STRATEGIES FOR RESILIENT SUPPLY CHAIN WITHIN A CIRCULAR ECONOMY ENVIRONMENT: APPLICATION OF SYSTEMS DYNAMIC APPROACH TO THE UK (GRID UPGRADE) ASTI FRAMEWORK

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BACKGROUND & MOTIVATION

The global natural ecosystem is shrinking in size and volume, and the traditional linear extract-produce-use-dump model is unsustainable[1].

The linear system generates wastes and emissions in harmful concentrations which inhibits replenishment and restoration of the natural ecosystem [2], leading to depletion and shortages of resources that are increasingly challenging the ecosystem in the form of hurricanes, drought, forest fires, Pandemics and climate change [3].

Other factors include urgency for decarbonization, acceleration of net zero targets – 50GW Renewable energy by 2030, Geopolitical tensions, energy security and SDGs [4].

There is need for alternative novel approaches and Circular economy (CE) presents a new practical approach to sustainable development and reducing emissions [5]

OBJECTIVES

- To analyze supply chain (SC) resilience in the context of a circular economy and identify key stages, operations and activities that conceptualizes a circular supply chain for the UK Energy transmission sector.
- To develop SC models using systems dynamics (SD) approach for testing hypothesis and strategies / scenarios to identify resilience factors and their influence on the SC behavior.
- To understand impacts of circularity on energy transmission SC and identify opportunities to improve resilience and develop more resilient strategies.
- To validate SD as a suitable methodology for understanding SC behavior in the CE context.

CAUSAL LOOP DIAGRAM: RESILIENT CAPABILITIES

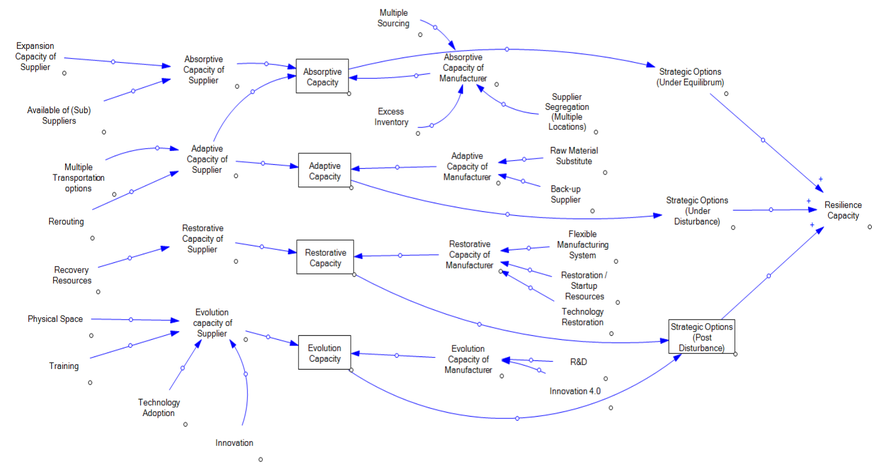

Figure 1: Causal Loop Diagram of Resilient Capabilities.

SYSTEM DYNAMIC MODELS(S)

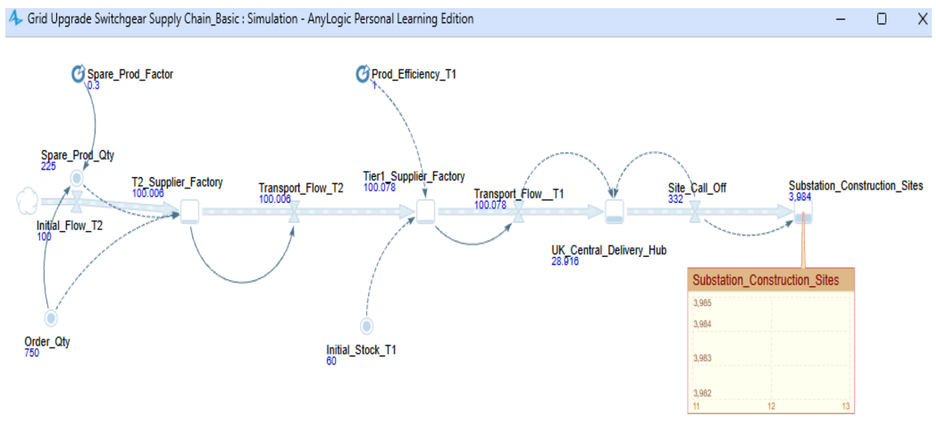

Figure 2 : Linear 400KV GIS SC Model under Equilibrium (Absorptive Capacity)

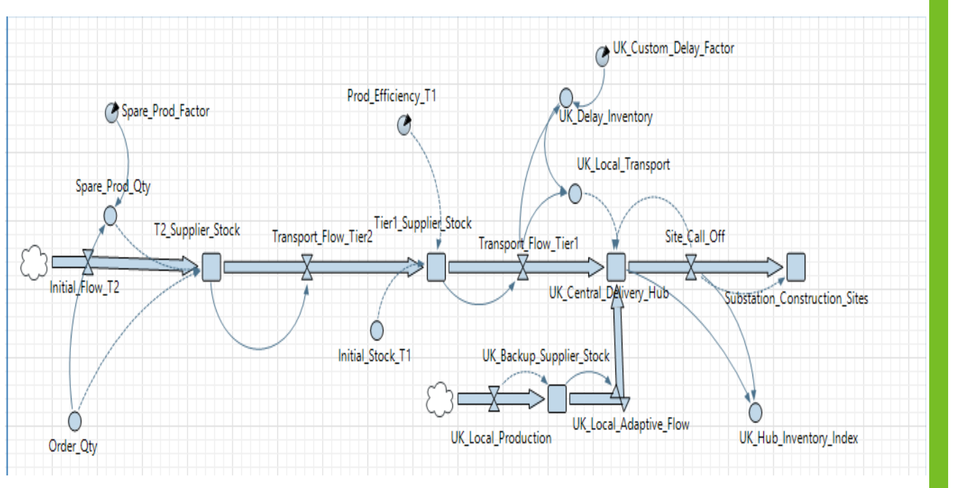

Figure 3: 400KV GIS SC Model with (Local) Adaptive Capacity.

400KV GIS HALL

Figure 4: 400KV GIS Indoor configuration

400KV GIS SUBSTATION

Figure 5: 400KV GIS Outdoor Configuration

Figure 6: Onshore Converter Station Overview

INTERPRETATIONS OF PRELIMINARY FINDINGS

I. Systems dynamics modelling is a suitable methodology for researching SC resilience.

II. The effectiveness of a resilience strategy is dependent on factors internal and external to the Individual project(s) or organization(s).

III. Resilience analysis of the ASTI Framework SC is better when considered at a cluster or region level.

APPROACH

- Conceptualize the energy Transmission SC.
- Develop and analyze Causal Loop Diagram to understand key factors influencing resilience in the supply chain.
- Develop systems dynamic Models under specific boundary conditions and run simulations.
- Propose strategies for improving resilience and development of more resilient strategies

NEXT STAGES OF RESEARCH

- Expand the Causal Loop Diagram to identify and reflect specific circular strategies.
- Develop and validate systems dynamic models of circular resilient strategies for Transmission sector – develop a model to reduce inputs for 400kv SF6 Free GIS Substation Construction and Installation.
- Simulate scenarios/strategies, analyze results and make recommendations accordingly.
- Publication of results and completion of Thesis.

PUBLICATION

Nwonu, E, Munive-Hernandez, E and Dao, C. “Developing a framework to improve supply chain resilience for offshore wind energy organizations using a circular economy approach”, Conference Proceedings of the 8th Industrial Engineering and Operations Management Conference, Paris 2025.

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