

## From linear flows to recycling management

More and more resources are needed to meet the growing global demand for raw materials. The extraction and use of naturally occurring materials (such as sand, gravel or natural stones, but also copper, rare earth elements or gold) is associated with economic growth and prosperity but. On the one hand, it also leads to major environmental damage and the progressive depletion of high-quality geological mineral deposits as well as an increase of anthropogenic (man-made) waste streams and landfilling of materials.

One of the major waste management objectives is the recovery of raw materials from urban stocks (infrastructures, buildings and equipment stock) and waste. This conserves resources and reduces the impact on the environment.

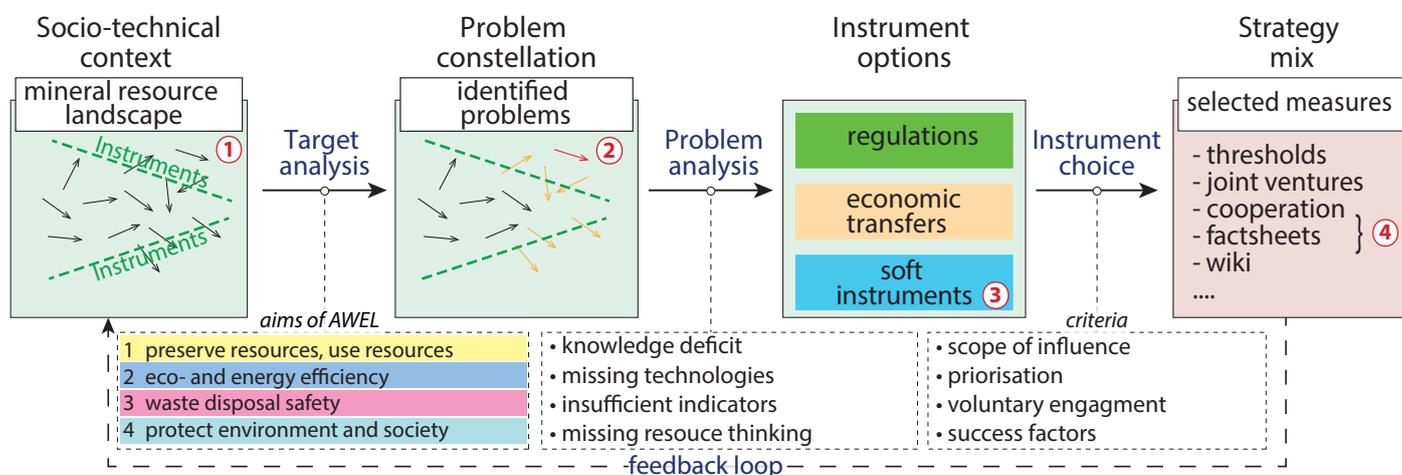
## Urban Mining

‘Urban Mining’ looks at the urban stock and waste streams as valuable sources of raw materials that we must make the best use of. This includes the exploration and characterisation of anthropogenic raw material stock and waste material flows as well as, for example, technically complex processes to recover valuable elements such as copper, aluminium and gold from the slag of municipal solid waste incineration (MSWI) plants. Urban Mining is one of the focal aspirations of long-term sustainable global development.

In the Federal Constitution, which seeks a balance between the economic, environmental and social development, the people of Switzerland have set themselves the overall objective of resource conservation. Similarly, the action plan for waste and resource management 2011 ... 2014<sup>1</sup> of the Zurich Office for Waste, Water, Energy and Air (AWEL) also formulates the conservation and utilisation of resources as a priority: a direct contribution to sustainable development in Switzerland. The better use of resources and reduction of the environmental footprint is of interest to all parties, however, this poses the challenge of formulating a unified strategy with a corresponding knowledge base for evaluating the measures.

## Waste management in context

Switzerland's demand for raw materials per capita (material footprint 2008: 31 t / year; worldwide average of 10.5 t / year)<sup>6, 12</sup> and waste generation (waste production in 2012: 2.3 kg / day; worldwide average of 1.2 kg / day)<sup>8</sup> is significantly higher than the global average. This shows that there is still a ‘problem of strategy’<sup>2</sup> because the objectives of private and public organisations are not being achieved (Figure 1). Once this deviation from the targets has been detected, a problem analysis is required in order to identify the causes. From the available options of instruments, appropriate measures can be selected in order to formulate a sound strategy. The choice of the strategy instruments already represents a part of the strategy formulation.<sup>2</sup>



**Figure 1** Process of the strategy optimisation for a resource-conserving waste management. Example sequence: 1) too low recovery rates identified, 2) lack of knowledge recognised as one of various causes, 3) selecting a research collaboration as a ‘soft’ instrument, 4) cooperation integrated into the strategy mix. Graphics: Mark Simoni

## Development of knowledge as a strategy

1. In Switzerland, the objective of conserving resources still is insufficiently fulfilled, some of the existing instruments are either weak or incompletely implemented (target analysis).
2. The inadequate understanding of raw materials systems and a lack of basic knowledge are two clearly identifiable strategy problems that are widespread both internationally and in Switzerland (problem analysis).  
There are significant gaps in our knowledge especially concerning the contents of recyclables in urban stocks and material flows, as well as with regard to the social, environmental, technical, economic as well as legislative frameworks.

3. The AWEL decided to initiate a research collaboration with the Swiss Geotechnical Commission SGTK and the GEO Partner AG in order to conduct an ‘Urban Mining Potential Study’ to build knowledge and and develop a better understanding of the system.
4. The potential study simultaneously acts as a defined instrument for identifying (1) the need for action (degree of target compliance), (2) possible causes of problems (problem analysis) and (3) feasible courses of action (instrument selection), as well as a means of documenting and communicating the findings.
5. The acquired knowledge will provide a basis for making informed decisions and determine suitable measures.

## The Urban Mining Potential Study of the AWEL

To evaluate the potential of Urban Mining, various criteria can be referred to: the economic value (quantity and price), the potential environmental damage, the technological and energy requirements for the recovery, but also social aspects such as the number of sector-specific jobs or the state of occupational safety. Another central issue is the evaluation of the opportunities (instrument options) for influencing stock or process owners (e.g. private recycling organisations; the AWEL as representative of the public sector) within a defined resource management target system. A comprehensive evaluation of the Urban Mining potential therefore requires a multi-criteria analysis. A comparison with primary production (raw material extraction from geological deposits) can be used for an evaluation of the respective relative pros and cons of the recovery of raw materials.

This approach was also followed in the framework of the substance dossiers (SD) developed for the Urban Mining Potential Study. The term ‘Urban Mining Potential Study’ in this context describes the approach of a systematic search for data and processing of information according to the ‘five capitals model’<sup>3,7,10</sup>. Relevant and concise information on a variety of raw and waste materials is compiled according Giurco and Cooper<sup>7</sup> on the basis of ecological, economic, technological, social and governance-related aspects. It is of central importance that of all these aspects are taken into consideration for a responsible long-term policy regarding raw material use.

In the context of the ‘Urban Mining Potential Study’, substance dossiers were compiled on gold, copper, antimony, gypsum and rare earth elements (REE). Deliberately, five substances / material groups with different characteristics were selected, while respectively focusing on well-defined problems such as the potential of recycling copper from MSWI slag. Depending on the substance, the relevance for waste management can be the prevention of environmental damage (gypsum), the economic potential (gold in MSWI slag), both previous aspects (copper in MSWI slag), inadequate knowledge and lack of recovery technology (antimony) or weak management systems (REE).

The substance dossiers put forward a general comparison (Table 1) between primary production (from the rock) and secondary production (from the end-of-life product / waste) and aggregate available information, while incorporating expert knowledge.

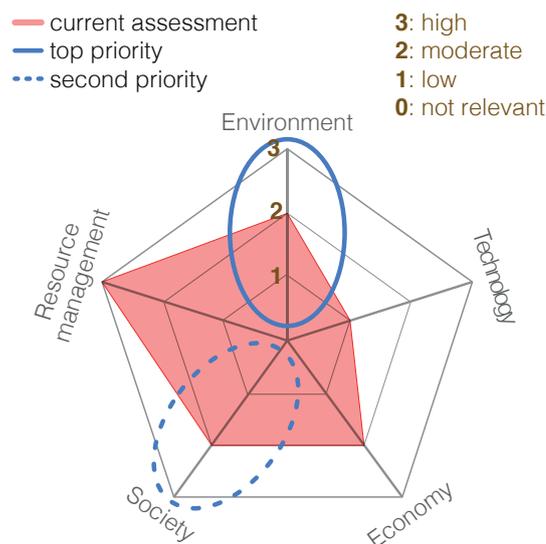
**Tab. 1** The examination of the Urban Mining potential uses the following structure:

Chap.	Topic	Key words
1	Importance of the raw material	Applications, general overview, global overview, problem relevance
2	Understanding the system	Swiss import-export statistics, supply and demand, material flows
3	Primary / secondary raw materials	Geological deposits, secondary (recycled) raw materials, recyclable contents
4	Environment (ecological domain)	Ecotoxic effects, environmental impacts of production and recycling
5	Technology (technological domain)	Extraction and recycling technology
6	Economy (economic domain)	Investment costs, production costs, prices, criticality
7	Society (social domain)	Health effects, social harm and benefits
8	Resource management (governance domain)	Regulatory framework, open issues, subjective measurement of success

## Indicators

In order to measure and monitor the progress, the appropriate methods and indicators must be selected<sup>11</sup>. They should be relevant, accepted, credible, simple and robust.<sup>4</sup> Ecological criteria such as eco-points in the ‘method of ecological shortages’<sup>5</sup>, ‘resource efficiency’ or ‘reduction indicators’ (e.g. volume requirement of the stored waste) are required, internationally as well as in Switzerland<sup>9</sup>.

Since there are still no suitable quantitative measuring indicators for example for ‘governance’ or ‘technology’, an expert assessment (consensus of several people) was compiled in each substance dossier for stating the benefits of recycling.



**Figure 2** Assessment of the Urban Mining potential of a substance based on a qualitative expert assessment. Current evaluation based on the criteria (red) and key priority areas for action (blue lines) as defined in the substance dossier.

## From the Urban Mining Potential Study to the strategy

Priority areas for action are recognised based on the examination of the Urban Mining potential for selected materials and waste. This process is supported by the examples shown in the above spider diagram, which visually illustrates the sustainability aspects of a particular area (see all SD).

The areas of action and the resulting or proposed measures and shortfalls (see also Chap. 8 of the SD) are reviewed in the context of waste management planning of the Canton of Zurich and are incorporated into cantonal Waste and Resource Management action plan for 2015 ... 2018.



### Literature

Due to limited space, the bibliographic references are summarised in a separate document.

[http://daten.sgk.ch/rohstoff-monitoring/AWEL\\_Introduction\\_Literature\\_EN.pdf](http://daten.sgk.ch/rohstoff-monitoring/AWEL_Introduction_Literature_EN.pdf)

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