Promoção da **resi**liência urbana através da gestão de **st**ocks de recursos urbanos

ResiSt

The material stocks

Index

- The in-use stocks - metals
  - Copper
  - Iron
  - Aluminum
- Landfill mining

Metals in-use stocks

Metals have the potential for almost infinite recovery and reuse.

(Gordon, R.B., Bertram, M. e Graedel, T.E. 2005)

Metals incorporated in products can be considered “mines” of secondary resources.

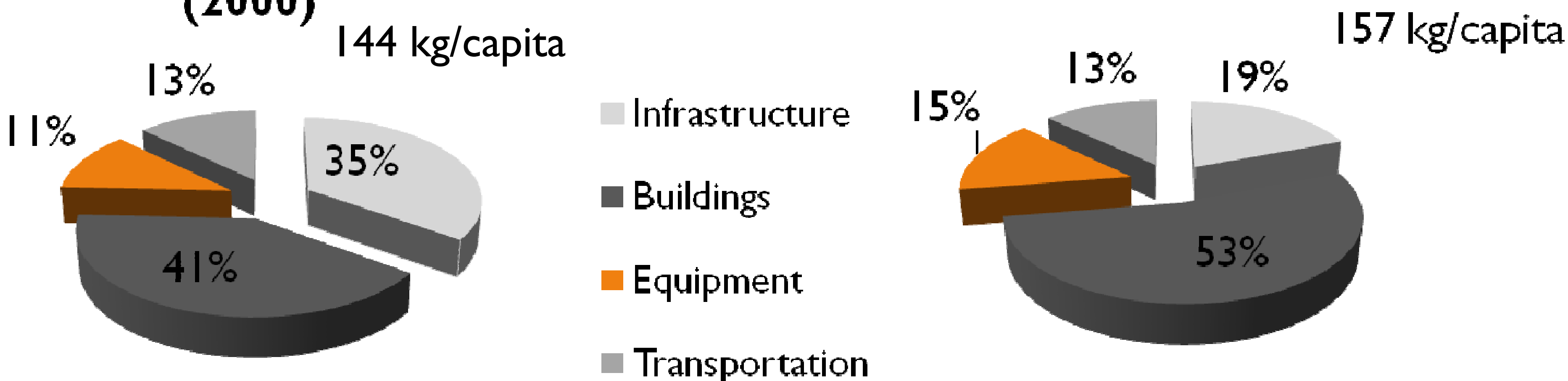
(Recalde, K., Wang, J. e Graedel, T.E. 2008)

Copper

- The increase of copper's demand is a potentially large constraint on the future availability of virgin copper.
- Most of the copper processed during the last few decades still resides in society, mostly in non-dissipative uses.

Copper in-use stock in New Haven, USA (2000)

Copper in-use stock in the State of Connecticut, USA (2000)



(Drakonakis, et al., 2006)

(Rauch, et al., 2007)

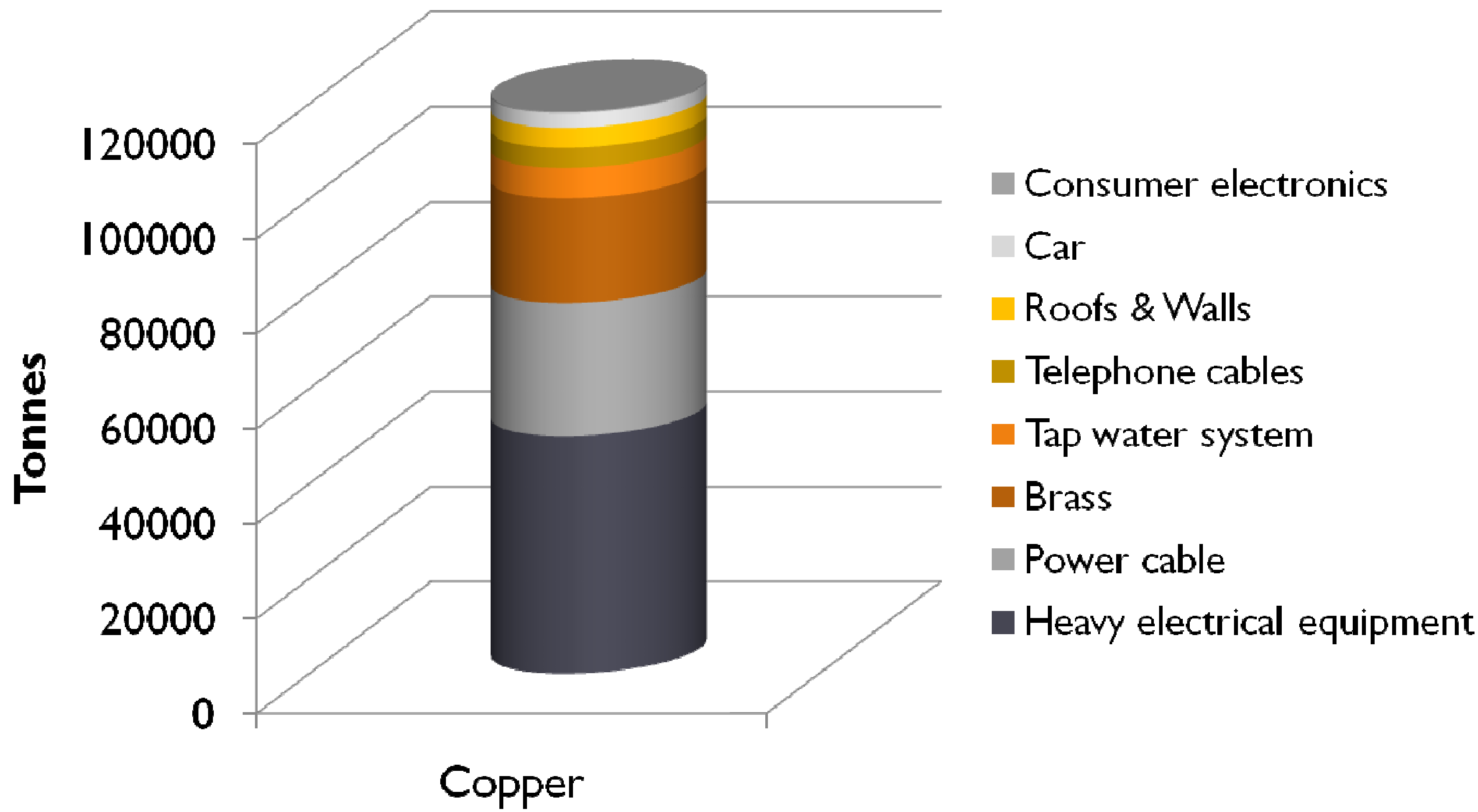
Spatari, S., et al. 2002. *The contemporary European copper cycle: 1 year stocks and flows.* s.l. : Ecological Economics, 2002.

Copper in Connecticut, 2000

- Buildings – 83.9 kg/capita
  - Wiring → 38.8 kg/capita
  - Plumbing → 35 kg/capita
- Infrastructure – 30 kg/capita
  - Water distribution system's service lines → 13.9 kg/capita
  - Electricity transmission & distribution → 8.9 kg/capita
- Equipment – 23.7 kg/capita
  - Industrial machinery & appliances→ 12.9 kg/capita
  - Electric & electronic → 6.4 kg/capita

Rauch, J., Eckelman, M. e Gordon, R. 2007. *In-use stock of copper in the state of Conneticut, USA.* s.l. : Yale School of Forestry & Environmental Studies, 2007.

Copper in Stockholm, 1995

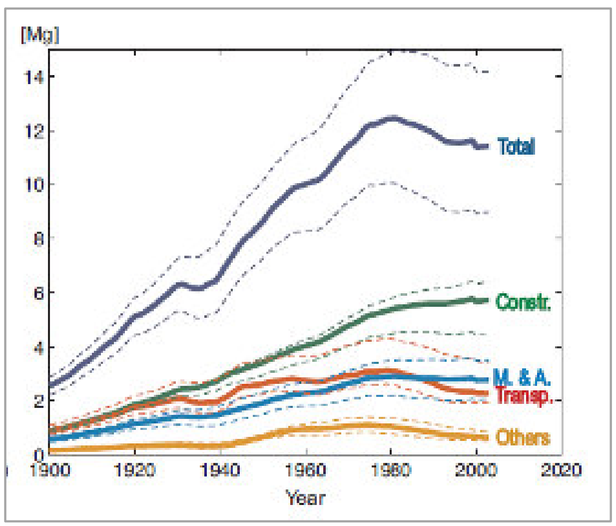


Sorme, L., Bergback, B. e Lohm, U. 2000. *Century perspective of heavy metal use in urban areas.* s.l. : Water, Air and Soil Pollution: Focus 1, 2000.

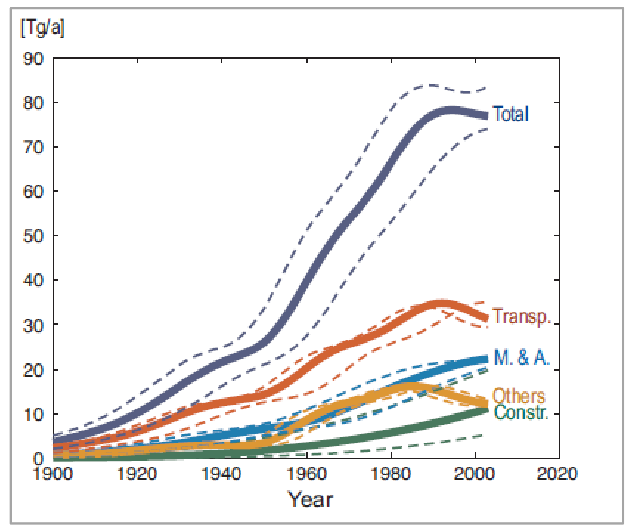
Iron

- Iron is by far the most widely used metal, comprising >90% of the metal tonnage produced worldwide.
- At the global scale, anthropogenic iron stocks are less significant compared with natural ores but their relative importance is increasing.
- In 2004, 50% of US steel was produced in electric arc furnaces, which use scrap almost exclusively as an iron source.

Historic US iron stocks in products in use, per capita



Historic iron flows in obsolete products generated in the US



Muller, D.B., et al. 2006. *Exploring the engine of anthropogenic iron cycles.* s.l. : PNAS, 2006.

Iron in Connecticut, 2000

- Buildings
  - Industrial buildings → 2539 kg/capita
  - Commercial buildings → 1764 kg/capita
  - Residential buildings → 1226 kg/capita

Structures & Heating, ventilation and air conditioning

- Transportation
  - Automobiles → 1656 kg/capita

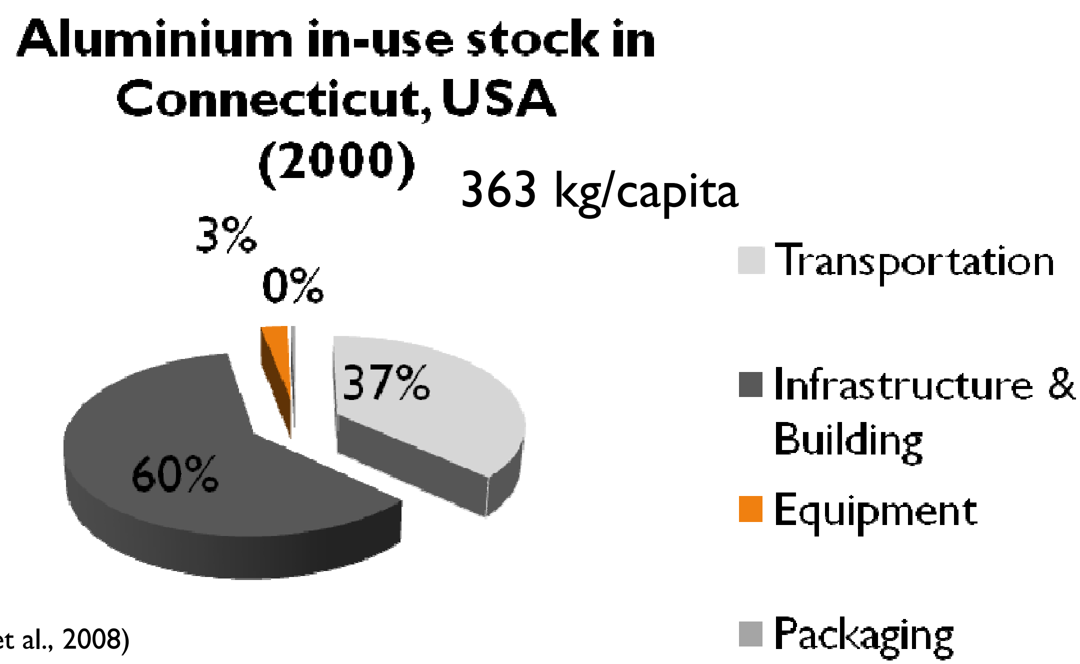
Cars and light trucks & Marine vessels

- Infrastructures
  - Water supply and distributions mains → 487 kg/capita

Eckelman, M., Rauch, J. e Gordon, R. 2007. *In-use stocks of iron in the state of Connecticut, USA.* s.l. : Yale School of Forestry & Environmental Studies, 2007.

Aluminium

- The energy required to produce aluminium from scrap metal is approximately 5% of that required for primary production.
- The lifetimes of aluminium in buildings and infrastructure is estimated to be 40-50 years, in transportation facilities10-30 years and in packaging only several months.



(Recalde, et al., 2008)

Recalde, K., Wang, J. e Graedel, T.E. 2008. *Aluminium in-use stock in the state of Connecticut.* s.l. : Resources, Conservation & Recycling, 2008.

Aluminium in Connecticut,2000

- Infrastructures & Buildings
  - Residential buildings → 92.8 kg/capita
  - Commercial buildings → 97.7 kg/capita

- Transportation
  - Light vehicles → 81.7 kg/capita
  - Marine vessels → 32.7 kg/capita
  - Aircraft → 80% Al content

Recalde, K., Wang, J. e Graedel, T.E. 2008. *Aluminium in-use stock in the state of Connecticut.* s.l. : Resources, Conservation & Recycling, 2008.

Landfill mining

"Landfill mining" is a process of excavating a landfill using conventional surface mining technology to recover e.g. metals, glass, plastics, soils and the land resource itself.

(Van der Zee, D.J., Achterkamp, M.C. e Visser, B.J. 2004)

The composition of waste recovered is dependent on the type of landfill, particular practices of deposition and the level of decomposition of waste, and the type and quantity of industrial waste and/or trade in them were deposited.

(Anacleto, S. 2008)

Landfill mining - Advantage

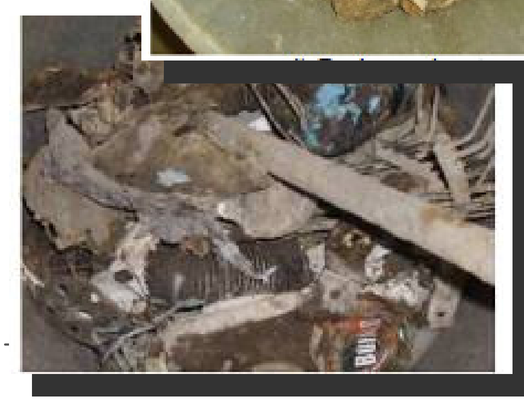
- Conservation of landfill space
- Reduction in landfill area
- Elimination of a potential source of contamination
- Mitigation of an existing contamination source
- Energy recovery
- Recycling of recovered materials
- Reduction in management system cost
- Site redevelopment

Hogland, W., Marques, M. e Nimmermark, S. 2004. *Landfill mining and waste characterization_a strategy for remediation of contaminated areas.* s.l. : Water Cycles Waste Management, 2004.

Landfill mining - Advantage

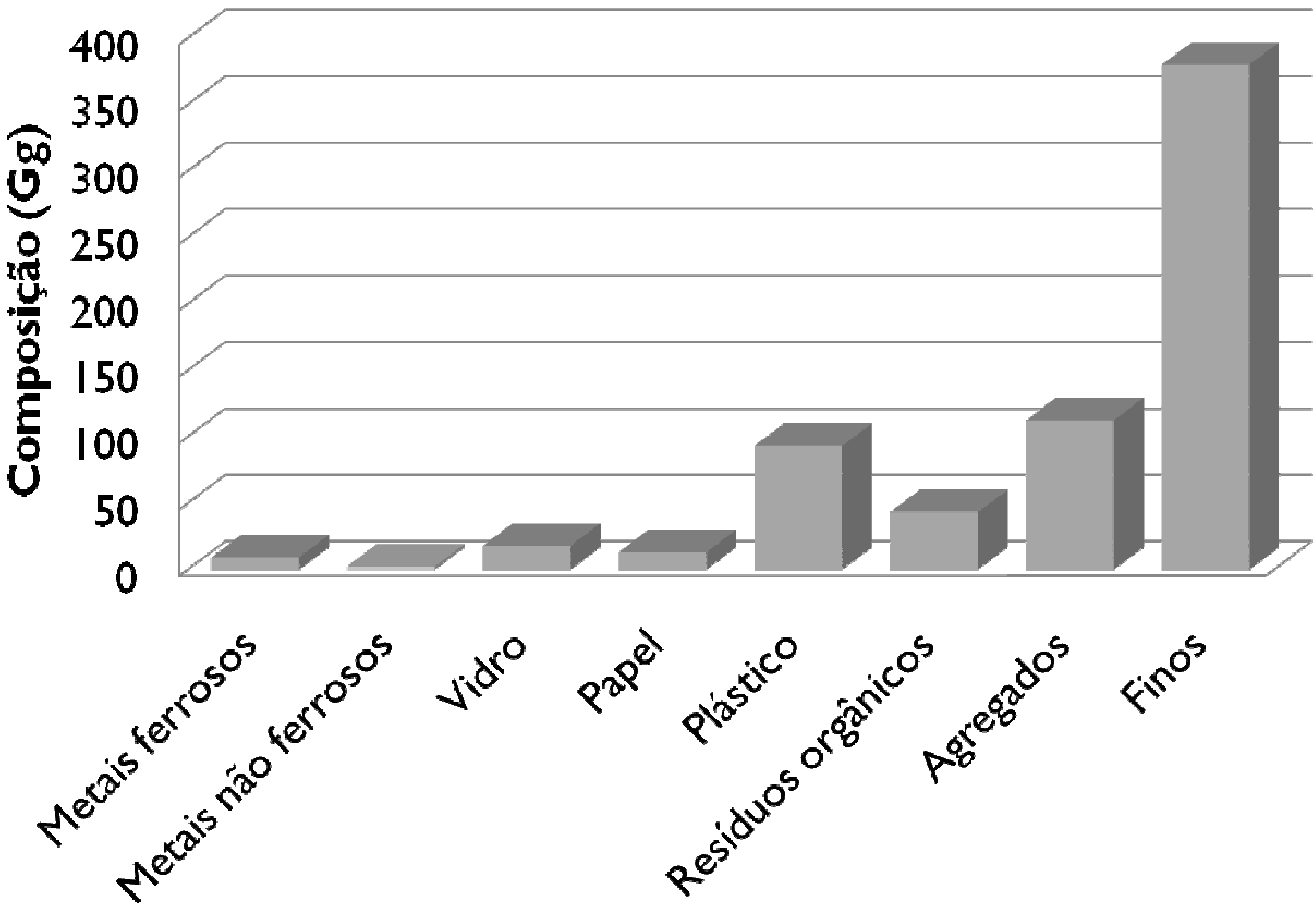
Reuse of such substances as:

- Soil cover material
- Material for energy recovery
- Wood for the production of woodchips
- Stones, bricks and mortar for road construction
- Concrete for crushing into coarse material
- Metals as iron, copper and aluminium for industry



Hongland, W. 2002. *Remediation of an Old Landsfill Site.* s.l. : First Baltic Symposium, 2002.

Landfill mining in Moita, 2007



Anacleto, S. 2008. *Técnicas para recuperação de resíduos depositados em antigas lixeiras. Caso de estudo: Lixeira da Moita.* s.l. : FCT/UNL, 2008.

Landfill mining in Moita, 2007

A mineração da lixeira permite:

- Reciclar 380 mil ton de finos como material de cobertura
- Utilizar 150 mil ton de fracção combustível para produção de CDR
- Obter 9.4 mil ton de materiais ferrosos
- Obter 2.7 mil ton de materiais não ferrosos
- Libertar até 91% do volume da lixeira

A estimativa do tempo necessário para o processamento de todos os materiais é de pelo menos13 anos

Anacleto, S. 2008. *Técnicas para recuperação de resíduos depositados em antigas lixeiras. Caso de estudo: Lixeira da Moita.* s.l. : FCT/UNL, 2008.

ResiliSt

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The material stocks

The in-use stocks

"In-use" refers to material that are currently providing services to people.

(Eckelman, M., Rauch, J. e Gordon, R. 2007)

The "material stock" is composed out of all the products that contain materials and have a life span longer than 1 year.

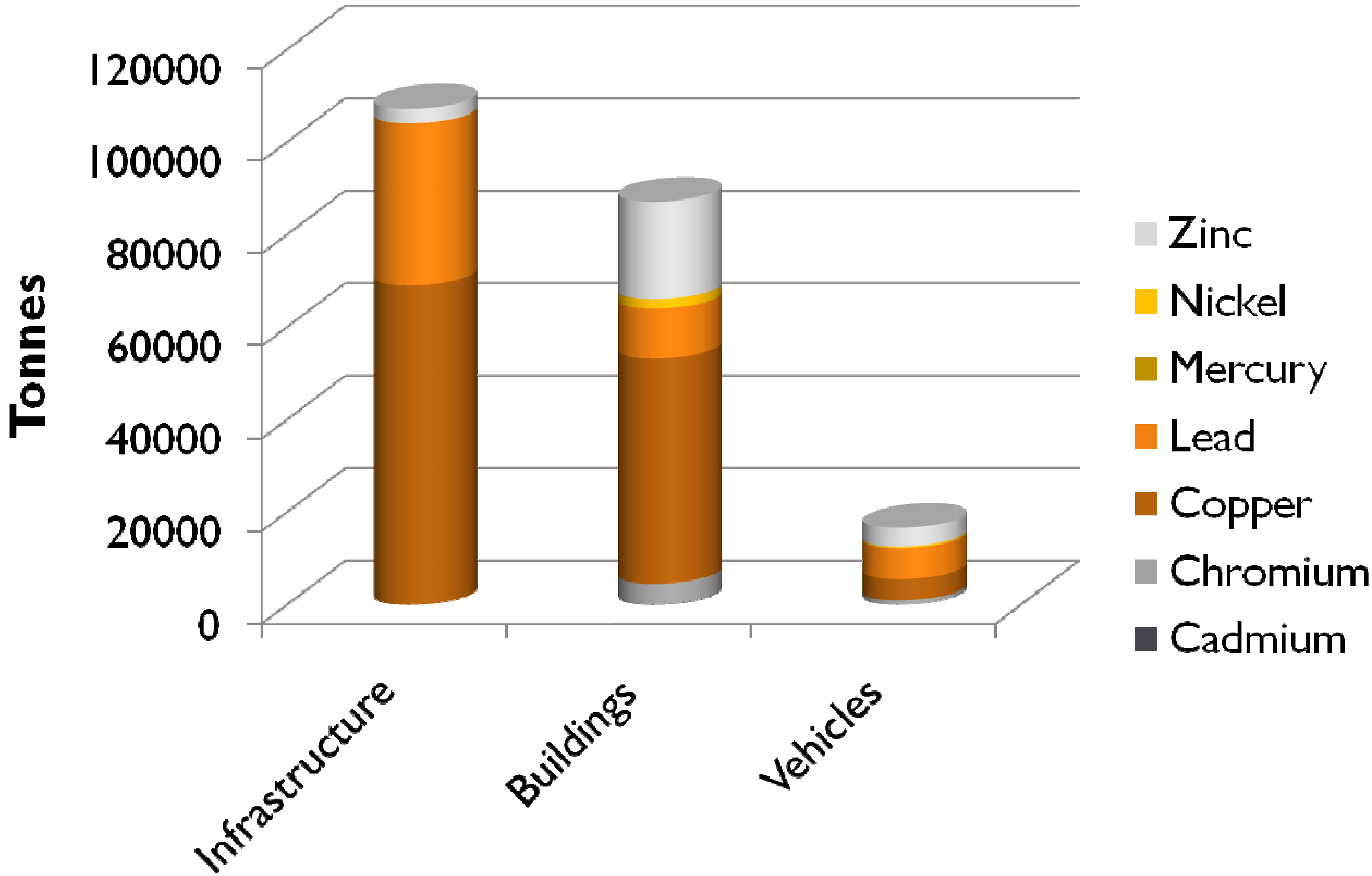
(Elshkaki, et al., 2004)

Three types of products:

- *In stable use* → products with predictable life spans and potential for recycling
- *In hibernating use* → products with a predictable life span but with low commercial value at end of life
- *In dissipative use* → products with short lifetimes and low recycling potential

(Mao, J., e Graedel, T.E., 2009)

Heavy metal stocks in Stockholm, 1995



Sorme, L., Bergback, B. e Lohm, U. 2000. *Century perspective of heavy metal use in urban areas.* s.l. : Water, Air and Soil Pollution: Focus 1, 2000.

Lead

- In 2000, the lead in-use stock in Portugal was about 12.9 kg/capita.

Toxicity of lead

- The replacement of lead pipes in water supply infrastructure
- The use of lead – free electrical components in consumer applications
- The development of lead – free solders

Decline in lead demand and, over time, in lead in-use stocks

- The future availability of lead for recycling will exceed its demand.

68% Batteries

20% Pipes and sheets

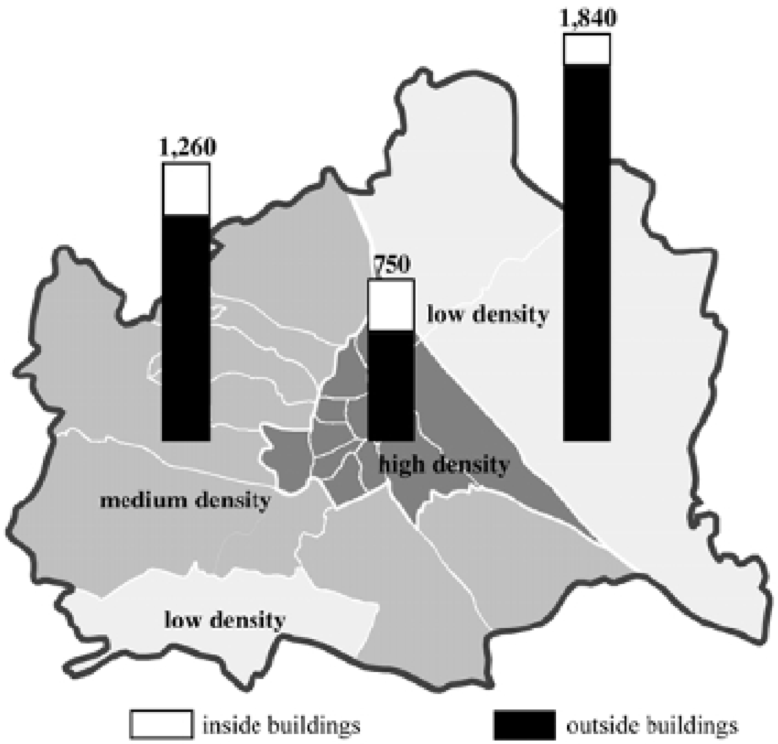
8% Others

4% Alloys

Mao, J. e Graedel, T.E. 2009. *Lead in-use stock.* s.l. : Jounal of Industrial Ecology, 2009.

Lead in Vienna, 1991

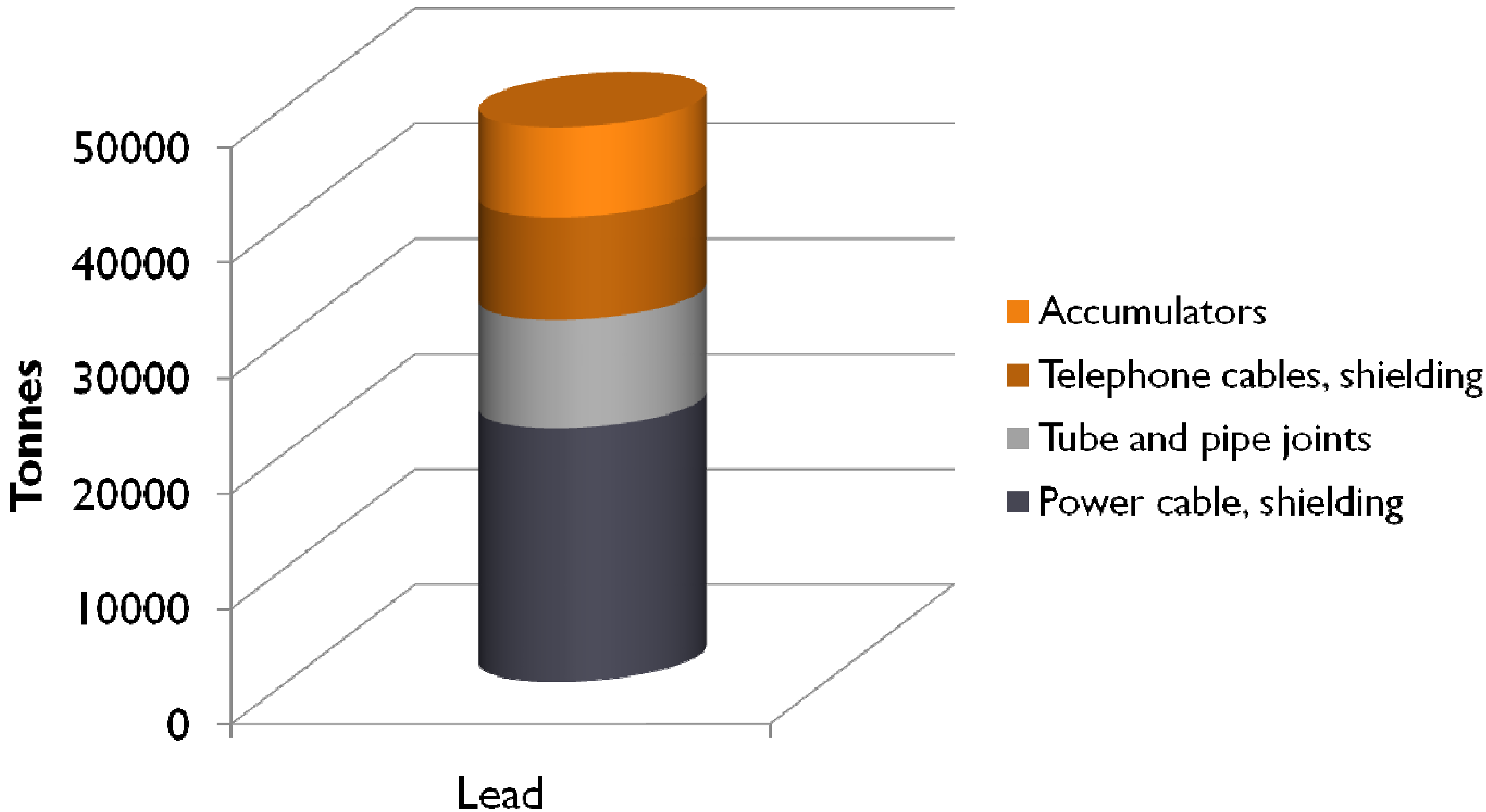
- The 20 000 ton of lead water pipes have a re-use potential to produce 1.6 million traditional car batteries.



Infrastructure density and lead stocks in Vienna in kg Pb per 1000 m²

Obernosterer, R. e Brunner, P.H. 2000. *Urban metal management: the example of lead.* s.l. : Water, Air and Soil Pollution: Focus 1, 2000.

Lead in Stockholm, 1995



Sorme, L., Bergback, B. e Lohm, U. 2000. *Century perspective of heavy metal use in urban areas.* s.l. : Water, Air and Soil Pollution: Focus 1, 2000.

Zinc

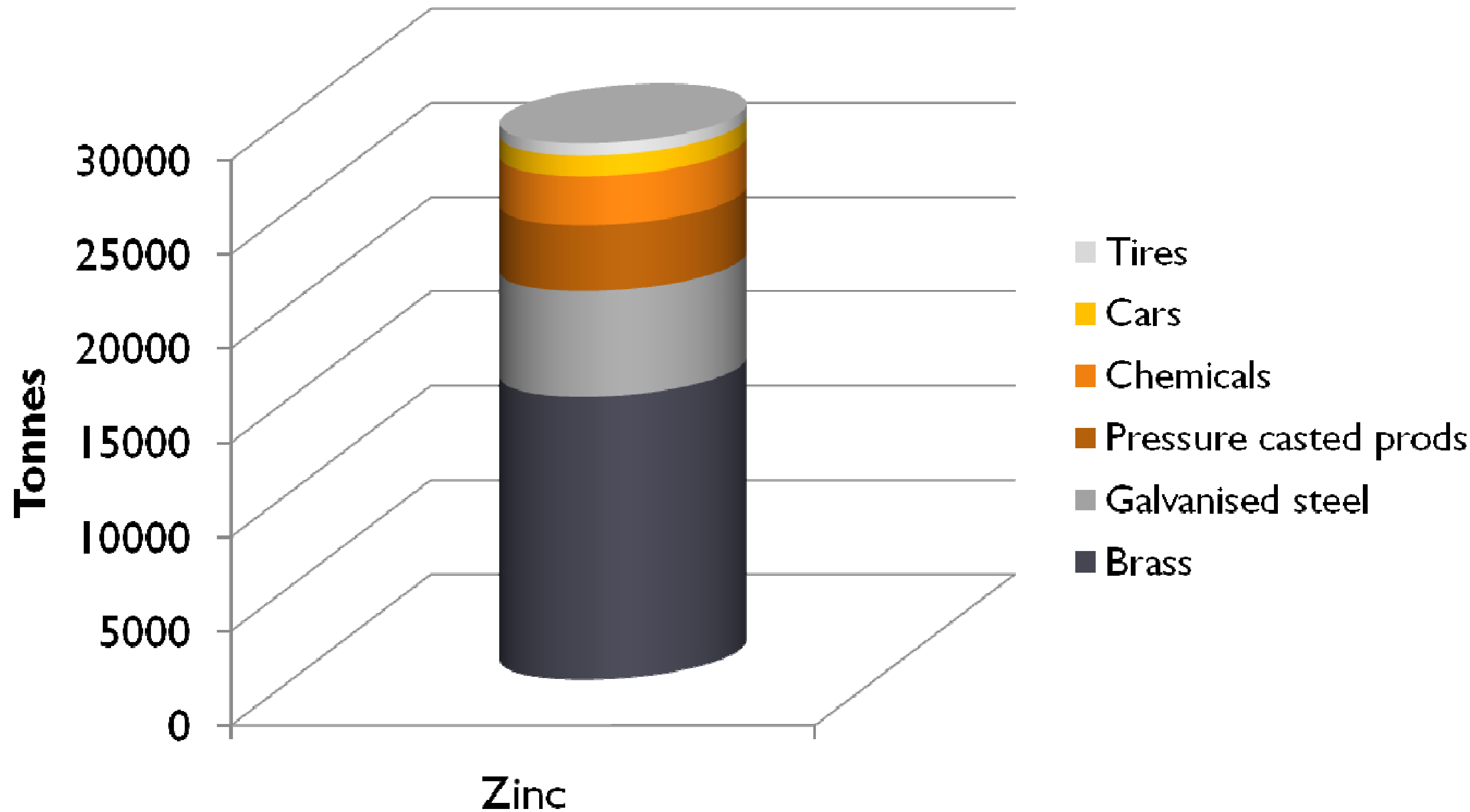
- To provide comparable services with existing technology to a large part of the world's population, current technologies would require the entire zinc ore resource.

- Between 1850 and 1990, in the U.S. , 73Tg of zinc placed in service, 23Tg remains in use, only 4Tg were recycled and 46Tg (63%) were lost in waste repositories or were dissipated.

The important uses of zinc are inherently dissipative, as in galvanizing and brass in brake linings.

Gordon, R.B., Bertram, M. e Graedel, T.E. 2005. *Metal stocks and sustainability.* s.l. : PNAS, 2005.

Zinc in Stockholm, 1995



- **Sorme, L., Bergback, B. e Lohm, U. 2000.** *Century perspective of heavy metal use in urban areas.* s.l. : Water, Air and Soil Pollution: Focus 1, 2000.

Nickel

A major use of nickel is as a component of stainless steel

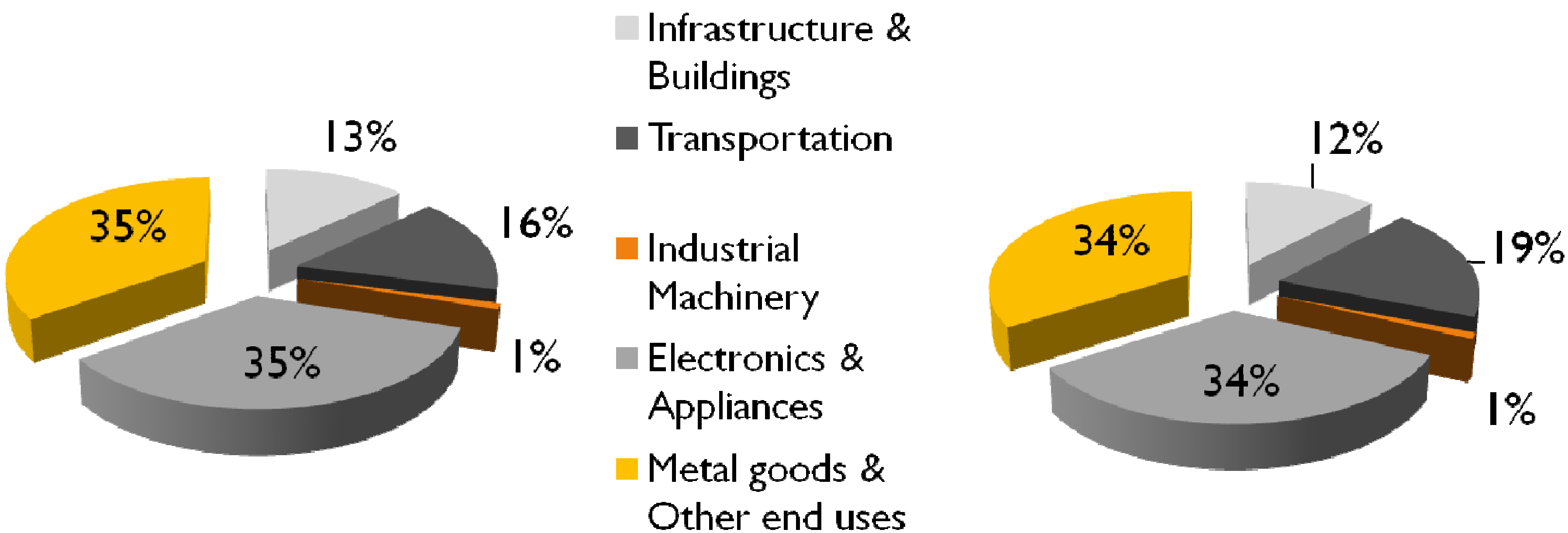
- Buildings & Infrastructures
  - Chimney liners, smokestacks, bank vaults, kitchen sinks
- Transportation
  - Passenger vehicles, buses, large and specially trucks, rails
- Industrial machinery
  - Machinery (industrial and construction), manufacturing machinery
- Household appliances and electronics
  - Computers, refrigerators/freezers, stereos/radios, stoves
- Metal goods and other end uses
  - Cookware, kegs, restaurant equipment, fasteners

Rostkowski, K., et al. 2006. "*Bottom-up*" *study of in-use nickel stocks in New Haven, CT*. s.l. : Resources, Conservation & Recycling, 2006.

Nickel in New Haven, 2000

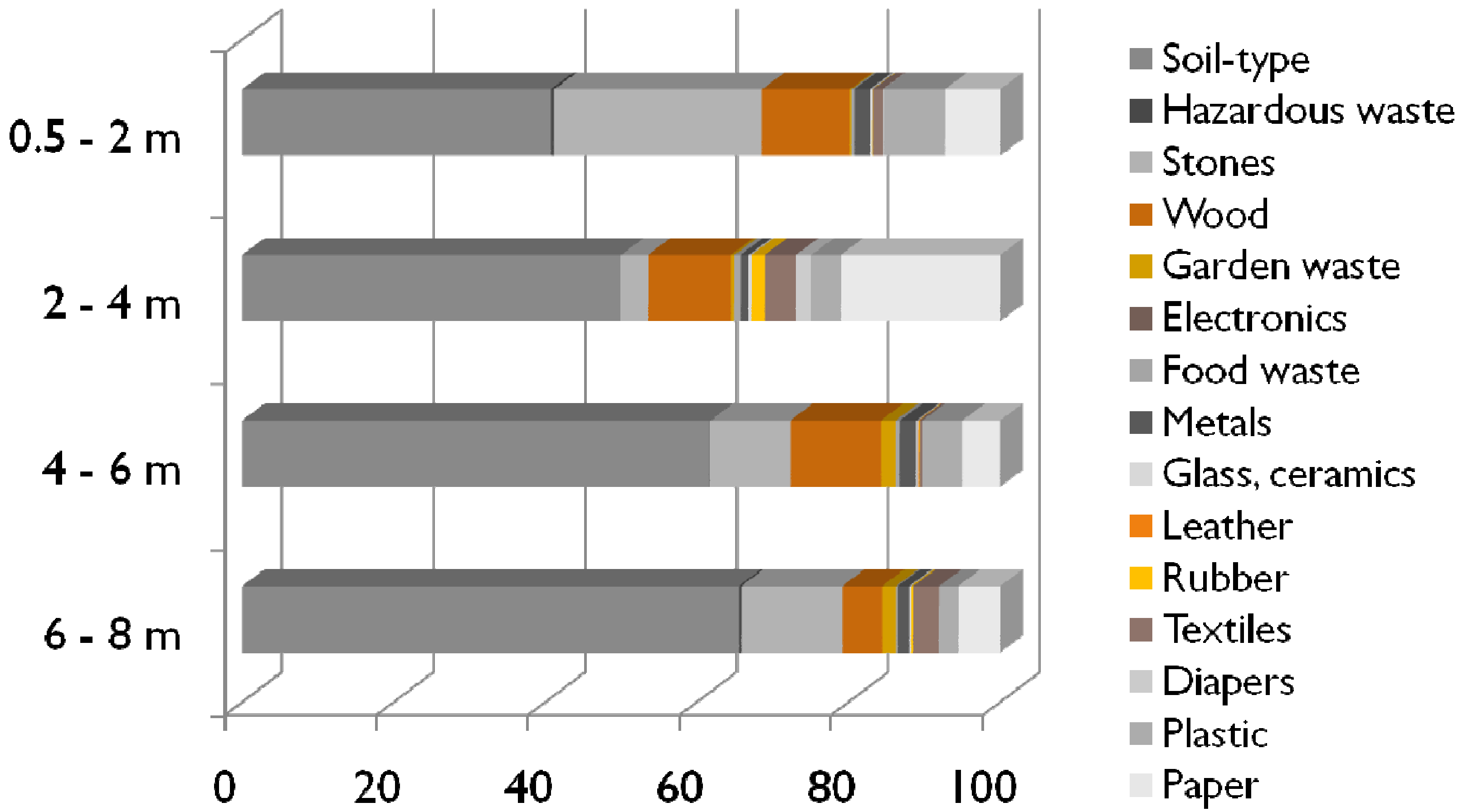
The nickel in-use stock in New Haven is about 2.6kg/capita.

Nickel stocks excluding non-resident transportation | **Nickel stocks including non-resident transportation**



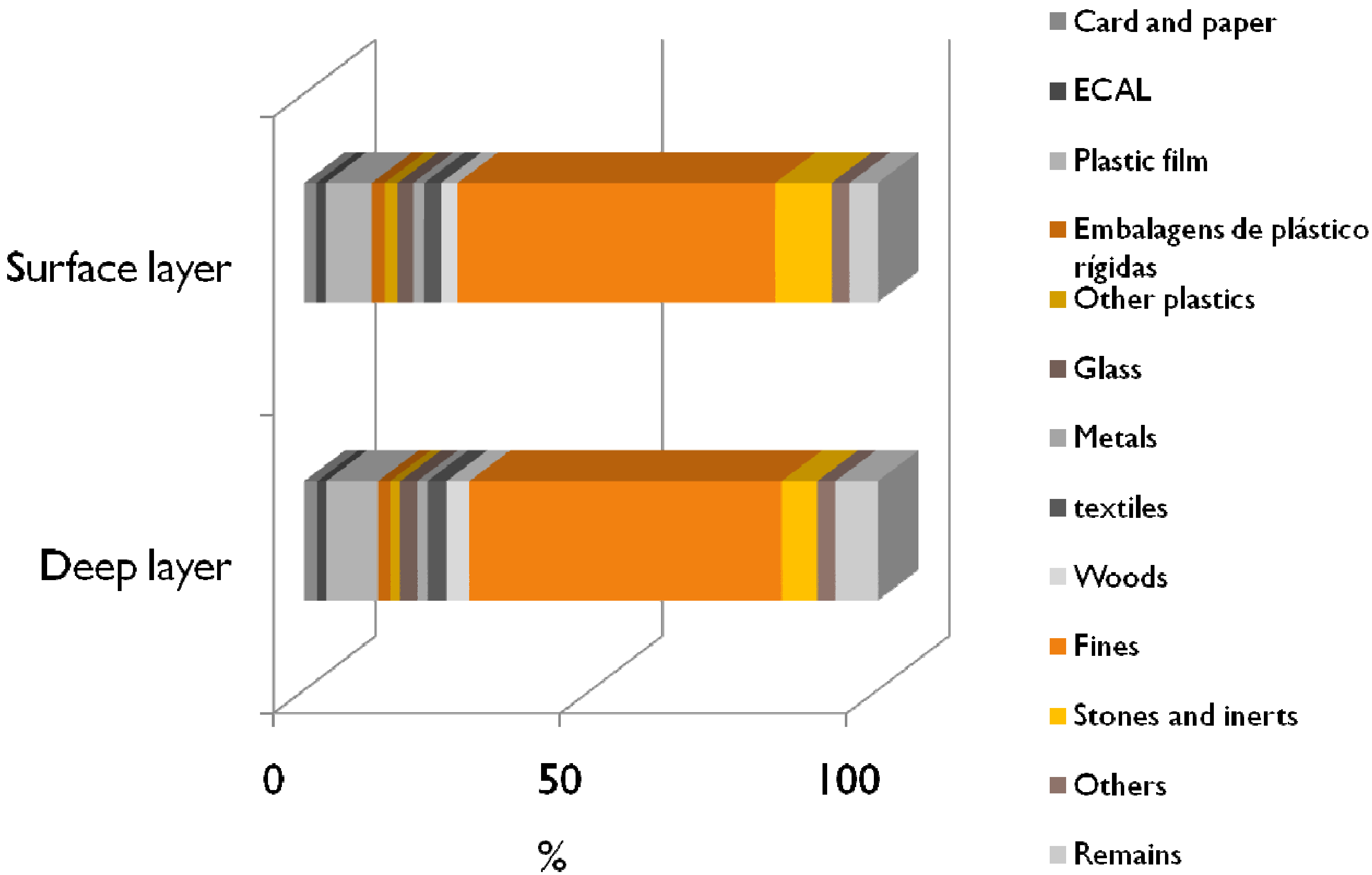
Rostkowski, K., et al. 2006. *"Bottom-up" study of in-use nickel stocks in New Haven, CT.* s.l. : Resources, Conservation & Recycling, 2006.

Landfill mining in Sweden, 1996



Hogland, W., Marques, M. e Nimmermark, S. 2004. *Landfill mining and waste characterization_a strategy for remediation of contaminated areas.* s.l. : Water Cycles Waste Management, 2004.

Landfill mining in Moita, 2007



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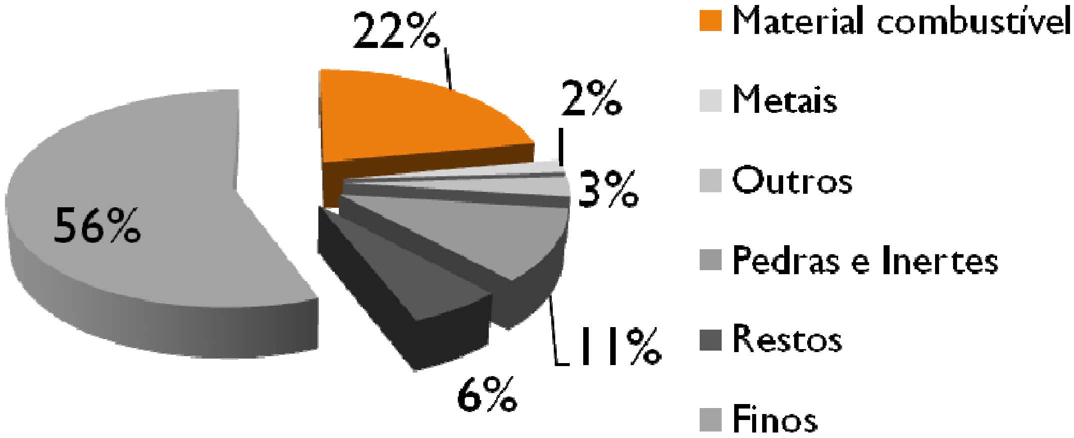
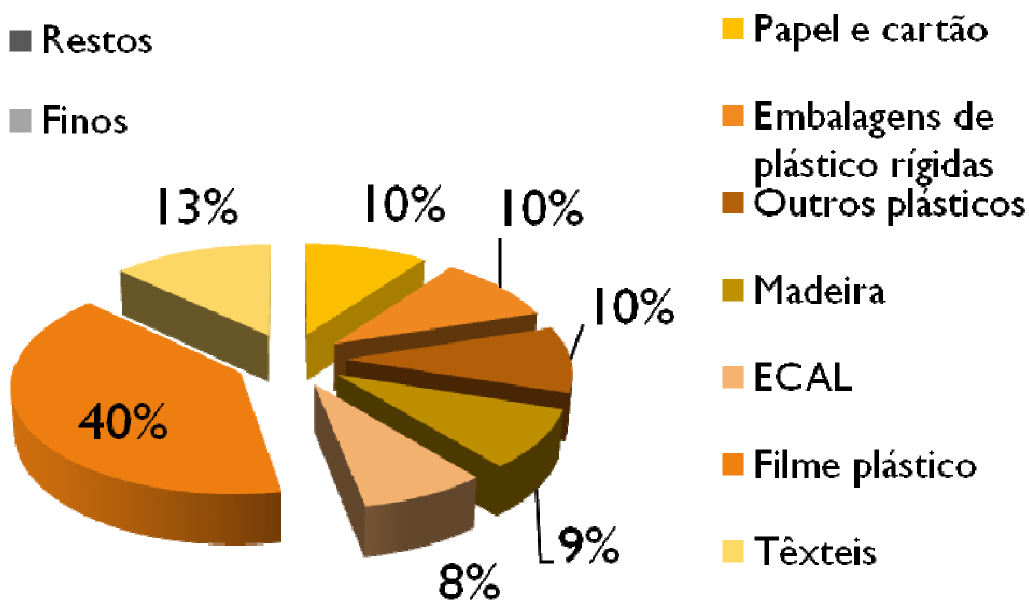
Landfill mining in Moita, 2007

Composição física média dos resíduos depositados na lixeira da Moita – 673 233 ton





Composição do material combustível dos resíduos depositados na lixeira da Moita

Anacleto, S. 2008. *Técnicas para recuperação de resíduos depositados em antigas lixeiras. Caso de estudo: Lixeira da Moita.* s.l. : FCT/UNL, 2008.

Traditional and urban mines

- Mineral ores change very slowly over time, anthropogenic stocks change rapidly and therefore require better monitoring;
- Mining production of mineral ores can readily be adjusted to changes in demand provided that necessary reserves, capital and labour are available, whereas urban mining faces physical limitations because it is restricted to products in use becoming obsolete;
- The material in urban mines in generally of higher quality than mineral ores because already processed and purified material often requires less energy and technology to re-employ;
- There is extensive knowledge about the size and chemical and physical properties of geological ores but there is very little understanding of anthropogenic material stocks and their dynamics.

Muller, D.B., et al. 2006. *Exploring the engine of anthropogenic iron cycles.* s.l. : PNAS, 2006.