies will decide how much she will do on efficiency

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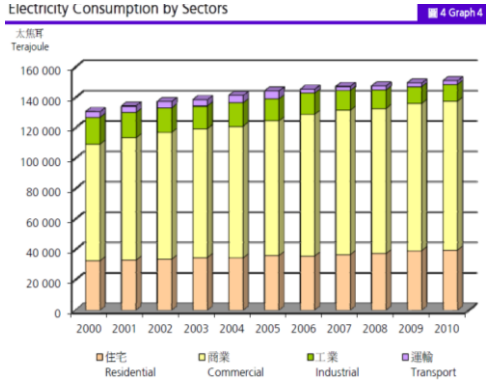
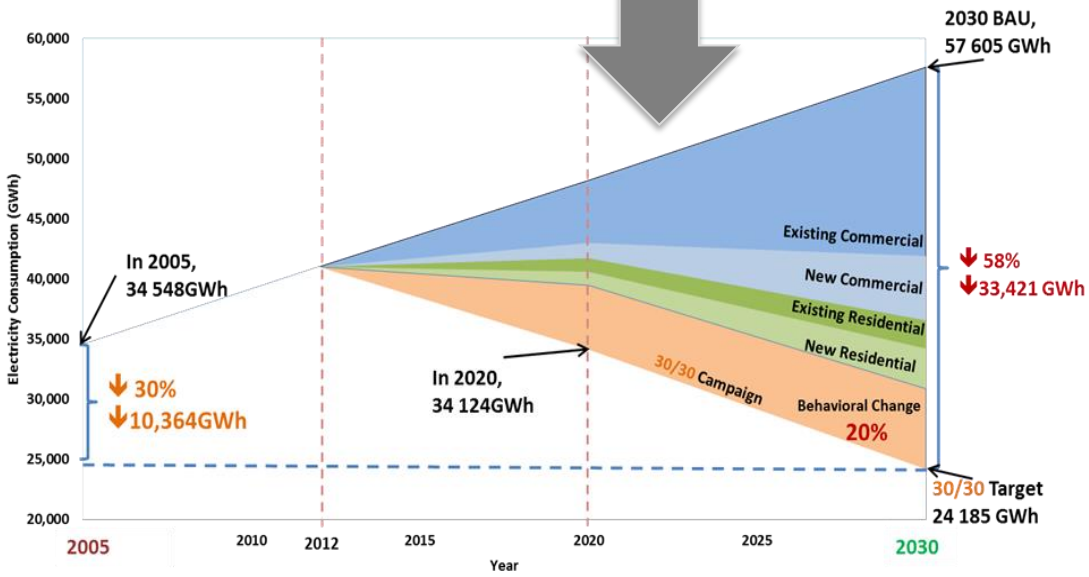
Demand Side – Energy Consumption and CO2-e from Buildings

Source: Carbon Manager, HKPC 2008



Source: EMSD Hong Kong Energy End-use Data 2012

Low Carbon Urban Transformation



Source: HKGBC HK3030 Paper

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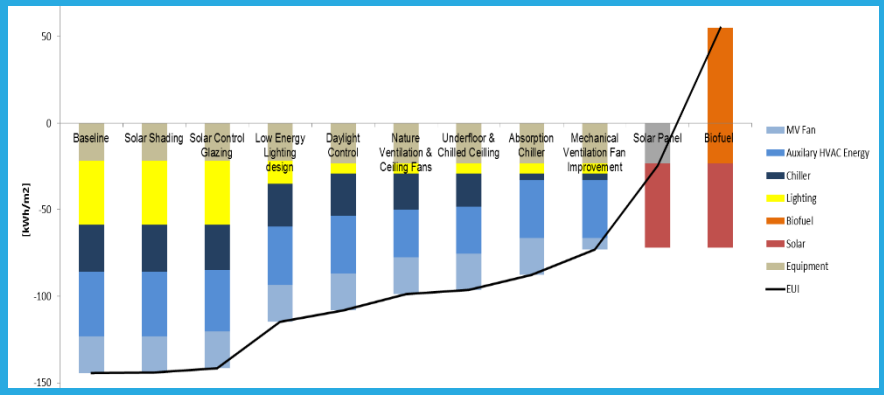
Design Strategies

How to attain High Performance and toward Energy+?



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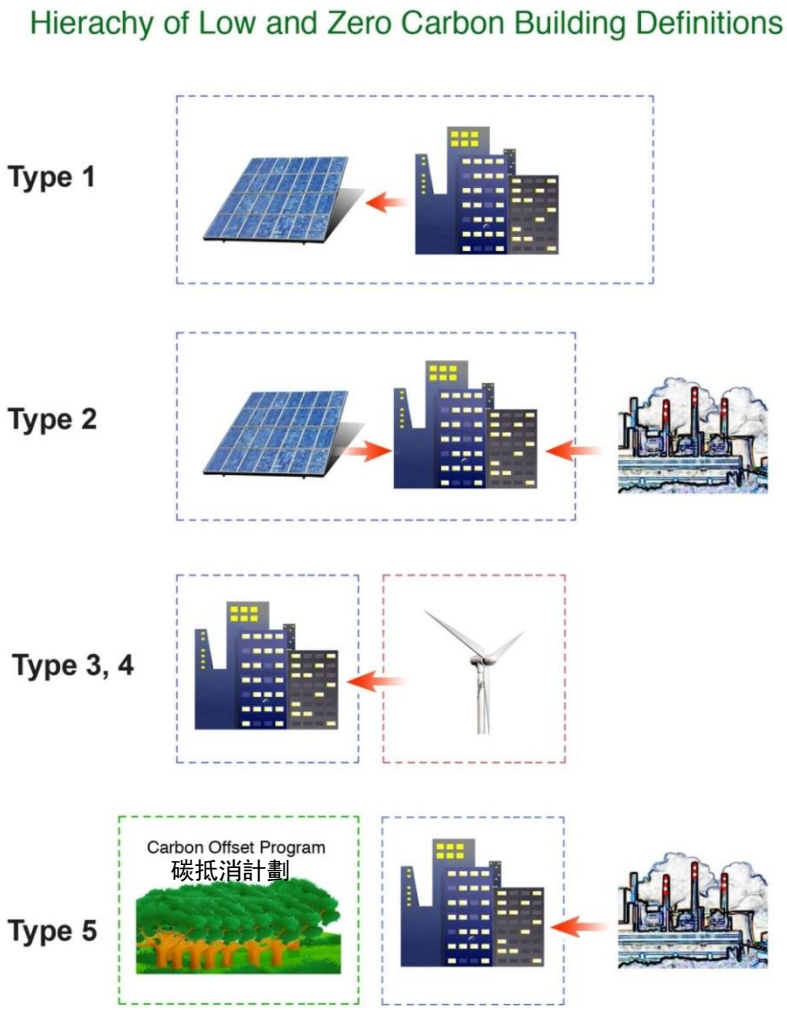
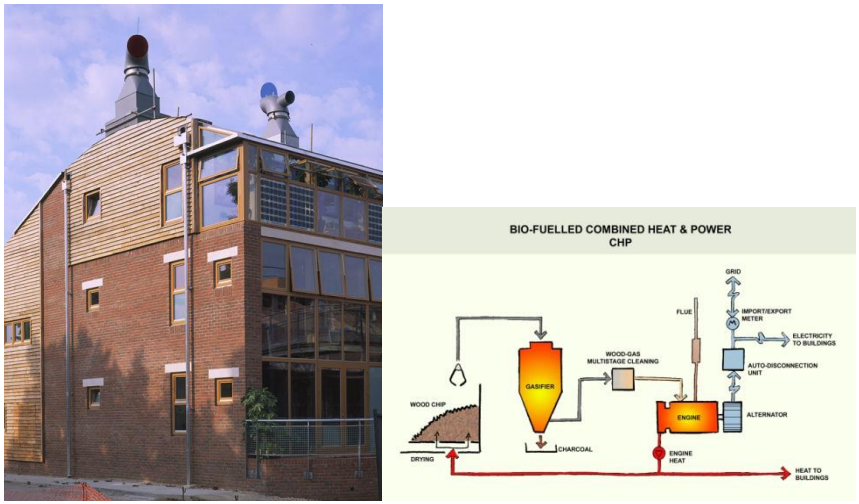
Building Design – Hierarchy of Zero Carbon

Five general categories of zero carbon definitions (UKGBC 2007):

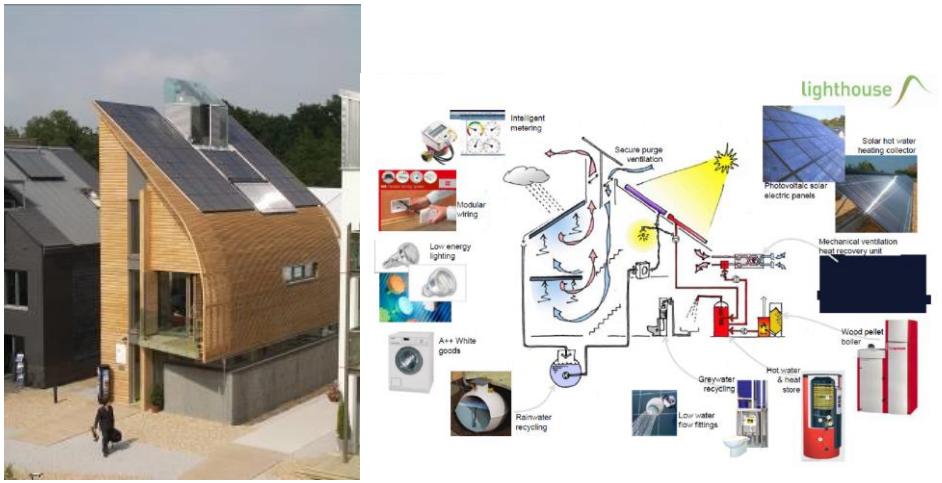
1. Building is completely self sustaining. All energy demands are met by onsite Low and Zero Carbon (LZC) Generation.
2. Building is connected to local emission producing grid. However production of onsite LZC energy offsets the power consumed from grid over an annual basis
3. Building is connected to locally available LZC power supply
4. Building is connected to distant or international LZC power supply.
5. Building emissions are offset with carbon credits purchased from carbon markets.



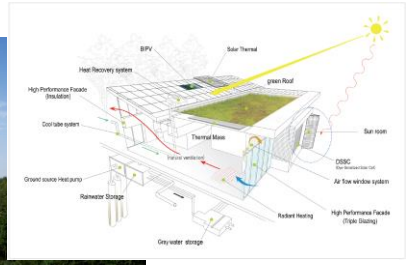
Zero Energy/Carbon – Examples



(a) Beddington Zero Energy Housing Development (BedZED)



(b) Kingspan Lighthouse Zero Energy House



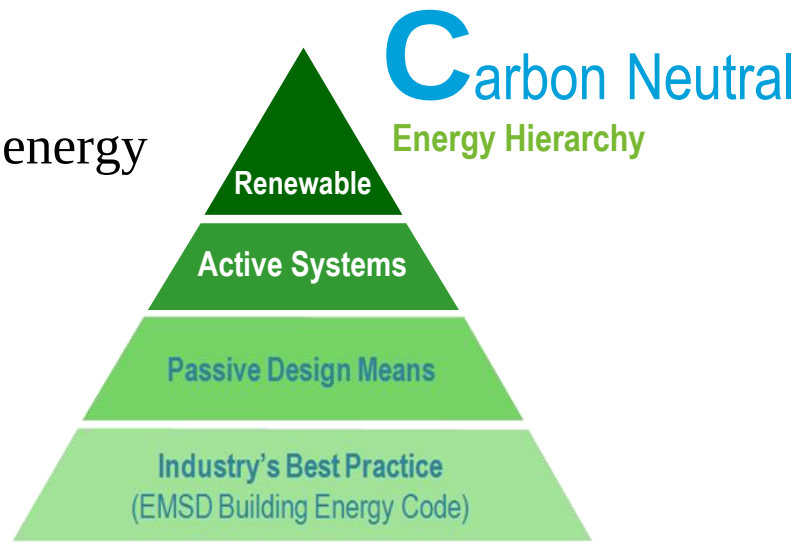
(c) Samsung Green Tomorrow

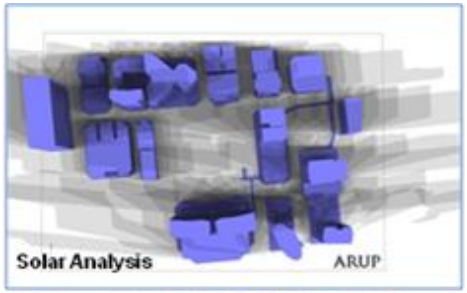
(d) Construction Industry Council Zero Carbon Building

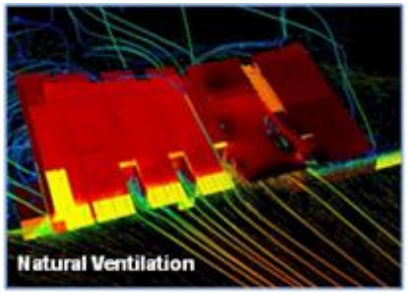
Carbon Neutrality

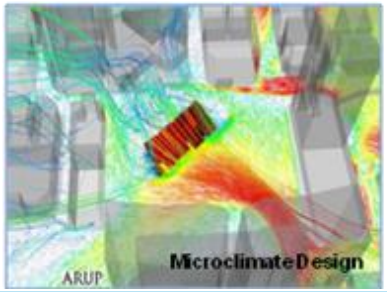
Four primary strategies of the step-by-step energy management concepts

- Local context, baseline and best practices
  Demand controls
- Efficient use of Energy
- Renewable energy source



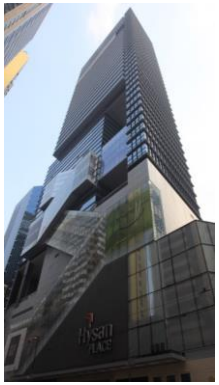






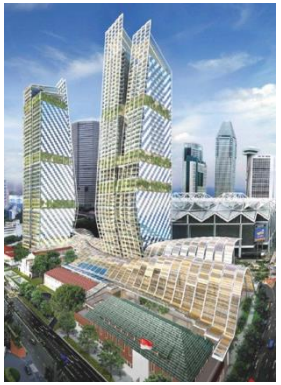
Low Carbon - Zero Carbon Building and High Performance Building

Zero Carbon Building



Hysan Place

Ping An IFC



South Beach, SG

CQ Super High-rise

TKP 2A

Raffles City, HZ

CRC SZ Bay

Raffles City, CQ

NW Centre

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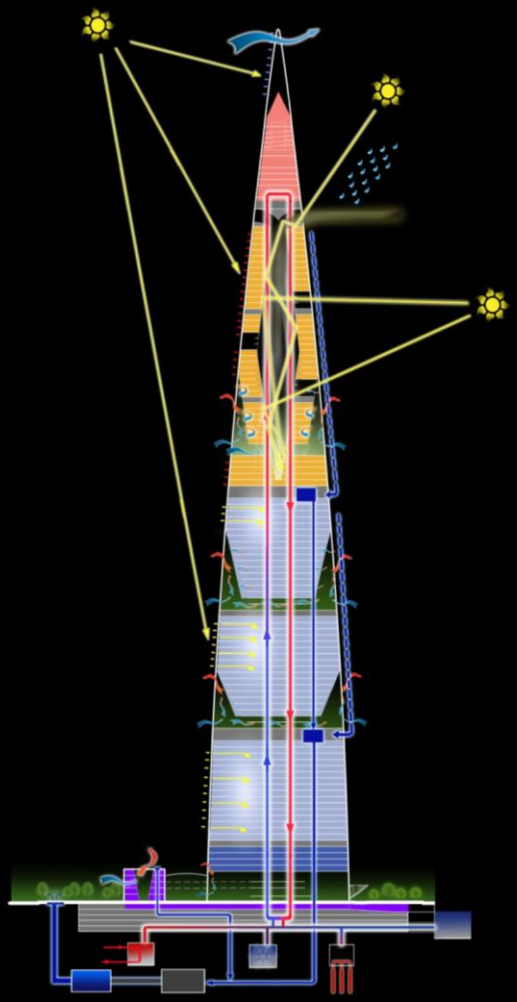
21st Century Sustainable Tower

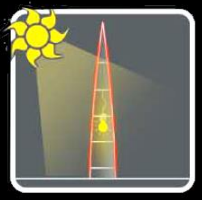


Air Ventilation

Building Mass

Green City

Pre-cool in Summer



Pre-heat in Winter

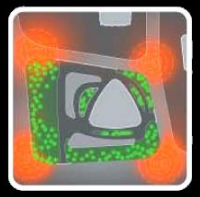
Water Recycling

Renewable

Hybrid Ventilation

Solar Shading

Hybrid Car



Microclimate

GSHP

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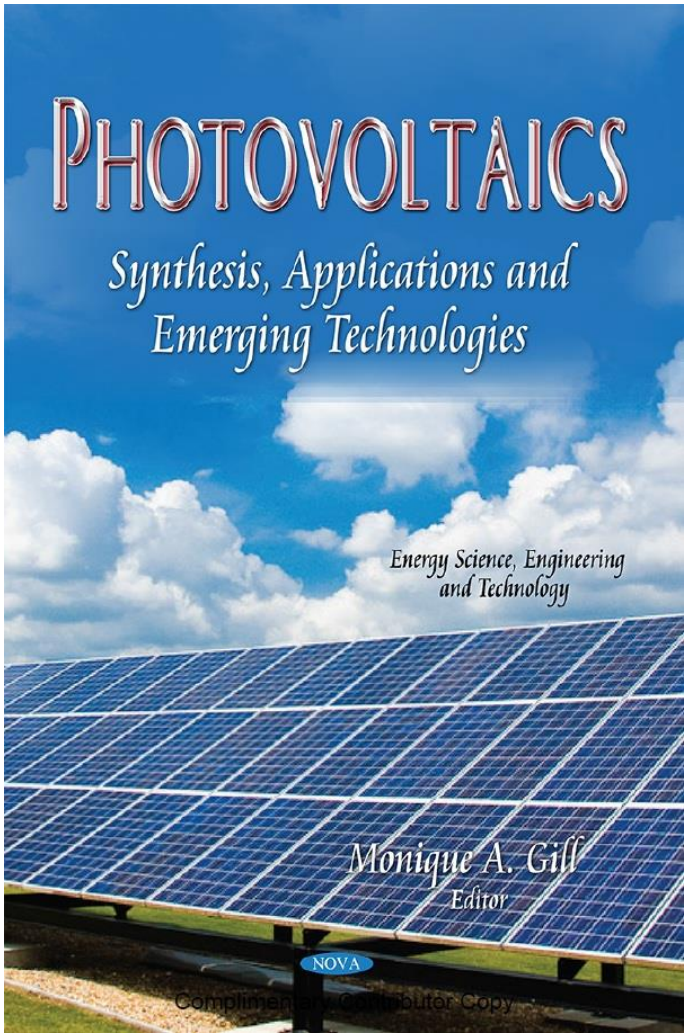
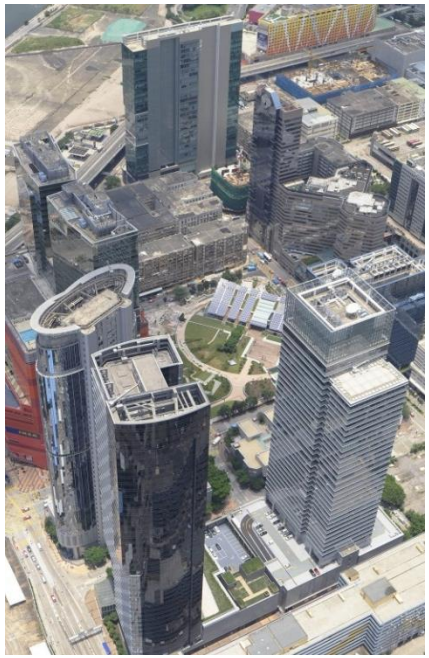
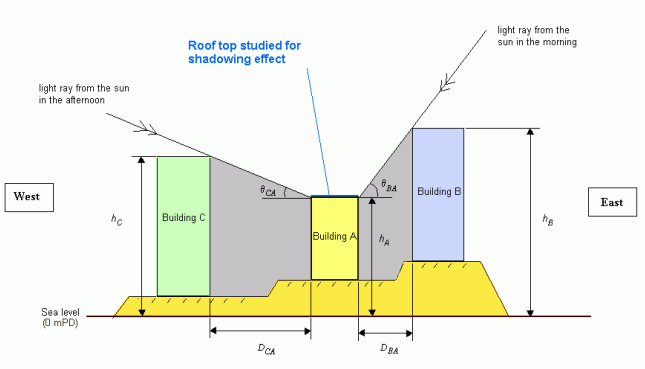
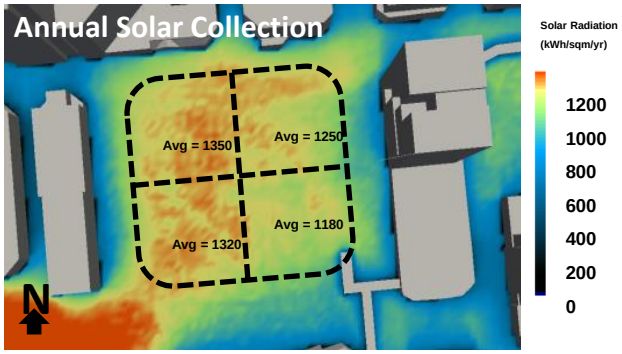
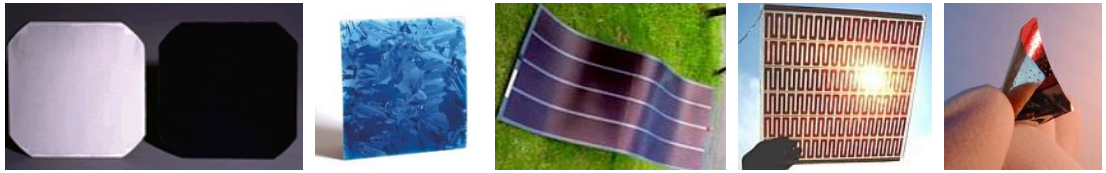
Renewable Energy: Solar Energy











Citation:
Cheng, V.S.Y., Tong, J.C.K. (2014). Effect of Urban Density on PV Performance. In M.A. Gill (Ed.), Photovoltaics: Synthesis, Applications and Emerging Technologies (pp. 173-196). Nova Science Publishers, Inc., Hauppauge, NY.

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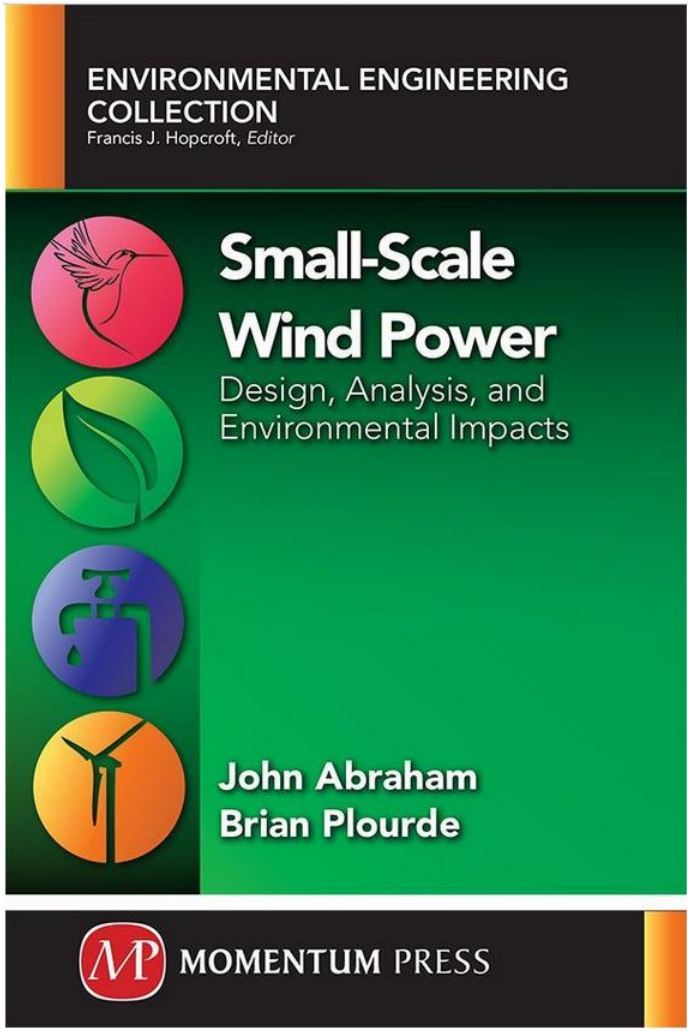
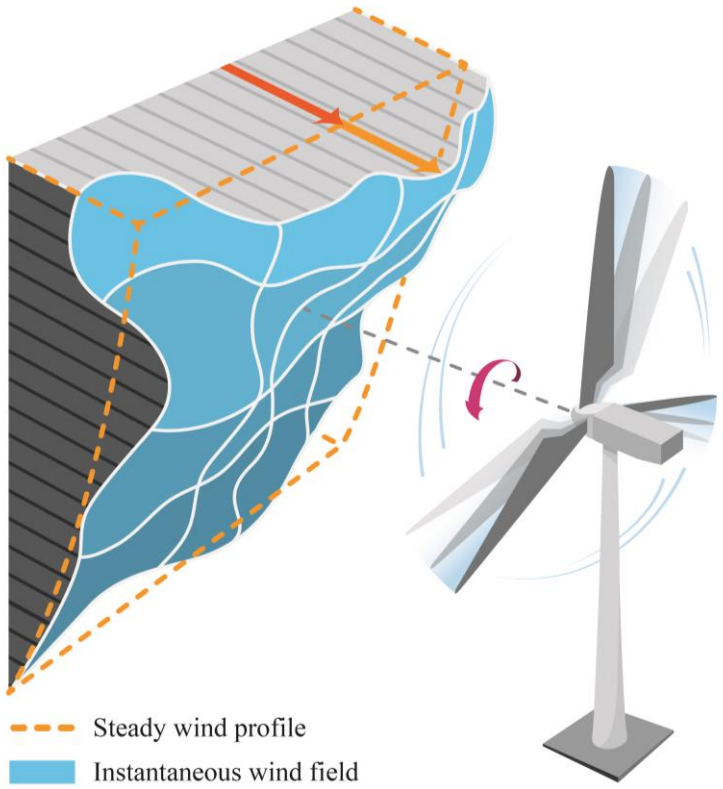
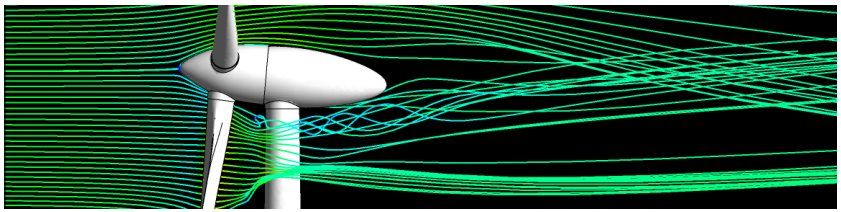
Renewable Energy: Wind Energy



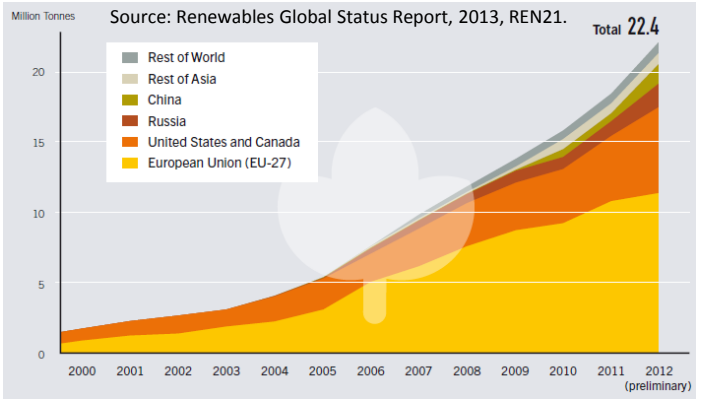




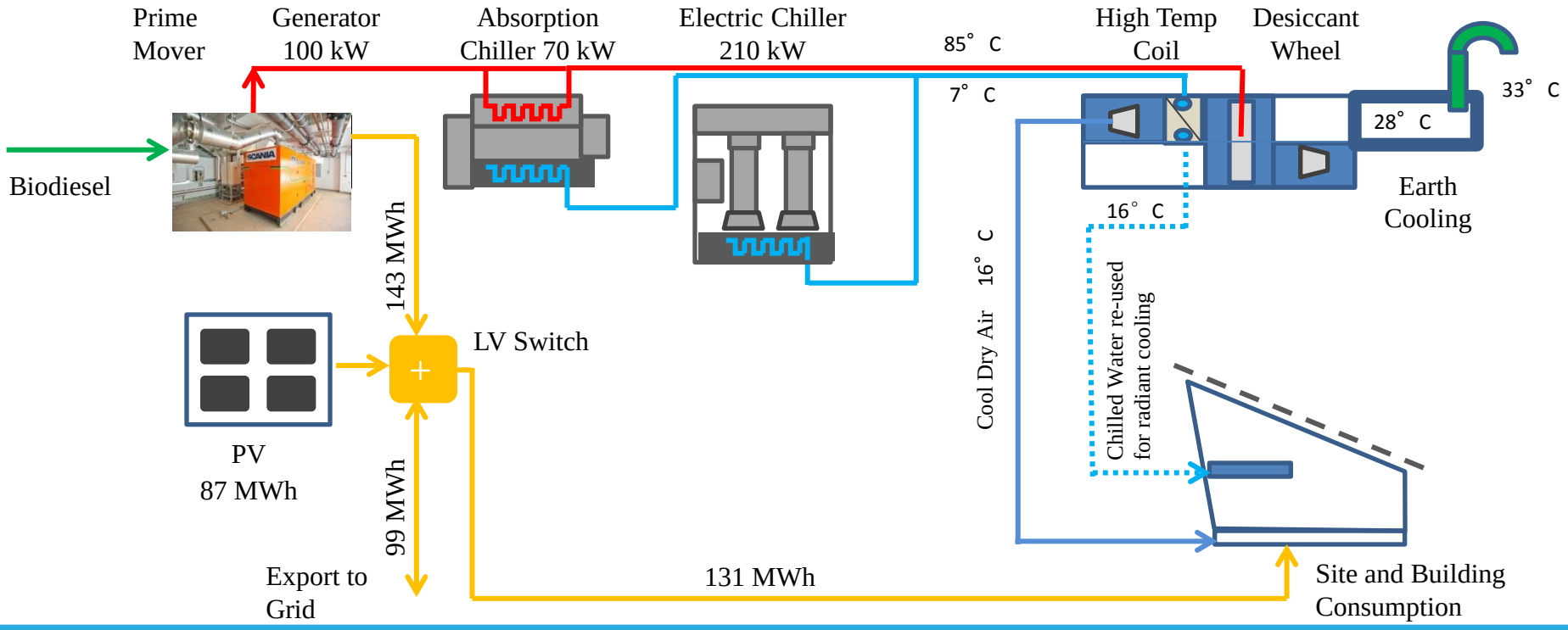
Citation:
Tong, J.C.K. (2014). Numerical Simulations of Small Wind Turbines - HAWT Style. In J.P. Abraham and B. Plourde (Eds.), Small-Scale Wind Power: Design, Analysis, and Environmental Impacts (pp. 129-146). Momentum Press, New York, NY.

Renewable Energy: Biodiesel Tri-generation System

- Power generation by combustion of Biodiesel
- Hot water from waste heat for dehumidification and space cooling
- Zero carbon emission source for space cooling and power
- Exceeded power supply to the grid for embodied carbon trade-off



Wood Pellet Global Production, by Country or Region, 2000–2012



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Beyond Built Environment

What else can we do to go beyond?

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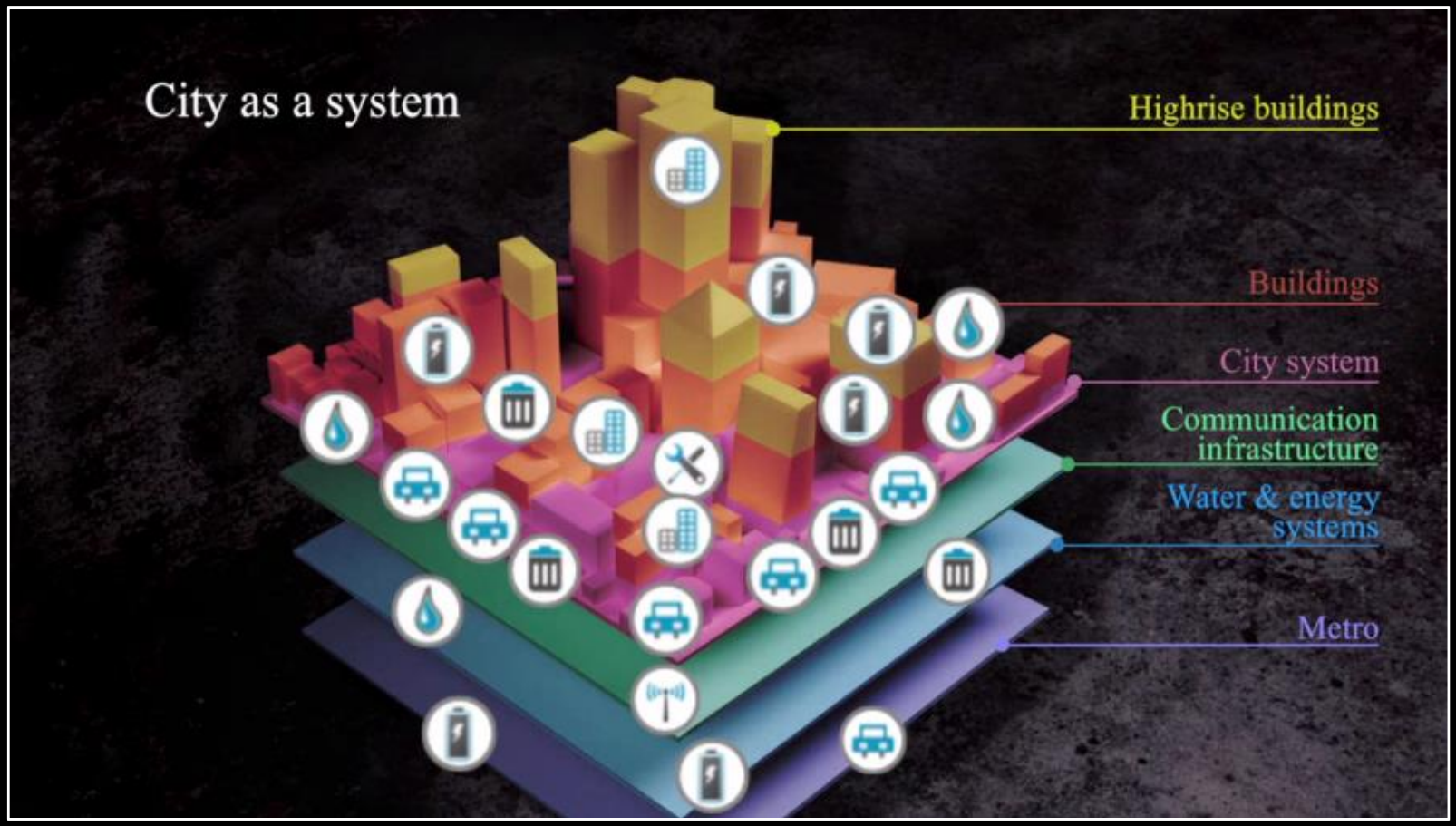
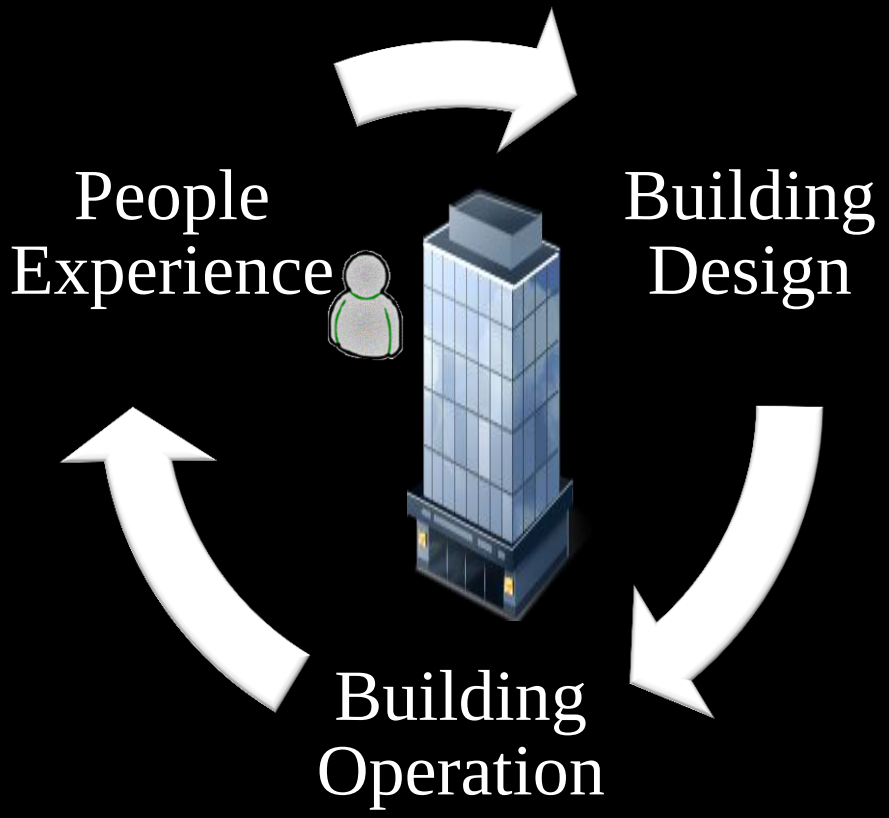
Step Changes



New Model

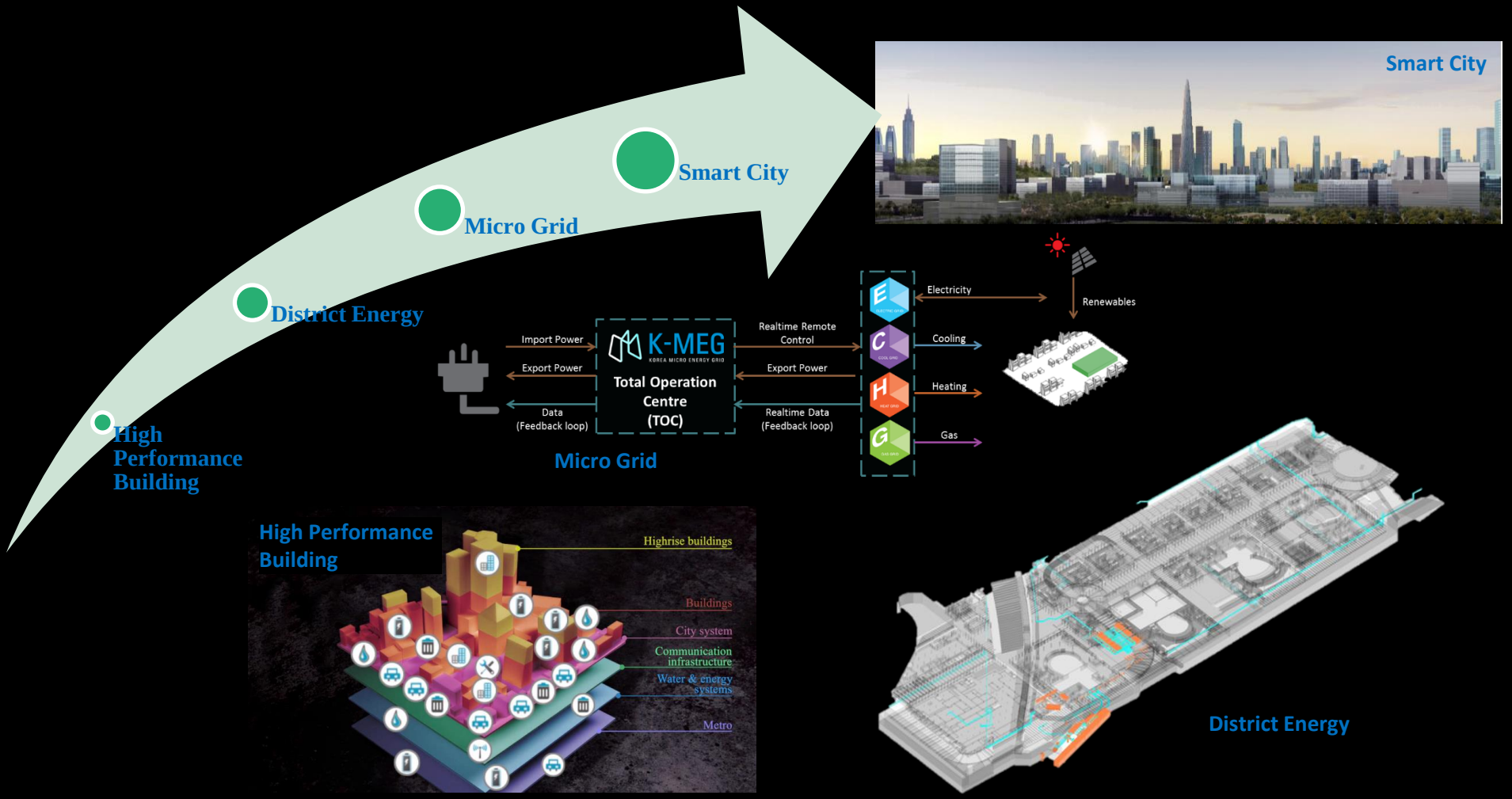
From Design to People



IEA EBC Annex 66 Occupant Behavior

Arup's Total Building Sustainability

Evolution from Building to Urban Development



Thank You!

Dr. Jimmy Tong, PE, MHKIE, BEAM Pro

Associate | Building Sustainability

Arup

Level 5 Festival Walk 80 Tat Chee Avenue Kowloon Tong Kowloon Hong Kong

+852 2528 3031

Jimmy.tong@arup.com

www.arup.com

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