Asset Management Models Brief Review and Framework Development for Energy Sustainability & Sustainable Development

Joseph Akpan[1], Oludolapo Akanni Olanrewaju[2]

Department of Industrial Engineering
Durban University of Technology
Durban, SA
22176142@dut4life.ac.za[1], OludolapoO@dut.ac.za[2]

Abstract

Despite, other operational disciplines like projects, risk, health & safety, environment, and quality management have a variety of global frameworks and models, asset and maintenance management has just recently been created. To help practitioners recognize the variables and constructs that might support decisions towards effective and efficient physical asset management, a variety of organizations, groups, consultancies, and researchers have provided numerous models, terminologies, and frameworks. According to Global Forum on Maintenance & Asset Management (GFMAM) most recent framework, ensuring the asset value is effectively exploited requires considering sustainability as one of the principal components. Although companies have clearly established processes for asset management, there has not been a comprehensive framework to link physical asset management systems with energy sustainability towards meeting sustainable development objectives. With the growing demand for energy and the resulting worries about the reliability of associated asset that employs these energies to generate value for the organization, global asset sustainability becomes necessary. A sound business technique is no longer asset efficient if the energy performance that goes along with it, is not understood. Using asset management systems to achieve sustainable development is still not thoroughly and independently investigated, both in industry practice and academic study. Continuous enhancement of asset management systems under the context of sustainability requires a robust study and framework that will allow organizations to understand the various established subject groups and principles within the performance of asset management system and their contribution towards sustainability– thereby ensuring that:
(i) The 6 subject groups and 39 principles of the asset management landscape by GFMAM are evaluated based on their influence on the energy sustainability & sustainable development perspective: and
(ii) Organizational major targets and performance indicators under these subject groups are aligned in the context of sustainable development. The following issues will be addressed in this paper: The current state of energy sustainability measured and how they can be linked to asset management system performance, and how can this be tied back to business performance.

Keywords
Asset Management, Energy, Framework Development, Sustainability

1. Introduction

Sustainability and sustainable development are key concerns for businesses and society at large, leading to significant alterations in the workplace and in the global economy. When it comes to issues like sustainability, practically every firm has a tough time identifying the criteria needed to accurately analyze and manage the asset management structures. To achieve long-term sustainability in the age of technological and economic diversity and the anarchy caused by global warming, cross-disciplinary solutions are essential. Impending increases in global energy demand as well as the associated costs of climate change necessitate multidisciplinary approaches(Dovì & Battaglini, 2015), including those from the fields of science and technology as well as social sciences and politics as well as the fields of the environment and the economy.(Edwards, 2019) Some businesses are employing asset management techniques to address these difficulties, and energy management is one of a number of asset management tools that can assist in assessing the capability gap between the assets an organization needs and the assets it owns in order to accomplish its mission.(Griffin et al., 2014) Energy sustainability issues are being addressed by considering energy resources, tools, techniques, case studies, strategies and technologies that are aligned with Goal #7 of the Sustainable Development Goals (SDGs) 2030, which aims to provide affordable, reliable, sustainable, modern, and clean energy to over 3 billion people around the world by the year 2030. From the moment a requirement such as energy sustainability is conceived in the asset life cycle, frameworks and standards can be developed which are can be employed at any point to understand why the need (iso, 2014), what effort (Uso & Del, 2014), how to implement the strategies (Iso, 2014), in the asset's life cycle to help manage potential liabilities, intended to preserve and/or restore the equipment and teams' working conditions so that they can fulfil a certain role as needed from time to time.(Adolfo Crespo Márquez, 2007) Several frameworks or reference models have previously been established to aid firms in coping with these issues and "moving" in an asset management environment that is always changing and evolving. Using the 31 principles and six topic groups defined by Global Forum on Maintenance & Asset Management (GFMAM) (GFMAM, 2010), a non-profit group promoting and improving the maintenance and asset management profession s by working together on knowledge, practices, and standards, this research would be able to provide appropriate measures for optimizing asset management sustainability with energy focus, which would be the emphasis of this study. These characteristics of GFMAM ideas should be addressed and included in asset management models as well. Specific asset management models and frameworks are examined in this study, and topics for further investigation are identified to develop current models more thoroughly, so that sustainability may be included. It is also important to note that these models should have a proven, consistent approach to continuous improvement to achieve world-class performance.

1.1 Background

This section includes background information on physical asset management, energy sustainability and sustainable development to build a common understanding of the research's primary subjects.

There is nothing new about managing physical assets in many areas that are asset-intensive (Linda & Eric, 2010), such as aviation, civil engineering, and public infrastructure. (Bulita, 1994) Indeed, physical asset management dates back to the 1960s before the concept of terotechnology(Mitchell et al., 2002) was conceived in the 1970s as a result of asset reviews with regard to investment, cost and performance outcomes, which initially aimed to optimize the value of asset portfolios over the course of their entire life cycle. In order to meet a business or organizational goal, asset management is the collection of activities that identify what assets are needed; identify funding requirements; acquire assets; provide logistic and maintenance support systems; dispose of or renew assets; effectively and efficiently meet the desired objective. (Nicholas A. J. Hastings, 2010). We can see from this definition that "asset management" includes a far larger range of operations than "maintenance," solely concerned with keeping existing equipment in safe condition (Nicholas A. J. Hastings, 2010). In this another approach by Davis (Davis, 2013), the assets are viewed as required systems that respond to their environment, change and normally deteriorate with use, and progressively grow old then fail. It's a mindset that sees physical assets not as adding an additional and unchanging lump of waste. As defined by the Asset Management Council of Australia, it is "the management of physical assets throughout their life cycle to deliver the specified outputs of the company.". In the British Standards Institute's Publicly Available Specification on Asset Management (PAS 55) (The Institute of Asset Management, 2008), the following definition ofAsset Management is given: "...systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems". Incorporating a number of different disciplines (management, financial, economic, engineering and other practices) into physical assets with the purpose of attaining a high-quality service with cost-effectiveness can also be considered as asset management ((Government of Western Australia/Department of Local Government), 2011). In other words, asset management is the process of deciding what assets a company needs to achieve its goals and then obtaining and logistically managing those assets over their entire life cycle, from acquisition to disposal, utilizing solid technical and financial judgment and management principles. The interdisciplinary, collaborative practices utilized by an organization to maintain an asset's long-term life cycle balance between economic activity, environmental stewardship, and social growth, is what GFMAM gives as the definition for sustainable development (Global Forum on Maintenance and Asset Management, 2014). This is a conceptual study on asset lifecycle management that will serve as a foundation for future research into the advantages of incorporating energy sustainability into asset lifecycle management for sustainable development. Several other authors' information collected in the framework of several projects where they encountered the idea of energy sustainability in AM is used to add an emphasis on energy sustainability to sustainable development concepts with asset-related decision-making. This field expertise is supplemented by the brief literature research, which serves as the study's backbone, using a few exploratory application use cases.

The present state of knowledge and models generated in these fields are summarized in Section 2. The foundation for the examination of AM energy sustainability for sustainable development is explained in Section 3. Section 4 contains a few approaches for achieving energy sustainability. And section 5, concludes the paper by sharing other perspectives, and proposing possible model that could be worked on, to achieve asset management sustainability for sustainable development.

1.2 Objectives
This research will contribute to the body of knowledge by doing a literature analysis and examining current industry practices to better understand asset management systems and energy sustainability measurement. The proposed asset management framework intends to include outcomes and impacts of each asset management activity, clearly showing their relationship to energy sustainability, to establish an efficient energy performance measurement system and a procedural framework that can be used in the real world of business.

2. Brief Literature Overview

2.1 Asset Management's Evolutionary Practices: An Overview

Table 1.0. Era in Asset Management Practice

Era	Description	References
AM 1.0	AM seen as cost centers	(Muganyi & Mbohwa, 2017)
AM 2.0	The growing need for trustworthy, real-time information to predict maintenance and operations choices in managing asset life cycle	
AM 3.0	Predictive maintenance through sensors, data collecting during normal operations, and ERP storage for procurement, operational, and financial objectives is being developed.	(Amin et al., 2018; Catenazzo et al., 2019; Taylor et al., 2011)
AM 4.0	• **Digital Twin (DT)** Using DTs to predict system performance and long-term behavior, data continuity is granted digitally throughout the many phases of the system's lifecycle, and better maintenance decision making is improved.	(Doc et al., 2017)
	• **Smart Asset Management** EAM, or enterprise asset management, is a long-standing practice in large organizations. To remain competitive in an unpredictable economy, with rising global rivalry, more regulatory demands, and aging infrastructure, successful companies today are depending more on technology and smart asset management (SAM) than in the past	(Nel & Jooste, 2016)
	• **Sustainable Operations and Energy Efficient Assets** Asset management in perspective of climate change challenges and the replacement of anthropogenic sources of greenhouse gases with renewables in the drive for sustainability, given the global supply and demand profile.	(EU, 2021)

2.2 Asset Management's Models
Asset management models have been developed by several researchers and practitioners but the ones that will be presented for a brief review, are the ones developed by some of the institutions within the GFMAM, as well as the GFMAM society itself, will be considered. These bodies are ten in numbers, namely.

- Asset Management Council (AMCouncil), Australia;
- Associação Brasileira de Manutenção e Gestão de Ativos (ABRAMAN), Brazil;
- European Federation of National Maintenance Societies (EFNMS), Europe;
- French Institute of Asset Management and Infrastructures (IFRAMI), France;
- Gulf Society of Maintenance Professionals (GSMP), Arabian Gulf Region;
- Iberoamerican Federation on Maintenance (FIM), South America;
- Institute of Asset Management (IAM), UK
- Plant Engineering and Maintenance Association of Canada (PEMAC), Canada
- The Society for Maintenance and Reliability Professionals (SMRP), USA.
- The Southern African Asset Management Association (SAAMA), South Africa

It is important to highlight that some of these institutions are still in the process of developing holistic frameworks specific to only asset management, while noting that some others are working in distinct interest groups, with the overall aim of ensuring the GFMAM society meets its vision. Therefore, this paper can serve to contribute to practitioners' knowledge while producing these frameworks or working towards creating synergies within these institutions.

2.2.1 Model from Asset Management Council (AM Council), Australia

The AMCouncil has a Book of Knowledge (BoK) establishing a complete framework of AM best practices known as the abbreviation AMBoK, containing constructs of stakeholders, leadership, organizational objectives, asset management objectives, asset information, risk management and performance improvements by monitoring, all aligned within the context of strategy, operations, tactics, and maturity levels and terminology. (AMCouncil, 2014)

2.2.2 Model from Institute of Asset Management (IAM), United Kingdom

IAM has produced an asset management (AM) conceptual model that incorporates six groups of subjects covering the 39 above-mentioned AM themes first presented by the GFMAM. However, it is critical that an organization's general goals and strategy are matched with the various operations that must be integrated to achieve whatever purpose it desires. (IAM, 2014)

2.2.3 The GFMAM Asset Management Landscape Framework

Many thematic areas used for the interest group models from the rest of the eight societies under GFMAM are covered in GFMAM Framework, and those selected for discussion are ones related and linked to energy sustainability and sustainable development. The reviews will be classified under the GFMAM landscape subject groups, represented in table 1.0 below, for which sustainable development is found to have related principles based on the GFMAM asset management landscape framework (Global Forum on Maintenance and Asset Management, 2014). We have assigned numbers to each of the principles and found that after relating them based on the existing GFMAM framework that some principles share similar subject groups.

Following our preliminary literature analysis, sustainable development is the second highest with six related principles, compared with stakeholders' engagement having seven related principles. However, it is found that sustainable development is in four out of six subject groups, making it the only principle with such highest attributes. the These four subjects' groups are *Strategy & Planning, Asset Management Decision-Making, Risk & Review, Asset Information.* Therefore, this section provides an overview of the principles, sorting them approximately according to the categories and groups already established above.

Table 2.0. GFMAM landscape subject groups and principles (Global Forum on Maintenance and Asset Management, 2014)

	Landscape Subject Group	S/N	Principles			Related Principles				
A	Strategy & Planning	1	Asset Management Policy	2						
		2	Asset Management Strategy & Objectives	1	39	3	4			
		3	Demand Analysis	2	4					
		4	Strategic Planning	2	39	3	5			
		5	Asset Management Planning	4	9	10				
B	Asset Management Decision-Making	6	Capital Investment Decision-Making	2	3	4	7	8		
		7	Operations & Maintenance Decision-Making	6		15	17			
		8	Lifecycle Value Realization	2	3	4	6	7		
		9	Resourcing Strategy	5	18					
		10	Shutdowns & Outage Strategy	5		10				
	Lifecycle Delivery	11	Technical Standards & Legislation	1	2	4	5			
		12	Asset Creation & Acquisition	7						
		13	Systems Engineering	14						

		14	Configuration Management	13						
		15	Maintenance Delivery	7		16	17			
C		16	Reliability Engineering	2			35			
		17	Asset Operations	2	4					
		18	Resource Management		7	14	15	30	26	
		19	Shutdown & Outage Management	7		15	26			
		20	Fault & Incident Response	32	31					
		21	Asset Decommissioning and Disposal	19	8	31	25			
		22	Asset Information Strategy	2	23	24	25			
D	Asset Information	23	Asset Information Standards	22	24	25				
		24	Asset Information Systems	2	23	25				
		25	Data & Information Management	2	23	24				
		26	Procurement & Supply Chain Management	4	12	15				
		27	Asset Management Leadership	2	28	29	30			
E	Organization & People	28	Organizational Structure	2	29	27	30			
		29	Organizational Culture	27	28	30				
		30	Competence Management	27	28	29				
	Risk & Review	31	Risk Assessment and Management	2	8	6	7			
		32	Contingency Planning & Resilience Analysis	20						
		33	Sustainable Development	1	2	6	8	31	25	
F		34	Management of Change	31						
		35	Assets Performance & Health Monitoring	2	36					
		36	Asset Management System Monitoring	35	37					
		37	Management Review, Audit & Assurance	35	36					
		38	Asset Costing & Valuation	5	6	8	24	25		
		39	Stakeholder Engagement	1	2	3	4	5	6	7

3. Discussion

A new tendency has emerged in recent years, with the physical asset industry's responsibility to participate rising. Reduced industrial energy consumption is being driven by green manufacturing and globalization. A case study (SEE Action, 2017) on saving energy in industrial companies was undertaken by State and Local Energy Efficiency Action Network. Large multinational co-operations-Intel, General Mills, J. R. Simplot Company, and General Motors were considered in this study, using site visits and phone interviews. According to the study's findings from the four organizations, an industrial company's energy efficiency program is successful when it meets these three criteria: corporate commitment, good metric system, and efficient project planning systems. Corporate commitment can be done by establishing explicit energy efficiency improvement targets and holding plant management and employees accountable for achieving them, while ensuring that best practice project management is involved in public-interest projects. CIGRÉ (Conseil International des Grands Réseaux Électriques, CIGRÉ)(CIGRÉ, 2014) is a worldwide nonprofit professional association dedicated to high-voltage electricity that was established in France in 1921. CIGRÉ has developed a conceptual model that includes three levels of information requirements: corporate, network, and component — for asset management (AM) decision-making in the transmission and distribution of electricity. A Risk Management Regime's ability to make judgments is demonstrated by this technique, which shows how many layers of information are required. An asset management approach isn't a one-size-fits-all solution, according to the Institute for Asset Management (IAM)(IAM, 2014). For a given model to be effective, it must be applied to a certain organization and its unique conditions. Organizational requirements may necessitate changes to a model selected.

As asset management advances, many models will change and new ones will emerge, and this is what is expected in the future. Following the inference derived from table 2.0, asset management sustainability for sustainable development can be classified into majorly strategy and planning, asset management decision making, asset information, and risk & reviews, discussed below.

3.1 Strategy and Planning

Over time, asset management evolved to encompass more than just emphasis on maintenance management and has resulted in a growing body of knowledge that has been documented in a variety of places. To connect decision-making with a company's overall strategic objectives and key performance indicators, it is necessary to integrate planning across functional groups, in the management of concerns related to limited funding and increasing costs. To deal with the issues of dwindling resources and rising expenses on a continuous basis, some businesses are applying asset management concepts, with focus on seeing built and natural resources as strategic assets that must be efficiently managed.(Griffin et al., 2014) With asset management plans and strategies(Woodhouse, 2014), a business may identify and evaluate the performance of assets and systems throughout the life cycle.

3.2 Asset Management Decision-Making

For asset management initiatives to properly align with sustainability, clear links between goals and outcomes and particular strategic plan goals must be defined and continuously communicated throughout the organization (see Figure 1 below).(David C. Sklar, 2018)

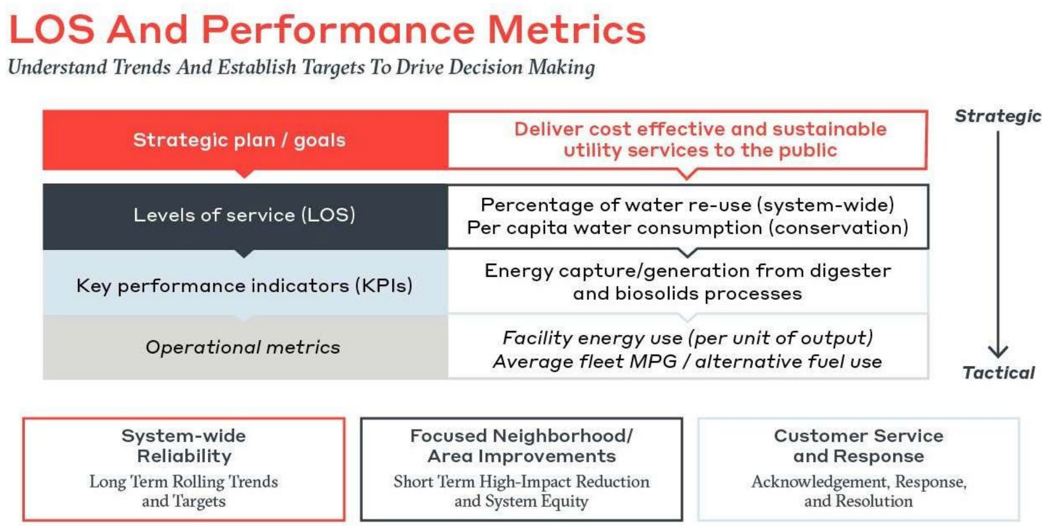

Figure 1. Asset Management Decision-Making using Level of Service and Performance Metrics for a Utility Company (David C. Sklar, 2018)

3.3 Asset Information

It is critical to get the necessary knowledge and information to make better decisions. Using this correct information allows adequate planning to prepare ahead of time to achieve service levels while minimizing risks and saving money because of better decision-making. All these factors contribute to a more efficient operation. When dealing with asset criticalities, information is critical, and this greatly helps in developing tools and processes to manage the risk associated with this related equipment and facilities.

3.4 Risk & Review

To keep track of all the variables that can affect an asset's performance, as well as the likelihood and impact of those variables, a risk management tool is required. Risk modeling and analysis must be used in asset decision-making to ensure that a competitive strategy planning, and implementation is achieved, while simultaneously reducing the negative consequences on the environment and society. There have been several risk models developed, but more work should be done to develop models that can offer decision makers with complete overviews of risk modeling that incorporate asset information management advances.

4. Approaches for Achieving Energy Sustainability and Sustainable Development with Assets

For asset energy sustainability and sustainable development, it will be best to begin with energy systems, having a lot of indicators for energy efficiency improvement. However, this can also be applied to other asset systems having elements for any or all of energy production, operation, consumption, and disposal. The integration of environmental, economic, and social sustainability into a complete study of energy systems is essential, given that as urbanization and the global economy continue to grow at an exponential rate in the modern world, demand for energy will rise in response to the increasing demand for sustainability. Universal energy demand has been anticipated to climb above 40 percent in the next two decades. (IEA, 2019)

In achieving this, several techniques need to be combined to achieve energy sustainability in asset. And it will be more beneficial for whatever approach employed, to consider proven approaches. These include.

- Life Cycle Sustainability Assessment Methods
- System, Process and Equipment Thinking Methods
- Technology Driven Applications

4.1 Life Cycle Sustainability Assessment

Life Cycle Sustainability Assessment (LCSA) is an inter-disciplinary framework for model integration rather than an actual technique; as such, there are several chances to integrate tools and methods in order to enhance LCSA's usefulness. (Kucukvar, 2013) One way to include more variables in LCSA's scope is to go from a micro-level (process-based) to macroeconomic analysis by including environmental, social, and economic considerations. (Huppes & Ishikawa, 2011) As a result, LCSA (Mannan & Al-Ghamdi, 2021) shares many similarities with the existing assessments for life cycle, incorporating economics-life cycle costing (LCC)(Stamford, 2019), social-social life cycle assessment (SLCA)(Stamford, 2019), and environment-life cycle assessment (LCA)(WEC, 2004).

Thereby.

$$LCC + SLCA + LCA = LCSA$$

Given an asset with dynamic interactions among the parameters that constitute LCSA, technique for energy efficiency for sustainability can be investigated.

4.2 System Thinking, Process and Equipment Investigation Methods

The LCA, LCC, and SLCA frameworks even being a system-based method, lack a grasp of interconnection and feedback interactions among distinct system constituents (a wide range of disciplines, processes, services, and products that have a direct impact on sustainability.). And Considering that LCSA hasn't been widely used in engineering, researchers (Cucurachi & Suh, 2015; Zamagni et al., 2013) have suggested that LCSA should be further developed to be a tool for a comprehensive quantitative assessment of sustainability by incorporating a wide range of socio-economic indicators, embracing causal relationships, and focusing on uncertainties in LCA results during the multi-objective decision-making, which is defined by system thinking approaches. As it is the case with energy assets, LSCA can be enhanced by considering individual system components for analysis as single, and also whole. The European Union newly adopted Industrial Emissions Directive (EU, 2021) highlights, that it's likely that not all the installation's activities and/or systems can be optimized for maximum energy efficiency at once. The most efficient use of energy may not be combined with the least number of other uses and emissions (for example, reducing emissions to the atmosphere without consuming energy may not be possible). One or more systems may be de-optimized to obtain the overall maximum efficiency of an installation. While optimizing energy economy is critical, other considerations, such as product quality or process stability must also be considered. When using primary fuels, it may be more sustainable to use sustainable energy sources and/or 'wasted' or surplus heat rather than using primary fuels.

4.3 Technology Driven Applications

Continuous energy efficiency is already partly attributable to technology such as digital solutions and services; to maintain that equipment and processes work as efficiently as possible, to support decision making and to identify areas for development, these systems use continuous condition monitoring techniques with embedded indicators to provide information needed to manage asset criticality and risk levels and make predictions for performance optimization, and continuous improvements.

5. Conclusion, Perspective and Future Work

By focusing on resource efficiency while considering commercial, technological, legal, and normative limits, market dynamics, and long-term viability, asset management goes a long way toward promoting sustainable development. One way will be by upgrades into renewables and hybrid supported energy asset systems. Maintaining a healthy balance between performance, cost, and risk is a critical part of physical asset management. Renewables could account for two-thirds of total energy consumption and 85% of total power output. (OECD, 2012) The amount of renewable energy that must be deployed must be increased at least six times over what is now planned. Electricity's part in overall energy usage must increase by double, and other utilization sources to a significant extent. To keep global warming to far below 2 degrees Celsius, energy efficiency and carbon emission control will be critical. If the global energy system is transformed, everyone will have access to inexpensive and reliable energy at a higher level of security. To keep the global temperature, rise well below 2°C, existing and projected policies offer a rather sluggish route, wherein the world would exhaust its energy-related "carbon budget" in less than 20 years. Meanwhile, the money set aside for a 1.5°C ceiling may be depleted in less than a decade. Reducing human health and environmental expenses would result in yearly savings of up to five times the extra cost of the shift by the year 2050, according to economic calculations. (Larsson, 2009; Seckin Salvarli & Salvarli, 2020) There will be roughly 40 million new employments connected to renewables and efficiency in the global economy by 2050. (Parrott & Warshaw, 2017) Acting sooner rather than later may save an estimated USD 11 trillion in energy infrastructure assets linked to today's polluting energy technologies. (World Economic Forum, 2018) As a result, fast, immediate, and long-term change is required in the energy system, that will facilitate proper management of these assets in achieving fast-track growth, more jobs, cleaner communities, and improved general wellbeing. Seeing these opportunities, there is a need to develop an integrated energy-centered reliability model of the asset management to evaluate an integrated energy system, creating a link between energy efficiency and the reliability impact of using the combined or intermittent switch to the alternative energy sources, offering suggestions on how to get the best results. Additionally, employment of digital twin in managing energy sustainability issues toward sustainable development for effective asset operational excellence.

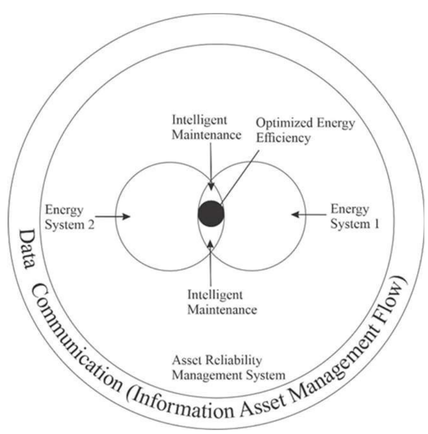

Figure 2. Proposed Energy-Centered Asset Management Reliability Framework for Hybrid (Dual Energy Sources)

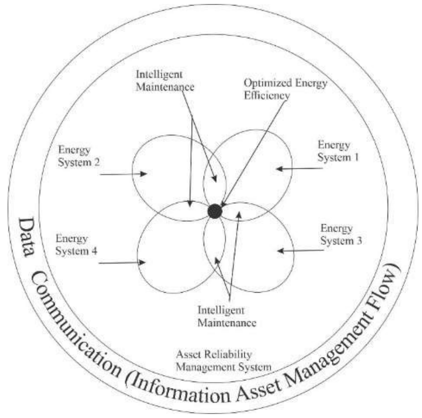

Figure 3. Proposed Energy-Centered Asset Management Reliability Framework for Hybrid System (Multi-Energy Sources)

Organizations, and homes all stand to gain from the recommendation of the proposed framework. The implementation of this framework will have a major impact on the development of a long-term energy system. Ultimately, securing a brighter future depends on moving forward with an energy transition that is good in all these ways as well as ecologically, socially, and economically. In recent decades, energy efficiency for sustainability has made significant progress, but there is no doubt that there is still potential for improvement. Theory and ideological conceptions continue to influence the commercialization of technology in a wide range of applications and sectors. The discovery of novel processes like intelligent censoring systems on assets, energy, and remote maintenance inspections employing robots has transformed our knowledge of theoretical boundaries. A better understanding of how these new technologies interact with assets, people, and the environment has resulted in a greater ability to achieve energy savings initiatives for asset systems as well as to achieve sustainability, reliability, and availability by the equipment. This plan necessitates that an organization have framework in place to adapt to these changes, and for that reason, a sustainability strategy, that is both operational and technologically effective must be a part of the framework, which ensures organizations don't go back to previous habits and performance levels as they progress.

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Biography

Joseph Akpan is currently a master's student in the Department of Industrial Engineering, Durban University of Technology (DUT), South Africa with a Bachelor's in Mechanical Engineering from the University of Uyo, Nigeria. Prior to his present studies, he worked shortly as a Graduate Engineering Intern at ExxonMobil Nigeria, where he had grown to develop interests in committing to research findings, exploring industry 4.0 technologies towards physical asset management, energy systems optimization, and engineering education. He is a Certified Maintenance & Reliability Professionals (CMRP), graduate student member of the Society of Maintenance & Reliability Professionals (SMRP), American Society of Engineering Management (ASEM), and the Nigerian Society of Engineers (NSE).

Oludolapo Akanni Olanrewaju is currently a Senior Lecturer and Head of Department of Industrial Engineering, Durban University of Technology, South Africa. He earned his BSc in Electrical Electronics Engineering and MSc in Industrial Engineering from the University of Ibadan, Nigeria and his Doctorate in Industrial Engineering from the Tshwane University of Technology, South Africa. He has published journal and conference papers. His research interests are not limited to energy/greenhouse gas analysis/management, life cycle assessment, application of artificial intelligence techniques and 3D Modelling. He is an associate member of the Southern African Institute of Industrial Engineering (SAIIE) and NRF rated researcher in South Africa.