COMBINING URBAN METABOLISM METHODS AND SEMANTIC 3D CITY MODELS

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Outline

- Urban Metabolism – stocks and flows
- Literature review
- CityGML and Relevant Application Domain Extension
  - Studies described using CityGML
- Feedback and Future Future steps
  - Advantage of 3D City Models
  - Limitation of current 3D City Models
  - Linking to System Dynamic tools

Urban Metabolism

- Metabolism is originally a biological concept describing the processes through which organism produces, maintains, and destroys its materials substances and energy
- Urban metabolism: a framework for operationalizing resources flow within cities to find possible improvements
- Concept to support sustainable development
  - Reduce input of resources
  - Increase efficiency of transformation
  - Reduce output of waste and pollution
- Examples of urban stocks and flows: (Energy, Materials, Water, Food, People, Money)
- Practical implementation of the concept to urban metabolism in spatial urban development has been limited

Findings of the literature review

- 2 different type of studies:
  - Indicator studies – Quantifying environmental impact and city development
    - Mostly based on the city as a whole → spatial aspect of flows within the city is neglected
    - Consider single flows or combined flows
    - Examples of indicators: Total inflow of metals, domestic material consumption, eco-efficiency
  - Sub areas studies (Fluxes) – stocks and flows of different sub-areas within city
    - Include spatial aspects, city is represented in form of nodes or cells
    - Produce maps of flow courses
    - Mostly focus on flows of people
- Time scale: one year or time series over several years

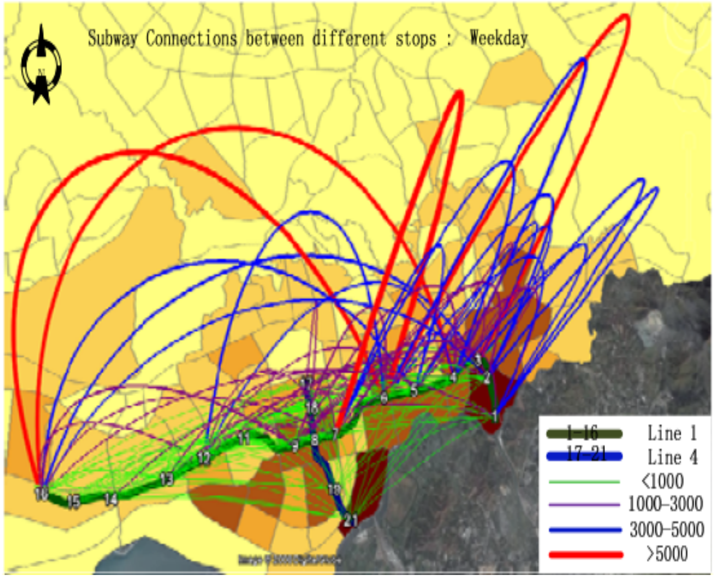
Findings of the literature review

- Required input data:
  - Numeric (e.g. volume of freshwater consumption)
  - Relational (e.g. relationship of several elementary indicators to one complex indicator)
  - Spatial (e.g. layout of public transport network)
  - Temporal (e.g. hourly energy consumption)
- Main problem:
  - Availability of data (on sufficient spatial resolution)

Findings of the literature review

Output:

- Elementary indicators (e.g. freshwater consumption)
- Complex indicators (e.g. eco-efficiency)
- Spatial visualization of flows (e.g. flows of people using the public transport network)
- Additionally: time series (historic or trend prediction)

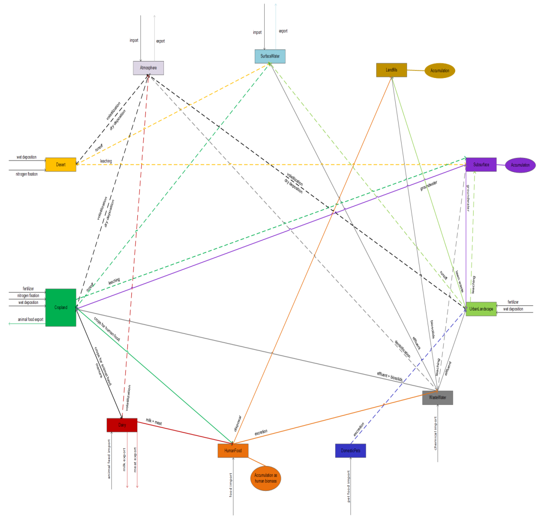


Modeling in CityGML

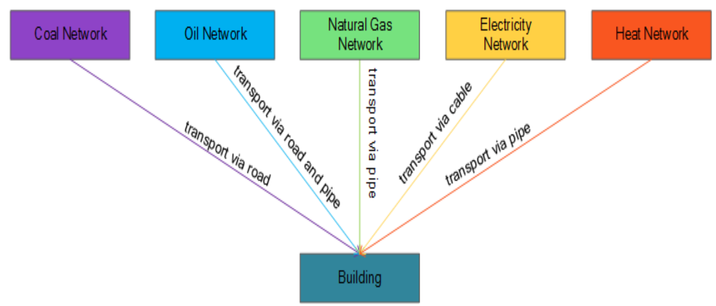
- CityGML = data format for geometric and semantic representation cities
  - Visible representation of a city (e.g. buildings, streets, vegetation)
  - "Hidden" information (e.g. year of construction, usage)
- Additional models used:
  - General Indicator Model: framework for connecting indicators to CityGML objects [Elfouly et al. 2015]
  - Utility Network ADE: extension for modeling networks (topographically & topologically) [Becker et al. 2012, Kutzner & Kolbe 2016]
  - Dynamizer ADE: extension for modeling time series of indicators [Chaturvedi & Kolbe 2017]

Case studies described using CityGML

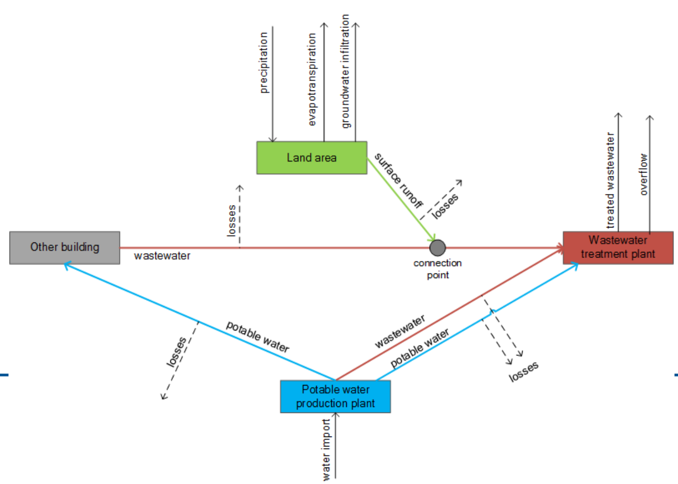
Nutrient Stocks and Flows



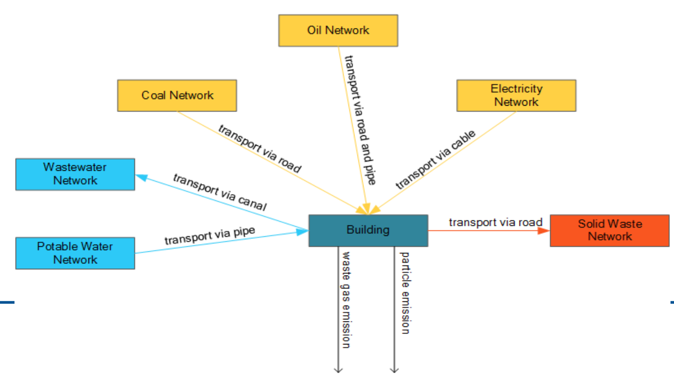
Energy and carbon Stocks and flows



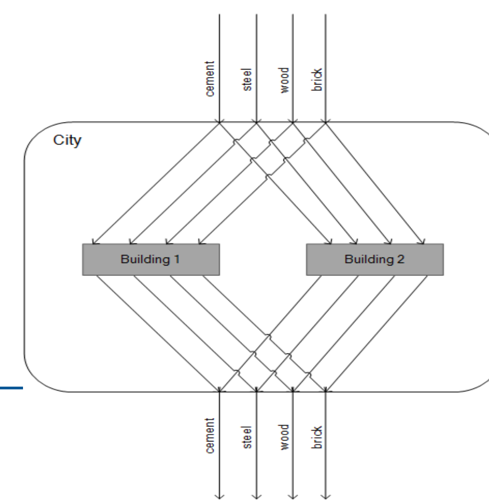
Modeling of water flows



Modeling of Eco-Efficiency



Material Stocks and Flows



Findings: Advantage of 3D City Models - CityGML

- Availability of data is improved
- Data is provided on building / street scale level
- A common modeling framework is provided
- Automatic derivation of data is possible
- Information on data accuracy is provided

Standardized semantic 3d city model could serve as a holistic and uniform database of urban areas combining urban stocks and flows with a 3d city model could facilitate the study of urban metabolism and thus support sustainable urban planning and design

Findings: Limitations

- UtilityNetworkADE:
  - Representation of commodity flows via road and rail not covered
  - Representation of natural (diffuse) flows, entities like atmosphere or subsurface aquifers need to be added
- Indicators
  - Lack of CityGML object attribute for storage of indicators
  - Modeling of indicators related to vehicles
- Dynamizer
  - No limitation, provide temporal change of indicators
  - Suitable to track the yearly development of the city, provide the foundation for calculating average values.

Findings: Coupling to urban dynamics