‘*e-casa*’ - Eco-friendly Household Waste System

Group 6

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‘*e-casa*’ - Eco-friendly Household Waste System

Executive Summary

The aim of this project is to create a household waste system System of that will not only reduce the waste produced by a generic household but do so by increasing value to the user. The final deliverable for this project will be a report that details the needs analysis, conceptual design, feasibility and risk assessment of the designed system. The coneptual design will be done with the use of *Core 9* to capture all identified needs accurately and produce system design documentation.

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Acronyms

e-casa Eco-friendly Household Waste System

SD System Dynamics

Chapter 1

Introduction and Background

1.1 Problem Background

Households consume and produce a variety of products and wastes. Products may take the form of food items, municipal water, electricity and other consumables which are used and then discarded, exiting the household as waste. For example, food clippings from preparing dinner or paper-based packaging is often discarded into dustbins alongside plastic and other waste types to be collected and transported elsewhere. Water used at bathroom sinks is disposed of as it is sent directly to the the municipal water system after use. Each type of waste generated by a typical residential household requires proceeding systems that will either store, repurpose or discard the waste.

Recent trends have made the consumer market ecologically aware of their own waste generation and many systems have been created to reduce the total waste output of a household. Such products include grey water systems, recycling bins and compost containers. There is a growing need for these means to be adpoted but presently no solution on the market that integrates all means into one comprehensive system for homeowners.

Because these systems operate independently, the outputs of one system are often not used as inputs to another. Integrating these systems to operate together could provide more value to the user and further reduce household waste. For example: using food clippings to create a compost heap and grow plants and foods in one's garden instead of disposing food clippings in a general waste bin and purchasing compost from a store.

1.2 Project Objective

Chapter 2

Concept Development Stage

2.1 Needs Analysis Phase

2.1.1 Operational Need Analysis

Operational Need - The name of the system to be developed and a descriptive representation of the problem to be addressed using letters, figures, charts, photos etc as deemed necessary. Is it a new system from the scratch? Is it a major upgrade of an existing system? Any market opportunities/technological capability in terms of availability and cost? Etc.

Eco-friendly Household Waste System (e-casa) is a sustainable household waste management system intended to fulfuill the increasingly prevalent need for sustainable living. The need for individuals and households to consume and dispose of resources in a more sustainable manner is becoming ever more pertinent because of increasing strain on the world's most essential natural resources such as water and coal. The need is driven by the requirement for individuals (and society as a whole) to reduce their negative impact on the environment by re-use, recycling and minimising resource use as these natural resources become more scarce. Successfully meeting this need will not only improve living conditions for societies but importantly alleviate pressure on governments and municipalities who have to manage and supply these resources. Although regulation does not yet fully drive this need, government encourages and sometimes imposes restrictions to encourage responsible water and electricity use. This is important to develop a sustainable mindset and awareness of waste generation. Because regulation is still limited on the use of these resources, the onus lies with society and individuals who are aware of and want to mitigate their negative impact on the environment.

e-casa is aimed at fulfilling the operational need of sustainable living for households by providing a system that makes it possible to manage and dispose of waste responsibly while simultaneously minimising water consumption. e-casa is also expected to provide long-term financial benefits to the user in the form of reduced water consumption costs and grocery bills (with some homegrown foods). Furthermore, there is the expected intangible benefit of the system - knowing one's adverse impact on the environment is mitigated.

Due to a lack of solutions currently on the market, there is an opportunity to enter a gap in the market with e-casa. However, this gap is anticipated to be small in size as this product will mainly be aimed at high income individuals aware of (and wanting to reduce) their impact on the environment. There is also an opportunity to market this system as a product to middle class individuals who have sufficient capital to purchase such a system now in order to reap the aforementioned financial savings down the line. However, this extension will likely only be beneficial if the financial savings are substantial enough to persuade these customers.

2.1.2 Operational Objectives

Requirements Analysis - what exactly do you want to do in this problem space? Which component(s) of the operational need will you be addressing?

The overarching objective that e-casa is intended to fulfil is to provide sustainable household waste management. This objective is deconstructed into three primary objectives, namely: *Provide Waste Sortation and Storage*, *Reduce Water Consumption* and *Provide long-term cost savings*. Figure 2.2 shows the operational objectives of the e-casa system.

*We need an objective tree of our own here that resembles Figure 2.1. Figure 2.2 is a work in progress of that so far.

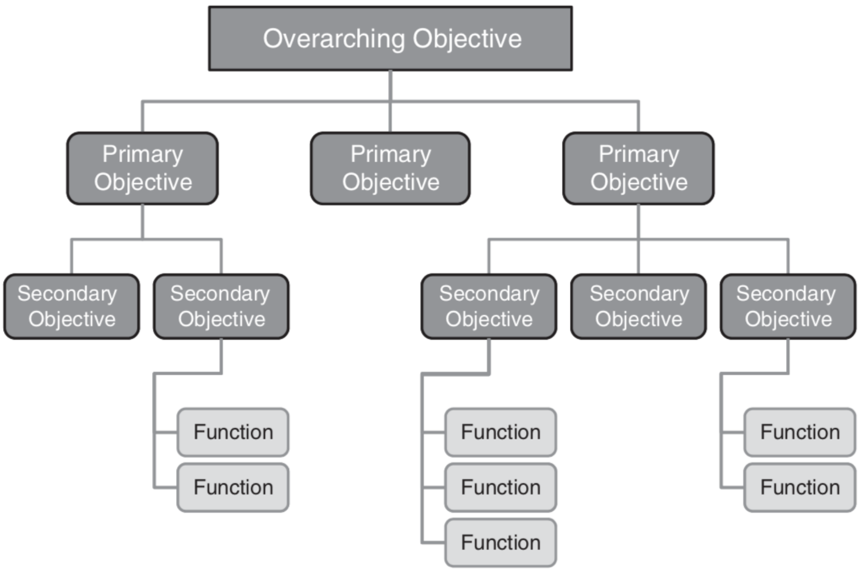

Figure 6.3. Objectives tree structure.

Figure 2.1: Objective Tree Structure

2.1.3 Functional Definition

What initial functions/processes/capabilities need to come on board to achieve the stated objectives?

Provide Waste Sortation and Storage - Sort waste according to its composition: paper, plastic, glass, organic material, e-waste and unusable waste. Organic material will then be retained within the household for composting and other waste types removed from

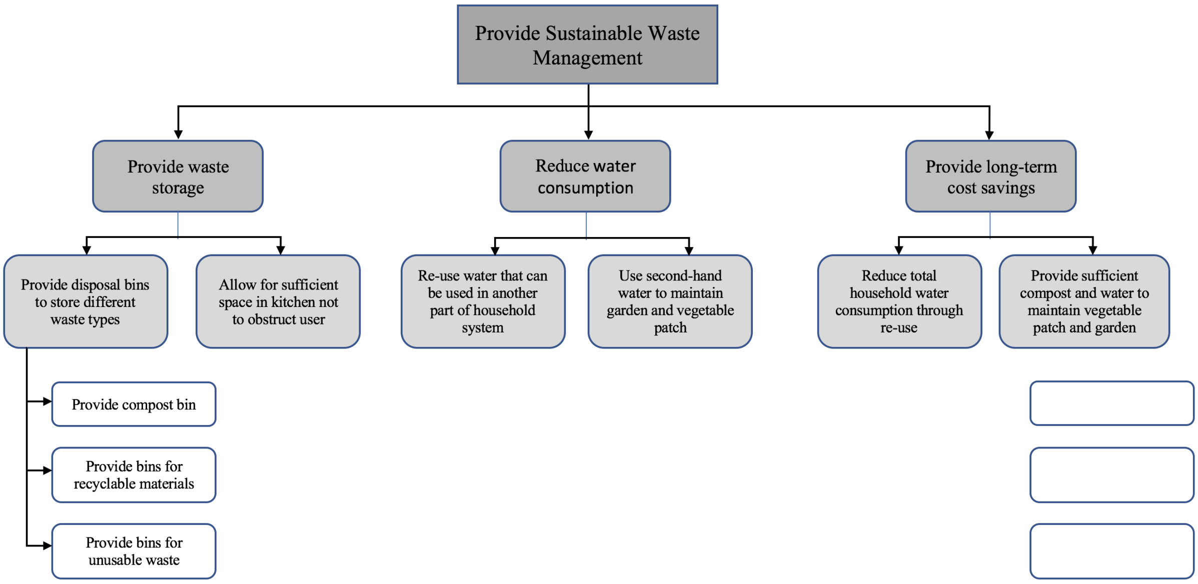

Figure 2.2: e-casa Objective Tree Structure

the household system for the local municipality waste collection service to pick up.

Reduce Water Consumption - A water re-use funciton must be provided to discern which water must be retained by the hosehold for use and which must be discarded into the municipal system based on the origin of the water. ie. Waste water from the toilet must be discarded into the municipal system but used water from the bathroom sink must be retained for re-use to flush the toilet or water the household vegetable patch. This function will also add value to the local municipality by reduce waste output and the volume of water that must be processed.

Provide Long-term Cost Savings - Effective utilisation (re-use) of water and organic waste will reduce the amount of water that needs to be purchased from the municipality, compost that needs to be purchased and eventually groceries that need to be bought. This functionality is essential to reduce the input costs to the household system and provide value to the system user.

2.1.4 Feasibility Definition

Physical Definition - Visualisation of the physical elements/hardware/software/technology etc.

At present there are household recycling bins available on the market that separate waste into the necessary categories. The technology is therefore currently available and feasible and a solution similar to that shown in Figure 2.3 would likely be purchased and used in the e-casa system.

There are also existing grey water systems although these usually vary case-by-case depending on the appliances linked to the system, the size of the storage tank and the quality of the filtration component. It is anticipated that a grey-water system much like the one in Figure 2.4 would be used for e-casa.

Figure 2.3: Household separation recycling bin

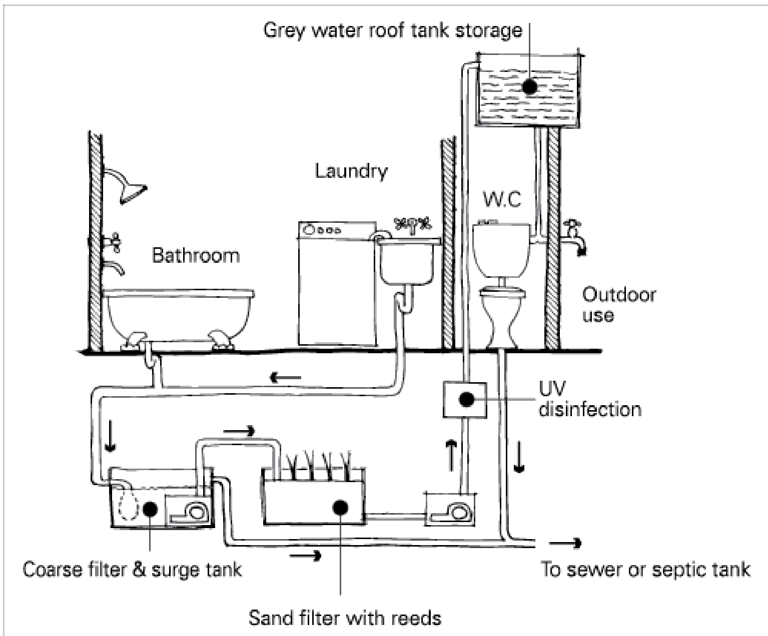

Figure 2.4: Household grey water system

2.1.5 Need Validation

Design Validation What we need to do: Define metrics to evaluate performance rquirements. Present scenarios and evaluate what the metrics would do.

To ensure the proposed system can fufill the identified need, metrics have been developed that will evaluate the performance of the system.

Water savings The volume of water saved is calculated by the volume of water diverted into the grey-water system and represents a direct saving to the user.

Waste reduction The mass of waste composted and re-used reflects the reduction is household waste output.

Household servicing cost The diverted water and re-used waste caters for household requirements that would otherwise require purchasing of items. This includes using municipal water to water the garden or purchasing compost for the garden. The service cost is thus the total cost of services and products required for the continued operation of a household.

Return on investment The return on investment can be defined as the period for which the savings generated by the system exceed the cost to implement the system.

The three metrics are to be evaluated using hypothetical scenarios, reflecting the expected environmental conditions to determine the appropriateness of the system. The following scenarios have been identified.

Long term system failure The water and waste savings are to be seen within the first usage cycle. This implies that once the system has re-used waste, the saving immediately materialises. The return on investment is expected to be achieved before the onset of long term system failure. The likelihood of system failure can be decreased with continued maintenance of the system.

External market competition No other competitors are presently offering an integrated system however, their are suppliers whom offer parts of the system. This implies that other suppliers can match or better the household service cost of the e-casa system. The reduced cost of implementing e-casa shall lie in the simple integration with current household systems. Customers would not require large renovations to install the system, reducing the over cost and improving the return on investment making the system marketable.

As defined by the metrics, the system is believed to achieve the objectives laid out by the defined need. Thus the system is able to fufill the identified needs.

2.2 Concept Exploration

2.2.1 Operational Requirements Analysis

analysing the stated operational requirements in terms of their objectives. Restating, redefining or amplifying (as required) to provide specificity, independence and consistency among different objectives

2.2.2 Performance Requirements Formulation

Translating operational requirements into subsystem functions and defining a necessary and sufficient set of performance characteristics reflecting the functions essential to meeting the system's operational requirements. Formulating the performance parameters required to meet the stated operational requirements.

2.2.3 Implementation of Concept Exploration

Exploring a range of feasible implementation technologies and concepts offering a variety of potentially advantageous options.

2.2.4 Performance Requirements Validation

Conducting effectiveness analyses to define a set of performance requirements that accommodate the full range of desirable system concepts and validating the conformity of these requirements with the stated operational objectives and refining the requirements if necessary.

2.3 Concept Definition

2.3.1 Performance Requirement Analysis

Analysing the system performance requirements and relate them with operational objectives refining the requirements as necessary to include unstated constraints and quantifying qualitative requirements where possible.

2.3.2 Functional Analysis and Formulation

Allocating subsystem functions to the component level in terms of system functional elements and defining element interactions, developing functional architectural products, and formulating preliminary functional requirements corresponding to the assigned functions.

2.3.3 Concept Selection

Synthesizing alternative technological approaches and component configurations designed to performance requirements; developing physical architectural products; and conducting trade-off studies among performance, risk, cost, and schedule to select the preferred system concept, defined in terms of components and architectures.

2.3.4 Concept Validation

Conducting system analyses and simulations to confirm that the selected concept meets requirements and is superior to its competitors and refining the concept as may be necessary.

Chapter 3

Engineering Development Phase

analysing the system functional specifications with regard to their derivation from operational and performance requirements and the validity of their translation into subsystem functional requirement identifying components requiring development

The system's functional specifications are translated into three subsystem functional requirements:

Grey Water subsystem - This system interfaces with the household's municipal water supply which is its primary input. It is also connected to multiple household components, namely: the washing machine, bath/shower, toilet cistern and garden. This subsystem has three functional capabilities. The first being to store grey water in a central tank to be recycled (re-used) in the system, secondly to sort re-usable water from unusable waste water and finally to transfer both the re-usable and unusable water in the subsystem to the appropriate destination (component). This subsystem also feeds grey water to the next subsystem (compost).

Compost subsystem - The compost subsystem interfaces with the household's garden and organic material stockpile components. It uses organic materials from the material stockpile to provide compost to the garden component. It's primary capabilities are to store organic materials and provide some form of visual management for the user to know when there is sufficient compost for the storage container to be emptied. This subsystem is connected to the grey-water subsystem which provides grey water as an input as well as to the Recycling and waste disposal subsystem which provides paper and other organic waste to the compost system.

Recycling and waste disposal subsystem - This subsystem interfaces with the household's kitchen as a component in order to receive all household waste as an input. It also intrefaces with the municipal recycling system at the point where waste is placed on the sidewalk for collection by the municipality's waste collection service. Its primary capability is to sort household waste into the relevant categories for re-use or disposal. Paper recyclables and organic waste collected by this subsystem are output to be used in the compost subsystem while other recyclables and non-recylable waste is disposed of to the municipal recycling system.

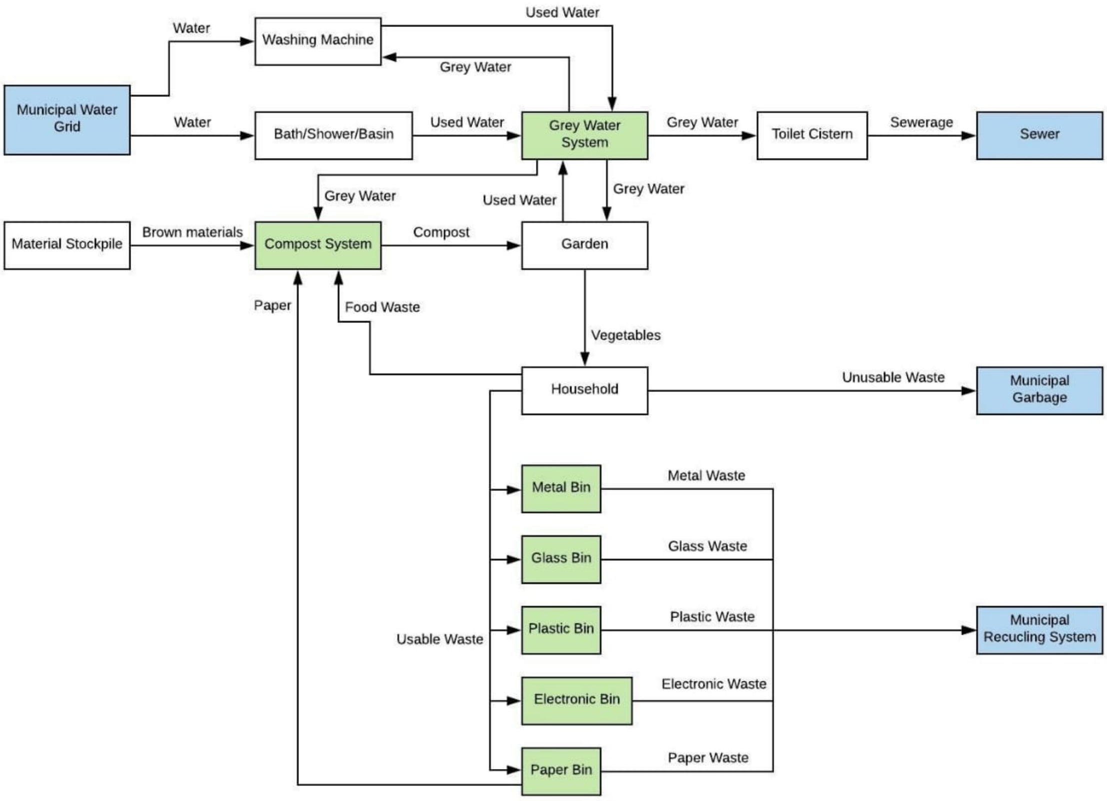

Figure 3.1: System Diagram

3.1 Advanced Development Phase

3.1.1 Requirements Analysis

3.1.2 Functional Analysis and Design

3.1.3 Prototype Development

3.1.4 Development Testing

3.2 Engineering Procurement Phase

3.2.1 Requirements Analysis

3.2.2 Functional Analysis and Design

3.2.3 Component Design

3.2.4 Design Validation

3.3 Integration and Evaluation Phase

3.3.1 Test Planning and Preparation

3.3.2 System Integration

3.3.3 Developmental System Testing

3.3.4 Operational Test and Evaluation

Chapter 4

Post Development Stage

4.1 Production and Deployment Phase

4.1.1 Transitions from Development to Production

4.1.2 Production Operations

4.2 Operations and Support Phase

Installation and test (system integration site, internal and external, disruptive or non-disruptive installation, early system operational difficulties encountered or that could be encountered, operational personnel) Logistics, Support and Maintenance schedule System Upgrades (hard and software upgrade plans)

Chapter 5

Software Design and System Dynamics

This phase is required to study the behaviour and structure of a system by carrying out sensitivity analysis tests. Only select critical elements or more as deemed fit from the designed system and apply to these to the modelling capability of a chosen software. Your algorithm/software approach should be such that a change in the value of one element's input can be quantitatively seen in other elements within the network. [Use software such as: Anylogic, Vensim, Stella, Dynamo++ etc] Phase II is tied to your ability to demonstrate sensitivity analysis, structure and behaviour of a system resulting from a change in one or more parameters of some system elements.

5.1 Core 9 System Design Structure

5.2 System Dynamics Analysis

==35marks==

5.3 Selected Elements for System Dynamics Analysis

==10/35marks== Reason for selecting these elements in a situation where the new network for SD differs from the main designed network ==5/35marks==

5.4 Sensitivity Analysis

==20/35marks== Simulation runs to demonstrate sensitivity analysis, changed system behaviour etc

Chapter 6

Conclusion

Appendix A

Some data as appendix