The Dutch Urban Mine, an inventory

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The resource challenge

- Resource extraction and use brings enormous benefits for society
  - They provide society with basic needs: food, shelter, clothing, energy, …
  - They provide society with the services that are essential for a decent quality of life: education, health care, trouble shooting, …
  - They provide society with stuff that enhances well-being: communication, travel, fashion, luxury products
- Resource extraction and use is the root cause of environmental problems
  - Fossil resources cause greenhouse gas emissions leading to climate change
  - Bio-resources cause land, water, and agrochemical use leading to loss of natural areas and pollution
  - Both of these cause biodiversity loss at an alarming rate
  - Mineral and metal resources require the use of fossil resources for their extraction and refinery, and in some cases are connected with supply constraints

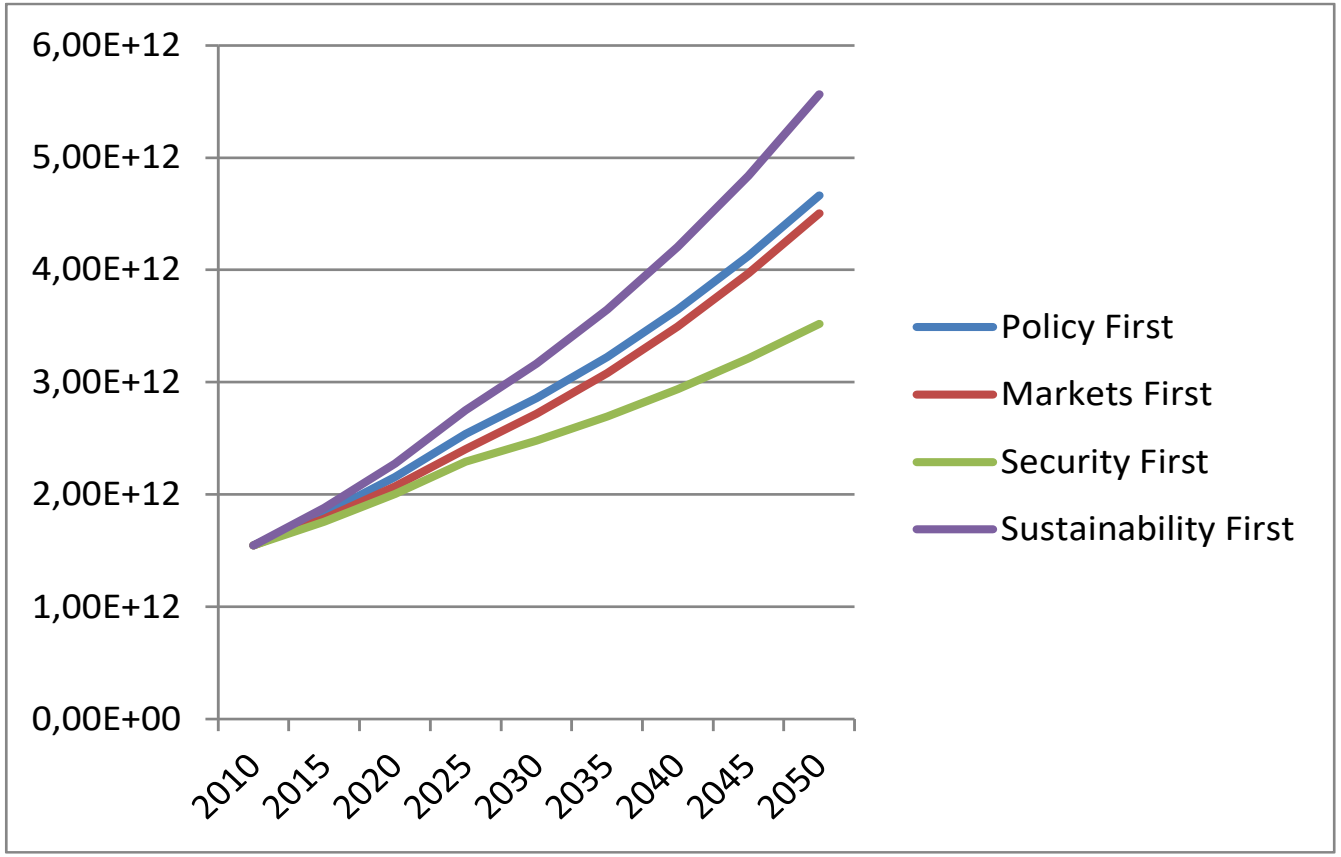
The resource challenge

- Tension between environmental goals and societal goals
- For environmental goals, resource use should be reduced
- For societal goals, resource use should be increased
  - Not just for the nice-to-have stuff
  - In many countries in the world, it is still about the basic needs!

The resource challenge

- Forecasting the demand for metals
- Why is “sustainability first” the highest?

Demand for 7 major metals, global level, kg/year, 2010-2050 (Elshkaki et al., 2018)

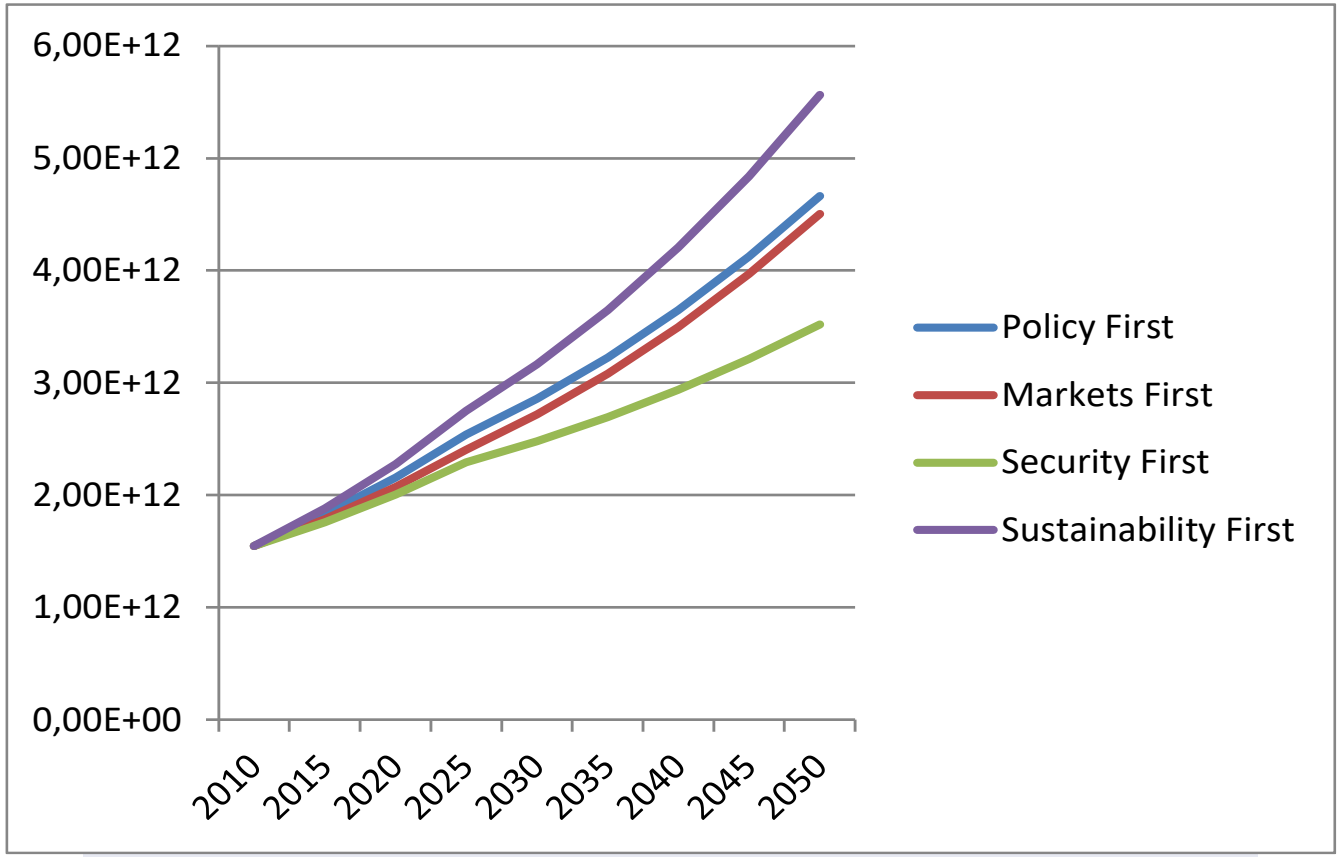


The resource challenge

- Forecasting the demand for metals (kg/y)
- Why is “sustainability first” the highest?

- Energy transition is only a very small part of that
- The main reason is the building up of the whole infrastructure of developing countries

- The resource transition is not (just) about lithium and cobalt, but (mainly) about concrete and steel!



The Dutch policy on circular economy

- Circular economy policies intend to reduce the need to extract resources from the environment by keeping the materials extracted in the past in use for as long as possible
- The NL has initiated a circular economy policy of their own
  - Grondstoffenakkoord: reducing primary resource extraction by 50% by 2030, complete circularity by 2050
  - Research program started, coordinated by PBL, to figure out what that means, in 2019: the Werkprogramma MSCE
- In the meantime, some more clarity via the ICER-reports
  - Circular economy is a means to an end: aims at reducing GHG emissions and biodiversity loss, at supply security for critical materials, and at new jobs &tc
  - Strategies to employ are: narrowing the loop, slowing the loop and closing the loop

Urban mining

- One project that has run for four years now aims at making a complete inventory of the Dutch urban mine
- The urban mine: resources applied in products, buildings, infrastructures that are presently in use
- **In a completely circular economy, the urban mine is our material basis**
- Knowledge about it is therefore essential, yet we know very little about it as it is not part of our statistics
- In a consortium of CML with CBS, RWS, Metabolic and several MScIE students, we have prospected the Dutch urban mine …
- … and to some extent did some future explorations on exploiting the urban mine

The Dutch urban mine

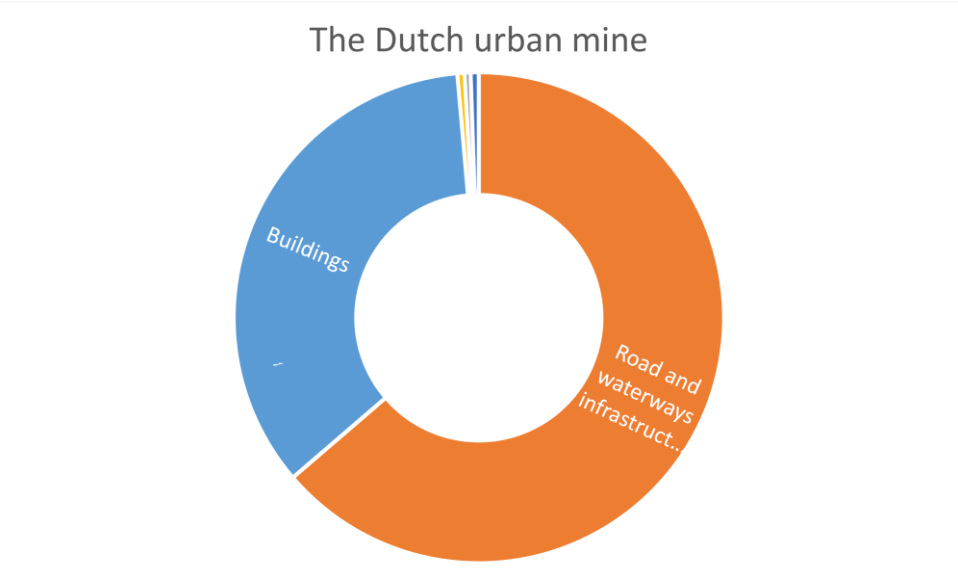
We investigated the following in-use stocks:

- ***Buildings – residential and utility***: using GIS data from the BAG together with data from literature on the material intensity of different types of buidings (4 res, 7 utility)
- *Road, **rail** and waterways infrastructure*: done by EIB, contracted by RWS
- *The **electricity, gas** and **water** infrastructures*: using GIS data from the grid managers and providers, combined with material content data from literature
- ***Vehicles*:** based on statistical information and material content data from Ecoinvent
- *Consumer electronics* and other *consumer goods*: based on statistical information and material content data from a variety of sources (among others ProSUM)
- *Textiles*: based on statistical information, classified roughly into biobased/other
- *Industrial machinery*: as consumer electronics

Explorations for future flows and stocks have been done for the applications in ***bold***

The Dutch urban mine

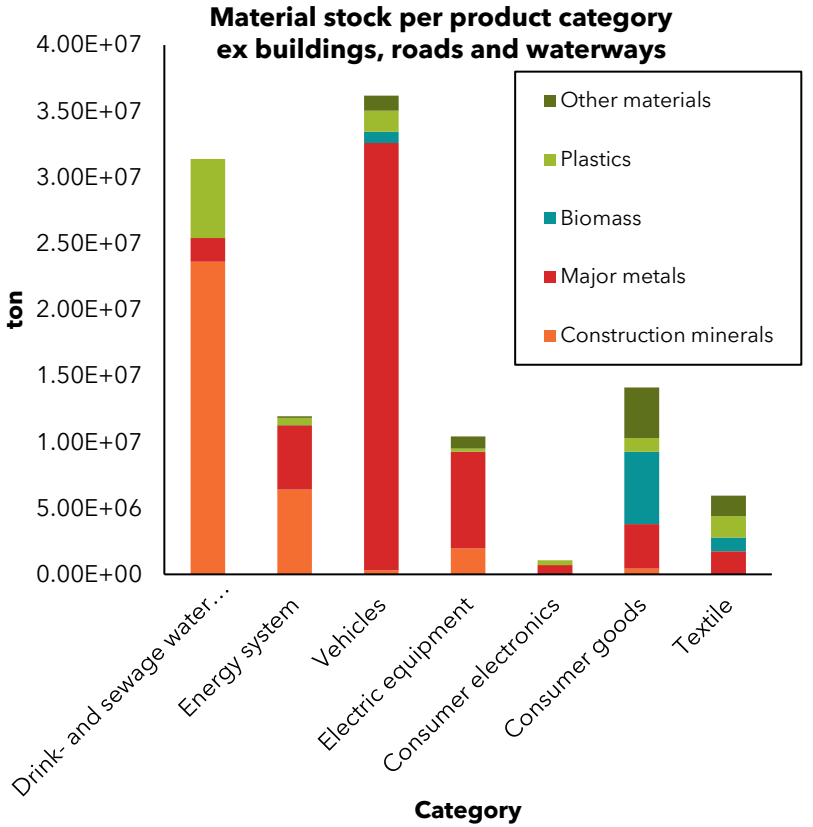
- The present Dutch urban mine adds up to **7.81 billion tonnes of materials, *or 447 ton/cap***
- More than half of that, **3.90 billion tonnes**, is sand, gravel, soil, clay used mainly in road and waterways infrastructure.
- The remainder is mainly construction materials such as concrete, cement, bricks etc., to be found mainly in **buildings**: **3.62 billion tonnes**



- These materials form 97% of the urban mine
- **1.17 billion tonnes** is used in coastal defense
- These materials are not scarce, nor have a high impact per kg, but they are used in such huge quantities that they are still interesting to address in a circular economy policy

The Dutch urban mine

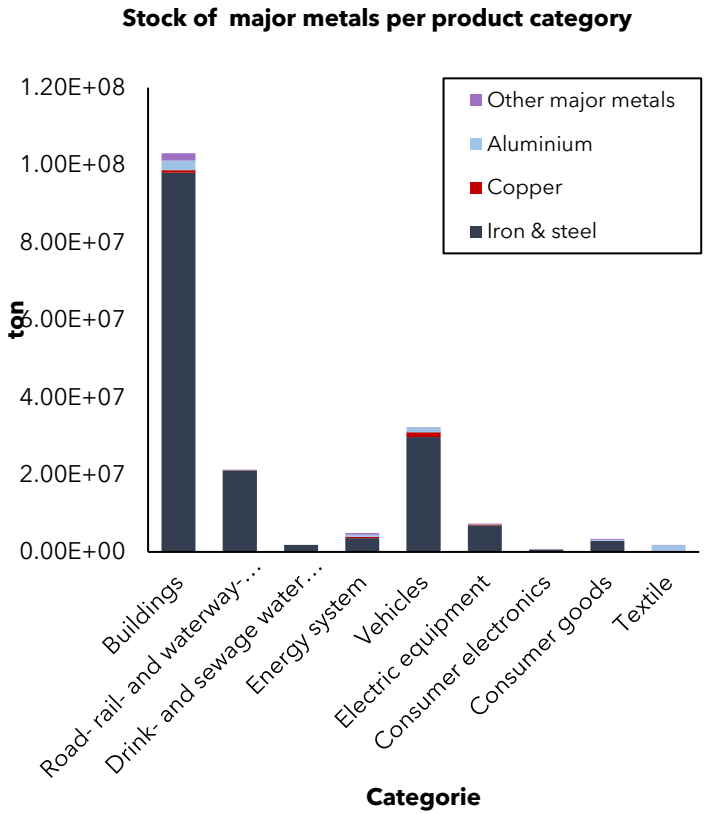
- The remaining 3% is still a lot, and contains some valuable materials:

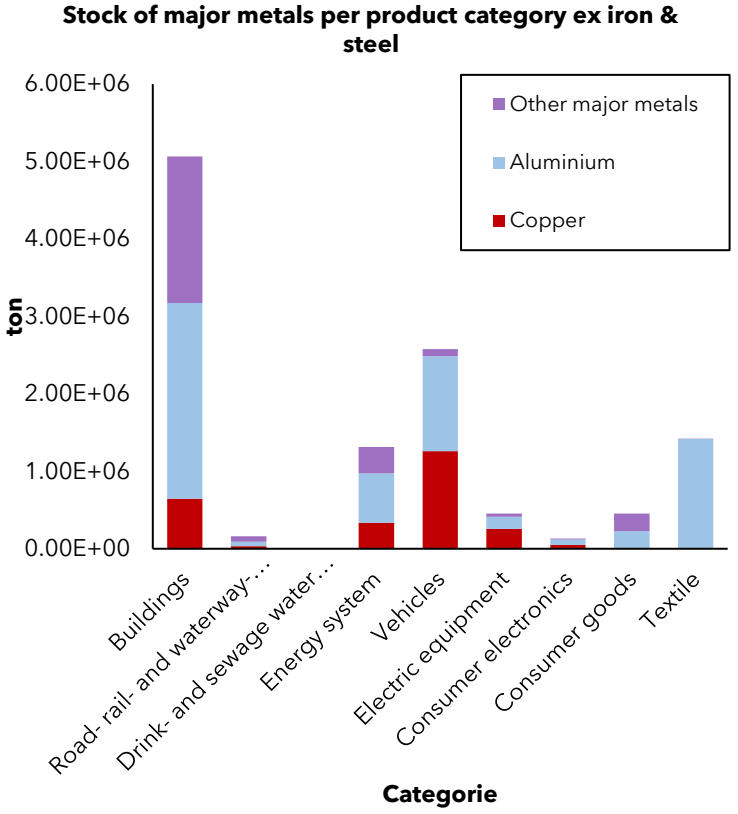


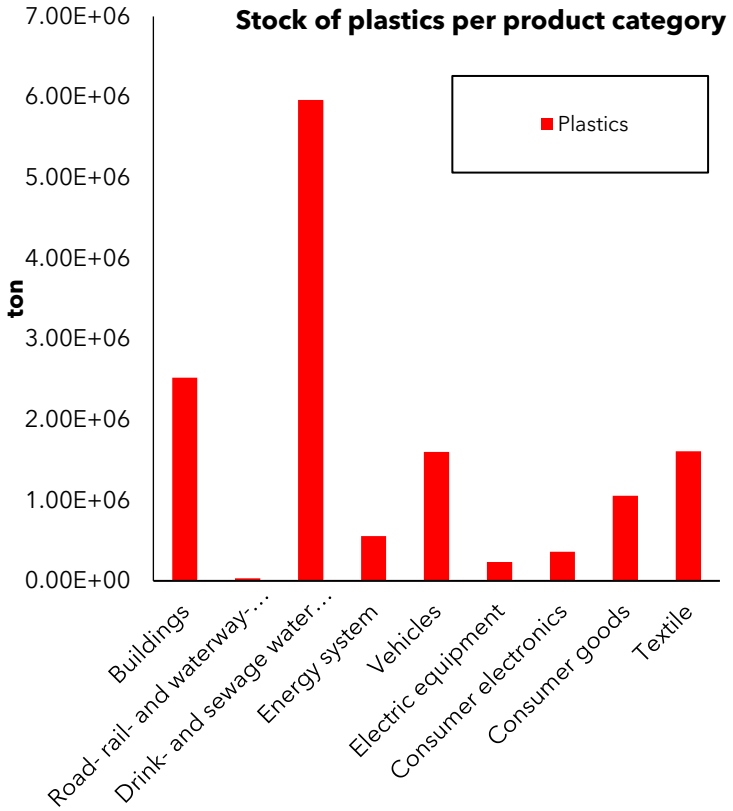
- These materials have a higher environmental impact per kg, and are important to include in a circular economy policy, to conform to the policy aim of reducing climate and other environmental impacts

The Dutch urban mine

- One can also look into specific (categories of) materials:

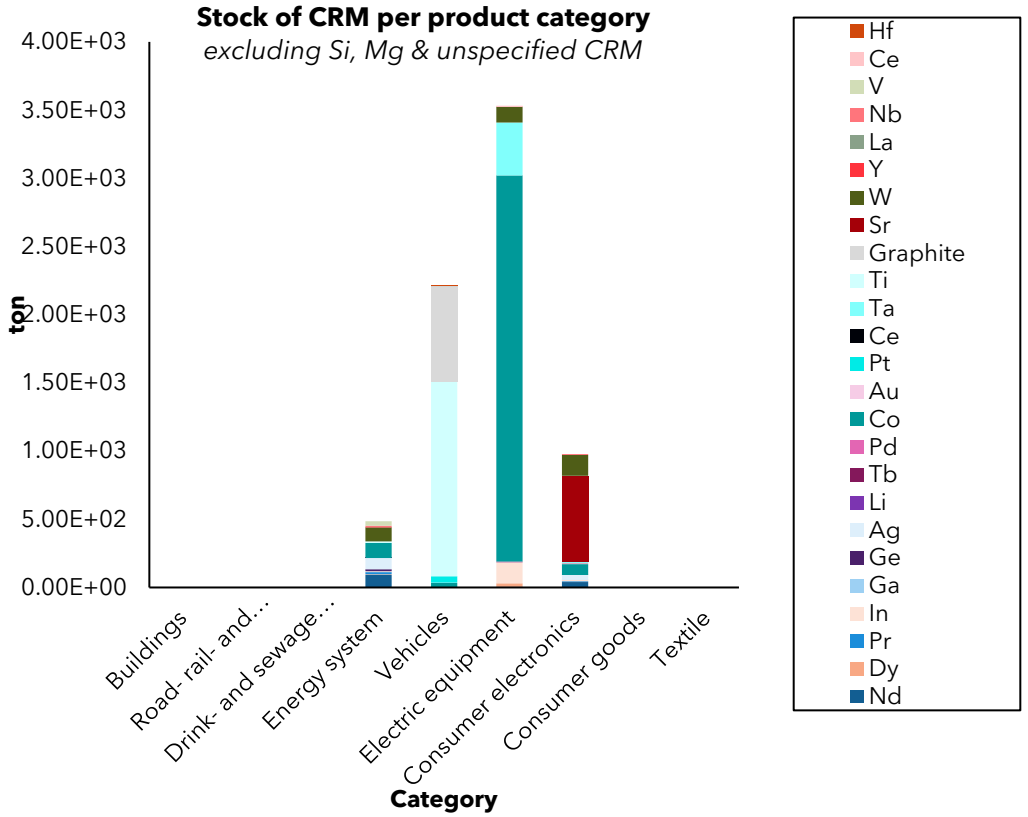






The Dutch urban mine

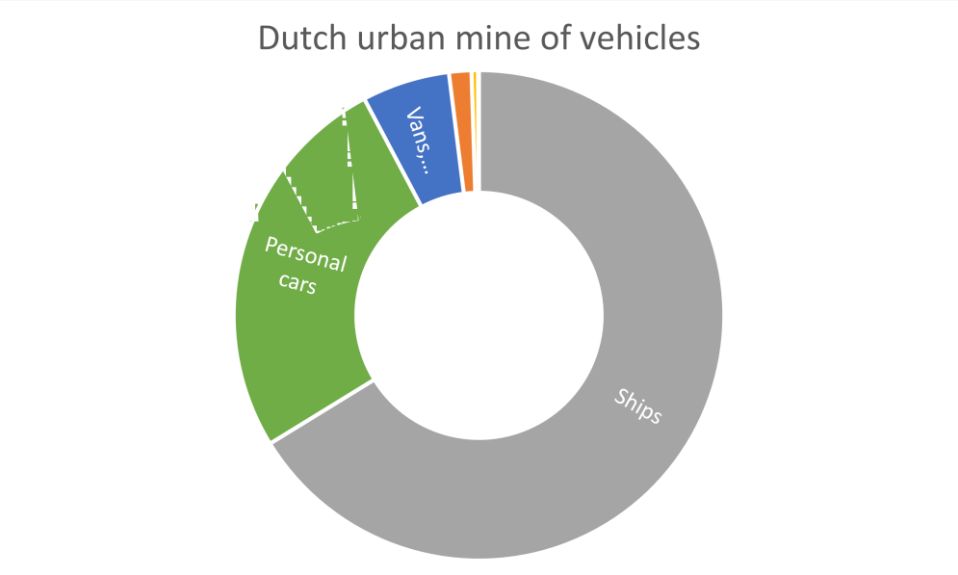
- Critical raw materials: very small in weight, but highly relevant for energy technology; supply security is an issue for these materials



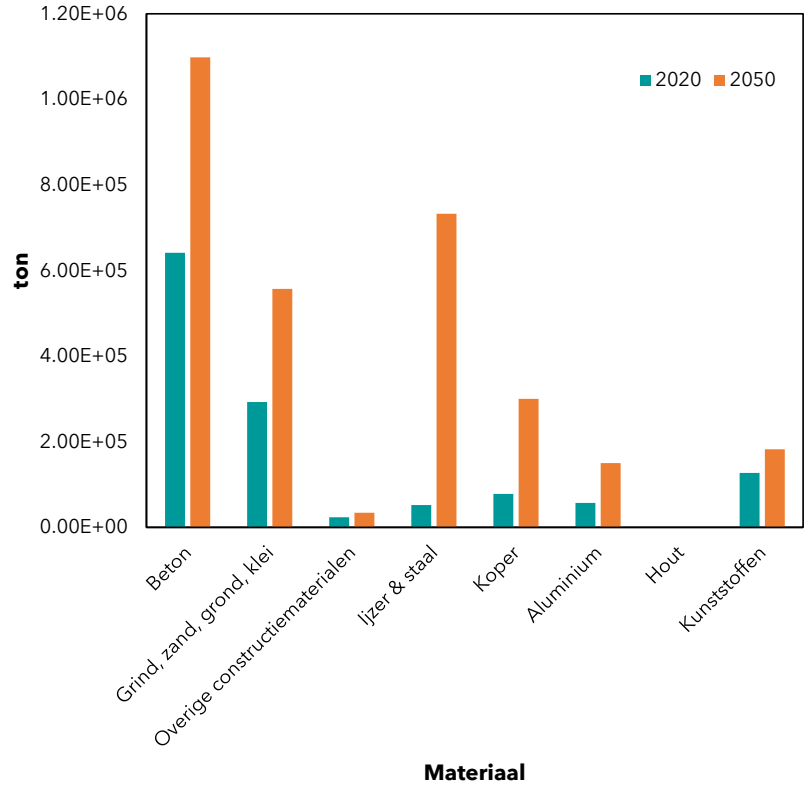
The Dutch urban mine

- So many things can be extracted from this database. Two examples:

Vehicles: not cars but ships contain the largest stock



Hibernating stocks in underground appliances



The Dutch urban mine

- Interpretation of the numbers
  - 447 ton/cap sounds like a lot, how does that compare to other investigations?
  - There aren't a lot of these studies around, most stock oriented studies are limited to a single material
  - Wiedenhofer et al. based on a century EW-MFA accounts and a rough estimate of life spans: global level number of 100 ton/cap, 320 ton/cap for developing countries
  - NL urban mine estimate in same order of magnitude; a bit on the high side but that may actually be true

- Comparison of urban mine with geological mine
  - For copper, the urban mine is 0.15 ton/cap for inhabitants of the NL, the geological mine (reserves) add up to 0.11 ton/cap at global level. So the urban mine is really significant!
  - For cobalt, the Dutch urban mine is 0.1 kg/cap, geological mine 7.1 kg/cap. Here the urban mine is much smaller. For now!

The Dutch urban mine

Our conclusions for the Dutch government:

- The good news: the NL has no (more) mines, but the urban mine is substantial and could be a relevant source of materials
- The bad news: presently the NL is not good at exploiting the urban mine – even the awareness of its existence is lacking
- The message: if we are serious about moving towards a circular economy, we have to start making plans for exploiting the urban mine now, and if we do there are some real opportunities to become leading in this innovative field

Accessing the Dutch urban mine

- So we know the amount of materials in the urban mine
- Now what? They are in appliances that are being used!

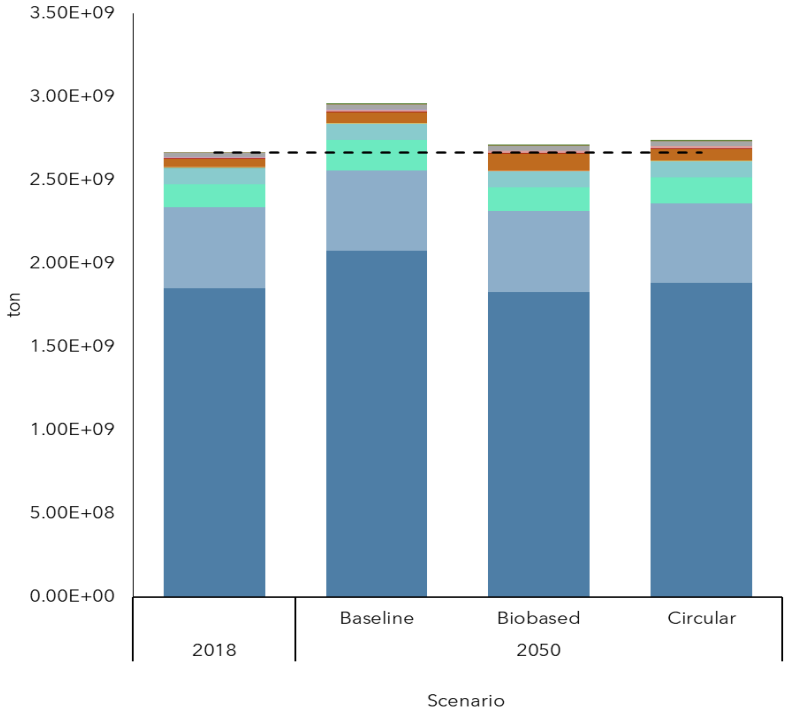
- Prospecting the urban mine: how much, where, **when!**

- Explorations of the future, using a variety of scenario-type information
  - Based on WLO-scenarios of PBL
  - With expansions for each sector: Berenschot scenarios for energy, Delta scenarios for water, Ruimtescanner scenarios for buildings
- Questions: how will the in-use stock develop, what will be inflows needed for expansion and maintenance, what will be outflows that can be re-used, refurbished, recycled etc.

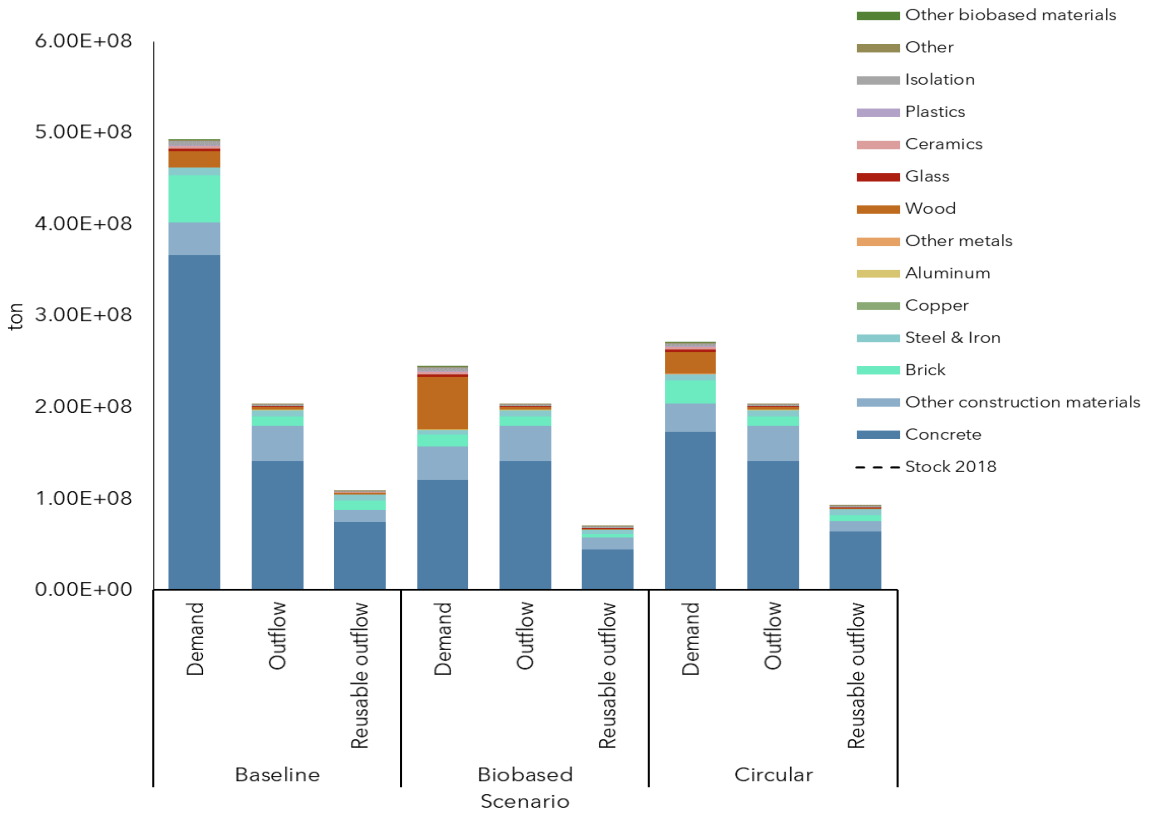
Future exploration for buildings

- Three material scenarios: baseline, biobased, circular

Material stocks in buildings, 2018 and (3x) 2050

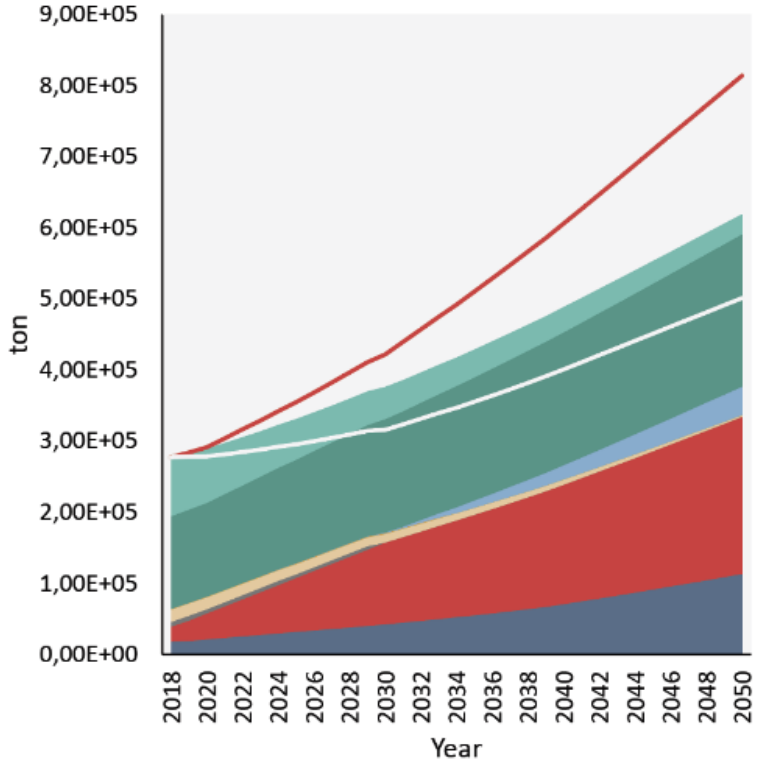


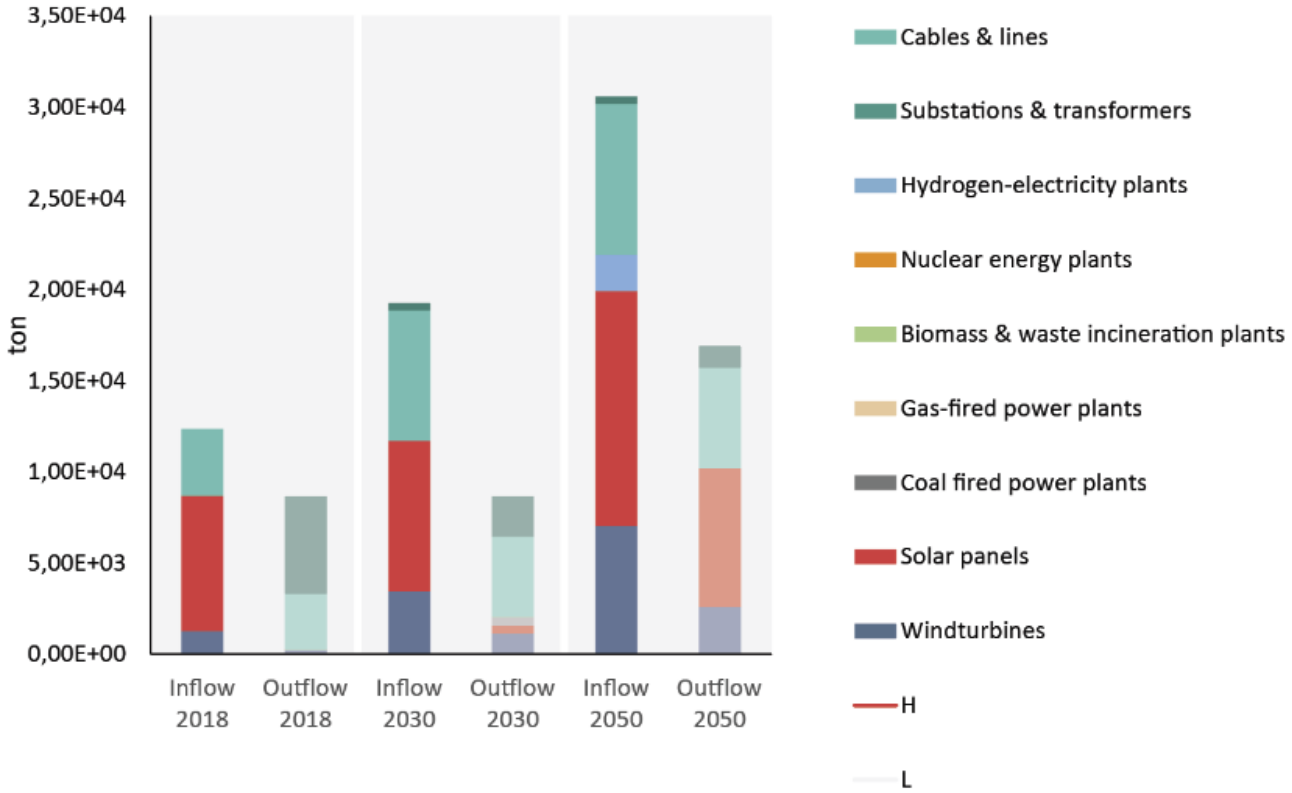
Inflows, outflows and reusable outflows, cumulative 2018-2050



Future explorations for electricity

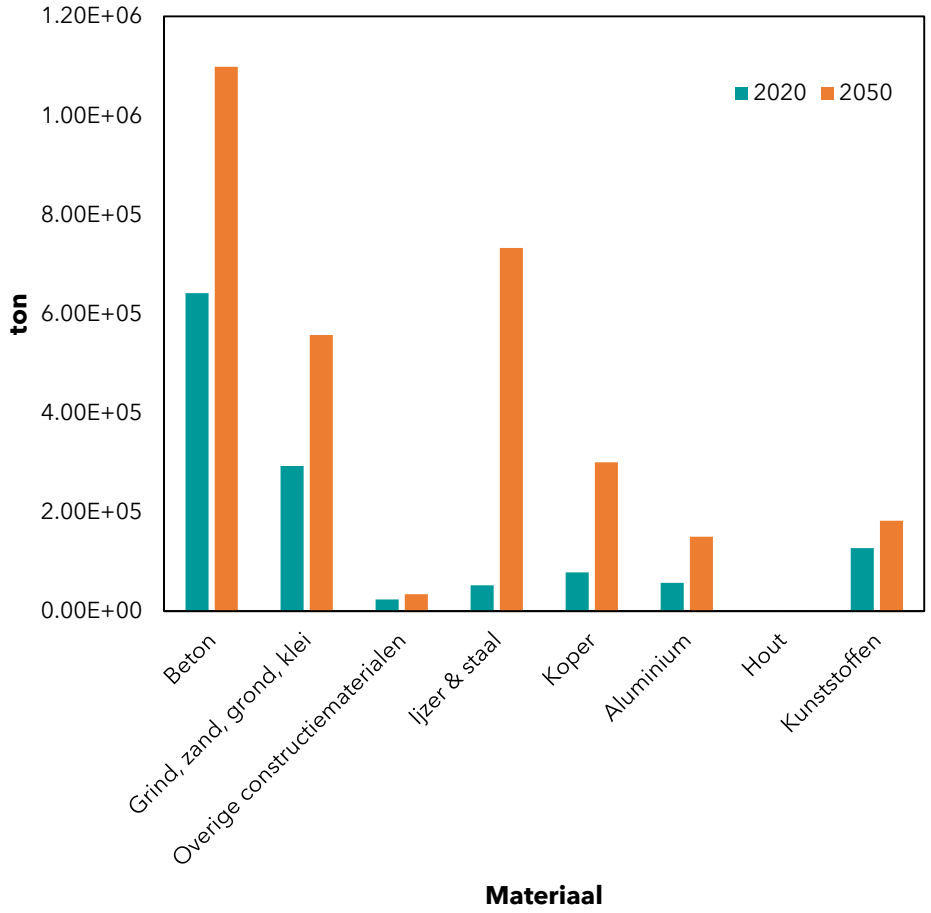
- Scenarios of installed capacity and grid expansion based on Berenschot report in terms of copper (right: stock, left: inflows and outflows) (information already outdated)





Accessing the Dutch urban mine

- The outflow is what we have to work with in a circular economy
- We don't know the future outflow but we can model it and anticipate on it: this amount comes out of stock in this period
- Urban mining plans should be drafted starting from these future outflows!
- In the meantime: why not start with the hibernating stocks? They are available now, and circularity schemes could be tried out on these stocks!



Accessing the Dutch urban mine

Where to go with the urban mining research?

1. We need to know what we have: internalize stock inventories in regular statistics
2. We need to know where it is: as much as possible, be spatially explicit
3. We need to know when materials become available: explorations of the future
4. Better data, especially on life spans and material contents – product passports, material passports
5. Strategies of exploitation: specific per application
6. Developing products and materials that are suitable for circularity
7. ….

Research team:

- CML: Janneke van Oorschot, Teun Verhagen, Lauran van Oers, Ester van der Voet
- CBS: Vincent van Straalen, Vivian Tunn, Kiki Kerstens, Roel Delahaye
- Metabolic: Nico Schouten, Pieter Witteveen, Merlijn Blok, Paul Groot, Martijn Kamps
- MScIE students: Jochem van der Zaag, Bas Roelofs, Judith Verschelling, Lowik Pieters, Emma van der Bent
- RWS and EIB: Jelger Arnoldussen, Thomas Endhoven, Jeffrey Kok