Urban Metabolism

City Typologies

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Urban metabolism and city typologies

1. Urban world
2. Urban metabolism
3. Urban morphology
4. Urban typologies
5. Urban technology
1 urban world
Socio-metabolic regime change*: urban growth**

Materials use (DMC = DE) by material types, 1990-2005

* Krausmann, 2008 and 2009  ** Fernandez 2007
Graphs showing the percentage of renewable and nonrenewable energy sources, with a peak around 1960 and a transition towards urban energy use by approximately 2008.
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urban metabolism
Urban Metabolism

Urban metabolism is the study of the physical flows required to serve the urban economy.

Master diagram – urban material flows – UrbMet.org
Import – export mass balance

Import and export, physical flows.

[Map and data visualization showing import and export mass balance over time with population growth from 1.65 in 1960 to 3.35 in 2005.]
Urban Metabolism of Singapore

DMC_{mobility}

DMC_{built
environment}

DMC_{goods
d_and
services}

DMC_{total}
Characterizing Singapore’s Water Dynamics
Singapore city-wide data

- **DMC (MT/cap.)**

- **Electricity (kWh/cap.)**

- **Water (m³/cap.)**

![Graphs showing relationships between GNI and DMC, Electricity, and Water consumption.](attachment:graphs.png)
Resource intensity of urban form
Neighborhood Analysis Tool

Population density of US

David Quinn, MIT PhD candidate
Daniel Wiesmann, IST PhD candidate
Urban resource intensity mapping
Atlanta Georgia: kilometers traveled per household to 19 services
Urban metabolism of the Back Bay
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urban morphology
urban typologies
Global City Typology

Typological characterizations along multiple axes

1. Economic
2. Historical, cultural
3. Physical, formal
4. Ecological, ecological services
5. Population, development, density
6. Resources, inputs/outputs/emissions

1. Krugman, Fujita, Florida, Glaeser,
2. Benevolo, many others and Fernandez
3. Angel, Adolphe, Batty, Bettencourt
4. Pickett, Grimm,
5. UN, World Bank, OECD
6. Urban metabolism community, Wolman, Kennedy, Saldivar-Sali, Noiva
Global developments have had an increasing impact on contemporary cities, regions and territories from the societal, economical and geographical points of view. Since 1998 the impact of world cities into globalization has been extensively studied by the Globalization and World Cities (GaWC) Research Network.

GaWC provides a geographic and economic-based overview of the world and its evolving configuration. Particularly relevant in this discourse is its categorization of world cities into α, β and γ tiers, based upon their international connectivity.

If the world is observed from the point of view of the connectivity of the world cities, a new image emerges, where each city is virtually oriented to other cities of the same level of interconnectivity. National or continental maps give way to a new world configuration intended as an archipelago, where each city appears utterly separated from its geographical surroundings and closer to other cities of the same level. The leading parameters for the new configuration are based on mutual connections, primarily in the global economic system.

The atlas shows the world cities according to the GaWC categorization of 2010. From this, a new configuration emerges, where expected national and local boundaries are presented in their real disposition based upon their international connectivity.

Shape of connectivity amongst world cities of same tier and Proportional Global Network Connectivity (GNC) Scores 2010, according to GaWC.

Map of Global Cities 2010. The map clearly shows areas of the world rather dense and others almost irrelevant in terms of world city connectivity.
Can cities be grouped in terms of their resource consumption?

Goals

- Identifying distinct states of urban resource consumption
- Understanding the basis for transitions between states and contributing to urban transitions literature
- Identification of clear models (species) of urban resource consumption – important for design
- Ultimately, contribution to policy discrimination – specific types of policy most appropriate to specific types of cities
Global City Typology

- Consumption
- Statistical analysis
- Case study affirmation

A typology based on urban resource consumption is partly discovered and partly constructed from available data and recent findings.
City typology: results of Phase I
Results of Phase I

Low levels all 8 categories
Most challenging developing regions

Kolkata, Islamabad, Phnom Penh, Dhaka
Lagos, Mumbai, Nairobi, Quito
Manila, San Salvador, Panama City, Cali
Casablanca, Tunis, Lima, Rabat
Bogota, Asuncion, Vilnius, Amman, Ulaanbaatar

EL is low (indicating relatively low standard of living) everything else medium
Significantly industrializing economies with access to abundant resources
Several are large cement producers (Bangkok, Mexico City)

Min, Hyderabad, Bangalore
Nagoya, Osaka, Yokohama, Tokyo
Beijing, Shenzhen, Bangkok, Istanbul, Mexico City
Belgrade, Tripoli, Sarajevo, Tehran, Budapest, Lisbon, Buenos Aires
London, Milan, Caracas, Barcelona, Madrid, Kuala Lumpur, Rome

TM, Bio, Con, low-medium.
TE, EL, FF, Ind medium, CO2 high
Members include mining and coal fed economies (Shanghai, Guangzhou, Johannesburg)

Kiev, Vladivostok, Santiago, Warsaw, Dublin, Athens, Prague, Berlin
Johannesburg, Cape Town, Guangzhou, Shanghai, Tashkent, Tel Aviv
Jerusalem, Hamburg, Copenhagen, Moscow, Seattle, Singapore
Abu Dhabi, Kuwait, Doha, Riyadh
Boston, Phoenix, Denver, Detroit, Vancouver, Melbourne, Sydney

All high
Low density + high affluence
Several have challenging climates (Phoenix, Detroit, Melbourne)
Transitions thought experiment
urban technologies
**PRODUCT DESCRIPTION**

Developed by Urban Green Energy (UGE) and GE Energy Industrial Solutions, the Sanya Skypump is a revolutionary hybrid system that combines electric vehicle (EV) charging with renewable energy generation. The Sanya Skypump sets Electric Vehicle (EV) owners free from reliance upon the energy grid. Urban Green Energy gave us an exclusive first look at this exciting energy-generating EV charger – hit the jump to see how it works!

The Sanya Skypump is a happy marriage between the GE WattStation and UGE’s solar-powered Sanya Streetlamp. The slim design can easily fit along roads or in parking lots, making EV charging easy and accessible. Many parking lots are already using solar-powered Sanya Streetlamps, so the Skypump would mesh in perfectly.

The Skypump is unique because it allows EV drivers to recharge their cars with green, renewable sources of energy. A UGE-4K wind turbine harnesses wind power, while solar panels on the Skypump’s roof generate electricity from the sun’s rays. The combined energy produced by the wind turbine and solar array is enough to significantly offset the charging station’s electricity use. The GE Wattstation can fully charge an average electric vehicle in only four to eight hours. The Sanya Skypump is an easy solution for electric vehicle charging that provides power, and nighttime illumination using renewable energy sources.

Features described by developers:

**Renewable Energy EV Charger**

The Sanya Skypump gives its users the assurance that the energy being used in their car is provided 100% by clean, renewable energy produced directly on-site. Powered by Urban Green Energy’s elegant 4kW turbine and taking advantage of GE’s advanced WattStation, the Sanya Skypump offers an excellent addition to the ever-evolving infrastructure necessary to support the electric vehicles entering the market.

**Advanced Casing, Graceful Design**

The heart of the Sanya Skypump lies at its base where the electronic components are safely and efficiently hidden from the elements. The base includes a touch screen which guides you through the different charging options, your notification preferences, and can display news and ads as needed.

**Dual-Axis Technology (DAT)**

UGE has developed and patented a revolutionary new dual axis design that eliminates the main concern of other vertical axis wind turbines, that of premature bearing failure. Through this technology, our turbines significantly outperform the competition by spreading both horizontal and vertical forces along the length of the axis. For you this means increased durability and power production along with lower vibration and resistance.

**Easy Assembly & Installation**

We have intentionally designed our Sanya line for quick, and easy assembly of all its components. From a turbine that can be assembled in about two hours, to slip joint towers, and an elegant enclosure for all the included electronic components, the installation of the Sanya Skypump is far from rocket science...

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**PROJECT DESCRIPTION**

**Department of Energy Finishes Largest Zero-Energy Building in US**

Walking the walk is key when playing the environmental game, which is why we’re thrilled to report that the United States Department of Energy has completed their new zero-energy research building in Colorado. It clocks in at 222,000 square feet and is the largest zero-energy building in the United States. Boasting 50% less energy usage than a conventional building of its size and a huge array of on-site solar panels, the new Research Support Facility is able to produce all the energy it needs to function without borrowing from the grid. The US government certainly seems to be leading by example with this passive beauty.

The Research Support Facility is located on the Golden, Colorado campus of the National Renewable Energy Laboratory. It will officially open in late August and it will be the working home of 800 federal employees. The building employs techniques new and old to reach its zero-energy status, many of which are hundreds of years old and help the building make the best of natural light from the sun as well as use the earth below it to help heat and cool the building.

Typical office buildings use as much as 30% of their energy expenditure on lighting – not so with the Research Support Facility. The entire east-to-west facing facade is made of as much glass as possible and brings light to all of the building’s interior spaces. It is also outfitted with a smart lighting system which sends employees an on-screen message on their computer monitor telling them when to open their blinds. Much of the construction material in the building is recycled including reclaimed steel natural gas pipes that are being used as structural columns. The DOE is hoping that this new building achieves a LEED Platinum rating for all of its green bells and whistles, and it looks like they have a great shot.
CO$_2$ fluxes from a tropical neighborhood: sources and sinks

**Eddy Covariance (EC) System**

Diurnal profiles of CO$_2$ fluxes measured by EC and emissions by source types estimated by bottom-up approaches. The green and black lines correspond to the average fluxes measured from Oct. 2010 to Oct. 2011 on weekdays and Sundays and holidays, respectively. The dashed lines indicate ±1 standard deviation of the measured fluxes on weekdays. The emissions were calculated for weekdays.
Recent Publications

1. City-Level Decoupling
   Urban resource flows and the governance of infrastructure transitions

2. Sustainable Urban Metabolism
   By Paulo Ferrão and John E. Fernández
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**Discussion...**