Spatially Enabling Above-Ground Resource Analysis to Support Better Decision Making
Above-ground resources

• The metal stocks in community served as mines above ground – the urban mine
  – Contained in buildings, urban infrastructure, transport systems, motor vehicles, equipment, electronic devices (e.g. mobile phones, computers, tablets, TVs and similar gadgets)....

• The variety of metals used in community grew rapidly (the International Resource Panel, UNEP, 2010)
  – Expanding metal mining activities
  – Creating more and more of metal stocks above ground in use
Above-ground resource analysis

• To understand
  – how much of above ground resources are present
  – what their lifetimes are
  – how they are distributed geographically

• Important for evaluation of
  – the economic values of the resources
  – the social and environmental impacts of mining these resources
  – effectiveness of existing and future collection and recycling infrastructure
Urban Mining Process

- Quantification of stocks
- Localisation of stocks
- Collection
- Separation
- Sorting
- Processing

How much of urban mines are present?
Where are the stocks located?
How are they distributed?

(from Zhu 2014)
The value of location

• Geographical or spatial variations in the distributions of metal stocks in community
  – All buildings have an address
  – All urban infrastructure and metal-containing objects or products are located at some physical locations

• Location-based stock data can be analysed to
  – develop plans for metal recovery and reuse
  – evaluate metal losses to the environmental during use
  – estimate costs to the anticipated market
  – in other ways, to generate positive business or organisational values
Spatially enabled above-ground resource analysis

- Incorporate location into above-ground resource analysis, e.g.
  - van Beers and Graedel (2007) analysed the spatial patterns of the in-use stocks of copper and zinc at four spatial scales in Australia
  - Tanikawa and Hashimoto (2009) estimated construction material stocks over time with spatio-temporal data in a Japanese city and a British city

- Conducted using a geographic information system (GIS) and a spatial database
locations, structure, length, diameter, and material stock per length of pipeline classified by structure and diameter, and material stock per area of roadway/railway classified by structure

locations, shape, area, floor space, structure, and material stock per area of building

(locations, shape, area, floor space, structure, and material stock per area of building)
Australian Recyclable Resources Atlas

- Interactive Web-based atlas
- Map the quantity and distribution of accessible resources from above-ground stocks
  - In-use above-ground stocks of copper, zinc and steel
Development of the Atlas

• Quantify the spatial distributions of material stocks by measuring the stocks directly
  – identify the major uses of a given type of materials
  – determine the material intensity, i.e. the typical amount of the materials in each unit of use (e.g. the amount of copper per metre of a power line)
  – measure the size of each use (e.g. the total length of the power grid)
  – calculate the material stock for each type of use
  – compute the total stock of the materials in a particular area
Major Uses

• Dwellings
• Motor vehicles
• Consumer durables
• Infrastructure
  – Power distribution
  – Telecommunication
<table>
<thead>
<tr>
<th>Reservoirs</th>
<th>Proxy indicators</th>
</tr>
</thead>
</table>
| Building and construction (plumbing tube + built-in electrical) | Single family house  
    Unit in shared living complex  
    Other dwelling  
    Commercial and governmental business  
    Industrial business |
| Infrastructure (power distribution)            | Single family house  
    Unit in shared living complex  
    Other dwelling  
    Commercial, governmental, and industrial business |
| Infrastructure (telecommunication)            | Single family house  
    Unit in shared living complex  
    Other dwelling  
    Commercial, governmental, and industrial business |
| Transportation                                | Passenger motor vehicle  
    Commercial motor vehicle  
    Railway transport |
| Consumer durables                             | Low income household  
    Medium income household  
    High income household |

<table>
<thead>
<tr>
<th>Reservoirs</th>
<th>Proxy indicators</th>
<th>Unit</th>
<th>Proxy data (kg Cu/unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building and construction</td>
<td>Single family house</td>
<td>Dwelling</td>
<td>195</td>
</tr>
<tr>
<td>(plumbing tube + built-in electrical)</td>
<td>Unit in shared living complex</td>
<td>Dwelling</td>
<td>110</td>
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<td></td>
<td>Other dwelling</td>
<td>Dwelling</td>
<td>65</td>
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<tr>
<td></td>
<td>Commercial and governmental business</td>
<td>Dwelling</td>
<td>From 140 (&lt;5 employees) to 6600 (&gt;100 employees)</td>
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<tr>
<td></td>
<td>Industrial business</td>
<td>Dwelling</td>
<td>From 970 (&lt;5 employees) to 65,500 (&gt;100 employees)</td>
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<tr>
<td>Infrastructure (power distribution)</td>
<td>Single family house</td>
<td>Dwelling</td>
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<tr>
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<td>Unit in shared living complex</td>
<td>Dwelling</td>
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<td>Other dwelling</td>
<td>Dwelling</td>
<td>24</td>
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<tr>
<td></td>
<td>Commercial, governmental, and industrial business</td>
<td>Business</td>
<td>From 120 (&lt;5 employees) to 2400 (&gt;100 employees)</td>
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<td>Infrastructure (telecommunication)</td>
<td>Single family house</td>
<td>Dwelling</td>
<td>7</td>
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<tr>
<td></td>
<td>Unit in shared living complex</td>
<td>Dwelling</td>
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<td></td>
<td>Other dwelling</td>
<td>Dwelling</td>
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<tr>
<td></td>
<td>Commercial, governmental, and industrial business</td>
<td>Business</td>
<td>From 12 (&lt;5 employees) to 620 (&gt;100 employees)</td>
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<tr>
<td>Transportation</td>
<td>Passenger motor vehicle</td>
<td>Vehicle</td>
<td>14</td>
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<tr>
<td></td>
<td>Commercial motor vehicle</td>
<td>Vehicle</td>
<td>29</td>
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<tr>
<td></td>
<td>Railway transport</td>
<td>Meter electrified track</td>
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<tr>
<td>Consumer durables</td>
<td>Low income household</td>
<td>Household</td>
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<td>Medium income household</td>
<td>Household</td>
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<td>High income household</td>
<td>Household</td>
<td>58</td>
</tr>
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</table>

(From van Beers, D.; Graedel, T.E. Spatial characterisation of multi-level in-use copper and zinc stocks in Australia. *Journal of Cleaner Production* 2007, 15, 849-861.)
In-use copper stocks in dwellings (by statistical area level 1)

- SA1 code: 2132605
- Name: Victoria
- Amount (kg): 57,903

Additional Features

• Spatially enabled reporting
  – Maps presenting data aggregated at different geographical areas
  – Graphs for comparisons between regions
  – Summary statistics for selected geographical areas
Potential Users

- Mining industries – estimate the stock of metal required to deliver any given service to a population, and create scenarios of potential metal demand based on different assumptions of technology choice, population growth, and other relevant factors.

- Metal Production Industries – develop scenarios of discards from stock in use.

- Waste Management and Scrap Industries – develop discard scenarios linked to in-use stock.

- Public Health and Environmental Agencies – develop discard scenarios to predict effects on public health and/or the environment.

- Public Policy Organizations – estimate scrap supply for certain metals in the case of disruption of trade in either metal commodities or final goods containing metals; promote the environmental benefits of metal recycling.

  (the International Resource Panel, UNEP, 2010)

- The public – improve the public’s awareness of metal stocks, and may lead to a higher recycling rate.

- Researchers – use as input data for material flow analysis and life cycle assessment (LCA); generate knowledge on the future trends in metal use and recovery.