Energy Productions Using Combined Cycle Gas and Vapor at Maputo Thermal Power Plant

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ABSTRACT

Access to electricity is one of the instruments for the development of any society nowadays, about 1.2 billion people in the world are living without electricity today. At least 600 million people in sub-Saharan African countries are livingwithout electricity, and the Maputo province and Maputo city in Mozambique are not any exception faced with the electrical shortage. The UN Sustainable Development Goal (SDG) 7 states that access to affordable, reliable, sustainable, and modern energy for all people throughout the world should be achieved by the year 2030. The rate of electrification in the urban areas in Mozambique is about 67% and the national electrification rate is 40%. With higher energy potential resources such as coal, natural gas, and renewable energy resources. Mozambique still has one of the low electricity consumption per capita in the region about 443 kWh which is paradoxes. The government of Mozambique has introduced reforms in the electricity sector since 1995 and considers the access to modern forms of supplying electricity to be highly important in the fight being waged against poverty. The objective of this research is to see the process of the gas conversion to electricity using the combined cycle gas and vapor at Maputo Power Plant in Maputo, Mozambique. In this secondment, the rigorous chemical analysis of water in the Power Plant is of relevancy for obtaining improved water quality which is intimately related to good energy production. To succeed this goals, we look forward to implementing Desalination and demineralization methods of water from locally constructed wells that is actually used to operationalize the generation process of the combined system.

Keywords
Energy, combined gas-vapor thermal power plant, desalinization, demineralization

1. Introductions

The current scenario of electricity access in Mozambique is not much favorable to eradicate poverty because the rural area still has low rata electrifications with 27% and a compere in Sweden is 100% while the urban area in Mozambique is about 67%and the national electrifications rate is 40% (EDM, u.d.). With higher energy potential resources (coal, natural gas, renewable energy resources) Mozambique still has low electricity consumption per capita about 443kWh (Uamusse, et al., 2019). The Figure.1 show the electricity production and consumption of the last eighteen years. Today Mozambique the energy consumption average is 12 billion kWh (Mulder & Tembe, 2018). The UN Sustainable Development Goal (SDG) 7 states that access to affordable, reliable, sustainable and modern energy for all people

throughout the world should be achieved by the year 2030. This "requires expanding access to electricity and clean cooking fuels and technologies, as well as improving energy efficiency and increasing the share of renewable energy", for those in need of this (UN, 2018).

Three socio-economic effects of electrification stand out, even if it has recently been questioned based on experience gained in Asia and Latin America whether these results are fully transferrable to the African context and specifically to Mozambique. Positive effects of full access to electrification are often stated as being, in particular, educational benefits, improvements in income, and a decrease in respiratory diseases (Uamusse, et al., 2019). Electrification and SDG Goal 7 have also been related to several other important SDG goals, among these the following: 1) overcoming poverty, 3) achieving good health and well-being, 4) providing an education of high quality, 6) providing clean water and good sanitation, 8) providing decent work and economic growth, 9) promoting industrial development, innovation, and infrastructure improvement , and 13) supporting actions regarding climate matters. Thus, electrification and SDG 7 can be seen as enabling factors for achieving an adequate degree of sustainable development

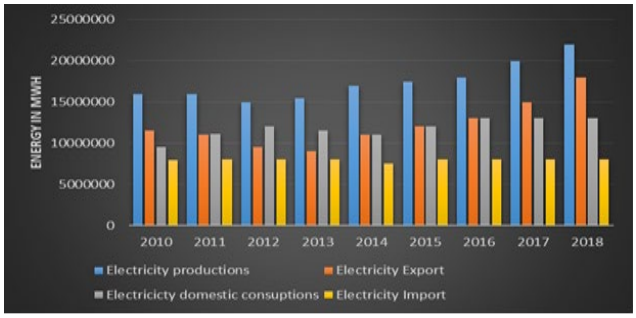

Figure 1: Mozambique energy productions, import and exportations **(Uamusse, et al., 2019)**

The present work is currently developed at Electricidade de Moçambique (EDM) in Maputo, at Maputo Thermal Power Plant (CTM) that operates according to two thermodynamic cycles (Gas and steam or Vapor). This plant aims to supply electricity to Maputo. The Mozambique power utility, "Electricidade de Moçambique, E.P." (EDM) manages the bulk of the electricity distribution in Mozambique, it is also responsible for power generation facilities and transport infrastructures along with the country. Fig 2 depicts the Maputo Power Plant Layout. This infraestructure has install two gas turbine units installed and one vapor turbine. The gas turbine is working using the Brayton cycle and the vapor turbine working using the Rankine cycle with total energy productions 106 M.
The main objective for secondment of engineering academics was to expose them to industrial systems, modern equipment, and engineering methods to inculcate a culture of practical and relevant applications. Moreover, in this perspective, the study will be in two months and at the end will

Figure 2: Maputo thermal power plant. The Maputo Thermal Power Plant (CTM) that operates according to two thermodynamic cycles (Gas and steam or Vapor) **(EDM, u.d.)**

2. Methodology

The methodology for this work will comprise two phases as presented is subsections 2.1 and 2.2. The first one, will be the principle of operation of the plant system, which consists of understand the combined thermodynamic cycle gas and steam and shows in Fig 3 and, is described in subsection 2.1. The next method for this training is the water quality analysis in the Power Plant that should be improved to have good energy production and the water quality methods will be *Desalination* and *demineralization* of water from Maputo city. Fig 3 is showing the combined gas and vapor turbine and the principle of operations the exhaust gases from the gas turbine cycle serve to heat the water used in the steam or Rankine cycle and contributing to increasing the efficiency of energy production and efficiency close to 50% .

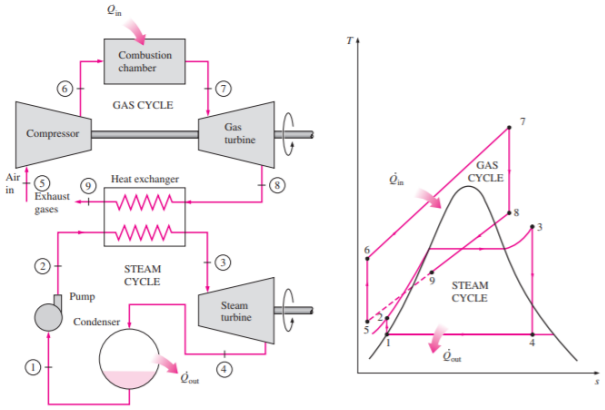

Figure 3: The combined thermodynamic cycle gas and steam.

In the coming months the work will focus on the reoperation of a group of turbines that has been stopped due to a breakdown and improvement of water quality using the desalination and demineralization methods

2.1. The principle of operation of the plant with combined thermodynamic cycle gas and steam

As depicted in Figure 3 (Cengel, 2007), the is describing the binary cycle gas and vapor. In this cycle, energy is recovered from the exhaust gases from the top cycle by transferring it to the steam in a heat exchanger that serves as the boiler. And, the steam cycle may involve regeneration as well as reheating. Energy for the reheating process can be supplied by burning some additional fuel in the oxygen-rich exhaust gases. The combined cycle increases the efficiency without increasing the initial cost greatly. Consequently, many new power plants operate on combined cycles, and many more existing steam- or gas-turbine plants are being converted to combined-cycle power plants. Maputo Thermal Plant is one of efficiencient well over 40 percen**t.**

2.2. Water quality analysis in the Power Plant

The main goal is to improve the energy efficiency in terms of its production. In order to have good energy production, the water quality needs to be carefully analyzed. This justified in our principal methodology, which relies on implementation of *Desalination* and *demineralization* methods of water obtained from locally constructed wells in order to improve the water quality, which is intimately elated with improved energy production in combined systems of energy production. In doing so, we bealive that improvements in water quality will be achieved by performing a

rigorous chemical analysis of water in the Power Plant and, therefore, this will introduce benefits the performance of the proposed system order in terms of good energy production.
The seawater desalination process is consisting to convert seawater into fresh water. Firstly, seawater is delivered by intake pump and sent into desalination plant. Then raw water is pre-treated before entering into SWRO system for there is much impurity in sea water, meeting requirements on RO feed water while in water resources field and water treatment process, demineralization refers to the removal of dissolved solids from feed water and process streams.

2.3. Possible impacts and effects

The Maputo Combined Turbines Thermoelectric Plant uses water taken from locally constructed wells. This water contains, in addition to mineral residues, a high concentration of salt. The presence of these two elements compromises the performance of the generation system in addition to representing a risk for the better conservation of the Infrastructure; the following problems can be identified:

- Corrosion of the metallic parts in the assembly of the equipment caused by the excess of salt contained in the water;
- Effect of obstruction in the circulation ducts by the layers of minerals contained in the water
- Highly salty water and, with the presence of mineral material residues, negatively influences the operation of the turbines and, therefore, in the generation efficiency.

3. Results and Discussions

Since the work was interrupted due to the state of emergency that forced all students and trainers to stop working, the internship was consisted to visit the Maputo Thermal Power Plant and hoping that with a survey of the state of emergency due to the coronavirus and restarting the work. With this work, the relevant results are expected to be:

- Dominate the thermal energy production industry to be able to explain to students,
- Help the industry rebuild the damaged turbine,
- Improve the quality of water used in the industry.

Following these procedures, we bealive that Improvements in water quality in the Power Plant will be introduced and therefore, this will benefit the performance of the analyzed system in terms of better energy production. However, since both methods, the *Desalination* and *demineralization* involve additional infrastructure units, we expect that additional energy supply will be needed. However, on evaluating the costs of additional energy supply compared with the benefits introduced by the proposed strategy, the proposed framework will be of great relevance for the power generation in the Maputo power plant.

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Biography

Miguel Meque Uamusse is an Assistant Professor at Faculties of Engineering , Eduardo Mondlane University in Mozambique. Mr Uamusse holds Master's degree in Renewable Energy at University of Dar-es-Salaam in Tanzania in 2012, an PhD in hydropower renewable energy and water resources at Lund University. Mr. Miguel research focuses on Renewable Energy Technology and water resources. In Renewable energy is focuses in biomass, solar, hydropower energy as solutions for rural electrifications in Mozambique including.

Acknowledgements

The authors would like to thank Eng Arlindo Mahumane from EDM at CTM for valuable input to this secondment. The data from the presented study will be from the Maputo Termal central and will use in the paper conference