WASTE REFINERY
Document 1
Problem Situation Document

1.00.00 Problem Situation Document

1.01.00 Configuration Management

Version	Date	Name
v1	090411	nwk
v2	090426	nwk
v3	090511	nwk
v4	090918	nwk
v5	091018	nwk
v6	110308	nwk

1.02.00 Vision

This project is an attempt to build a waste refinery.

1.03.00 Mission

The mission is to transform the waste stream into a resource stream.

1.04.00 The System Function

The system must be able to transform the waste stream in to a series of resources.

1.04.01 The system should be able to accept household waste in it's raw un-sorted form.

1.04.02 The system should extract energy from the waste stream, and use this energy to process the waste stream. Surplus energy should be sold. The energy sold could take the form of biogas, steam, heat or electricity.

1.04.03 After the waste has been processed, the waste should have been separated into discrete recycle ready component groups.

1.04.04 Components that have a ready market should be sold. Components that are not able to be easily sold should be incorporated into value added products that can be sold, such as packaging, side walk paving or road base.

1.04.05 Surplus water and exhaust gases that are not sold for industrial use, should be released into the environment in a responsible way.

1.05.00 History of the Problem and the Present System
In the past waste was usually disposed of in a landfill, or incinerated. Both of these methods are environmentally unsustainable. Numerous attempts have been made to mitigate the environmental impact of waste disposal. However few go as far as the waste refinery project - which aims to recycle all waste.

1.05.01 The customer need
To be viable in the long term, all societies need an ecologically sound, and sustainable, way of dealing with waste.

1.05.02 The goal
The goal is to develop a financially viable, and environmentally sustainable, system which totally recycles all waste, eliminating the need for a landfill.

1.05.03 The business need
All material activities and transactions should be recorded. Access to the records should be available where appropriate.

1.05.04 The community need
Employment types that are un-desirable, such as the hand sorting of waste, should not be created by this project.

1.05.04 The industrial need
The production of a stream of raw materials, that can be used by industry with little, or no, further processing.

1.06.00 The scope of the system
The system will include a method of granulation of the waste stream into very small particles.

After being ground down the particles are to be sorted into like groups. At the same time as the waste is ground and sorted, organic components are digested.

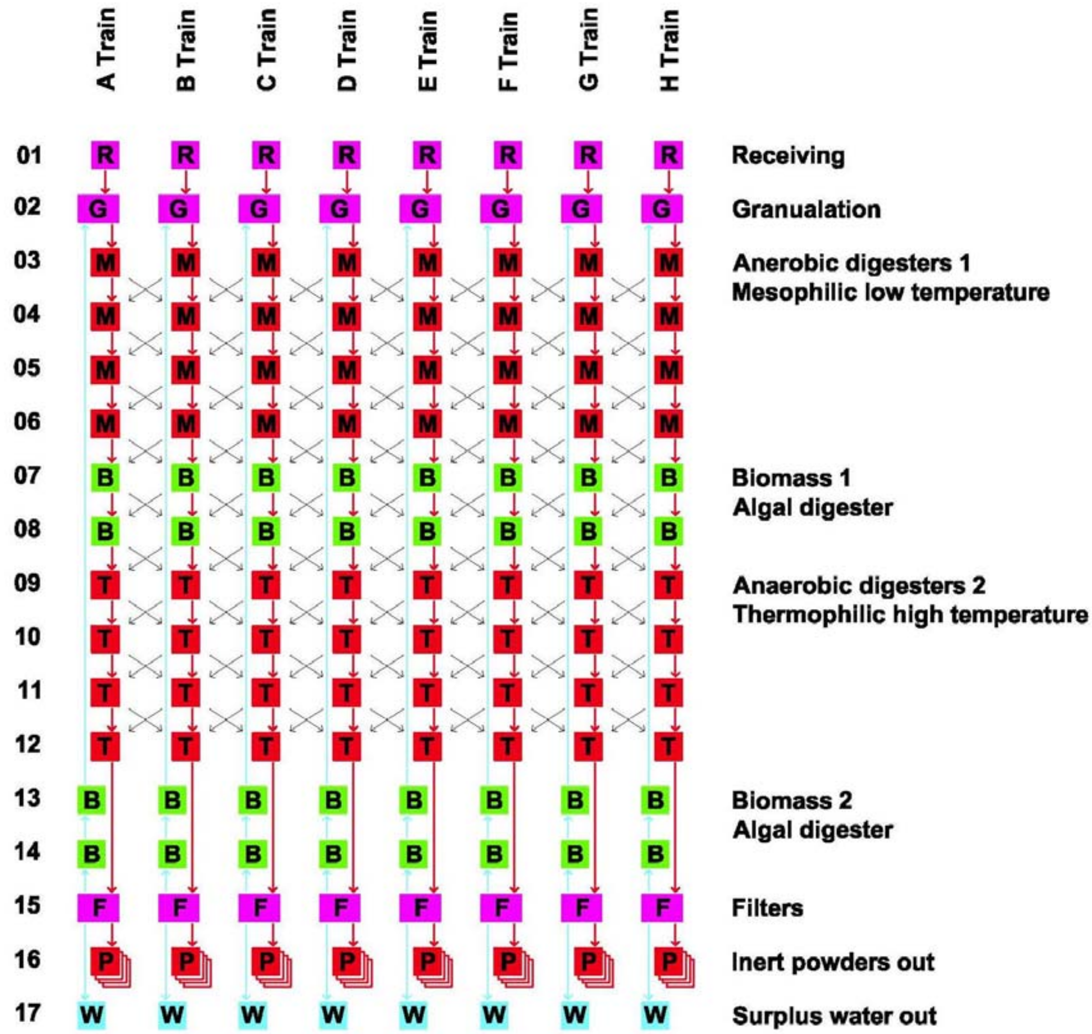
Also complex reactive chemicals occasionally found in the waste stream, are broken down into simpler forms because fine particles are more chemically reactive. As a result the end products of the process are transformed into more stable and inert particles.

The resultant sorted particles can be sold. Any resultant particles that are not able to be sold are further processed until they can be sold. Or incorporated into value added objects that can be sold.dd

1.07.00 The concept

To process the waste stream a number of processes are envisaged.

Diagram 1.07 showing the plant layout



The envisaged plant will consist of a number of waste processing trains, columns A to H shown.
Each train will consist of recieving modules (row 01).
The granulation modules will reduce the particle size of the waste (row 02).

Waste form each grinding module will be passed to a digester module (row 03).
As shown in the diagram between row 03 and until row 12, the waste passes from on row to the next, and also to the adjacent trains (columns) on each side. The waste will be sorted with heavy particles directed towards column A and lighter particles to column H.

The first array of digesters (row 03 to row 06) are mesophilic digesters.

The second array of digesters (row 07 to 08) will introduce sunlight and CO_2 will produce algal biomass at the same time as further digesting waste and the digestate from the first array. This algal biomass growth process is repeated at the end of the waste refinery as the water is returned to the start of the waste refinery process.

The third array of digesters (row 09 to row 12) will be thermophilic digesters that will further digest the waste and algal biomass.

The first and third arrays will generate biogas for a combined heat and power electricity generator. Surplus heat and electricity from the electricity generator can be sold.

At the end of the process particles are delivered in sorted groups. The particles will be ready for sale for recycling into new products.

The water at the end of the process is re-cycled to the start of the process, and the small amount of surplus water that is generated is fed into a small vertical flow reed bed.

Having a modular system means that waste can be passed around any module if it is out of commission. Therefore even without several modules, the plant would be able to continue to function.

In addition to the items shown in the above diagram, the plant will require additional modules including electrical generators, administration, and so on.

1.07.10 Initial process.

The initial process will be to receive waste usually from waste trucks. And then to granulate the waste. Also water will be added to achieve a target mixture of 20% solids. Granulation of the waste will make it more reactive, digestible and sortable. Also the during the recycling waste products are often granulated during re-processing, so this should not add to the overall cradle to cradle cost of recycling. A conventional granulation method would use a shredder and then a roller mill, however alternative methods may be used.

1.07.20 Secondary process.

The secondary process is to pass the waste through an array of biological digesters. In the array each digester also acts as a centrifuge, which means that waste is progressively sorted as it passes through the array. Organic components make up about 75% of the waste stream, and the digesters will process this portion of the waste stream. It is currently envisaged that secondary process will consist of a number of phases -

1.07.21 Low temperature digester phase -

This will be a low temperature anaerobic digestion methane producing phase, using mesophilic bacteria at about 35°C. Mesophilic bacteria are able to cope with a wide range of conditions and are well suited to the start of the array where the waste is relatively un-sorted. This phase will produce biogas.

1.07.22 Algal phase -

Sunlight and CO_2 from the exhaust from the combustion of biogas and biomass are introduced. This phase will increase the biomass available for the next phase.

1.07.23 High temperature digester phase -

This will be a high temperature anaerobic digestion biogas producing phase, using thermophilic bacteria at about 50°C. Thermophilic bacteria are not as resilient to changing conditions and are more suited to the end of the array where the waste in each digester is more consistent.

1.07.24 Filtering phase

Water will be filtered out and the material will be in different discrete groups, in most cases loaded into bulk sacks or ISO containers ready for sale.

1.07.30 Tertiary process.

The tertiary process is to use the water from the system to generate biomass, and at the same time generate a suitable source of water for the water recycling phase of the system. Also surplus water generated by the system can be sold or released into the environment as steam, or as a liquid. In addition material not easily sold, can be further processed into value added products, and then sold.

1.07.33 Water recycling phase -

Various filters are used to extract water from the mixture. The water can be passed through a reed bed and sand filter array to produce biomass and filter the water. Some surplus water from the biogas combustion phase can be lost to the atmosphere by transpiration and the reeds are harvested for biomass. Surplus water can be stored to be re-used to process that next batch of waste.

1.08.00 Customer

The Waste Refinery project is the contracting agency for the system feasibility study and is responsible for all requirement definitions.

1.09.00 Stake holders

Anyone affected by the disposal, collection and processing of waste is a potential stakeholder

Generally the direct customer will be a local municipal government which is usually charged with disposing of waste. The ultimate source customer is usually the consumer who needs some way of disposing of their waste, however the consumer normally pays for waste disposal indirectly via a local government levy.

Other stake holders are the regional and central governments, and their agencies. Some government organizations have in household waste management operations. However it is not uncommon for waste management to be outsourced to a private waste management company. Private waste management companies sometimes deal direct with customers, but usually this occurs only with large industrial companies. In addition to those directly employed in the waste management field there are a number of peripheral businesses that provide maintenance, intellectual property, and other services to the industry.

Also their are people who have a direct interest in waste management because of their proximity to waste management installations. In addition because of environmental concerns, there are people who have an ethical interest in waste management issues.

1.10.00 Program Phases

The Waste Refinery project will attempt to raise funds to complete the following phases.

1.10.10 Phase 1:
System Conceptual Design, Risk Analysis and Demonstration Planning
Design the system of chemical reactions, functional decomposition, and the mass balance calculations.
Status – completed.

1.10.20 Phase 2:
Pilot Plant Phase.
Design of modules and control systems.
Build prototypes of each module.
Build pilot train and build train control system.
Build several trains, and operate and evaluate pilot plant.
Determine practical design parameters for full scale plant.
Demolish pilot plant, or if practical maintain as test bed for improved module design.

1.10.30 Phase 3:
Build a full scale plant.
Demonstrate practical system.

1.10.40 Phase 4:
Find suitable sites for future plants.
World wide roll out of plants.

1.11.00 System Environment

1.11.10 Social & Economic Impact
The Waste Refinery project will ensure that the plant will not have a negative social and economic impact.

1.11.20 Environmental Impact
There is no negative environmental impact with the proposed system works as envisaged. Failure of a module must be able to be managed within the system. There should be no toxic material produced, and no damage to people and property.

1.11.30 Interoperability
Each module of the system will be capable of communicating with other modules and responding to the status of connected modules.

1.11.40 Recommended procedure
After a theoretical verification of the system design, each module should be produced and tested. After the performance of each component has been determined, a rational assessment of the whole systems viability can be determined. Should an example of each components suggest that the system as a whole would be workable, then a full working refinery can be delivered.

1.11.50 Key decisions
Key decisions that must be made are to establish from a bio-chemical analysis, if the refinery is theoretically viable. After that all the components and processes of the refinery should be identified, quantified, tested and verified.

1.11.60 Project metrics
Measurement used to gauge the quantifiable components of the systems operation.

1.11.61 Performance

The ability of the plant to digest, and sort, waste will be measured.

1.11.62 Reliability

The reliability of the plant, and of it's components, will be measured.

1.11.63 Cost

The intention is that the plant should be able to finance it's own running costs, and in addition, it should generate a surplus to contribute to the financing of the capital cost.

1.11.64 Schedule

The schedule is to be determined.

1.11.65 Risk

The risk of the refinery is to be determined. The design of the refinery will attempt to reduce risk by the implementation of a modular, non critical system. This means that all components will be modular and interchangeable, so that sub-systems can be swopped out for maintenance. Also no single module should be a bottle neck, the material flow through the system should be via several paths, so that the failure of one part, or several parts can not block the system as a whole.

1.12.00 Systems Engineering Management Plan

1.12.01 Document 1: Problem Situation
Status - Current

1.12.02 Document 2: Customer Requirements
Status - Current

1.12.03 Document 3: Derived Requirements
Status - TBA

1.12.04 Document 4: System Validation
Status - TBA

1.12.05 Document 5: Concept Exploration
Status - Current

1.12.06 Document 6: Functional Models
Status - Current

1.12.07 Document 7: Design Model
Status - TBA

1.12.08 Document 8: Data Management
Status - Current

1.12.09 Documents 1-8 (Final Project Submission)
Status - TBA