On Logistics Management for Prosumer Business Information System Development and Implementation

Full Paper

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Abstract

Managing prosumer businesses is challenging with different types of renewable and non-renewable energy resources. The development and implementation of energy systems pose additional challenges when prosumers pursue sustainable production while simultaneously trying to mitigate gas emissions and energy losses. Issues associated with energy emissions and supply shortfalls must be addressed before developing prosumer business information systems and reaping their benefits. Innovative IS (Information System) solutions are needed to align different energy systems and prosumer coalitions that require cautious implementations. The purpose of the research is to develop IS artefacts, strategizing energy systems, establishing essential logistics requirements for smart-grids to ensure sustainable energy supplies. A conceptual Prosumer Business-based Design Science Information System (PBDSIS) framework is developed, collaborating IS articulations of prosumer business data artefacts in ecologies, where energy production and distribution need crucial logistics support and implementation of IS artefacts. The framework is implemented in prosumer business domain using open-source data.

Keywords: Business information systems, design science and action research, prosumers, energy trading

1 INTRODUCTION AND MOTIVATION

Energy is produced by both conventional and unconventional resources and consumed by a variety of users. Managing various types of resources is a serious challenge facing businesses in the prosumer energy production and trading sector. The prosumers carry out diverse business operations without green energy strategies in place and smart-grid operationalization in rigid logistics (Espe et al. 2018). Clean energy production, uninterrupted supply of energy and prosumer coalition objectives have motivated this research on prosumer business. The delivery of affordable and quality prosumer products and services to masses are other related areas of research. The means by which IS and its robust articulations can facilitate the construct design and delivery of quality products and services to masses at reasonable prices needs to be made explicit. Broadly, the aim of this study is to integrate the IS approach with prosumer business research and demonstrate how smart-grid-based energy supplies can be managed using IS articulations. Case studies suggest that businesses have avoided failure and been more successful when they have implemented knowledge-based IS, and the success is measured in terms of productivity and profitability (Li et al. 2013; Bari et al. 2014; Forms of Energy 2019).

We introduce Design Science as an accepted IT research approach to schematize artefacts, generate various framework articulations and accommodate multiple design features in action-based prosumer business energy research (Espe et al. 2018). Collaborative efforts with Design Science (DS) and Action Research (AR) features have motivated us to strategize and generate IS-based artefacts needed in smart energy grid blueprints, while managing prosumer coalitions and accepting conventional and unconventional energy resources in clean energy environments. The research investigates new pathways of IS articulations and develops prosumer energy DS tools to prepare for system implementations while managing prosumer coalitions in clean energy environments. The tools needed for the design of new artefacts are examined. In addition, we plan to assess the existing artefacts in terms of improvements needed to motivate the prosumers and their affected attribute dimensions of the energy systems. Typical attributes include electricity generation and consumption, various greenhouse gas emissions with added electricity generation from coal, natural gas and oil resources and countrywide energy-emission patterns. Power transmission losses and energy use affected by greenhouse emissions are other factors considered in the modelling. Production of electricity (mostly from coals), the types of coals and the amount of electricity generated are key attributes. Renewables and non-renewables are compared to perceive the knowledge of energy strategy, how it can affect the business design-science-guided prosumer coalitions and energy grid plans. To take DS and AR features into account in energy business research, a conceptual framework is needed to connect prosumers through various IS artefacts in spatial dimensions and cognize the spread of greenhouse gases. In addition to meeting utility grid requirements and develop coalitions, we have analysed the energy patterns of prosumers in both renewable and non-renewable environments, and their usage in different spatial contexts, in particular, the energy scenarios of a developed country.

The paper is structured as follows. The need for current research, the motivations for IS design and pathway descriptions including design and action-based research for prosumer energy strategies with smart grid layouts are presented in Section 1. Section 2 comprises the literature survey and its evaluation within the prosumer-energy domain. The research goals, research questions and objectives are stated in section 3. In Section 4, the research approach taken, the need for DSIS smart energy grid pathways, their descriptions and presentations, including the requirements of design-science and action-research, are explained. The overall methodological approach of DSIS and the guidelines for implementation of artefacts in prosumer energy business design-science, including evaluation specifications are discussed in Section 5. The conventional and unconventional digital energy systems are also described. Various design aspects of digital energy systems, with additional insights about big data in smart energy systems, are provided. Data, visual, and interpretation analytics are illustrated with data views acquired from cuboid metadata structures. Results and discussions of models and methodologies, including the outcomes of prosumer digital energy, are described. The conclusions and future research outlook are presented in Section 6.

2 RELATED WORK AND ITS EVALUATION

In addition to the general statement, the literature review reveals research gaps that need to be addressed and which help to define the research purpose. Before investing in prosumer business research development and the implementation of PBDSIS, the issues and challenges associated with greenhouse gas emissions, the causes and consequences of energy losses must be addressed. An increase in energy demand is felt when power resources are constrained. It has become necessary to improve energy supply management systems, reducing the complexity of prosumer energy systems with active, linked power grid strategies. Several power companies have adopted green energy solutions with little consideration given to prosumer business (Vinyals et al. 2012). Traditional power sources and loads, as well as new customer-owned devices such as storage units for electric vehicles, are discussed in El Rahi et al. (2016). Costello (2013; 2018) examine the key factors associated with prosumers and how organizations harness the power systems to corroborate with the IT Global market competition through personalization. Kotilainen and Saari (2018) investigate consumers' attitudes towards technology-driven renewable energy resources in five European countries, using an empirical research approach. The policies have an influence on consumers and producers in terms of decision-making strategies and adaptable renewable energy solutions. Eunice et al. (2018); Sumesh et al. (2019) examine the literature on prosumer community-based smart grids by reviewing relevant literature, published in reputed energy and technology journals between 2009 and 2018 (El Rahi et al. 2016). The literature focus is on prosumer community groups and prosumer relationships, presenting propositions and describing several energy research directions. However, in their research, the authors have not addressed the issues of prosumer coalitions and their connectivity or energy shortfalls. Current research is being conducted to understand how energy production and trading are affected by the issues of greenhouse gas emissions and transmission losses. Although prosumer-personalization can improve the software development cycles and innovations incorporating individual expert skills, the prosumer connectivity, types of energy sources considered in energy production and its shortfalls, have not been the focus of previous researchers.

3 ISSUES AND CHALLENGES

The problem of energy trading between prosumers and their businesses can be resolved when the production and consumption of energy are occurring simultaneously. The research goal is to meet energy demands at affordable prices by devising optimal prosumer business design-science IS artefacts enabling the acquisition and storage of renewable and non-renewable energy data sources. Without strategic prosumer-business-associated design-science IS artefacts, the blueprints may not be able to be sustained for power grids, which may be the case when greenhouse gas emissions affect the prosumer coalitions. It can affect the optimization of consumption as well as the distribution of energy resources in both renewable and non-renewable scenarios. The impacts of greenhouse gases and transmission losses may have to be taken into consideration when developing prosumer business information systems. The modelling of IS artefacts with improved energy management systems in such heterogeneous and dynamic environments is a significant step for smart energy grid deployment. Another challenge is posed by heterogeneous green energy environments, where effective design and evaluation of power transaction methods among players (substations, utility grid, renewable and non-renewable energy sources, electric cars, and users) are needed when dealing with greenhouse gases and energy shortfalls during distribution. With increased involvement of green energy sources and prosumer's capacity to control the renewable energy usage, new opportunities can arise for energy trading, encouraging the use of sustainable energy supplies in both energy environments. As a result, prosumers may have to efficiently solve problems related to what or where or when to trade energy (Bari et al. 2014). Even though the size of energy grids affects the energy distribution and localized energy trading markets with smart grids, their associations with other utility grids and energy management may at times complicate the energy supplies issues such as pricing (Tuballa and Abundo 2016). Different types of IS artefacts come with a variety of design features to integrate and connect different prosumer energy systems and their users. The DSIS-guided prosumer business in the current research has the added scope to evaluate and further iterate the artefact designs.

The previous researchers neither analyse prosumer-based business design-science nor consider various aspects of gas emissions and energy losses in their design that may affect the energy production and supplies in different geographic locations (Tuballa and Abundo 2016). In the absence of IS articulations, the energy market and coalition of prosumers may have compromised energy supplies (Espe et al. 2018). IS articulations with motivation of the DSIS with DS and AR features can search for disrupted connections between energy systems and prosumer coalitions. It can attract new energy users even in different logistics scenarios. Similar and dissimilar models can be envisaged based on the types of energy resources, prosumer coalitions in diverse logistics, and even on prosumer behaviours. The models may be visualized based on the size of the prosumer business design, supply and demand of energy to prosumers. In addition, the DSIS articulations can bring together categories of prosumers using similar and dissimilar energy systems, to determine efficient energy utilisation among micro-grids. Even customers are assessed in environments where energy interruptions and losses occur because of poorly connected grids and non-renewable greenhouse gases. The DSIS with DS and AR features can resolve issues of connectivity, interoperability and usability that may have been implicit in the logistics management, including smart energy grid design and development stages. Moreover, the implementation of smart energy grids in real-time environments, which needs flexible DSIS articulations and utility property evaluations even in Big Data magnitudes.

4 GOALS, RESEARCH QUESTIONS AND OBJECTIVES

Managing prosumer-energy information systems is analogous to organizing any business information system (Tuballa and Abundo 2016). A large number of heterogeneous and multidimensional data sources are managed by several energy players. Different types of data reside in many prosumer-based energy industries together with their linked applications in diverse knowledge domains. We aim to meet the following research goals and objectives:

1. To share a common understanding of the structure of entities and dimensions of artefacts linked to different digital energy systems; and to use and reuse data structures with domain knowledge in multiple contexts when building logistics for prosumer coalitions;
2. To make domain assumptions flexible in terms of interpretation and implementation, in case the prosumer knowledge about the domain changes; and
3. To analyse the prosumer business-domain knowledge through data mining and visualization artefacts. Data views extracted from warehoused digital energy-based prosumer metadata can be visualized in new knowledge domains.

Research Questions

RQ1 - How are the data artefacts designed and integrated, considering the heterogeneity and multidimensionality challenges arisen in logistics management in diverse energy system scenarios?

RQ2 - How is digital energy metadata explored for attribute connections, presented for interpretation in new knowledge domains, keeping in view the types of energy resources, energy users, logistics and prosumer needs and behaviours?

RQ3 - Can the data structuring, integration, data mining and interpretation artefacts of DSIS deliver prosumers' digital energy business information solutions?

Research Objectives

In this research, we intend to design and develop artefacts as new innovative constructs and models with a prosumer-energy focus. The IS artefacts are vital in the development of an integrated DSIS framework (Nimmagadda et al. 2018).

1. RO1: Design and develop knowledge-based structures integrating semantic information and rules/axioms, collaborating logical data schemas within a prosumer-energy supported data warehouse repository. The logical schemas are intended to represent prosumers, energy systems and logistics, all validated by DSR guidelines.
2. RO2: Investigate and develop data mining models, present the explored data, interpret the data views for extracting useful prosumer information for knowledge discovery.
3. RO3: Interpret multidimensional data views from warehoused metadata that can add business value in new knowledge domains.

5 RESEARCH APPROACH AND METHODOLOGY

The mixed-methods approach is gaining popularity in multidisciplinary research where multiple domains and systems need collaborative efforts (Neuman 2000) with unified metadata. In multidisciplinary research investigations, empirical data instances used in building data models may have undergone a rigorous process for metadata unification in order, for example, to obtain interpretable prosumer business knowledge and information needed by positivists and interpreters in the form of qualitative and quantitative measures (Neuman 2000). As investigated in Nimmagadda et al. (2018) data interpretation is one of many artefacts used in articulating the DSIS framework. The interpretation articulated in the PBDSIS is meant for drawing inferences from metadata of prosumers and energy-type data views and their factual instances, after envisaging them by means of data mining and visualization artefacts. In both contexts, interpretation is intended to achieve the following objectives:

- To establish continuity in research findings by linking the results of PBDSIS with studies of other interconnected empirical findings regarding prosumers and energy scenarios and their management.
- To corroborate with exploratory, explanatory, and confirmatory including inference-based data mining schemes. Our explanatory mining goal is to explain observed events or conditions such

as the scenario where energy exploration has been increased in a particular prosumer coalition regime, which may have been impacted by greenhouse gas and CO2 emissions. To meet the exploratory goals, we analyse the empirical data instances for new and or unexpected associations such as those between electricity production and CO2 emission factors. We intend to confirm the hypothesis for a developed country, and show how a particular energy source can create greenhouse gases in comparison with other energy sources.

In this section, the methodology is expected to provide rigor in design science. As suggested by researchers in Neuman (2002), we adopt an approach relevant to the interpretation of empirical data instances both qualitatively and quantitatively; these include the mapping and modelling of prosumer energy data scenarios in terms of spatial-temporal attributes. Historical data instances collected for spatial-temporal attributes are used to build constructs and models of the DSIS. Churchill (1979) offered a research paradigm for developing constructs and their measures in marketing businesses. The conceptual framework unifies and brings the constructs together in a repository with scattered bits of information. Brocke and Buddendick (2006) proposed a conceptual modelling with new software engineering and model guided service-oriented architectures. They emphasize the application of reusable conceptual models with promising design science articulations that can deliver new applications in software engineering. Nimmagadda et al. (2018) signify the research with DSR approach with increasing evaluation of software prototype, though a new research direction. However, the works lacks rigor and fails to show the relevance of prototyping in business research. The authors summarize that DSR can adopt different paradigms such as positivist, interpretative artefact, construing that DSR is an acceptable and pluralistic research approach. The DSR concepts and tools as described in Hevner et al. (2004); Ploesser (2012); Vaishnavi and Kuechler (2007) have contributed to our motivation to develop logistics and prosumer-based business design-science concepts and tools.

5.1 Design Science Research and Prosumer Business Information Systems

In typical industry-based IT design scenarios, a new product (artefact) is created using design science articulations. DSR is a decidedly IT research methodology, presenting factual evaluation of strategic rules and iterative measures within a range of business process, construct and artefact design projects. The design knowledge specifically reflects the perception of the artefact and its performance in the DSIS framework. In the current research, we propose Prosumer Business Design Science Information System (PBDSIS) with a logistic development agenda. Prosumers are both producers and consumers. The energy producers not only produce, but also consume oil, gas and condensate from both conventional and unconventional energy resources. The energy supply depends on the demand generated by consumers. In addition, prosumers and their coalitions are critical in the planning of smart energy grids and sustainable energy supplies. In the PBDSIS, we integrate the energy (including their types) and prosumer entities using multidimensional models as depicted in Figure 1. It is necessitated in logistics management phase including design, development and implementation of prosumer business information systems. Hence, PBDSIS is designed for articulating various prosumer business events and upgrade the smart grid technology.

5.2 The Need for PBDSIS in Logistics and Smart Energy Management

With the increased use of energy resources by multiple prosumers, an enormous increase in databases has occurred, in particular regarding information overload in renewable and non-renewable energy businesses. As stated in Research Objectives 1 and 2, we focus on building constructs and models and their collaboration in the prosumer energy development process, for which the PBDSIS appears to offer a pathway for a smart energy and logistics management strategy. We draw dimensional models based on real data attributes and their instances, as shown in Figure 1. We use data instances from published open and shared data sources to model the constructs and models of prosumer energy businesses (Forms of Energy 2019). As demonstrated in Figure 1, the notion of dimension and fact instances provides semantic information, particularly in regard to hierarchical data relationships between elements and processes of the energy and prosumer schemas. The dimensional models show the structuring of data in prosumer and energy business concepts, and include numeric measures, units and estimates and their dimensions (Figure 1). In addition, the energy and prosumer schemas show the details of interrelationships, connecting prosumer and energy attribute dimensions. The other players included in the modelling are substations, the utility grid, renewable and non-renewable energy sources, electric cars, prosumers and energy users. They need these feasible logistics together with DSIS-guided prosumer business coalitions.

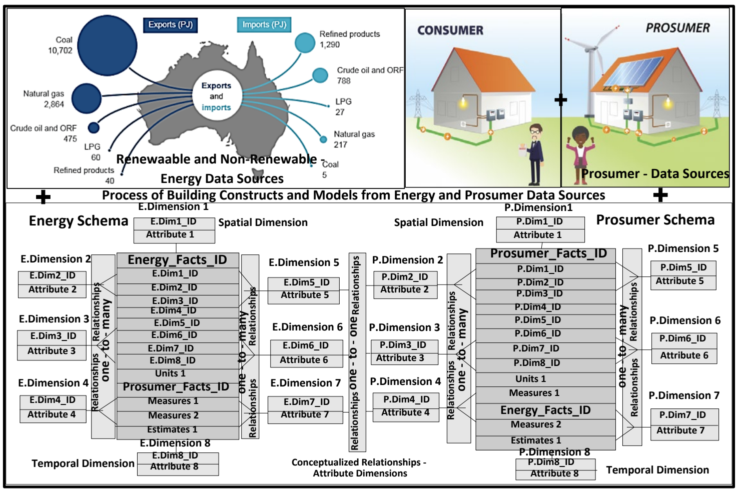

Figure 1: Connecting Energy Types to Prosumer Schemas (Research Objective 1)

5.3 Design Pathways and their Requirements in DSIS Constructs

Descriptions of entities and dimensions used in multiple domain applications of prosumer energy and logistics management are given in Costello (2018). To design a prosumer-based energy framework, renewable and or non-renewable data sources are selected to build models that are appropriate for prosumer supply chains. Prosumers form groups (coalitions) in order to trade energy with buyers and suppliers (Sumesh et al. 2019). Models representing prosumers with their similar and or dissimilar attributes have been collaborated with models of different energy systems and characteristics of associated logistics. The research highlights building knowledge-based artefacts (Research Objective 1) for prosumer business design-science IS articulations using DS and AR features and assembling their relationship-models, based on types of energy sources with linked logistics and prosumer coalition data patterns. The parameters needed in order to connect the energy and prosumer models provide pathways for meeting prosumers' business requirements, with improved logistics and utility evaluations. The role of IS artefacts in coalition formations should meet the prosumer business design-science challenges with rules for minimum energy disruption, and the maximization of production using green and clean energy logistics.

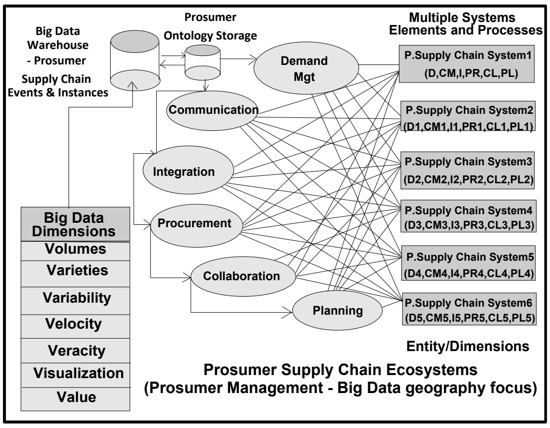

Figure 2: Connecting the prosumer supply chains in Big Data scale (Research Objectives 1 and 2)

The prosumer supply chains, as described in Figure 2 in multiple ecosystems, are interpreted in different geographic contexts with diverse prosumer business scenarios on a Big Data scale. In the course of analysing various conceptual models of prosumer-based supply chains, we investigate several Big Data events. These events might derive from multiple prosumer-based supply chains in which various elements and processes and their attributes experience data integration challenges. For example, prosumer products or services offered by different supply chains are categorised, based on prosumer coalitions and energy data types, to represent them in new knowledge domains. It is an integration process with multiple chains, to form prosumer coalitions in warehouse repositories. An ontology-based approach that depicts the conceptualization of the entities and dimensions in multiple domains arranges multidimensional data in a warehouse environment as in Shanks et al. (2003). Multiple constructs and models (Figure 1) are expanded according to the multiple prosumer business supply chain systems as depicted in Figure 2. In regard to Research Objective 2, the formation of a dynamic coalition is based on IS artefacts intended to integrate and assess the benefits among different participants in energy trading partnerships (Vinyals et al. 2012). Coalition events occur between players based on the balance between supply and demand. They are articulated in the IS strategies to resolve energy disruptions based on even energy losses and poor grids in difficult logistics. Previous research that examined dynamic prosumer coalitions among energy users and grids, did not address the issue of managing different types of energy sources and the logistics needed for production (Li et al. 2013).

6 PBDSIS ARTICULATION FOR LOGISTICS AND SMART ENERGY GRID PATHWAYS

Data interpretation is an important articulation of the DSIS related to a positivistic approach (Neuman 2000). New insights about interpretation presented in new knowledge domains for prosumer energy systems have motivated us to create promising prosumer coalitions and smart energy grid groups in clean energy environments. New insights are presented in the form of data views, characterized in multidimensional visions that provide interpretations in new knowledge domains. Multidimensional prosumer-energy metadata and their data views deduced from DSIS data volumes can be interpreted by energy managers and data analysts in prosumer businesses, in particular, to deal with spatial-temporal attributes (Nimmagadda et al. 2018). They are important for assessing the prosumer energy grids, and their linked IS artefacts in different geographies. For the purpose of evaluating and implementing the artefacts of PBDSIS in energy systems, certain guidelines are followed with evaluable utility properties (Venable et al. 2016). When designing the PBDSIS in the form of multidimensional warehouse repositories, the repositories must be evaluated against certain benchmarks. How successful the metadata structure, its data- and map-views are in yielding interpretable domain knowledge from energy scenarios and further facilitating the assessment of clean energy logistics, is discussed in the following sections.

6.1 PBDSIS Modelling Guidelines Followed

The validity of the PBDSIS framework and its linked artefacts depends on the deployment of DSR guidelines and their performance in multiple domain applications. The performance varies according to the hardware and software facilities and their adaptability in energy systems. Poorly-designed constructs and models can affect the warehouse repositories and their sizes, compromising the overall performance of DSIS. The schemas designed for businesses and operated in a clean energy environment must be optimized and made flexible for adaptation to other domains. For example, for domain scenarios of renewables and non-renewable energies, models are made adaptable by means of semantically-deduced attributes (Brocke and Buddendick 2006; Bari et al. 2014). The outcome of PBDSIS mapping and modelling must ensure:

- Careful implementation of DSIS in multiple industries.
- Standardisation of data warehousing and data mining methods and their linked artefacts.
- Consistency, reliability, integrity, and quality of prosumer-energy data.

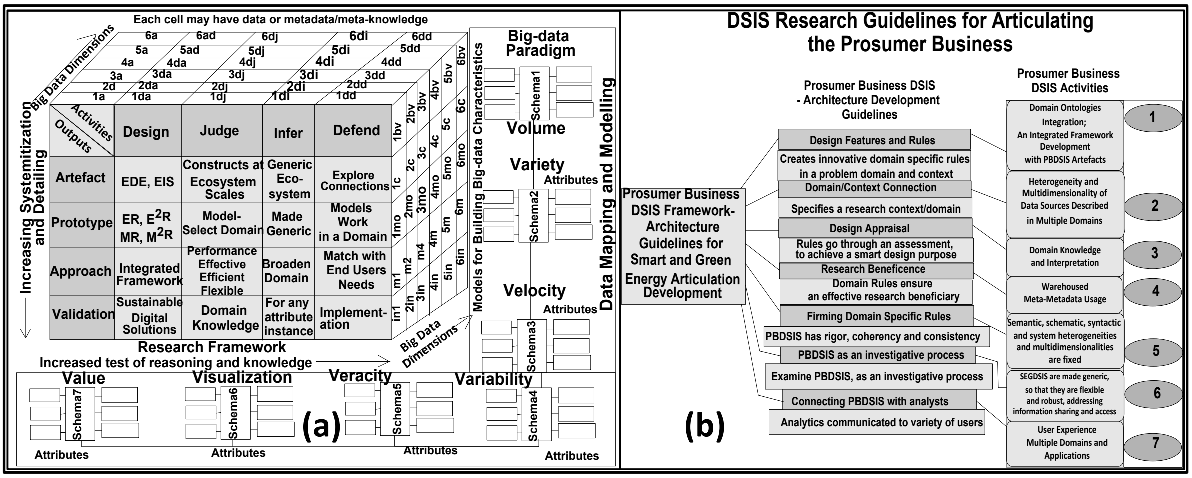

Figure 3: (a) Big data-guided PBDSIS Development (b) DSR guidelines for articulating IS Artefacts in Prosumer Businesses (Research Objectives 1 and 2)

The framework depicted in Figure 3a needs to comply with DSR guidelines (Figure 3b) and prosumer business rules (Vaishnavi and Kuechler 2007). The DSIS framework is aligned with research activities such as 'design', 'judge', 'infer' and 'defend' in multiple scenarios of prosumer businesses. The expected outcomes are 'artefact", "prototype", "approach" and "validation of models by data instances" in prosumer-energy business domains. The overall framework is flexible enough to connect to different artefacts, and can even be linked to big data to capture a larger picture of hardware, software and algorithmic features when developing PBDSIS for big data (Nimmagadda et al. 2018). Various cuboid cells are filled with a volume of big data instances that represent the overall metadata with meta-knowledge of prosumer-energy including, interoperability utility occurrences in multiple industry scenarios. The following are the DSR guidelines used to guide and validate the IS articulations of PBDSIS, as depicted in Figure 3b:

1. The framework presented in Figure 3a requires innovative artefacts with design features, including DSR guidelines as presented in Figure 3b.
2. Specific domain or domains are made explicit to contexts.
3. The artefact designed has a purpose, yielding solution for the problem domain.
4. Artefact innovation is vital to ensure, effective problem solution and its usability.
5. The artefact has a scope of rigorous, coherent and consistent problem solution, forming domain-specific rules.
6. The process whereby the artefact is created must be generic and effective, in constructing solution spaces in any domain, thereby making the scope more explicit.
7. Results must be communicated effectively to a variety of research audiences and prosumer business design science analysts.

6.2 Design Specification: Construct/Artefact Description

For the design of an artefact in the prosumer-energy environment, we have identified and documented various prosumer business rules and constraints. Entities, dimensions and objects are appropriately classified with their respective business rules and constraints. While designing multidimensional data models, business rules are periodically reviewed rigorously, keeping in view that the constraints of prosumer energy scenarios are current when managing the heterogeneity of data structures. Data models designed in each domain are confirmed with their data relationships with matching business rules and constraints of the framework in business scenarios. Taking the logistics data events into the artefacts of PBDSIS for modelling, the scope of IS artefacts is further analysed, characterizing and reviewing the business rules of supply chains that control the prosumer business processes. Both data model designers and users are responsible for framing business rules and constraints. Typical business rules are: at least one prosumer must exist within an energy industry, and each system must have at least one or more renewable and or non-renewable source. Each renewable or non-renewable source is capable of producing energy. For building relationship attributes, each energy source has at least one prosumer connection. From the model development perspective, one-to-one, one-to-many or many-to-many relationships must be imposed on artefact designs.

6.3 Evaluation Specification: Assessing the Value of Artefacts

Specific queries are made in the form of data views extracted from metadata cubes in support of crucial technical and financial decisions as required for energy use and management. The prosumer energy systems need robust and flexible warehouse repositories in order to manage the heterogeneity and multidimensionality of prosumer business datasets existing in multiple primary industries, websites and company servers (Forms of Energy 2019). The PBDSIS framework, the guidelines of which conform to the requirements of business development, can systematize the data mapping and modelling processes, integrating data structures in different knowledge domains and applications. In addition, the framework can assess multidimensional domain-ontologies and their adaptabilities that guide warehouse architectures. Building an ontology-based data warehouse, as a digital prosumer-energy solution manifests with the fact of resolving semantics, schematic, syntactic and system heterogeneities attributed by entities and dimensions of the energy industry and prosumer coalitions including their evaluable artefacts.

6.4 Evaluation of PBDSIS Framework and its Artefacts

The findings answer the research questions and fulfil the purposes of the research. Empirical data instances acquired from Forms of Energy (2019) are used to design IS artefacts and integrate with PBDSIS. Information system artefacts and the empirical data events are critically examined, ensuring that they are aligned with industry standards and offer viable business solutions. Data attributes involved in the integration and connectivity processes are made interoperable at the implementation stage of the PBDSIS framework as described in Figure 4. Interoperability of prosumer data entities, dimensions or objects conceptualized in geospatial dimensions as represented in Figure 4, are part of the development of PBDSIS for managing prosumer businesses and their contexts in different geographic environments. The parameters of the constructs and models can be changed to meet the diverse industry scenarios associated with prosumer businesses. As additional requirements may be necessary for the implementation of the framework, the models are envisaged with scenarios in case one prosumer system needs to interact in geo-spaces with applications of business models in other systems, conforming the IS artefacts in controlled semantics, syntactic and schematic view considerations (Nimmagadda et al. 2018). Schematic models presented in Figures 3 and 4 illustrate use and reuse artefacts in multiple domains and prosumer business contexts. Cuboid metadata representation is interpreted from interoperable PBDSIS events in multiple industry scenarios (Figure 4a) .

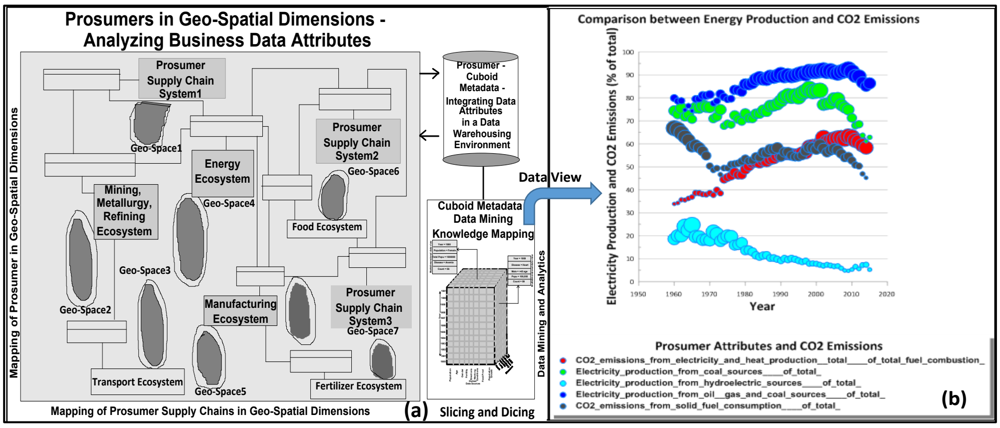

Figure 4: (a) Interoperability analysis of prosumer businesses in geo-spatial dimensions (b) data view drawn from cubes for interpretation (Research Objective 3)

In addition, several existing knowledge-based ontologies (Shanks et al. 2003) are imported into new applications of PBDSIS with merely a change of attributes and instances of prosumer-energy domains. The evaluated framework articulations can consistently deliver accurate and precise digital energy information solutions to energy research projects. As an example, in Figure 4b, 2D data visualization plot views are represented as multivariate statistics and analysed to build regression models in the interpretation of new insights of prosumer energy systems. As shown in Figure 4b, the graphical data view reveals data properties, detecting patterns of prosumer attributes, including emissions created by electricity production that can support the logistics of PBDSIS implementation in the energy industries.

7 RESULTS AND DISCUSSIONS

The discussions of results explain the contribution of the research. Before the full benefits of the artefacts and framework can be obtained, we reiterate that greenhouse gas emissions and energy losses occurring with linked logistics and energy distribution systems are assessed using data mining and visualization models. Real-life energy scenarios are used to demonstrate the accuracy of the constructs and models with the overall viability of the DSIS framework. The assessment of methodologies is conducted by using the operational empirical data instances, which are available in open and shared sources (Forms of Energy 2019). Prosumer cuboid metadata represented in multidimensional warehouse repositories are implementable through the interpretation of evaluable data slices and dices extracted from the data cube as presented in a schematic view in Figure 4a. As shown in Figure 4b, the bubble plots drawn between dependent and independent variables of prosumer energy business data attributes for a developed country describe prosumer coalitions have roles in energy production and consumption as discussed in Steinbach and Wellmer (2010). The framework and its linked IS artefacts are tested to explore the links between prosumer attributes and logistically manageable greenhouse gas emission attributes. Bubble plots can indicate the different alignments of dependent or independent variables of prosumer supply chain measure attributes in different scalar descriptions. We present the results in 2D bubble plots, in which the diameter of each bubble varies in size, with representation of additional dimensions in spatially varying prosumer logistics and prosumer supply chain management data. The large bubble size is interpreted as strength of energy and prosumer attributes, whereas attributes within small bubbles are weaker. The instances are from the independent attribute variable "year", with "production of electricity" as the dependent variable. The data views extracted, as shown in Figures 5a, b c, have been analysed with different prosumer energy scenarios and time-periods. The analysis results support logistically-guided PBDSIS implementations.

The energy production attribute comprises predominantly coal, gas and oil resources, coal in particular as shown in Figure 5b. CO_2 emissions and heat generated from solid fuel consumption correspond to the usage of coal, gas and oil resources for the generation of electricity.

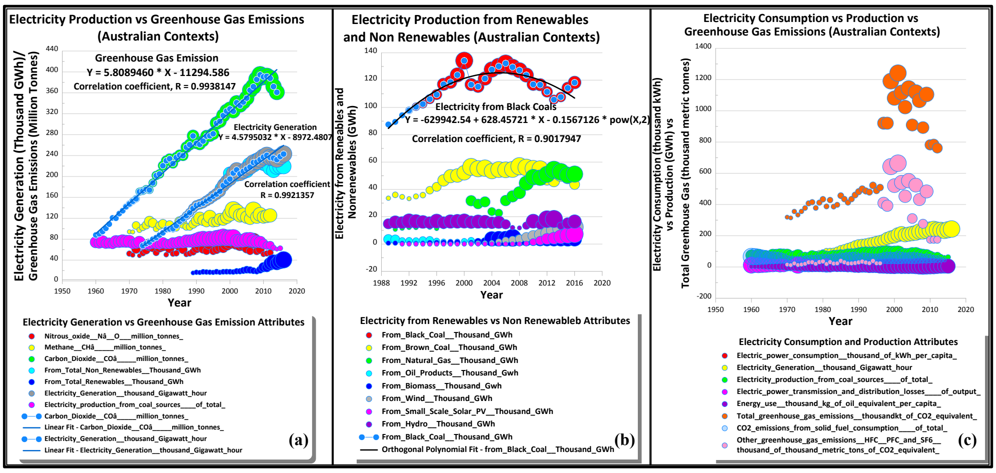

Figure 5: Presentation of prosumer data views with their attribute trends

CO_2 emissions generated from electricity and heat production are also in good alignment with the CO_2 emissions from solid fuel consumption. However, hydroelectricity has less emissions in the initial years of the analysis. As shown in Figure 5, we plot various data views to analyse the electricity generation with respect to greenhouse gas emissions. The trends for the use of non-renewable resources match those of electricity production, but at the cost of generating greenhouse gas emissions as shown in Figure 5a. Several polynomial regressions are computed to evaluate the relationships between dependent and independent variables of prosumer activities and renewable energy attributes. As shown in Figures 5a and b, the electricity produced from both renewable and non-renewable resources is plotted and generates polynomial regressions to analyse the correlations between usage of renewable attributes. In a developed country, electricity created from black coal has dominated the energy production scenarios.

8 CONCLUSIONS AND OUTLOOK OF FUTURE RESEARCH

The conclusions state the main claim of the research and contribution. The IS approach is developed to analyse impacts in prosumer energy businesses. We assess IS artefacts, their use and application in the prosumer energy industry. To better manage energy scenarios in the dynamic environment of digital energy systems, the methodology presented in the research, together with the impact of the PBDSIS framework, its design, development and implementation are analyzed in terms of energy industry practice. The accommodation of renewable and non-renewable resources in green and clean energy environments in prosumer coalitions can facilitate and resolve the connectivity and interoperability challenges of framework implementations in prosumer energy systems. In addition, the approach has the potential to expand with a number of coalitions and classifications, by decentralizing managerial aspects of renewable energy usage and trading with energy buyers and suppliers. Specifically, different types of data and their sources, available in the form of renewables and non-renewable sources, have motivated us to carry out empirical research with volumes of instances. Cuboid structures generated and data views extracted from cuboid data warehouse repositories are used for interpreting the production scenarios affected by renewables and non-renewables and their attributable logistics where prosumer coalitions are implanted within energy systems. However, the issues pertaining to the compatibility of constructs, models and methods associated with domain applications must be addressed before the framework can be implemented successfully. The artefacts explain the usability, flexibility and interoperability properties necessary for construing the attribute models of PBDSIS in IPM contexts.

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