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Load shedding and the energy security of Republic of South Africa

Keywords

load shedding, energy security, Republic of South Africa, blackouts, Eskom

Abstract

Studies on energy security can be found in many academic publications and in government and think-tank reports. Main goal of this article is to present the energy system in the Republic of South Africa, to discuss the phenomenon of load shedding and it indication of proposed changes required to existing solutions. Authors based their research on available literature newspapers articles, direct observation and the interviews with the residents of Johannesburg. South African's economy is the second largest in Africa, just behind Nigeria. It accounts for 24% of continent's GDP. It is ranked as an upper-middle income economy by the World Bank. The major producer and distributor of electricity in RSA is Eskom, which provides over 95% of the country's energy usage. Load-shedding, also referred to as rolling blackout, is an intentionally electrical power shutdown. In South Africa it affect entire country.

1. Introduction

Energy security is an issue of critical importance to many different stakeholders, including policy makers, businesses (in particular major energy consumers), and the larger community whose quality of life depends on uninterrupted energy supply [2]. Studies on energy security can be found in many academic publications and in government and think-tank reports. Authors of many publications are building many complex models for increasing energy security. The direction of the design and development of energy infrastructure, modern technology and governments' initiatives on diversification on energy sources were analysed by them. All this described activities are made to ensure supply of the energy. The authors of this article, looking on presented background, has decided to discuss the opposite of current trends. Main goal of this article is to present the energy system in the Republic of South Africa, to discuss the phenomenon of load shedding and he indication of proposed changes required to existing solutions. Authors based their research on available literature, newspapers articles, direct observation and the interviews with the residents of Johannesburg.

2. Literature review

Energy security is an important issue. The authors observe an increasing number of the publications on this subject in recent years. Ang and the others [2] has prepared a review of the research and the publications related to the energy's security. They based on a survey of 104 studies from 2001 to 2014. They noticed, that the average number of studies per year has increased over time. Out of the 104 studies, 83 provide specific definitions of energy security and 51 cover energy security indicators and/or indexes.
The interest in energy security is based on the notion that an uninterrupted supply of energy is critical for the functioning of economy [30]. However, an exact definition of energy security is hard to give as it has different meanings to different people at different moments in time [1]. Studies such a Chester[9] and Vivoda [42] point out that the nature of energy security is polysemic and multi-dimensional. One would therefore expect that the meaning of energy security is highly context dependent, such as a country's special circumstances, level of economic development, perceptions of risks, as well as the robustness of its energy system and prevailing geopolitical issues.

We will be discussed the energy security in the meaning of security a weel-functioning energy system. Security in this meaning has at least two aspects, security of supply and security of demand. The relative importance of these aspects depends on the role of the actor or the country within the energy economy [28]. In this article, the authors focused attention on security of supply.

For most actors and countries security of supply is the most important aspect and is also the field most commonly discussed in the literature. Definition of energy security in this meaning include an availability aspect (stable and uninterrupted supply) and a price aspect. Security of supply depends on a chain of well-functioning infrastructure and networks stretching from energy extraction through transportation, transformation, refining and distribution all the way to energy end use. Potential natural or human threats to the functioning of the system occur all along these chain. The importance of a well-functioning network has made energy dependency a central concept in the energy security discourse. [28]

The threats to security of supply can be viewed as multi-level effects [see 28]. There are primary causes leading to interruptions or market imbalances. They could consist of inadequate production capacity, technical or operational errors, weather events or antagonistic behaviour such a terror attacks, blockades or wars. These direct causes often depend, at least partly, on indirect causes. Indirect causes could include lack of new investment in capacity and quality, lack of maintenance of existing systems, lack of education, lack of physical protection and political unrest.

Ang and others defined seven major energy security themes or dimensions[2]: energy availability, infrastructure, energy prices, societal effects, environment, governance, and energy efficiency. Due to the case described in this article, the authors attention was focused only on selected aspects of energy security.

- **Energy availability**

Diversifications and geopolitical factors are key issues that determine energy availability. Through diversification of supply source, energy importers can reduce and better mitigate the risks of import disruptions. [2]

- **Infrastructure**

Infrastructure is integral in providing stable and uninterrupted energy supply. These facilities include energy transformations facilities and distribution / transmission facilities (e.g. electricity transmission lines). Adequate investments on these facilities ensure that sufficient energy is available in the short and long terms. The reliability of these facilities is crucial to prevent shortages or blackouts.[2] The need for adequate and robust infrastructure with spare capacity is also essential for uninterrupted physical availability of energy products on the market [21]. Good infrastructure is also a prerequisite to stable energy supplies and important component of "economic energy security"[27].

- **Societal effects**

The energy is a basic necessity of life. Lesbirel [32] posits that a goal of energy security is to insure against the risks of harmful energy import disruptions in order to ensure adequate access to energy sources to sustain acceptable levels of social and economic welfare. The Center for Energy Economics emphasize that energy security should ensure that "the economic and social development of the country is not materially constrained"[7].The UK Department of Energy and Climate Change stresses on the social equity aspect of energy security[14].

- **Governance**

Sound government policies help to hedge against and mitigate short-term energy disruptions. Forward-looking governments support the effective planning of infrastructure needs to ensure long-term energy security. Policies related to energy taxes and subsidies impacts the energy security of the nation. Increasingly, counties are engaging in energy diplomacy with foreign policies geared ensuring energy supplies from exporting regions. In addition, the government has an important role to play as the key information gatherer, since high quality data facilitates effective large-scale planning for energy security.[2]

Many of the publications mentioned the "four As of energy security" introduced by the Asia Pacific Energy Research Centre [3]:

- Availability – or elements relating to geological existence.
- Accessibility – or geopolitical elements.
- Affordability – or economical elements.
- Acceptability – or environmental and societal elements.

It should be noted that these are by no means isolated categories but subject to a complex interplay [30].

Interruptions in the power supply have attracted a great deal of attention in recent years [13]. There are many articles on this topic (see e.g. [13], [20], [31]). There have been several efforts to assess the cost of power interruptions and power quality [31]. But it is very difficult because the consequences of one

supply interruption differ from the consequences of another. De Nooij and other described the causes of this situation [13]:

- There are different types of electricity users. Interruptions in hospital, in industrial plants and in private households have very different consequences.
- The perceived reliability level: the higher the perceived reliability, the less firms and households are inclined to take precautionary measure and the greater the damage caused by an interruption.
- The moment when the interruption occurs. The season, the day of the week and the time of day determine which activities are interrupted.
- The length of the interruption also determines the costs.
- A notification before an interruption lowers the consequences of that interruption.
- The effects of electricity interruptions are smaller when the interruptions are structural (e.g. daily) than when they are incidental. If the supply is interrupted regularly, people prepare for it even if they are not warned beforehand. Although the cost per interruption are lower, the total damage will be greater because of the larger total number of interruptions and because additional costs might arise.

The costs of supply interruptions are measured in two ways[13]:

- As the damage per unit of electricity that is not delivered. This is the value of lost load (VoLL). This value is particularly useful if a supply shortage occurs. In such case, some users have to be cut off. The total costs can be minimized by cutting off the users with lowest VoLL.
- As the amount of damage per hour. These latter values are useful when making decision about investments in network reliability. If damage caused per hour in certain regions id high, the benefits of investments in these regions are also high.

Most of the studies are country-specific where energy security for a country (or region) is analysed. A majority of the studies deal with large energy importers, such as China, Europe, Japan, and the United States [2]. In this article, the authors decided to describe a case of South Africa - a well develop country, in which government decisions led to limited power supplies to the people and institutions all over the country.

3. South Africa – short development history

South African's economy is the second largest in Africa, just behind Nigeria. It accounts for 24% of continent's GDP. It is ranked as an upper-middle income economy by the World Bank [40]. It has also many world-class companies with global reach. Among them are[41]:

- Billiton, largest mining company in the world;
- Anglo American, second largest mining company in the world;
- South African Breweries, second largest brewing company in the world;
- Old Mutual, global insurance and financial services company;
- Didata, global IT company;
- Investec, large international investment bank.
- Sappi, global paper and packaging company
- Sasol, largest energy producer in Africa and huge chemical concern;
- MTN, large mobile phone corporation with networks in half of Africa;
- Barloworld, international manufactured goods and logistics company;
- AngloGold, another mining megacorporation;
- Naspers, big international media company, with significant presence on huge Chinese market.

South Africa all this (and much more) achieved in less than 10 years on the global market. Earlier, because of the international sanctions, the country had to be self-sufficient.

In 1948 the National Party won the elections and started implementing race-based policy called apartheid. The government's decisions effectively divided economy into two sectors: privileged "white" sector and impoverished "black" one. The policy was widely criticized in the world and led to economic sanctions against the country in the 1980s [15], [44].

After years of international sanctions under apartheid regime, in the last 20 years SA's GDP has almost tripled - to US$400 billion.

On the April 26, 1994, voters of all the races were able to participate in the country's first free democratic elections. After apartheid era ended, South Africa came out of the economic stagnation and international isolation. New government has received international recognition and encouragement. At the same time the government of the New South Africa faced pressures to: speed up economic growth, strengthen the position of South Africa among international investors and donors and in the same time they had to improve the living conditions of the (black) majority of citizens.

After two decades of democracy South Africa created growing and sizable African middle class. In

the same time population who lives below poverty line is still 26%, with official unemployment rate above 20% (unofficial estimates are even twice as high) [40].
South Africa's economy and development has been based on country's rich natural resources. During twentieth century South African mineral wealth was recognized as one of the biggest in the world, except Soviet Union. As Rita Byrnes concluded: "South Africa produced nearly half of the world's gold and ranked among the top ten producers of a dozen other valuable minerals, including diamonds and copper. The mining industries provided the foundation for the strongest economy on the continent, which, by the mid-twentieth century, included a comprehensive transportation system, an extensive electric power grid, and a significant manufacturing sector. South Africa's main resource deficiency is oil, and as a result, many industries rely on coal rather than on imported fuels"[6].
The economic sanctions against South Africa covered trade and finances. In the trade, Japan and European Commission, sanctioned import of the Krugerrand – a famous gold coin – and certain steel and iron products. USA had similar position. The sanctions also forbade import of products from enterprises which were partially controlled by state: uranium, coal, textiles, agricultural products, and food as well as export of petroleum products. There was also OPEC's oil embargo [24]. Of course there were loopholes and exceptional clauses (mainly for Great Britain and Germany).
The economy was in recession from 1989 through most of 1993, largely in response to worldwide economic sanctions and the long-term effects of apartheid. The inflation was very high. Standards of living of the part of the black population were low. Economic growth continued to depend on decent world prices for gold and on the availability of foreign loans. Some sectors of economy started to recover, but were stopped by 1992-1993 civil war between African National Congress and Inkatha.

To improve the life of South Africans and to grow the economy the leading party after free elections – ANC – passed a Black Economy Empowerment law and created various affirmative action programs. This is a program to redress the inequalities of apartheid by giving previously disadvantage groups economic privileges previously not available to them. It includes employment preferences, skills development, ownership, management and preferential procurement. [34].
Political decisions within BEE programs, family connections (traditional African help idea) and huge corruption and bribery (most well know case of so-called South African arms deal, unresolved until today) most probably hampered economic growth. The corruption scandals in the government and parastatals are common. The worst future scenario reminds history of the neighbouring country – Zimbabwe. Zimbabwe bankrupt ten years ago, was left with no electricity, no fresh water, empty shops, no schools, no roads, no petrol and hyperinflation. Zimbabwe's peak month of inflation is estimated at 79.6 billion percent in mid-November 2008 [23].

4. Eskom – background history

The major producer and distributor of electricity in RSA is Eskom, which provides over 95% of the country's energy usage. Eskom was established in 1923 as the Electricity Supply Commission (ESCOM) by the government of the South African Union in the terms of the Electricity Act (1922). In afrikaans language (main language of the Republic of South Africa) it was named "Elektrisiteitsvoorsieningskommissie" (EVKOM).
Names were combined in the 1986 and the company is known now as Eskom [17]. The Eskom Conversion Bill of 2001 make Eskom converter into a public company with a share capital held by the state (named Eskom Holdings Ltd).
The previous governance structure (the Electricity Council, a government body, and the Management Board) was replaced by the Board of the Directors. The Board is responsible for providing strategic leadership, guarding standards of corporate governance and ethics, policy setting, setting the criteria of efficiency and delegation of detailed planning and implementation of the policy of the Executive Management Committee (EXCO). The Board meets each quarter and monitors the compliance of EXCO with set policy and achievements of its objectives. The Board has approved a charter that provides guidance to the directors in fulfilling their duties.
The Government of the Republic of South Africa is the sole shareholder of Eskom. It is represented by the Minister of Public Enterprises. Every year Eskom has to prepare, in consultation with its executive authority (the Minister of Public Enterprises), a "shareholder compact" documenting the mandated key performance measures and indicators to be attained by Eskom as agreed between the Board of Directors (Board) and the executive authority. Thus the relationship between the shareholder and the Board is preserved and the Board is responsible for ensuring that proper internal controls are in place and that Eskom is effectively managed.
Anton Eberhard found Eskom's problems have their source in the very low prices for selling energy (very

low by the international standards). The low prices are *de facto* imposed by the government for political reasons. In Eberhard's opinion, the prices could be kept at low level because Eskom had no substantial investments for many years. Its last large expansion program was in 1970s. The investments were amortized in later years. In this way, Eskom could sell energy cheaply, at the cost of future energy security of the country [17].

Eskom's first primary reason to exist is to ensure adequate supply capacity to South Africa. After 1994 Integrated Electricity Planning (new institution responsible for recourses planning approach) started to plan how to meet the expected demand. Political changes have led to rapid changes in the number of people living in villages and towns. The demand for electricity was rising sharply with population growth in the cities and significant per capita growth income.
Between 1994 and 1999 about 2.8 million households were connected to the national grid. It is estimated that by 2025 about in total 11.4 million households will be connected [12]. And this official data, which do not take into account hundreds of thousands people living in the "squattercamps" (South African name for unofficial settlements), using electricity and not paying a rand to get it. In 2001, Free Basic Electricity policy (FBE) was introduced by Eskom after suggestions made by the Department of Minerals and Energy (DME). The government argued that ''conventionally, the average poor household does not consume more than 50 kW h of electricity per month"; and, hence this amount was to be offered free of charge. Additionally, it is difficult to determine a baseline as to who is poor and thus qualifies for the subsidy. Therefore, it was decided that the subsidy becomes available to all consumers regardless of their income levels. Consequently, there is an amount of electricity consumed that is not connected to price but to the population that use it [26].

5. African philosophy

The institution of the nation or state on the African continent is experiencing continuous crisis. Starting in the 1990s, there have been numerous attempts to democratize African societes through the adoption of Western cultural models. According to professor Vorbrich, African societies should be treated as post-tribal ones. It means that cultural features and structural elements typical tribal society (ethnocentric attitude, concentration of social roles in the same person, collectivism, man subordinated to the community, the relationship of seniority, blood relations) are intermingled with the institutions and principles imported from the western cultural circle (the concept of the nation, the doctrine of freedom parliamentarism, individualistic attitudes). [43]
This creates a society where power is still exercised by the ruler for life, and people respect him. Instead of an individual that has a right to his/her opinion, there is a community and belonging to it determines human existence. It is called philosophy of Ubuntu. In guni language of South Africa it means "human kindness". In southern African region it means also "the belief in a universal bond of sharing that connects all humanity". According to Michael Eze the core of ubuntu can be summarized as follows: "a person is a person through other people". People must be a part of community, must work together. Without the community human is not a human anymore. This cultural factor makes it very difficult to members of the society of the African country to oppose the government's decisions. [18]

6. Load shedding

In 1998 Eskom generation capacity model and max demand forecast showed problems in ten years time [38]. It was told that existing plants without proper conservation can't work for next 10 years. And the pace of population growth in South Africa made obvious that new plants will be needed soon. First shortages started in 2007. As a result in the first quarter of 2008 blackouts all over the country became commonplace with damaging effects on South African economy. Approximately R50 billion were lost from the economy according to National Energy Regulator of South Africa [33]. Eskom argues that lack of capacity can only be solved by building new power plants. After the electricity crisis of 2008 the expansion of electricity production had become a necessity. However, until today no new generators have been build. At the begging of November 2014 the Majuba power plant lost its capacity to generate power after collapse of one its coal storage silos. Two weeks later last silo had major crack and caused a complete shutdown. On December 2014 turbine of Eskom's Duvha Power Station experienced a mechanical failure and shut down.
Eskom, with their slogan "powering your world", announced in November 2014 "load shedding" for whole country. This is how the company explains what load-shedding is [17]:

- When there is not enough electricity available to meet the demand from all Eskom customers, it could be necessary to interrupt supply to certain areas. This is called load shedding. It is different

from a power outage that could occur for several other reasons.
- It is a last resort to balance electricity supply and demand. We will only apply load-shedding when all other options have been exhausted.
- It is an effective way to avoid total collapse of the electricity supply grid (a national black-out) which will have disastrous outcomes for South Africa. If unbalances on the power is not managed this could lead to the risk of collapse of the entire power network. If this occurs, it could take more than a week to restore power to the entire country. By rotating and shedding the load in a planned and controlled manner, the system remains stable.

Despite the policy pursued by the government information about periods and regions of predicted blackouts, the consequences for the country are enormous. The impact on the economy is huge. Mining operations are shut down. It takes several hours for miners to be evacuated from the mines, which causes enormous losses. Smelters and refineries take hours to restart after a break in power supply. Traffic management systems and traffic lights cause considerable congestion and a drop in productivity, offices reliant on internet services and technology have no option but to close, hospitals have come under increased pressure and many government administration services such as home affairs simply close as a result of load shedding. According to energy and economy expert, Chris Yelland: "the controlled blackouts since December 2014 have had a serious negative economic impact. Stage one cost South African economy R20 billion per month (10 hours of blackout per day for 20 days a month). Stage two of load shedding, cost economy R40 billion per month, while stage three is estimated to cost R80 billion per month. These cost to productive economy for load shedding in SA are based on a cost of unserved energy of R100 per kWh (stage 1 is up to 1000MW stage 2 is up to 2000MW, stage 3 is up to 4000MW)" [39]. Bureau for Economic Research (BER) economist Hugo Pienaar says Eskom's load shedding schedule was the main trigger that caused him to revise down his 2015 GDP growth forecast from 2.9% to 1.9% just a few days later [5].

Load shedding also has important social consequences. Communities are informed about areas and time of load shedding via internet and television. Then they have to plan their life accordingly. Lack of power for a few hours means that people do not have access to water, lights, phones and computers. They often spend time unproductively. It causes depression, dissatisfaction, discouragement and feelings of lack of security. The result is a reduction in the quality of life in the region and a negative perception for governments' actions. Also the sense of danger to life, health and property is raising. Since the announcement of the load shedding crime in South Africa has risen by 20% [37]. Blackouts make robbery and crime easier, house alarms stop working, as well as others systems of security. Interruptions in the supply of energy also translate into the creation of significant difficulties in prosecuting criminals (traffic jams, lack of access to information, limited communication capabilities for the police).
On February 2015, during State of the Nation, president of the country, Jacob Zuma, said that South African energy problems are product of apartheid and government is not to blame for current blackouts. He accused analysts for misleading the people in South Africa regarding the state of Eskom and the provision of electricity. He said that analysts did not state the facts, blaming the current government for the electricity crisis [45]. The president also comment on Majuba silos damage as a planned sabotage made by political opponents. In 2015 (January, February) the whole population of South Africa already doesn't have power for 2 weeks. And next load shedding is planning.

7. Poland and possibility of Load shedding

The situation in South Africa should be a warning to the actions taken by the Polish government in the energy security. Analysis published in the [36] shows that the current power grid is outdated, underinvested and will start to fail in the next several years. This implies the need to accelerate the processes of reconstruction and modernization of 220 kV lines. Another problem is a simplification of formal procedures in the investment process. At the same time the demand for electricity will increase (projected average growth rate of electricity demand by 2025 is close to 1.28% [36]). There is need for expansion of the transmission network. This problem relates primarily to the north-eastern part of Poland, with lowest density of the power grid.
The Ministry of Economy warns that the power shortages will start in 2016-17. The worst may come in the winter of 2017, when there will be not enough new power blocks, and some of the old ones will end their life. The energy blocks must be periodically renovated, and this means temporarily falling energy supply [8], [19] [22].
Need for expansion of the transmission network also stems from EU directives. About share of renewable energy in electricity production and the requirements

associated with the expansion of cross-border mergers. The EU also mandates the expansion of renewable energy sources (wind farms, solar farms), but in Polish case they will be not able to replace the losses from conventional sources in predictable period of time. The wind farms in Poland are especially unstable power source. The government plans to build at least one nuclear power plant to replace old coal based power plants. However the planned delivery of the first nuclear power plant, if it will be built at all (there is considerable political opposition to the project from the Greens and local communities), is probably around 2025 in the best case. As for today there is still no decision even on the place of construction of a nuclear power plant and the Polish Nuclear Energy Programme is constantly being delayed and changed.

Investments in energy are long-term projects. Poland only began to build energy infrastructure. Investments in energy are also necessary because a growing economy needs more power, even if thanks to new technologies become more efficient. Experts estimate that GDP growth of 1 percent. increases the economy's demand for electricity by 0.7 percent.[4]

8. Conclusion

The South African case in an example of a spectacular management failure. The country with developed energy infrastructure started to experience power shortages solely because of lack of maintenance and long-term investment planning. This caused economic losses which can be counted in billions of US dollars and social losses which are difficult to estimate in details (but still very significant). The situation in South Africa should serve as a warning for other countries, where economic and energy balance analysis suggest possibility of power shortages. Poland is one of such countries.

Comparing the situation of both countries one should note, however, that despite predicted increase of energy demand and limited infrastructure capabilities, the situation in Poland is much better than in South Africa:

- In South Africa goverment has 100% share in the monopolist company producing and supplying energy. In Poland the ownership share in the energy companies is much more diversified, and while government has the controlling share in much of this sector, his influence is much more limited.
- South African Eskom is the sole modern energy company in the whole region. Poland is a part of European Union, which guarantees her possibility to buy and import energy from abroad and participate in trans-border energy transmission projects. She will also get support in case of energy crisis.
- The nuclear power plant in South Africa was closed down without possibility to start it again. Poland has plans to build a nuclear plant – but this plan has to be finalized.

Authors think that Poland should treat South African experience as a warning and a case for improving quality of used energy system. It should also implement, according to suggestion of Kemmler and Spreng [29] strategy of "promoting energy efficiency and reducing energy intensity" as a part of policy to tackle energy security problems. Such approach may protect the citizens of Poland from lack of energy security, which is experienced by South Africans today.

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