Using Enhanced IDEF-SIM (EnIS) Technique to Model Sustainable Supply Chains (SSCs) (Part II)

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Abstract

A Sustainable Supply Chain (SSC) is a complex supply chain management system which follows the tenets of sustainable development and encompasses multiple interconnected business processes across all four product life phases – Pre Manufacturing, Manufacturing, Use, and Post Use. Using the Enhanced IDEF-SIM (EnIS) technique presented in the previous work, this study will demonstrate the modeling capabilities of the technique on the automotive industry. In order to demonstrate this new technique, the Sustainable Supply Chain for Vehicles (SSCV) will be used.

Keywords: IDEF Technique; Sustainable Supply Chain; Enhanced IDEF-SIM

1.0 INTRODUCTION

Sustainable development is the ability to meet the needs of the present without compromising the ability of future generations (United Nations, 1987). Amongst the companies that have quickly responded to the issue of sustainable development are the Original Equipment Manufacturers (OEMs) of the vehicle industry. Vehicles are complex products that consume a lot of resources and energy during its four product life cycle phases of Pre-Manufacturing, Manufacturing, Use, and Post Use. The Pre-Manufacturing Phase refers to a group of business processes that took place before manufacturing of materials and components, and is usually associated with Mineral Extraction, Vehicle Research and Vehicle Design business processes. The second phase which is the Manufacturing Phase refers to a group of business processes which consists of Material Production, Component Manufacturing, Vehicle Assembly and Vehicle Distribution; whereas the Use Phase encompasses Vehicle Use, Vehicle Servicing and Vehicle Repair business processes. The final phase or the Post Use Phase is where vehicles are deemed to be no longer useable by its last owner and are disposed. It is in this phase that vehicles are identified as End-of-Life Vehicles (ELVs). Furthermore, apart from entering the Post Use Phase naturally (time-based), it is also possible that vehicles become ELVs prematurely (function-based) (Mat Saman and Blount, 2006).

In any case, the residual value of resources and parts available in ELVs are enormous and should be recovered. Recovering ELVs will enable the recycling of materials, the reuse of as-is components, and the remanufacturing of used parts into remanufactured spare parts. Plus, it would be better for the environment and society, as less landfills are needed and abandoned vehicles too will be recovered. Furthermore, by recovering ELVs the supply chain configuration for the vehicle will evolve from one being “open looped” to a “closed looped”. This is in line with the Closed Looped Supply Chain (CLSC) configuration definition provided by Blumberg (2005) and Amara and Barbosa-Povoa (2006). However, having a CLSC configuration alone does not mean a supply chain has achieved sustainability standards, as a Sustainable Supply Chain (SSC) is the planning and management of sourcing, procurement, conversion and logistics involved during Pre-Manufacturing, Manufacturing, Use and Post Use phases in the life cycle in closed loop through multiple life cycles with seamless information sharing about all product life cycle stages between companies by explicitly considering the social and environmental implications to achieve a shared vision (Badurdeen et al, 2009). Based on this definition, a SSC would be a super system which is made up of multiple interconnected business processes stretching across the entirety of the product's life cycle. In the case of vehicles, its Sustainable Supply Chain for Vehicles (SSCV) would even include multiple tiers of sub-business processes operating within a single business process.

Furthermore, unlike conventional forward vehicle supply chains where numerous companies converge their resources and information at OEMs, there exist a second converging point for SSCV and it is located at the reverse end of the supply chain. The reverse end of the supply chain would also be the location for all of the Post Use Phase business processes. Therefore, in order to systematically understand the complex relationship between all business processes involved and the infrastructure in place, a holistic model of the entire SSCV is required. In this study, the Enhanced IDEF-SIM (EnIS) technique describe in the previous work will be used to demonstrate its potential.

2.0 MODELLING USING THE EnIS TECHNIQUE

The EnIS technique is similar to both the IDEF0 and Enhanced IDEF0 techniques in terms of organizing the modelled environment into hierarchical structures. This hierarchy is given in Table 1, and is made up of six tiers: (1) Super System Layer, where only node A0 is modelled; (2) System Layer, where nodes represent individual business processes; (3) Sub-system Layer, where nodes model business functions that existed within each System Level nodes; (4) Group Layer, where nodes model groups of processes that existed within each Sub-System Level nodes; (5) Process Layer, where nodes are used to represent processes that existed within each Group Level nodes; and, (6) Agent Level, where nodes model individual agents working within each Process Layer nodes. In order to demonstrate the modelling potential of the EnIS technique, two business processes from the SSCV Relationship Model shown in Figure 1 is chosen. The two business processes are: (1) the ELV Collection business process; and, (2) the Depollution business process.

Table 1. Enhanced IDEF-SIM technique modelling hierarchy

Tier	Layer Name	Node Numbering Format	Representation
1	Super System	A0	Entire supply chain
2	System	A1, A2, A3 … A*x*	Business Process
3	Sub-System	A1-1, A1-2, A1-3 … A1-*x*	Business Function, Department, Shop
4	Group	A1-1-G1, A1-1-G2, A1-1-G3 … A1-1-G*x*	Section, Line
5	Process	A1-1-G1-P1, A1-1-G1-P2, A1-1-G1-P3 … A1-1-G1-P*x*	Process, Machine, Jig, Equipment
6	Agent	A1-1-G1-P1-1, A1-1-G1-P1-2, A1-1-G1-P1-3 … A1-1-G1-P1-*x*	Individual Worker

2.1 Modelling of Node A14

The first Post Use Stage business process is the ELV Collection Business Process, and its EnIS model is shown in Figure 2. In this Business Process, both premature and natural ELVs are collected together with OEM's End-of-Use (EoU) Development Vehicles, Prototype Vehicles, and Benchmarked Vehicles. Besides collecting ELVs, this business process also collects Abandoned Vehicles (AVs). Upon processing, all collected ELVs and AVs will be sold to the next business process as either Sorted – Good Quality, Sorted – Poor Quality, or Unsorted ELV. Therefore, demand for which type of ELV is needed, plus the availability of ELVs and AVs in the market will be essential information that this business process needs to manage. ELV Collectors would also need to understand the appropriate know how, capability, performance, and technology required to operate the business process. In terms of energy required by this Business Process, it can either be self-generated or taken from the main electrical grid.

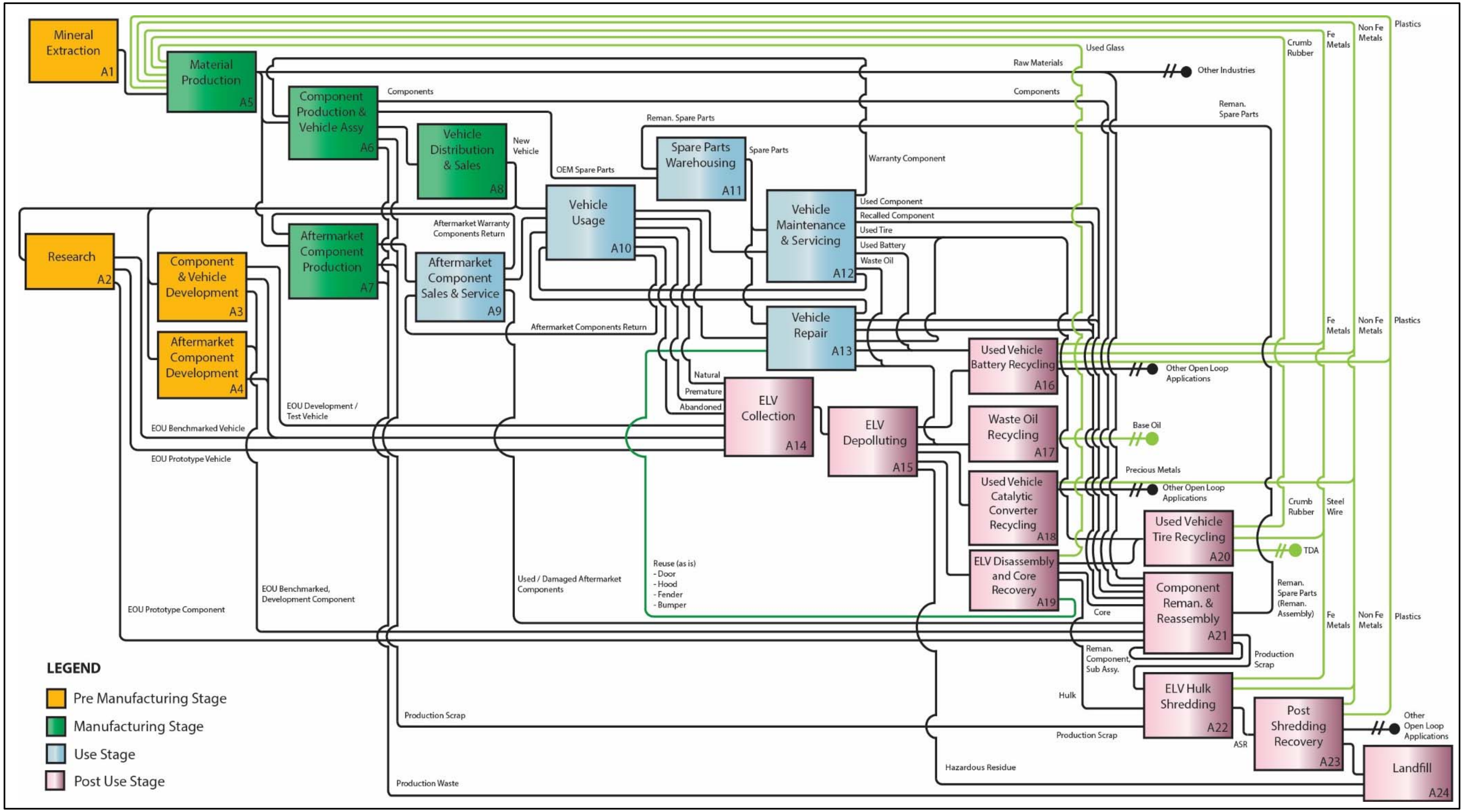

Figure 1 Sustainable Supply Chain for Vehicles (SSCV) Relationship Model

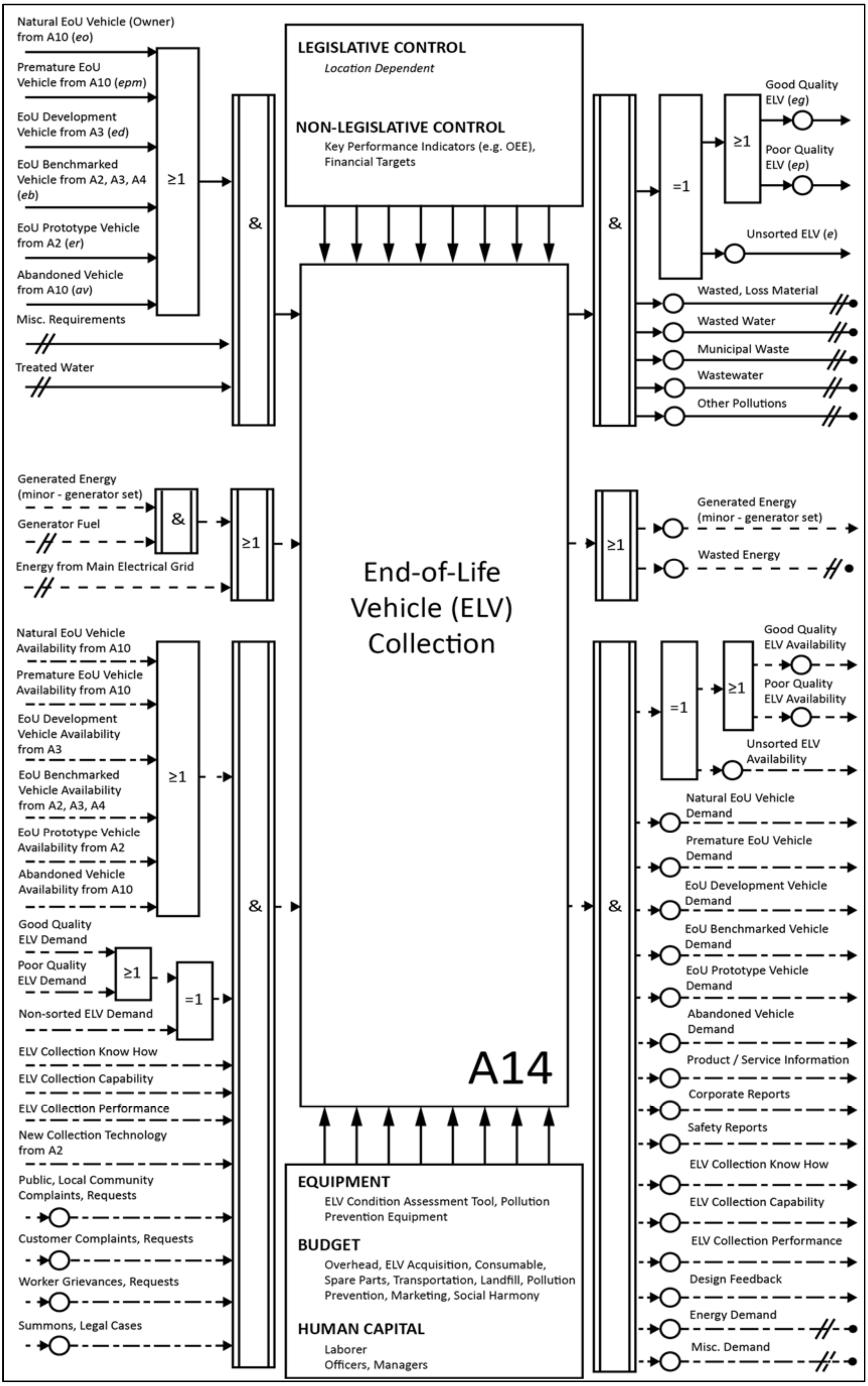

Figure 2 Enhanced IDEF-SIM relationship model for ELV Collection Business Process (Node A14 of the SSCV)

2.2 Modelling of Node A15

The ELV Depolluting business process is the second Post Use Stage business process for the SSCV, and its EnIS model is shown in Figure 3. In this business process, ELVs are acquired from the previous business process and is depolluted. The resulting depolluted ELVs are then sold to the next business process as either Sorted Depolluted ELVs or Unsorted Depolluted ELVs. Apart from depolluted ELVs, parts removed by the depollutioning process are also sold to its respective buyers making this business process a diverging node in the supply chain. Therefore, the management for the numerous parts and product demand would be critical to avoid this business process from holding excessive inventory. Furthermore, adequate know how and technology on ELV depollutioning and hazardous material management is critical in ensuring environmental protection and societal wellbeing. In terms of energy required by this Business Process, it can either be self-generated or taken from the main electrical grid.

3.0 CONCLUSION

The proposed Enhanced IDEF-SIM (EnIS) technique proposed in the prior work is demonstrated here on two business processes within the SSCV Relationship Model. Based on the two models, the EnIS technique is more than capable to model Sustainable Supply Chains as it allows entities to be separated into material and product, energy, and information entities. Furthermore, by adopting IDEF3 rulings instead of the rulings proposed by IDEF-SIM, the EnIS technique is more flexible in modelling complex relationships. Financial models are also possible to be derived from such a detailed representation of the object, be it at business process level or below. It was also shown that the EnIS technique is capable to model six layers of systems, and this would allow the hierarchical modelling of agents, with its relationships traceable up until super-system level. However, as stated in the previous work, even though it is possible to model agent relationship, there are more work to be done to model agent behaviour using EnIS.

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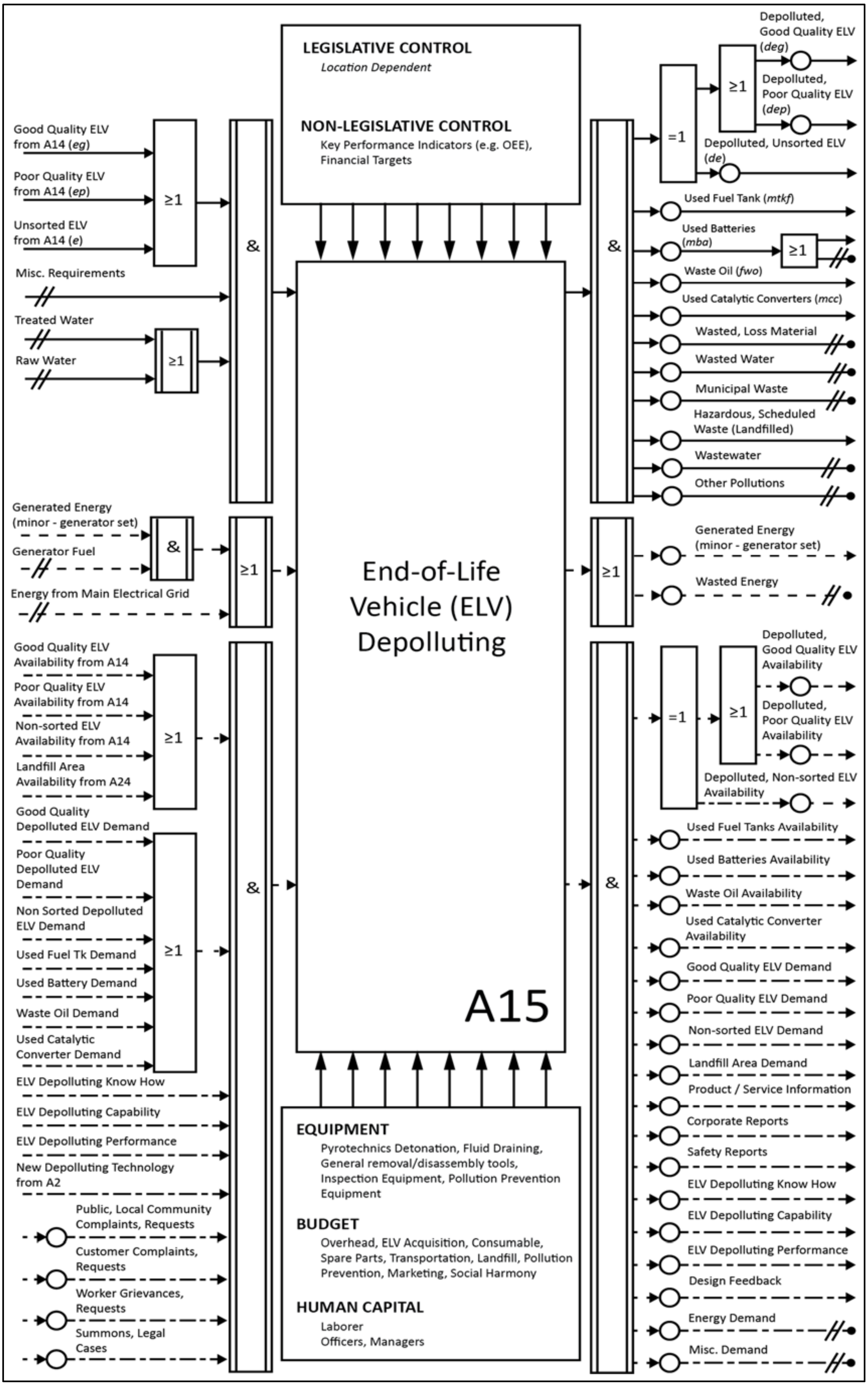

Figure 3 Enhanced IDEF-SIM relationship model for ELV Depolluting Business Process (Node A15 of the SSCV)