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03-04: Odd biomass fractions – Supply chains

Considering the collection systems for refuse fractions, and limiting the discussion only to the clean fractions mentioned in chapter 02-04, office and other paper waste should preferably be treated separately since it may form the basis for recycle paper production as well as it may constitute a clean fuel fraction, household waste should be treated separately and clean stem-wood waste should be kept separate to maintain the qualities possessed by this fraction.

In large office buildings or office blocks, the organisation of separate paper bins and the separate collection of office paper waste may well be organized in a cost-effective way so that the waste can be treated properly. Household waste fractions paper and dry paper packaging may be included in the same collection, provided dedicated vehicles are available and that the system is planned for it.

At construction sites as well as in industrial areas, again the sorting and collection of wood-waste can be organized in a cost-effective way providing a clean fuel fraction at a competitive cost. Household wood-waste is typically only a small fraction and requires no special attention unless impregnated material is frequent.

Both above fractions are dry, they can be stored without significant problems or risks and the waste generation is basically local and can be identified.

Digestible and fermentable industrial waste fractions do pose a problem since they are – per definition – rapidly decaying substances that have to have a short cycling time from where they are first created to where they are finally treated. Hence, a supply chain for these fractions must be designed for the special situation and for the special locale where it shall be applied. You may want to refer back to the biochemical treatment discussed in text section 03-00-04 and more specifically to table 03-00 2 on this. General aspects on the specific problems caused by digestible fractions are also discussed in 03-03-00. The major amounts of domestic sector biodegradables are food scrapings from restaurants, hospitals and alike together with park and garden wastes. For large producers – such as restaurants – a separate collection system is the most viable while, for park and garden wastes, the most common is to have separate collection stations.

The fraction causing the main problem is the household waste. However, some general comments may be made for this fraction.

03-04-01: Aspects on household waste collection

Obviously, the system to collect household waste must be depending on the nature of the households.

03-04-01a: Apartment houses – full service

In apartment houses, city centres as well as densely populated residential areas, the full service system should be preferred. With a full service system, a common waste collection bag or container is made available to the tenants on the ground floor. The deposit of waste into the central container may be by a refuse chute or that the individual waste bag must be brought down and manually be put into the container.

The waste collection room should also be equipped with small containers for paper, glass, metal and/or other fractions. The fundamental idea with the full service collection is that the individual tenant shall not have to leave the building but can get rid of all their refuse at one place inside the house, regardless of the subsequent process.

The waste containers are emptied on a regular basis and a simple visual control that fractions are duly separated can be done in the individual building. Hence, information feedback to the tenants can easily be organized within this system and the separation efficiency can be maintained at a high level. The company/organization responsible for collection and transport will finally have the full responsibility to keep the different fractions separated for further transport.

03-04-01b: Free-standing houses – kerbside service

With single-family free-standing houses, terrace houses or semidetached houses, the situation becomes different and individual waste bins to be placed by the roadside on collection day become the most attractive alternative. In this case different waste bins may be dedicated to different fractions, often separated by a colour code, but the driver of the collection vehicle will not be able to see what is actually in the bin and the separation actually obtained is often inferior to what can be achieved by a full service system.

For a system like this to work properly, it is crucial that household confidence is high and it simply may not happen that a bin of a certain colour is ever seen to be collected in the wrong vehicle.

03-04-01c: Bring system

With a bring system, the households are required to bring the waste to collection stations and to put the separate waste fractions each into its own container. Since this requires that the households not only separate the fractions at home but also pack them so as to make the transport to the collection station comfortable, it tends to give as a result that any waste fraction that might be wet or cause bad smell indoors is wrapped in plastic bags and that a plastic fraction is hence present in all the different waste fractions.

In apartment houses – where space for storing the household waste for a period of time may be an issue – this type of systems tend to counteract waste fractioning. A common reaction by the tenant is to strive for a minimization of the amount of waste stored in the apartment and to carry only one bag at a time to the collection station. Hence the garbage bag is filled to the rim and the priority to minimize carrying tends to take over the priority to keep fractions separate.

03-04-01d: Vehicles for different system solutions

Depending on the number of fractions to be collected there are a great number of different vehicles available for the collection, two of which are the most common in cities.

For **full-service systems** the rear-loading and compressing truck is the most common. One main advantage by the rear-loading truck is that it works also in narrow inner-city areas and that the operational space required is limited. Another advantage is that the most common rear-loaders can handle also loose material. Rear-loaders with two parallel compartments are available, but most common are the ones with only one compartment. Thus, logistics may have to be organized so that several trucks are in operation, each handling only one or two fractions.

A major drawback with full-service systems is that the transport from the waste collection room to the truck typically requires manual transport and hence the truck must carry a workforce of, typically, 2-3 workers. Assuming one driver and two assistant workers, two buildings may be served at the same time while – in case of a heavy container or bag – both workers may in some cases be needed simultaneously. The manual hauling from collection room to truck is not only labour intensive but also time consuming.

Therefore, full-service systems tend to be expensive but at the same time they may provide a good fractioning.

With **kerbside systems**, side-loading trucks are dominant competing with rear-loading. With standardized household waste bins, the emptying into the side loader can be automatized so that the whole operation can be performed only with one driver in the truck. However, cheap as it is, the side-loading truck is unsuitable for narrow streets or city centres. Another problem with automatized side-loaders is that loose material cannot be handled.

With colour-coded bins or bags, or with separate collection days for different fractions, a high degree of fractioning can also be achieved.

Colour-coded bags can be collected in one operation and then be automatically separated at the plant using robots. Such systems are already in place and tend to work well though recent studies seem to indicate that transparent bags with coloured polka-dots on them tend to improve the precision of the separation as compared to non-transparent bags with a solid colour. The results are only preliminary but it is believed that the citizens become more precise in their sorting efforts if the garbage is visible inside the tied-up bag than if it is hidden inside a non-transparent bag. Colour coding can just as well be combined with full-service systems provided the bags are robust enough to survive the chute.

To maintain the participation of the citizens, the colour-coded bags must either be delivered to the door in connection with the collection or they must be easily and freely available close to the living areas.

With **bring systems** for collection, the most common is to use either container-carrying trucks or open trucks to which the collection containers are emptied. In the latter case, it is obvious that paper, plastic and other lightweight material well suited for compaction to economize transport cannot be handled while heavier fractions and materials that shall not be compacted such as glass or metal for recycling are often handled this way. However, the system as such allows certain flexibility depending on the containers and the number of fractions can easily be extended, provided space is available.

Depending on the maintenance of the containers and the trucks, the container handling may cause technical problems. Thus, this type of systems require a thorough planning and also tend to require a higher maintenance cost than the other ones – though the handling is potentially very smooth and efficient if only the equipment is well maintained.

However: Bring systems are not well suited for organic waste and – as pointed out above – tend to "produce" less well-defined fractions than the other systems. For storage-insensitive fractions, though, like glass, paper and metal, they work well and are widespread.

03-04-02: What is best?

The individual household does not want to keep wet residual waste indoors for any prolonged period of time. Hence, for comfort reasons, the individual would want to dump this waste either in the chute (full service) or in an outdoor waste bin (kerbside collection) as soon as possible. These are also the preferred and most common systems to collect mixed household refuse and wet organic materials. Several different questionnaires tend to show the same tendency, namely that these are the methods preferred by the households.

However, the attitude towards dry waste fractions that are insensitive to storage is quite different. Such waste fractions – glass, paper, metals and plastics – may well be accepted to be stored in the individual households for a period of time and then brought to collection stations, provided space is available in the house or apartment. For paper waste – which is a large fraction of total household waste and hence may become a nuisance to carry to a collection station – full service and kerbside are both common systems in parallel to bring systems. Glass, metals and plastics, though, are most commonly collected using containers to which the material must be brought by the individual citizen (bring systems).

There is a successively increasing awareness among individuals and households that waste recycling and re-use is of crucial importance to the sustainability of modern society and in most western and European countries, the households are willing to take part of this responsibility.

There is also a trade-off and the households may accept the responsibility and extra work associated with waste fractioning only if they are convinced that the municipality and the subsequent handling and treatment actually takes full advantage of the separation done. Hence feedback to the citizens is crucial and it is essential that the infrastructure and the logistics work properly so that no mistakes occur.

Given this, the most common system solutions are either full-service or kerbside collection of combustible residual as well as organic waste fractions and bring systems for paper, plastic, metal and glass fractions. In case a full-service system is established, paper and plastic fractions are often incorporated in this while glass and metal fractions are most often handled by a bring system.

03-04-03: Handling alternatives

The above text and the systems outlined all serve one and only one purpose, namely to produce the cleanest possible fuel fraction at the lowest possible cost. However, since no guarantees can ever be provided, the composition of the fraction finally delivered will always be variable. Therefore, and to be able to recover the energy from the variable fuel quality at an environmentally acceptable level, the so-called "waste incineration directive" (2000/76/EC) and a number of other federal laws are in effect in this area. Some of the most prominent laws (all accessible online at http://www.eur-lex.europa.eu) are the waste framework directive 75/442/EEC from 1975, the hazardous waste directive 91/689/EEC and the waste shipment directive (EEC) 259/93, all with their later additions and amendments.

Article 10 in the waste incineration directive specifies in some detail not only the measurements to be performed at plants using waste fraction as a fuel but there are also certain design requirements with respect to the gas residence time and the combustion temperature. Altogether, these requirements make waste-fired energy plants expensive not only to build but also to operate and it is sometimes advantageous to co-ordinate the waste handling systems for a region or a number of municipalities rather than to build incineration plants in every community. In such cases, waste may be hauled long distances between regions, between states or even internationally. However – though the waste itself may be treated elsewhere – the ultimate responsibility for the treatment still remains with the company, organization or authority that originally collected it. It will be up to the authority originally holding the waste fraction to set up and negotiate the contracts for the final handling and it will also be up to the original authority to follow up these contracts.

Looking now specifically at the two main fractions that may be "produced" through a proper infrastructure (text sections 03-04-01a--d) they are:

- A clean, reasonably dry, biomass-rich combustible fraction suitable for use in CHP plants (04-00-08e), for co-combustion (04-00-08m) in coal-fired plants or in industrial processes.
- A clean organic fraction suitable for composting, for anaerobic digestion (04-00-07) or for fermentation (04-00-06), usually in combination with other substrates.

It was pointed out in chapter 01-04-00 that fuel fractions originating from waste sometimes may have unacceptably high contents of chlorine, other halogens, sulphur and heavy metals. Of special importance in the case of combustion in CHP-applications or any other processes involving electricity production are the corrosive compounds formed from chlorine and sulphur. Other important compounds in the flue gases from combustion include molten and corrosive ashes.

The sensitive parts in the plant are, primarily, the steam superheater surfaces, exposed as they are to high internal steam pressures, to high temperatures and, on the outside, to corrosive flue gas components. The corrosive properties of the gas will thus set an upper limit to the steam temperature and –pressure attainable and with waste derived fuels this limit may sometimes be as low as 400 °C and about 80 bar, comparable with the data in nuclear power plants and far below those attained in any modern coal- or biomass-fired plants, not to mention those achieved in gas-firing.

The steam pressure and the steam temperature prior to the turbine (you may want to refer back to 04-00-08f) are the two parameters of highest importance with respect to the total electricity efficiency.

As can be understood from the previous paragraphs, the quality control with respect to fuel fraction analysis is of utmost important in case of waste streams for energy.

03-04-04: Planning aspects

An individual community is often too small to host a waste-fuelled CHP-plant, simply because the specific cost for RDF or SRF combustion is higher than for clean biofuels.

Hence, planning for energy-from-waste must most often be based on a regional perspective and the systems for waste collection and separation, as well as the technologies used for the collection and transport, need be co-ordinated between municipalities.