1. Summary

Integrating a fermentation system into existing composting facilities requires an initial investigation into the significant framework conditions, in addition to purely technical/economic systems planning. As with all market processes, customers need to be surveyed regarding their requirements for the following products: composted solid fermentation residue, liquid fermentation residue and biogas. Only then can the actual planning begin in a purposeful way. While planning, the use of existing plant components should be given priority, especially with respect to materials receiving, substrate preparation, and the aerobic treatment and final composting stage; system adaptations should be kept to a minimum. The likeliest way to achieve this is by issuing a separate request for tenders to the satisfaction of the plant operator.

2. Background

The integration of a fermentation system for power generation as well as for partial removal of organic substances in the existing organic waste compost facilities is currently being reviewed and implemented at several sites across Germany. Important reasons behind these considerations, plans and investments include:

- Environmental considerations
  * In the context of limited resources, in terms of both fossil fuels and plant nutrients and humus-forming materials, the combination of an energy application (fermentation) and a materials application (composted solid fermentation residue and potentially also liquid fermentation residue) constitutes an optimal utilisation of “biowaste” as a resource [4].
  * In addition, as opposed to cultivating plants for fuel, biogenic wastes that require collection and treatment in any case constitute a resource that does not compete with food and feed production.
  * With regard to the climate balance, composting is near-neutral, imposing a slight CO₂ load, whereas the combination of fermentation with material utilisation of the composted fermentation residues yields a clear climate balance benefit [2]. This is the case despite the initial report of enhanced methane emissions during fermentation[1], for which the data does not permit generalised conclusions to be drawn.

- Economic considerations
  * The upstream placement of a fermentation process requires capital expenditure and imposes operating costs that can, in the best case, barely be covered by revenues from the supply of electricity, heat or gas, or by the lower costs realised in the downstream composting process.
  * The amendments to Germany’s Renewable Energy Act created strong incentives primarily in the area of fermenting products defined as renewable raw materials. The explicit mention of the fermentation of organic waste in connection with the material utilisation of composted fermentation residue as an innovative technology was a strong political signal.
  * At suitable locations with over 20,000 Mg/a of plant input, the processing and feeding of biogas into the natural gas grid becomes both interesting and economical.
• Other reasons

* The composting facilities that opened in Germany primarily in the 1990s are currently undergoing phases of technical and economic depreciation, meaning that large investments would be required for the integration of a fermentation facility.

* By integrating fermentation facilities, the volumes handled by the remaining composting plants can be increased. At locations that outsource biowaste volumes, or where additional external volumes can be acquired, there are incentives in place for the integration of fermentation systems.

* Upstream fermentation systems may allow for the reduction of existing odours generated by I/O waste facilities.

This summary of motives indicates that it is not so much a pure question of economics as it is a combination of environmental and other considerations prevalent at suitable locations that should cause operators to at least seriously examine whether a fermentation plant makes sense. To the extent that the answer is affirmative, a series of fundamental issues must be considered when planning the integration of such a system.

The authors are involved in a variety of conceptual and planning initiatives regarding the integration of fermentation stages. Some practical examples are presented below. Based on prior experience, the most important factors to consider while integrating fermentation plants into biowaste compost facilities will be covered below.

3. Starting at the end...

When you first consider planning a fermentation system as an upstream component in a biowaste compost facility, you tend to start with technical and economic considerations. Our experience suggests that one should first determine how the products of fermentation – fermentation residue (solid and sometimes also liquid) and biogas – will be used. As with all marketed products, the first thing to verify is what the customer (farmer, compost producer, thermal consumer, gas supplier, etc.) needs, in exactly which quality, at what time, as well as what fees or surcharges he is prepared to accept.

It is also necessary to critically examine the existing infrastructure of the biowaste composting facility with respect to its utility to the future overall plant. Only after considering these three topics –

• Utilisation of fermentation residue,

• Biogas utilisation,

• Utilisation of existing infrastructure

is it possible to fruitfully consider issues such as what fermentation technique to use, the integration of existing technology and components, and economic issues. In the meantime, there is a significant number of fermentation procedures available on the market that can be differentiated according to the categories presented in Figure 1. These categories do not consider partial fermentation, where only the percolated or pressed liquid portion of the biowaste is fermented.
3.1. Utilisation of fermentation residue

The procedures used to prepare the fermentation residue (which are often expensive and resource-intensive) must be described thoroughly [5]. Due to the impact of further processing of the fermentation residue on total costs, and in order to continue serving existing biowaste compost customers, the following issues should be considered:

- How has the compost/substrate been used until now?
- Will this recovery method be retained over the long term (10 to 20 years)?
- Is it possible to identify new and interesting sales channels?
- Under what conditions can liquid fermentation residue be sold?

Figure 2 illustrates the requirements that apply to fermentation products, both from a legal perspective and in terms of requirements imposed by customers and other actors. In terms of solid composted fermentation residue, experience at many plants has shown that [7]

- the product does not differ from the compost in terms of appearance or smell once the fermentation stage is commissioned.
- the salt content is lower.
- the nutrient content is reduced, especially in terms of water-soluble nutrients.
In all fermentation procedures, including tunnel fermentation, there is always excess percolate or liquid fermentation residue whose volume and composition is dependent on the inputs, the procedure and plant operation. Plant operation offers a series of options that can be used to influence the volumes of liquid fermentation residues that occur:

- When separating the fermentation residue, maximum drainage is generally not the objective, but rather a dry matter content that allows for proper composting, often in connection with added structural material.
- Returning the liquid fermentation residue for mixture into the biowaste plays an important role in the continuous process.
- Depending on the time of year and the progress of the composting process, liquid (sanitised) fermentation waste may be used to moisten the compost.

Significant quantities of excess water occur during both moist fermentation and continuous dry fermentation (the quantities are presented in Figure 3). The important thing here is to provide sufficient storage capacity for liquid fermentation residues in the plant planning process. Even during discontinuous dry fermentation, excess water is produced by the percolation process, although only on the order of 10% of the material input.

In addition, it has been shown that in areas where intensive livestock farming is practised, and which are thus characterised by large quantities of organic fertilizers (dung), agricultural use of liquid fermentation residues is difficult to promote. In agricultural areas with a low density of livestock on the other hand, acceptance of fermentation residue used as liquid fertilizer is generally high, since it is used as a compound agricultural fertilizer, to the extent that transport distances do not exceed 5 to 10 km. Where agricultural use is not possible, the liquid fermentation residues must be sent to sewage treatment plants.

![Figure 3: Biowaste fermentation: Excess water differentiated according to fermentation procedure](source: Herstellerangaben 2008 und eigene Berechnungen)
In most cases the liquid fermentation residue is used agriculturally. However, sanitation in accordance with the German Biowaste Ordinance must be ensured. This is the case for thermophilic procedures (≥ 50 °C) beyond a minimum residing time (proven via process verification) [3]. When using mesophilic procedures, it is necessary to sanitise the liquid fermentation residue or excess percolate by warming it to 70 °C in sanitation tanks which generally obtain their heat from the cogeneration plant’s waste heat.

The issue of how to sanitise the solid fermentation residue is somewhat different. The solid residue is generally mixed with a certain proportion (10-30%) of unfermented biowaste or green waste in order to provide a suitable structure for the composting process. In addition, these materials add quickly degrading substrates to the fermentation residue, thus ensuring the self-heating needed for sanitation. At present, in Germany it is possible to mix sanitised solid thermophilic fermentation residue with green waste and utilise it without any further sanitisation. After the amendment to the relevant ordinance, this exemption is only granted in limited, exceptional cases [3].

In summary, in addition to the sanitation issues presented above, one of the primary issues is how to use the liquid fermentation residue generated by the selected procedure (see Figure 4).

---

**Figure 4:**

Occurrence of liquid fermentation residue as a criterion in the selection of suitable fermentation procedures (simplified representation)
3.2. Utilisation options for biogas

Figure 5 presents the utilisation options for biogas schematically. The standard procedure is to use the biogas produced via a cogeneration plant for electricity and heat generation. However, since biowaste treatment plants are generally constructed in outdoor areas, environmentally and economically significant exploitation of the generated heat is limited to heating the fermenter and potentially also the operations building.

![Diagram of biogas usage concepts]

Figure 5: Summary of biogas usage concepts

Alternately, a micro-gas pipeline can be run to a suitable heat consumer from a distance of a few hundred meters up to a few kilometres, making the operation of a cogeneration plant at this location an interesting alternative (see e.g. [6]) for which the economics should be examined.

While preparing the biogas and using it via a dedicated filling station (e.g. for the waste vehicle fleet) after compression (≥ 200 bar) basically seems attractive, it is hardly ever implemented given the present framework conditions (energy tax exemption for natural gas, etc.) [6].

On the other hand, there is a great deal of interest in bio-natural gas fed into the natural gas grid after preparation to be used in power plant generation or as a biofuel or part-ially renewable heat source. In addition to a sufficient volume of biogas (≥ 250 Nm³ raw biogas/h ~ 20,000 Mg biowaste/a), another prerequisite for the profitable operation of the biogas preparation and feeding systems is a natural gas pipeline equipped to receive the volumes located no more than a few kilometres away. The legal and economic conditions required to supply and utilise the prepared biogas volumes have improved significantly in Germany in recent years. Figure 6 illustrates the potential revenues associated with on-site conversion into electricity without heat utilisation and bio-natural gas generation from a facility currently under planning. The additional costs associated with the second option should be compared to the first one.
For this reason, when planning an upstream system, it is necessary to check which utilisation options are available for the biogas at the given location with respect to potential recipients of the generated heat or gas (see Figure 7).

The significant variations in terms of potential revenues generated by a biowaste fermentation plant according to the various utilisation methods do not mean that preparation and feeding of biogas always constitutes the optimal biogas utilisation method. This method is dependent on several factors, especially location and volume-dependent costs associated with gas preparation and feeding. However, the illustration makes clear that given favourable circumstances for bio-natural gas generation, high specific gas revenues mean that fermentation procedures with high specific biogas yields are given preference.

Note that in the case of bio-natural gas feeding, when employing micro-gas grids or generating fuel, there will be no waste heat available from the cogeneration plant to heat the fermenter and/or for use in sanitation or fermentation residue drying. Sometimes, these
Optimising Composting Systems

Rational heat utilisation possible at location?

Microgas pipeline (< 5-10 km) up to heat consumers possible?

Processing and feed into natural gas grid possible?

All procedures in connection with cogeneration unit

All procedures in connection with microgas pipeline and cogeneration unit

Procedures with high specific gas yields

Figure 7:
Gas utilisation concept as a criterion for the selection of suitable fermentation procedures (simplified representation)

Figure 8: Biowaste fermentation: Gas revenues differentiated by fermentation procedure

Input Nm³/Mg

Dry fermentation, discontinuous (DF-D)

Dry fermentation, continuous (DF-C)

Wet fermentation (WF)
concepts involve the continued operation of a cogeneration plant at the fermentation facility whose output is sufficient to heat the fermenter. Alternately, the waste heat from the gas preparation procedure (amine scrubbing) and/or compressors may be used, or an external renewable heat source (often wood-fired boilers) may be operated.

### 3.3. Available spaces and existing infrastructure

The objective of the planning process for integrating a fermentation facility as an upstream component into an existing composting plant is necessarily the extensive utilisation of existing technologies and infrastructure. The evaluation of existing infrastructure for the purpose of determining a chargeable asset value is often a significant component of additional planning in order to provide a rational basis for making difficult decisions about which plant components to continue using, which to upgrade, and which to replace.

#### 3.3.1. Available spaces

Table 1 provides an overview of the spatial requirements of various fermentation processes for plants with an input of 20,000 Mg of biowaste and 40,000 Mg of biowaste, respectively. This information does not take into account the spatial requirements for the final composting of the fermentation residue. The specifications regarding discontinuous dry fermentation should be supplemented to include the significant traffic areas required to fill and empty the boxes.

<table>
<thead>
<tr>
<th>Input of biowaste</th>
<th>Spatial requirements by procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td>Wet fermentation</td>
</tr>
<tr>
<td></td>
<td>m²</td>
</tr>
<tr>
<td>20.000 Mg</td>
<td>4.500 – 5.000</td>
</tr>
<tr>
<td>40.000 Mg</td>
<td>6.000 – 8.000</td>
</tr>
<tr>
<td>per Mg</td>
<td>0.15 – 0.25</td>
</tr>
</tbody>
</table>

The spatial requirements of the fermenters rise steadily from upright fermenters (moist fermentation, continuous dry fermentation), recumbent fermenters (plug-flow) up to the spatially intensive box fermenters. On the other hand, in procedures with fermenters that have low spatial requirements, more auxiliary units are required, i.e. for substrate preparation, fermentation residue preparation and storage of liquid fermentation residue, meaning that the total spatial requirements for the various procedures are not very different.

#### 3.3.2. Receiving and processing technology

Processing requirements differ significantly. The greatest requirements are imposed by moist fermentation, followed by continuous drive fermentation procedures. Both types of procedures involve a process crushing and sifting the waste after receipt, as well as removing extraneous material, and in many cases also a sand trap. The first two do not involve an adaptation of the composting plant. With the exception of the sand trap, these functions are generally present in composting facilities, and should be integrated into the fermentation concept with as few adaptations as possible to the extent that their functioning is satisfactory, and should only be upgraded if needed.
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Small box fermenter facilities often function without upstream processing. Coarse-textured material is often required for this fermentation procedure; intensive percolation is also required. Immediately after fermentation, the fermentation residue is too moist for processing. Removal of extraneous materials and conditioning is performed at the end of the solid fermentation residue composting process. When integrating box fermenters, the trick is to continue using the receiving area of the existing composting plant, but to schedule the current materials conditioning stage as the last procedural step. It is generally necessary to switch to mobile units.

4. Selection and integration of suitable technology

Based on the studies and considerations presented in Chapter 3, it is now possible to develop one or more concrete concepts for the upstream system.

Table 2: Summary evaluation of the dry fermentation procedure using plug flow and box fermentation as an example (based on 2008 manufacturer specifications and author’s calculations)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Plug-flow</th>
<th>Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport, delivery of biowaste</td>
<td>Direct delivery by collection companies, no reloading, no transport to external composting facilities, positive environmental balance for roads system</td>
<td></td>
</tr>
<tr>
<td>Transport, delivery of green waste</td>
<td>Continuous feeding: seasonal peaks: Intermediate storage + Boxes better able to deal with seasonal peaks ++</td>
<td></td>
</tr>
<tr>
<td>Quality requirements for biowaste input</td>
<td>Material processing mandatory, processing and removal of extraneous materials prior to fermenter + Material processing optional, not susceptible in terms of extraneous materials, separation of extraneous materials during compost processing ++</td>
<td></td>
</tr>
<tr>
<td>Quality requirements for green waste input</td>
<td>High percentages of woody and straw like materials not allowed – Not susceptible in terms of woody material +</td>
<td></td>
</tr>
<tr>
<td>Maintenance costs</td>
<td>Metering, processing, mixing, drainage – – Limited to fermenter technology +</td>
<td></td>
</tr>
<tr>
<td>Process stability</td>
<td>Precise process control required in fermenter – – Individual modules can be removed from the process; if one box fails the others continue +</td>
<td></td>
</tr>
<tr>
<td>Gas yields</td>
<td>High continuous gas yields + Gas yields fluctuate as a result of discontinuous operation per box, good overall management required for even gas generation –</td>
<td></td>
</tr>
<tr>
<td>Fermentation residue</td>
<td>Fermentation residue drainage required for process control – – Solid fermentation residue only, drainage not required ++</td>
<td></td>
</tr>
<tr>
<td>Storage tank needed for liquid thermophilic fermentation residue</td>
<td>– Small storage tank for percolate requiring disposal +</td>
<td></td>
</tr>
<tr>
<td>Advantage: Fermentation residue is generally sanitised, with less solid fermentation residue requiring final composting ++ Disadvantage: Fermentation residue and excess percolate not sanitised, large amounts requiring final composting, sanitation must be ensured – –</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User experiences</td>
<td>User experiences since 1997/98, process is mature ++ User experiences since 2003: many new developments in the procedural steps over the last two years +</td>
<td></td>
</tr>
</tbody>
</table>
4.1. Procedural comparison

Each of the basic available fermentation procedures summarised in Table 2 is available from a series of providers that use various concepts and technologies to implement the given procedure.

However, the studies and considerations set forth in Chapter 3 do often allow a preliminary choice to be made. For example, if the surface area is severely limited, and if the input volume also needs to be increased, the best solution would be the moist procedure / plug flow procedure, especially with upright fermenters. If, in other cases, there is a healthy demand for liquid fermentation residues (e.g. in agricultural regions with a low livestock density), the thermophilic procedure that does not require subsequent sanitation of the fermentation residue might be a good solution. On the other hand, in locations where the waste heat from the cogeneration plant cannot be used elsewhere, subsequent sanitation of the liquid fermentation residue is easy to achieve in some cases.

These examples only cover a small sample of the considerations required in the planning process. The decision-making chain is not linear; because the issues are interrelated, a multi-dimensional decision-making matrix is necessary. Table 2 presents a simplified example comparing two frequently used procedures.

However, some important criteria for the selection and design of suitable fermentation procedures will be presented below.

As shown in Table 2 the plug flow and box procedure both have different strengths and weaknesses when it comes to the various criteria. These need to be taken into account accordingly during the actual system planning.

4.2. Utilisation of existing infrastructure

The integration of a fermentation system into existing composting plants is generally favourable not only because these biowaste reclamation sites have already been built, but because parts of the existing infrastructure can be harnessed.

The objective should be extensive reuse of:

- Receiving and processing areas,
- Fermentation residue composting,
- General infrastructure.

The new technology essentially consists of:

- Fermenter, including substrate feed,
- Biogas utilisation (cogeneration plant, gas processing, etc.),
- Aerobisation and fermentation residue conditioning,
- Storage tank for liquid fermentation residue and percolate,
- Process control system.

4.2.1. Receiving and processing

It is often possible to use the existing receiving (scale, receiving bunker, dosing systems) and processing equipment (crushing and sorting units) extensively. Discontinuous dry
fermentation is also supplied directly with unprocessed biowaste. The separation of extraneous materials is undertaken in the composted fermentation residue. In all fermentation procedures, fermentation residue is not immediately suitable for processing, since it is generally too moist.

The objective of the planning process for the integration of a fermentation plant must be to integrate existing functional receiving and processing units into the new plant. In the event of a planned increase in throughput, the processing systems should be either expanded or adjusted operationally (by adding additional shifts). After processing, new equipment must be added in order to feed substrate to the fermenters, consisting of wheel loaders, sliding trays, pumps, or similar.

**4.2.2. Aerobic treatment areas and exhaust air treatment**

Of special significance to fermentation integration concepts is the continued use of the existing composting technology. Conditioning the fermentation residue for subsequent composting is essential in this respect. When employing continuous fermentation procedures, separation into solid and liquid fermentation residue is essential for subsequent composting of the solid component in terms of the dry matter content of the fermentation residues (see Figure 9). Likewise, aerobisation of solid fermentation residues is essential in order to guarantee rapid transition from the anaerobic composting phase to the aerobic phase. Existing units such as a conditioning drum or aerobic conditioning boxes are used to this end. It makes sense to monitor exhaust air flow from the aerobisation process separately in order to be able to treat this exhaust airflow in a focused manner in the event that emissions requirements should become more stringent in the future.

![Figure 9: Typical dry content of fermentation residues from various fermentation procedures](source: Biogas Nord, Strabag/Linde, BEKON)

Source: Raussen, T.; Lootsma, A.: Am Ende anfangen – die Aufbereitung von Gärresten stellt für große Vergärungsanlagen einen maßgeblichen Verfahrensschritt dar (Starting at the end – the processing of fermentation residue as an essential procedural step in large fermentation plants). In: Müllmagazin (2008), Nr. 2, pp. 14-20
To the extent that the aerobic treatment area has proven itself to be a reliable component in the composting process, and as long as it is in sound technical condition, it can be used to compost the solid fermentation residue with minor adjustments. Since organic material is already broken down in the fermentation process, and since the required intensive aerobic treatment time is shorter, the full composting capacity is not required. In other words: Circumstances are especially favourable if the capacity of the whole plant is 30 to 50% higher than the previous pure composting plant, since this means that the existing intensive aerobic treatment area can be used in an optimised fashion. Remember to consider that the solid fermentation residue is frequently mixed with 10 – 30 % unfermented biowaste or green waste in order to ensure a favourable composting structure, and so that a sufficient quantity of rapidly degrading organic material is available for the sanitation process (temperature profile).

4.2.3. Final composting and warehouse

The composted fermentation residue largely corresponds to the biowaste[7], meaning that the facilities for final composting and potentially also substrate preparation, etc., can be reused.

Depending on the procedure, when using the residue in agricultural applications, a storage facility must also be built for the liquid fermentation residue and excess percolate accumulating over a six-month period. On the other hand, if disposal via a wastewater treatment plant is planned, processing stages must be provided for accordingly in keeping with treatment plant specifications.

4.2.4. Electrical and Programmable Logic Controller

A dedicated process control system for the fermenting process is included in a typical scope of delivery. Parallel operation with the control system for the existing composting facility is certainly feasible. These are the important interfaces to take into account: Processing – dosing, fermenter discharge and ventilation technology.

4.2.5. Miscellaneous

Miscellaneous facilities such as

- Social, office and staff amenities areas
- Substrate mixing, packing lines, etc.
- Rain water and wastewater collection

demonstrate sufficient capacity and will be retained or upgraded as needed.

5. Profitability

The depreciation status of existing technology and components has a significant impact on the profitability of planned upstream systems. Many of the composting plants built in the 1990s have largely depreciated in terms of their plant technology. This is not the case for the components whose integration into the new combined fermentation facility with composting of the solid fermentation residue is generally a prerequisite for the profitability of the overall concept. Thus classic upstream systems whose input volume can be increased to the point where the solid fermentation residue harnesses the entire composting capacity are considered economically optimal.
5.1. Costs and revenues

The following figures illustrate the typical specific costs (average values as well as deviations) for various biowaste fermentation procedures (not including the cost associated with fermentation residue treatment) based on manufacturer specifications. While Figure 10 illustrates specific investment costs, Figure 11 highlights typical areas for the specific operating costs. Finally, Figure 12 illustrates the various levels of revenue to be anticipated from the various fermentation procedures.

Figure 10: Specific investment costs for various biowaste fermentation facilities (Plant: 20,000 Mg/a)
Source: Data based on: 2008 manufacturer specifications and author’s calculations

Figure 11: Specific operating costs for various biowaste fermentation facilities (Plant: 20,000 Mg/a)
* excluding capital costs, costs associated with fermentation residue treatment, excluding revenues from biogas utilisation
5.2. Treatment costs

Treatment costs must take into account final composting as well as the costs or revenues associated with the marketing of the substrate. -> may be significant
6. Practical examples

6.1. Wiefels dry fermentation plant

Domestic waste generated by approximately 630,000 inhabitants of north-western Germany (Friesland, Wittmund, Cloppenburg, as well as the cities of Oldenburg, Wilhelmshaven and Delmenhorst) is treated at the Wiefels waste management centre.

Initially, the waste is mechanically processed, with a high resource recovery rate. The portion that is not recycled directly consists largely of organic substances. In order to recover renewable energy from this portion, the waste management authority is building a dry fermentation facility to complement the existing moist fermentation system.

Figure 14 below shows a simplified version of the process cycle.

![Figure 14: Wiefels dry fermentation facility block flow diagram](image)

The dry fermentation concept is based on a box procedure provided by the WTT/Heitkamp Association, whereby the material is fermented in a gas-tight fermentation tunnel. The facility consists of eight interconnected fermenter tunnels and one percolate fermenter. After a fermentation stage lasting approximately three weeks, the waste is forwarded to fermentation residue composting tunnels for subsequent aerobic treatment. After mixing with the fermentation residue from the moist fermentation process, the material is placed in a landfill.

Wiefels plant data:

- 20,000 Mg residual waste/year,
- 1,900,000 m³ biogas/year,
- 3,976,645 kWh/year,
- Equivalent of approximately 1000 households,
- The plant has been in operation since the end of July 2011.
Figure 15:

Visualisation of dry fermentation at Wiefels

Source: WTT

Figure 16:

Building site: Picture taken March 22, 2011

Figure 17:

Commissioning: Picture taken July 2011
6.2. Dry fermentation system employed as upstream system 60,000 Mg/a

Stadtreinigung Hamburg (SRH) operates a compost plant near Hamburg (Bützberg) to treat biowaste from Hamburg and the Storman district.

The plant is currently being expanded to include a dry fermentation system upstream of the composting system. This enhancement can be used to increase composting capacity by reducing composting time while continuing to use the composting plant facilities with as few structural and process engineering changes as possible. This is facilitated by pre-treating the material (fermentation) in the new upstream dry fermentation system.

The following plant components are currently being constructed for dry fermentation:

- Fermenter with dry fermentation logistics area;
- Dry fermentation warehouse;
- Waste air treatment consisting of a biofilter with an upstream acidic scrubber;
- Supply (biomass spoiler);
- Gas processing and feed (construction and operation by external operators).

The biogas produced by the facility is processed to natural gas quality by a gas processing system and fed into the public grid.

Figure 18 illustrates the functionality of the plant once the dry fermentation system has been added.

Figure 18: Photomontage of the Bützberg/Hamburg facility
(existing plant on the right, upstream system on the left)
Figure 19: Block flow diagram for the Bützberg/Hamburg plant
7. Conclusions

Experience has shown that the essential parameters to consider when integrating an upstream fermentation plant into an existing biowaste composting facility are the three following location-dependent factors:

- Options for using the fermentation residue,
- Options for using the biogas,
- Options for integrating existing infrastructure and technology.

The current legal and economic framework conditions enable cost-neutral construction and operation of an upstream system under optimal conditions. The advantages include increased throughput, reduced odour emissions, and an improved carbon and energy balance. A tiered approach to issuing a request for tenders and specifications has proven expedient for planning purposes.

8. Literature


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