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Comparing solar PV (photovoltaic) with coal-fired electricity production in the centralized network of South Africa

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ABSTRACT

South Africa has a highly centralized network, in which almost all electricity is produced in Mpumalanga and transmitted throughout South Africa. In the case of the Western Cape, electricity has to be transmitted over 800–1370 km. This generates losses and entails high transmission costs. Investments in additional production and transmission capacity are needed to cope with the growing demand. Although there is a large potential for solar energy in South Africa, investments are lacking while large investments in new coal-fired power plants are being executed. These coal power plants do not only increase the need for heavier transmission infrastructure, but also have a higher CO_2 emission level and a higher pressure on water reserves. This paper performs a more comprehensive cost-analysis between solar energy production and coal production facilities, to make a more elaborate picture of which technologies are more plausible to foresee in the growing demand of electricity. The current centralized electricity infrastructure makes the investment in large production facilities more likely. However, it should be questioned if the investment in large centralized solar parks will be more beneficial than the investments by consumers in smaller solar PV facilities on site.

1. Introduction

South African electricity production is characterized by a large share of coal-fired power plants. Eskom is accountable for 95 percent of the total power production in South Africa [1]. Approximately 95 percent of the current base load coal-fired power plants of Eskom are to be found in the North Eastern part of South Africa [2]. The presence of large coal reserves in the region is the main reason for locating the power plants here. The proximity to the coalfields lowers the coal transmission costs. These coal-fired power plants not only consume large amounts of coal and emit carbon dioxide, but also use a lot of cooling water. Besides the water usage for cooling purposes, the upstream mining and coal handling processes also require a lot of water and energy.

Apart from the inland production of electricity, around 1000 MW electricity from the 'Cahora Bassa' hydro scheme, located in Mozambique, is imported through Kruger Park, making the power production density of the North Eastern part of South Africa even denser [3]. This production capacity is expected to grow even further, with the need to build additional electricity production capacity. Currently two new coal-fired power plants are also being built in the North Eastern region of South Africa [4]. Because of the large number of coal-fired power plants in the North East regions of South Africa and imported electricity from Mozambique, large amounts of electricity need to be transmitted throughout the country making the electricity network highly centralized. Fig. 1 shows the electricity grid connecting the Western Cape to Mpumalanga.

Centralized networks have their advantages and disadvantages. The downside of the current layout of the electricity infrastructure is the electricity losses that occur because of transmission. For the transmission of electricity throughout South Africa, Eskom applies different levels of surcharges, varying from 0 to 3 percent of the total electricity price [5]. Despite the surcharges, the price of electricity throughout South Africa does not differ much, resulting in artificially-low electricity prices in many parts of the country. Another downside is the large investments that have to be made in the current infrastructure due to growing demand and aging of component parts [6]. In the next decade, Eskom will invest USD 18.25 billion – based upon average exchange rate for 2012 of 0.1222 ZAR/USD [7] – in the current electricity infrastructure [8].

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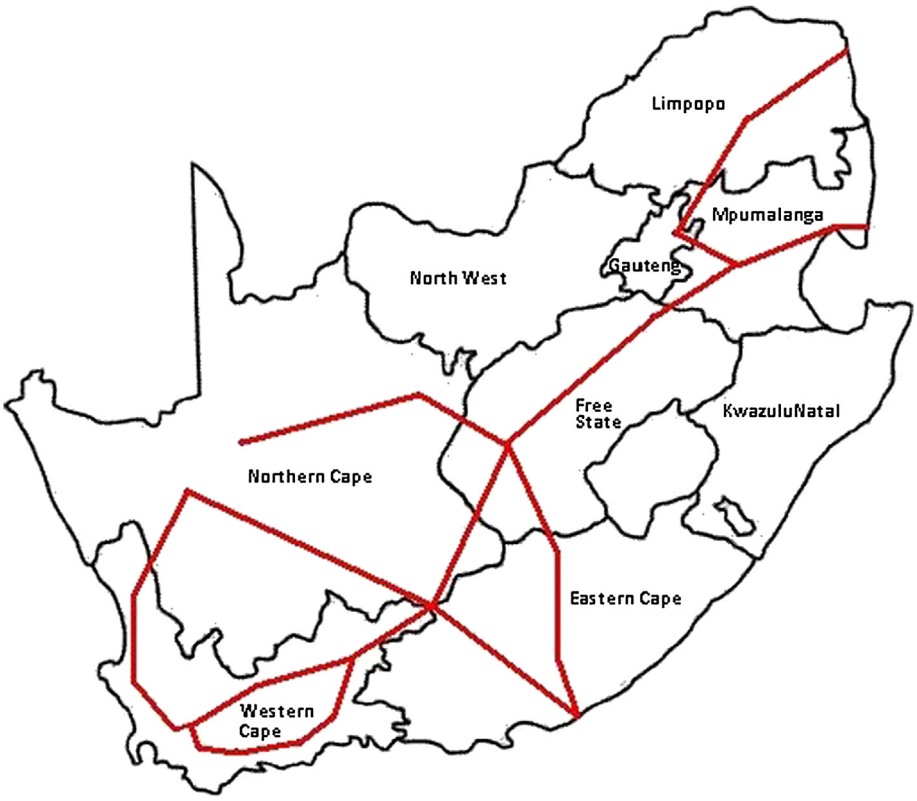

Fig. 1. Electricity grid connecting Western Cape to Mpumalanga [2].

Electricity prices have however been kept low on purpose, in order to electrify as many households in South Africa as possible, making the accessibility to electricity for the wide range of citizens throughout South Africa an important factor for low electricity prices. The access of electricity has been a politically important programme over the last 20 years and is well established within the policy of Eskom. Cross-subsidization has enabled Eskom to provide energy at low prices and create higher electricity accessibility for all layers of the society [9]. It is only in the last couple of years that Eskom has been requesting a large price increase, up to 35 percent, to the National Energy Regulator of South Africaxe "National Energy Regulator of South Africa: NERSA" (NERSA) to restore energy prices. The originally-approved tariff increase of 25.9 percent by Eskom for the year 2013 has been revised by NERSA, which has restored this initial approval to 16 percent [10]. Eskom has clear motives regarding the price increase for electricity, to generate funds to expand their production and transmission capacity to cope with rising demand. Eskom is having difficulties with loan approvals to be able to fund new plants, infrastructure and maintenance because of the low revenues, due to low electricity prices. The other factor that keeps the revenues at low levels is the historical relationship between large mining companies and Eskom. For example BHP Billiton has a massive rated consumption capacity of 1000 MW but still pays rates that were negotiated in 1990.

2. Status quo of thermal power sector in Republic of South Africa

It is expected that electricity prices will increase during the coming years. Current energy prices in South Africa could be kept low because of certain circumstances that characterize the electricity sector.

The first important factor is that most of the electricity producing assets have been paid for, which leaves just the operational costs to be incurred [9]. A large number of the coal-fired plants in operation at the time of writing are old, resulting in a very low share of coal-fired power plants that is younger than 20 years [11]. The old fleet of coal-fired power plants has a downside as it is characterized as the least efficient operating worldwide, according to different technical criteria of coal-fired power plants from the WEPP (World Electric Power Plants) database [12]. In addition, quite a large number of these plants will soon reach the ends of their respective life times which will necessitate the building of new and much more expensive ones. In 2008 the inadequacy in generation and transmission capacity resulted in large blackouts throughout South Africa, which depend on electricity from South Africa's power plants. Due to the overloaded network, outdated electricity production fleet and rising electricity demand in South Africa there is a gap between supply capacity and demand, resulting in a higher use of electricity generation plants with lesser cost-effectiveness, like oil-fired plants in the area surrounding Cape Town [6]. Currently large new coal-fired power plants are being built in the North Eastern region of South Africa, at Medupi and Kusile, to lower the risks of future blackouts and to cope with rising demand. These new power plants will however create an even larger difference between the bulk of power production and the large load centres [6]. Congestion on the network during peak hours will increase because of the investments in additional electricity capacity and an increase in demand load on the electricity network. The investment in the electricity infrastructure in South Africa has not been optimal, and large parts of the infrastructure are approaching and even exceeding maximal load levels during peak demand and need investments. For this reason Eskom is planning to invest USD 18.25 billion, during the period 2013–2022, in