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The Case for an Energy Management System Approach for the Airports

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Abstract

Energy plays a key role in the development of any country and human's wasteful and excessive behavior of energy use without control can lead to high energy prices. The current trend of excessive energy resource use threatens the sustainability of future generations' development hence, the creation of a long-term sustainable solution to manage energy efficiency should be the greater focus throughout the energy value chain [7]. Saving energy is the lowest-cost way to cut greenhouse gases. These significant cuts are achievable if they align with a sector transformation, adopting disruptive technologies and business models. Transformation cannot be achieved through the market alone, and building stakeholders need to adopt a sense of urgency and a new mindset in which building energy is a top priority. It requires businesses to apply expertise and finance to develop and promote new approaches to energy efficiency and policyholders need to introduce strong regulatory frameworks that support market transformation. A case study of the King Shaka International Airport's implementation of an Energy Management System Approach is presented here. The study highlights the need for a systematic approach to energy management and how this should work in an airport environment.

Keywords: Energy Management System, Barriers to Energy Efficiency, Objective Energy Target.

1. **Introduction**

The number of airports has recently increased due to the fast growth of the aviation industry and the increment in the number of new destinations added to the flight network. The dynamic structure, 24-hour servicing, performing flight operations safely and the provision of comfortable conditions for passengers in terminal buildings, have led to an increase in the energy consumption of airports. Energy management has become an important topic for the continuous improvement of energy performance in airports as they are sites with high and intense energy consumption.

The rapid growth of the aviation industry (by an annual average of 5%) and the addition of new routes to the flight network in recent years have led to an increase in the number of airports. The fact that the aviation industry makes a contribution of approximately 2.2 trillion dollars to the world economy with more than 3.3 billion passengers per year is also an indication of to what extent it is great [1]. The main reasons for this increase are the increase in passengers' demand for air transport and the addition of different points (city/country) to the flight network. The inclusion of different flight points in this network has led to an increase in the number of airports and relevant facilities, as well. Airports have a dynamic and complex structure that contains many service secctors within themselves. The main focal point especially in ground services is terminal buildings. However, dynamic processes and services, the systems or elements for the safe realization of flight operations, and ensuring comfort conditions of passengers in terminal buildings at the airports are considered as components that are directly connected to energy resources. Nowadays, the fact that airports achieve a sustainable infrastructure in environmental impact processes is primarily possible by the development of effective and efficient energy management systems. Indeed, as it is seen in sectoral examples, energy management has become an important issue for the continuous improvement of energy performance at airports which are high and intensive energy consumption areas.

The increase in the number and capacity of the airports primarily leads to an increase in demand for energy for the airports. When it is considered around the world, it is seen that a large part of this energy requirement at airports is provided by fossil fuel sources, like coal, natural gas, and oil. It is known that fossil fuel-based energy consumption and this ever-increasing demand lead to economic, social, and environmental problems, as well. Other energy resources, including hydroelectric, are considered to be renewable and therefore sustainable in the long term. The energy generated from renewable resources does not mean that it has zero emissions and is environmentally harmless. A certain amount of damage is caused to the environment in the processes of obtaining the raw materials of renewable energy systems from nature and producing, installing, maintaining, and recycling them [2, 3].

Energy management is the most effective way to prevent energy waste [4]. While there is a potential for energy efficiency in almost every sector around the world, it is possible to improve the energy potential by 40% even in the countries that use energy most efficiently, with current technology and efficient energy management [5]. Energy management should be addressed holistically to decrease energy intensity and energy-induced environmental impacts without compromising comfort and quality of service at airports which are high and intensive energy consumption areas [4]. The segmentation of the airport to be made most generally will be important for the establishment of the energy management approach. Airports can be examined in two sections: air side and land side. The section called land side consists of a terminal building, cargo terminal, and parking area. The air side section (apron, runway, control tower, maintenance facilities, etc.) includes all areas and structures related to aircraft [6].

Cheap and reliable electricity for industrial use was one of South Africa's most important competitive advantages. This is no longer the case and the damage that it has caused to South Africa's international reputation and national confidence has been incalculable. In January 2008, huge blackouts occurred throughout the country. The national grid almost crashed [1]. The opening up of world markets has provided new buyers for South African products but, at the same time, has introduced new international competition. Developed countries such as those belonging to the Organisation for Economic Cooperation and Development (OECD), have been steadily reducing the energy intensity of their economies over the past 25 years.

In contrast, the energy intensities of developing and transitional economies have increased. Rapid industrialization and investment in inefficient technology have exacerbated the situation. In their report for the U.S. Initiative on Joint Implementation, the International Institute for Energy Conservation (IIEC 1996) points out that 'Developing country industries will not be able to compete when their outdated factories consume three times as much energy as more modern facilities' and 'efforts to cut energy costs and remain competitive are creating lucrative (energy) markets.' The energy intensity of a country is an indicator that describes energy use against the value of production (or per capita). However, energy intensity cannot be used by itself as a comparative measure of energy efficiency unless the types of industries of the countries are similar. Developed countries have generally shifted from energy-intensive processes (mining and materials processing) with relatively low product value, to low-energy industries (computer chips, information technology) with relatively high value [8].

Every country in the world is beginning to face up to the challenge of sustainable energy to alter the way that energy is utilized so that social, environmental, and economic aims of sustainable development are supported. South Africa uses 40% of the total electricity consumed on the African continent [9]. The country's abundant coal reserves have contributed to an economic environment where the electrical unit price is amongst the cheapest in the world. One of the undesirable outcomes of this has been that energy efficiency has been overlooked to make way for priority considerations, such as plant expansions and increases in production throughput.

The commercial sector may not be as energy-consuming as the Industrial sector. It accounts for 3.5% of the final energy demand and when compared to the 43% contributed by the industrial sector to the final energy demand, it can easily be counted as insignificant; however, the commercial sector alone contributes 45% towards total national Gross Domestic Product [9]. The profitability of the commercial sector is thus vital and fragile in that rising costs may eat into profits and threaten viability in time.

One of the main focuses of any airport operator like Airports Company South Africa in providing a world-class airport experience is its infrastructure where quality, operational efficiency and the cost at which this comes are some of the challenges faced. Added to these challenges is the impact of factors outside the organization. In a global context, the consumption of electricity, the security of its supply and the carbon-dioxide emissions associated with it have growing concerns. For a business like Airports Company South Africa, this concern comes with an associated cost and exposes the business to rising energy costs.

2. Description of King Shaka International Airport

King Shaka International Airport is owned and operated by Airports Company South Africa SOC Limited (ACSA) and was commissioned in 2010. King Shaka International Airport started operations in May 2010. This world-class facility offers a host of features to make your traveling experience as comfortable and pleasurable as possible. Shops and restaurants, a bank and a post office are just a few additional features King Shaka International Airport has to offer.

King Shaka International Airport, conjointly referred to as La Mercy Airport, is the major airport in the city of Durban, South Africa. King Shaka International Airport replaced the existing Durban International Airport was decommissioned upon the opening of the new airport and cost R6.8 billion. King Shaka International is said to be three times bigger than Durban International Airport and has five times as many shops. The differences between the old Durban International Airport and the new King Shaka International Airport are highlighted in Table 1.

The Terminal Building has an Air Conditioning Plant with a Chiller Cooling duty capacity of 9MW provides cooling to the terminal building. Separate air-conditioning decentralized systems serve other buildings on site. King Shaka International Airport also has a significant amount of Lighting in the Terminal building and more than 30 other buildings on site above 60,000 square meters in total. This number excludes public areas and open car parks. King Shaka International also has specialized Lighting such as runway edge lights over the 3.7km length and Precision Approach Path Indicators to guide aircraft landing and take-offs and serve as a visual aid to Pilots and this is aside from lighting the taxiways, Apron bays (where aircraft dock) and roads.

Table 1. Comparison of Old Durban International Airport Facilities with New King Shaka International Airport Facilities

Item	Old Durban International Airport	New King Shaka International Airport
Runway Length	2.4 km	3.7 km
Aircraft Parking Bays	23	34
Air Bridges	None	16
Annual Passenger Capacity	4 400 000	7 500 000
Check-in Counters	52	72
Common-Use Self-Service Kiosks (CUSS)	4	18
Passenger Terminal Building Floor Area	30 000 m^2	103 000 m^2
Retail Space	2 900 m^2	6 500 m^2
Retail Outlets	23	52
Public Parking Bays	2 490	6 500

The airport also has many pumps on site for various applications. Jet A1 Fuel is circulated to the Apron from the six-million-liter storage capacity Jet A1 Fuel Farm. Sewerage is treated onsite by two Wastewater Treatment Plants located North and South of the King Shaka International Airport Site. Potable Water is circulated to King Shaka International Airport from an onsite reservoir via a booster pump station down the water reticulation system Bulk water supply line 11.25 km long.

3. The business case for an Energy Management System

3.1. Old Approach of Energy Management at Airports Company South Africa, King Shaka International Airport

The old approach taken by King Shaka International Airport to address the energy challenge is the oldest prevailing approach in almost all businesses and across all ACSA-operated airports. It is the reduction in energy demand by changing certain technologies such as lighting to more energy efficient ones than the existing ones, implementing time schedules to HVAC systems and lighting where the infrastructure capabilities exist. The execution of these tasks is typically run from an engineer's or project manager's office and is sometimes their initiative to reduce energy demand, however, sometimes be the result of a marketing representative presenting their technologies which highlights possibilities. This approach results in pockets of initiatives and activities being executed, many times in isolation from each other.

3.2. Risks and Disadvantages of the Old Approach of Energy Management

The old approach of managing energy reduces energy demand for the airport, however, maintaining this reduced energy consumption is dependent on the following:

a) No additions/refurbishments or changes to be made to the airport infrastructure.

b) The personnel key to implementing the changes is retained.

c) The service providers maintain how they operate and maintain the equipment consuming energy.

d) The stakeholders' and all users' activities to maintain the amount of energy they are using toward a constant or decreasing amount.

Due to the nature of the risks that threaten the maintenance of reduced energy demand and the pockets of initiatives that are most times isolated and run by specific people in the organization results in an unsustainable approach to energy management. The old approach to energy management is unsustainable in that:

i. There is no overall, long-term direction or vision for the future. The interventions are on a "reaction" basis, i.e. to correct technology choices to energy efficient ones as energy was not part of the criteria when it was chosen and or the current technologies have been outdated.
ii. It does not have overall control over how energy is used at a specific airport site and no set standards or limits have been communicated to all users such as design engineers, contractors, service providers, operators, tenants, retailers and other stakeholders in this regard.
iii. There is no continuity through personnel changes for that specific airport as one would not conveniently know the projects initiated and the projects to be initiated or the plan intended in this regard.
iv. There is little protection against untested/unproven technologies and unsuitable systems entering the airport space if initiatives are started as a result of marketing initiatives alone bearing in mind that energy efficiency is a new technological focus area for South Africa.
v. There are no time-convenient, collated references for energy efficiency continuity to follow an energy-efficient project back to its origin.
vi. Investments in the long term can be wasted due to a lack of control of energy usage on the site as there is no guarantee that these energy savings would be sustained by further initiatives and operational control when required.
vii. Airport operations do not always incorporate energy efficiency into all their activities and thus investments in and for energy efficiency are not always maximized.

viii. There is a possibility that unsuitable technology choices can be repeated for other airports as there is no communication of learnings from previous energy efficiency projects across airports unless personnel take the initiative to seek advice from other airports before implementation.

ix. It is much dependent on personnel's initiative to save energy and not on an airport-specific committed and supported target and obligation to save energy through a company energy management system process.

4. The new sustainable Energy Management System

The vision and purpose of the ACSA Energy Management System is to map out the path to Airports Company South Africa-operated airports reduced dependency on the electricity grid for its power requirements (power generation) with a short-term goal of reducing energy demand (Demand Side Management or DSM) through the implementation of efficient engineering technology systems and optimizing processes requiring power with a view towards creating an ACSA standard which contains energy specifications for all future buildings and infrastructure.

The three main aims of the ACSA Energy Management System are to do the following:

1. Achieve and maintain Energy Efficiency at all ACSA-operated airports in a structured and collective manner.
2. Integrate Energy Efficiency and Management into existing operations, maintenance activities and ACSA departmental influences, stakeholders, service providers, tenants', retailers', and passengers' activities to sustain an Energy Efficient culture.
3. Draw up and uphold policies that specify minimum energy requirements for all future buildings and equipment at ACSA-operated airports progressing toward compliance with existing Energy Standards.

These three aims address all the factors highlighted in Figure 1. Taking Figure 1 into consideration, corporate policies in line with corporate energy targets need to be taken into consideration. This implies that all new buildings and infrastructure energy consumption needs to be investigated in line with the energy targets and this needs to be implemented to achieve the energy reduction target. Operation of the current infrastructure should be optimally adjusted to economically suit the achievement of energy reduction targets and more importantly to ensure that the operation of current equipment does not absorb energy savings made by interventions and initiatives.

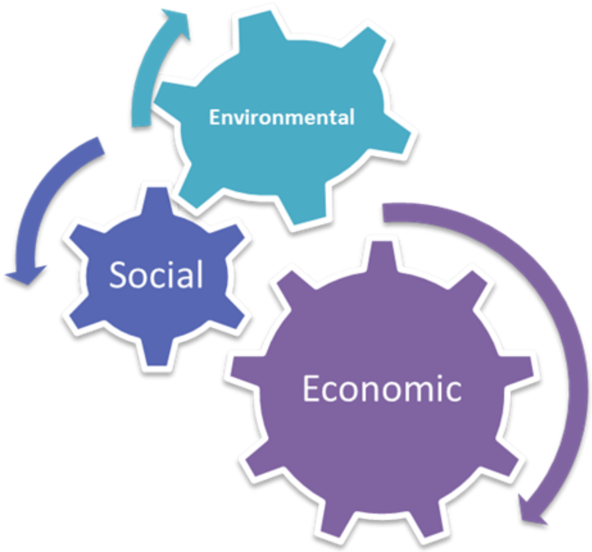

Figure 1: Typical business process factors mesh.

Leading the implementation of the Energy Management System is a national team called the "Energy Forum" which consists of one Energy Management Representative from each of the four business units across the nine airports that Airports Company South Africa owns and operates. Each Energy Forum representative is supported by a local "Energy Management Team" which is made up of key people managing operations and maintenance of significant energy users and executing energy reduction projects and initiatives. The Energy Forum will, in light of the aims of the Energy Management System, assess the current state of the airports, set goals for Energy Efficiency and Conservation and then create a time-based roadmap to Energy Efficiency. The Energy Forum will also develop and maintain a "Standards and Guidelines for Energy Efficiency" Document for all new infrastructure and facilities entering the airports' space. The Energy Team will convert the time-based Energy Efficiency Roadmap into actionable plans according to a Plan-Do-Check-Act Cycle. They will also execute and implement initiatives to reduce energy consumption and ensure that all energy is controlled and accounted for. The loop will then be closed by the Energy Team reporting back to the Energy Forum on the progress of the Energy Efficiency Roadmaps and suggestions for improvement of the system and the technical content for updating the "Standards and Guidelines for Energy Efficiency" document. The ISO 50001 Energy Management Standard Plan, Do, Check, Act Cycle will streamline all activities requiring energy and ensure that it is managed to achieve the deliverables of the Energy Management Policy as well as administer control over airport activities' energy consumption which will ultimately fulfill the Energy Management Plan ensuring the sustainability of the ACSA Energy Management System.

The focus of the Energy Management System will be to reduce electrical energy (kWh) consumption used from the electricity grid in a sustainable manner that will rely on a system function and thus be decoupled from dependence on specific persons only. This process will control and manage all new energy-intensive infrastructure entering the space and changes of current energy-intensive infrastructure within the space. Implementing an ACSA Energy Management System will sustainably address the energy challenge through changing technologies, legislation, resource availability, personnel, service providers and stakeholders and reduce the risk of exposure to rising energy costs, ensuring the security of energy supply and by doing this, reduce greenhouse gas emissions.

The first line of change that the new system proposes from the old approach is the way we set energy consumption reduction targets and how this is achieved. The approach to be used to reduce energy sustainably will be to understand the energy consumption of the airport before one sets targets and makes plans to reduce energy consumption. Energy Consumption Data will be collected together with data such as Passenger numbers, Cooling Degree Days and any other possible information on the operational activities of the airport. These data will be correlated against the energy consumption to find out the driver of the energy consumption. This will typically be done via a regression analysis. Figure 2 shows a regression analysis done for Cooling Degree Days and Figure 3 for Departing passengers.

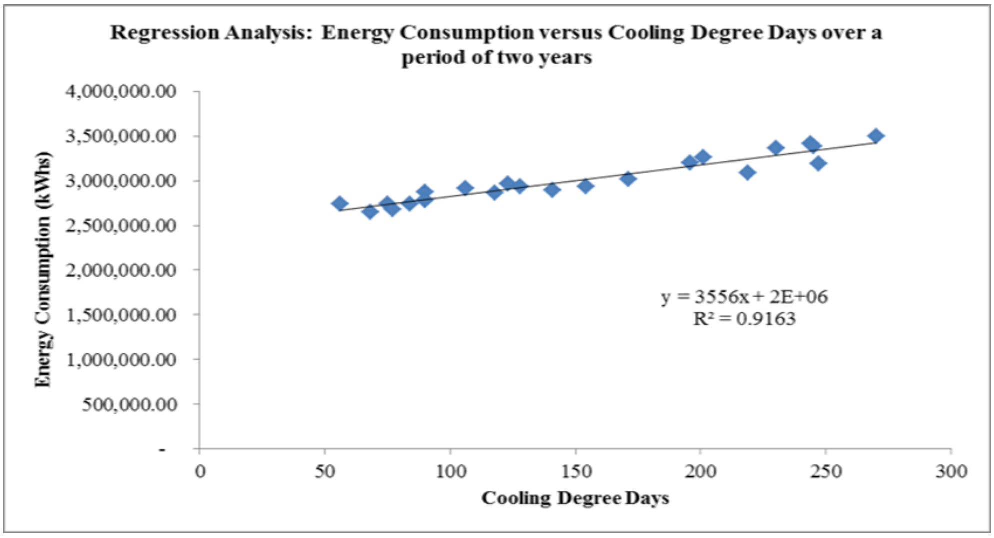

Figure 2: Regression Analysis for correlation of Cooling required with Energy Consumption

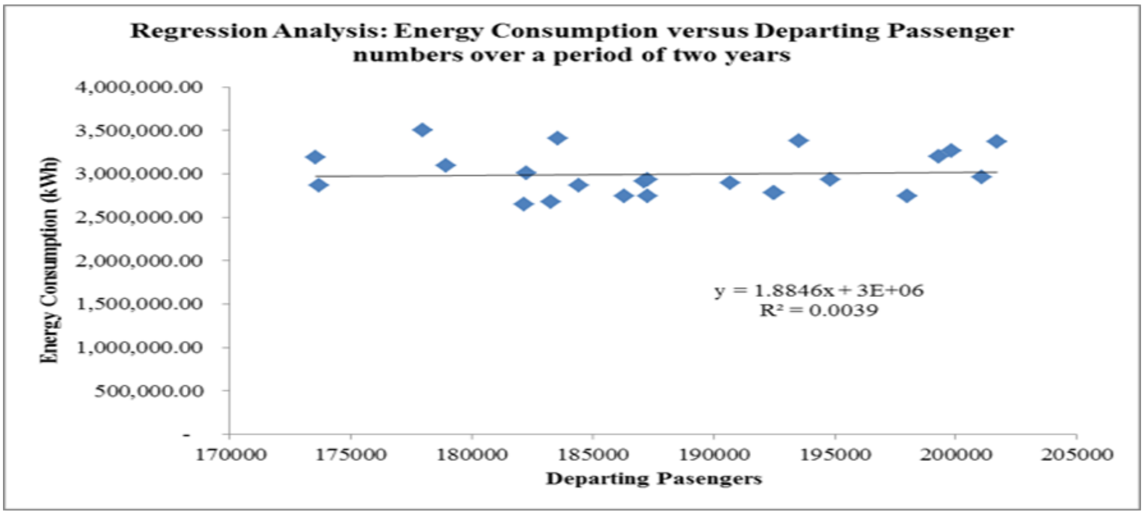

Figure 3: Regression Analysis for Correlation of Departing Passenger Numbers with Energy Consumption

From Figure 2, it can be observed that there is a strong correlation between the amount of cooling required and the Energy Consumption. They have a direct relationship where more than 91% (R^2 value of 0.9163) of the time, they correlate. From Figure 3, it can be observed that there is almost no correlation between energy consumption and departing passenger numbers, similar will be observed if a regression analysis is done for arriving passengers as the numbers are the same. This tells us that energy consumption is not affected by the number of passengers passing through the system.

Once an understanding of what drives the energy consumption, the share of the energy consumption needs to be understood per energy user, i.e. for an airport, lighting, air conditioning, water heating, computers/electronics devices, plug loads, pumps, motors, fans and miscellaneous. This exercise needs to be done such that 80% of the electrical load is known. The top 3 energy consumers making up about 80% of the pie are referred to as Significant Energy Users (SEU). This will give information as to where money should be invested to reduce energy consumption sustainably. From Figures 2 and 3, it can be deduced that the total heat load in the building has a significant solar heat gain component which then implies that if we aim to reduce energy consumption considerably, our best spend of Capital would be to invest in deflecting the solar irradiation from our facilities.

Reducing energy consumption does not automatically imply investment of capital expenditure. The SEUs will need to have their operation and maintenance schedules looked at to ensure that they are operated and maintained in the most efficient manner possible. This inquisition will require a technical audit to be done on the SEUs to highlight component and system inefficiencies and opportunities for improvement. These opportunities for improvement need to be prioritized according to organizational parameters, which are typically “high investment, low investment” and ease of execution, i.e. “easy, difficult”.

Looking at the equation in Figure 2, it can be seen that a significant amount of energy (2 000 000 kWhs) is the baseload Energy Consumption of the airport. As much as the drivers of the energy consumption are known and understood, the users contributing to this baseload need to be known and investigated, for their efficiency and their relevance to the prevailing technology market. One also needs to understand whether the users contributing to the baseload are optimally controlled for its use. This will reduce the baseload which is also a sustainable energy reduction.

5. The difference between the old system and the new sustainable system

An example of an energy reduction target and the shortfalls towards sustainable reduction of energy consumption follows:

Energy Consumption Reduction target: Reduce Energy Consumption by 10%.

This is usually given by the top management with a view of energy costs being reduced by 10%. There are many issues with this type of target. Firstly, if this is a year-on-year reduction of energy consumption by 10%, then in 10 years, it will be logical that there will be no energy consumption from the national power grid and this is not the expectation of the top management team. Much of the issue lies in the objective interpretation of the target, taking into consideration factors that may affect the baseline. If we use the period July 2012 to June 2014, taking a target of 10% energy saving with the period July 2012 to June 2013 as a baseline, refer to Figure 4 for the interpretation of the "objective target", i.e. reduction of energy in line with the energy driver and the conventional target interpretation of reduction in energy consumption from the period's actual absolute baseline. Sustainable energy savings are achieved when energy consumption is reduced according to the energy driver or drivers. From Figure 2, it was established that the amount of cooling required was an energy driver.

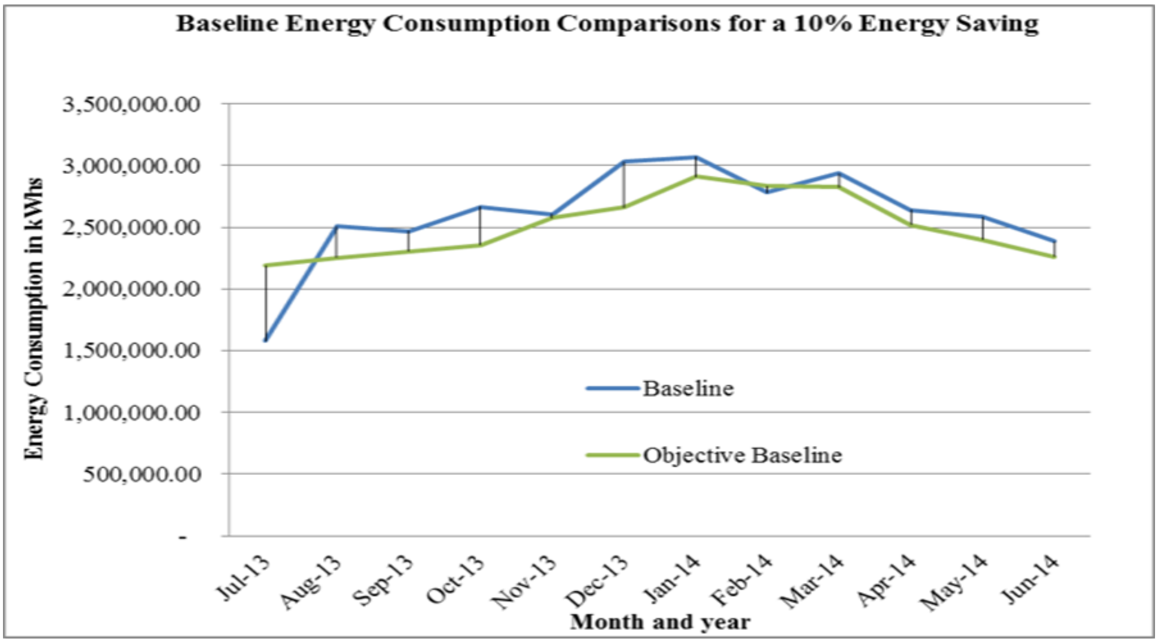

Figure 4: Diagram indicating the difference between a conventional baseline of 10% reduction in Annual Energy Consumption and an Objective Baseline of 10% reduction in Annual Energy Consumption according to the driver of Energy Consumption.

Ensuring a correct target interpretation, objectively, including those components entering the site boundary, leaving the site boundary and changing within the site boundary is the key to sustainable energy management. To address the energy challenge in a sustainable manner that will take ACSA sustainably forward in the Energy Management and related infrastructure/technological space will be to establish a process that will be committed to reducing energy demand and introducing a mix in energy supply to ensure the security of energy supply and reduce the risks of exposure to rising electricity costs.

6. Barriers to Energy Efficiency

Energy Management is a means to overcome barriers to energy efficiency. Top management's commitment to the Energy Management System and diligent dissemination to the rest of the organization is key to its success. The ACSA Energy Management System requires time, human resources and respective mandates so that Energy Management becomes a company culture for the sustainability of the Energy Management System vision. Integration of energy efficiency into departmental activities, deliverables of service providers, contractors and design engineers contracts need to include energy efficiency clauses and stakeholders need to actively share in the vision. All activities required for the ACSA Energy Management System process to take place need to be suitably supported with the required tools, resources, funds and time to be successful as it will be mindful of the interests of the business in its mandate.

Barriers specifically to the Energy Management System described can be:

- Lack of Top Management support and honor of commitment

- Lack of time and human resources
- Lack of Tools
- Resistance to change
- Lack of understanding of the Energy Management System
- Lack of skills
- Inadequate awareness and lack of sound communication with stakeholders
- Ineffectiveness of integration of Energy Efficiency into departmental activities
- Lack of Capital
- Lack of training

7. Conclusion

The ACSA Energy Management System will take Airports Company South Africa forward in terms of infrastructure efficiency in the airport space locally and put us in an advantageous position internationally in terms of Energy Efficiency to maintain our status as a world-class airport operator.

The following Airports Company South Africa goals and initiatives will be supported sustainably:

a) ACSA Environmental Management System (EMS) Policy, Energy & Water aspect supported.

b) Reporting of Energy saving initiatives to the Department of Transport facilitated.

c) ACSA Strategic Initiatives Workstream of improving operational efficiency supported.

d) Business Unit-specific Departmental Key Performance Indicators with regards to Energy savings supported.

e) The operational cost of infrastructure across all airports will be significantly and sustainably reduced allowing more control and prediction of operational budgets in terms of energy, associating science with its spending for the lifetime of the infrastructure which are the assets of the business. The ACSA Energy Management System ensures the sustainability of energy management through internal organizational changes and external global changes.

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