

Chapter 23

Logistics 4.0 Energy Modelling

Megashnee Munsamy

Mangosuthu University of Technology, Umlazi, South Africa

Arnesh Telukdarie

Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg, South Africa

Pavitra Dhamija

Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg, South Africa

ABSTRACT

Logistics activities are significant energy consumers and known contributors to GHG emissions, hence optimisation of logistics energy demand is of critical importance. The onset of the fourth Industrial revolution delivers significant technological opportunities for logistics optimisation with additional benefits in logistics energy optimisation. This research propositions a business process centric logistics model based on Industry 4.0. A Logistics 4.0 architecture is developed comprising Industry 4.0 technologies and associated enablers. The Industry 4.0 architecture components are validated by conducting a Systematic Literature Review on Industry 4.0 and logistics. Applying the validated Logistics 4.0 architecture to a cyber physical logistics energy model, based on the digitalisation of business processes, a comprehensive simulation is developed identified as the Logistic 4.0 Energy Model. The model simulates the technological impact of Industry 4.0 on a logistics network. The model generates energy and CO₂ emission values for “as-is” and “to-be” Industry 4.0 scenarios.

INTRODUCTION

Logistics operations is an essential component of the economy for movement of raw materials, in-process goods and finished products contributing to the gross domestic profit of a country and influencing social development. Logistics operations are also accountable for delivery of essential items of food and medicines (Liu, Yuan, Hafeez, & Yuan, 2018).

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Logistics operations may be in-house, a sub function of the business or external such as third-party logistics enterprises and comprises warehousing and distribution sites. Warehousing is required for storage of goods to achieve planned delivery targets, whilst distribution facilities include delivery and receiving stations for checking of goods specification prior to acceptance or issue for delivery. There are several modes for delivery of goods; road, rail, air and sea, with most being fossil based such as diesel, heavy fuel oil, unleaded kerosene, naphtha kerosene blend and low sulphur fuel oil. Additionally, logistics operations require goods movement equipment of forklifts, reach truck and pallets stackers, all of which are traditionally fuel based. Hence logistics operations are contributors of Green House Gas (GHG) emissions (To, 2015). Global freight emissions are predicted to increase by 160% in 2050, unless appropriate reduction measures are implemented (Liu et al., 2018).

The concept of Green Logistics (GL) is developed, which aims at developing environmentally sustainable logistics operations (Liu et al., 2018). In achievement of GL, GHG emissions reduction is required, hence the fuel and electrical energy demand of logistics operations require optimisation.

Presently, all industrial sectors are undergoing the Fourth Industrial revolution, the digitalisation of industry. The suitability of Industry 4.0 for optimisation of the logistics industry is acknowledged in literature (Hofmann & Rusch, 2017). Application of Industry 4.0 enables identification of solutions for resolution of current challenges to logistics operations of third party networks, flexibility, coordination, cooperation, collaboration, integration of key processes and global components and energy optimisation (Kain & Verma, 2018). Energy saving of 10-30% is achievable by adoption of Internet of Things, an Industry 4.0 technology (CGI, 2017). This research investigates the potential application of industry 4.0 technologies to simulate and optimise logistics processes.

The research theoretical contribution is in logistics and industry 4.0. Energy models is a well-established methodology for energy evaluation and optimisation. Due to the recent developments of Industry 4.0, energy models have minimal integration of Industry 4.0 technologies and the impacts to energy demand. In resolution of optimisation of logistics operations forwarding reduction of energy demand and GHG emissions, application of Industry 4.0 technologies is proposed. This presents a research gap of a lack of an appropriate tool to evaluate the energy demand of Industry 4.0 enabled processes and comparatively analyses the impacts of Industry 4.0 technologies on energy demand. A Logistics 4.0 Energy Model is proposed that evaluates the impact of Industry 4.0 technologies on logistics operations energy demand and GHG emissions.

The researchers' review best practice architecture and technology components that collate to deliver a Logistics 4.0 Energy Platform. The researchers adopt a multinational logistics business model, superimpose Industry 4.0 Architecture and add technological digital components for integration and automation. This Logistics 4.0 Energy architecture is reviewed relative to research publications. The authors finally provide a simulation based on the Logistics 4.0 Energy model.

DEFINITION OF A TRADITIONAL MULTINATIONAL LOGISTICS BUSINESS ARCHITECTURE

The team commenced the research by developing a baseline using current scenarios. A business model view of a logistics business is constituted to define the enablement landscape to deliver on logistics. This includes strategic, operational and control components. Strategic components, usually developed in an Enterprise Resources Planning platform comprises:

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