03-03: Putrescibles – Supply chains

03-03-00: Introduction to handling of digestible biomass

European technologies all use extensive pre- and post-digestion processing units, regardless of the waste source or digester type. Pre-sorting is necessary to prevent clogging of the pumps and to reduce the amount of reactor volume occupied by inert material. Even source-separated waste inevitably contains metal and plastic contaminants and must be pre-sorted. A typical sorting line includes the following components;

- Receiving
  - Can include some visual (manual or robotic) sorting and removal of bulky or potentially harmful items
  - Provides a buffer for inflow rate fluctuations
- Particle size reduction
  - Can be mechanical and/or biological
  - Relies on the relative ease of reducing the particle size of the organic fraction
- Separation
  - Can be based on magnetism, density, and size

03-03-01: Properties and handling of municipal solid waste

Figure 03-03 1 shows some of the material processing units used in the Dranco and Valorga dry digester systems. The receiving area allows for unloading of raw MSW and isolation of MSW from different sources. Some receiving areas use robotics to minimize human contact with the waste. Others incorporate a sorting line for workers to manually remove the most obvious inorganic materials. Once the MSW has been loaded into the mechanical separation system, human contact is minimal as biological and mechanical processes prepare the MSW for density and/or size separation.

Figure 03-03 1: Dry digester material handling equipment.

Clockwise from top left: staging area with robotic claw; rotating bio mixer drum; over from trommel screen sieves; high-speed drum with integrated sieve and magnetic separator; high-solids slurry pump; feed mixer with steam injection; and dosing unit with steam injection and high-solids slurry pump.

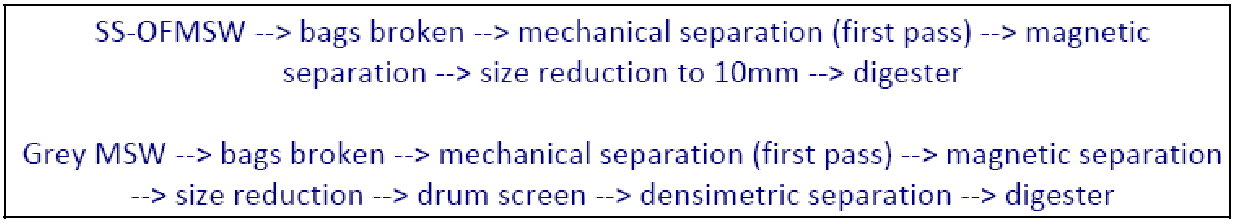
Density separation requires wetting the MSW; therefore it is more commonly applied when using low-solids digesters.

Organic material breaks into smaller particles more easily than inorganic material, therefore a mechanical macerator or agitator is often employed prior to screening. In addition, some aerobic treatment can help break down the organic matter. This may also be accompanied by a loss of digestible organic matter; therefore short retention times are used. Between several hours and one or two days is typical for rotating drums, or "biomixers," which combine agitation with aerobic treatment. Biomixers are currently used at about 20 MSW plants in the U.S. for aerobic composting where retention times of 3-5 days are used.

Recently the researchers at the University of California, Davis studied the biogas production potential from the organic materials separated from MSW (i.e. OFMSW) using rotating drums at six MSW composting facilities in the U.S. They found that the organic materials had high biogas and methane yields even when the MSW had spent only 24 hours in the drum (unpublished data). This indicates that AD systems could be incorporated into the existing MSW composting operations in the U.S. for energy recovery from OFMSW.

In a rotating drum system, a sieve may line the sides of the drum allowing undersized particles to pass to the dosing unit while expelling oversized, primarily inorganic, particles. Alternatively, the waste may pass through one or more trommel screens after the drum for sieving. Dosing units store mixed waste to even out fluctuations in the content and volume of MSW going to the digester. They can also be used for heating and inoculating the digester feed. Heat may be added as steam, which can be produced using waste heat from engine generators. Some systems have a separate feed mixer which combines the sorted MSW with digester paste in order to inoculate the new feed and bring it to the appropriate MC.

In Bassano, Italy, a Valorga digester accepts source-separated waste and grey waste [1]. As can be seen from the diagram below, even source-separated waste passes through a primary sieve and a magnetic metals removal unit. The grey waste which is the inorganic fraction of the source-separated waste consists primarily of inorganic materials. (In fact, organics make up only 10-16 percent of this material, and paper makes up an additional 34-50 percent.) The grey waste passes through an additional drum screen and densimetric separator which suspends the waste in water, removing the floating layer as well as the heavy particles that sink to the bottom.



SS-OFMSW --> bags broken --> mechanical separation (first pass) --> magnetic separation --> size reduction to 10mm --> digester

Grey MSW --> bags broken --> mechanical separation (first pass) --> magnetic separation --> size reduction --> drum screen --> densimetric separation --> digester

Figure 03-03 2: Bassano, Italy pre-processing diagram. Adapted from [1]

The Treviso wastewater treatment facility found its anaerobic digesters to be too large for processing waste activated sludge (WAS) only, so they built a separation unit to remove the organic fraction of MSW for co-digestion with the sludge [2].

As can be seen in Figure 03-03 2, the waste passes through a shredder and magnetic separator, then a second shredder and trommels, and finally a density separator. The emerging waste is 96 percent organics and paper as compared with 76 percent for the incoming waste and 24% of the incoming organic and paper materials are lost during the sorting process. Metals are reduced by 100 percent, plastics are reduced by 93 percent, and glass is reduced by 98 percent.

03-03-02 Properties and collection of manure and droppings

Animal manure and slurries from cattle and pig production are the basic feedstock for most agricultural biogas plants in Europe. The type of equipment and procedures used to collect and handle manure depends primarily upon the consistency or “thickness” of the manure. The term “solids content” or “percent solids” is often used to describe this characteristic in manure.

Different species of livestock excrete manure with different percent solids (http://www.extension.org/pages/31732/farm-energy-anaerobic-digestion-and-biogas).

The percent solids of manure excreted by swine, beef and dairy falls within a rather narrow range (10 to 13 percent solids), while poultry manure is excreted at a considerably higher solids content. The solids content of excreted manure is often changed by such processes as adding bedding, drying manure on a lot surface, adding wash-water or dewatering the manure by solids separation.

Solid manure is typically generated in systems where bedding is added to manure to absorb moisture and enhance environmental conditions in the production area. Solid manure can also result from drying conditions such as occur on the surface of a beef feedlot. Solid manure is usually collected using scrapers, box scrapers, blades, front-end or skid-steer loaders or similar devices. Equipment sizes range from small blades suitable for tractors of 50 hp or less to large bucket loaders mounted on dedicated power units for operations generating large volumes of manure.

Slurry manure is typically generated in systems where little or no bedding is added to the excreted manure/urine. Slurry manure is typically between 5% and 15% solids. It is "thicker" than liquid manure, but cannot be stacked or handled the same way as solid manure. The simplest manure collection arrangement for slurry manure is the slotted or perforated floor over a manure collection tank. In this scenario excreted manure simply falls through openings in the floor on which the animals stand and collects in a tank.

Slurry manure can also be collected using scrapers. In this case the manure is usually confined in an alley (dairy free-stall barn) or gutter under slats (swine confinement building). A scraper moves along the length of the alley or gutter and deposits the slurry manure in a reception pit or tank at the end.

Another type of slurry manure collection device utilizes a vacuum to “suck” slurry manure from a concrete surface and deposit it into a tank. This approach eliminates the need to pump the slurry manure into a tank or wagon.

Slurry manure has fluid properties that allow it to be moved by pumps that are specially designed to handle thick fluids containing solids and stringy material. Slurry manure pumps are designed with open-type impellers and usually have cutting or chopping devices at the inlet to the impeller to minimize plugging problems. Low-pressure/high volume slurry pumps are used to fill tank-wagons and move manure in other applications where higher pressures are not required. High-pressure slurry pumps are used to move manure through long pipelines and provide the needed pressure for land application in crop fields.

Liquid manure containing 5 percent solids or less generally results from the addition of wash-water or rainwater to manure. Examples of liquid manure sources include lagoons, holding ponds and dairy parlour wash-water.

A typical example of a collection system resulting in liquid manure is the flush removal of manure from a dairy free-stall barn. In this scenario dilute lagoon wastewater is pumped into flush tanks which in turn release the water into free-stall alleys to wash the manure to the lagoon. Another form of dilute or liquid manure is runoff from lot surfaces. In these cases, most of the manure solids remain on the lot, or are removed by solids separation devices prior to a lagoon or holding pond that receives the runoff. The runoff then contains primarily fine suspended or dissolved solids that result in dilute liquid in the receiving basin.

03-03-03: Properties and handling of sewage and industrial sludge

Anaerobic reactors have been used mainly for industrial wastewater treatment. Researches have shown that anaerobic systems such as the Upflow Anaerobic Sludge Blanket (UASB), the Anaerobic Sequencing Batch Reactor (AnSBR) and the Anaerobic filter (AN) can successfully treat high-strength industrial wastewater as well as low-strength synthetic wastewater. Application of anaerobic systems for municipal sewage treatment is so far very limited. The predominant reason given for is, that municipal sewage are to weak (to low BOD or COD) to maintain high biomass (in the form of granules – suspended solids or fixed film) content in reactor.

There are, however, some successful examples in pilot and full scale.

- Orozco [3] investigated a full scale anaerobic baffled reactor (AnBR) to treat municipal sewage of an average BOD of 314 mgO_2/l for a hydraulic retention time of 10.3 hours, (organic loading rate 0.85 $kg/m_3 \cdot d$) and achieved a 70% removal efficiency. It has to be stressed that the process was run at very low temperature between 13 and 15 °C.
- Treatment of domestic wastewater in a UASB and two anaerobic hybrid (AnH) reactors was conducted by Elmitwalli et al. [3] at a temperature of 13°C. For pre-settled wastewater treatment, the AnH reactors removed 64 % of total COD, which was higher than the removal in the UASB reactors.

The majority of anaerobic digestion plants are operated under mesophilic conditions (approx. 35°C), however, most wastewaters are released for treatment at temperatures below 18°C.

Therefore wastewater is commonly heated prior to treatment, thus consuming up to 30 % of the energy produced. The main objective is to decrease the cost of sewage treatment and minimize the amount of excess sludge produced. There is, however, another important aspect which can make application of anaerobic treatment as the first step of municipal or industrial treatment attractive. It was many times proven that many difficult (refractory) biodegradable organic compounds can be decomposed (at least to simpler substances) under anaerobic conditions.

A drop in temperature is accompanied with a change of the physical and chemical properties of the wastewater, which can considerably affect design and operation of the treatment system. For instance, the solubility of gaseous compounds increases as the temperature decreases below 20 °C. This implies that the dissolved concentrations of methane, hydrogen sulphide and hydrogen will be higher in the effluent of reactors operated at low temperatures than those from reactors operated at high temperatures. The high increase of solubility of CO_2 indicates that a slightly lower reactor pH might prevail under psychrophilic conditions.

Anaerobic treatment of domestic wastewater can also be very interesting and cost-effective in countries were the priority in discharge control is removal of organic pollutants.

03-03-04: Adapting the substrate to the process

In this section a review is made based on [4].

In principle, all organic materials can ferment or be digested. However, only homogenous and liquid substrates can be considered for simple biogas plants. Waste and wastewater from food-processing industries are only suitable for simple plants if they are homogenous and in liquid form. The maximum of gas-production from a given amount of raw material depends on the type of substrate.

The material added to a biogas process is substrate (food) for the microbes and its properties have a major influence on process stability and efficiency. Substrate composition is important both for the amount of gas formed and the quality of the gas. The composition ultimately also affects the quality of the digestion residue (digestate), both in terms of plant nutrient content and potential contamination (metals, organic compounds, disease-causing organisms, etc). Choosing the right material gives you the opportunity to influence the outcome of the process, maximise energy output and produce a biofertilizer of good quality.

03-03-04a Suitable substrates for biogas production

Many different types of organic material can potentially be used for biogas production, probably many more than those used today. The main source of organic material for biogas production in several countries today is sludge from municipal wastewater treatment plants. Other common substrates for biogas production in co-digestion plants include slaughterhouse waste, waste from the food and feed industries, source-sorted food waste and manure.

Examples of other materials which are also treated in these facilities include waste from grease traps, fryer fat, wastes from the dairy and pharmaceutical industries, grass silage, and distillation waste (residues from ethanol production). In the future, different (energy) crops and waste from the agricultural sector are also likely to become important substrates for biogas production.

Less common materials that are currently being evaluated for biogas production include algae, grass, feathers and woody biomass (e.g. willow). Total biogas production in Sweden today corresponds to an energy output of about 1.3 TWh/year (in Europe ~98 TWh), but the theoretical potential energy production from domestic wastes, excluding forest waste, is considered to be around 15 TWh/year [5], [6].

Figure 03-03 3: The proportion of biogas production from different substrates at the Swedish co-digestion plants (sewage sludge not included) [5]

Choosing a substrate for a biogas process

Many different organic materials can be decomposed to biogas in a digestion chamber. Some materials are more appropriate than others, and some general guidelines can be applied.

However, process parameters such as load, temperature and retention time have a great influence on how efficiently a given substrate is broken down.

The function of a particular material in a biogas process may also depend on what pre-treatment is applied and whether it is the sole substrate or if it is co-digested with other materials. The presence of toxic substances or lignin, which is not at all broken down in a biogas process, also plays a role.

03-03-04b The importance of substrates for microorganisms and gas production

The composition of a substrate is very important for the microorganisms in the biogas process and thus also for process stability and gas production. The substrate must meet the nutritional requirements of the microorganisms, in terms of energy sources and various components needed to build new cells. The substrate also needs to include various components needed for the activity of microbial enzyme systems, such as trace elements and vitamins. In the case of decomposition of organic material in a biogas process, the ratio of carbon to nitrogen (C/N ratio) is also considered to be of great importance (Table 03-03 1).

It is important that the ratio is not too low, in other words, that there is not too much nitrogen relative to carbon. If so, the process can easily suffer from ammonia inhibition. The ratio should also not be too high, since the bacteria in the process may then experience nitrogen deficiency. It is hard to say exactly what ratio is optimal because it varies with different substrates and also with the process conditions.

Material	C/N-ratio
Cattle manure, liquid	6 – 20
Chicken manure	3 – 10
Swine manure, liquid	5
Straw	50 – 150
Grass	12 – 26
Potatoes	35 – 60
Sugar beet/beet foliage	35 – 46 / 14
Cereals	16 – 40
Fruits and vegetables	7 – 35
Mixed food waste	15 – 32
Slaughterhouse waste, soft tissue	4
Slaughterhouse waste, guts	22 – 37
Food waste	3 – 17
Distillery waste	8

Table 03-03 1: C/N ratio of some materials that can be used as a substrate for biogas production. The ratio can vary slightly depending on the origin/culture of a given material [4]

It is also preferable to use a substrate that is not too diluted, that is, contains too much water in relation to the amount of organic substrate. If the material is too dilute, and contains too little organic matter, the risk is that microorganisms are washed out in a continuous process. This is because their growth rate is low. The preferred water content depends on the type of process used. A highly diluted material can be treated by various techniques to retain the microorganisms, for example, using a carrier material or adding back biomass.

A good outline for a continuous process, which is generally used for more solid waste, is a dry solids value (DS) of 7-10%. The dry solids content of the sludge that is digested in sewage treatment plants is usually somewhat lower, around 4-6%.

Another factor of importance is the bioavailability of the substrate to the organisms. Chopping up the material increases its availability to microorganisms, which can speed up the gas formation process and provide a higher yield.

The bio-degradation is estimated starting from the production of methane biogas obtained during the tests compared to the theoretical maximum production. The protocol is based to the measure of the production of methane by a closed engine in which are put in contact a known quantity of the sample to test and a known quantity of anaerobic micro-organisms, the latter being placed under favourable conditions for the degradation of the sample.

In the table below (03-03 2) you will find the potential of methane production for some agricultural wastes in m^3 of methane per metric ton of raw material.

Matter	Methane potential (*m*^{3}*/tonne*)
Liquid bovine manure	20
Contents of paunch	30
Bovine manure	40
Potato pulps	50
Brewery waste	75
Shearing of lawn	125
Corn residues	150
Lubricate from slaughter-house	180
Molasses	230
Used grease	250
Cereal waste	300

Table 03-03 2: Methane potential of some (mainly) agricultural wastes

03-03-04c Influence of different substrate components on the process

Different components in the substrate can provide varying amounts of gas because of differences in energy content. The components can also influence the process in other ways. Some general information is given below on anaerobic digestion of materials with a high content of protein, carbohydrate or fat.

Protein-rich materials

Many organic wastes contain proteins, which, just like fat, are rich in energy and produce a relatively high amount of methane in the biogas. Examples of materials that are rich in protein are slaughterhouse waste, swine and chicken manure and stillage waste from the ethanol industry. Other materials such as food waste also contain proteins, but in smaller quantities.

Proteins consist of long chains of amino acids. There are 20 different amino acids in proteins, and the composition of the chains varies. Common to all amino acids is that they have amine groups ($-NH_2$). In a biogas process, proteins are first converted to individual amino acids or peptides (short chains of amino acids) during hydrolysis.

In the next step, fermentation, the amino acids are broken down and amine groups are released as ammonia (NH_3) or ammonium (NH_4^+). Ammonia and ammonium are in equilibrium with each other. Which of these dominates depends strongly on the prevailing pH and temperature. At high concentrations, ammonia (not ammonium) can kill many organisms. In the biogas process, methane-producing microorganisms are the first to become inhibited when the concentration of ammonia begins to increase. This inhibition results in process instability.

Carbohydrate-rich materials
Carbohydrates are a common name for various sugars, including simple sugars such as glucose, disaccharides (two sugar units joined together such as in sugar cane), or chains of sugars (polysaccharides). The group of polysaccharides includes cellulose, hemicellulose, starch and glycogen. Plant-derived materials are typical carbohydrate-rich substrates.

Since carbohydrates are, between themselves, very different in their nature, they are digested at different rates in the biogas process. Simple sugars and disaccharides are broken down easily and very quickly. This may seem good, but it can lead to instability problems due to increasing contents of fatty acids.

Hydrolysis and fermentation occur very rapidly for substrates containing high contents of the sugars just mentioned. However, methane producing microbes are slow-growing and this becomes a process bottleneck because they are important to drive the degradation of fatty acids. The background is that the methane producers cannot force the degradation of the fatty acids at the rate at which they are formed, which causes these acids to accumulate. Because of the accumulation of fatty acids, and because carbohydrate-rich materials tend to have poor buffering capacity, there is a risk of process problems due to decreasing alkalinity.

Materials with high sugar content should be mixed with another material containing less digestible compounds and preferably more nitrogen in order to achieve a balanced process. This is to ensure that the initial stages of the process are not too fast. An alternative is to use a two-step process, where the acid formation and methane formation steps are separated. Examples of materials that are rich in rapidly degradable sugar compounds include pure sugar solutions, fruits, potatoes and sugar beets.

Polysaccharides are composed of various sugars, and they are also degraded at very different rates in a biogas process. Starch is the commonest polysaccharide in major dietary items such as potatoes, rice and pasta. It consists of straight or branched chains of glucose and is digested relatively easily in the biogas process. Too much material which is rich in starch can lead to similar problems as with simple sugars, that is to say that the process goes "sour".

Cellulose is the most common organic compound on earth, and therefore represents a large potential for biogas production. However, it is much more difficult to degrade. Cellulose is an important component in the cell walls of plants and consists of long chains of the sugar glucose. In the cell wall, a number of parallel chains of cellulose bind to each other to form microfibrils. Because of this complex structure, cellulose is not soluble and therefore difficult to digest.

Lignin, which is an aromatic compound with a very complex structure, does not decompose at all in the biogas process. Hemicellulose is composed of several different sugars, not only glucose, and the exact composition varies depending on its origin (i.e. different plants have different hemicelluloses). Hemicellulose also consists of branched polysaccharides, which reduces its degradability. Because of the complex structures of cellulose and hemicellulose, and the fact that they also are bound to each other, hydrolysis is the step that slows the rate of degradation of plant material. The enzymes secreted by the hydrolysing microorganisms have difficulty "accessing" the structure, and the hydrolysis step is therefore slow.

In the case of cellulose-rich materials such as straw or silage, pre-treatment determines the rate of hydrolysis, and thus by extension, the rate of production of gas. Accessibility and digestibility can be improved by disrupting the material. The smaller the particle size, the better the accessibility. Chemical pre-treatment, which breaks up the crystalline structure of cellulose, can increase the rate of degradation and provide a higher yield. However, the microorganisms in the biogas process are themselves able to degrade cellulose, given enough time.

Fatty materials
Typical fatty materials that are currently used in biogas processes are slaughterhouse waste, grease trap waste, waste from the dairy industry and various oils, such as fryer oils. Like protein-rich material, fat is very energy-rich and can produce a lot of gas with a high content of methane.

However, fat may also cause problems with process instability.

Fats consist mainly of fatty acids and glycerol, and vary with respect to the composition of the fatty acids. They are usually classified as either saturated, monounsaturated or polyunsaturated fats. Saturated fat is found in meat and dairy products, polyunsaturated fats, for example, are found in fish and corn oil, and monounsaturated fats are found in vegetable oils and in nuts. Saturated fat has a higher melting point than unsaturated fat, making it less available for biodegradation. Pre-treatment with heat may increase the digestibility of these fats.

Triglycerides (neutral fats) are the commonest type of fat. They are readily hydrolyzed in a biogas reactor into long chain fatty acids (LCFA) and glycerol. Glycerol is rapidly converted into biogas while the degradation of LCFA is more complicated. A further complication is the fact that several LCFA’s at high concentrations have an inhibitory effect on many different organism groups in the biogas process, including the methane producers.

Another aspect is that the long chain fatty acids have surface-active properties and therefore readily form foam if concentrations become too high. A survey recently carried out at 13 co-digestion plants showed a clear link between the percentage of fat in the input material and the frequency of foaming [7]. It was also common for slaughterhouse waste or grease-trap waste to foam in both the tanker truck delivering the material to the plant and the substrate mixing tank. The problem was greatest in the summer months when temperatures were relatively high.

The reason for this is that the hydrolysis of fat started before it went into the digester, and this process was accelerated when the temperature was high. During hydrolysis, LCFA’s were released, resulting in foaming. When this material was added, the reactor became overloaded with high concentrations of fatty acids, which also caused foaming problems.

If fatty acids are released slowly during the digestion of fats in the actual biogas process, and if excessive concentrations are not reached, there is less risk of instability than if the process is instantaneously loaded with high contents of LCFA's.

Difference in compositions between substrates will hence provide significant differences in their methane potential, as demonstrated by the following table where a few industrial wastes are listed:

Type of waste	**Composition of org. material** *(OM: Other organic matter)*	**Organic cont.** *(% by weight)*	**Methane yield** (*m^3/tonne*)
Stomach & intestines	Carbohydrates, proteins, lipids	15 – 20	40 – 60
Flotation sludge[1]	65-70 % proteins, rest lipids	13 – 18	80 – 130
Bentonite-bound oil	70-75 % lipids, rest OM.	40 – 45	350 – 450
Fish-oil sludge	50-50 % lipids and OM.	80 – 85	450 – 600
Org. househ. waste[2]	Carbohydrates, proteins, lipids	20 – 30	150 – 240
Whey	75-80 % lactose, rest proteins	7 – 10	40 – 55
Whey (*concentrated)*	75-80 % lactose, rest proteins	18 – 22	100 – 130
Size water	70 % proteins, rest lipids	10 – 15	70 – 100
Marmelade	90 % sugar, fruit acids	50	300
Soya oil/Margarine	90 % vegetable oil	90	800 – 1000
Methylated spirits[3]	Alcohol	40	240
Sewage sludge	Carbohydrates, lipids, proteins	3 – 4	17 – 22
Sewage sludge (*conc*)	Carbohydrates, lipids, proteins	15 – 20	85 - 100

[1] De-watered
[2] Source-separated
[3] 40 % alcohol

Table 03-03 3: Methane potential of some (mainly) industrial and societal wastes

03-03-05 Biogas policies in European Union [8]

The biogas sector has never before aroused so much attention as it does today. Elected officers and investors' interest has been fired by the gradual introduction of regulatory restrictions on the treatment of organic waste and the renewable energy commitments recently made by the European Union member states.

The biogas sector is gradually deserting its core activities of waste cleanup and treatment and getting involved in energy production, with so much enthusiasm that in some countries its scope of action has extended to using energy crops. Across the European Union, the sector's progress is as clear as daylight, as in 2009, primary energy growth leapt by a further 4.3%.

Biogas production has the advantage of reconciling two European Union policies. Firstly it falls in line with the main objective of the Renewable Energy Directive (2009/28/CE) that is aiming for a 20% renewable energy share in gross final energy consumption by 2020. It also meets the European organic waste management objectives enshrined in European regulations (Directive 1999/31/CE on the landfill of waste) that require Member States to reduce the amount of biodegradable waste disposed of in landfills and to implement laws encouraging waste recycling and recovery (Directive 2008/98/EC on waste). Methanization is considered to be the best environmental waste energy recovery method.

These policies have prompted a number of Member States to encourage biogas production and they have set up incentive systems for paying for electricity (feed-in tariffs, green certificates, tenders). In a number of countries, the biogas market is stimulated by additional payments for the use of energy crops. They aim to spur on the increase in renewable energy production, while the policy also enables farm holdings to reduce their energy dependency and diversify their incomes in the event of falling cereal, milk or meat prices. Other countries are dubious about the environmental soundness of using energy crops such as maize for methanization, preferring to convert already existing waste feedstock. The use of maize as a biogas feedstock is particularly controversial because of the crop's high water footprint and demand for inputs, and the same argument applies to its use as a bio-fuel feedstock.

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