Executive Summary

Megacities concentrate large amounts of people, absorb a large quantity of resources and generate vast amounts of waste and sewage, thereby contributing considerably to the use of the environment as a sink. The quantity of resources consumed and urban residues produced per capita tend to rise steadily with increased per capita income. Proper management of municipal solid waste is critical to the health of urban residents and therefore to the sustainability of the city. Within the research project "Risk Habitat Megacity" Municipal Solid Waste (MSW) management in the Metropolitan Region of Santiago de Chile has been analysed with respect to sustainability.

In this paper the “Integrative Helmholtz Sustainability Concept” is presented, which is the basis for the evaluation of MSW management in Santiago de Chile. This includes the selection of most relevant indicators, the determination of their actual values as well as the definition of target values to be reached in the future.

In Santiago de Chile the amount of MSW produced increased from about 0.8 kg/(cap*day) in 1995 to about 1.2 kg/(cap*day) in 2008, with a total generation of nearly 3 million tons/year. Although the composition of MSW has changed and the organic fraction decreased in the course of time the biogenic components still remain the most important waste fraction. Treatment of MSW in Santiago de Chile is limited mostly to final disposal, without any previous biological or thermal treatment, nor recovery of biomass. Santiago is operating three relatively new landfills, where approximately 90% of the municipal solid waste is disposed of. The rest of the waste is recycled, mainly as an informal activity. Large quantities of landfill gas are produced every year, contributing to climate change. Landfill gas emissions and their associated impacts can either be mitigated by collecting the gas from the landfill and burning it or by using it as a fuel source.

On the basis of this actual situation different scenarios for waste arising, waste composition and waste management – including separate collection of different waste fractions, mechanical and mechanical-biological treatment, biogas production as well as enhanced recycling activities – for the year 2030 are presented and evaluated by selected sustainability indicators.
1. Introduction

Urbanization is one of the most dramatic processes of global change. Particularly in mega-urban regions, it anticipates trends with both regional and global consequences that are not yet well understood. Mega-urbanization does not only involve unprecedented growth, high population density, and a concentration of economic and political power, but also a complex variety of simultaneous and interacting processes. They turn the urban habitat into both a space of risk and a space of opportunity.

A research initiative of the German Helmholtz-Association, which started in 2007, analyses mature megacities in Latin America, the most urbanized region in the world. Its large agglomerations are of crucial socio-economic importance for the entire continent. At the same time, urbanization in the region is about to reach a new dimension. The first case study is the Metropolitan Region of Santiago de Chile (RM Santiago), the centre of one of the most urbanized countries in Latin America. This agglomeration suffers from megacity-typical problems and offers the scope to uncover emerging trends. In addition RM Santiago offers an excellent research infrastructure and research partners with international recognition.

The analytical framework of the initiative is innovative due to its integrative and interdisciplinary character, which allows scientists and policy makers to deepen the understanding of megacities as a system. The sustainable development concept serves to formulate the target dimension of the project. The risk concept assists in identifying problems and evaluating their relevance. The governance concept focuses on the actors and options for managing megacities.

The project applies the three analytical concepts to various megacity-typical application fields, such as land use management, socio-spatial differentiation, energy systems, transportation, air quality and health, water resources and services, and waste management, which is the focus of this paper. For further information about the Risk Habitat Megacity (RHM) Project see (UFZ 2010).

In the following chapters the sustainable development concept is described and applied to evaluate the actual situation of the management of Municipal Solid Waste (MSW) in RM Santiago. In addition different scenarios of the management of MSW in RM Santiago for the year 2030 are presented, evaluated and compared by selected sustainability indicators.

2. The integrative sustainable development concept

With the integrative Helmholtz sustainability concept (for a detailed description, see (Kopfmüller et al. 2001) an analytical tool that is both theoretically and conceptually well-founded and consistent is applied for the evaluation of MSW management in RM Santiago. The concept is based on the three constitutive elements of sustainable development – the postulate of inter- and intragenerational justice, the global perspective, and the anthropocentric view – that are translated into three general goals: to secure human existence, maintain society’s productive potential, and preserve society’s options for development and action. These goals are further concretized by a set of sustainability rules, such as the “satisfaction of basic needs” with regard to accommodation, food, and health; “equal access to education and information”; the “opportunity of autonomous subsistence bases on own income”, the “sustainable use of renewable and non-renewable resources”, an “adequate development of human and knowledge capital”, “maintenance of social resources”, or the “preservation of cultural heritage and cultural diversity”. These rules constitute the core element of this concept. They describe guiding principles for action, defining a priori universally valid minimum requirements for a global sustainable development. Hence, they serve as basic orientation for future development and provide a comprehensive set of evaluation criteria (relating to
countries, cities, societal sectors, strategies, and innovations). These general sustainability rules can be further concretized by application field specific sustainability indicators. A schematic representation of the architecture of the Helmholtz integrative sustainability concept is shown in figure 1.

![Figure 1: Architecture of the Helmholtz integrative sustainability concept](image)

3. Waste management in RM Santiago – actual situation

RM Santiago has an area of 16,000 km² (2% of the total area of Chile) with about 6.7 Mio. inhabitants (for the year 2007), which is approximately 40% of the total population living in Chile. Total production of MSW in 2007 was roughly 2.9 Mio tons resp. 1.2 kg/(cap*day). In 1995 the corresponding value was 0.8 kg/(cap*day) (Szanto 2006; Braeutigam et. al. 2008). In addition, the organic fraction decreased from 68% in 1990 to 50% in 2007 (Szanto 2006). Therefore the share of other fractions increased, e.g. paper and cardboards from 15% to 18% and plastics from 6% to 10%. These changes are correlated with the rising income levels in Chile. These – steadily increasing – amounts of MSW have to be managed properly in order to avoid negative impacts on health and environment and thus present a challenge for stakeholders involved in waste management, who should develop adequate strategies for waste reduction and waste treatment, taking into consideration the existing legal, social and financial framework.

Figure 2 shows the current waste mass flow of RM Santiago for the year 2007. Actually MSW management in RM Santiago is based on final disposal; therefore of the almost 3 million tons generated in 2007, 87% were disposed of in the three existing sanitary landfills. Usually, MSW is left in bags or containers at the streets, where the major part is collected by the formal sector. The frequency of collection varies from three times a week to daily.

Regarding recycling, about 374,000 tons of waste, mainly paper, cardboard and metals are collected and separated by the informal sector. A recycling rate of about 14% is achieved only due to the high contribution of the informal sector. In many low and middle income countries, collecting, sorting, trading and recycling of disposed materials provides income to thousands of people. In general, they work in parallel to the formal waste management system. But they work in an independent manner, not being contracted by the municipalities or other responsible entities of the waste area, do not pay taxes and are not included in social welfare or insurance schemes (Wilson et al. 2006). RM Santiago is not an exception; according to non-official estimations there are between 4,000 and 15,000 people working as primary collectors in the city (Astorga 2008, MNRCH 2009). They col-
lect valuable materials in the streets, using tricycles as transport and working tool. They separate and classify the materials, selling them to middlemen, who finally deliver them as secondary raw materials to production companies.

Publicly organized recycling is less than 1% (about 25,000 tons per year). In addition segregate collection of biowaste amounts to about 10,000 tons per year, from which about 3,300 tons of compost are produced.

In RM Santiago waste management is based on final disposal. RM Santiago utilizes three relatively new landfills: one started its operation in 1996, the other two in 2002. They are equipped with a bottom liner and a collection system for leachate. A part of the landfill gas produced is captured and flared. Capturing and flaring is financed by Clean Development Mechanisms (CDM) projects, which result in extra income for the operating companies of the landfills. In November 2009 a plant to generate electricity from the landfill gas started operation in Loma los Colorados landfill with two generators of 1 MW power capacity each.
The electricity is sold to the national network. The landfill gas that is not used is still being flared, but it is planned to extend the generation capacity to 14 MW by the end of 2011. Moreover it is planned to extend the total capacity gradually to generate 28 MW by 2024 (Keller 2010, KDM 2010)

4. **Sustainability indicators for “Waste management”**

In order to be able to evaluate the current system of MSW in RM Santiago as well as management scenarios for the year 2030 the “Integrative Helmholtz Sustainability Concept” was applied. This means that the general sustainability rules of this concept were concretized by sustainability indicators which are relevant for the management of MSW in RM Santiago. These indicators were quantified by their actual values. In addition, in order to be able to evaluate the future development of the management of MSW in RM Santiago, appropriate target values were assigned to each of the indicators.

On the basis of an extensive evaluation of the relevant literature about sustainability indicators for different regions (Germany, Europe, international indicator systems, Latin America) a set of more than 100 indicators was established and assigned to appropriate sustainability rules. This work was done within a Diploma Thesis (Seidl 2008). Together with stakeholders and scientists from RM Santiago a selection of the most relevant indicators was performed. Criteria for the selection of these indicators were:

- a) validity, i.e. indicators should properly reflect how the sustainability of waste management is affected by changes in indicator values;
- b) data availability;
- c) possibilities to define quantitative goals, and
- d) indicators should be simple to understand, even by people or working groups not directly related with the field.

The following indicators were selected:

**Specific waste arising**

As already mentioned, the amount of waste generated has increased very fast during the last decades in RM Santiago. This increase is mainly a result of the economic development of the country during these years. The Chilean legal framework is deficient in political measures on waste prevention or minimization strategies. Therefore, without any incentives, specific waste production will increase further.

To define a target value, international trends were analysed. These trends show that an upper level of specific waste production is reached, when a certain degree of economic wealth has been achieved. This upper level amounts to about 2 kg/(cap*day) (IMF 2009, OECD 2006, PAHO 2005). As a comparison, the amount of MSW production in Germany, a country with many regulations and incentives for waste reduction, is 1.57 kg/(cap*day) (Statistisches Bundesamt 2009), for Berlin, this value amounts to 1.3 kg/(cap*day) (Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz Berlin 2009), both for the year 2007. Therefore a maximum target value of 1.6 kg/(cap*day) is suggested and agreed by stakeholders and scientists from Chile for 2030.

**Waste fraction that is recovered as material or energy**

Recycling in RM Santiago is well positioned if compared with other Latin American countries, with a recycling rate of 14%; however, not all the recycling potential is being used. At the national level a recycling strategy for RM Santiago was developed by CONAMA (CONAMA 2005), its goal was to achieve a recycling rate of 20% in 2006, a value that has not been achieved so far. In 2009 a new goal of 25% for the year 2020 was established.
In RM Santiago, recovery targets should address not only the recycling of the inorganic fraction, but also the biogenic fraction, because it corresponds to almost 50% of the total MSW. Additionally, the informal sectors’ participation should be involved in the solid waste recycling system. Consequently, based on the already set political targets for recycling and alternative energy uses in Chile, a total recovery of 36%, including composting and energetic recovery, is proposed for 2030.

**Amount of mixed waste pre-treated to reduce organic carbon content in relation to total mixed waste**

Currently, MSW is sent to landfills without any previous pre-treatment and there are no political targets regarding pre-treatment of waste in Chile. In the EU on the contrary, according to the landfill-guideline 1993/31/EG, EU member states have to reduce the organic fraction of MSW, which is brought to landfills, gradually. In Germany, final disposal at landfills is now limited to waste with an organic content of not more than 3%. Additionally special limit values for the organic content of waste that has undergone mechanical-biological treatment were introduced. Since the deadline, the amount of municipal waste landfilled has fallen to 1%.

In order to reduce the negative impacts of waste disposal at landfills, pre-treatment of mixed waste in RM Santiago should increase to 100% of collected mixed waste, however, due to the relatively low experience in Latin America in these issues, the suggested value for RM Santiago in 2030 is 50%.

**Emissions of greenhouse gases resulting from waste management activities**

The most important greenhouse gas related with MSW in RM Santiago is methane from anaerobic biodegradation of wastes disposed of at landfills. Own calculations result in emissions of about 140 kg CO$_2$-eq/(cap*year) for RM Santiago. For Germany, the corresponding values are 50 kg CO$_2$-eq/(cap*year) for 1990 and 13 kg CO$_2$-eq/(cap*year) for 2005 (Butz 2009). Collecting and flaring landfill gas is an option to reduce these emissions. In addition separate collection and treatment of biowaste reduce landfill gas emissions. For example, separate collection and composting of 50% of garden and food waste in RM Santiago would reduce landfill gas emissions (measured as CO$_2$-eq) by about 30% (Bräutigam et al. 2009). Therefore a target value of 70 kg CO$_2$-eq/(cap*year) for RM Santiago for 2030 (50% of the actual value) might be realistic.

**Income level of informal workers in relation to individual household income**

Another sustainability requirement is that all members of society have the chance to secure their subsistence, with jobs activities chosen voluntarily. In the specific case of RM Santiago, a vulnerable group is formed by the informal primary collectors. The income level of this group in relation to the average individual household income is used to operationalize the sustainability goal of assuring independent livelihood.

Earnings of informal primary collectors are difficult to determine. First, there are variations in the materials prices, as well as in the amount of materials collected. Not all the waste pickers work the same amount of hours or days and do not have the same working areas or collection capacity. Therefore their income is very variable.

Several publications analyse experiences on formation of scavengers’ cooperatives, which have improved scavengers’ living conditions and income. In addition the incorporation of scavengers into formal systems can save cities’ money and offer, at the same time, steady income to their members. The target value for the income of the informal collectors is set at 100% of the average individual household income. It is assumed that this value is enough to guarantee basic needs, improve living standards and reduce poverty.
Costs of MSW management in relation to GDP

The investments in MSW management services should be affordable for a country. Similar levels of investment for MSW management in countries with different economical developments imply a much larger fraction of the GDP invested in the less developed countries. The selected indicator to measure how affordable a particular waste management strategy in a region is, corresponds to the fraction of GDP spent in MSW management. Usually, the fraction of GDP spent in MSW management lies between 0.2 and 0.5%, therefore an increase of the actual value of 0.22 % to 0.30 % in 2030 is proposed for RM Santiago.

Table 2 in chapter 6 (this table also shows the development of the indicator values for the different scenarios taken into consideration) summarizes the sustainability indicators, their current values and their target values.

5. Scenarios for the Management of MSW in RM Santiago for the year 2030

Within the RHM-project different explorative framework scenarios were set up. The aim of these framework scenarios is to give a general description of the political, social and economical conditions for a specific year in the future, 2030 in this case. For the three framework scenarios, taken into consideration (Business as Usual – BAU, Collective responsibility - CR and Market Individualism – MI) qualitative and in some cases quantitative descriptions of factors, which have an influence on the political and social general conditions in the country and especially in RM Santiago were given (so called driving factors and associated key-words). Driving factors categories taken into consideration were: economic development, institutional framework/governance, demographics, technological development, societal value systems, and education. Based on these driving factors and associated key words their influence on the management of MSW in RM Santiago in 2030 is described by so called qualitative storylines. On the basis of these storylines quantitative data for waste arising, waste composition and amount of different waste fractions to be recycled, recovered or treated were set up.

5.1 Storyline scenario “Business As Usual (BAU)”

This scenario is characterized by a material consuming culture. Environmental laws and regulations are weak and flexible. The political aim is to achieve waste recovery targets by improving recycling and biological treatment. Increase of climate change prevention policies promotes the use of landfill gas as renewable energy source. With help of the civil society and NGOs, new recycling programs with participation of the primary informal collectors are developed, creating a favourable framework for acceptance of the informal workers. However, the informal waste sector, even if continuing playing an important role in recycling, is only partially integrated into the formal waste system. The technological advancements promote application of biological treatment technologies, which helps to achieve recovery targets. Technology developments have also improved collection efficiency of landfill gas, contributing to increase the share of renewable energies into the energetic grid.

5.2 Storyline scenario “Collective Responsibility (CR)”

This scenario is characterized by high emphasis on social values instead of the possession of products. Environmental laws, regulations and target values in the environmental area are established. Recovery targets are achieved by improving recycling and biological treatment and increasing the amount of waste pre-treated. Increase of climate change
prevention policies has promoted the collection and use of landfill gas as renewable energy source.

The influence of NGOs on waste management is relevant, in particular promoting recycling, source separation and acceptation of the informal sector. The organization and efficiency of the informal sector has improved noticeably. Community organizations play an important role in collection of recyclables. The informal sector has decreased in number, due to poverty reduction. However, the quality of their work has increased. They have formed strong groups and work in collection of segregated materials and further processing in stock centres. Public investment in environmental campaigns has contributed to create more participation and acceptance by civil society.

Technology development is not a priority in this scenario, but a tool used to achieve environmental goals. Landfills accomplish with international standards and collection and treatment of leachate and landfill gas.

5.3 Storyline scenario “Market Individualism (MI)

This scenario is characterized by a consuming and materialistic culture. Environmental laws and regulations area are weak and flexible and are influenced by private interests and markets.

The driving factor to recover valuable materials and energy from waste is given only by the economical profit. There is a large interest in technological development, thus, alternative technologies for recovery of MSW are developed if costs and profitability are favourable.

Publicly organized recycling systems, including biological treatment are almost non existent. Recycling takes place only voluntarily by drop off systems. The role of the public sector in recycling is inexistent, and they do not have any interest in working together with the informal sector. Private production companies might show some interest in working together with the informal sector, as a way to recover secondary raw materials at low costs.

5.4 Waste arising, waste composition and waste management

Table 1 shows the results for waste arising, waste composition and waste management for the scenarios. These data are the result of the quantitative implementation of the three storylines, taking into consideration the data for the development of the GDP and the population given within the framework scenarios. Especially data for waste arising are based on a correlation between GDP and waste produced per capita, therefore the increase of waste arising (from about 3.0 Mio tons in 2007 to 5.6 Mio tons in the BAU scenario, 5.0 Mio tons in the CR-scenario and 6.1 Mio tons in the MI-scenario) results from both, an increase of the GDP and an increase of the population, living in RM Santiago.

Specific arising of MSW is much higher in 2030 in all scenarios compared to the year 2007, with the highest value of 2.0 kg/(cap*day) in the MI-scenario. The relevance of waste collection by the informal sector (bin, bag informal and segregated collection by organized collectors) is highest in the CR-scenario (17.5% of total arising of MSW) compared to 12.8% for the year 2007, 10.5% in the BAU-scenario and 9% in the MI-scenario. Treatment technologies, which are nearly non-existent in 2007, gain in importance in the different scenarios; but only in the CR-scenario mechanical-biological treatment of collected mixed waste is implemented. This will result on one side in a reduction of the organic fraction of waste, which has to be disposed of in landfills and on the other side in the production of “Refused Derived Fuels” (RDF), which can be used e.g. in cement plants as an energy source. Energy production from landfill gas is taken into consideration in all scenarios. The recycling rate, which amounts to 14% in 2007, increases to 20% in the MI-scenario, to 30.6% in the BAU-scenario and it reaches the highest value in the CR-scenario (42.8%).
Table 1: Waste Management data for different scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>6,700,000</td>
<td>8,006,625</td>
<td>7,610,399</td>
<td>8,261,621</td>
</tr>
<tr>
<td>MSW arising (Mg)</td>
<td>2,933,000</td>
<td>5,653,188</td>
<td>4,955,564</td>
<td>6,100,286</td>
</tr>
<tr>
<td>specific MSW arising (kg/(cap*day))</td>
<td>1.20</td>
<td>1.93</td>
<td>1.78</td>
<td>2.02</td>
</tr>
</tbody>
</table>

Collection (%)

| bin,bag formal | 86.06 | 75.66 | 66.80 | 87.68 |
| bin,bag informal | 12.75 | 4.90 | 2.28 | 9.04 |
| segregated by municipality | 0.14 | 1.33 | --- | --- |
| segregated by organized collectors | --- | 5.61 | 15.19 | --- |
| drop off containers | 0.72 | 7.50 | 7.48 | 2.99 |
| segregated biowaste | 0.34 | 5.00 | 7.98 | --- |

Treatment (%)

| mechanical | --- | 19.67 | 13.36 | 21.92 |
| mechanical biological (RDF) | --- | --- | 13.36 | --- |
| biological (anaerobic digestion) | 0.34 | 5.00 | 7.98 | --- |
| energy from landfill gas | yes | yes | yes | yes |

Recycling (%)

| informal processing | 12.75 | 4.90 | 2.28 | 9.04 |
| mechanical treatment | --- | 6.51 | 10.01 | 7.72 |
| segregated collection municipality | 0.12 | 1.19 | 15.19 | --- |
| segregated collection organized collectors | --- | 5.61 | --- | --- |
| drop off containers | 0.72 | 7.50 | 7.48 | 2.99 |
| biowaste | --- | 4.89 | 7.80 | --- |

Sum Recycling (%) | 13.58 | 30.60 | 42.76 | 19.76 |

6. Sustainability analysis of the three scenarios

Table 2 shows the results of the scenario analysis. Specific arising of MSW increases in the three scenarios, exceeding the maximum target value proposed for 2030. Furthermore, the main deficit correspond, like in the current situation, to the amount of waste that is pre-treated before disposal in landfills and associated emissions of greenhouse gases. The fraction of GDP spent in MSW management in the three scenarios suggests that the technologies selected in each case are feasible for implementation.

The BAU-scenario shows improvements in the amount of waste recovered, attributable to installation of mechanical sorting plants and segregated collection of biowaste and recyclables through organized informal workers, in addition to energy recovery from landfill gas
and biogas. The organization of the informal workers it is also reflected in their income improvement.

Table 2: Sustainability indicators for the different scenarios

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2007</th>
<th>Target</th>
<th>BAU</th>
<th>CR</th>
<th>MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific waste arising [kg/(cap*day)]</td>
<td>1.20</td>
<td>Max. 1.6</td>
<td>1.93</td>
<td>1.78</td>
<td>2.02</td>
</tr>
<tr>
<td>Waste fraction recovered as material or energy [%]</td>
<td>13.9</td>
<td>36</td>
<td>31</td>
<td>43</td>
<td>20</td>
</tr>
<tr>
<td>Income level of informal workers in relation with individual household income [%]</td>
<td>76</td>
<td>100</td>
<td>113</td>
<td>154</td>
<td>-</td>
</tr>
<tr>
<td>Amount of mixed waste pre-treated to reduce organic carbon content in relation to total mixed waste [%]</td>
<td>0</td>
<td>50</td>
<td>0</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Greenhouse gases emitted during waste management [kg. CO_{2eq}/(cap*year)]</td>
<td>143</td>
<td>71</td>
<td>235</td>
<td>153</td>
<td>296</td>
</tr>
<tr>
<td>Costs of MSW in relation to GDP [%]</td>
<td>0.22</td>
<td>0.30</td>
<td>0.16</td>
<td>0.17</td>
<td>0.16</td>
</tr>
</tbody>
</table>

The lowest waste generation value is achieved in the CR-scenario, which is attributed to changes in economical and social factors that affect this variable. This scenario reaches the target values for the recovered amount of MSW and the income of the informal workers, and it shows progress in the pre-treatment of waste. Nevertheless, the released GHG are still far away from the target value. This fact can be attributed, among other reasons, to the still large amount of organics being deposed of at landfill sites.

The MI-scenario shows large deficits in almost all the indicators. Of special importance is the income level of informal waste workers, which does not improve in comparison with current values, putting into jeopardy the possibility of this group of people to secure their subsistence.

7. Policy Implications/Recommendations

In general, recommendations towards sustainable MSW management should integrate government policy, technological development, efficient production, adequate costs calculations, etc. The weight given to these factors within each scenario differs according to its specific characteristics.

The large increase of total MSW arising in the three scenarios produces a large pressure on the current infrastructure of waste management. An obvious measure corresponds to MSW prevention strategies. However, the challenge would be to create the legitimacy and support for these policies in a BAU-scenario. Another important measure to deal against amounts of waste arising includes capacity adaptation, such as construction of landfills before its lifetime has been reached. Recommendations towards improvement of waste treatment include the alternative of substituting fossil fuels in power plants (not only in cement plants) by refuse derived combustibles. Additionally, other policy areas such as renewable energy policies, environment and climate change prevention policies can give an impulse towards energy recovery from waste; these kinds of policies could be developed in time within the BAU-scenario.

In the CR-scenario there is also an increase of the total waste arising, but the trends are lower than in the two other scenarios. Prevention policies are also recommended, in order to decrease pressures on waste management infrastructure. Prevention policies are likely to be accepted in this scenario, as well as policies promoting energy recovery from waste. Another measure in this area corresponds to adequate spatial planning, to create markets for the heat produced in waste to energy plants. Moreover, command and control strategies, which involve direct regulation, monitoring and enforcement, can play an important
role in achieving targets to divert wastes from landfills. In order to improve the management of the biowaste, supplementary informative instruments to promote home composting, can work out well in the CR-scenario. Both recommendations improve the amount of waste pre-treated, reducing greenhouse emissions, which correspond to the largest sustainability deficits in this scenario.

The MI-scenario presents several sustainability deficits, and it seems a big challenge for policy makers to create prevention and recovery policies in this scenario, which assumes a very material world, paying low attention to environmental issues. Strong pressures occur at final disposal sites, due to the large amount of waste produced and low recycling rates. Even though it is not likely that policies promoting recovery of material and energy from wastes will take place in this scenario, secondary raw materials and energy markets could have an effect on recovery rates. In order to stimulate these markets, economical instruments could be also implemented, if there is government commitment. Of special importance are revenue providing instruments, which motivate producers to change manufacturing processes reducing solid wastes. Examples are tax reduction, or charge reduction, based on use of secondary raw materials in production processes.

Acknowledgement

The Project is supported by the “Initiative and Networking Fund” of the German Helmholtz-Association.

References:

Astorga, A. (2008): Personal interview with Andrés Astorga, national consultant in the scrap and metal area, May 2008, Santiago de Chile, Chile


Keller, A. (2010): Personal interview with A. Keller, project manager, KDM Energía y Servicios S.A. (Energy and Services), Transfer Station of Quilicura, Santiago de Chile


