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PSA Projects Centralised organic matter processing (COMP)

SYNOPSIS Centralised Organic Matter Processing uses biological processes to de-pollute organic wastes and produce marketable products. Organic matter, including sewage sludge, household, industrial and agricultural wastes, are digested and then composted to produce biogas, electricity, heat, compost and liquid fertiliser.

The views expressed in this paper are those of the author and do not necessarily reflect those of PSA Projects Limited.

1 INTRODUCTION

Globally there is a need to conserve finite resources and to protect the environment. As a result the subject of waste disposal is often scrutinised to develop areas where resources may be recycled or used as energy. Most media attention to this subject is directed at the recycling of household wastes. However, in terms of total quantities of organic wastes requiring disposal, sewage sludge and household waste is only a small fraction. The aim of this paper is to outline the organic waste situation and to discuss potential benefits that can be derived from the re-processing of "organic waste products" through Centralised Organic Matter Processing (COMP).

1.1 The Availability Of Organic Wastes

Sources of organic waste include sewage sludge, household kitchen, paper and garden wastes, wood and food wastes from process industries, livestock and crop wastes from agriculture, and food and paper wastes from commercial enterprises.

Before going into the quantities available, two terms may need clarification. The first is "as arising" which refers to the quantity of waste, in its naturally occurring state, i.e. containing a considerable and variable amount of water in the case of organic wastes. The second is "dry matter" (DM) which is the equivalent mass of the waste with no water content, ie. fully dried.

It should also be noted that all reported quantities tabulated are estimates due to the variation in moisture content at the point of measurement. Reported quantities also need interpretation HMSO (1) values, for example, report agricultural wastes to occur in over twice the quantity referred to here. The reason being that all animal waste, including that produced in the field, has been included. The figures presented below refer only to stored quantities of livestock slurry which are intrinsically available for further processing.

All organic waste is a renewable resource and each year roughly two hundred million tonnes, as arising, is disposed of, mostly in an unsustainable manner. Table 1 shows a breakdown of all wastes produced in the United Kingdom (1) and (2).

By comparing the total quantity of available organic wastes with that of more commonly mentioned wastes, the extent of the organic waste problem can be appreciated. For example, the total quantity of household waste produced each year is only twenty one million tonnes as arising, or, only ten percent of the total quantity of organic waste produced per annum. Combined, the organic dry matter content of sewage sludge and household waste accounts for about eleven percent of the total available nationally.

Table 1 United Kingdom Wastes (mt) after (1) and (2)

	Organic Dry Matter	Organic As Arising	Total Occurring
Sewage Sludge	1.2	30	30
Household	3.4	13.4	21
Ind/Commercial	16	53	86
Mineral			238
Demolition			30
Agricultural	23.5	103.6	103
Total (mt)	44	200	508

1.2 Existing Organic Waste Disposal

A large proportion of our water resources are polluted as a result of existing organic waste disposal practices. About thirty percent of fresh water resources and eighty percent of bathing waters fall outside recommended environmental standards (3). See Table 2.

Table 2 Water Pollution in Britain (3)

Environmental Feature	Consequence of Current Practices
Rivers and Canals	33% of 41390km classed as grade A
Tidal Rivers	50% of 2800km classed as good
Estuaries	68% of 2730km classed as good
Bathing Waters	77 of 446 comply with EC standards
Sewage Works	17% of 4427 in breach of consents

The agricultural, sewage and process industries account for about sixty percent of all water pollution incidents in Britain (3). The lack of serious response to such pollution (over twenty three thousand reported incidents each year) can be judged on the evidence that less than one and a half percent of these incidents result in a prosecution (3). This is not to belittle the existing legislative procedures, or to imply negligence on the part of the process operators; but to emphasise the untenability of current waste disposal practices.

Other damaging effects of existing organic waste disposal practices include:

(a) The release of methane, a potent greenhouse gas, from uncontrolled landfill site.

(b) The release of carbon dioxide and smoke from field straw burning.

(c) About three million hectares of arable land having soil low in organic matter and dependant upon chemical fertilisers and pesticides to sustain continuous cereal cropping (4).

(d) A burdensome disposal cost to the waste producer.

(e) A loss of the benefits and value inherently available from organic wastes to society in general.

(f) And of most significance, by the way we deal with our wastes, the reinforcement of the notion that we live outside of any natural ecological system and have no responsibility to ensure the sustainability of our means of production.

2. CENTRALISED ORGANIC MATTER PROCESSING (COMP) - PROCESS DESCRIPTION

2.1 COMP - A Summary Of The Principles

Today with a greater awareness of our need to conserve energy and protect the environment it is more important than ever to recognise the opportunities that exist in areas which have traditionally been considered as problems.

Centralised Organic Matter Processing (COMP) has been developed to solve current organic waste related environmental problems, to exploit opportunities created by recent changes in both the power generation and waste disposal industries, and to address requirements relating to waste in the Environmental Protection Act, 1990. It will also find application throughout the rest of the world wherever population densities are sufficiently high.

COMP relies on integrated waste management on a community scale to realise financial and environmental benefits. The idea is to process organic matter from a collection area to produce energy, nutrients and biomass for re-use. Figure 1 overleaf, shows a typical COMP scheme.

Incoming organic wastes are stored and, if required, shredded/pulverised before mixing the wastes of feedstock. Following mixing the wastes are anaerobically digested to produce biogas (mostly methane) and a stabilised slurry. The biogas is utilised to produce electricity and heat. The slurry is separated into solids and liquid, the solids going on for composting, and the liquid for use as a liquid fertiliser.

The collection area in which organic matter recovery and processing takes place is of vital importance. The area must be large enough to yield suitable and timely quantities of organic matter, together with the required economies of scale in transport and processing, and most importantly the market for product sales. For optimum results in England the collection area should have a radius of about five kilometres

Once established COMP will promote biomass production through both agricultural production and the implementation of functional landscape design (5).

2.2 Sizing And Locating The COMP Scheme

Before the scale and location of the COMP scheme is decided, it is impossible to prepare the operational specification and therefore impossible to design the transportation, handling and processing systems.

The scale or size of the COMP scheme may depend on financial or political factors. In the case of political factors it may be that the area to be served by the COMP scheme is dictated by the area covered by the Waste Disposal Authority or the District Council. However, regardless of the geographical area that may be imposed on the COMP scheme, it is the financial factors that will govern the level of activity within the COMP scheme. The financial factors of most importance are those related to:

(a) The transport system for the recovery of liquid and solid organic wastes.

(b) The central processing plant for the conversion of organic wastes into fuel, energy, compost and fertiliser.

(c) The distribution system for the products identified for sale.

These financial factors can be accurately discerned once the location of the scheme is decided.

Considering the location of the COMP central processing plant, it may be the availability of a site that decides the location, rather than the selection of an ideal location. However, supposing that there is a choice in location then the following factors should be considered in making the choice.

(a) Geography, to reduce the transportation costs the plant should be as near as possible to the centre of the waste catchment area.

(b) Topography, to reduce transportation costs the plant should be, on average, below the level of the majority of waste sources.

(c) Proximity to an existing sewage treatment works to reduce the cost of transporting sewage sludge.

(d) Transportation, road access should be ensured and grade and width considered.

(e) Aesthetics, to make the plant appear less conspicuous screening should be considered, both natural and developed.

2.3 Organic Waste Recovery

In order to carry out an initial feasibility study of a proposed COMP scheme it is necessary to estimate the quantities of organic wastes available for processing. Table 3 shows the results of an analysis (7)(6) of organic waste availability for England and Wales.

Initially the organic matter availability for the COMP scheme may be based on the assumptions in Table 3. However, as the viability study for the scheme progresses, it will be necessary to use local sources of information and site visits to confirm the availability of organic matter supply.

In order that the organic fraction of household refuse and industrial/commercial wastes can be made available to the COMP enterprise the waste will require separation at source. This will require the provision of separate collection containers and an adjustment to the waste collection practices of the existing waste collection concerns. The feasibility of such changes will need to be carefully assessed during the initial stages of the project. The main incentive for such changes will be through the provision of reduced disposal charges, made possible by the elimination of the requirement to landfill the wastes.

A reduction in the waste disposal transportation cost is also probable as the wastes need only to be delivered to the local COMP plant rather than a more distant landfill site or regional incineration plant. Examples of where source separation is successfully employed are the Borough of Milton Keynes and Leeds in England and Dusseldorf, amongst many other cities, in Germany.

Various grades of paper and plastic wastes would remain available for incineration where waste incineration is also planned or in operation. In fact the exclusion of wet organic matter may increase the efficiency of the incineration plant.

Table 3 Organic Matter Recovery Assumptions For England & Wales (6)(7)

Type of Waste	Availability DM	% DM as arising	C/N Ratio	Density
Sewage Sludge	47.4kg DM/person pa	5	6:1	-
Household Refuse Organics (8)(9)	154kg DM/person pa	32	30:1	170kg/m^3
Livestock Slurries (2)	97t DM/rural km^2 pa	20	-	-
cow	36l/day	15	17:1	-
pig	45l/day	2	6:1	-
poultry (1000)	136l/day	27	5:1	-
Crop wastes (2)	79t DM/rural km^2 pa	24	70:1	100kg/m^3
straw	-	31	100:1	-
vegetable	-	14	15:1	-
Process Wastes (10) (food, drink and wood processing)	103t DM/urban km^2 pa	-	250:1	-
Industrial/Commercial (11) (cardboard, paper, wood)	2435t DM/urban km^2 pa	30	150:1	100kg/m^3
Urban Vegetation (12) (civic landscape maintenance)	388t DM/urban km^2 pa	30	100:1	60kg/m^3
Biomass Cropping (11) (from agricultural set aside)	93t DM/rural km^2 pa	30	100:1	60kg/m^3

2.4 Storage And Handling

Storage of organic wastes at the COMP plant will be required so that at all times an appropriate blend of wastes can be produced for anaerobic digestion. Table 4 shows some assumptions for costing storage and handling facilities (11).

The actual storage requirement will be affected by the following:

(a) Overall size of the anaerobic and hence feed rate.

(b) Seasonal factors in the supply of wastes, for example: Autumn for agricultural crop residues, and Winter and Spring for livestock slurries.

Special attention needs to be paid to the prevention of nuisance (smell and vermin) resulting from the storage of organic wastes.

Table 4 COMP Storage And Handling Assumptions (14)

Item of Equipment	£ Cost (est)
Solid Waste Storage	
Silos (with auger)	350/m^3
Clamp (timber or concrete)	30/m^3
Liquid Waste Storage	
Slurry stores (metal)	27/m^3
Tractor Loader	15,000
Conveyors	
Belts (3m, 4t/h)	2,400
Auger (7m, 1.75t/h)	5,500
Mill & Mixer (1,000kg, 4.5kw)	3,850

2.5 COMP Shredding/Pulverising

To facilitate and promote thorough mixing and anaerobic digestion it is essential that the wastes are all reduced to a common size. The smaller the solid matter particle size the greater the efficiency of the anaerobic digestion process. Hence greater biogas production and depollution that can be achieved.

The main difference between shredding and pulverising is that the former cuts or slices the waste material and the latter smashes the material. Pulverising a material exposes a far greater surface area upon which the bacteria, present in the anaerobic digestion vessel, can act. Table 5 gives some typical costs for the shredding/ pulverising process (11).

Table 5 COMP Shredding/Pulverising Assumptions (11)

Process	Feed rate	Capital Cost	Running Cost
Pulverising	14 t/h	£80,000	£3.7/t/h
Shredding	3 t/h	£55,000	£17/t/h
	17 t/h	£100,000	£3.2/t/h

2.6 Anaerobic Digestion And COMP

The advantages of employing anaerobic digestion to process organic wastes are twofold. Firstly the depollution of the waste is achieved, and secondly energy is liberated in the form of biogas. Specifically these advantages include:

(a) Reduction in biological oxygen demand

(b) Destruction of weed seeds and pathogens

(c) Reduction in total solids content.

(d) Reduction and control of odour

(e) Production of biogas

(f) Nutrient content preserved

(g) Nutrient mineralisation and hence availability increased.

The average composition of available organic wastes occurring within a typical COMP scheme area would be that of a wet slurry. Thus a low solids mixed anaerobic digestion system is recommended. Currently several companies manufacture such systems in the United Kingdom (15). The energy and mass balance of a typical COMP system is shown in Figure 2.

2.7 Compost And Liquid Fertiliser Production

Following anaerobic digestion the resultant slurry is separated to produce a solid and liquid. The nutrient balance of which will be the same as the original influent.

The separated solids require stabilisation, and possibly blending with other organic and inorganic materials, to produce a marketable product. This is achieved through a composting (aerobic digestion) process. Similarly the separated liquid will require maturation before becoming available as a marketable liquid fertiliser or plant food. Some liquid may also be recycled to the beginning of the process to produce the required influent solids/liquids ratio, see Figure 2.

3. THE MARKET FOR PRODUCTS DERIVED FROM COMP

3.1 The Market For Electricity

Electricity is produced in the COMP scheme through "Combined Heat and Power" (CHP). Electricity produced through CHP may be sold directly to an Electricity Generation Company. Nationally, if COMP were fully implemented to process all available organic wastes, COMP could supply between five and twelve percent of the national electricity demand (14).

3.2 The Market For Heat

Heat is produced in the process of generating electricity through CHP. The heat will be in the form of water at between seventy and ninety degrees centigrade. In the short term this heat may be wasted in order to save the capital costs needed to utilise the heat. In the longer term a district heating system could be constructed, either supplying a local factory or greenhouses, or domestic dwellings.

Under full implementation of COMP, between five and eight percent of national natural gas consumption could be replaced. The anaerobic digestion process itself requires between twenty and forty five percent of the heat produced through the process of CHP (6).

3.3 The Domestic/Garden Product Market

The domestic/garden product market includes the following product varieties: composts, grow bags, lawn foods, liquid plant foods, manures, peats and soil conditioners. The annual UK market for these garden products is about two hundred and thirty million pounds (17). Compost and peat products take about one hundred million pounds of the market, and represent roughly one million tonne (0.5mt DM).

In order to secure this market, segregation of various organic wastes may be required through the COMP process, see Figure 1. This will guarantee that an end product can be produced free of contamination for example, from sewage sludge.

Considering only the outlets distributing peat and compost (9600 outlets), it is possible to find roughly how many outlets there are in, say, 10 or 50 square kilometres (17). This is useful to know as it may influence the catchment area of the CRWP plant. In fact there are on average 2 outlets per 50km^2.

However, in considering where the CRWP scheme should be located, it is essential to ensure it is near an outlet for compost sales.

3.4 The Agricultural/Horticultural Fertiliser Market

The agricultural/horticultural fertiliser market is dominated by four main product varieties: the nitrogen fertilisers, the phosphate fertilisers, the potash or potassium fertilisers, and the combination fertilisers. These products are presently manufactured from mineral and fossil fuel resources. Chemical fertiliser production currently accounts for about two and a half percent of UK energy consumption (18) or roughly 62 TWh.

Table 6 shows and compares the current consumption of chemical nutrients in UK agriculture, and the nutrients available from organic matter wastes. It can be seen that the agricultural fertilisers demand could be met by fertilisers derived from organic wastes. There are two forms in which organic waste derived fertilisers could be delivered to agriculture, as a compost and as a liquid. In the liquid form delivery could be achieved by tanker or by the setting up of a networked piping system for organic irrigation to agricultural enterprises within the COMP scheme catchment area (20).

4.0 THE VIABILITY OF COMP

4.1 The Financial/Economic Viability Of A Typical COMP Scheme

A typical COMP scheme would cover 80 square kilometres and process approximately 161 thousand tonnes of organic waste annually, with a dry matter content of about 14 thousand tonnes. For such a scheme an estimated financial breakdown is shown in table 7.

Table 6 Agricultural Fertiliser Consumption And Nutrient Availability From Organic Matter Wastes, 1989 (18) (19)

	000 nutrient tonnes					
	Nitrogen, N		Phosphate, P		Potash, K	
	Kt	£m	Kt	£m	Kt	£m
Uk Agriculture	1289	460	358	105	452	72
Organic Wastes	968	344	658	192	643	102

Table 7 Estimated Financial Breakdown Of A Typical COMP Scheme (6)

	£000
Capital Costs	
Anaerobic Digester (800m^3)	3200
Combined Heat & Power Plant (800KW)	240
Shredders, Loaders, Conveyors, Buildings	687
Design & Project Management	500
Contingency	700
	(a) 5327
Running Costs	
Labour	138
Fuel	21
Maintenance	41
	(b) 200
Revenue*	
Credit for receipt of Wastes	810
Electricity	424
Heat	231
Low grade Compost	142
High grade Compost	1168
	(c) 2775
Net Revenue (c) - (b)	**2575**

* Note Revenue from Liquid Organic Fertiliser not included.

Other financial/economic benefits include:

(a) A reduction in the national import expenditure on chemical fertilisers.

(b) The creation of employment opportunities both for running the COMP scheme and within the product marketing sectors.

(c) A reduction in domestic rates as waste disposal quantities and costs reduce.

(d) Farmers participating in a COMP scheme would benefit from cheaper fertilisers, cheaper waste disposal, and the opportunity to capitalise on organic premiums on produce sales.

4.2 The Environmental Benefits Of COMP

Environmental benefits potentially attainable through the implementation of COMP in the UK include:

(a) Up to twelve percent of existing National electricity consumption met and a corresponding saving in fossil fuel resources.

(b) A further two and a half percent saving in National energy consumption used for chemical fertiliser production, and a saving in associated fossil fuels and mineral resources.

(c) With full utilisation of COMP produced heat, up to eight percent of the national natural gas consumption may be replaced.

(d) Environmental improvement to agricultural land as soil organic matter content is built up and nutrient leaching is reduced. Organic agricultural practices may also encourage the reduction in use of chemical pesticides and their environmental impact.

(e) Replacement of all peat products may be achieved which would result in a saving of peat wet lands and their flora and fauna.

(f) Sufficient liquid organic fertiliser for all agricultural irrigation needs and a subsequent reduction in water demand.

(g) The encouragement of growing biomass crops, especially coppicing will help lock up atmospheric carbon dioxide and reduce the effect of carbon dioxide emissions from fossil fuels.

(h) Potentially a total reduction in organic waste related water pollution.

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Figure 1 A Typical COMP Scheme

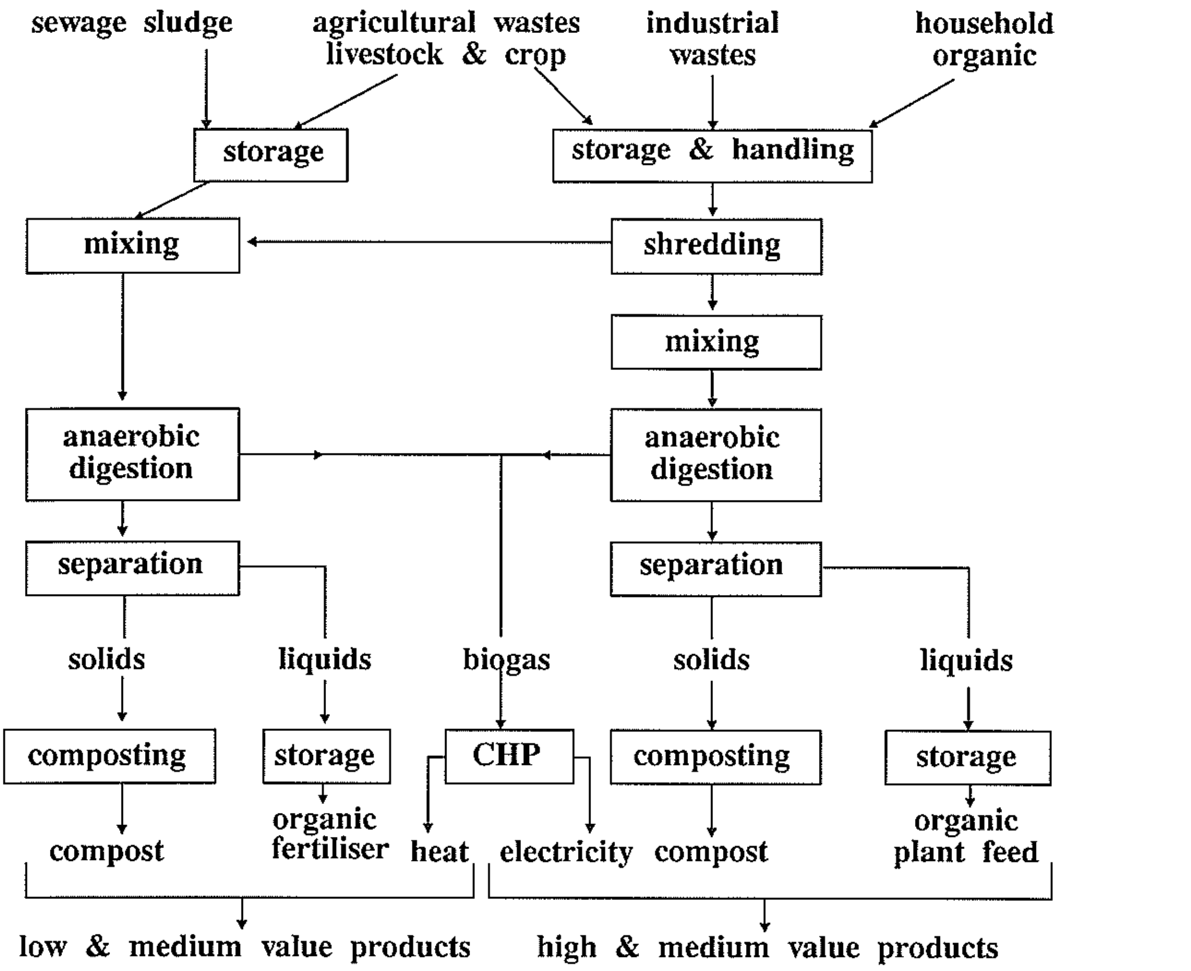

Figure 2 A Typical COMP Energy And Mass Balance, after (14) (15) 16).