Application of the Agile Energy Model to the Procure to Pay Process

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Abstract - **Multinational Manufacturing Corporations (MMC's), which account for a fair percentage of the manufacturing industry encounter challenges with energy quantification and optimisation. Traditional energy models, which have long been used for energy system evaluations have limited application at MMC's due to model characteristics of high level of expertise, data and time intensive, long time horizons and large spatial detail. The Agile Energy Model utilises business processes for energy evaluation and optimisation. The features of the Agile Energy Model supporting application at MMC's are generic, reproducible, ease of use, minimum user input data and time requirements and transparency of the evaluation process. It enables the energy quantification of non-traditional activities of finance, HR, ICT and sales and marketing. The methodology of application of the Agile Energy Model is demonstrated with the established procure to pay process.**

Keywords - **Agile Energy Model, energy systems modelling, Multinational Manufacturing Corporation**

I. INTRODUCTION

Energy systems' modelling is not a new concept and has always been utilized in its basic form as energy balances, with the oil crisis of the 1970's focusing attention on the benefits of energy systems' modelling[1-3]. Energy modelling is a tool utilised by industry, government, academia and researchers to [1-3]:

- review and optimise current energy systems,
- forecast energy demand,
- develop energy pathways,
- assist in policy analysis and development,
- identify the interaction and relationships between energy-economy, energy-environment and energy-economy-environment.

Energy modelling is complex and continuously evolving due to the dynamic nature of energy systems; security of resource availability and political, environmental, economic and social changes[1]. Traditional energy models focus on either the energy sector only, the energy-economy or the energy-economy-environment[1]. These models typically characterise the energy system from primary energy resource through conversion technologies to final energy demands for specific geographic dimensions, as illustrated in Fig. 1[1]. A review of 11 energy system models; E3ME, GEM-E3, REMIND, OSeMOSYS, NEMS, MARKAL, MESSAGE, POLES, TIMES, WEM and LEAP is conducted to [1, 2, 4, 5]:

- determine the purpose/application of energy models: energy optimisation, greenhouse gas emissions reduction and policy analysis,
- characterise the energy models: input data intensity, skills and time requirements, model complexity, spatial detail and time horizon and
- comprehensively analyse the energy models.

The review identified the following characteristics hindering the application of traditional energy models at Multinational Manufacturing Corporations (MMC's):

- Scope of application: A MMC is spatially smaller in comparison to the local, national, regional and global geographic dimensions.
- Long time horizon: Typically utilised for medium to long term analysis and planning as the impact of change in the above mentioned geographic dimensions are realised after a period of time. A MMC has to focus on the short, medium and long term, as the impact of change is rapid.
- High data requirements: Availability of recorded data varies among MMC's and the integrity and situational validity of the recorded data has to be assessed.
- Time intensity: MMC's may not have the option of long data gathering periods, as it impacts business performance.
- Diversity of MMC's: All the operational activities of a MMC, ranging from HR to production, contribute to the energy profile of a MMC and thus has to be evaluated.

These limiting characteristics together with a business centric approach is used to develop the Agile Energy Model, which utilizes business processes for energy evaluation and optimization at a MMC. The key features of the Agile Energy Model distinguishing it from traditional energy models and supporting its application at MMC's are [1]:

- Generic: The methodology and approach is consistent, with only the business processes differing across MMC's.
- Reproducible: Various sites of a MMC may follow the same manufacturing process, thus when conducting the next evaluation for the same manufacturing process only specific user inputs require updating. This ensures that only the first MMC energy evaluation starts from a base zero.
- Minimum modelling and data collection time: This is enabled by the business processes and energy resources databases.

- Integration of human behaviour: Business processes explicitly details the activities and requirements of personnel hence demonstrating the impact of human activities on energy consumption.
- Transparency of the evaluation process: Each step of the energy evaluation process is clear and justifiable. The databases provide transparency and consistency of inputs.

This paper outlines the development and the methodology of application of the Agile Energy Model.

II. ANALYTICAL HIERARCHY PROCESS

Analytical Hierarchy Process (AHP) is a methodology for aiding in decision making developed by [6]. It is used by government, industry, academia, research and public institutions for multi-criteria decision making, planning and resource allocation, conflict resolution and prioritization[6]. AHP is applied to priority rank the reviewed energy models together with the Agile Energy Model for application at MMC's.

The first step in the AHP process is the pair-wise comparisons of the criteria for evaluation of the alternatives, with the alternatives being the energy models. The criteria for evaluation of the 12 energy models are: data intensity; modelling time including data collection and model simulation; skills requirement; model reproducibility; use of proprietary software and applicability to MMC's. The six criteria are pair-wise compared using the Saaty Rating Scale and the weighting of each criterion is determined. The criterion applicability to MMC's is identified as having the highest influence on the selection of the energy model. To validate the consistency of the ratings of the pair-wise comparisons, the consistency ratio (*CR*) is calculated. The *CR* is less than 10%, thereby validating the results. A *CR* greater than 10% indicates a high inconsistency in comparisons[6].

The next step is the priority ranking of each alternative for each criterion, to determine the energy model rankings. The *CR* is calculated for each criterion and is below 10%, confirming consistency of comparisons. The results ranked the Agile Energy Model as having the highest priority followed by the E3ME energy model, with a difference of 40% between the two. This large difference is attributed to the Agile Energy Model design being specifically aligned to the requirements of a MMC as compared to that of the E3ME model. The E3ME model has a significantly larger geographic dimension and considers the interaction among energy-economy-environment.

The findings of the AHP further support the development of the Agile Energy Model.

III. AGILE ENERGY MODEL

The fundamentally different approach of the Agile Energy Model is illustrated in Fig. 1 and Fig. 2.

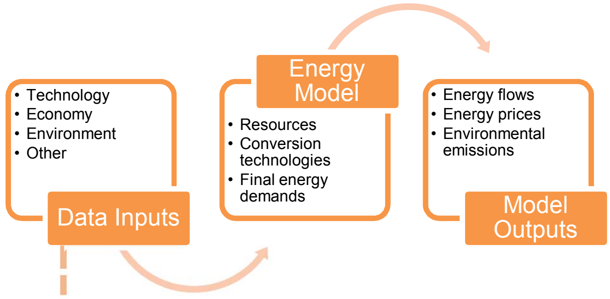

Fig. 1. Traditional approach to energy modelling

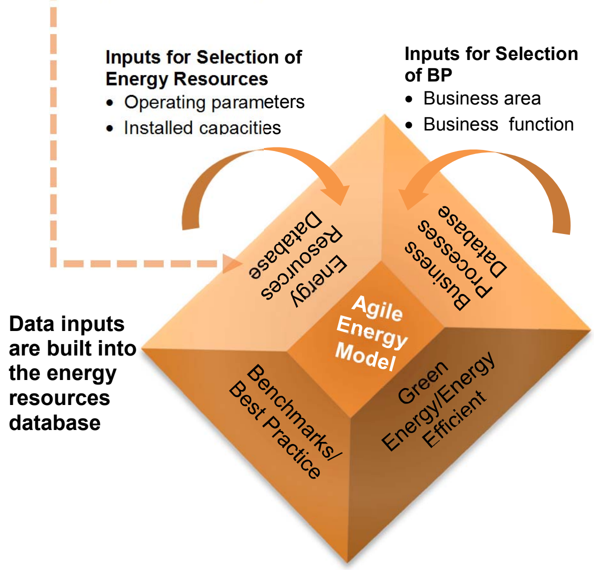

Fig. 2. Agile Energy Model approach to energy modelling

The two databases are the building blocks of the Agile Energy Model, with the remaining two blocks specifically utilized for optimization.

A. *Business Processes Database*

This database enables the fundamental change in approach of the Agile Energy Model, the use of business processes. A review of the following well established business process hierarchies is conducted; ARIS process architecture, SAP process hierarchy and the APQC process classification framework[7-9]. The review highlighted a number of similarities in the hierarchical frameworks and stemmed the development of the four level hierarchical framework for the business processes database, as illustrated in Fig. 3.

The primary source of data for Levels 0 to 3 is [9] due to its generic nature but extensive detail. The database has 16 enterprise functions, 78 business functions, 279 business process and 835 process steps, with expected increase in the number of business functions, business processes and business process steps.

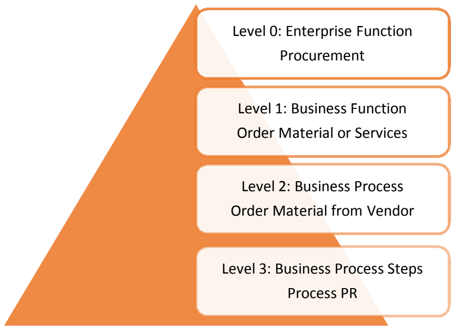

Fig. 3. Business process hierarchical framework

B. *Energy Resources Database*

This database contains an extensive range of energy resources required by a MMC, consequently negating the need for intensive user inputs. The database is expected to have in excess of 1000 unique energy resources, necessitating the database be broken down into four categories:

- Building: This includes ventilation, lightning, and HVAC.
- ICT: This includes computers, servers, network connections, telephones and security devices.
- Logistics: This includes all fleet vehicles and warehouse equipment.
- Manufacturing: This includes all process equipment such as compressors, heat exchangers and distillation columns and control and instrumentation.

The database is structured on the design characteristics of the energy resource and includes a number of sub-levels. At the lowest sub-level, which describes a specific resource, the operating parameters, capacity and power demand of the resource is quantified and categorised as low, medium or high. The operating parameters are defined as the critical parameters influencing the size/capacity and power demand of the resource. The classification ceases when the difference in power consumption of the sub-levels is negligible. A compressor from the manufacturing database is detailed below, with Level 0 being the compressor.

- Level 1: Positive displacement
  - Level 1.1: Reciprocating
    - Level 1.1.1: Single acting
    - Level 1.1.2: Double acting
  - Level 1.2: Rotary
    - Level 1.2.1: Single rotor
    - Level 1.2.2: Multi rotor
- Level 1: Dynamic
  - Level 1.1: Centrifugal
    - Level 1.1.1: Single stage
    - Level 1.1.2: Two stage
  - Level 1.2: Axial

This structure results in each energy resource having its own unique identifier such as "Compressor_Positive displacement_Reciprocating_Single_acting," which is utilised to:

- identify the user specified energy resource in the database,
- identify the specific operating parameters requiring user input and
- classify the resource power demand and size as either low, medium or high.

The unique identifier together with the breakdown of the database into four categories streamlines the modelling process, considering the large volume of data being processed for each evaluation, whilst supporting database management.

For validation and application of the Agile Energy Model two manufacturing sectors are considered; the petrochemical and steel manufacturing sectors. The selection of these two sectors are guided by their high energy intensity and their significant presence in South Africa. The petrochemical industry, which is inherently complex and diverse is an excellent test environment for the Agile Energy Model.

C. *Modelling Methodology*

The Agile Energy Model applies a simple methodology for the solution of a complex problem. The complexity of operations of MMC's are captured in the scope and detail of the business processes database, whilst illustrating the codependency among business functions. The codependency is clearly demonstrated with a maintenance activity, which requires co-operation among the production, maintenance and planning departments. If materials require purchasing, it extends to the procurement, logistics and finance departments.

The modelling methodology is illustrated in Fig. 4. The user does not directly interface with any of the databases in the model.

IV. DEMO OF THE AGILE ENERGY MODEL

To demonstrate the application of business processes for energy evaluation, a demo of the Agile Energy Model is developed in Microsoft Excel VBA. The demo model demonstrates the process from business process selection to energy demand quantification for the selected business process. At this initial stage of model development, energy optimization is not demonstrated.

The business process selected for energy evaluation is the procure to pay process, an established business process across all MMC's. The procure to pay process is a cross-functional business process, encompassing processes from the business enterprise functions of procurement, logistics and financial management, hence demonstrating the interdependencies' of business processes.

The first step is the selection of the business process, with the user interface illustrated in Fig. 5. Each user selection populates the proceeding list box until the business process is selected.

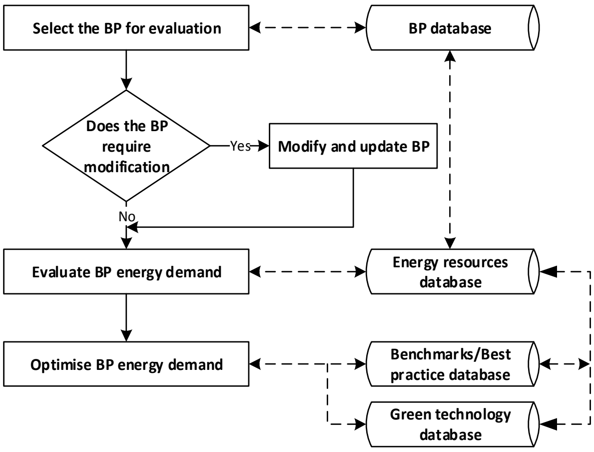

Fig. 4. Methodology for evaluation and optimisation

Once the user selects the business process, an active Microsoft Visio document opens. The user is required to review the selected business process and either modify the business process and/or continue to the next business process, if applicable, as illustrated in Fig. 6. Each business process is cross referenced to a proceeding business process, if applicable, which may not reside in the same business enterprise function. In this scenario, the "Order material from vendor" business process is cross referenced to the "Manage external inbound receipts" business process, which is part of the logistics function. This is further cross referenced to the "Accounts payable" business process, which is part of the financial management function. The selection and modification, if applicable, of the three required business processes completes the first step of the energy evaluation process.

The next step is the energy demand quantification of each business process. A menu displaying the selected business processes allows the user to select the required business process for evaluation, which may not be in the order of the selection process detailed above.

Similarly for the selected business process, a menu displaying the business process steps allows the user to select the required step. Thus the user can select the business process step in order of the process or not.

Selection of the business process step requires the user to select the category of resources required; ICT, building, manufacturing or logistics. The user can only select one option, however once the energy resources are selected in the first category, the menu option is available for selection of another category. The selection of a specific category displays the available energy resources, with selection of a resource prompting the user for further clarity as required. The user is required to input the operational time for each selected resource. This process is illustrated in Fig. 7 for the "Order materials from vendor" business process, with the ICT database being applicable for all process steps. In the fully enabled Agile Energy Model, the model identifies the category of energy resources based on the unique identifier of each business process step, with the user

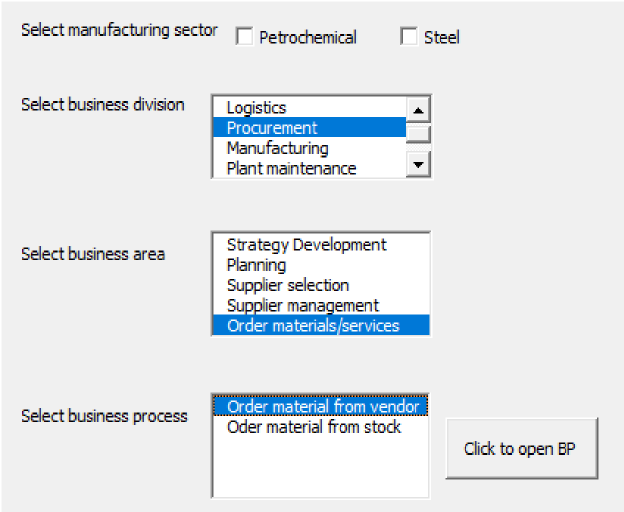

Fig. 5. Selection of business process for evaluation

having the option of agreeing to the selection or not. A single category of energy resources is not expected to be applicable to all process steps as illustrated in the "Order materials from vendor" business process, thus the automation of the selection in the fully enabled model.

The above process is followed for each selected business process to calculate the energy demand of the procure to pay process.

V. CONCLUSION

The review of existing energy system models clearly emphasized its limited applicability to MMC's. This together with the need for effective and efficient energy use, presented the opportunity for the development of the Agile Energy Model for MMC's. The keys features of the Agile Energy Model supporting its application at MMC's are; reproducibility, generic, ease of use and limited data inputs and modelling time.

The demo model demonstrated these features in the methodology of application to the procure to pay process, thus supporting the approach of business processes for energy evaluation at MMC's. However, this is the initial stage of development, with the fully enabled Agile Energy Model expected to be "intelligent" and comprehensive and encompassing all activities from quantification of baseline energy demand to an optimized energy system.

Future work is to develop and validate the fully enabled Agile Energy Model. A case study is to be conducted at either a petrochemical or steel MMC, due to the complexity of operations and high energy demands.

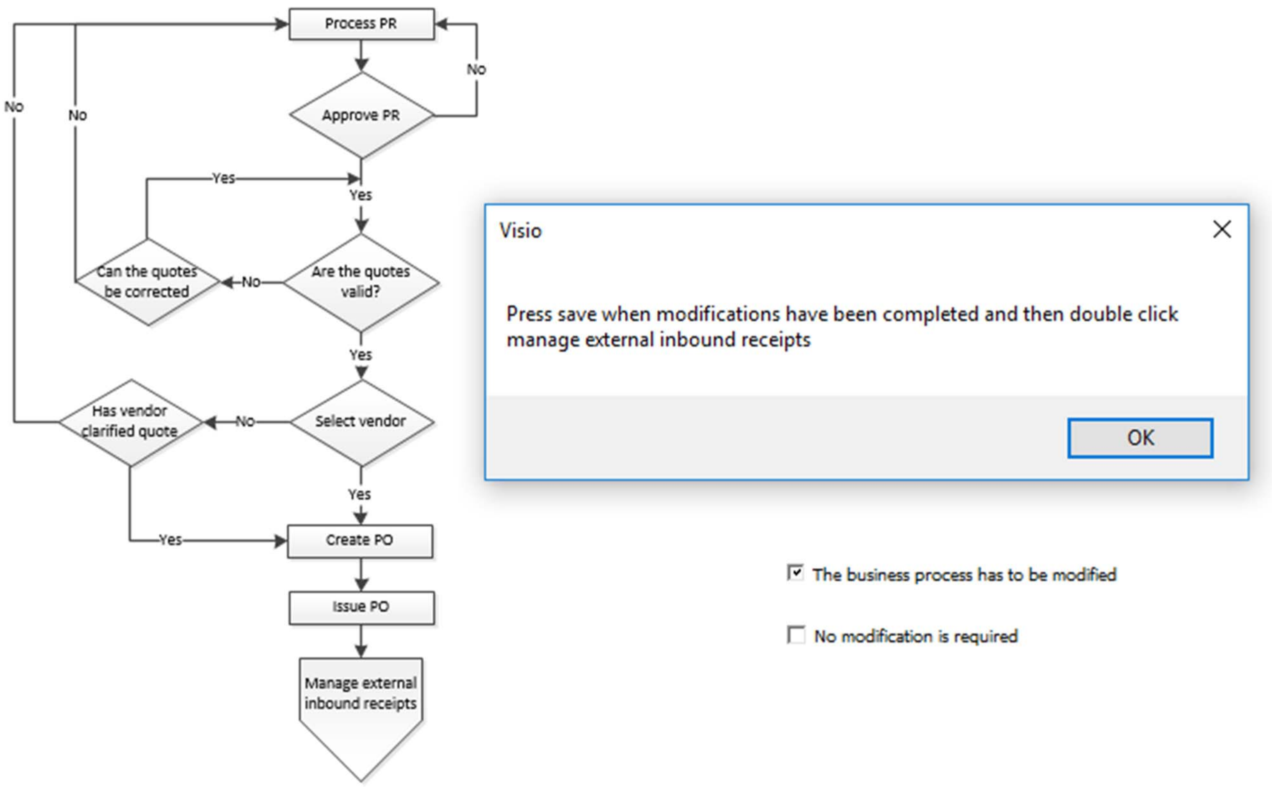

Fig. 6. Selected business process for review

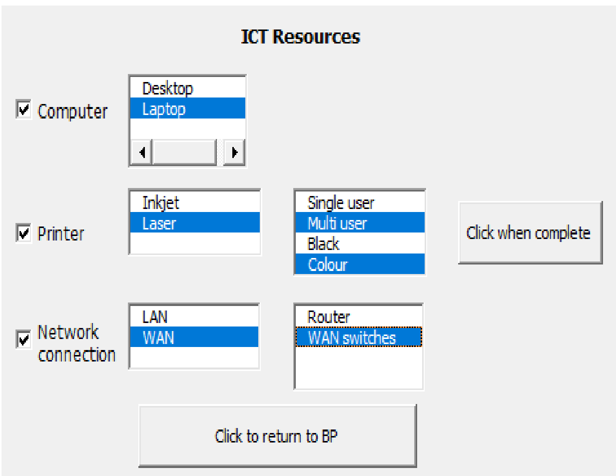

Fig. 7. Selection of resources from the ICT database

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