Embodied Energy Analysis and Visualisation Tool

Deirdre O'Connor*, Hugh Melvin, Jamie Goggins, Mark McCaffrey

College of Engineering and Informatics, NUI Galway

Ryan Institute of Environment, Marine and Energy, NUI Galway

Background

Embodied Energy (EE) is the energy consumed over the duration of a product's life cycle. Having the quantity of EE clearly visible to designers during the design process should make them conscious of the impact their decisions are having on the EE of a product. This is increasingly important due to rising costs of energy and awareness of environmental impact. EE comprises direct and indirect energy. Direct energy is the energy used for the main process, whereas indirect energy is used to create the inputs of goods and services to the main process. There are three main methods used in EE analysis: **process, input-output and hybrid. Hybrid analysis is a combination of process and I-O analysis. It can be either process based or I-O based.**

This research proposes to investigate the different methods of analysis and to develop a unique EE software tool to assist engineers to accurately calculate the EE of a product. The tool will focus on the manufacture of concrete specifically in Ireland.

Analysis

The accuracy and completeness of EE analysis is very much dependent on the method used. There have been many methods developed for assessing EE (Table 1).

Process methods were the first methods used to assess EE. I-O analysis was modified into an energy analysis tool by Herendeen and Bullard (1974). Bullard et al (1978) developed a Process Based Hybrid Analysis. Treloar (1997) developed an Input-Output Based Hybrid Analysis.

Process Analysis (GJ/m^2)	Input-Output Analysis (GJ/m^2)	Process Based Hybrid Analysis (GJ/m^2)	I-O Based Hybrid Analysis (GJ/m^2)
8	12.5	17.8	25.8

Table 1: Comparison of results from different methods of analysis of an office building (Goggins et al (2010)).
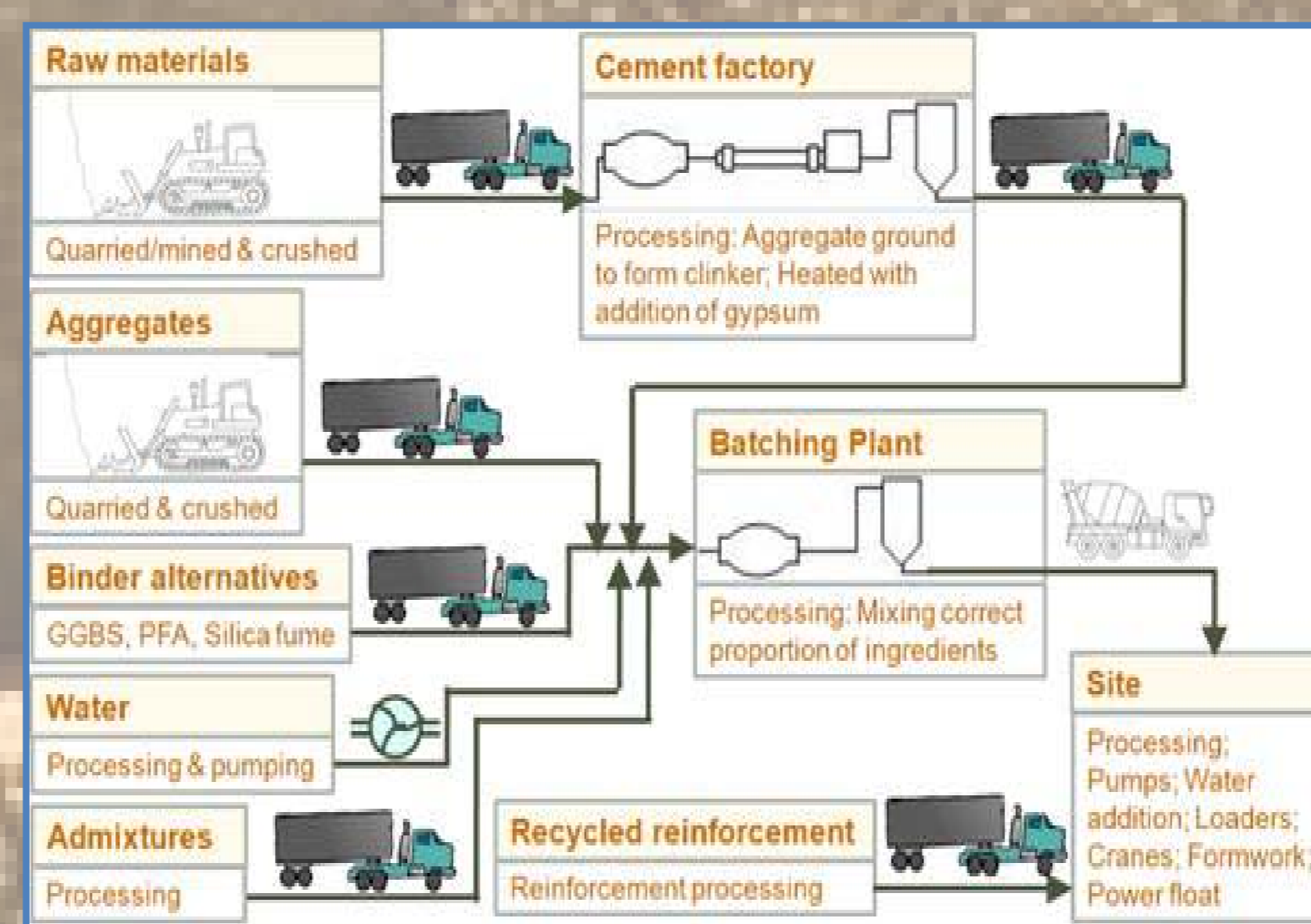
Concrete

Figure 1. Process of concrete manufacture (Goggins et al (2010))

As the production of energy from fossil fuels is environmentally unfriendly, materials that have a lower EE are more sustainable than those with a higher EE.

Concrete has a relatively low EE. However according to the Cement Sustainability Initiative (2008):

Concrete is the second most consumed product in the world after water

Over two tonnes per person on the planet being used per annum.

Associated high usage in construction results in higher total emissions than any other material (Figure 2).
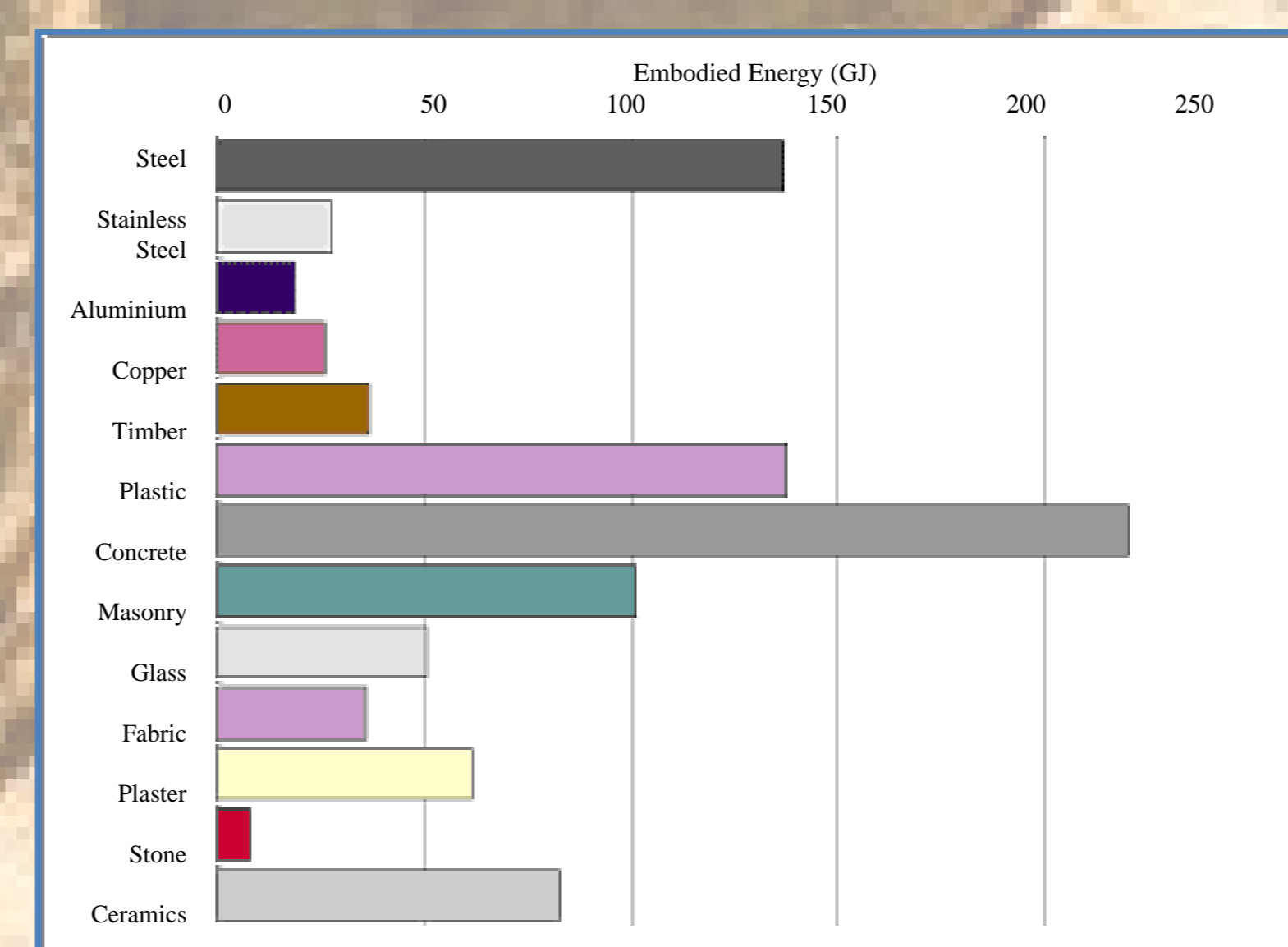

Figure 2: Embodied Energy in Buildings (www.tececo.com)

For concrete, replacing OPC (Ordinary Portland Cement) with GGBS (Ground Blast Furnace Slag), a by-product of steel manufacture reduces EE (Goggins et al 2010).

Visualisation

A web based analysis and visualisation tool will be implemented to calculate the EE of concrete. This tool will use all the different methods of EE analysis. The main functions of the tool include:

The option to change cement (CEM I, CEM II/A or CEM II/B)

To calculate energy values associated with aggregate, water, reinforcement and delivery

To calculate percentage wastage

These calculated figures will be compared and displayed graphically in terms of equivalent CO_2.

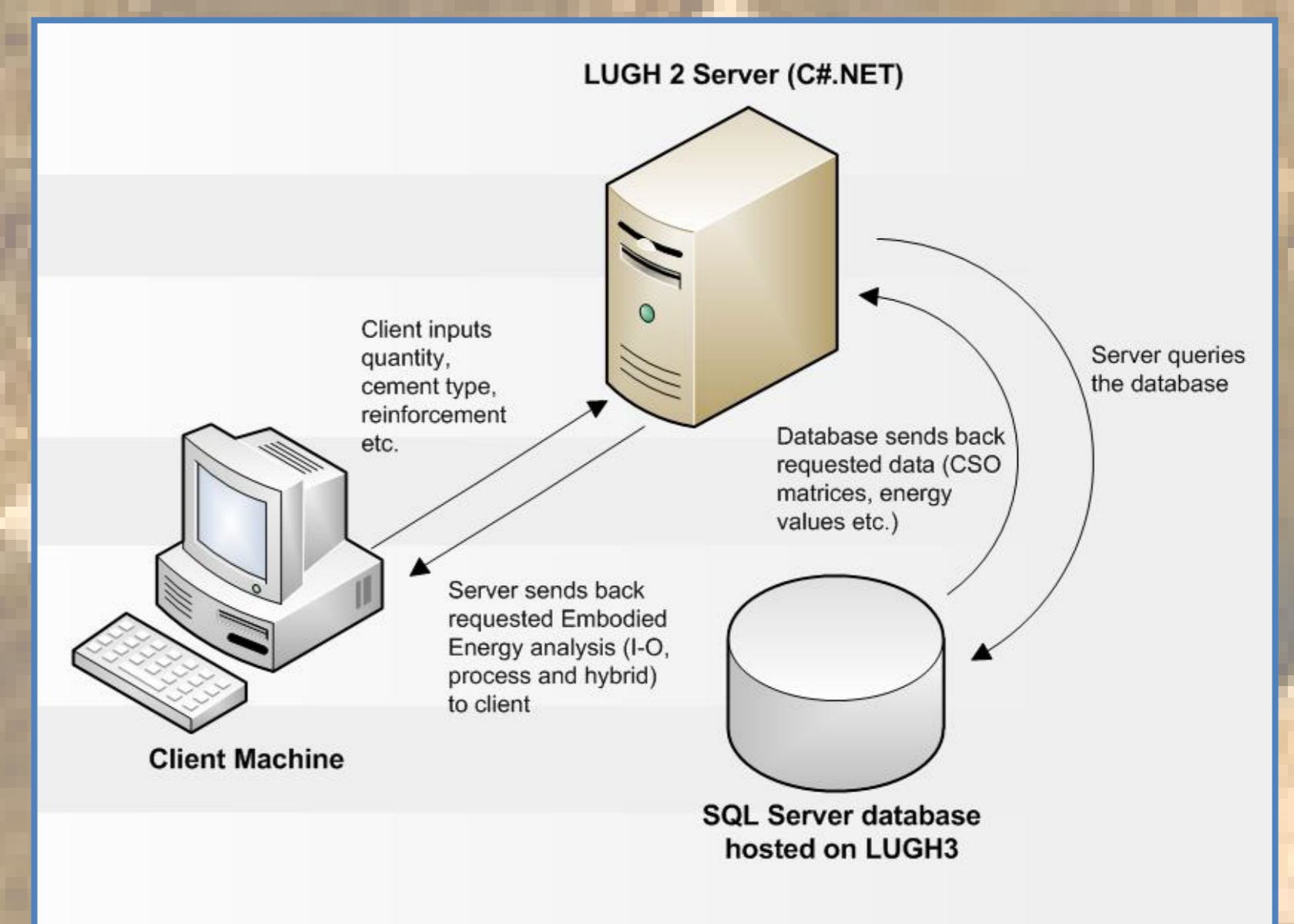The architecture is depicted in Figure 3:

Figure 3: System Architecture

The tool will be implemented via a website hosted by the LUGH2 server in the IT building and will interact with a SQL Server database, hosted on LUGH3.

References

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*d.oconnor22@nuigalway.ie

NUI Galway
OÉ Gaillimh