ECOGI
Pre-treatment of biomass for anaerobic digestion

Mechanical pretreatment and separation of organic waste from households and industry to obtain a pulp for biogasification

Testplan

J.no.1004

Version 4, Dec 4th 2012

Table of contents

1. Introduction

This test plan is the implementation of a test design developed for verification of the performance of an environmental technology following the ETV method.
The format used for reporting follows guidelines in Ref.6.

1.1. Verification protocol reference

J.no. 1004

1.2. Name and contact of proposer

Proposer

Komtek Miljø af 2012 A/S, Drivervej 8, DK 6670 Holsted
Contact: Bjarne Larsen, phone: +45 7020 54 89, e-mail: Bjarne@komtek.dk

1.3. Name of test body/test responsible

Danish Technological Institute, Verification Centre, Life Science Division, Kongsvang Allé 29, DK-8000, Aarhus, Denmark.
Test responsible: B. Malmgren-Hansen (BMH), phone: +45 72201810, e-mail: bmh@teknologisk.dk.
Internal reviewer: Lotte Bjerrum Friis-Holm (LBFH), phone: +45 72201837, e-mail: lbfh@teknologisk.dk.

2. Test design

The test design is based on 3 repeated test runs of the ECOGI for each of two different kinds of waste in order to evaluate the customer claims concerning the following issues:

- Recovery of organic matter[1] in pulp
- Purity of organic matter in pulp
- Energy consumption per ton waste
- Water consumption per ton waste

The two types of waste are:

1. Organic fraction from household waste Vejle Kommune (waste sorting system).
2. Waste from supermarket (50 %), assorted waste, closer defined by Komtek, when the test is carried out (50 %)

[1] Organic matter is defined as material which can be converted into biogas within a normal period of operation approx. 25-30 days of mesophilic operation and 18-21 days of thermophilic operation . Wood pieces of size >5*5*5 mm are not included as they are not considered digestible within a normal operation period in a biogas plant.

Every test run consists of 3 batch runs. The samples taken under the 3 batches are combined to one test run sample (Figure 1). Three tons waste is processed per batch.

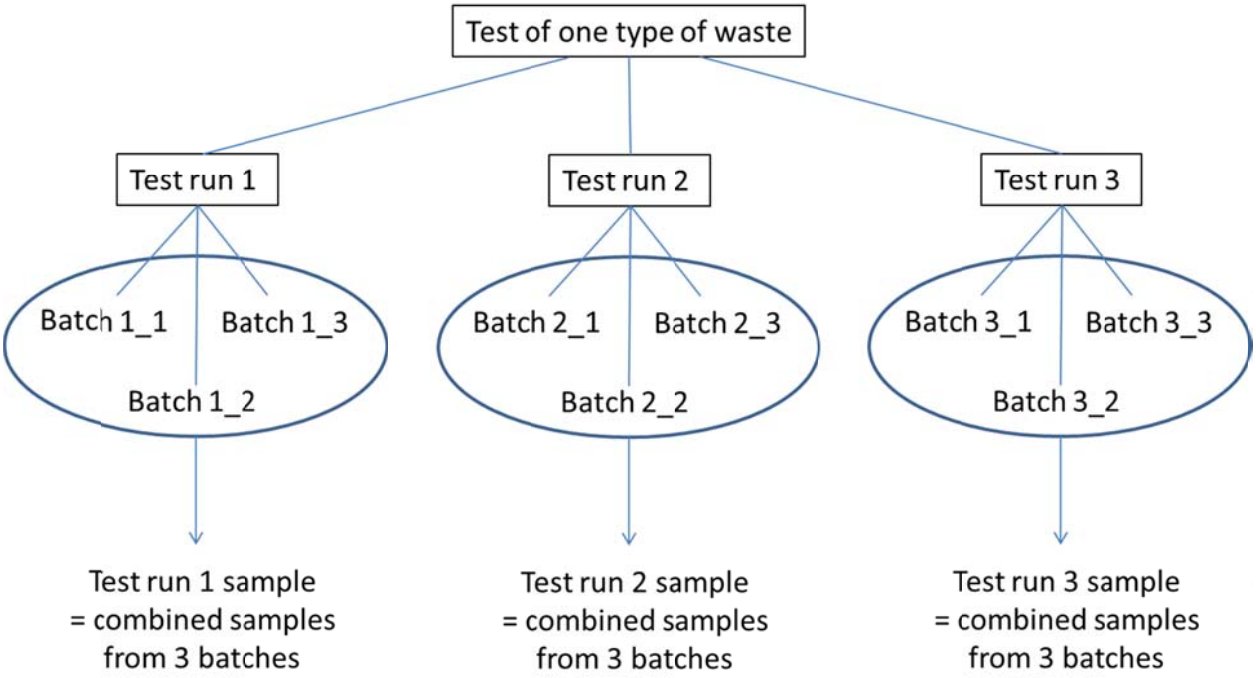

Figure 1: test runs and sampling for the two waste types

Calculation of purity:
Purity of biopulp is calculated as given in appendix 3
Recovery of biopulp:
Recovery of biopulp is calculated as given in appendix 3.

2.1. Test site

The test site is Komtek A/S, Drivervej 8, DK 6670 Holsted

2.1.1. Types of test sites

The site is a plant performing composting operation with a separate treatment of organic waste using the developed ECOGI process.

2.1.2. Addresses

Test site

Komtek A/S, Drivervej 8, DK 6670 Holsted

2.1.3. Descriptions

The ECOGI plant is placed in a separate closed building at Komtek. All equipment in the building including necessary ventilation is run by electrical power which can be logged separately from other facilities at Komtek.

2.2. Tests

2.2.1. Test methods

Measurement of recovery and purity is based on measuring all mass flows during operation of the ECOGI shown in Figure 2 and analysis of a number of parameters of representative samples taken from some of the mass flows.

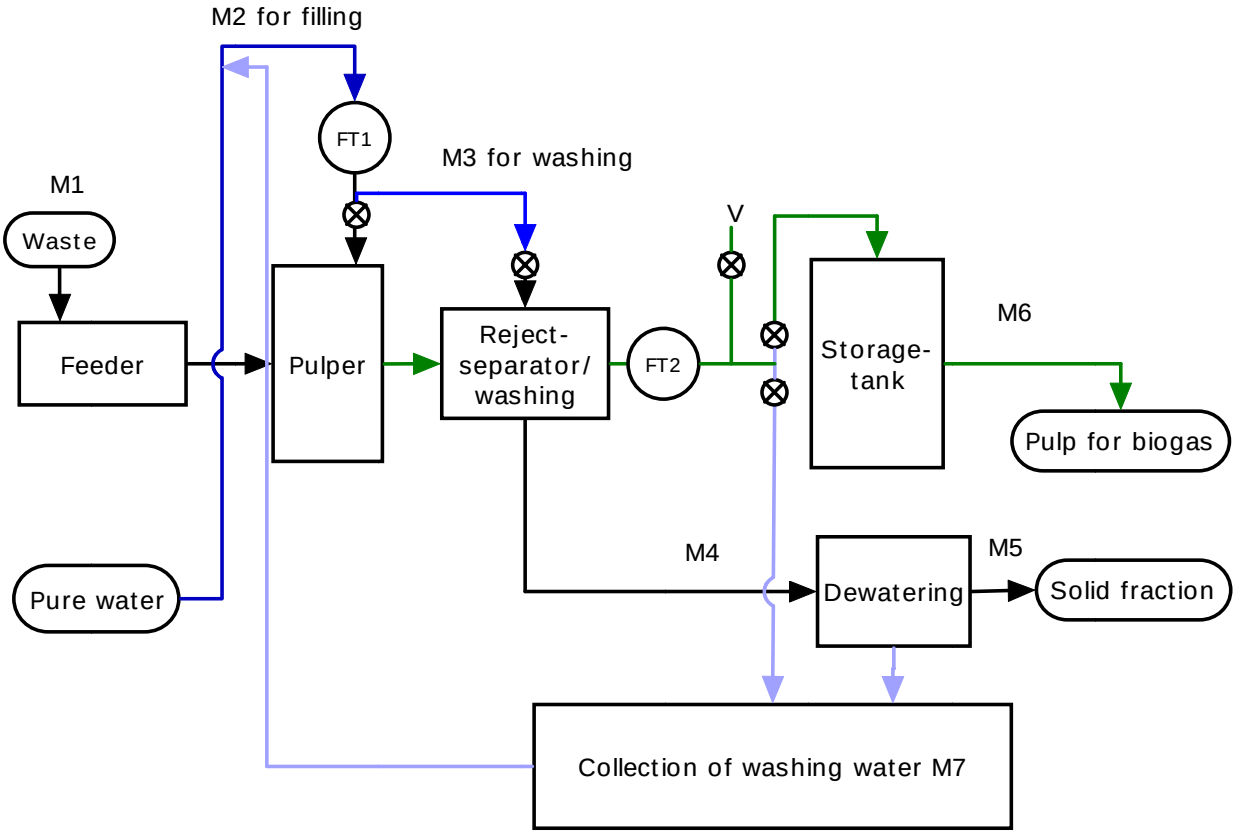

Figure 2 Mass flows in test

- M1 weight
- M2 weight (using FT1 - flow transmitter)
- M3 weight (using FT1 - flow transmitter)
- M4 weight will decrease during transport for drainage

- M5 weight will be recorded after drainage, 60 liter of the solid fraction per test run is sampled representatively for organic content test
- M6 weight, representative sampling of each batch while pumping for test of anorganic content in biopulp.
- M7 volume (by height measurement in tank) before and after a test run.. Representative samples will be taken after each test run while pumping the washing water out of the reservoir after each test run.

The electricity consumption is measured by reading the electricity-meter of the hall, the ECOGI is operating in, before and after every test run. The ECOGI is the only operating machine in this hall.

Basically three tests are performed on the samples taken out during test for one wastetype, see appendix 3 for detailed description of the tests and sampling :

Biopulp purity test (sampling position V)

This test determines the purity of the biopulp by sorting the inorganic residues out of the biopulp sample by sieving the biopulp, flushing with warm water and hand sorting of organic rests on the sieve. The inorganic residue is dried and weighed.

Organic content test in solid fraction (sampling position M 5)

This test determines the loss of organic matter in the ECOGI process, which is the biopulp not being washed of the solid fraction in the ECOGI process.

Automatic washing in a specially designed washer is performed repeatedly on the solid fraction following filtration in order to determine rest organic matter in the solid fraction. The subsamples will be dried, manually sorted for organic/inorganic matters and analysed for dry matter.

Organic content in washing water (sampling position V during recirculation of content from collection tank)
This test determines the organic residue in the washing water. This test is performed for mass balance reasons only and will not be included as loss of organic material in our calculations, because the washing water is recycled to the pulper in normal operation for reuse in next pulping step and thus the content of organic matter is not lost.

The TS (Total Solids) and VS (Volatile Solids) is analysed from representative samples.

2.2.2. Test staff

The test staff is

Bjørn Malmgren-Hansen (BMH)	Sampling,dataanalysis and reporting (TI)
Sabine Lindholst (SBL)	Sampling, analyses, data analysis, reporting (TI)

2.2.3. Test schedule

Task	Timing
Application definition document	August 2012
Verification protocol with test plan	November 2012
Test	December 2012
Analysis phase	December 2012-january 2013
Test reporting	January 2013
Verification	February-march 2013
Verification report	March-April 2013

2.2.4. Test equipment

The test equipment includes besides the ECOGI sampling containers, buckets, sieves with different mesh sizes, small wheel loader, pitch-fork, sorting table with drain for water collection, small shovels, drying ovens, concrete mixer with attached 10 mm sieve, weights, flowmeters. For further details see Appendix 3 In-house test methods.

2.2.5. Type and number of samples

The types and number of samples per type of waste are summarized in the following.

Sample	Sampling position	Number of batch samples	Number of test samples	Number of samples per waste type
Biopulp	**V**	**9**	**3**	**3**
Solid fraction	**M5**		**3**	**3**
Collection tank	**V**			**3**

In general the following practise for sampling, subsampling and sample handling of suspensions will be used.

Sampling of main sample from inlet and outlet

The main samples are taken from valves with sufficient dimension (1") to ensure that no material is stuck in the valve. Before obtaining the sample at least 2 litres are discarded. A 10-15 litre bucket is used for sampling the main samples. For details see Appendix 3.

Preparation of subsamples

In all subdividing of samples care must be taken to produce representative subsamples as some fibre material may float or sink.

Depending on type of the homogeneity of the biomass pulp the subsamples will be obtained in the following way:

1) ***Homogenious pulps:*** a subsample is made by stirring main sample well during transfer to subsample
2) ***Inhomogenious pulps with floating layers or fast sinking layers***: Sieving of fibres is performed followed by propotional weigh of solid and liquid fractions into subsamples.

The most appropriate subsampling method will be decided when inspecting the main samples

Handling of samples
All fibre material is refrigerated if tests are performed within 2-3 days or frozed down for later analysis.

2.2.6. Operation conditions

Before each test of waste, the whole system is flushed with clean water until no visible rest from the previous operation can be observed any longer. Further all conveyers for solid input and output waste are cleaned. Each batch test uses 30 minutes pulping. The actual operation condition is listed in the test report.

2.2.7. Operation measurements

- Total power consumption during treatment will be recorded
- Water consumption during treatment will be recorded

2.2.8. Technology maintenance

The test is a short term performance test of 2-3 days. Maintenance requirements are not covered in the test.

2.2.9. Health, safety and wastes

While testing, the personal wears a protective suit and gloves, safety glasses in case there is risk of splashes and in if necessary breathing protection. The waste can be deposited in a general waste container.

3. Analysis and measurements

3.1. Analytical laboratory

Analytical laboratories providing analysis of any kind as part of the verification tests, within or outside the test centre body has the responsibility for:

- Maintaining an ISO 17025 accreditation with the quality management system required herein.
- Application of accredited analytical methods, where available
- Application of other methods according to both international standard methods or in-house methods that are validated as required for accredited methods

The selected analytical laboratory subcontractors shall be listed by the test centre, test sub-body.

3.2. Analytical and measurement parameters and methods

The used analytical laboratory methods are listed below:

Analytical parameters	Standard
Total solids (TS)	EØF 103°C
Total volatile solids (Loss on ignition) (VS)	DS 204

3.3. Analytical and measurement performance requirements

See details in appendix 3.

3.4. Preservation and storage of samples

Samples for tests are stored in labelled 1 l PE bottles, freezed and sent directly to analysis after the tests (1 week). Solid fraction samples are dried directly on site in aluminiums foil trays, transported to Teknologisk Institut afterwards and stored at room temperature until VS analysis.

3.5. Data management

Data is recorded in logbook and spredsheet during measurement.

3.6. Data storage, transfer and control

The data to be compiled and stored are summarized in table below. Analytical raw data are filed and archived according to the specifications of the laboratories quality management systems.

Data type	Data media	Data recorder	Data recording time	Data storage
Test plan and report	Protected pdf	Test responsible	When approved	DTI protected data storage
Test details at laboratory and full scale	Excel, word etc.	Test staff at test site	During Test	DTI protected data storage
Calculations	Excel	Test responsible	During calculation	DTI protected data storage
Analytical reports	Protected pdf, paper	Test responsible	When received	DTI protected data storage

4. Quality assurance

4.1. Test plan review

Internal review of the test plan will be done by LBFH
External review of the test plan as well as performance control of analyses and measurements will be done by Thorkild Qvist Frandsen (TQF), Agrotech, phone: +45 87 43 84 68, e-mail. tqf@agrotech.dk.

4.2. Data integrity check procedures

All transfer of data from printed media to digital form are checked twice and between digital media are checked by spot check of not less than 5 % of the data. If errors are found in a spot check, all data from the transfer are checked.

4.3. Test system audits

None

4.4. Data integrity check procedures

Data and calculations are controlled by at least 2 persons (BMH and SBL)

4.5. Test system audits

None required.

4.6. Test report review

Internal review of the test report will be done by LBFH, phone + 45 72201837, e-mail: lbfh@teknologisk.dk
External review of the test report will be done by:
Thorkild Qvist Frandsen (TQF), Agrotech, phone: +45 87438468, e-mail: tqf@agrotech.dk.

5. Test report

The test report will contain part of the test plan and a test data report according to requirements in EU general verification protocol v.1.0 (ref.6).

6. References

Appendix 1Terms and definitions

Terms and definitions used in the protocol are explained in Table 6.1.

Table 6.1 Terms and definitions used by the DANETV test centres.

Word	DANETV	Comments on the DANETV approach

Word	DANETV	Comments on the DANETV approach
Analytical laboratory	Independent analytical laboratory used to analyse test samples	The test centre may use an analytical laboratory as subcontractor
Application	The use of a product specified with respect to matrix, target, effect and limitations	The application must be defined with a precision that allows the user of a product verification to judge whether his needs are comparable to the verification conditions
DANETV	Danish centre for verification of environmental technologies	
(DANETV) test centre	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body	Name will be changed, when the final nomenclature in the EU ETV has been set.
Effect	The way the target is affected	The effect could be concentration reduction, decrease in treatment period, pH increase etc
(Environmental) product	Ready to market or prototype stage product, process, system or service based upon an environmental technology	The product is the item produced and sold and thus the item that a vendor submit for verification
Environmental technology	The practical application of knowledge in the environmental area	The term technology is covering a variety of products, processes, systems and services.
Evaluation	Evaluation of test data for a technology product for performance and data quality	None
Experts	Independent persons qualified on a technology in verification	These experts may be technical experts, QA experts for other ETV systems or regulatory experts
Matrix	The type of material that the product is intended for	Matrices could be soil, drinking water, ground water etc.
Method	Generic document that provides rules, guidelines or characteristics	An in-house method may be used in the absence of a standard, if

Word	DANETV	Comments on the DANETV approach
	for tests or analysis	prepared in compliance with the format and contents required for standards.
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use	None
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product	The performance parameters must be established considering the application(s) of the product, the requirements of society (regulations), customers (needs) and vendor claims
Procedure	Detailed description of the use of a standard or a method within one body	The procedure specifies implementing a standard or a method in terms of e.g.: equipment used
Producer	The party producing the product	None
Proposer	Any legal entity established in or outside the European Union presenting an innovative environmental technology for verification under the EU ETV pilot programme	None
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis	None
Target	The property that is affected by the product	Targets could be *e.g.*. contaminant concentration
Test centre, test sub-body	Sub-body of the test centre that plans and performs test	None
Test centre, verification sub-body	Sub-body of the test centre that plans and performs the verification	None
Test/testing	Determination of the performance of a product for parameters defined	None

Word	DANETV	Comments on the DANETV approach
	for the application	
Vendor	The party delivering the product to the customer	Can be the producer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance	None

Appendix 2 References/methods (verification protocols, requirement documents, standards, methods, existing data)

1. DANETV. Centre Quality Manual, DTI 2009.

2. European Parliament and Council. Directive 2006/42/EC of the 17th May 2006 on machinery and amending Directive 95/16/EC (recast).

3. European Council: Directive 89/655/EEC of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work (amended 2007/30/EC).

4. ISO 12100-2:2003: Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles.

5. Measurement protocol for biogas potential measurements for ETV tests at DANETV (Method 1 and 2).

6. EU general verification protocol version 1.0 December 15th 2011.

Appendix 3 In-house test methods

Purity test for biopulp

Sampling position: V (after solid fraction separator)

Materials needed:
1 l beaker
1 mm sieve

shower with water
bristle
foil trays 500 ml
oven
magnifying glass
tweezers
white paper
weight 0.1 g precision
photo equipment

Sampling method for a batch sample (three batch samples are combined to one test sample - there will be sampled 3 test samples per waste type):

Draining of the solid fraction separator lasts 240 - 300 seconds per batch. One batch sample is composed of three 2-litre samples taken at 45 seconds, 120 seconds and 200 seconds after start of emptying the solid fraction separator using valve V.

All 3 batch samples are mixed together in a 20 l bucket representing the test sample for one batch. Subsamples for further analysis are taken after thorough mixing.

Analyses undertaken with biopulp to determine the amount of not biodegradable material in the biopulp (purity test)

1 liter well mixed biopulp sample is weighed and sieved with a 1 mm sieve and flushed carefully with lukewarm water (35 ˚C to 50 ˚C).
The residue on the sieve is dried at 103 ˚C for 24 hours (until constant weight) and hand sorted for organic residues on a white sheet of paper. The non-organic residue is weighed and documented with photo showing any content of plastic, metal and glas parts.

All 3 test samples of biopulp batches is analysed for TS and VS (double analysis) at DTI.

Calculation of purity:
The purity will be calculated as wet corrected to 15% total solids, that is the total solids content in normal operation of the system including a screw press draining of the biopulp and on dry basis:

Calculation of purity (wet,%) =
g dry matter -non organic/g biopulp input (corrected to 15% TS)*100
Calculation of purity (dry,%) =
g dry matter -non organic/g biopulp input (dry)*100

Organic content in solid fraction test

Sampling position: M5

Materials needed:

Concrete mixer closed with a 40 mm sieve
90 l container
10 mm sieve
2 mm sieve
Weights for 30 kg, 10 kg and 2 kg
Sorting table
Soup ladle
1 l measuring beaker
Thermometer
Sampling method for a test sample (the solid fractions of the three batches are laid in one pile, resulting in one test sample after processing as described below):

The solid fraction from a 3 tons waste treatment (1 batch) corresponds to approximately 600 kg. The solid fraction is deposited from the conveyor belt into a special designed container with holes in the bottom, placed on top of the washing water collection basin. The water allows dripping of for 15 minutes, where after the solid fraction is tipped on the ground, so that it lies spread out. The container is weighed on a weighbridge before filling and after dripping of. The solid fraction from the next two batches is processed alike. The pile on the ground must not exceed 0,5 m in height.
Six 90 l buckets are filled with the solid sample on the ground with a pitch-fork, picking alternating from the top, middle and bottom of the pile on different places. These subsamples are deposited in the shovel of a little wheel loader, mixed by hand with a pitch-fork, tipped off and spread on the ground again. A 60 l sample is taken out with a pitch-fork by slicing through the whole pile on the ground.

The amount of biodegradable material in the solid fraction is determined, representing the loss of biopulp in the system.

Washing of sample and deviding in different size fractions

1. The 60 l sample is weighed and filled into a concrete mixer that is closed with a 40 mm sieve.
2. The sample is washed in the concrete mixer for 5 minutes under addition of 50 l cold water
3. After 5 minutes while it is running the concrete mixer is tipped to an angel of 15 ˚, tipping the < 40 mm solids into a bucket with an attached 10 mm sieve, until no more solids come out of the concrete mixer (approximately 15 minutes). The collected 10 - 40 mm fraction on the sieve is kept in a separate bucket, while the collected liquid is sieved on a 2 mm sieve. Both the solid fraction 2 to 10 mm on the sieve and the liquid are kept separately for further analyses.
4. Step 2 and 3 is repeated once with cold water and once with warm water (35 - 50 ˚C). The water amount for these two washing steps may be reduced to around 25 liter.
5. The solid fraction > 40 mm is taken out of the concrete mixer after the second washing step.

The washing procedure described above results in four separated solid fractions: > 40 mm, 10 - 40 mm, 2 - 10 mm and the washing water with the fraction < 2 mm

Further sorting and analyses:
Washing water fraction 0 - 2 mm:
TS and VS from a representative subsample, taken by dipping a 1 l beaker into the sample while stirring well with a soup ladle

The other three solid fractions:
Hand-sorting of every fraction after drying (the suitable drying method is under development) into 4 types of materials:
1. non-bioconvertable material (plastics, metal, glas, textile…)
2. bioconvertable material - food waste
3. bioconvertable material - nonfood (wood, paper,…)
4. Other (undefinable waste)

The four fractions are documented by photography and description of especially 3. bioconvertable material - nonfood fraction.
All fractions are weighed and TS and VS of subsamples of all 4 fractions are analyzed.

Before sorting it will be tested whether a gentler drying program for TS (50 ˚C instead of the standard 103 ˚C has to be preferred due to less degradation of some vegetables at lower temperature In that case, drying time has to be prolonged until constant weight is reached.

Fraction 2 and 3 are sorted further. Wood material of too large dimensions to be considered degraded in biogasification will be separately sorted out and weighed. The size of nondegradable wood is set to larger than 5*5*5 mm.

All other organic fractions from 2-40 mm are added proportionally to a specially developed chain crusher which produces a rough pulp which will be analyzed for TS,VS.

Calculation of recovery
Recovery of organic matter in biopulp will be calculated based on the organic VS content of the biopulp compared with the loss of organic VS in the solid fraction excluding wood larger than 5*5*5 mm:

Recovery of biopulp % =VS of biopulp/ (VS of biopulp-VS of solid fraction)*100 for each test run.
This is a worst case calculation of the recovery meaning that the actual recovery in terms of produced amount of biogas will be higher. The reason is that some of the large particles in the solid fraction which is down sized in the chain crusher are not expected to be completely converted in a biogas process within normal operation time.

Optional (not required in this ETV)

The samples from crushing will be frozen and may be used to compare the methane production from the organic fraction derived from the solid fraction with the methane potential of the biopulp. It is estimated sufficient to use one combined proportional sample per waste type for biopulp and one for organic content of solid waste. Each can be analyzed according to the in house protocol at DTI (Ref.5).

Washing water (optional)

Sampling position: V (after pumping the washing water backwards)

The organic content in the washing water is reintroduced into the biopulper in normal drift and will not be lost. It was decided in this test to determine the organic content in the washing water for mass balance reasons.

The collection tank for the washing water is emptied before each test run. After collecting water from all three test runs, the volume of the water in the tank is registered and a representative sample is taken for the determination of TS and VS while recirculating the water/residue.

Appendix 4 In-house analytical methods and measurements

Drying method:

The method for drying the organic fractions is tested before test is performed. Two drying methods are compared: drying with 50 ˚C for ≥ 48 hours –until constant weight and drying with 103 ˚C for one day or until constant weight. The low temperature drying is expected to make recognition of organic matter like carrots, potatoes etc easier as they are not heat treated as much. If there is no difference, the standard drying method at 103 ˚C will be used, otherwise the low temperature method is to be preferred with a prolonged drying time, determined in the test.

Biogas method (optional)
In house protocol are available (Ref.5).

Appendix 5 Data reporting forms

Not specified here. All necessary data must be given in tables.