Presentation JB Baher, Leonardo and Yulya

Urban metabolism (UM) questions cities' material and energy systems by identifying paths and transformation processes of all kinds of flows in urban contexts.

In particular, one of its objectives is tracing the origin and destination of materials, energy, water, emissions and waste flows to understand relationships between the cities and other spatial areas (hinterlands) that lead to political, social and environment consequences.

We propose a new approach which combines methodologies to understand the politics of UM and to analyze metabolic links between hinterland and consumption territories, in order to develop a "political-industrial ecology" of urban metabolism (Breetz, 2017; Cousins and Newell, 2015).

A framework for the metabolic relationships between cities and hinterlands towards circularity?

A comparison between Nantes St Nazaire (France) and Gothenburg (Sweden)

Summary

I. Context & research question**: The territorialisation of Urban metabolism: the "flow" approaches and the "territory" approaches**

II. Three ways to do it**:**
   - **I. Analyze flows of materials and the metabolic-spatial relationships with hinterlands**
   - **II. Identify local opportunities for industrial symbiosis**
   - **III. Interrogate social relationships and infrastructure in the Circular economy**

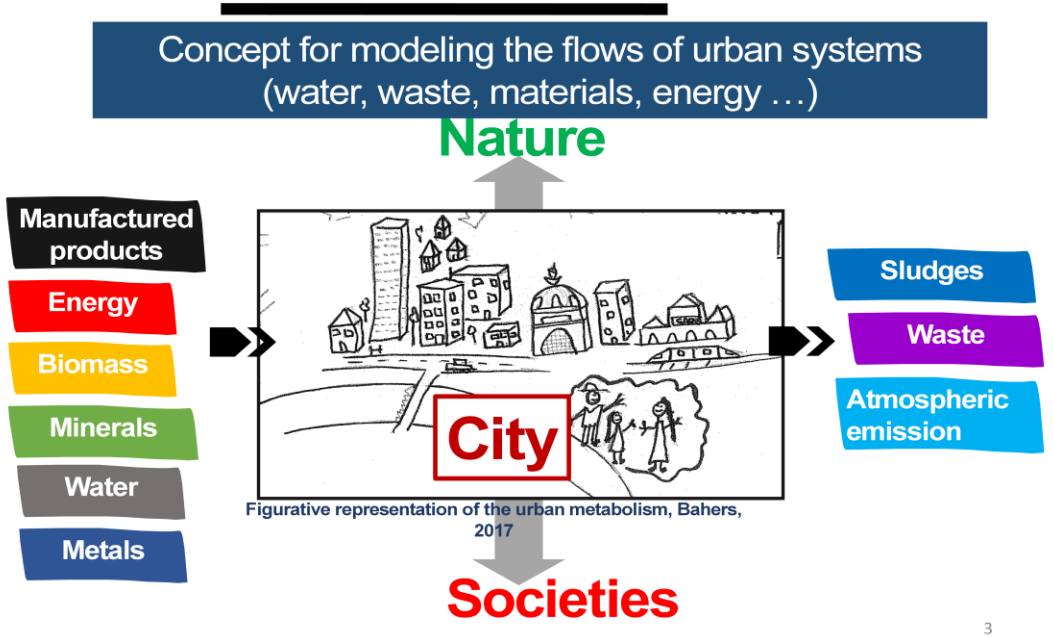
III. Conclusion**: A transition or consolidation of the dominant regime?**

I. From industrial ecology and social geography

II. According to previous works and future works.

III. A political context of circular economy ?

I. Context & research question: **The territorialisation of Urban metabolism:**



Figurative representation of the urban metabolism, Bahers, 2017

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Cities are at the heart of nature-society interactions. Nature provides resources (biomass, energy, etc.) to urban societies, which consume them and reject surpluses in various forms: solid wastes, liquids, atmospheric emissions, urban sludges that impact nature in return.

These flows are analyzed in the context of urban metabolism which aims to understand how cities consume and transform energy and all types of materials (inputs and outputs).

It is therefore a formidable theoretical framework for modeling urban flows

And which challenges the notion of circular economy, which is a new paradigm that is flourishing in the operational sphere today, and aims to break this non-virtuous cycle of the linear economy and to end the wasteful management of waste and the depletion of resources

However, there is a need to spatialize and territorialize these systems

Territorialisation of Urban metabolism

Significance of interrelated relationships between cities and supply and discharge territories

Figurative representation of the urban metabolism, Bahers, 2017

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That's what I tried to imagine by sketching it here
These flows link urban societies to other territories, which receive their waste and supply them with:
- Energy and biomass for food but not only

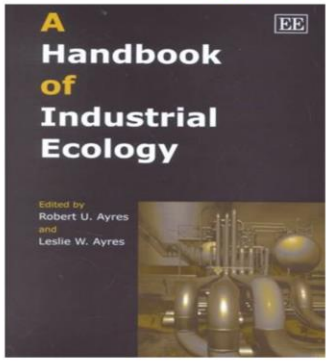
- In materials, manufactured products, wood for different industrial and service uses
-

Transported by truck, freight and maritime transport via port infrastructures

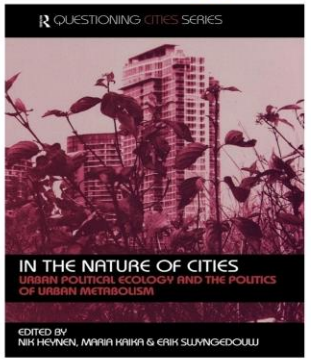
Thus, sustainability, via urban self-sufficiency, is not considered at the city scale alone, but highlights the links of interdependence with the supply and discharge territories.

The three « ecologies » of urban metabolism

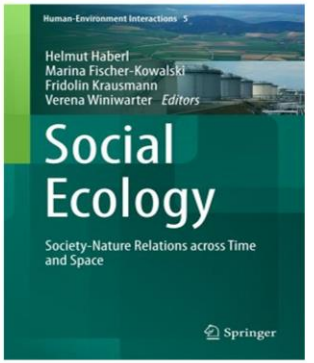
Industrial Ecology



Urban Political Ecology



Social Ecology



Towards the "**political-industrial ecology**"

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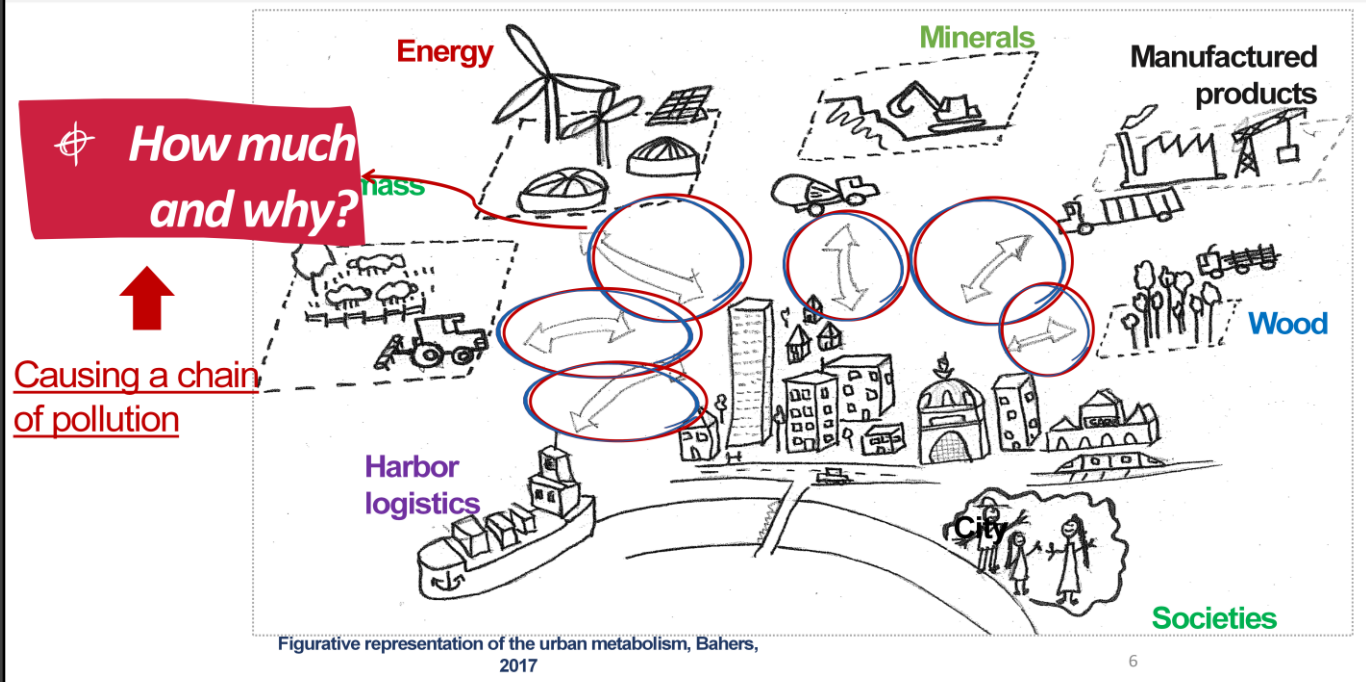
Three scientific currents mobilize the concept of urban metabolism and argue in such a tumultuous way:
- There is the Industrial Ecology, from the engineering sciences, which focuses on the intensity of flow circulation
- There are the proponents of Urban political ecology, geographers and sociologists, who uses the term rift metabolic of MARX in order to characterize the decline of urban environmental conditions due to industrialization
- Then those of the Social Ecology which is interested in the evolution of the socio-ecological regimes

Metabolic relationships and political-industrial ecology



Figurative representation of the urban metabolism, Bahers, 2017

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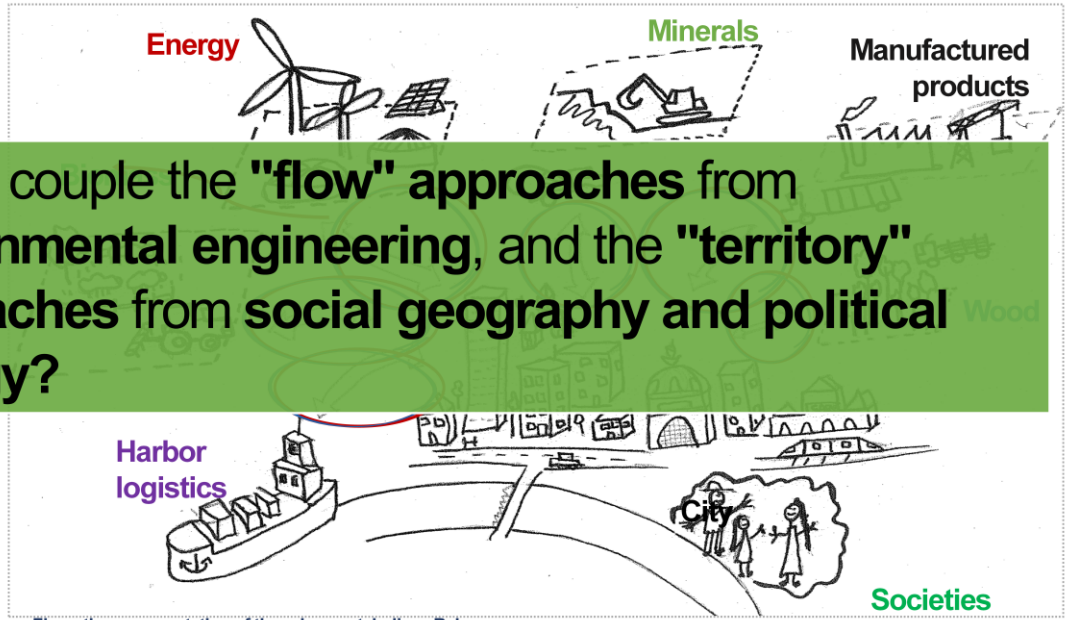
The objective of this research is twofold.
First, it aims to tracing materials and energy flows (as How much), in order to provide insights on its territorial organization (as Why here).

Transited through these port cities, flows of goods and energy are very important that cross the oceans to the regions concerned, **causing a chain of pollution** that extends local emissions through distribution and consumption, but also through ocean pollution related to transportation.

Metabolic relationships and political-industrial ecology



How to couple the **"flow" approaches** from **environmental engineering**, and the **"territory" approaches** from **social geography and political ecology?**

Figurative representation of the urban metabolism, Bahers, 2017

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It highlights the heterogeneity in the visions for the territorialisation of circular economy by the actors and how it compares to what it is observed physically with the flows ?

Second, these results will be be used to discuss the potential contribution of a socio-material framework to understand relationships (power and synergies relations) to evaluate transition initiatives currently investigated in the territory.

The role and influence of different actors on metabolic flows and their management are a key issue to understand the governance of flows.

Case study: *Nantes-Saint-Nazaire* harbor & city

Nantes Saint-Nazaire metropolitan area: a claimed "eco-city" ambition

éco.Métropole
Nantes Saint-Nazaire

Dossier « Eco-cité » du pôle métropolitain
ource : Agence d'Urbanisme de la Région Nantaise, 2013)

Port de Saint-Nazaire
(Source : Agence d'Urbanisme de la Région Nantaise, 2013)

We have studied the Nantes Saint-Nazaire metropolitan area, which is constituted by an urban area and a port zone.

This harbor consists in a complex network of highly energy-intensive industrial sites operating in the steel, petrochemical and agri-food industries.

In particular, the territory is home to the 2nd largest crude oil refinery in France.

Case study: *Goteborg* harbor & city

Gothenburg: a model sustainable city?

Source : Gothenburg Centre for Sustainable Development

Source : https://www.portofgothenburg.com/

Gothenburg is home to the largest port in Scandinavia, which handles almost 30% of Sweden's foreign trade (42 and 22.2 million tons of freight and oil respectively) and 1.7 million passengers per year.

Goteborg is seen as a city that is very dynamic and pioneer in terms of sustainable development, which is currently reflected in a transition to the circular economy.

II. Three methods to do it:

Approach 1: **Analyze flows of materials and the metabolic-spatial relationships with hinterlands** *(slides 11-16)*

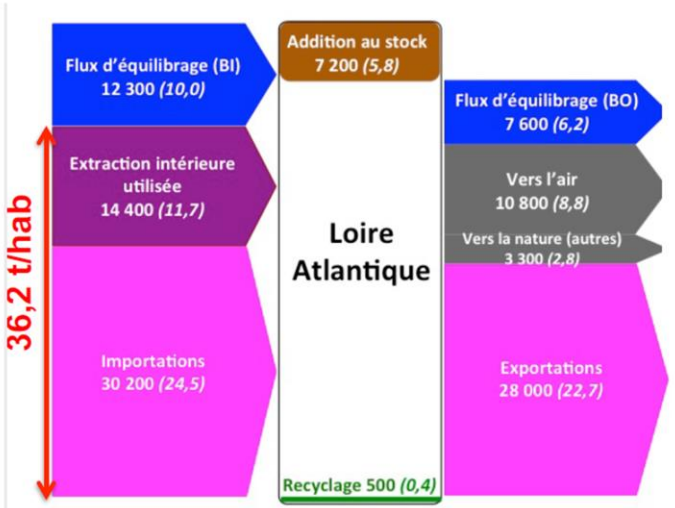
Approach 2: **Identify local opportunities for industrial symbiosis** *(slides 17-20)*

Approach 3: **Interrogate social relationships and infrastructure in the Circular economy** *(slides 21-23)*

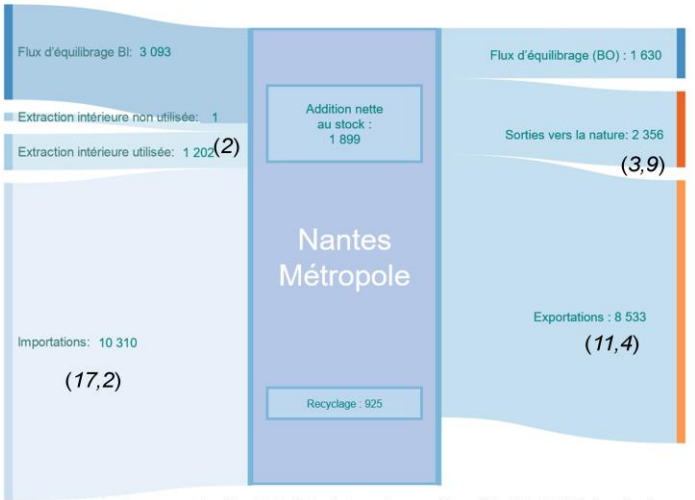
Three methodolgical approaches to adress the territorial dimension of UM

… which need to be coupled.

Approach 1 : MFA of port-cities (Nantes Saint Nazaire



S. Barles, 2016. data : 2003
Loire-Atlantique = Nantes Saint Nazaire metropole area (1,4 millions of hab., area = 6809 km^2, density = 206 hab/km^2)



Bahers et al., 2018: Nantes city (646 500 hab.)

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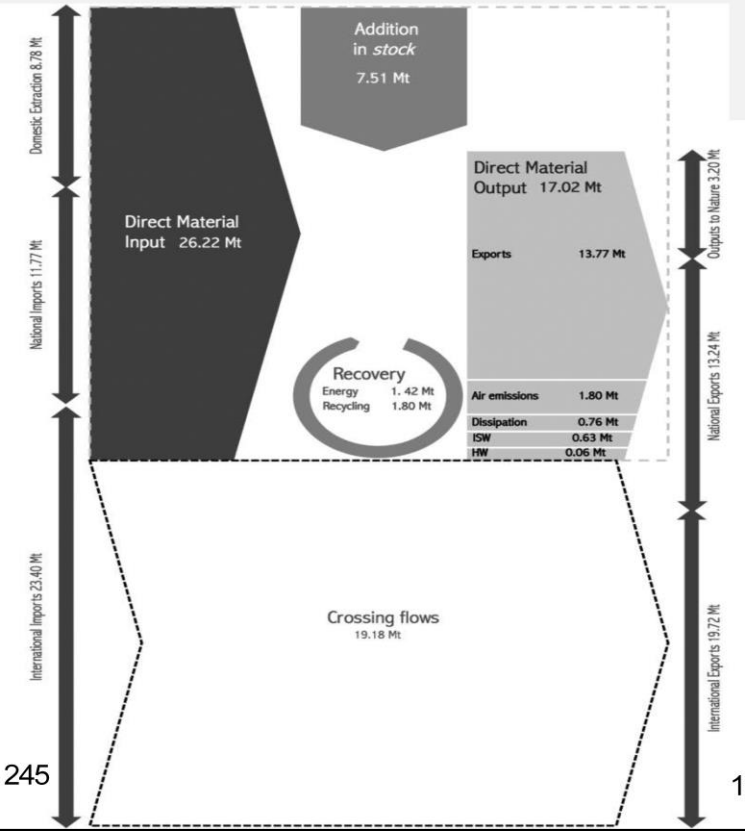
In Loire Atlantique : DMC = 13,5 t/cap / DMI = 36,2 t/cap

In Nantes : DMC = 8 t/cap / DMI = 19,4 t/cap

Results: MFA of port-cities (Goteborg)



Rosado, 2015. data : 2011
0.95 million of hab, area = 3695 km^2, density = 245 hab/km^2)

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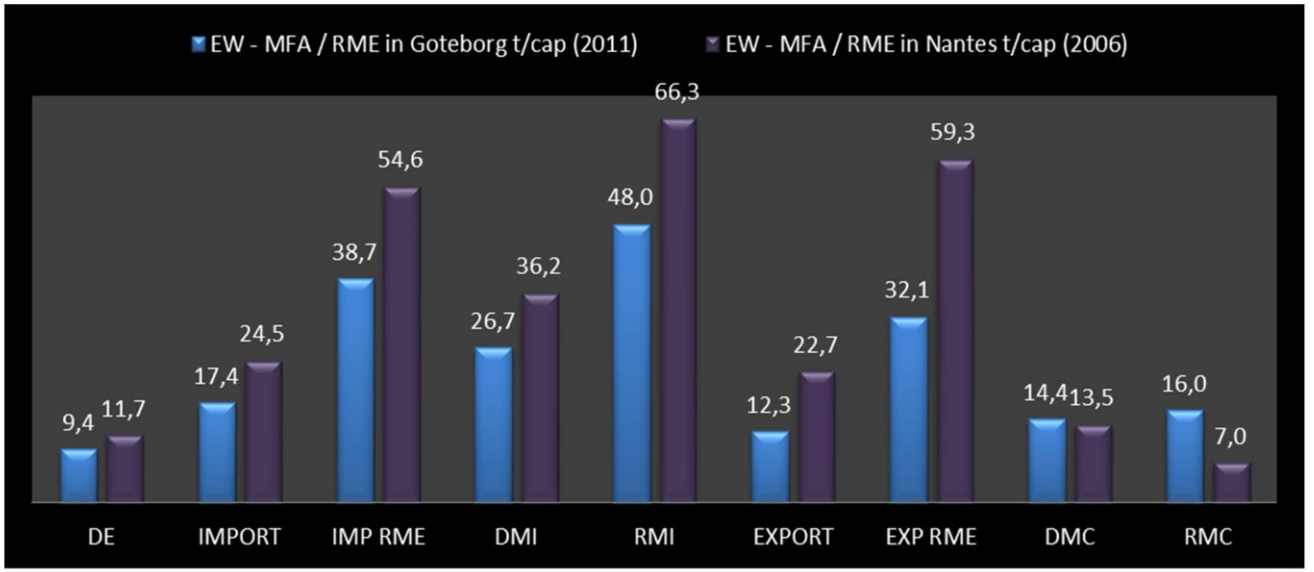
In Goteborg : DMC = 11,88 t/cap

/ DMI = 26,22 t/cap

Results: Comparison in RME



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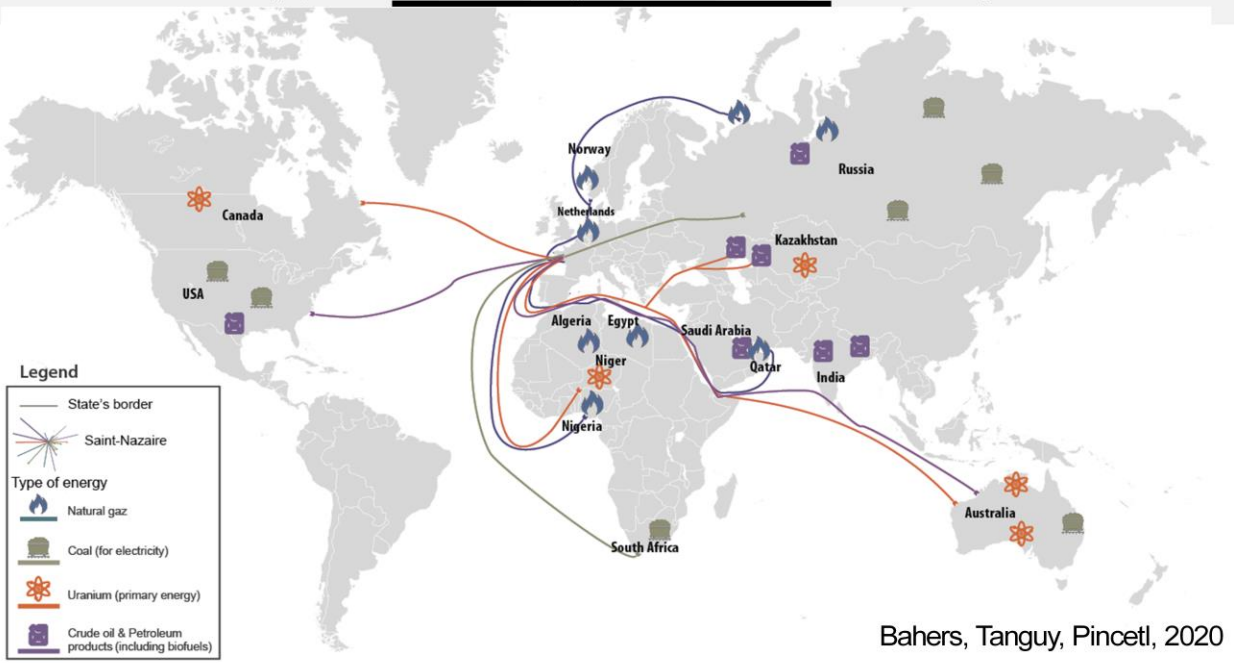
Raw Material Equivalents of Imports (IMPRME) account for the total amount of primary material extraction in foreign countries required along the whole supply chain to produce the imports.

Raw Material Consumption (RMC) illustrates the domestic final use of products in terms of Raw Material Equivalents. RMC thus captures the amount of domestic and foreign extraction of materials needed along all supply chains to produce the final products consumed in a country.

First results with the assumption of coefficient for RME-import and RME-export (Eurostat)

Approach 1: **Spatial relationships**



Bahers, Tanguy, Pincetl, 2020

Author: Bahers, Sources: CARENE, BASEMIS, GRAND PORT, AILE, World Nuclear Association, USGS 2015 © : projet OPTIMISME, UMR ESO CNRS, 2018

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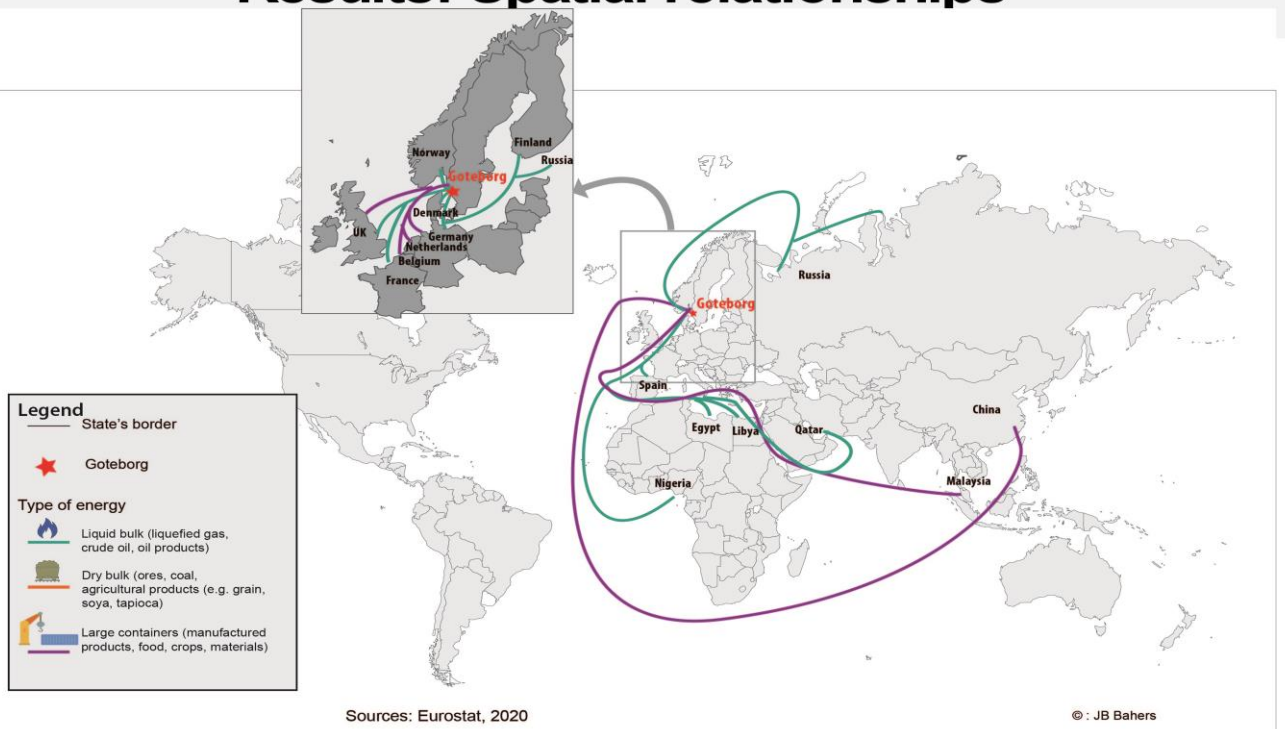
When the supply is observed under a primary energy perspective (uranium, coal, natural gas, crude oil and renewable), 97% of primary energy consumption come from foreign sources.

Therefore, the energy sector is highly globalized, characterized by an intensification of maritime transportation routes.
This situation is far from a potential for territorial autonomy, but reveal hidden flows (which consist of secondary energy consumption, such as electricity consumed in processing natural gas or diesel to transport wood or coal)

In the Saint-Nazaire port area, hidden energy flows account for most of the territory's metabolism.

Results: Spatial relationships



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Main imports of flows throug the port

It demonstrates the globalized material and energy footprint of cities.

The metabolic relationships' framework is useful to understand how the "hinterlands-city" relationships shape and are shaped by the city's metabolism.

Results: Spatial relationships

- **Harbors represent the hidden face of Supply chain of cities, as infrastructure of capitalocene**

- **The indirect flows of imports, towards externalization, towards Raw material equivalent (RME) for imports express a chain of pollution** that extends local emissions through distribution and consumption and a **dependency on a distant hinterland and ecological inequalities.**

- **Power relationships between supply and consumption territories (derived from metropolization of Brenner; world-ecology of Moore)**

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What spatial relationships reveal:

Hidden
Indirect
Power

Approach 2: **Identify local opportunities for industrial symbiosis**

$$\mathbf{M}_{n,m} = \begin{bmatrix} m_{1,1} & m_{1,2} & \cdots & m_{1,m} \\ m_{2,1} & & & \vdots \\ \vdots & & \ddots & m_{(n-1),m} \\ m_{n,1} & m_{nm} & \cdots & m_{n,m} \end{bmatrix}$$

Material Classes
Harmonization of Imports, Exports and Extraction
28 categories of materials for 13,135 products
Addressing material management issues
Recycling potential and economic value of waste

$$\mathbf{T}_{n,y} = \begin{bmatrix} t_{1,1} & t_{1,2} & \cdots & t_{1,y} \\ t_{2,1} & & & \vdots \\ \vdots & & \ddots & t_{(n-1),y} \\ t_{n,1} & t_{nm} & \cdots & t_{n,y} \end{bmatrix}$$

Average lifespan
Statistical distribution in time based on Weibull for 13,135 products

ACCOUNTING TECHNICAL FEATURES OF FLOWS PRODUCTS

$$\overline{IWR}_{ji} = \frac{1}{t}\sum_{t=1}^{4}\frac{w_{jit}}{\sum_{j=1}^{42} w_{jit}}$$

Industrial waste footprint
Waste generation profiles for 42 types of industries and 300 types of waste

$$IIR_{jk} = \frac{1}{t}\frac{I_{jkt}}{\sum_{i=1}^{1264} I_{jkt}}$$

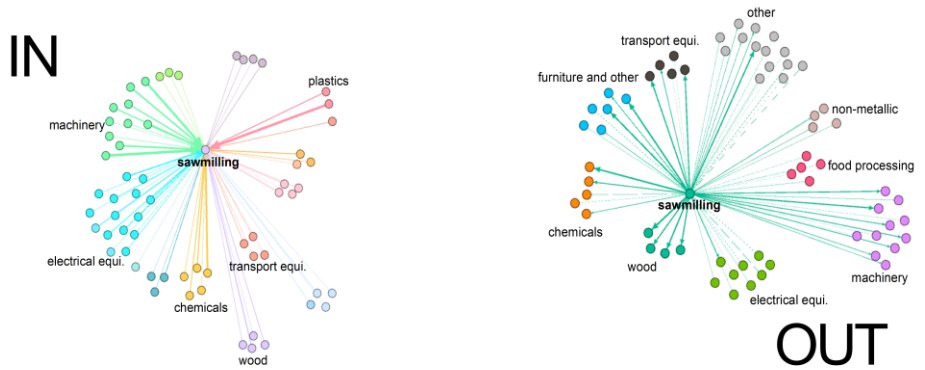
Industrial material demand
Weight of input materials for 103 industries and 1264 types of products

Life Cycle Impact
LCA for 71 representative products for all 10000 products for 6 impact categories

Patricio, Kalmykova, Rosado, 2019

With the flows of products and materials properly and with as much disagreggation possible (the UMAn model allows for 1000 product types) a set of databases can be developed to allow for obtaining more information about the resources used. The disagreggation of products into material types, the assignment of lifetimes to products, the description of waste profiles and material inputs in economic activities, and finally the life cycle impacts associated with them. This will allow describing the flows in multiple dimensions.

Approach 2: **Identify local opportunities for industrial symbiosis**

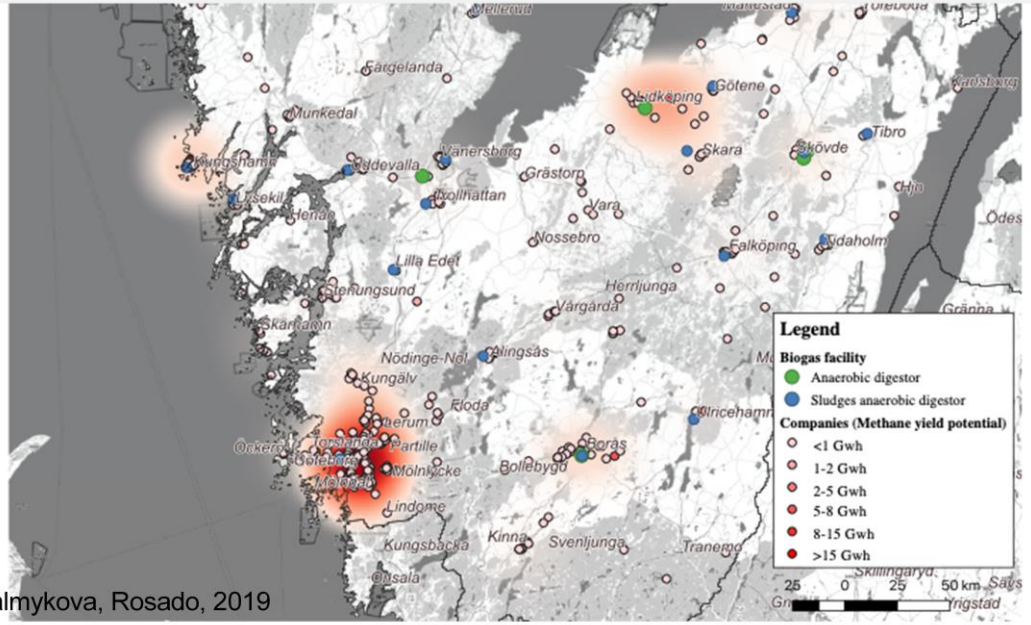


MAP DETAILED VALUE CHAINS

Patricio, Kalmykova, Rosado, 2019

One such dimension is to link value chains, by combining information about material input and output from each economic activitiy to the next, by looking into the origin and destination of 1000 products, plus 300 categories of wastes. This allows for describing theoretical value chains.

Approach 2: **Identify local opportunities for industrial symbiosis**



Patricio, Kalmykova, Rosado, 2019

IDENTIFICATION OF POSSIBLE WASTE EXCHANGES IN GOTHENBURG, WEST SWEDEN

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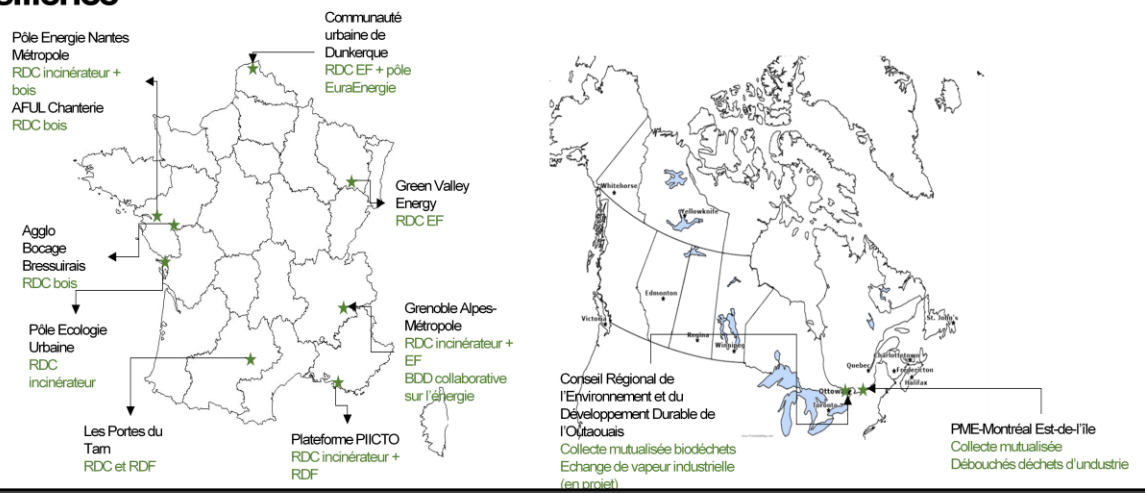
Using value chains descripttion it is possible to spatialize information by looking into specific flows and connecting them, for example, with identifying opportunities for industrial symbiosis. In this example, a characterization of all wastes with methane wield being produced by economic activities was made for West Sweden region and potential users of this wastes to produce biogas were geolocated. This allows for identifying within the boundaries of the studied region the spatial distribution of resources and where large concentrations occur to identify clusters.

Approach 2: The socio-spatial drivers of industrial symbiosis

According to 11 semi-structured interviews of leaders of industrial symbiosis (France & Quebec)

- **Economic legitimacy**, before environmental
- Most often **a-territorial** strategy (e.g. the distance is not important)
- Reflection in hollow of the project leaders on energy autonomy and **territorial resilience**



"The economic logic is above all. If the environmental assessment is positive, it is not enough. The economic logic must be found there. We cannot function only on public subsidies! » (Project manager at PIICTO, 2017)

Approach 3: Social relationships and infrastructure in CE transition

Type of territorial cooperation - Synergetic metabolic links	Interviews in Goteborg	Interviews in Nantes Saint-Nazaire
Proximity	- *"upscale good practices"* - *"economies of scale"*	-*"geographical proximity: an economic model where energy production would be close to consumption"*
Territorial autonomy	- *"inclusive economy and sharing costs";* -*"influence of regional planification"*	- *"building these interdependencies between territorial actors"* - *"solidarity between rural and city"*

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Regarding the actors, we interviewed 25 professional actors in Nantes-Saint-Nazaire and 5 in Goteborg , from the "circular economy" chain.

Topics of the interviews
- Spatial perception of energy transition and more generally of the management of energy resources (appropriation of the stakes, role of the spatial question, proximities)
- Territorialisation of energy policies (the role of territorial actors, the contribution of multi-scalar approaches, the confrontation of skills with sectors)
- Operationalization of energy synergies (infrastructures, networks, scales)
- Issues of taking metabolism into account (actors' configurations, dematerialization, short circuits

Approach 3: Social relationships and infrastructure in CE transition

Type power relationships and conflicts	Interviews in Goteborg	Interviews in Nantes Saint-Nazaire
Hidden flows	*"if we do the plastic ban, we would have to look for other more distant waste"*	*"hidden energy flows account for most of the urban metabolism "*
Competition around local resources	*"second hand are often reused (recycled ?) in Africa"*	*"various public authorities are not coordinated and are fighting for their legitimacy "*
The weight of infrastructure	*"waste import for good quality"*	*"these centralized networks cannot coexist with short supply chains "*

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Approach 3: Social relationships and infrastructure in CE transition

Vision of the spatial dimension of CE	Interviews in Goteborg	Interviews in Nantes Saint-Nazaire
Local and circular washing / modernization	*"politicians don't realize what they signed on to the metropolitan circular economy objectives"*	*"Local and circular : These are small solutions to give yourself a green image, but they are financial chasms"*
Business approach, lack of environmental dimension	*- "sharing costs"* *- "this is a green argument, being a pioneer allows you to sell to people concerned with environmental issues".*	*- "A big risk of rebound effect for the CE is to unconsciously launch into eccentric and very expensive solutions"*

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Discussion : Transition or consolidation of the dominant regime?

A socio-political context of circular economy?

A **socio-spatial and material framework**: combining methodological approaches to understand **a « political-industrial ecology » of urban metabolism** through relation between cities and supply territories

The contradiction of the CE transition in France and Sweden
It is difficult to impose CE transition when a territory is an important node of the global materials market. Fossil fuels, trade, waste management are still seen as great providers of employment.

That's why a socio-material framework of UM is very interesting to reveal:
What are the power conflicts between different materials/energy/waste stakeholders?
What are the spatial competitions for the resources and infrastructures ?

This leads to a political-industrial ecology perspective which extend the material flow approach to the social and political perspectives of urban metabolism.

References of the methodological approaches

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