Sustainable service provision in cities – Building a City CLEWs framework

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Outline of Presentation

• Framing the issue
• Policy Relevant concepts and questions
• Strategy: *Mapping interactions between resource-to-service systems and identifying Urban Nexus points*
• Case Studies:
  - Water and Energy modelling in NYC
  - Early results from Stockholm energy service mapping
• Preliminary Conclusions of mapping and modelling efforts so far
• Next steps
For a city to function and prosper, a minimum set of services needs to be accessible (physically and economically) to its citizens.

The end goal can therefore not be to provide electricity, car lanes etc. to populations, but to deliver services: e.g. provide comfort, lighting and mobility.

In terms of how these services are provided, there is a set of conventional infrastructure solutions that cities tend to apply (e.g. large centralized water, wastewater, power and heat systems)

...but emerging innovative, and eco-systems based solutions have the potential to meet or partially meet one or several of those needs resource-efficiently, or even “resource-neutrally”

A service driven approach doesn’t necessarily stick to sectorial boundaries - identification and evaluation of such service providing solution therefore call for a nexus approach
UN-HABITAT 2013, State of the World’s Cities 2012/2013: Prosperity of Cities

...prosperity refers to a sense of general and individual socioeconomic security for the immediate and foreseeable future, which comes with the fulfilment of other, non-material needs and aspirations.
A high score on the infrastructure index doesn’t seem to guarantee a high prosperity index...

*How can we assess service provision not solely based on the level of infrastructure in place, but in terms of “enhancing prosperity”?*

*How can we include the interaction between seemingly parallel resource-to-service systems in our (CLEWs) assessment?*

Answering these questions might help evaluate the ”true gain” of unconventional and emerging technologies/solutions (e.g. green infrastructure)
Relevant city concepts: Urban metabolism

The extended metabolism model of the city (adapted from Newman 1999)
How are the flows in the Urban Metabolism framework interlinked, where are the feedbacks and how can these interlinkages assessed?
Cities demand Resilience in terms of...

- **Robustness / Systemic integrity:**
  - the amount of disturbance that a system can absorb while still remaining within the same state or domain of attraction

- **Coordination:**
  - the degree to which the system is capable of self-organization (versus lack of organization or organization forced by external factors)

- **Adaptability / Self-improvement:**
  - the degree to which a system can build and increase its capacity for learning and adaptation.

(Walker, Anderies, and Abel (2001))
How is this relevant for the City nexus framework?

- **Robustness / Systemic integrity:**
  - What capacity reserve and redundancy do the resource-to-service flows need to have, to absorb disturbances? How are CLEWs-interlinkages affecting this?

- **Coordination:**
  - are some of the resource-to-service flow options more and less dependent on centralized/external organization to function?

- **Adaptability / Self-improvement:**
  - how can we measure flexibility through a city CLEWs framework?
Exploring City Service Provision - Strategy

Map the variety of existing and potential chains/flows between resources and services

1. Define the essential services
2. Map how they are provided in case study cities
3. Track the dynamics and interlinkages of these flows
4. Identify measures to quantitatively assess these dynamics and interlinkages
5. Assess potential City CLEWs analysis tools
6. ...with added value through comparative analysis

Test approach and make comparative analysis based on generic/stylized city models for
- New York
- Stockholm
- Chicago
a New York City Case Study

- Development of a NYC WaterMARKAL model -

Building a foundation for modelling implications of long-term planning of water and energy in New York City

A Collaboration between the division of Global Energy Systems, Uppsala University and the Energy Policy and Technology Analysis Group, Brookhaven National Laboratory, USA

Conducted in 2011
Example of conceptualising urban water and energy flows (from NYC)

**Resources Delivered**
- Natural Gas (Canada, Imports...)
- Refined Oil Products (Fuel Oils, GSL, DSL...)
- Renewables (Bio fuels, Wind, Solar..)
- Electricity Imports (Upstate, NJ, Canada...)

**Conversion & Pre-Treatment**
- Hudson River (freshwater)
- East River (saline water)
- Upstate Reservoirs
- Groundwater
- Precipitation

**Distribution**
- Croton Filtration Plant
- Catskill/Delaware UV-Plant
- Desalination (e.g. R.O.)
- Pumping
- Disinfection

**End Uses**
- Space Heating (boiler/heat pump...)
- Lighting (incandescent/halogen/LED...)
- Cooling (Central AC/Heat Pump/...)
- Envelope/Ventilation
- Electric Appl. (Computers, TVs...)
- Refrigeration (Conv./Energy Star...)
- Cooking (Stove/Oven/Grill...)
- Water Heating (Electric/Oil/Solar...)
- Dishwashing (Machine/by hand...)
- Faucets/Shower (Conv./Low-flow...)
- Toilets (Conventional/Low-flow...)

**Post Demand Treatment**
- Municipal Solid Waste

**Transportation**
- Passenger Car
- Light/Heavy Trucks
- Electric Vehicles (EV’s)
- Public Transit – Buses
- Public Transit – Subway
- Commuter Rail – Passenger/Freight (Ship/Air travel)

**Wastewater Treatment**
- Newtown Creek
- Wards Island
- Hunts Point
- North River
- Owls Head
- Bowery Bay
- Coney Island
- Jamaica
- Tallman Island
- 26th Ward

Emissions Tracking at all Stages of Energy Use
Example of conceptualising urban water and energy flows (from NYC)

**NYC ENERGY SYSTEM**

- Natural Gas
  - Canada, Imports...
- Refined Oil Products
  - Fuel Oils, GSL, DSL...
- Renewables
  - Bio fuels, Wind, Solar...
- Electricity Imports
  - Upstate, NJ, Canada...

**NYC WATER SYSTEM**

- Hudson River (freshwater)
- East River (saline water)
- Upstate Reservoirs
- Groundwater
- Precipitation

**Resources Delivered**

**Conversion & Pre-Treatment**

- Distributed Generation
  - gas, geothermal, solar, CHP

**Distribution**

**End Uses**

- Space Heating (boiler/heat pump...)
- Lighting (incandescent/halogen/LED...)
- Cooling (Central AC/Heat Pump...)
- Envelope/Ventilation
- Electric Appl. (Computers, TVs...)
- Refrigeration (Conv./Energy Star...)
- Cooking (Stove/Oven/Grill...)
- Water Heating (Electric/Oil/Solar...)
- Cloth washing (Conv./Energy Star...)
- Dishwashing (Machine/by hand...)
- Faucets/Shower (Conv./Low-flow...)
- Toilets (Conventional/Low-flow...)

**Residential & Commercial**

- Process Heat
- Combined H&P
- Machine Drive
  - E to buildings
  - W to buildings

**Transportation**

- Passenger Car
- Light/Heavy Trucks
- Electric Vehicles (EV’s)
- Public Transit – Buses
- Public Transit – Subway
- Commuter Rail – Passenger/Freight
  - (Ship/Air travel)

**Emissions Tracking at all Stages of Energy Use**

**Wastewater Treatment**

- Municipal Solid Waste
- Waste & Wastewater to Energy & Heating

**WATER TREATMENT**

- Croton Filtration Plant
- Catskill/Delaware UV-Plant
- Desalination (e.g. R.O.)
- Pumping
- Disinfection

**Eco-system Services / Green Infrastructure**

**IN-CITY GENERATION**

- Ravenswood (ST & CC)
- Astoria (ST)
- Brooklyn Navy Yard (CC & ST)
- Arthur Kill (ST)
- East River (ST & GT)
- Kennedy Intl. Airport. (CC)
- Astoria (CC & GT)
- Narrows (GT)
- Gowanus (GT)
...
a New York City Case Study – the Reference Water-Energy System

NYC REFERENCE WATER SYSTEM

SOURCES [MGD]
- Imported water: Upstate Water 1335
- In-city water: Groundwater 108
- Freshwater 358
- Saline Water 2231
- Recycled Water 0.0
- Precipitation 551

TRANSFORMATION [MGD]
- Upstate Water Consumption 276
- Residential 770
- Commercial 133
- Industrial 75
- Public 124
- Energy Production 588
- Irrigation 0.7

WATER USE SECTORS [MGD]
- Public Supply 1107
- Combined Sewer 1475

WASTEWATER SYSTEM [MGD]
- WPCP
  - Rockaway 21
  - Oaktown beach 29
  - Fort Richmond 30
  - Red Hook 32
  - 256th Ward 56
  - Tallman Island 59
  - Jamaica 83
  - Coney Island 86
  - Owls Head 96
  - Bowery Bay 104
  - North River 124
  - Hunts Point 127
  - Wards Island 290
  - Newton Creek 221

DISCHARGE [MGD]
- Septic Tanks ~9
- Controlled Discharge 4048
- Uncontrolled Discharge (by default unknown) ~129

Data Year: 2005

Taken from R. Segerström’s Thesis Work Performed at the Brookhaven National Laboratory, USA.
a New York City Case Study – the Reference Water-Energy System

Direct Energy Interactions in the NYC Water System

Taken from R. Segerström’s Thesis Work Performed at the Brookhaven National Laboratory, USA.
a New York City Case Study
- indicative results

Early stage model testing where high and normal market shares of “low flow” appliances were compared.

Reductions in Water Consumption

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Reductions in primary Energy Consumption

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*Figure courtesy of R. Segerström’s Thesis Work Performed at the Brookhaven National Laboratory, USA.*
Simplistic model of Stockholm

- Development of a Stockholm OSeMOSYS model -

with capability to capture resource-to-services dynamics

In collaboration with UIUC, department of Urban Planning
Simplistic model of Stockholm

Initial test of using the OSeMOSYS model to assess urban resource-to-service patterns

- Only electricity
- Production of electricity happens outside the system, hence only import technologies and distribution modelled

Example A: Comparing lighting service, tested in two scenarios

- 1: looking at how a decreasing price on efficient light-bulbs can affect overall system cost and electricity consumption
- 2: keeping light bulb prices equal, assessing how an increased price on grid electricity (e.g. through a carbon price) affects the cost-effectiveness of efficient light bulbs.

Example B: Adding decentralized electricity production option to the model

- Including PV-roof top modules to the system (coarsely modelled)
- Assessing the economics of this technology when modelling an increasing carbon price
Pushing for Efficient lighting: Test run for decreasing price off efficient bulbs

- **Price of Incandescent bulb**
- **Price of Efficient bulb**

- **Production of Incandescent bulbs**
- **Production of efficient bulbs**
Stockholm: Preliminary results

Total Stockholm multi-family residential electricity demand:

With current prices for efficient light bulbs

With decreasing price for efficient light bulbs
Testing the potential impact of a higher carbon price on selected appliances (or “service supplying technologies”)
- Efficient light bulbs
- Roof-top PV-modules on Multi-family household buildings
Early conclusions: benefits of OSeMOSYS to assess urban resource-to-service flows

- Flexibility: the model can be driven by "service demand" rather than "fuel demand" (opens up for assessment of efficiency/conservation measures)
- Technology neutral and optimizing on cost
- Harvesting the benefits of the developed resource flow assessment tools already in use
- Opening up for the possibility to link regional/urban assessments with national and multi-national analysis
- Open-source, accessible and transparent
Next Steps

Coupling OSeMOSYS with the **Land-use Evolution and Impact Assessment Model**,
Next Steps
Next Steps

CITY PLANNING SUPPORT TOOL

OSeMOSYS

LEAM

...
Long term vision of such a City Planning Support Tool

To contribute to the research community addressing challenges of global population growth and urbanisation

Desired use of the build up Urban CLEW model

- Evaluate integrated solutions for
  - energy access and
  - water & sanitation?
- Assessment of the technological opportunities
  - in combination with analysis of social dynamics
  - and political dialogue
- Using easy to access, open source modelling tools with the potential to spur broader review and application.

*Most of this growth is expected to occur in informal settlements in large cities.*
Thank you!

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