Energy Efficiency in Manufacturing in the context of the Fourth Industrial Revolution

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Abstract

The twentieth and twenty-first centuries have dawned with their unique problems that have been brewing for many decades and slowly consuming the environment, causing it to deteriorate at a very rapid rate. In recent years' energy, efficiency has significantly gained research interest in stature, it is necessary to alter the way that energy is utilized. Energy-intensive sector such as manufacturing industry in South Africa can provide a competitive advantage on a national scale and could gain cost advantage against global competitors, if the energy productivity demand improves across the economy through lean energy-efficient opportunity in manufacturing operations and fourth industrial revolution. The need for energy efficient manufacturing industries requires the understanding of different customer's energy demand and ability to fulfill these demands while maintaining the economies of scale at the same time. These can be achieve by segmenting manufacturing into various sectors to focus on high intensive energy users, and then gradually give attention to the others. The paper identified and investigated the existing gap in the train manufacturing plant equipment lists through determination of equipment energy demand profile and presents an analysis of the proposed energy efficiency initiative using 80-20 Pareto analysis principle to analyze the equipment lists.

Keywords
Energy Efficiency; Manufacturing; Pareto analysis; Fourth Industrial Revolution

1. Introduction

The changes among manufacturers in the industry, in the quest for meeting customised product and the variability in customer's demand requires process technology diffusion. These aspects are associated with the new programming language development and the network complexity. The increasingly mature and complex market has gradually shifted from a sellers' market to a buyers' market, which in turn creates a tendency that forces a transformation on production philosophy from mass production to intelligent production (Brettel *et al*., 2014). Industrial energy efficiency can be influence by changes in industrial processes and by changes in capacity utilisation (Ren21 GSR, 2016). The social, environmental and economic aims of sustainable development need to be supported and energy efficiency (EE) is regarded as one of the most cost effective ways of meeting the varying demands of sustainability (Oyedepo, 2012). The benefits of energy efficiency to the environment are self-evident, only three decades ago did the issue of environmental safety and energy shortage crisis became publically known (Newman *et al.* 2012). These benefits are of particular relevance, furthermore Eskom (the national power supply authority in South Africa) stated that in 2002 the use of coal as the primary fuel in electricity generation, accounted for 36% of the world's electricity production and is going to remain so until 2028 (Statistic South Africa, 2005). South Africa remains one of the highest emitters of the greenhouse gas CO2 per capita in the world (Burck *et al.* 2014). Hu *et al.* (2012), states that the energy being consume is attracting much attention due to its environmental impact and with this being one of the reasons that the Eco-design bill was promulgated into law according to Motenbroek *et al.* (2012). Green manufacturing also has the potential for economic benefit as a byproduct of its implementation (Newman *et al.* 2012), for example reducing the energy consumption and reduces the overheads of that specific machine. All machines can be included in the energy saving strategy as alluded to the above improvement in energy efficient methods to reduce the operating cost of the machine and therefore indirectly reduces the emissions produced during the generation of electricity.

The International Organization for Standards (ISO), which is also developing standards that will support the trends of energy and resource efficiency (Gotze *et al.* 2012). Santos *et al.* (2011) reported that in the past 20 years that there have been some major efficiency improvements, which have occurred, for example energy requirement of machines have been reduce by 50% (Gotze *et al.* 2012).

The research latched onto the vision of the energy efficiency strategy for the Republic of South Africa in order to encourage sustainable energy sector development and energy use through efficient practices. Minimising the undesirable impacts of energy usage upon the health of the global population and the environment, and contributing towards secure and affordable energy for all, and only now is this issue of high priority with the International Energy Agency (IEA) predicting a 1.5% increase in energy demands from 2007 to 2030 (Ren21 GSR, 2013). Renewable Energy Policy Network for the 21st Century presented a report on the global renewable power generating capacity to have reached 26% and expected to supply 21.7% of global electricity demand by end 2012. Total renewable power capacity worldwide would have exceeded 1470GW by end 2012; and South Africa is ranked 12th in the world in terms of top emitters per capita. In 2012, the energy ministers of the Southern African Development Community (SADC) and the East African Community (EAC) formally agreed to establish similar regional renewable energy and energy efficiency promotion programmes, while South Africa projected energy efficiency target to reduce final energy demand by 12% by 2015 (Eskom, 2015). Little work have been done to date on the interrelations between Fourth industrial revolution in the context of Manufacturing. It is the ability to assign identities to extremely small batches of products and materials and to locate them precisely that enables the key Industry 4.0 functions of tracking the items involved in production processes at each level of the supply chain, inside and outside of the factory. In order to denote the process of close integration of information and communication technologies (ICT) in manufacturing and logistics through the potential deployment of Cyber-Physical Systems (CPS), leading to a fourth industrial revolution. CPS enables continuous data collection and analysis across entire value networks through Machine-to-Machine (M2M) communication using the Internet of Things (IOT). Tiwari, 2015 proclaimed that it would certainly be necessary to develop robust strategies to mitigate the risks and challenges associated with manufacturing growth using fourth industrial revolution concepts.

This paper begins by providing a brief introduction of the fourth industrial revolution concept and its relationship with manufacturing, section 2 talks about the reviewed literature on fourth industrial revolution, and then discussed it in the contexts of "smart manufacturing", the "energy efficiency" and "green technology". Section 3, is the energy efficiency initiatives, and section 4 presents the results, observation and recommendation, while section 5 provides a number of conclusions with acknowledging remarks in section 6.

2. Literature Review

The need for energy efficient manufacturing industries requires the understanding of different customer's energy demand and ability to fulfill these demands while maintaining the economies of scale at the same time. These can be achieve by segmenting manufacturing into various sectors to focus on high intensive energy users then gradually give attention to the others. Studying competitors' actions, predicting energy demand uncertainty (Johansen *et al*., 2012), and focus on the trade-offs between different performance objectives as well as achieving the fit between production capability and energy market demands. Both requirements emphasize companies' capability of collecting and managing massive information from the International Energy Agency (IEA). In 2002, approximately 75% of energy needs of South Africa were satisfied by means of coal (Statistic South Africa, 2005), with 53% generating electricity. The need for energy efficiency arose from the effort made to have the deployment of the intended energy efficiency solution as a key policy towards maximizing profits. Many forward-thinking industrial and commercial entities support the energy towards efficiency as well as all the work done to date and how critical it is to provide both the non-connected and connected customers with proof of greater control over their electricity use coupled with time-based rates; in order to curb the loss of revenue through energy waste by introducing an energy efficient means that will allow customers to make informed decisions by providing highly detailed information about electricity usage and costs.

Electricity affects many manufacturing industries with regard to emissions, meaning that the excessive quantities of energy consumed by production machines that constitute the heart of all manufacturing operations. No manufacturing process can be performed without a machine tool to cut, bend, weld or grind the material into the desired geometry, these indirectly produce emission that affects the environment, energy saving is vital and crucial for everyone in order to save the environment. The manufacturing industry accounts for more than 37% of the world's energy consumption (IEA, 2012). In the United States 42% of the energy was consumed by the manufacturing sector (Hu *et al.* 2012), while industry accounts for almost one third of global energy with approximately 40% of it contributing to carbon dioxide (CO2) emissions (Ingarao *et al.* 2012). Green manufacturing

or technology is needed to counteract the energy demand growth trends, according to Xie *et al.* (2010); it is the key technique to a sustainable manufacturing industry.

2.1 Fourth Industrial Revolution Concept

As one of the means to improve this energy required capability, the concept of "Fourth Industrial Revolution" initiative by the German government in cooperation with industrial and scientific organisation in 2012, is a phenomenon based on Cyber-Physical Systems (CPS), the Internet of Things (IOT) and Services and cloud computing. The promotion of the fourth industrial revolution and the acquisition of a leadership position in manufacturing sector in the world, were the main objectives of Germany (Bartodziej, 2017). At the same time, USA developed the "Advanced Manufacturing Partnership" plan, a reindustrialization plan, aimed at innovating manufacturing through the adoption of intelligent production systems and improving the occupational levels of the country in order to increase productivity and reduce costs. In 2015, France launched the "Alliance for the Future program" to implement the digitization process for support innovation, and in 2016, Italy, approved the "Fourth Industrial Revolution" plan (Gausemeier *et al*., 2016).

A generalized approach to manufacturing energy efficiency based on a machine-level study was developed by Fysikopoulos et al. 2014, while Brizzi et al. 2013 presented a case study on the remote monitoring of robot energy consumption, demonstrating the capability of intelligent applications for managing manufacturing processes. The work of Lennartson et al. and Riazi et al. both in 2016, presented more energy efficiency based on process optimization, where an algorithm is introduced that allows reducing energy consumption for industrial robots up to 30% by adapting acceleration and deceleration behavior, without substituting hardware or negative consequences on the production rate. Thiede et al. 2013 argue that environmentally related aspects are currently not sufficiently considered as standard functions in manufacturing system simulation tools, which is a more IT-based concept is the energy simulation of manufacturing systems; one potential solution approach is presented by Herrmann et al. 2011 where a flexible energy flow-oriented manufacturing system was simulated. Similarly, Zhao et al. 2015 analyze the sustainability impact of manufacturing by introducing a new information model for product lifecycle management that integrates an energy simulation framework. The more general approach at energy efficiency in manufacturing is the methodology for planning and operating energy-efficient production systems which was proclaimed by Zhao et al. in 2015, while Caggiano et al. 2016 propose a multi-purpose digital simulation approach dealing with sustainable Manufacturing systems design through Discrete Event Simulation and 3D digital human modeling. This is allowed in a demonstration case from the aerospace industry for a very significant reduction of energy consumption as well as an increase in energy efficiency as presented by (Weinert, 2011), and details modeling approaches and discusses the simulation tools that allow for combining Building Energy Modeling and Manufacturing Process Simulation into a holistic approach (Garwood et al. 2018). The Fourth Industrial Revolution paradigm will be a step towards more sustainable industrial value creation and holds a great opportunity to realize the creation of sustainable industrial value in all three dimensions of sustainability: environmental, social and economic.

2.2 Smart Manufacturing

Fourth Industrial Revolution embodies smart manufacturing by applying advanced information and communication systems, and high technology. In 2013, Lee proclaimed smart manufacturing as a data-driven paradigm that facilitates the transmission and sharing of real-time information across networks, with the aim of creating manufacturing intelligence in implementation of energy efficient and demand side management initiatives with specific emphasis on alternative energy technologies. These can serves as the implementing platform for the Smart Grid Initiative (SGI), in support of the Department of Energy's and South African Energy Development Institute (SANEDI).

The objective of smart manufacturing is similar to traditional manufacturing and business intelligence, as they both focus on transforming raw data to knowledge (Donovan *et al*., 2015). Multiple advanced manufacturing schemes such as the flexible manufacturing system (FMS) and the agile manufacturing system (AMS) have been developed by manufacturers in order to achieve high flexibility and energy efficiency at lower costs (Wang *et al.*, 2016).

Among these schemes, the areas of application of agents and multi-agents system were corroborated by Adeyeri *et al*. (2015), through the proposed framework engine of agents' technology for reconfigurable manufacturing system for Fourth Industrial Revolution; in which all manufacturing resources are defined as intelligent agents as corroborated by Adenuga *et al*., (2016), as a potent tool for solving complexities in manufacturing equipment and machines in the present age technological growth, as well as indispensable tools for projecting into the fourth industrial revolution, that cooperate with each other to achieve dynamic energy efficient reconfiguration.

However, the smart manufacturing comprises an extreme emphasis on real-time collection, integration, and sharing of information across physical and virtual platforms, which will achieve a flawless stream of operation. The realisation of energy efficient manufacturing necessitates the adoption of smart manufacturing, and this will include sequential phases of data integration and contextualization; simulation, modelling, and analytics and process and product innovation according to O'Donovan *et al*. (2015). It is generally believed that the realization of smart manufacturing is simply too complex for any individual organization (Davis *et al*., 2012). It is however achievable through vision of real-time, digitized and data-driven smart factories that are based on sophisticated simulation models. Data analytics to optimize performance (O'Donovan *et al*., 2015) with the combination of smart devices and big data analytics is vital (Wang *et al*., 2016) and the intelligent distributed agents that are capable of dynamically reconfiguring the systems. This will happen through the analytics provided by the global feedback and information management that enables machines, conveyors, and products to communicate and negotiate with each other to adapt themselves for flexible and energy efficient production of diverse products (Wang *et al*., 2016).

2.3 Energy Efficiency

Energy efficient practices are align with the principles of continuous improvement and lean manufacturing. Energy Efficiency (EE) involves a reduction in the energy input of a given service or level of economic activity, according to International Energy Agency (IEA) and the World Energy Council (WEC). Energy usage tariff often makes up a large part of the business expenses in terms of costs and affects competiveness and productivity; while industrial energy efficiency can be influenced by changes in industrial process. Manufacturing processes' near-term energy-saving opportunities comes from energy-smart procedures applied to operations. Government policies and programs, environmental regulations and technological and managerial innovations affect energy use in the manufacturer's implementation of energy efficiency.

The cost effectiveness of energy efficiency is a key criterion to determine whether to finance a related project and a method to identify the lowest cost and most beneficial option from among competing alternatives for achieving the stated is regarded as cost-effectiveness analysis objective (GEF 2005). Quantitative and qualitative approaches are used to conduct cost-effectiveness analysis, and also a criterion consider for both quantitative indicators and qualitative approaches for reviewing project proposals and estimating their cost effectiveness (GEF 2011). In a quantitative cost-effectiveness analysis, indicators that best describe project outcomes would be identified, and the cost of achieving a unit of each of those indicators for the competing alternatives would be computed. The alternative that has the lowest cost per unit of indicators would be regarded as the most cost-effective means of realizing the stated outcomes.

2.4 Green technology

The rising costs in energy also offer opportunities for manufacturing industry to achieve practical energy reductions of about 20 or 30 percent of the savings without capital investment, using only procedural and behavioral changes by strategically building energy efficiency decision-making into production. Manufacturers will identify new ways to cut costs, raise productivity, and improve shareholder value; meet environmental standards through reduction in plants carbon footprint; improve competitiveness through improved production efficiencies; create business and environmental benefits of power factor correction; reduce energy and electrical costs and free up capacity on electrical supply transformers. Green technology cannot be removed from Fourth Industrial Revolution technology that is currently being developed and does not only address the manufacturing machines; it includes the development of green procedures or / and processes as contained in the Department of Energy's and South African Energy Development Institute (SANEDI) and SADC Centre for Renewable Energy and Energy Efficiency within in the Southern African region (SACREEE).

3. Energy Efficiency Initiatives

The proposed EE initiatives taken into consideration the application of diversity factor of 0.25, 0.4, 0.45, 0.5, 0.7, 0.8 and 1, in the design of the electrical load profiles. They includes the use of pareto analysis by applying 80/20 principles for the psychological drivers and barriers to energy management; increasing EE efforts from the demand-side point of view; imploring on the management the factors that drives or impede the decision making on energy issues and suggested the possibility of improving energy management practices.

The aggregated and analyzed data is to be used to enhance and automate decision-making process on the opportunities to explore the energy efficiency ideas, which is the fourth industrial revolution, has big data as prospect. It is expected that it will revolutionize the working practices and proffer an opportunities to optimize the

connected machines energy usage. This will in turn allow the manufacturing companies to adopt the framework ad EE initiatives to produce more, using less energy, much quicker than they could before.
The following methods are proposed for the implementation for the projects that is related to energy efficiency, comprising:

- The use of power electronics lights fittings with more efficient alternatives as a replacement for the non-energy efficient lights fittings; revenue enhancement for the energy efficiency resource initiatives with specific emphasis on alternative energy technologies and energy efficient means to save energy and reduce cost.
- The use of ISO 5000-certified energy management system for Energy Efficiency and Demand Side Management (EEDSM), as the pursuit of cost-effective energy efficiency measures on the customer side, as well as various conservation measures, for least-cost overall energy system optimisation. It can also incorporate dynamic load response to real-time market signals or direct load control by utilities based on predetermined criteria.
- Energy harvesting in Advanced Asset Management (AAM); and use of Software in Active Network Management.

4. Results, Observations and Recommendations

The principle of the Pareto Analysis was adopted to prepare the results based on the Zipf distribution pattern in linguistics (λ) and a discrete probability distribution with parameters (N).

Cumulative percentage ≥ Nominal rated power (N) ……. Equation 1

N € {100, 200, 300, ---} ……..... Equation 2

In addition to being a static technique, the Pareto Analysis is a creative and practical way of looking at the causes of problems. It stimulates ideas about thinking and organizing. This method of analysis (Pareto Analysis) helps identify the main causes (20%) that leads to 80% of the problems that need is to be solved.

4.1 Measuring – identify the problems and documenting them in a table

Based on interviews and reports, an equipment lists data was collected from which problems can be the following sum total of the energy consumed by socket, which is 1760 kilowatts, equivalent of 17.7%; Cathedral (1 and 2) series spot welding machines is 1200 kilowatts, as 12.04% and spot welding machines as 4338.1 kilowatts, equivalent of 43.6% was deduced. Subsequently, these problems are documented in a table 1 and after grouping. We then apply the 'cause-effect' theory to each item so that the source of each documented problem can be found.

Table 1: Train manufacturing plant equipment lists with identified and documented rated power after grouping

Equipment Lists	Nominal Rated Power Total (kW)	Cumulative unit	Cumulative percentage
Socket	1760	1760	17.67079
Cranes	144	1904	1.445792
Auxiliary Converter	302.4	2206.4	3.036163
Battery Charger	160	2366.4	1.606435
Car Turn table and Coupling jig (1T)	60	2426.4	0.602413
Cathedral (1 & 2) series spot welding machine	1200	3626.4	12.04827
Instruments for Testing	590.99	4217.39	5.93367
General Power 1100m²@50VA/m²	226.25	4443.64	2.2716
Hot Water Generation	215	4658.64	2.158648
Lighting	491	5149.64	4.929749
Spot welding machine	4338.1	9487.74	43.55548
various welding tools	230.2	9717.94	2.311259
Ventilation Fans and pumps	242	9959.94	2.429734
	9959.9		100

4.2 Determine their order of importance

The equipment list were organized in ranking order of importance from the highest nominal power consumed by equipment down to the least power-consumed equipment in descending order as shown in table 2.

Table 2: Train manufacturing plant equipment lists with rated power order of importance after grouping

Equipment Lists	Nominal Rated Power Total (kW)	Cumulative unit	Percentage Unit	Cumulative %
Spot welding machine	4338.1	9487.74	43.55548	43.55548
Socket	1760	1760	17.67079	61.22627
Cathedral (1 & 2) series spot welding machine	1200	3626.4	12.04827	73.27454
Instruments for Testing	590.99	4217.39	5.93367	79.20821
Lighting	491	5149.64	4.929749	84.137959
Auxiliary Converter	302.4	2206.4	3.036163	87.174122
Ventilation Fans and pumps	242	9959.94	2.429734	89.603856
various welding tools	230.2	9717.94	2.311259	91.915115
General Power 1100m²@50VA/m²	226.25	4443.64	2.2716	94.186715
Hot Water Generation	215	4658.64	2.158648	96.345363
Battery Charger	160	2366.4	1.606435	97.951798
Cranes	144	1904	1.445792	99.39759
Car Turn table and Coupling jig (1T)	60	2426.4	0.602413	100.000003
	9959.9		100	

4.3 Mark or score each recorded problem

Having identified the order of power consumption, the analyzed score show that welding sections, which are inductive in nature, consume an estimated 73.34% of all electricity used in rail industry for construction purposes. It would clearly be useful; therefore, if we were able to measure accurately the welding machines consumption in real-time using data. That same data can then be used to boost or enhance machines performance as well as increasing throughput with reduce tariff through the energy efficiency initiatives.

4.4 Group the identified problem and add the marks or scores

The grouped scores show that 73.34% of the energy consumed can be traced to 26.66% of the causes. The proposed Pareto analysis rule will helps in prioritizing the decisions by the management know which ones will have the greatest influence on their overall goals and which ones will have the least amount of impact. It also creates the idea that 80 percent of a project's benefit can come from doing 20 percent of the work.

4.5 Take action

Form the Figure 2, which shows the pareto-analysis results using 80-20 application for the load profile for the train manufacturing plant equipment lists, it is deduce that the blue area of energy consumption range of between 0 to 500 kilowatts are the 26.66%, which is the train manufacturers' energy inputs that includes primary energy input which involves the total volume of energy assembled to serve plant needs**;** central generation powerhouses where fuel is converted to heat and power by a steam plant, power generator or cogenerator; distribution, which pipes heat and sends power from central generation to process units; energy conversion, which consisting of motors, fans, pumps and heat exchangers that transforms heat and power to useable work; and processes, in which converted energy transforms raw materials and intermediates into final products. They include Supply Park, car body shell, training center, office block, lightings, canteen, facilities management building, car body wash, fitting deck and water testing. They are regarded as the continuous energy users, while 73.34% ranges between 500 and 4500 kilowatts are majorly concentrated energy used for welding purposes, and are intermittent in use according to operational demand for car manufacturing subject to the functionality of the all the other machines.

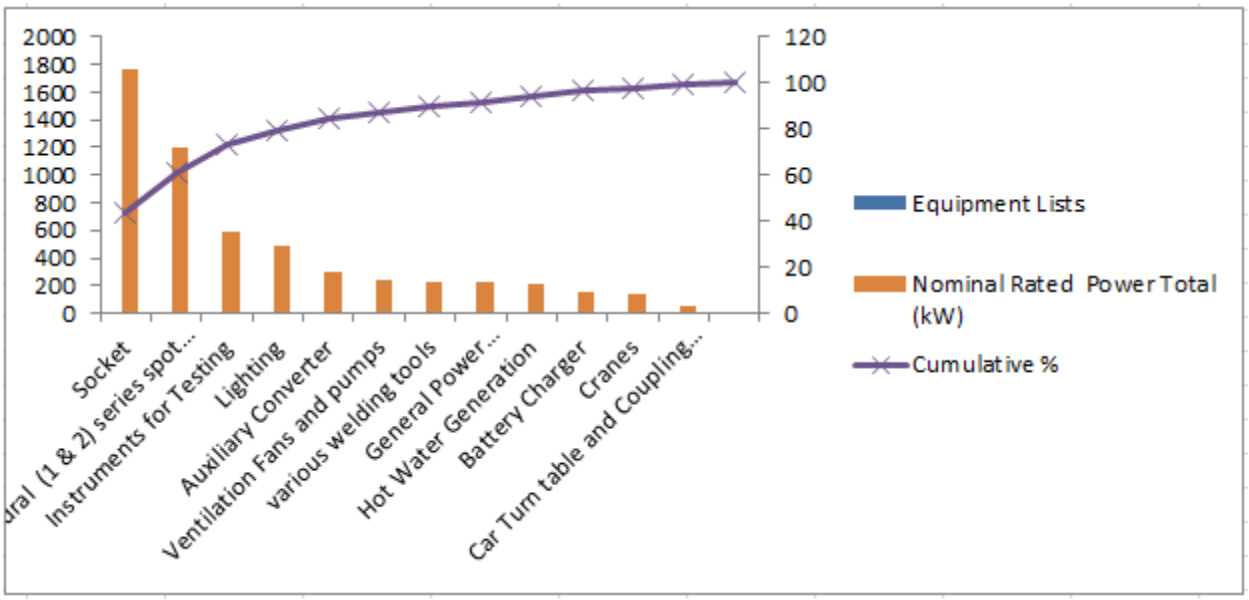

Figure 1: Pareto-Analysis principle results using 80-20 application for the Gibela plant equipment lists

4.6 Observation and Recommendation

There is an opportunity for EE in South African manufacturers' context in water, and wastewater infrastructure through the installation of energy efficient motors and variable speed drives (VSDs). Energy efficiency requirements, measurement methods, appropriate labeling of energy efficient electrical and electronic apparatus with require mandatory standards on compliance and energy use in the built environment, with all new buildings and extensions to buildings requiring energy efficiency initiatives, to ensure that at the time of purchase, buyers have all the relevant energy consumption information at their disposal. There is also the methodology and required tool for calculating energy savings for projects submitted on the 12L energy efficiency tax rebate programmes, which will help the end users to explore alternative means and adhere to certain minimum energy performance standards to ensure their energy security, leading to the rise of the energy services market. Industrial Policy Action Plan (IPAP) 2014/2015, which includes the MCEP that will provide, enhanced manufacturing support. The Production Incentive (PI) programmes will include a green technology-upgrading grant of between 30-50% for investments in technology and processes that improve energy efficiency and greener production processes. Information from a recent South African Cities Network (SACN) study indicates that treatment works can reduce energy consumption by 5% through installing energy efficient motors and by a further 15% through installing VSDs (South African Local Government Association (SALGA) 2014). The following other areas have been identify with energy saving potential: pumps of most types and functions, aerobic wastewater, water treatment plant and sewage treatment systems. Turning off lights in unoccupied areas or after hours; Changing from Electrode boilers to gas-fired boilers; generating electricity from waste-heat or from burning waste material; and replacement of lights fittings with more efficient alternatives. Additionally, Potential quantitative energy savings include Pumps and pumping (common potential ranges: 5% to 30%); Waste water treatment (production of compressed air and biological treatment up to 50%) and Energy and heat generation on wastewater treatment through CHP/Cogeneration; Wind, PV, Mini gas turbine up to (55% – 100%). The achievement of Potential quantitative energy savings target can also be realized by the establishment of the Manufacturers Energy Management Plans (MEMP), which interventions might include small scale renewable technologies, cogeneration plants, and energy efficient measures in companies, offices, industry operations, or vehicle fleet. These MEMP will provide business opportunities to support manufacturing companies/entities to prepare themselves for the issuing of certificates for energy management (ISO50001) through the adherence to:

- Energy baselines calculated by a certified energy auditor or measurement and verification professional in accordance with SANS 50010.

- Energy efficiency saving potentials identified by a certified energy auditor
- Energy performance indicators for monitoring energy performance.
- Reports on the implementation of the energy management plans, and achieved energy savings.

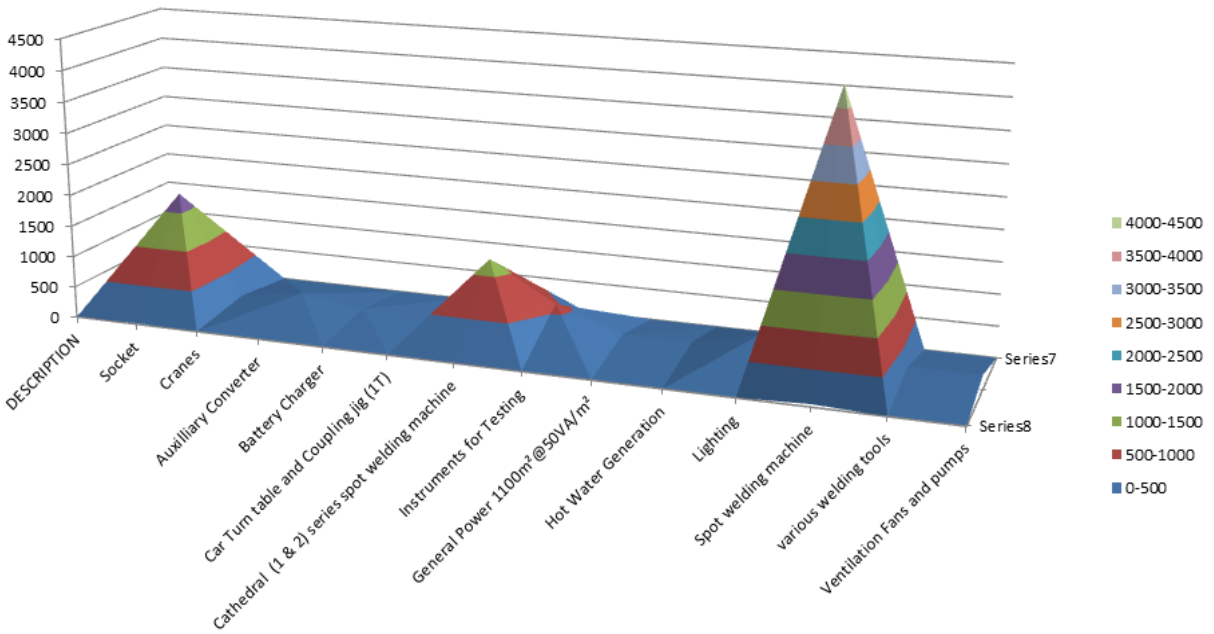

Figure 2: Pyramidal chart representation for Pareto-Analysis principle with scaling nominal rated power for the Gibela plant equipment lists using 80-20 application

5. Conclusion

This article has sought to justify precisely why Energy Efficiency initiatives approaches are well suited to developing energy cost reduction in general and green house emission footing reduction in particular. These general points are then made concrete by showing how they apply Pareto analysis principles to analyze the plant equipment lists in train's manufacturing industry. These findings have important industrial policy implications, which need to be integrated to ensure a balance between energy efficiency and manufacturing industry growth. This is because improved energy efficiency is associated with a number of benefits: energy security, environmental quality, development, consumer welfare among others, which eventually promote growth. Although some manufacturing industries had already latched into this energy efficiency initiative and helping to stimulate investment into energy efficiency via South Africa national energy efficiency strategy. There is the need to monitor, enforce and evaluate such strategies on a continuous basis, as these are key to identifying gaps and achieving the value added services, intensive in energy consumption and CO2 emissions. However, policy makers within the manufacturing settings need to understand fully the barriers that hinder investment in cost-effective energy efficiency in their industrial sector, couple with the rising electricity prices and the need to provide good and services by the manufacturing in the fourth industrial revolution is to ever-increasing cost of production. They must design and implement policies and programmes that help enterprises overcome the barriers and have to focus on all possible measures to improve the cost efficiency of service delivery in order to be financially sustainable. They must tackle both barriers that are within enterprises and industries, and those that are external to enterprises and directly under their control. These include energy prices and utility tariff structures.

The author proposes that the implementation of this energy efficiency initiatives will afford the car rail manufacturing company the potential benefits of prioritizing the decisions by the management to know which ones will have the greatest influence on their overall goals; and which ones will have the least amount of impact on the

reduction in energy consumption; and creates the idea that 80 percent of Energy Efficiency project's benefit can come from doing 20 percent of the work.

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