



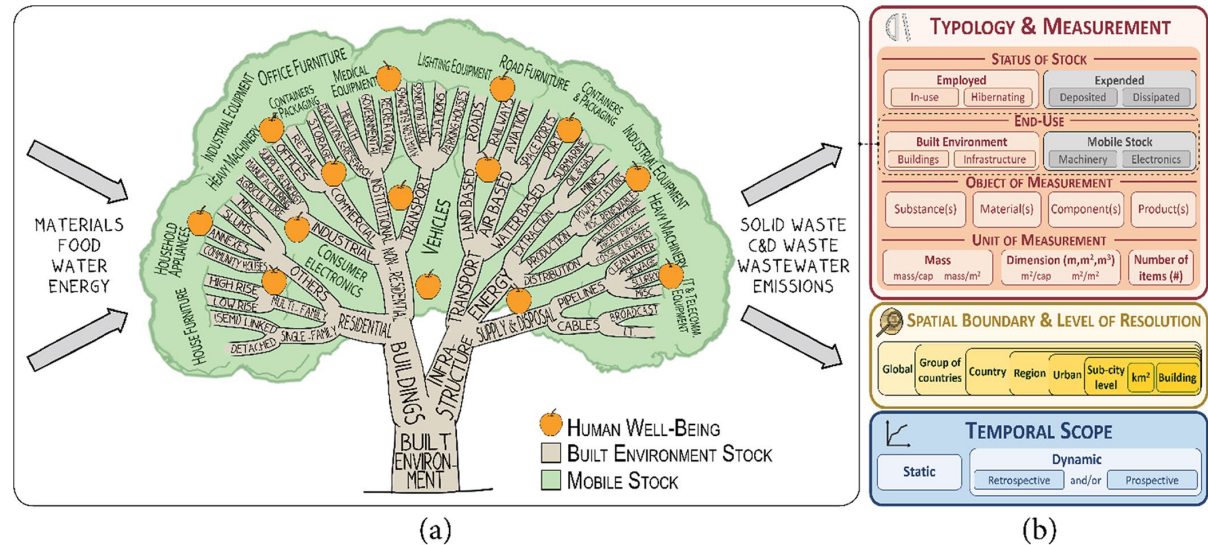
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Embodied emissions of Swedish road infrastructure - a material flow analysis

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Overall research question

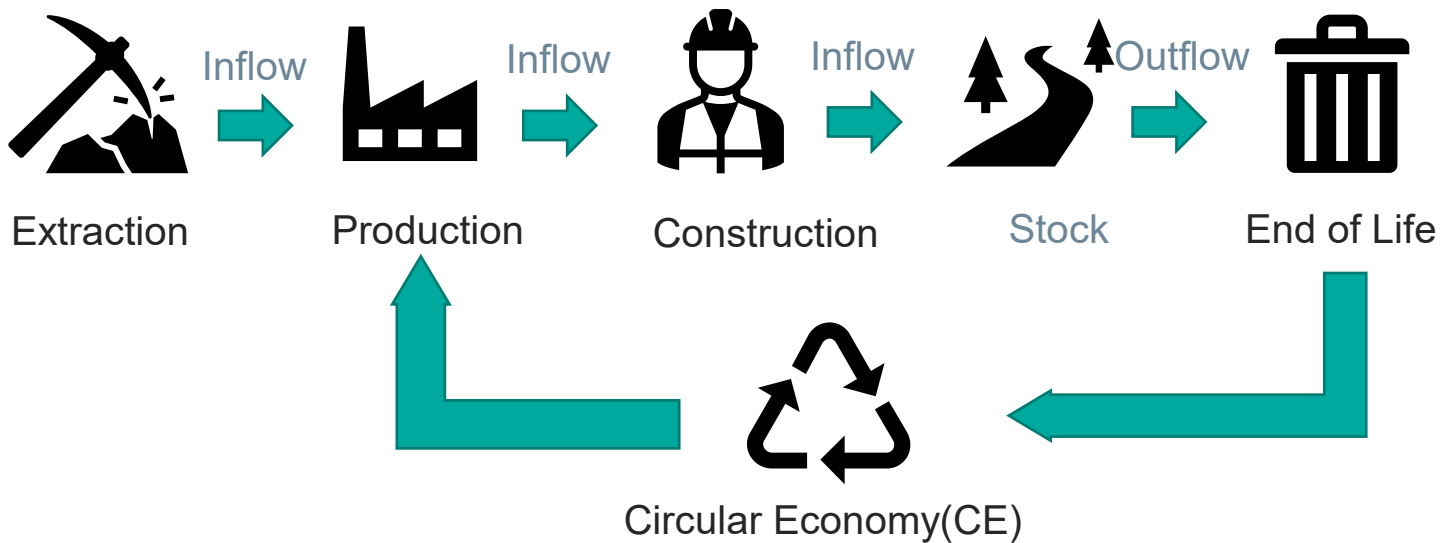
- How to quantify embodied emissions in Swedish built environment?
- How to reduce and mitigate these embodied emissions in the future?
- Focus on material stocks and flows using a bottom-up approach.



Source: Lanau et al.
2019

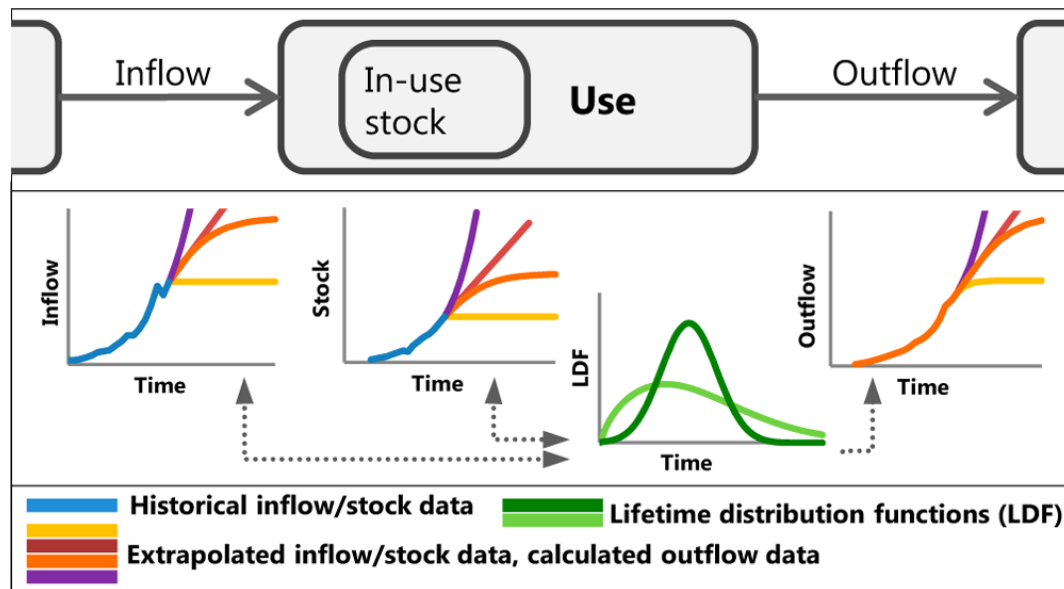


What is Material Flow Analysis(MFA)?



Why MFA?

- Accounts for stock dynamics based on lifetime distribution
- Extrapolates future in-use stock and inflow
- The inflows can be coupled with scenarios (e.g., Ida's work) and/or LCA to simulate decarbonization pathways



Source: Müller et al 2014

Methodology

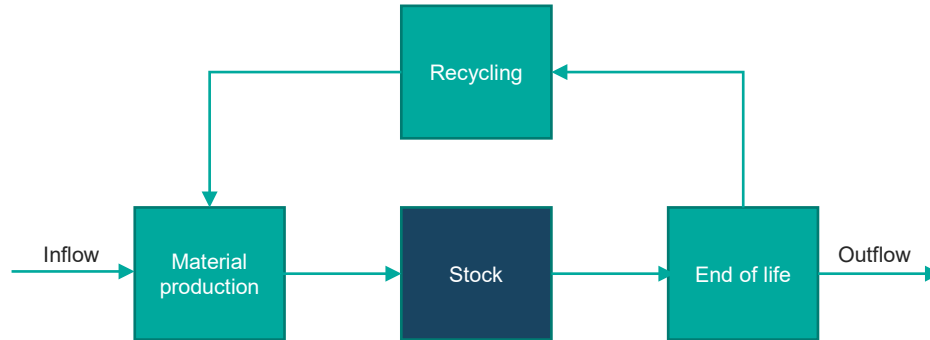


Infrastructure
stock

$$\text{Stock} = \text{Length} * \text{Material Intensity}$$

Length data: Swedish Transportation
Administration 'Lastkajen' database

Material Intensity: 'Klimatkalkyl' tool



Required stock data:

Lifetime distribution

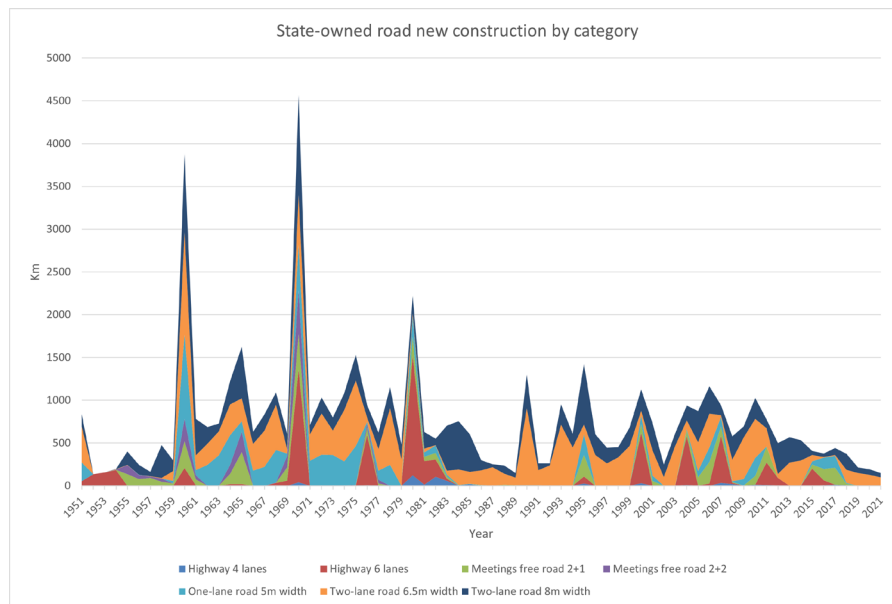
Construction year

Maintenance frequency*



State-owned roads

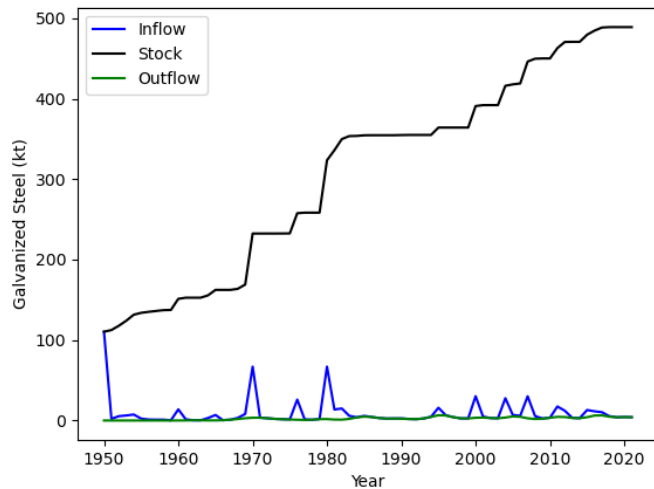
- Construction years represent when the roads enter the stock
- Data for municipally and privately owned roads are incomplete/does not exist
- This distribution is normalized and applied to the other roads



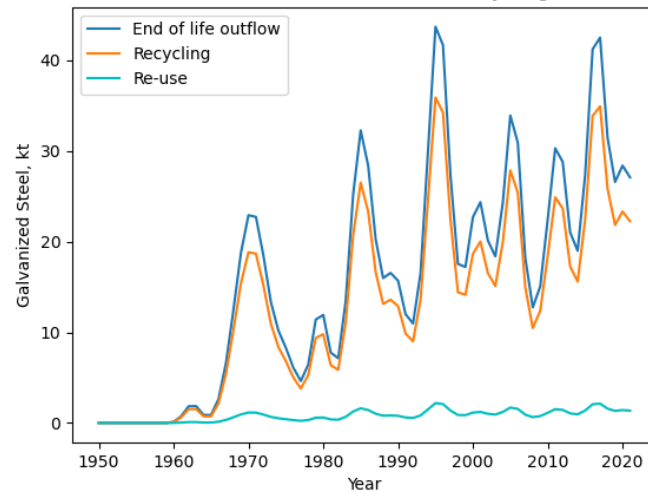


Galvanized Steel

Galvanized Steel stock and flows

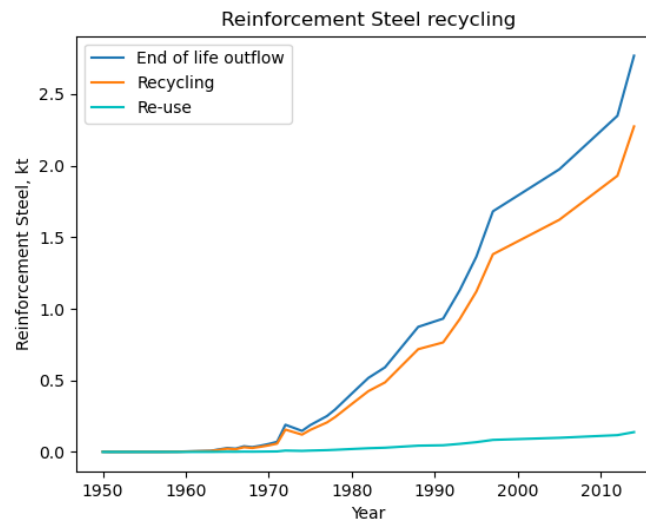
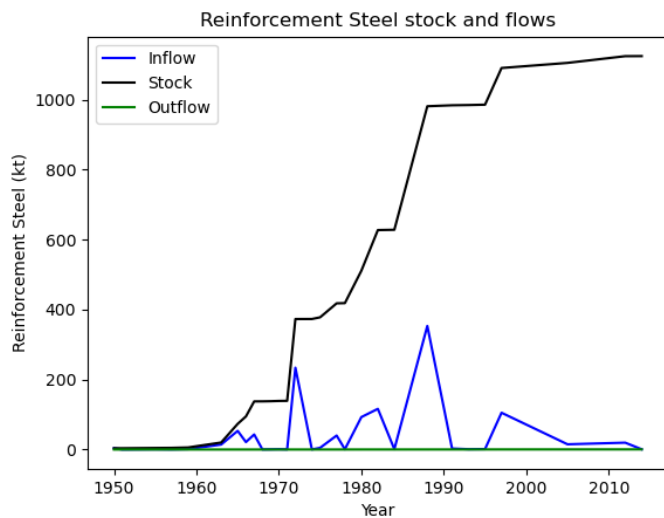


Galvanized Steel losses and recycling





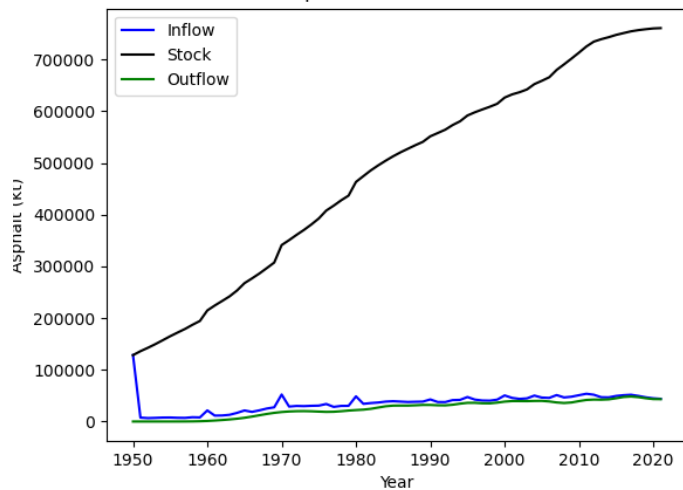
Reinforcement Steel



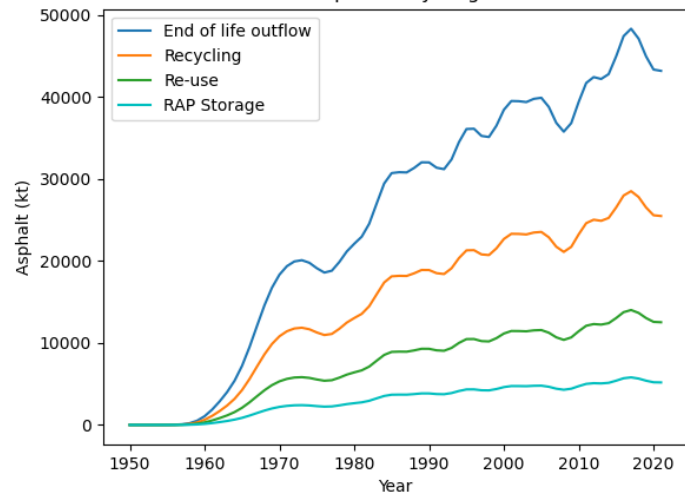


Asphalt

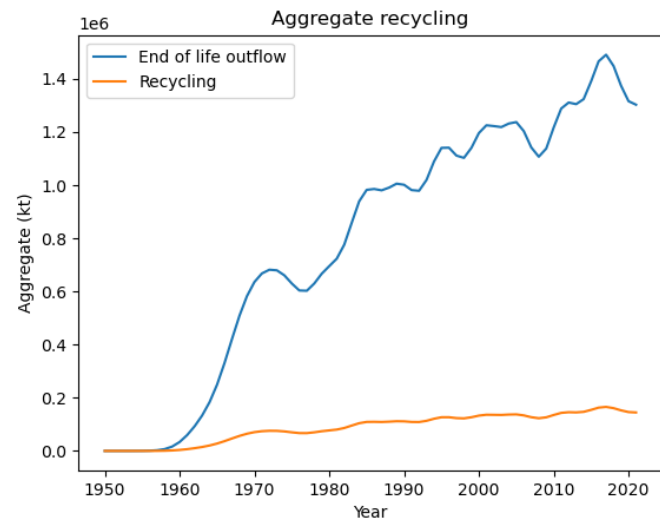
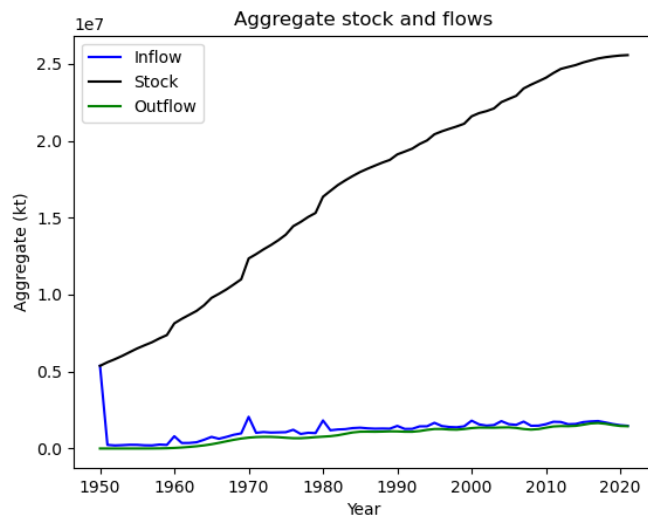
Asphalt stock and flows



Asphalt recycling

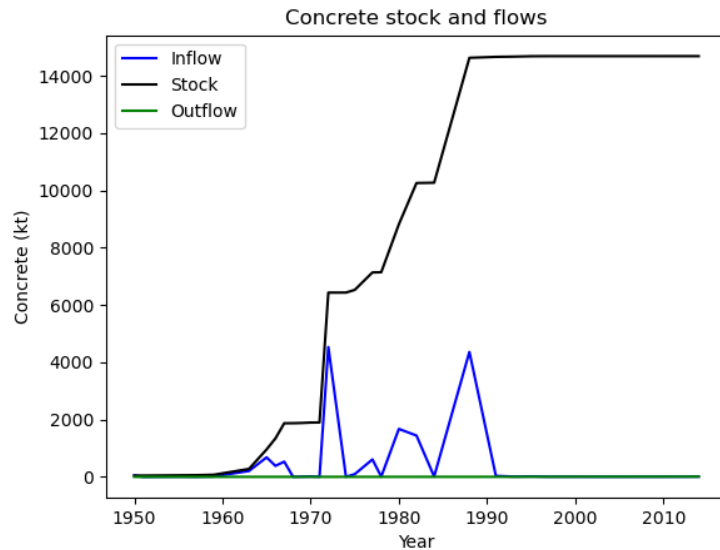


Aggregates





Concrete



Challenges and planned work

Challenges:

- How to account for the wear and tear caused by driving since these materials are lost to the environment and thus cannot be recycled.
- How to account for the impacts of future climate change on roads' maintenance needs

Planned work:

- Future extrapolation/projection of the stock and flows
- Apply scenarios and/or LCA results to account for embodied CO₂ emissions
- Work on railways and other parts of the built environment

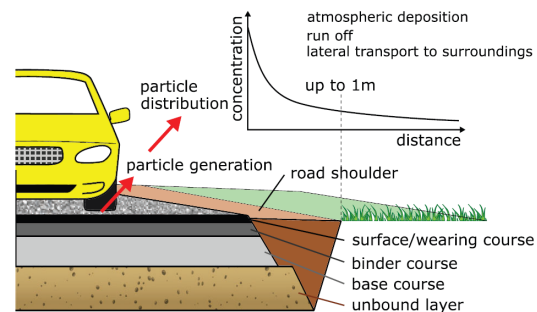


FIGURE 2 Illustration of the asphalt road layer structure and the pollution pathway of abrasion particles. Particles are generated through tire-surface course interaction and distributed according to mass and environmental conditions, leading to an exponential declining distribution from the road edge

Source: Grossegger 2022



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