1. INTRODUCTION

In Germany currently 8.5 Mio. t/year of biowaste and garden waste are separately collected and recovered. The theoretical potential of bio- and garden waste lies between 13 and 15 Mio. t/year. The practical feasible potential for separate collection of bio- and garden waste is estimated to be 10 to 11 Mio. t/year. Most of the biowaste and garden waste is treated in composting plants but the number of anaerobic digestion plants (AD) is growing steadily. There is a number of composting technologies as well as AD technologies available with an operating experience of 10 to 20 years. Besides AD an increasing number of biomass plants are requiring biomass fuel from garden waste. Both types of plants are subsidized by the German Renewable Energy Law.

Source separation is in general more established in the Western parts of Germany than in the Eastern parts. In areas with low population density separate biowaste collection leads to significantly increasing collection costs.

SITA Deutschland GmbH is recovering 220 kt/year bio- and garden waste and is operating 15 experienced composting plants with a total capacity of 220 kt/year. SITA is observing an increasing number of requests of municipalities and public tenders asking for AD treatment and for solutions regarding a positive CO₂-balance (savings). SITA is operating waste to energy plants and is responsible for fuel supply of various incinerators.

The new German government announced in its coalition agreement that more biomass from waste and organic residues should be recovered and that recycling processes should be more sustainable. Extension of separate collection of biowaste is announced to start in 2015.

On the other hand there is an overcapacity in incineration and energy recovery services in Germany which is leading to low market prices. There is an increasing number of waste to energy plants with high energy and cost efficiency. Even those non subsidised plants are using the (non-separated) biomass on a high sustainable level. But also other non subsidized players as lignite-fired powered plants are in tight competition to get the biowaste and garden waste or fractions of it.

2. CURRENT SITUATION IN BIOWASTE AND GARDEN WASTE RECOVERY

First of all the German understanding of the terms of biowaste and garden waste has to be defined:
Biowaste: mainly separately collected kitchen and garden waste from private households

Garden waste: Separately collected waste from garden and parks, etc.

Left over food, supermarket waste and waste from food industry etc. are commercial waste streams and do not belong to this definition of biowaste, even if the markets are connected to the market for biowaste.

This paper is focusing on the question of separately collected biowaste from households. The situation of biowaste and garden waste recovery in Germany is summarized in Table 1.

| Service offers of municipalities:                               | 72 % of municipalities for 65.4 mio. inhabitants (80%) |
|                                                               | 56 to 60% of people of those municipalities are affiliated |
|                                                               | 97% of municipalities offering garden waste collection |

| Affiliation rates for separate collection                      | 36.6 Mio. inhabitants = 45% |
|                                                               | 45.8 Mio. Inhabitants = 55% |

| Volumes separate collection:                                  | - 4.18 Mio. t/y 114 kg/capita & year (collected) |
|                                                               | 51 kg/capita & year (all) |
|                                                               | - 4.36 Mio. t/y 55 kg/capita & year (collected) |
|                                                               | 53 kg/capita & year (all) |

| Not yet separately collected organic potential in household waste | 4.9 Mio. t/y, 54 kg/capita & year |
| practical feasible potential for additional separate collection | 1.0 – 1.5 t/y, 12-18 kg/capita & year |

| Treatment plants (biowaste + garden waste)                     | 11.1 Mio. t/y capacity in around 1000 plants, |
| Compost plants Aerobic                                          | 2 Mio. t/y capacity in around 70 plants |
| Anaerobic digestion plants biowaste                             | |
| Overcapacity Treatment                                          | 4 - 5 Mio. t/y |

Table 1: Key figures of current German biowaste recovery
In addition to these figures the current situation could be characterized for biowaste as follows:

- **Separate collection**: Separate collection is established in many municipalities. Biowaste is collected in 80 l to 1.100 l bins. (summer half year: weekly/biweekly, wintertime every 2 or 4 weeks).

- **Composting**: Germany has an established system of separate collection, composting with well-proven technologies, a well-functioning system for compost quality control and marketing. German environmental standards are requesting bigger plants and enclosed rotting system as well as biofilter for exhaust air purification. Discussion regarding VOC-emissions is gaining more and more importance. Many composting plants are already depreciated. Because of this fact cost can be low.

- **Anaerobic digestion**: Some anaerobic digestion plants are also using well proven technologies although a number of new technologies like tunnel-AD are currently coming up. It is no significant risk to build and operate an AD plant for separately selected biowaste anymore. Discussion regarding VOC-emissions and emissions of other greenhouse gases is gaining more and more importance as well. Anaerobic digestion plants are aided by German renewable energy law (long term guaranteed revenues for electricity).

- **Market for compost products and digestates**: The market for compost products has developed positively. Some years ago farmers as well as soil manufacturers and landscaping companies were still paid to take compost. Currently the price is around 0 €/t free delivered. The price for liquid digestate or sludge digestates is negative (to be paid for recovery). The prices vary depending on local demand and quality of the compost products. Prices are below the theoretical value of the included nutrients.

- **Compost from MSW**: Compost from non-separately collected MSW is of no significance any more. It is only allowed to be landfilled.

- **Prices**: Market price (gate fees) for biowaste composting is between 30 and 60 €/t, for anaerobic digestion between 40 and 70 €/t, and for garden waste between 15 and 25 €/t depending on the region and boundary conditions of the tenders. Currently, prices for incineration varies between 50 and 80 €/t (gate fee incinerator).

- **Development of volumes**: The volume of separately collected biowaste is more or less stable within the last 5 years (around 8.3 - 8.5 Mio. t/y). This indicates that there are only a few municipalities which expand or start new separate biowaste collection activities. From the beginning of the 90’s to the end of the 90’s the compost volume has been increased from 2 to 8 Mio. t/y because of legislation and “green motivation” to develop recycling. This rapid increase occurred eventhough composting was more expensive compared to landfilling and incineration. Within the last ten years the volume did not increase significantly anymore.

- **Social acceptance**: The separate collection of biowaste is predominantly accepted by the population if no additional and high fees will be demanded, if people have enough space to store the bins (odour etc.), and if treatment plants are working well and without negative impact to the population.
2. NEW LEGISLATION

The German Ministry of the Environment issued a draft of a new waste act (“Kreislaufwirtschaftsgesetz”) in order to implement the European Waste Framework Directive into national law. The draft act provides for source separation of biowaste until 1.1.2015 to gain higher volumes of biowaste for digestion and composting.

To reach the German targets for CO₂-reduction biomass from biowaste must be recovered, although the absolute potential effect to the German energy balance (max. potential saving of 0.2 % of primary energy consumption) is not very impressive.

A study conducted by the German Federal Environmental Agency (UBA, LIT 1) comes to the conclusion

- That there is still organic potential in household waste of about 4.9 Mio. t/y,
- That in total the extension of source separation could lead to an increase of 1.3 – 2.0 Mio. t/y of separately collected biowaste and garden waste
- That the average organic content in residual bins could decrease from 34 to 27 % if source separation will be extended.

The new legislation is under discussion between politics and the association of private and public waste management.

- Not all municipalities, German States (Länder) or public waste management associations agree with the idea to change their running systems. In particular municipalities and states with low population density, well established other systems, and cities want to decide by themselves whether they implement a separate collection system or not. Also exceptions for inner city areas are claimed.
- Many municipalities worry about negative effects on the fees.
- Most environmental organisations agree with the proposal as well as the SPD and the Green Party and the leading private waste management association BDE.
- Most of the owners and operators of MBT and MSW incinerators are not in favour with the idea to enforce separate collection.
- The local and public energy suppliers (Stadtwerke) as well as public and private waste companies see a chance to gain more biomass for own Anaerobic Digestion projects. But the strategy of the German government to prolong running times of Germany’s nuclear power plants is counterproductive for all green energy projects.

3. CO₂-BALANCE OF DIFFERENT WASTE TO RECOVER BIOWASTE

One key question in evaluating source separation and treatment of biowaste compared to non-separate collection is the question of greenhouse impacts of the entire value chain. A number of studies have been carried out in Germany regarding this issue (see LIT 2 to LIT 6). SITA summarized the CO₂-balances of those studies and concluded a CO₂-balance for typical situations, taking into account the most important effects. The most important effects influencing the balance are structured as follows
A. collection and treatment process
+ Debit
- Emissions due to collection and transport
- Emissions during treatment process
  (CO₂ from biowaste: neutral)
- Energy consumption (electricity, heat, gas, fuel)

- Credit
- Generation of recyclable electricity, heat, steam

B. recycling of products (compost, digestate, ashes)
+ Debit
- Emissions during recycling of the products

- Credit
- Substitution / replacement fertilizer
- Substitution / replacement soil conditioner like turf
- Longterm fixation of carbon
- (Substitution / replacement of straw for energy recovery, see LIT 4)

A typical CO₂-balance for a composting plant (closed plant with biofilter, state of technology), anaerobic digestion and co-incineration (typical German efficiencies, no separate collection) is shown in the next figures.

Figure 1: Balance for biowaste: composting for a typical situation
Figure 2: Typical CO₂ balance for biowaste: Anaerobic Digestion

Figure 3: Typical CO₂ balance for biowaste incineration in MSW incinerators

It could be concluded that composting of separated biowaste has an overall low negative CO₂ impact of around + 30 kg in this example. This negative impact is describing high improvement compared to landfilling where it could be some hundred kg CO₂ negative impact due to landfill gas emissions! Compared to composting, anaerobic digestion (total credit – 90kg/t biowaste) has a small but noticeable advantage compared to incineration (total credit – 65 kg/t).
Taking into account that all technologies can be developed and improved in the future (process, emission control, optimizing energy recovery by combining heat and power usage) the CO₂-balance can be improved in optimized situations (figure 4).

Figure 4: CO₂ balance: state of technology/typical situation compared to situation with optimized technology.

It can be concluded that the potential for improvement of composting is low compared to the potential for optimizing AD and incineration situations. There is no general answer if AD or an optimized incineration is the best way to treat biowaste. Only if water contents of biowaste are very high (>> 60%) and organic content is anaerobically biodegradable AD is mostly the better solution.

Only if you take into account that humus from compost-digestate is replacing straw (partly left on the field) and this straw is additionally recovered in biomass power plants the result will change. This assumption was made in the Hamburg study (LIT 4). The study came to the conclusion that AD has a clear advantage compared to co-incineration.

4. CONSEQUENCES FOR THE FUTURE OF SOURCE SEPARATION IN GERMANY

The German system of separate biowaste collection is a well proven system with high acceptance; except in areas with very high and very low population density. If the system will be developed to a higher degree of connected people and increasing volume as well as a higher percentage of anaerobic digestion to recover energy a number of effects could occur.
In average, fees will not increase significantly, but locally the fees can increase. First and foremost municipalities with low population density fear a second separate collection as well as municipalities with own MSW treatment installations (incinerator, MBT).

An increase of separately collected biowaste will effect a decrease of MSW for the market. The average heating value of MSW will rise slightly because of the reduced amount of organics. It will have a negative impact on efficiency and throughput of the incinerators.

The effect on the market for burnable waste and MSW is not yet clear. A reduction of 1.3 Mio. t/y MSW (which could additionally be collected separately) will create an additional demand for about half the amount of burnable waste (0.6 Mio. t/y). Compared to the total capacity of MSW treatment of about 24 Mio. t/y the effect is low but considerable. But there is still an overcapacity in treatment of about 2-3 Mio. t/y.

The population is generally willing to develop the German recycling system if there are really convincing arguments.

For the greenhouse gas balance of Germany additional biowaste collection will not have a very huge effect. It will be more important to optimize the energy balances of the single plants, whether they are AD plants or incinerators.

For optimizing the total balance for nutrients and humus additional treatment of biowaste and additional production of compost and compost digestates is positive. The demand for this product will develop positively in the future.

5. REFERENCES

LIT 1 Umweltbundesamt (publisher), Kern e.a.: Aufwand und Nutzen einer optimierten Bioabfallverwertung hinsichtlich Energieeffizient, Klima- und Ressourcenschutz, Berlin 2010


LIT 3 Senatsverwaltung für Gesundheit, Umwelt- und Verbraucherschutz Berlin (publisher), Wiegel e.a., Nutzung von Biomasse in Berlin, 2009

LIT 4 Dehoust e.a., Optimierung der Abfallwirtschaft in Hamburg unter dem besonderen Aspekt des Klimaschutzes, Darmstadt 2008

LIT 5 Umweltbundesamt (publisher), Dehoust + Vogt e.a., Klimaschutzpotenziale der Abfallwirtschaft – Am Beispiel von Siedlungsabfällen und Altholz, FKZ 370831302, 2010-09-26

LIT 6 Bayerisches Institut für Abfallwirtschaft (publisher), Ökoeffiziente Verwertung von Grünstoffen und Bioabfällen in Bayern, 2010.