

VILLES ET ECONOMIE CIRCULAIRE

Changement à la marge ou de système ?

Aristide Athanassiadis – 1er Juin 2023



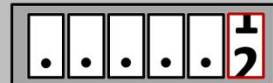
Aristide.athanassiadis@epfl.ch

EPFL

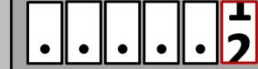


www.epfl.ch/labs/herus
www.metabolismofcities.org

ENERGY

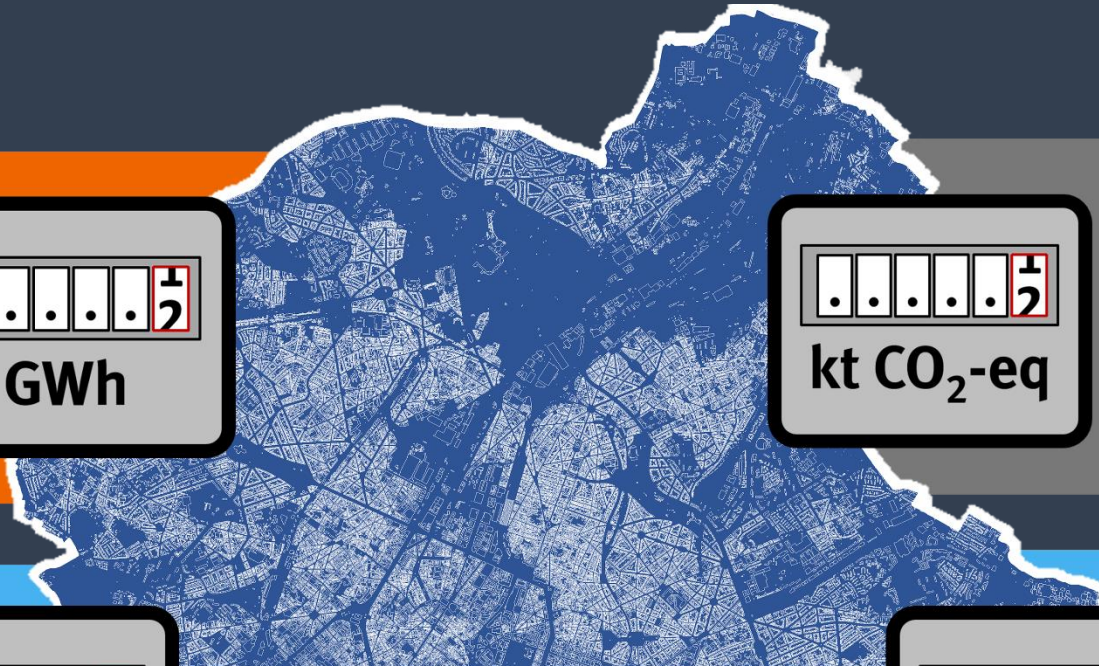


GWh



kt CO₂-eq

GHG EMISSIONS



Petite intro

**Chercheur,
Administrateur,
Accompagnateur,**

Quelques projets



INSTITUT DE CONSEIL ET D'ETUDES EN DEVELOPPEMENT DURABLE

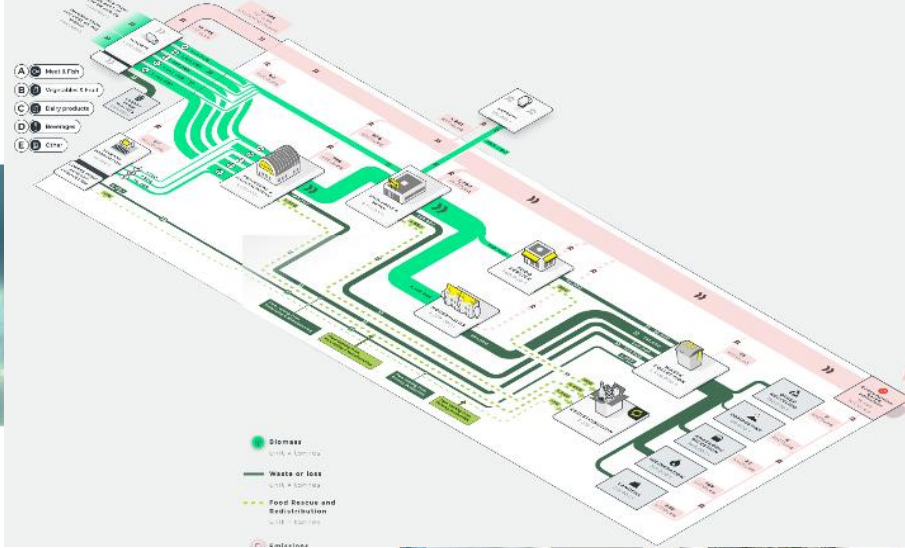


Métabolisme de la Région de Bruxelles-Capitale : identification des flux, acteurs et activités économiques sur le territoire et pistes de réflexion pour l'optimisation des ressources

Rapport final juillet 2015



EcoRes
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10 SECTOR-WIDE CIRCULARITY ASSESSMENTS

CITYLOOPS **METABOLISM OF CITIES**

MÉTROPOLÉ NICE CÔTE D'AZUR

Eaux Matières

Territoire: MNCA | Type de flux: Eau | Année: 2020 | Détail: Niveau 1

Flux	Valeur
PRECIPITATIONS	1 038 174 km ³
ACHAT D'EAU	6 635 km ³
IMPORTATIONS EAUX USEES	2 685 km ³
CAPACITE D'EAU	85 734 km ³
ASSAINISSEMENT	48 200 km ³
ASSAINISSEMENT NON-COLLECTIF	5 442 km ³
PERTES	30 316 km ³

POWERED BY: METABOLISM OF CITIES

OUR PLATFORM: © Creative Commons Attribution 4.0 International license. Our source code is available on Github.

EAU D'AZUR Métropole Nice eau et assainissement eaudazur.com

Circular Metabolism Chair

What Works for Brussels?

Towards a common understanding of the intersection between spatial and economic planning

September 2018



École d'été internationale 2020

"Ville, territoire, économie circulaire"

14 - 28 juin



Institut *edbec*

Université de Montréal



Université Gustave Eiffel

UNIVERSITÉ DE GENÈVE

Futurs Urbains
Urban Futures

Evaluation du Programme Régionale en Economie Circulaire de la Région de Bruxelles-Capitale

Un regard académique sur le programme initial et les réalisations (2016-2018)

Octobre 2018



Circular Metabolism Podcast

Philippe Bihouix
CIRCULAR METABOLISM PODCAST #65

STOP

A L'ÉTALEMENT DES VILLES

CIRCULAR METABOLISM PODCAST

Kate Raworth

DOUGHNUT ECONOMICS IN CITIES

CIRCULAR METABOLISM PODCAST #26

Tim Jackson

POST-GROWTH

LIFE AFTER CAPITALISM

Prof. Julia Steinberger
IPCC Lead Author

STAYING WELL WITHIN LIMITS

ENERGIE

METAUX

Dr. Olivier Vidal

CIRCULAR METABOLISM PODCAST #5

CIRCULAR METABOLISM PODCAST #48

FUIR LES GRANDES VILLES POUR SAUVER LA PLANÈTE ?

Prof. Guillaume Tabone

Metabolism of Cities

Geneva

Consommation d'électricité du réseau genevois, selon le genre d'utilisation, depuis 1984

Electric consumption in Canton Geneva by economic sector and public usage.

Remarks:

- The districts served by the Services industriels de Genève (SIG) do not correspond exactly to the territory of the Canton;
- CERN electric consumption is not accounted;
- The General Classification of Economic Activities (NOGA) was revised in 2002 and 2008 limiting the comparison of results between years;
- Before 2008, street lighting only. From 2008, street lighting and light signage included.

Attachments(s)

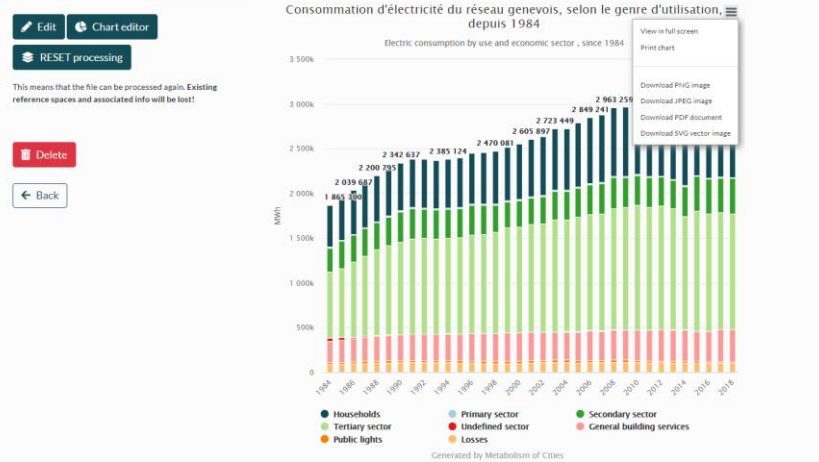
- T_08_03_2_01.xls (93.0 KB)
- T_08_03_2_01_processed.xls (96.5 KB)

Associated space

Geneva

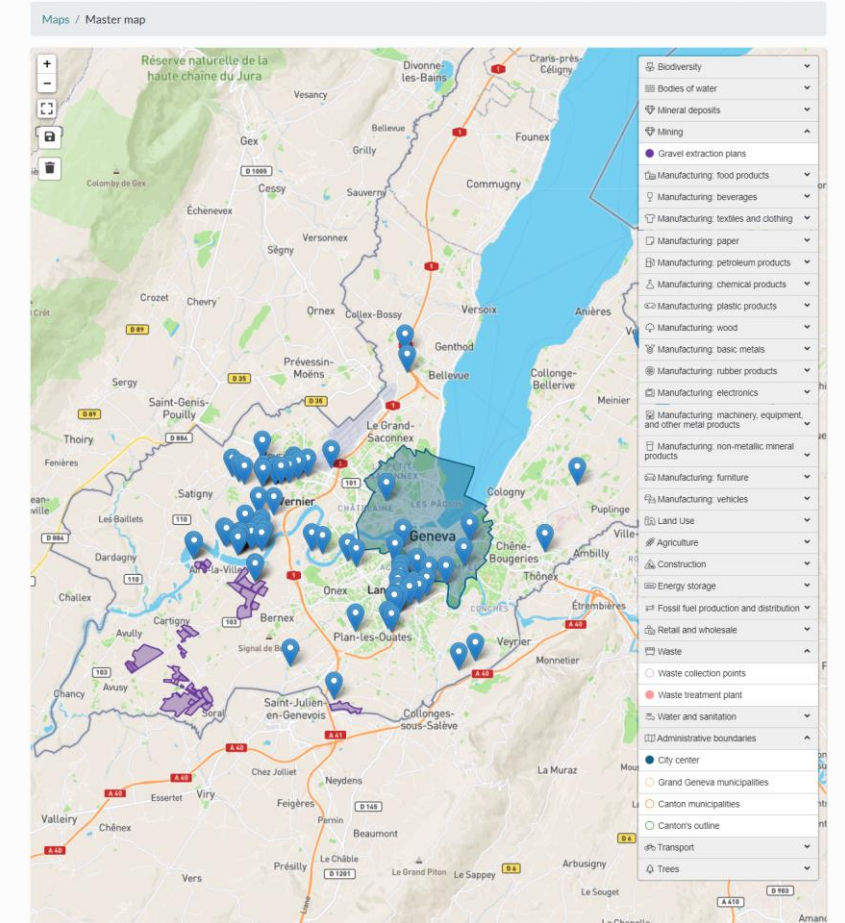
Data

Bar Column Drilldown Line Area Pie Table



Geneva

Master map | Geneva



Dashboard

Map Resources Space Staff Technology Latest

Layer All layers Type Any Date mm/dd/yyyy

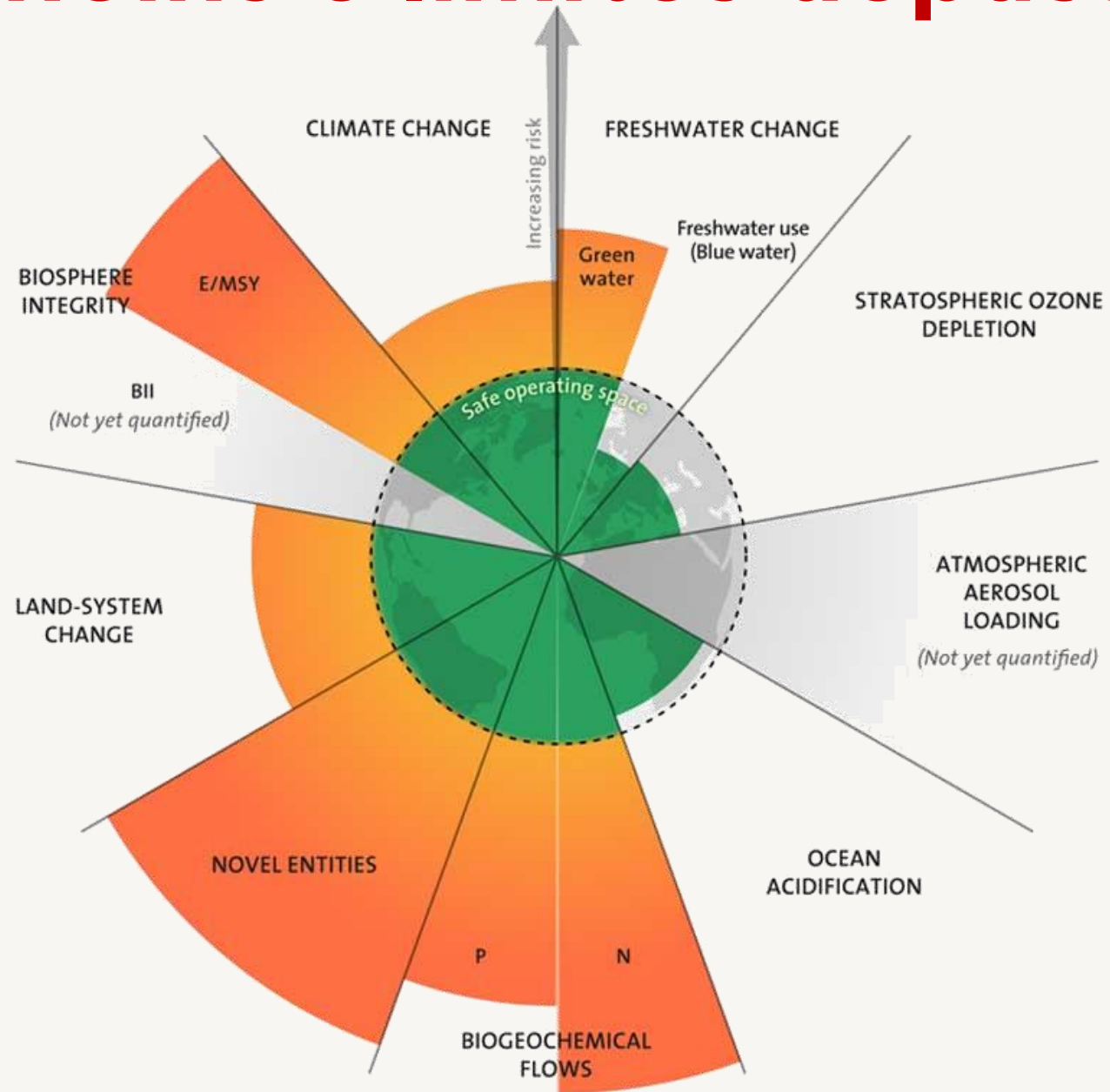
+ Add entry

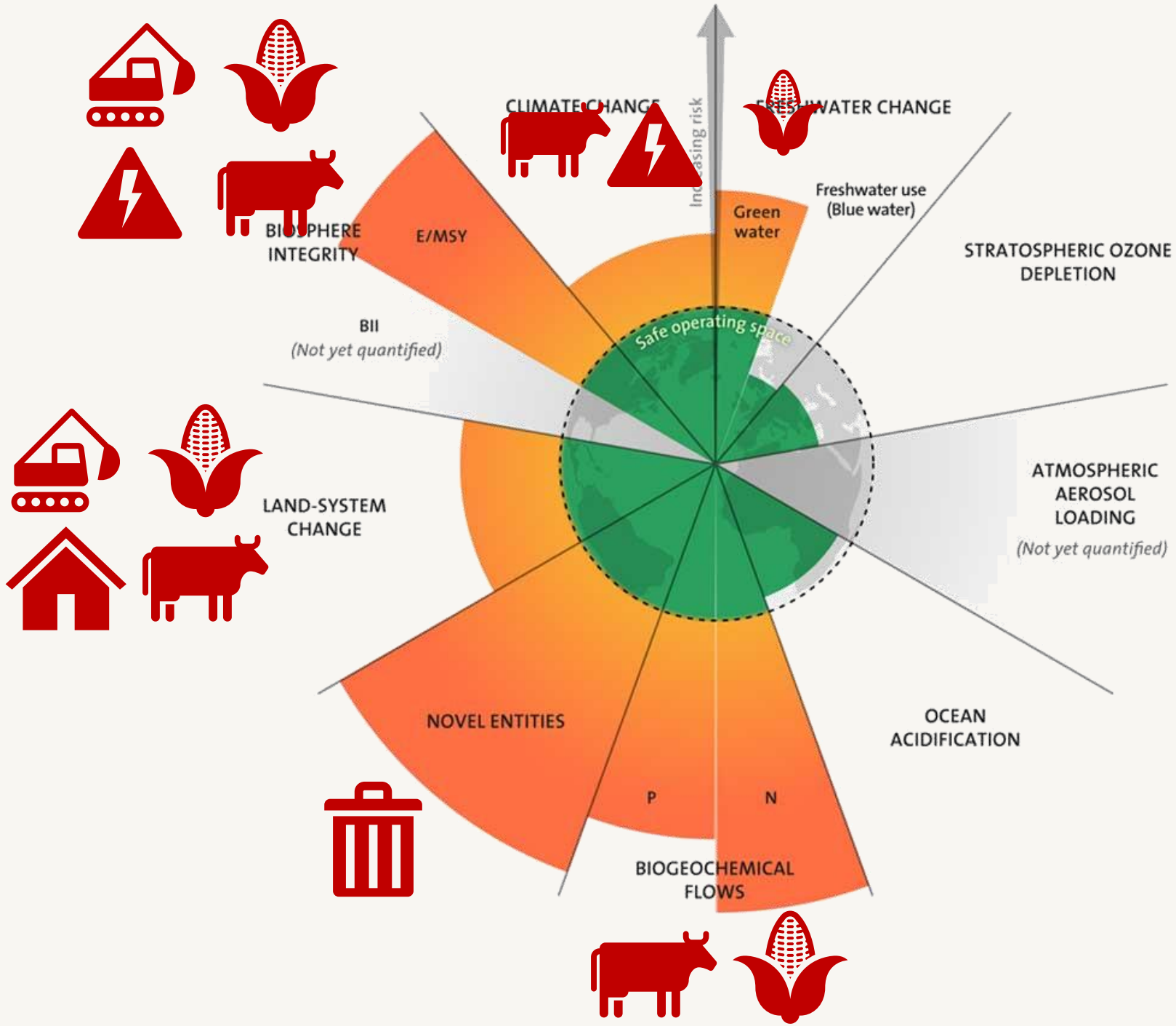
36 entries found

- Events space 100.0 Square metre
- General management 1.0 Item
- Events space 100.0 Hectare
- Low-skilled technicians (no formal training) 1.0 Item
- Food 2.0 Tonne
- Events space 400.0 Square metre
- Food 2.0 Tonne
- Coloured bottles 1.0 Short ton
- Events space 100.0 Square metre
- Events space 200.0 Square metre
- Electricity 3.0 Megawatt hour
- Other 1.0 Item
- Events space 100.0 Square metre
- Processing 1.0 Item
- General management 1.0 Item

Villes et Limites Planétaires

Au moins 6 limites dépassées

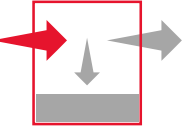




Steffen et al. (2015). Planetary boundaries: Guiding human development on a changing planet

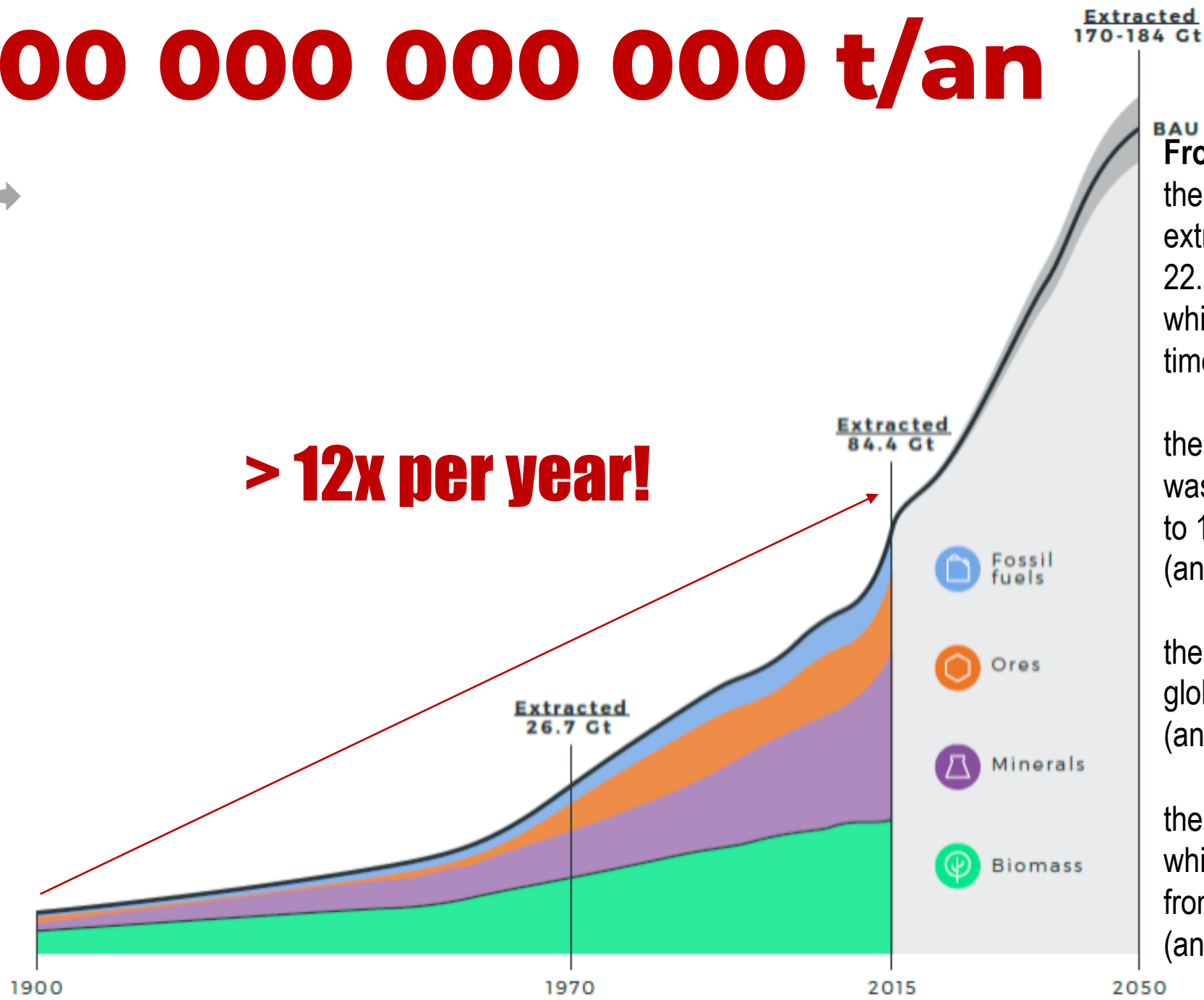
**Comment on est
arriver à cette
impasse ?**

100 000 000 000 t/a



Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, 52, 131-140.

> 12x per year!



BAU
From 1900 to 2015, the amount of biomass which was extracted globally went from 5.5 Gt/yr to 22.7 Gt/yr (an increase of 4.3 times) while global population increased by 4.5 times.

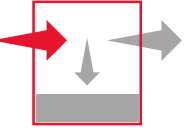
the amount of fossil energy carriers which was extracted globally went from 1 Gt/yr to 14.5 Gt/yr (an increase of 14.5 times)

the amount of ores which was extracted globally went from 0.2 Gt/yr to 6.5 Gt/yr (an increase of 33 times)

the amount of non-metallic minerals which was extracted globally went from 0.9 Gt/yr to 45.3 Gt/yr (an increase of 50 times).

- Fossil fuels
- Ores
- Minerals
- Biomass

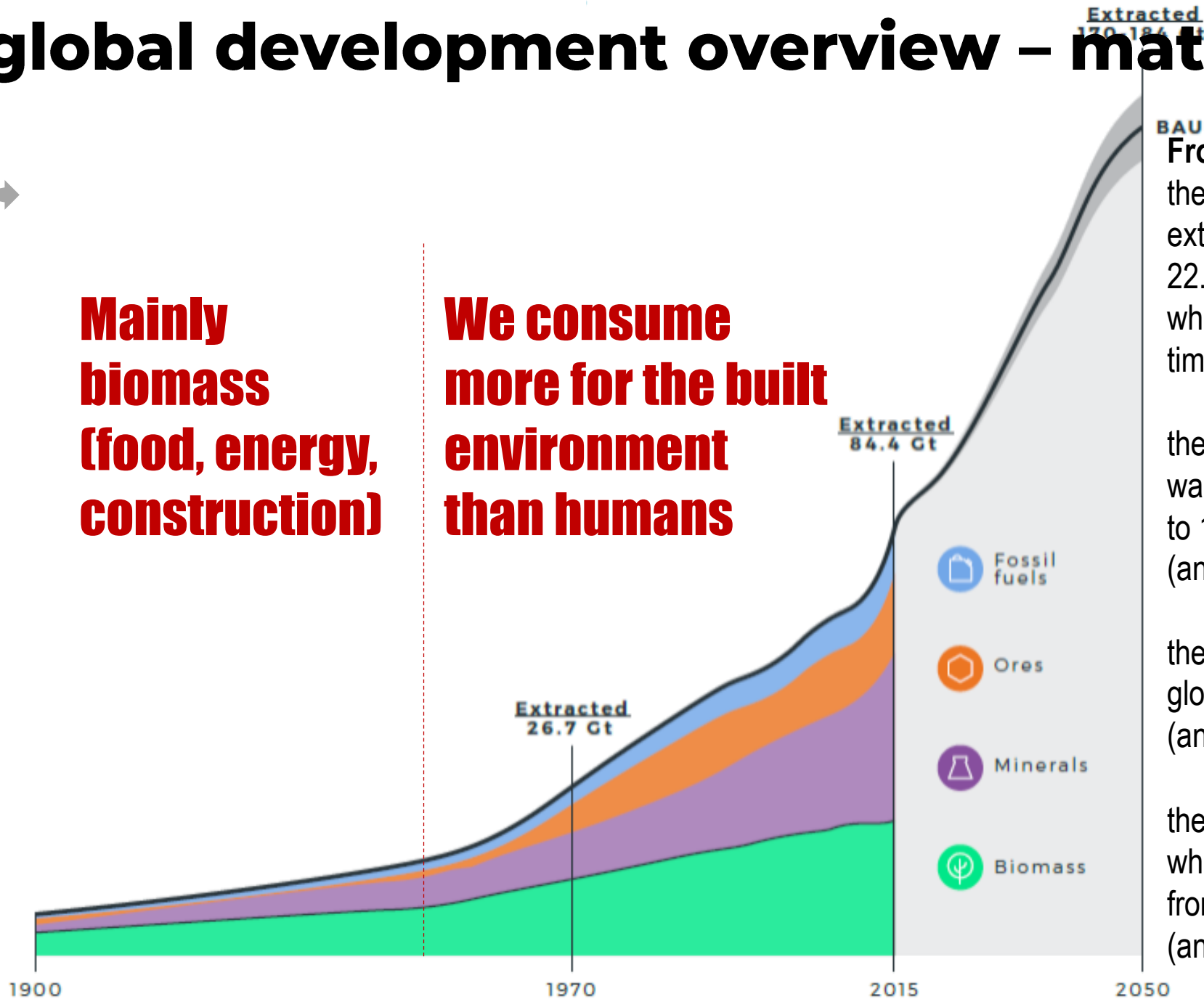
A global development overview – material extraction



Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, 52, 131-140.

Mainly biomass (food, energy, construction)

We consume more for the built environment than humans



From 1900 to 2015, the amount of biomass which was extracted globally went from 5.5 Gt/yr to 22.7 Gt/yr (an increase of 4.3 times) while global population increased by 4.5 times.

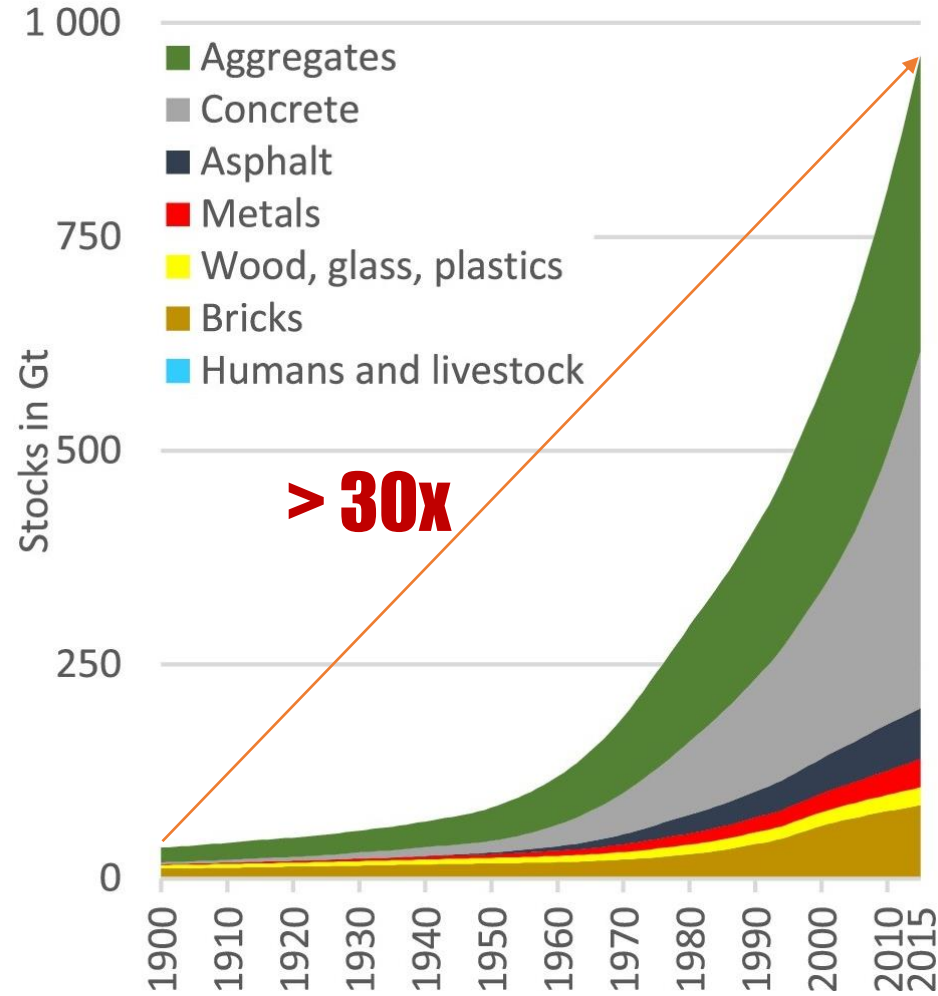
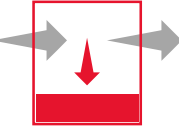
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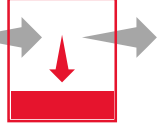
1 000 000 000 000 t (150/cap)

A global development overview – material stock



Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, 52, 131-140.

A global development overview – material stock

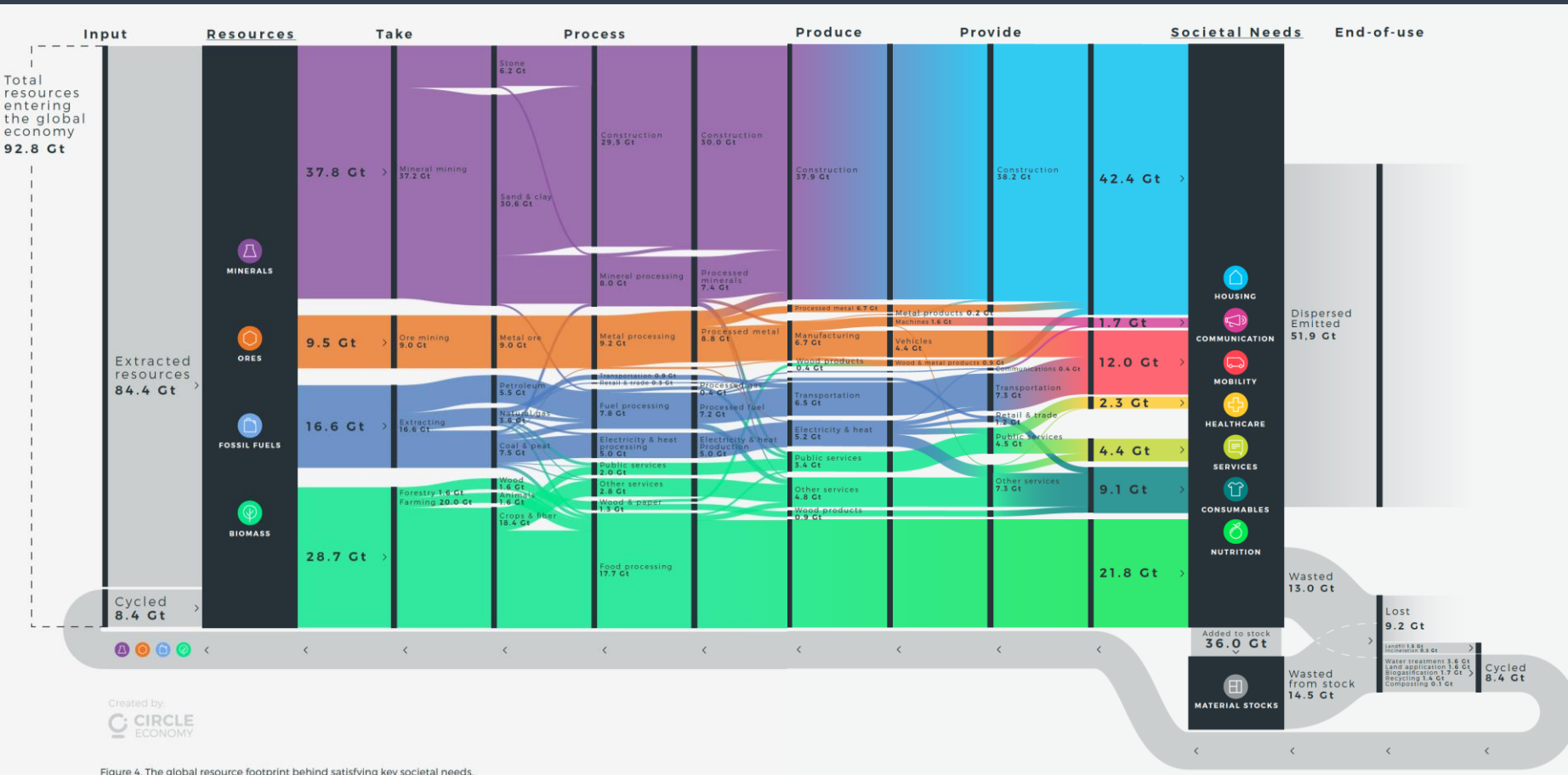


Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., & Milo, R. (2020). Global human-made mass exceeds all living biomass. *Nature*, 588(7838), 442-444.

Krausmann, F., Lauk, C., Haas, W., & Wiedenhofer, D. (2018). From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015. *Global Environmental Change*, 52, 131-140.

Circularité

Entrants



2018: 9,1%

2020: 8,6%

2023: 7,2%

Figure 4. The global resource footprint behind satisfying key societal needs.

Les villes au  des enjeux

Des villes linéaires et ouvertes



Desolidarisation / Linéarisation

Nouvelles infrastructures

**Spécialisation
d'Emplois** **Spécialisation
Spatiale**

Nouvelles technologies

City without resources ?

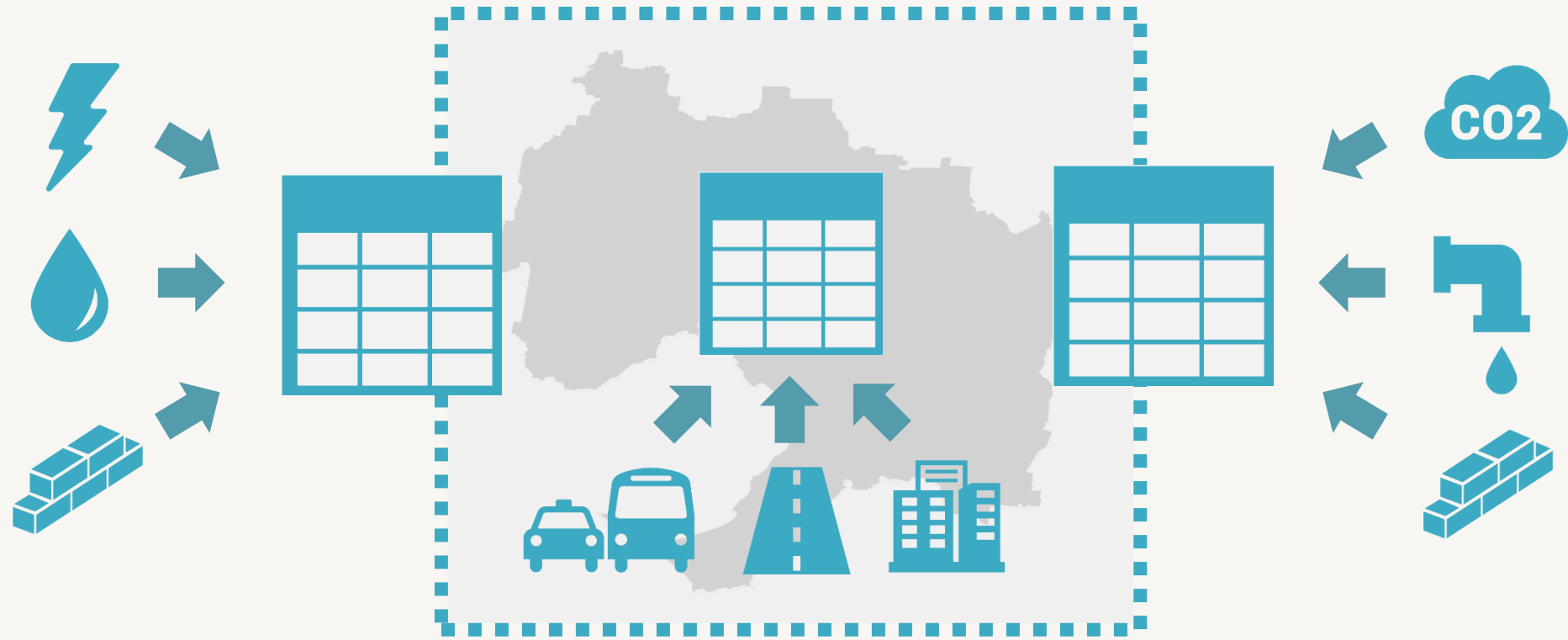
Et maintenant ?



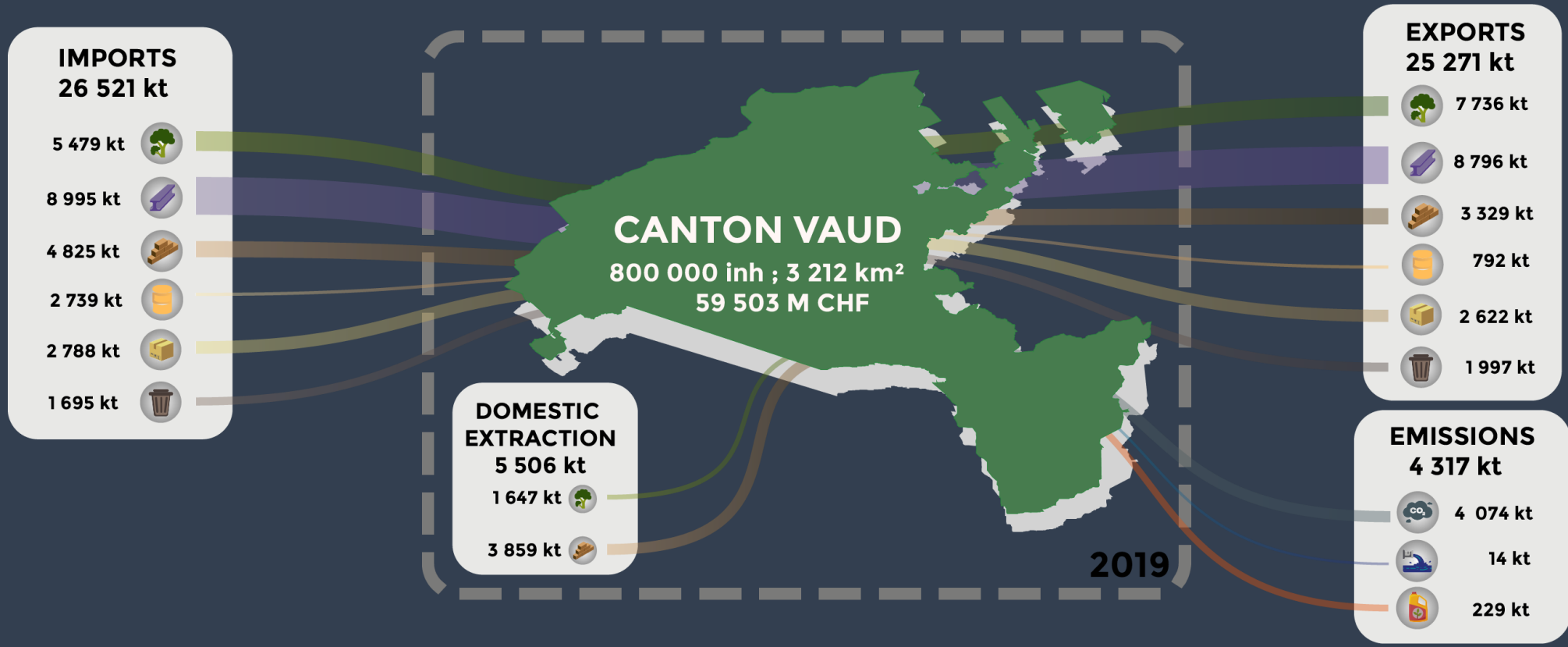
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Urban Metabolism

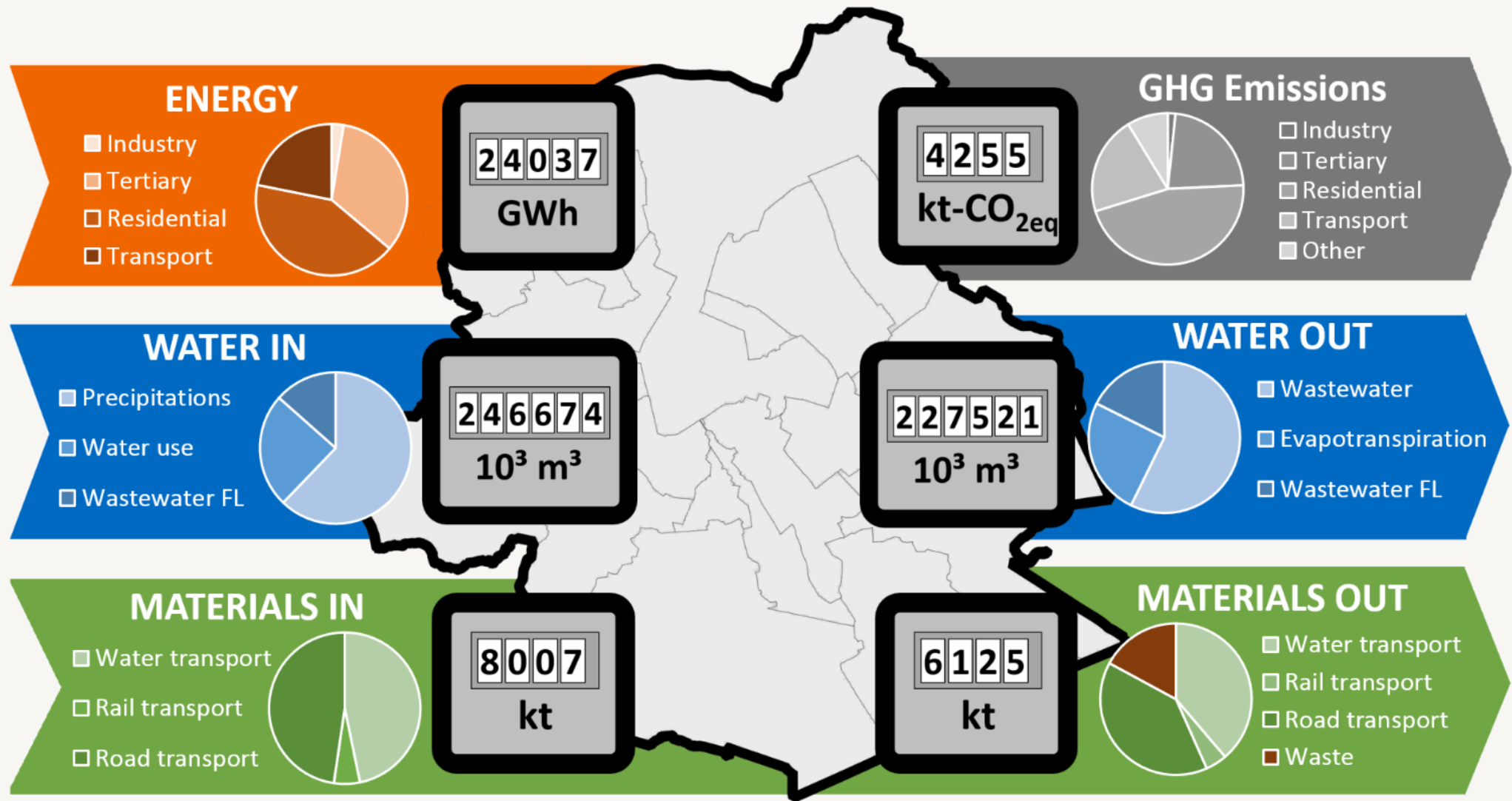


**An unconsolidated field studying stocks,
flows, infrastructures, actors and their agency
from a systemic point of view**

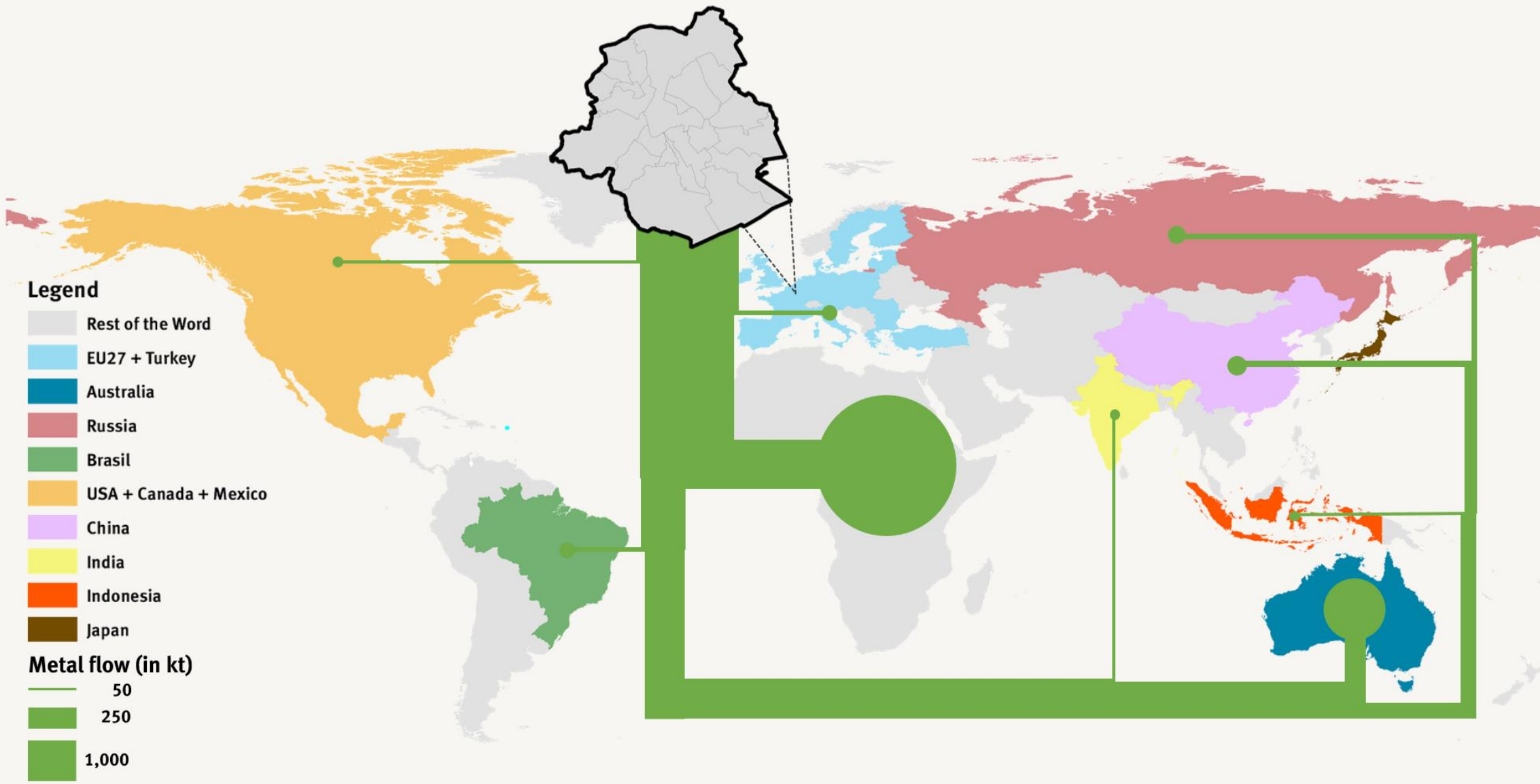


Legend

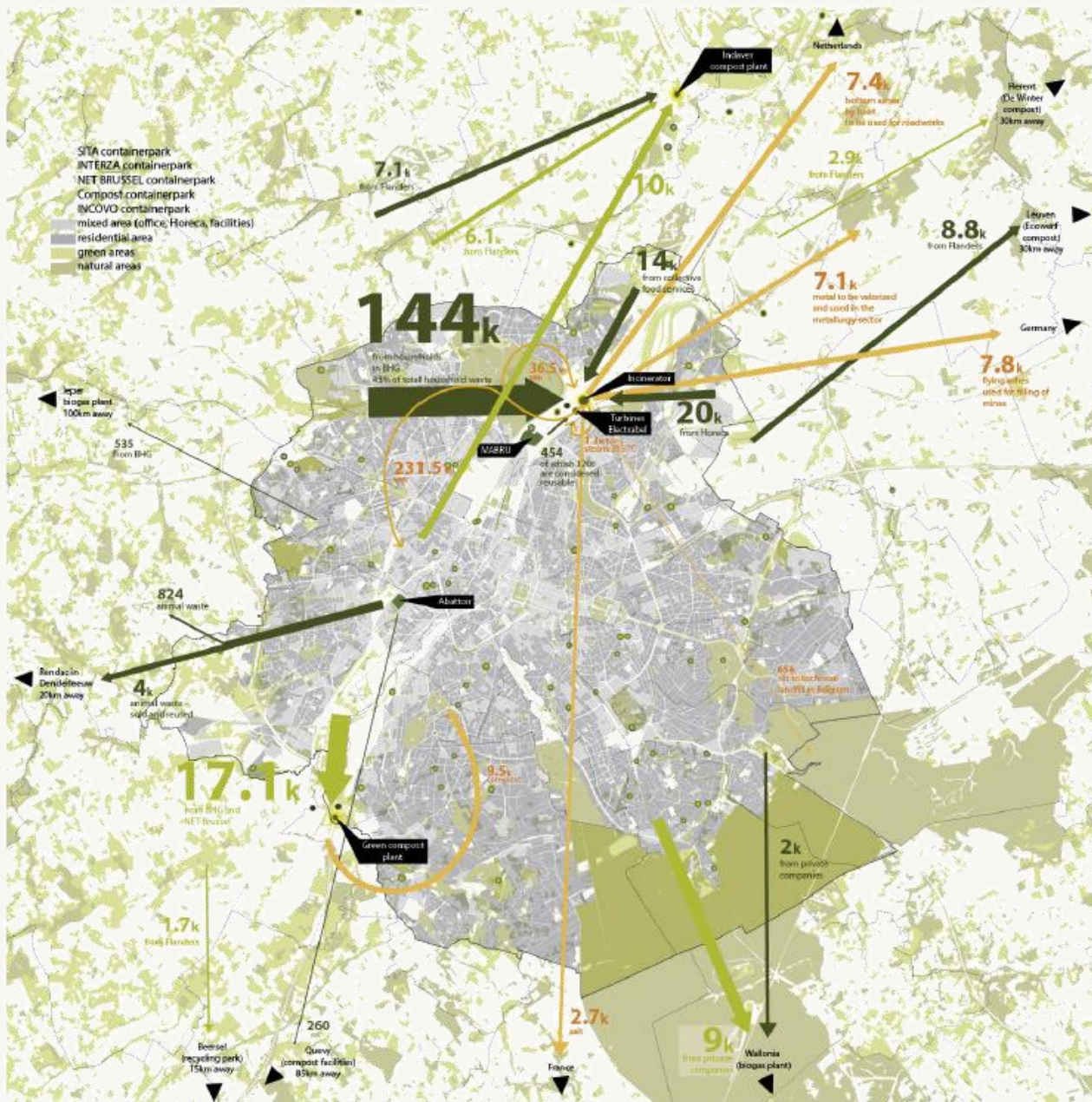
Biomass	Metal ores	Fossil energy carriers	Waste for final treatment	Emissions to water
Non-metallic minerals	Other products	Emissions to air	Dissipative use of products	



Brussels' urban metabolism - linear & open (3%)



Indirect flows



- tons/year of food waste
- tons/year garden waste
- tons/year processed waste

- SITA containerpark
- INTERZA containerpark
- NET BRUSSEL containerpark
- Compost containerpark
- INCOVO containerpark
- mixed area (office, Horeca, facilities)
- residential area
- green areas
- natural areas

Mapping flows, actors, infrastructure, agency

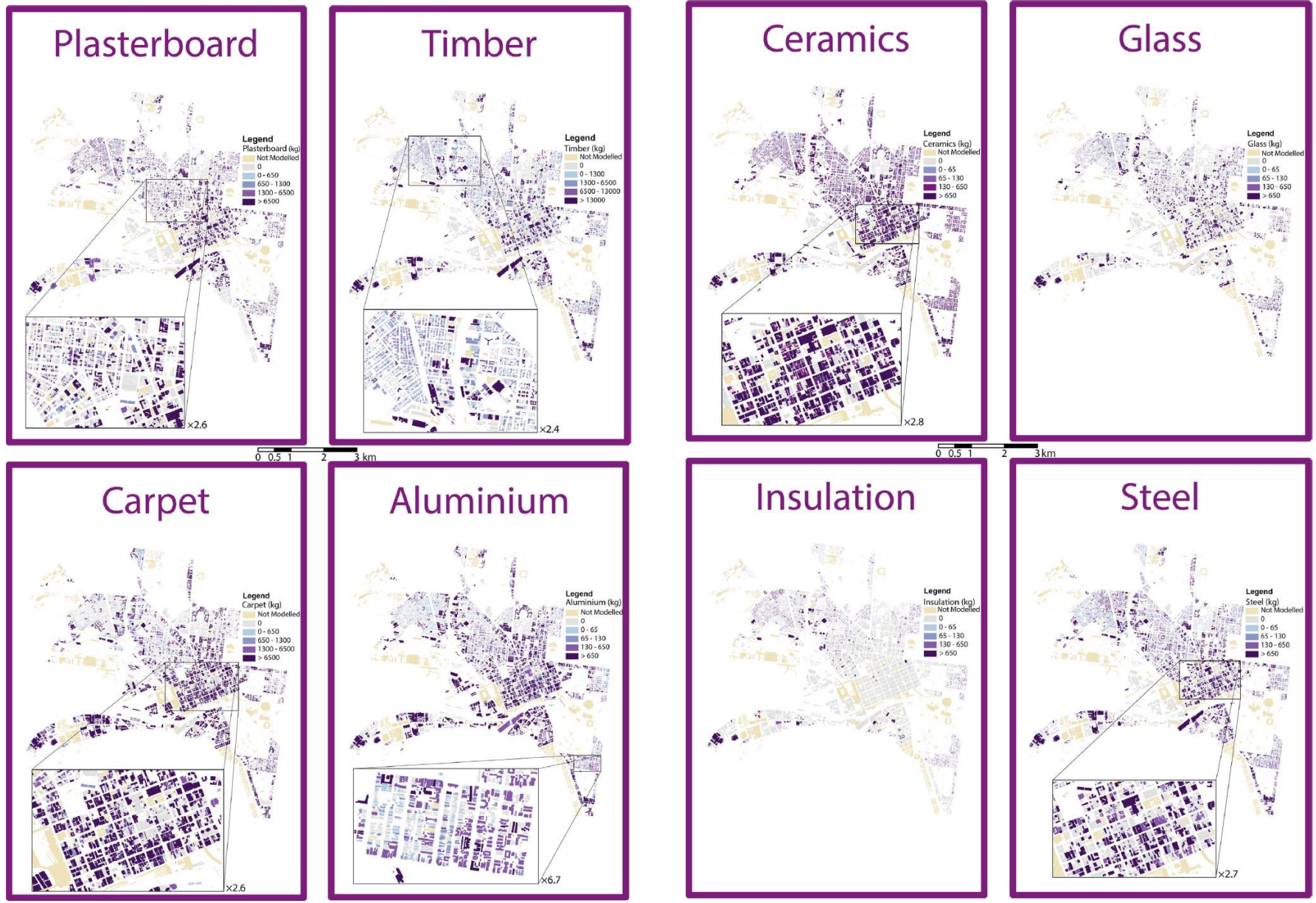


Fig. 4a. Estimated accumulated building material replacement flows in the City of Melbourne, for plasterboard, timber, carpet and aluminium, from 2018 to 2030.

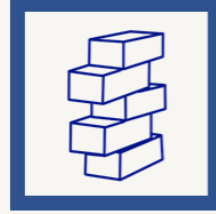
Fig. 4b. Estimated accumulated building material replacement flows in the City of Melbourne, for ceramics, glass, insulation and steel, from 2018 to 2030.

4D flow assessment

Stephan, A. and A. Athanassiadis. 2017. Quantifying and mapping embodied environmental requirements of urban building stocks. *Building and Environment* 114: 187-202.

Stephan, A. and A. Athanassiadis. 2018. Towards a more circular construction sector: Estimating and spatialising current and future non-structural material replacement flows to maintain urban building stocks. *Resources, Conservation and Recycling* 129: 248-262.

1 km²



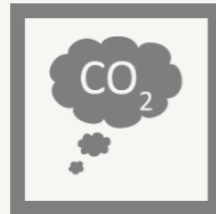
1 547 000 000 kg



10 000 000 GJ



17 700 000 m³



605 000 000 kgCO₂e

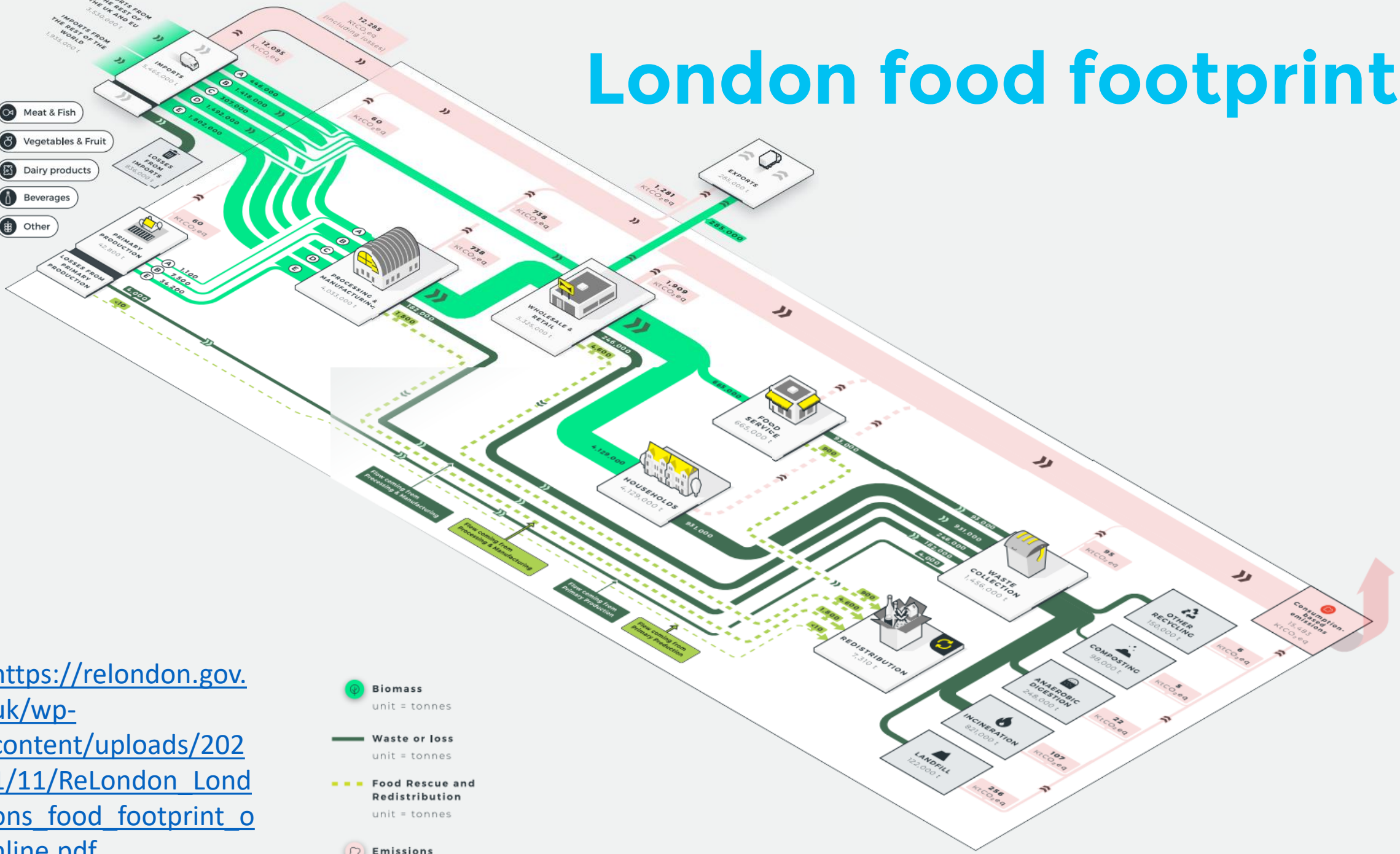
Stephan, A. and A. Athanassiadis. 2017. Quantifying and mapping embodied environmental requirements of urban building stocks. *Building and Environment* 114: 187-202.

Stephan, A. and A. Athanassiadis. 2018. Towards a more circular construction sector: Estimating and spatialising current and future non-structural material replacement flows to maintain urban building stocks. *Resources, Conservation and Recycling* 129: 248-262.

Explorer la mine urbaine – et ses impacts

London food footprint

- A Meat & Fish
- B Vegetables & Fruit
- C Dairy products
- D Beverages
- E Other



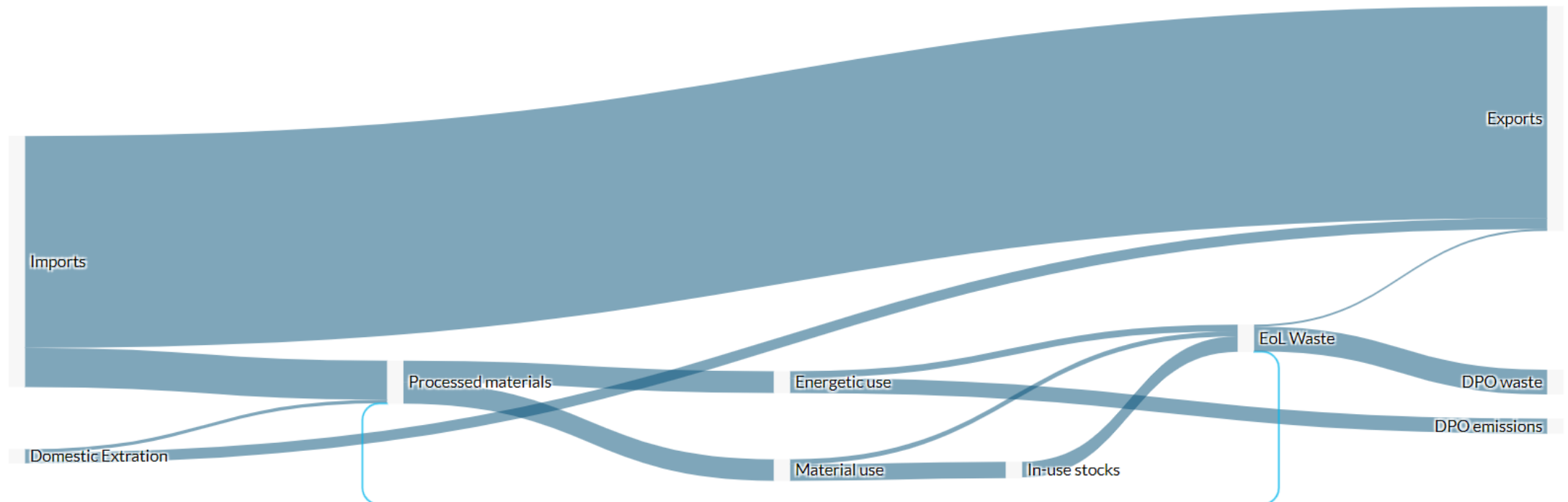
https://relondon.gov.uk/wp-content/uploads/2021/11/ReLondon_London_food_footprint_online.pdf

- Biomass**
unit = tonnes
- Waste or loss**
unit = tonnes
- Food Rescue and Redistribution**
unit = tonnes
- Emissions**
unit = KtCO₂eq

Circularity Apeldoorn

Material Flows in Apeldoorn

Measuring material flows and circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the Urban Circularity Assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows of the local economy of Apeldoorn are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the economy and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for a materials' circularity.



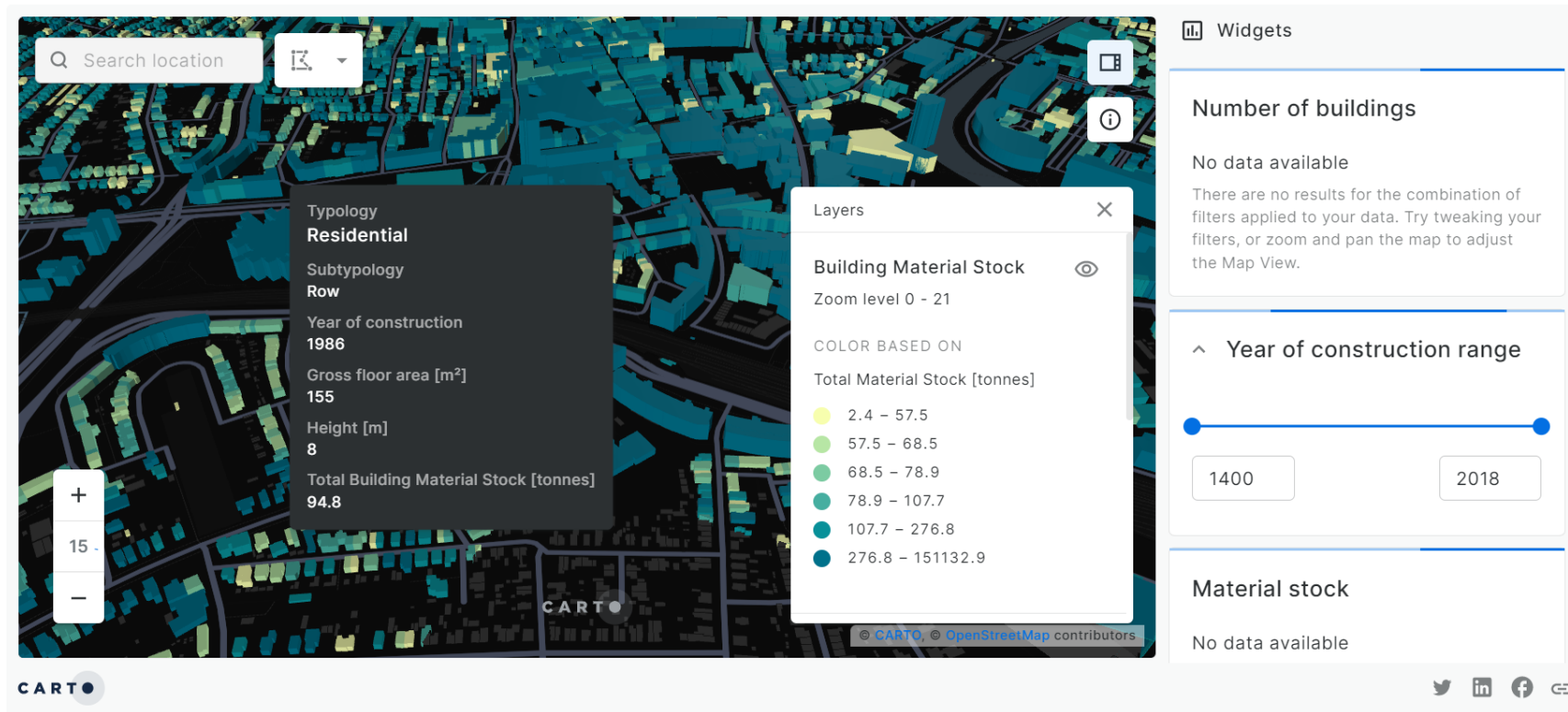
<https://cityloops.metabolismofcities.org/city/apeldoorn/uca-report/>

Material Stock Apeldoorn

Material stock in Apeldoorn

Determining and analysing the material stock of a city can, similarly to the material flow accounting, also be a data intensive endeavour. The intensity depends on the scope and the data availability. For the Urban Circularity Assessment, the scope includes all residential and non-residential buildings in the municipality. Unlike for the material flow quantification, the analysis is not done for one or several specific reference years, but considers all buildings that have been constructed and still exist, up until and including 2022 (year of study). The aim is to quantify the materials that every single building contains and represent them spatially on a map. Depending on the data availability around building typologies, age cohorts, building height and material intensities, different, specific quantifications and investigations can be made.

The embedded map allows to explore the building stock of Apeldoorn and interact with the different scales and buildings by zooming in and out, and clicking on the buildings to discover more about typologies and quantity of building materials. The widgets on the right can be used to account for certain information, e.g. the number of buildings in an area, or to filter for specific construction years, which in combination with the average useful life of buildings can be used to calculate the potential urban mine. Furthermore, an analysis can also be performed by using the lasso tool and drawing an area (a block, a neighbourhood or an urban area) to be analysed.



<https://cityloops.metabolismofcities.org/city/apeldoorn/uca-report/>

**Beaucoup d'études
mais quelles
conclusions ?**

**Trop petit,
trop peu,
trop lent**

**Quelles sont les
nouvelles pistes ?**

Réduire les entrants,

Faire de la place

Questionner les besoins



Combien de matériaux avons-nous besoin ?

Avons-nous la main d'œuvre ?

Echelle de temps ?

Gain net énergétique ?

Isoler, isoler, isoler

Combien de matériaux avons-nous ?

Avons-nous la main d'œuvre ?

Avons-nous la place ?



Source: <http://www.circulareconomy.brussels/bc-materials-bc-materials-de-la-terre-dexcavation-au-materiau-de-construction/#images-2>

Des matériaux locaux bio/géo-sourcés



Combien de matériaux avons-nous ?



Avons-nous la main d'œuvre ?



Avons-nous la place ?



Réutiliser la mine urbaine



Comment protéger du foncier ?

Comment réduire les m² par pers ?

En finir avec l'étalement urbain



Chaque nouveau m² construit =

urbanmanufacturing in

+ Flux pour opérer, maintenir, rénover

- De foncier pour besoins essentiels

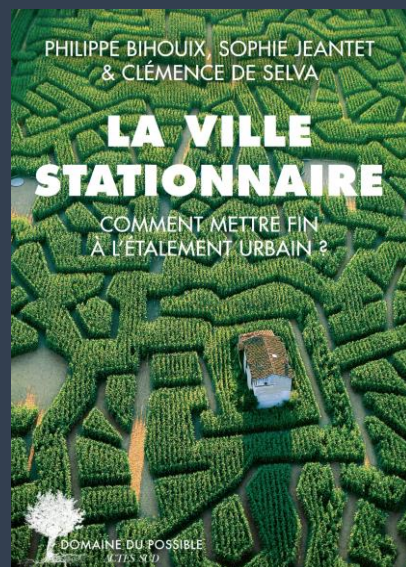


Préserver du foncier (productif, naturel, ..)

En conclusion

Réduire / Sacrifier

Ralentir



Reboucler

Laissez de la
place

Main d'œuvre

Relocaliser

Quelques piliers pour rester dans les
limites planétaires

Table 2

. Inventory of the prerequisites for *Decent Living Standards* (DLS) (Rao and Min, 2018a) alongside activity levels and direct and indirect energy intensities of products, supply chains and infrastructure. Numbers are rounded and presented as ranges where there are variations between countries or sub-activities (e.g. different transport modes). *Approximate* percentage increases for *Higher Demand* (HD) and *Less Advanced Technology* (LAT) scenarios are included where possible, but these cannot always be summarised in this high-level format. Full details can be found in the Supplementary materials.

DLS dimensions & services	Activity levels		Energy Intensities		
	Default levels	HD	Default (direct)	Default (indirect)	LAT
Nutrition					
Food	2000–2150 kcal/cap/day	15%	–	3 KJ/kilocalorie	30%
Cooking appliances	1 cooker/household	–	0.8 KJ/kilocalorie	1 GJ/app ⁺	50%
Cold Storage	1 fridge-freezer/household	–	0.44 GJ/app ⁺ /yr	4 GJ/app ⁺	–
Shelter & living conditions					
Household size	4 persons/household	–25%	–	–	–
Sufficient space	15 meters ² floor-space/cap [*]	80%	–	2–4 GJ/m ²	100%
Thermal comfort	15 meters ² floor-space/cap [*]	80%	20–60 MJ/m ² /yr	–	300%
Illumination	2500 lm/house; 6 hrs/day	100%	150 lm/W	14 MJ/house/yr	–
Hygiene					
Water supply	50 Litres/cap/day	100%	–	5–17 KJ/L	–
Water heating	20 Litres/cap/day	100%	96–220 KJ/L	–	50%
Waste management	<i>Provided to all households</i> ^{**}	–	–	180 MJ/cap/yr	200%
Clothing					
Clothes	4 kg of new clothing/year	33%	–	100 MJ/kg	–
Washing facilities	80 kg of washing/year	33%	2.4 MJ/kg	2 GJ/app ⁺	–
Healthcare Hospitals	200 meters ² floor-space/bed	50%	410–560 MJ/m ² /yr	14–23 GJ/m ²	130%
Education Schools	10 meters ² floor-space/pupil	50%	100–130 MJ/m ² /yr	4.5–7.5 GJ/m ²	150%
Communication & information					
Phones	1 phone/person over 10yrs old	–	28 MJ/phone/yr	110 MJ/phone	30%
Computers	1 laptop/household	–	220 MJ/laptop/yr	3 GJ/laptop	30%
Networks & data	<i>High</i> ^{**}	100%	–	~0.4 GJ/cap/yr	–
Mobility					
Vehicle production	<i>Consistent with pkm travelled</i> ^{**}	–	–	0.1–0.3 MJ/pkm	50%
Vehicle propulsion	5000–15,000 pkm/cap/year	3–10%	0.2–1.9 MJ/pkm ⁺⁺	–	100%
Infrastructure	<i>Consistent with pkm travelled</i> ^{**}	–	–	0.1–0.3 MJ/pkm	–

Millward-Hopkins, J., Steinberger, J. K., Rao, N. D., & Oswald, Y. (2020). Providing decent living with minimum energy: A global scenario. *Global Environmental Change*, 65, 102168.

Quelques besoins sont nécessaires et compatibles aux limites planétaires ?



ARISTIDE ATHANASSIADIS



CIRCULAR METABOLISM PODCAST



METABOLISM OF CITIES



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