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PREVENT PLASTICS

BIOLOGICAL ORGANIC WASTE TREATMENT

Business case
evaluation for organic waste
from food industry in Myanmar

switchasia GRANTS PROGRAMME

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4. LIST OF ABBREVIATIONS

a	Annum, year
AD	Anaerobic digestion
C	Carbon (chem.)
CAPEX	Capital expenditures
CH4	Methane
Chem.	Chemical
CHP	Combined heat and power generator
CO2	Carbon dioxide
H2	Hydrogen
IZ	Industrial zones
kWh	Kilowatt hour(s)
m^3	Cubic metre
MBT	Mechanical-biological treatment (plant)
MC	Moisture content
N	Nitrogen (chem.)
NH3	Ammonia
t	ton(nes)
Therm.	Thermal
VOC	Volatile organic compound(s)

5. PREFACE

Waste treatment has gained more and more importance in the last decades in global a perspective. Especially in Asian countries many changes in waste treatment are introduced or are a major topic in regional development plans.

The majority of the Asian municipalities have no implemented separate-at-source waste collection model. This leads to several problems for possible waste treatment methods as the high-water content of the organic fraction decreases the usable energy in incineration plants and the deposition of organics in non-sanitary landfills lead to the production and emission of climate-active methane and odour nuisance for its surroundings.

In this report, the status-quo and possible biological treatment of organic waste from industrial and agricultural sources in Myanmar is evaluated. Data about waste amounts, composition and current treatment are taken from the recent baseline study prepared 2020 by Thant Myanmar for the Prevent Plastics Project [1].

6. STATUS-QUO WASTE TREATMENT MYANMAR

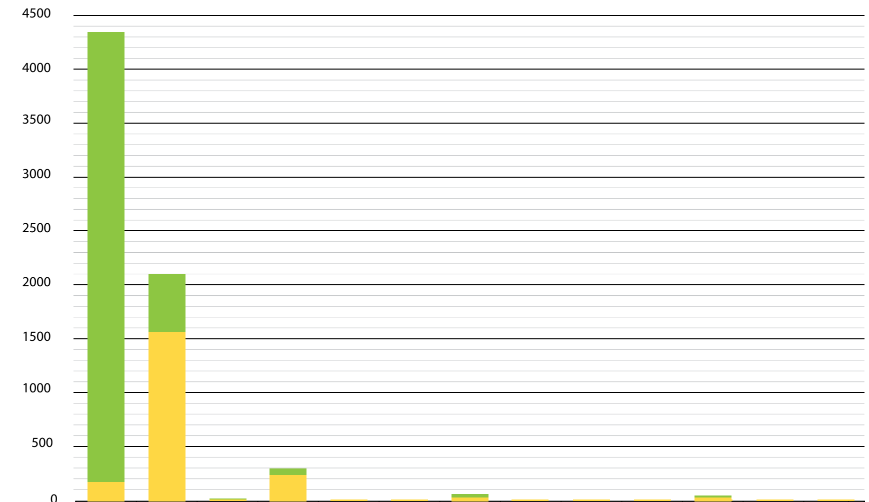
As stated in the baseline study by Thant Myanmar [1], the solid waste generation from industries in Myanmar is not well assessed since waste management is often individually organised.

The baseline study focuses on four industrial zones (IZ) in Myanmar, which are namely:

- South Dagon IZ 1 -SD,
- Shwe Pyi Thar IZ1 - SPT,
- Shwe Lin Ban - SLB and
- Mandalay IZ – MDY.

One of the main outcomes of this study is that the section of food production waste is by far the largest and this waste is mostly disposed off at dumpsites. This is illustrated in the following Figure 1.

Waste per industry [tons/month]



	Food	Garment	Construction	Consumer Goods	Paper-Printing	Water Cold Storage	Plastic	Machine Making	Electronics	Iron Works	Wood	Warehouse	Mechanical & Craft
Landfilled [t/m]	4342	527	45	05		12	01		1151				1
Recycled [t/m]	162	1570	1	239	05		30	55		54	15		5

Figure 1: Waste per industry including all 4 industrial zones. The waste is divided into recycled (blue) and landfilled (brown). In most cases the recycled component weighs stronger than the waste component, except for food waste [1].

Surveyed food sector not only produces with a total of 4,504 tonnes per month the highest amount of waste, but also by far the highest amount of landfilled material with 4,342 tonnes per month.

The composition of the produced waste from the food sector is with 95 % organics nearly totally suitable for biological treatment as shown in Figure 2.

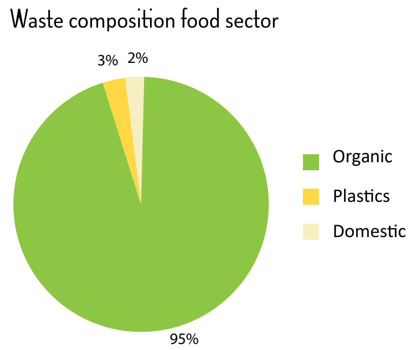


Figure 2: Composition of Food Sector waste. Own representation of data from baseline survey [1].

As shown in previous Figure 1 and Figure 2, organic waste produced by industrial food sector is not only the majority of the produced waste amount within the survey IZ with approx. 66% but is also the waste stream which is by far the most landfilled and least recycled.

With containing approx. 95 % organics, this waste stream leads to high environmental impacts when disposed of without any precautions at the landfill. The high biological activity leads to the production of landfill gas (mainly methane) which is climate active and explosive. This is harmful for climate and also for human health, additionally odour development around the landfills are a serious impact to its surroundings.

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7. EVALUATION OF SUITABLE WASTE TREATMENT TECHNOLOGIES FOR ORGANIC WASTE

7.1 AEROBIC TREATMENT

One biological organic waste treatment solution is the aerobic treatment. Aerobic treatment can be used to biologically stabilize the waste or to produce compost. The process parameter are depending on the aimed output specifications and framework conditions, such as available compost off takers.

Aerobic biological stabilization or composting is a process which leads to partial mineralization and humification of organic matter. Dead organic matter is decomposed with the participation of micro-organisms and soil fauna.

Composting is the process of converting natural substance under controlled conditions in the presence of oxygen (air), at a suitable temperature and humidity and the ratio C: N (30: 1). Organic matter, which is about the origin of plant or animal, is subject to natural conditions decomposition. This natural process is supplemented by controlling certain parameters, it is used for the processing of vegetable matter or waste food to humus products, such like composts, soil improvers and soil conditioners. The composting process takes place in two main phases:

First phase: This phase is an intensive exothermic process under aerobic conditions. It is characterized with a sudden temperature rise to about 40-45 °C (mesophilic temperature range). The main stage is a thermophilic phase reaching temperatures of 50-75 °C. These conditions are lasting for a period of 10-14 days. In the metabolism processes of the bacteria protein substances, carbohydrates, organic acids and fats are oxidized. The high temperature destroys the pupae of insects, insect eggs and the predominant part of coliform bacteria and sterilizes the material.

The optimum process temperature is < 65 °C for the thermophilic phase. At higher temperatures (> 70 °C) for a longer period of time the synthesis of certain substances is slowed down and may be elevated in the emission of odour. Short-term peak temperatures of up to about 80 °C are possible but do not affect adversely on the whole process.

Transitional phase is a period of decline in the temperature to about 50-40 °C. After about 21 days of intensive composting the process passes in the second phase.

The second phase: lasting approx. four weeks (variable depending on ambient conditions and the expected level of stabilization of organic matter). The process temperature ranges from 40-65 °C. Pathogenic organisms, spores and seeds are sterilized due to the high temperatures.

The activity of micro-organisms, including respiratory activity is monitored in real time by a sensor directly stabilized the waste.

There are different aerobic biological treatment technologies available with different retention times and weather dependencies. The higher the monitoring and defined conditions are adjustable, the more expensive the technology gets, but also decreases the needed land area. The different technologies are briefly compared in the following Table 1.

Table 1: Comparison of different aerobic biological treatment technologies.

Aspects	Open heap composting	Membrane composting	Box composting
Time needed composting	90 – 270 days	30 - 45 days	18 – 25 days
Time needed drying	> 90 days	12 – 15 days (< 15% MC*)	8 – 9 days (< 10% MC)
Output	Compost/ RDF	Compost/ RDF	Compost/ RDF
Land needed	Large area	Large area	Less area
Weather conditions	Impact of weather	Less impact of weather	No impact of weather
Invest/ process costs	- / -	0 / 0	+ / +
Volume capacity	Low – medium	Low – medium	Medium – high

*MC = Moisture content

Advantages of aerobic treatment technologies are its relatively low capital costs and low operational efforts. On the other hand, disadvantages are the large area needed, the decomposition of organics without energetical usage, off-takers of produced compost or RDF have to be near to decrease transport costs.

7.1.1 Example

There are many aerobic treatment plants all over the world decentralized in rural and centralized in urban regions. As an example of a mechanical-biological treatment plant (MBT) which includes mechanical pre-treatment of mixed municipal solid waste (MSW) to separate plastics and paper/cardboards from organics and aerobic organic waste treatment, the following MBT in Munofia, Egypt is shown.

Figure 3: Birdview of MBT in Monufia, Egypt, with mechanical pre-treatment within the hall and open windrow composting. [2]

In 2020, EUWELLE and its partner companies built a MBT plant for MSW treatment in Monufia/ Egypt with a capacity of approx. 30 Mg/h using one treatment line. The MBT plant consists of a mechanical pre-treatment and a biological treatment step. Organic load of the MSW input is approx. 60 % and the moisture content (MC) at arrival is approx. 40 % MC. After the treatment process, the organic fraction treated biologically has a MC of 15 %. Produced average fractions produced at this facility are as follows [% of input]:

- Compost (0 - 20 mm) approx. 20 %
- Low calorific fraction/ landfill (20 – 50 mm) approx. 20 %
- Evaporated moisture approx. 20 %
- Heavy residue non-organic approx. 10 %
- Products (paper/cardboard/metals/etc.) approx. 30 %

At this facility, the landfilled amount has been decreased by approx. 70 % (only the low calorific and heavy residue fractions are landfilled).

A virtual site visit can be seen on the YouTube channel of EuRec and EUWELLE [2].

7.2 ANAEROBIC TREATMENT

Anaerobic biological treatment is the technical utilisation of natural decomposition reactions of organics. Biogas production in nature occurs e.g., in sediments of freshwater ponds. Other natural production sites are sediment of freshwater rivers, march land and rice fields. The same process occurs in the intestinal of ruminants, as for example cows.

Contrary to the aerobic treatment, the anaerobic treatment is under exclusion of oxygen and does not generate as much heat due to no oxidation reactions. The degradation steps of organic material are shown in the following Figure 4.

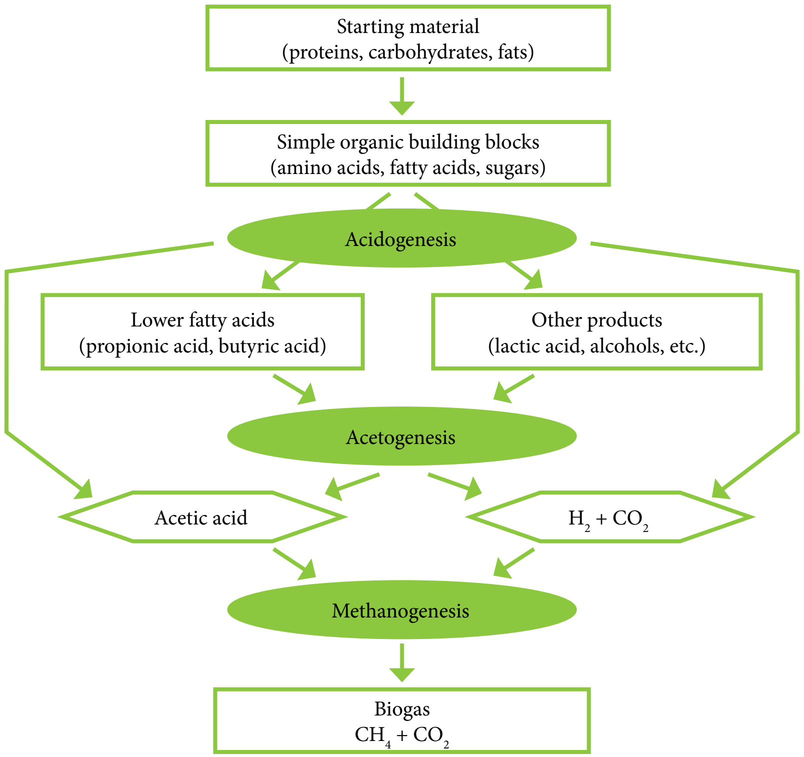

Figure 4: Biological degradation steps in anaerobic treatment [3].

The produced biogas has approx. the following composition:

- 50 – 75 % CH4
- 25 – 50 % CO2
- 1000 – 5000 ppm H2S
- Traces of H2, NH3 etc.
- Saturated with H20
- Heating value: 5 - 7.5 kWh/m³
  (compared to “natural gas”: 95 – 99 % CH4, heating value approx. 10 kWh/m³)

Landfills for example can also be seen as an anaerobic biological reactor when organics with high biological reactivity are disposed of there. Under some layers of new waste, the old waste reaches anaerobic conditions and decomposes the organics to landfill gas (methane, CH4). If this produced landfill gas is not collected and thermally/ energetically used, it is highly climate active when set free into the environment with a CO2 equivalence of 28 – 36 on a 100-year duration basis [4].

Biogas plants are using this natural degradation process in bioreactors with defined and controlled conditions to decrease the organic amount and to produce biogas.

There are different organic substrates suitable as input of a biogas plant, such as manure, agricultural waste, food/ organic waste, and sewage sludge from wastewater treatment plants. Depending on the material, different relative amounts of biogas per ton substrate can be achieved as it can be seen in Figure 5.

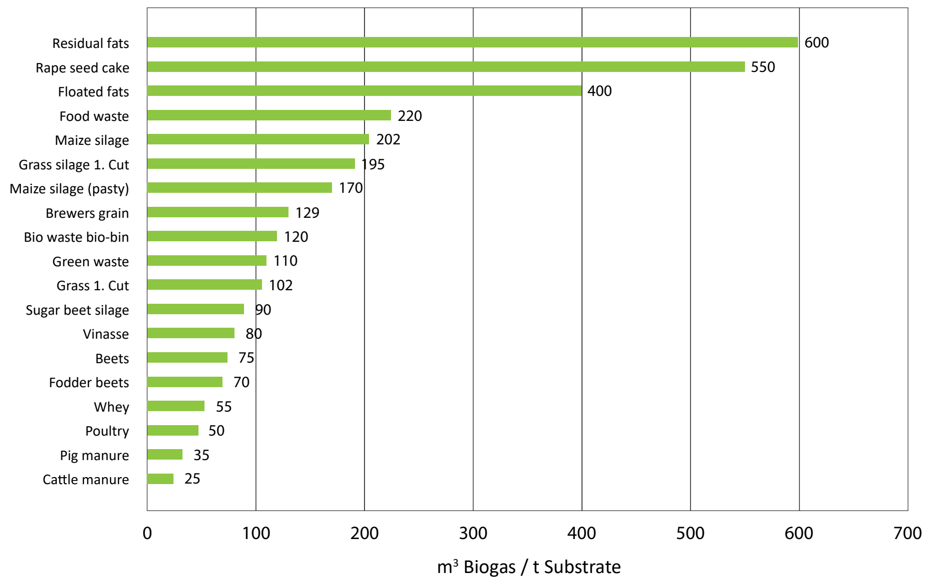

Figure 5: Relative achievable biogas yields per kind of input.

As it can be seen in Figure 5, food waste and fats are a potent substrate for biogas production with approx. 220 m³ to up to 600 m³ biogas per ton substrate.

In the following Table 2 different possible process parameter is shown. Depending on the respective framework conditions, such as input parameter, available area and water amount, the anaerobic digestion (AD) process can be designed respectively.

Table 2: Different AD process parameter.

Criterion	Open heap composting
Dry matter content within digester (≠ of the substrate)	• wet digestion • (Semi dry digestion) • dry digestion
Type of feed	• intermittent (batch) • quasi-continuous • continuous
Number of process phases Process temperature	• single-phase • two-phase Process temperature • psychrophilic • mesophilic • thermophilic

Residues from anaerobic waste treatment can also be used as fertiliser or soil improver after an aerobic post-treatment step and if the local legal framework allows it.

The advantages of the AD treatment are also illustrated in the following Figure 6.

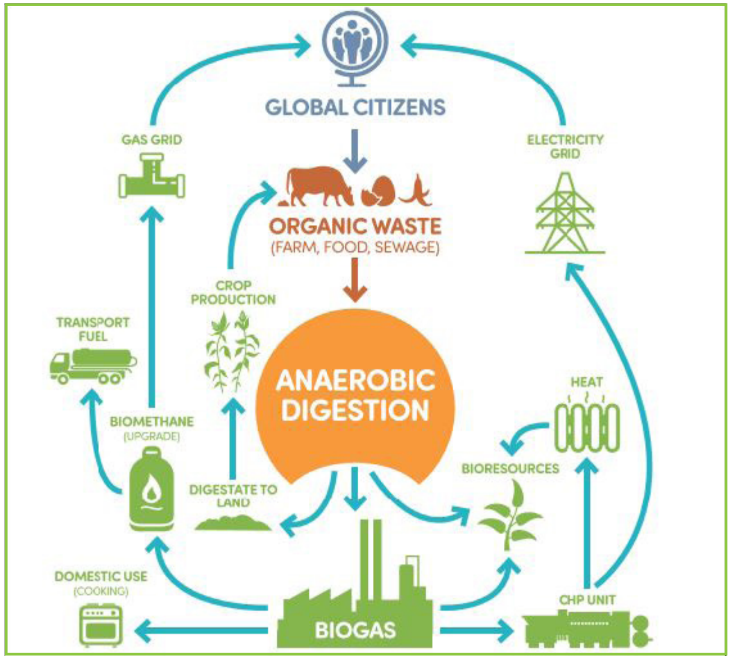

Figure 6: Circular economy of AD treatment of organic agricultural and food waste [5].

Figure 6 shows that via AD treatment, various products can be achieved with some post-treatment. Biogas for example can be directly used on-site in combined heat and power units (CHP) for the production on electricity and heat to operate the plant and for sale. Liquid and solid residues can be used as soil improver or fertiliser for local farmers.

Depending on AD technology and used substrate, the electric power output of commercial plants can be from approx. 500 kW to up to more than 10 MW.

Advantages of the AD-process (compared to uncontrolled spreading to agriculture, compared to composting and compared to landfill or even incineration)

- Biogas can be upgraded to natural gas quality and can thus easily substitute mineral fuels. Compared to the production of fuels from other renewable sources (e.g., pyrolysis of wood) AD is a very simple process.
- Residues that are spread (uncontrolled) to the land (or agriculture) will lead to significant emissions. AD thus not only prevent CO2-emissions, but also emissions of VOCs, CH4, N2O, etc.
- Only "energy rich" material is converted in the AD-process. Due to the degradation of e.g., proteins, Nutrients in the digestate are even better available for plants.
- Compared to e.g., the meat price, the price for renewable energy is very reliable.
- This is a big advantage to other renewable energy producing facilities (e.g., the production of renewable electricity with steam boiler fired with wood is only possible in large scale plants at the moment).

Compared to aerobic treatment, the anaerobic treatment needs higher investment and monitoring of process parameter. On the other hand, the AD treatment makes use of the complete input material by converting the easily degradable organics into valuable biogas and therefor usable for many applications and also the liquid and solid residuals can be used further in agriculture as soil improver.

Hence, the AD technology is the more attractive technology if there are highly pure input streams and local off takers of the products available.

8. CONCEPTION OF THE WASTE TREATMENT TECHNOLOGY

Based on the given information about the waste and local situation of waste producers and possible heat and power off takers within the industrial zones in Myanmar, a basic conception of an AD plant is examined in the following.

In general, there are four process steps needed in an AD plant as visualized in the process flow scheme in Figure 7.

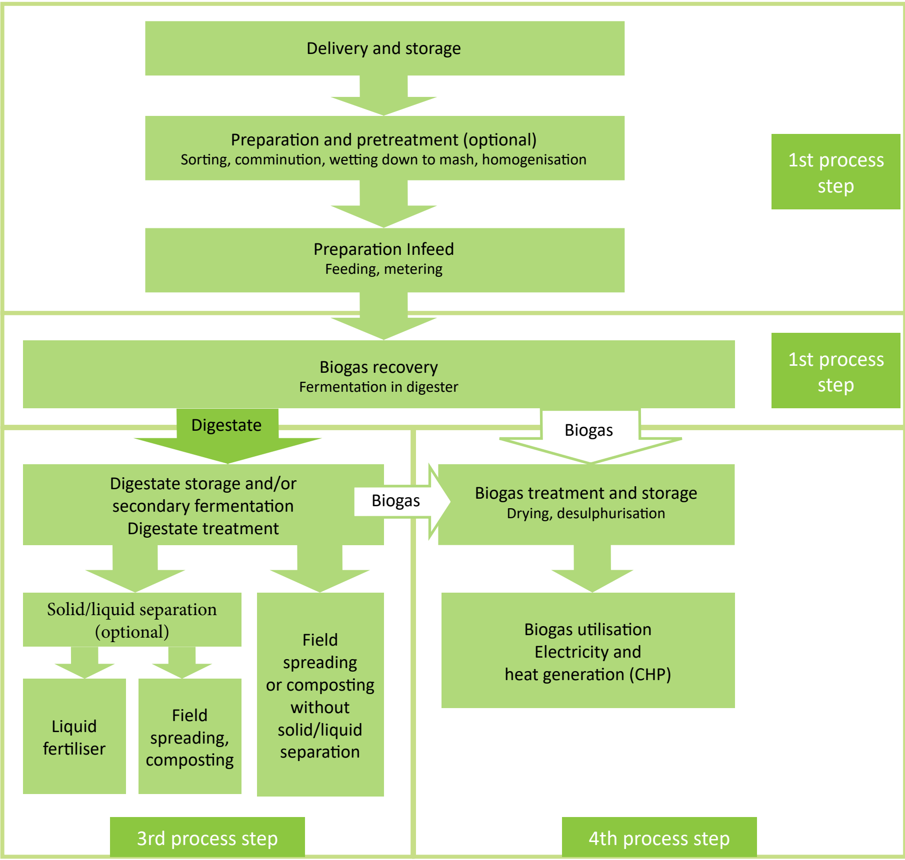

Figure 7: General process flow scheme of an AD Plant [3].

The first process step is the pre-treatment of delivered organic material. Depending on the material source, the pre-treatment can be easy if the material is free from impurities (plastics) or needs a separation step (e.g., via hammer mills).

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Step two is the AD process where the organic content is degraded by micro-organisms and methane is produced. This process can be designed according to the parameter shown in Table 2.

The third process step includes the digestate treatment after the AD process. Digestate describes the solid/liquid emulsion of nutrients in water and residual solid particles that have not been digested. Here, multiple treatments are possible:

- Field spreading or composting without solid/liquid separation:
  - The residues from the AD process are treated under aerobic conditions to reduce the remaining biological activity and to produce solid soil improver/ compost.
- Solid/ liquid separation:
  - The liquid can be used as fertiliser in agriculture as many nutrients are dissolved in the liquid phase.
  - The solid residues can either be also spread directly to fields (this is connected with odour emissions) or can be aerobically treated to decrease odour emissions and biological activity/ sterilisation.

The fourth and last step contains of the biogas treatment for further usage. This treatment is depending on the final usage and its respective quality requirements. Possible usages are feeding the biogas into an available local gas grid, this needs an upgrading of the produced biogas to natural gas parameter such as sulphur and water content and heating value. Also, when used in a CHP a certain processing of the biogas can be necessary to reduce sulphur and water concentration to avoid corrosion within the engines.

8.1 BIOGAS PLANT EXAMPLE

The needed equipment and detailed process needs to be adjusted case-by-case for each input material or mixture. Different sources produce different waste characteristics such as impurities (packaging), particle size or viscosity and density. A reliable feasibility study is mandatory to be prepared before concepting a biological treatment plant to meet all expectations.

An example of a small biogas plant using food/ organic waste is the biogas plant in Zagreb, Croatia. Here, the input material is a mixture of kitchen, supermarket, and food waste, which makes a pre-treatment necessary to separate packaging material.

The plant parameter are as follows:

- Substrates: 20,000 t/a
- Digester: 3,600 m³
- Post-digester: 1,000 m³
- Buffer tank: 490 m³
- Install. Power: 1,000 kWel.

The process scheme is visualized in the following Figure 8 showing all necessary process steps and equipment.

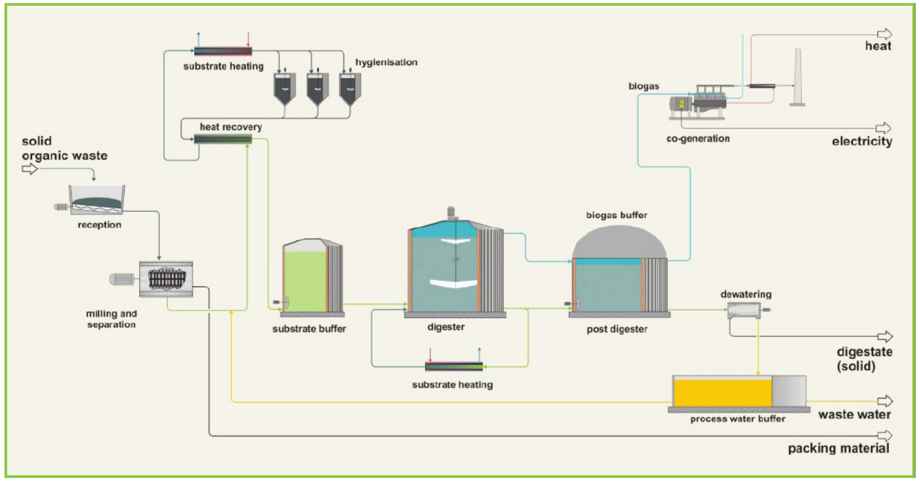

Figure 8: Flow chart of the exemplary biogas plant in Zagreb [6].

The real appearance of this exemplary plant is shown in Figure 9 with the view on the used substrate buffer tank, digester, and post digester/ biogas buffer.

Figure 9: Picture of the biogas plant in Zagreb. From left to right: buffer tank, digester, and post digester/ biogas buffer [6].

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One plant of this size of 20,000 tonnes food waste per year would treat approx. 40 % of the total produced food waste (approx. 54,000 tonnes per year) within the four IZ surveyed in the Baseline Report of Myanmar (see Figure 1).

8.2 FINANCIAL FRAMEWORK ASSUMPTIONS

Capital investments for a biogas plant are strongly depending on the plant size as scaling effects are large. For example, the needed monitoring equipment of measurement probes, IT hardware and software are needed in similar amount independent of the plant size. Hence, this equipment is expensive in relation to the other capital costs of a small plant.

In general, the relative costs depending on the plant size are shown in the following Figure 10 in investment costs per installed power generation.

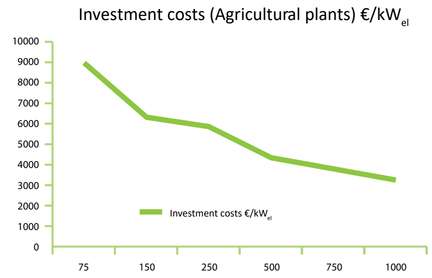

Figure 10: Investment costs of biogas plants [7].

The same cost dependency can be assumed for used combined heat and power (CHP) units showing the scaling effects of specific costs per electrical capacity in Figure 11.

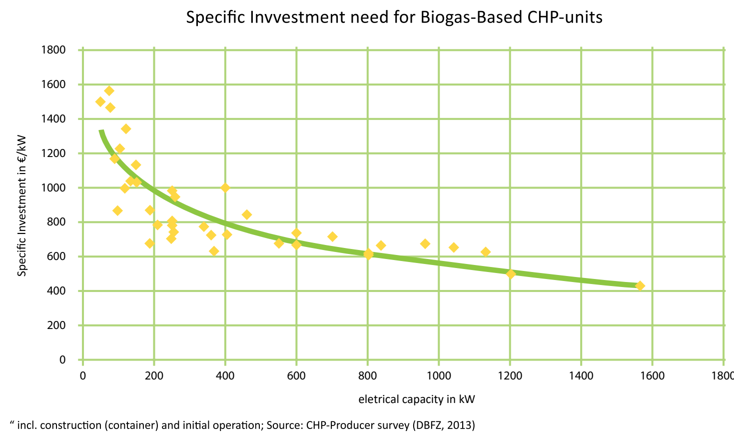

Figure 11: Specific CHP costs per electrical capacity [8].

It can be seen that also the specific investment costs of CHP units are decreasing with the size of installed power. Small CHP units are more expensive per produced kW than larger ones, this is also affected by the availability of smaller units as the market for high-capacity CHPs is larger.

8.3 EXAMPLES OF PLANT SIZES AND CAPEX COSTS

To give a rough estimation of capital expenditures (CAPEX) necessary for small commercial AD plants, the following Table 3 gives a simple overview on needed equipment and the respective cost range according to experience values.

Table 3: Exemplary plant AD plant sizes and costs according to experience.

Input material	Food waste		Mainly manure		Unit
Amount	4,000		12,000		t/a
	Min	Max	Min	Max	-
Electrical capacity/production	120	200	75	100	kw
Pre-treatment (bunker, hammer mill)	300.000	500.000	-	-	€
Digester	350.000	450.000	250.000	350.000	€
Controlling	100.000	120.000	80.000	100.000	€
CHP	200.000	280.000	125.000	180.000	€
Civil Eng./Construction	local		Local		
Total	950.000	1.350.000	455.000	630.000	€

The differences of these two plants are caused by the different substrate used. Food waste can be delivered by different sources (markets, food industry, private persons, etc.), hence it is likely to have a certain amount of impurities and needs a mechanical pre-treatment to separate it. Also the viscosity of food waste is relatively high and can be heterogeneous, hence the mixing and digester system needs to meet higher requirements.

There are few suppliers of very small demonstration AD plants who are specialised on container solutions for e.g. research facilities. One of such container solutions is shown in the following

Figure 12: Container AD solution “Bert Mobil AD”. [8]

This micro-AD has a manual pre-treatment table and the following specifications:

Table 4: Specifications of the micro-AD plant by Bert Energy GmbH. [8]

Input material	Food waste	
Amount	1	Ton per day
Electrical capacity/production	5 (el.)/ 12 (therm.)	kW
Pre-treatment (bunker, hammer mill)	Manual/ shredder	-
Digester container	33	m³
Gas storage	Membrane bag on top of container	
Construction area	6 x 25	m
Rough price:	50,000 – 60,000	€

Due to the very small capacity of 1 ton per day, this micro-AD is only suitable for research/ feasibility studies to evaluate certain substrates and/or operation parameter.

8.4 RISK ASSESSMENT

Safety assessment:

Environmental impact and human health insurance are of high priority for biogas plants as the produced methane is climate active and also explosive.

Hence, monitoring of possible leakages within the plant at pipelines and connection points and strict precautions in ex-zones are necessary. Especially open fire and smoking is prohibited in defined risk zones at the plant and frequent maintenance of the equipment is mandatory.

If these measurements are followed, biogas plants are a safe way to treat organic waste and produce valuable and environmentally friendly products from it, this is proven in thousands of biogas plants operated all over the world.

Financial assessment:

There have to be revenues made from plant operation. These revenues are mostly generated by waste accepting fees and/or selling of the products biogas/ electricity or fertilizer/ compost.

These revenues are highly depending on local framework conditions and if such treatment plants are supported by local government. Binding fees and product prices are essential for a positive financial evaluation of a plant and needs to be assessed case-by-case.

Resuming the previous price dependencies, it is clear that there is a break-even point of plant size where a plant investment can be financially feasible for commercial usage.

9. CONCLUSION

For the decision between the two presented biological treatment technologies it is essential to conduct an extensive feasibility study of the local framework conditions.

Local waste composition and respective off takers should be surveyed regarding input and output composition and possible revenues of the treatment.

Another essential parameter is the waste amount to be treated at the facility. As shown in the previous chapter, the specific investment costs decrease with higher capacity. Small plants, like e.g. demonstration plants, are relatively expensive and are likely to be not economic feasible as the operation costs are higher than possible revenues from waste acceptance fees and the sale of products.

A commercial feasible plant could be possible if at least half of the surveyed waste from the food industry surveyed in the Baseline Study by Prevent Plastics can be used as substrate for a biogas plant.

There are also very small biogas plants available with 1 – 60 kW as container solutions. Such a solution could be suitable for a demonstrating waste treatment capacity of 1-10 tons per day, but this has to be evaluated separately. It has to be considered that such small plants are not for commercial but for research/ feasibility studies and to evaluate certain substrates as pre-projects for larger facilities.

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