Venkatachary, Sampath Kumar; Prasad, Jagdish; Samikannu, Ravi

Article

Application of strengths, weakness, opportunities, and threats analysis in smart grid - virtual power plant for sustainable development in India and Botswana

International Journal of Energy Economics and Policy

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(4), 126-137.

Application of Strengths, Weakness, Opportunities, and Threats Analysis in Smart Grid - Virtual Power Plant for Sustainable Development in India and Botswana

Sampath Kumar Venkatachary[1]*, Jagdish Prasad[2], Ravi Samikannu[3]

[1]Amity University, Jaipur, Rajasthan, India, [2]Amity University, Jaipur, Rajasthan, India, [3]BIUST, Palapye, Botswana.
*Email: sampathkumaris123@gmail.com

ABSTRACT

A holistic view of energy stakeholders in a strengths, weakness, opportunities, and threats (SWOT) perspective for India and Botswana is presented here. SWOT analysis is based on the themes of market resources, energy technology and invention, and energy efficiency and climate. With this analytical frame work, the article discusses the strengths and opportunities while compensating weakness and mitigating threats. The action portfolio is directed towards enabling sustainable development, alleviating poverty and stresses the importance of comprehensive energy strategy towards building a strong economic profile while minimizing carbon foot print including energy efficient systems for the virtual power plant/smart grid/distributed energy resources.

Keywords: Strengths, Weakness, Opportunities and Threats, South African Power Pool, Sustainable Energy Development, Ethical Data Exchange

1. INTRODUCTION

The power sector is changing and changing fast. The transformation of this area from a centralized network-grid architecture to a decentralized hub making use of many renewable sources of energies like wind, photo voltaic (PV), hydro, biogas, biomass to form a distributed energy resource (DER) has accelerated the power generation sector. The growing awareness among developing nations to reduce carbon emissions and adhere to Kyoto protocol has evolved a more proactive consumer or prosumer. With many governments coming forward with subsidies for renewable energy (RE) sources has increased its attractiveness to the general consumer encouraging him with financial viability to install DER. This paradigm shifts from traditional power plants encompass diverse technologies with advanced software and hardware management tools that go beyond DER (Asmus, 2017 and Peter (2013).

According to IEO outlook, 2016, the electricity demand increases slowly over the next three decades. Non-OECD countries China and India lead the demand accounting for 50-60% of total increase in energy consumption over the 2012-2040 projection period (IEO, 2016). IEO reference case predicts an increase in electricity generation by 69% from 21.6 trillion kilowatt-hours (kWh) in 2012-25.8 trillion kWh in 2020, and 36.5 trillion kWh in 2040 and remains one of the most dynamic growth areas. This dynamic portfolio continues to evolve from separate, non-competitive grids to integrated national and even international markets (IEO, 2016). Annual energy requirement in many countries increasing manifold and in doubled in many countries. Many Governments have understood the problem and are now focusing on developing and incorporating advanced technologies. As of 2016, over 5 million people across the globe have been living without electricity, and this poses a major challenge to many developing nations (IEA, 2014). Efficiency, demand side management, optimal generation, improved grid transmission is essential and critical to minimize investment and achieving this goal. DER's and smart grids (SG) is a solution to this problem. As indicated by Gellings in his book, smart means an "intelligent use of Communications, Computational ability, efficiency, control with technology to enhance the overall functionality of the delivery system" (Clark, 2009). While the objective was to feed in maximum active power consumers in the past, but with the active participation of distributed Energy units, supplying energy will increase.

International Energy Agency estimates that to achieve the target of providing electricity to everyone by 2030 will require additional power sector investment of USD 33 billion per annum on average for Sub-Saharan Africa alone (UNEP, ILO, IOE, ITUC, 2008). Efficiency, demand side management, optimal generation, improved grid transmission is essential and critical to minimize investment and achieving this goal. Investment amounting to 6.1 trillion dollars with an average of $470 billion dollars in power sector includes in new power plants, T&D, grids, refurbishment of old machinery, infrastructures and power plants. Annually electricity sector investments doubled almost two and half times from around $290 billion in 2002 to $650 billion in 2012 out of which 50% of investment in T&D that is about $160 billion to around $240 billion in 2012. In investment in the energy sector was driven by non-OECD countries like India and China due to a surge in electricity demand which grew at an average of 6.5% in the last decade. Renewable energies like wind, solar PV farms accounted for a major investment sector in these countries primarily due to drop in PV costs. In India, despite doubling of generation capacity, unmet electricity demand stood at 9% in 2013 hindering economic growth. In India, most of the electricity installed capacities are owned by the states. Attracting private investors and private capital is essential for the energy sector. Private capital investment is expected to be 1.6 trillion dollars of power sector in the states by 2035. The major bottleneck to this investment is due to T&D losses which stand at 27% and low regulated end user tariffs. Utilities incurred a loss of about $14 billion in 2011-2012 in India. If these losses were reduced to the target level of 15%, it would increase to the annual generation capacity by 5% making the model financially solvent (IEA, 2016).

The traditional business model has drastically changed and evolved with the global economy, and balance between customer and supplier is more customer centric due to extensive development of technologies that have allowed the lower cost provision of information and solutions (Lai et al., 2014). Business, therefore, requires re-evaluating according to different propositions in many sectors. A business model provides information and articulates the logic of how it creates and provides delivery value to its customers while simultaneously outlining the architecture of business interests (David, 2010). SWOTs introduction to the business world by research in Stanford Research Institute has predominantly been adopted in many areas. (Humphrey, 2005) SWOT models have been used in the past to evaluate the sustainability of energy technologies but have been steadily gaining importance (Terrados et al., 2007) (Liu et al., 2011) (Markovska et al., 2009) (Ambe, 2017).

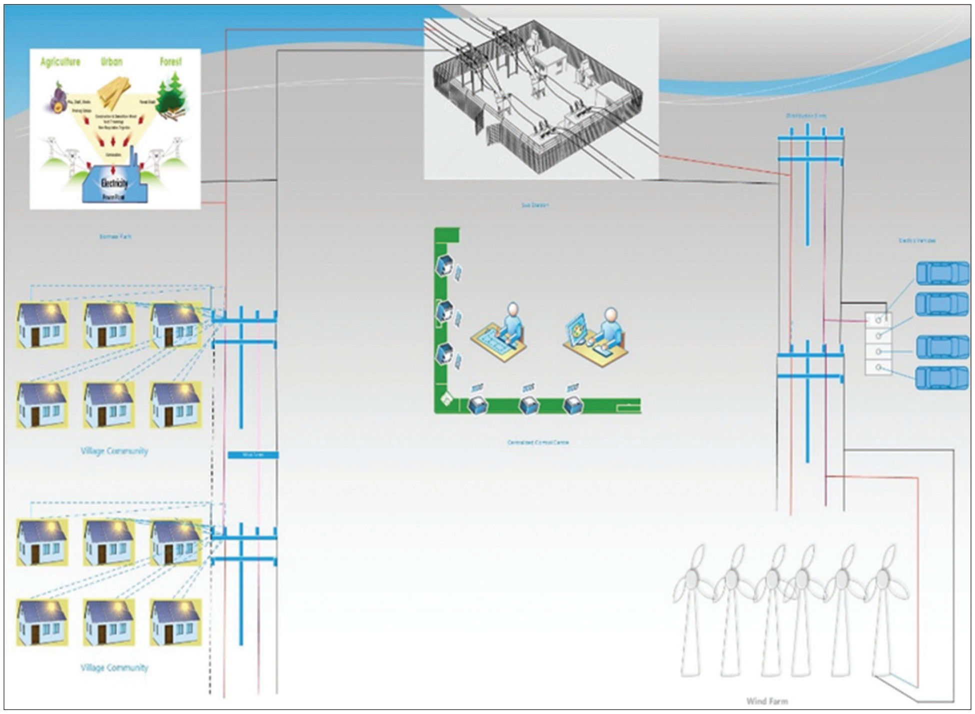
Against this backdrop, this paper aims to analyze the (Adrian, 2016) economic performance of the virtual power plant (VPP) in the markets of India and Sub-Saharan Africa based on specific scenarios and models based on SWOT while section 2 provides insights into previous research work. For this purpose the fundamental energy economics and trading options are explained in section 3, section 4 analyses the main values, portrays SWOT analyses and lastly, section 5 presents recommendations, discussion, and conclusion.

1.1. SG, VPP/DER's

The traditional electric grid face multitude of challenges in the form of infrastructures, which is outdated and unfit thereby increasing the demand. Network congestion issues due to the inability of the grid to react to challenges on time, imbalances in the form of blackouts prove to be costly for the utility companies due to communication challenges. The demand of the consumers to understand energy usage to make optimal usage and financial decisions, compatibility of the traditional grid to accommodate new emerging technologies in the form of renewable energy adds to the problem (Clement and Kevin) (Fangxing Li et al., 2010). The fundamental idea of the designing the Renewable distribution energy networks was designed predominantly for passive operation. The focus was mainly to distribute electricity, from the transmission level down to the consumer with unidirectional power flow, while the future, will call for the distribution system to be more actively controlled with fully utilized network and DER and RE units more efficiently. Against these challenges, it is essential to infuse smart technologies in the form of SGs and VPP.

The smart grid is a giant leap, and it bridges the gap between the traditional technology as it harnesses communication and information technology to enhance the grid reliability, integration of various RE sources, demand response, storage, and transportation. It also allows and enhances competition among the service providers, enabling greater use of intermittent power resources. It helps in establishing the wide area automation and monitoring capabilities needed for bulk transmission over longer distances and distributed power generation. It empowers efficient outage management, streamlines back office operations thus aiding the use of market forces to drive retail demand response and energy conservation. "Smart Grid will be an engine and act as a backbone infrastructure to enable new business models like smart city, electric vehicles, intelligent communities apart from more resilient and efficient energy system and tariff structures" (Anon., n.d). With its dynamic approach, Smart Grid technology undermines factors like policies, regulation, and efficiency of market thereby restricting the global power scenario aids in costs and benefits and services that normalize the marketing strategy. The concerns like secure communication, ethical data exchange, standard protocols, advanced database management and efficient architecture is also taken care of and addressed. "As is the benefits associated with this technology, it also comes with burgeoning issues in both technical and non-technical aspects. Researchers and power engineers are addressing to eliminate these key issues for the proper and sound implementation of the technology across a broad network. (Balijepalli & Khaparde, 24-29 July 2011). The VPP (Figure 1) model takes it cue from the Internet Model, where the active network is taken to the global level but distributes the control around the system. "As its name implies, a VPP does not exist in the concrete-and-turbine sense. Rather, it uses the smart-grid infrastructure to tie together small, disparate energy resources as if they were a single generator. Just about that any (Kumagai, 2012) power source can be linked up, and energy that's used can also contribute to a virtual power, not plant's capacity". To better understand the impact on the distributed generation, the focus should be on the VPPs from a technological and economic perspective. In simple terms, VPP will offer enormous benefits and the hosts will enjoy reaping the benefits in

Figure 1: Typical distributed energy resources - virtual power plant using smart grid technologies

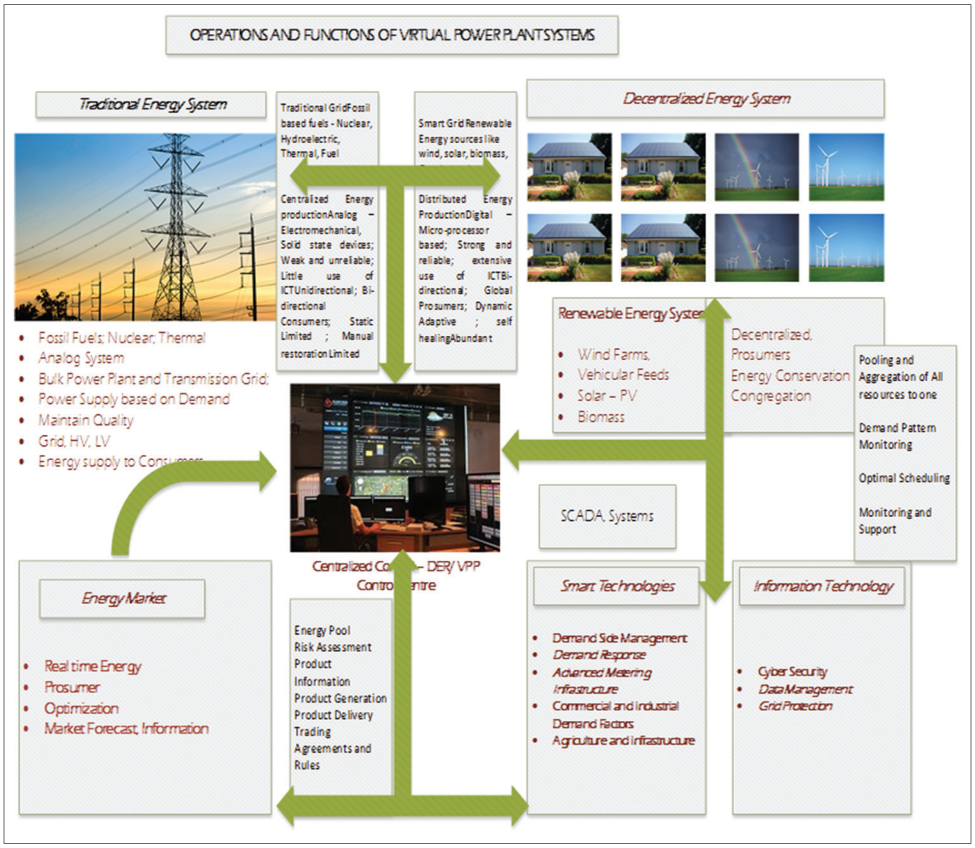


the form of efficient delivery and control system. While VPPs act as pools of autonomous generation units for producing both heat and electricity, the solar cells can only be provided to the consumers locally. In principle, VPPs are suited for long-distance transfer (Markus et al., 2012). VPPs can be termed as a manifestation of transactive energy implementing new technologies like demand response, solar photovoltaic systems, advanced batteries, electric vehicles thereby transforming consumers actively to participants in delivering services. VPP relies on software and smart grids (Asmus, 2017) to remotely and automatically dispatch and optimize DER. In other words emerging energy, the cloud allows consumers to actively participate in the generation and distribution of electricity in strategic ways to achieve business models that benefit consumers, producers, and distributors of energy. Figure 2 provides an overview of various functions in a VPP. The transition from the traditional energy approach to a distributed network approach in the form of VPP will enhance sustainability and efficiency and will result in dynamic changes to energy portfolio in the long run. VPPs will enable delivery of additional unutilized energy to the power feeders while increasing the amount of utilized energy more efficiently. This awareness will forth come due to the cost benefits, who will now be both consumer and prosumer (Rodríguez-Molina et al., 2014).

2. INSIGHTS INTO VPP MARKET AND SWOT IN ENERGY

Many factors influence the energy market. Market demand and response, energy infrastructure, government policies, physical distance, play a vital role in any business model. Demand Response in the energy market is the dominant factor in influencing the energy production, consumer consumption/behavior and is noticed in the open energy market. The energy market in India varies distinctly than in the Sub-Saharan countries of Botswana, South Africa, Zimbabwe, Swaziland, Lesotho, where the energy is exchanged in a South African power pool (SAPP) in a bid market. However, India shares a volume of similarities with Sub-Saharan region in climatic conditions, energy profile to name a few. In the US and other European countries, the market is driven by development and commercialization of market value creation like jobs, system efficiency and environmental incentive programs (Zheng et al., 2016; SAIC, 2011), unlike India and Sub-Saharan Africa. Bazilian et al. proposed that the “current and emerging smart grid concepts, systems make a significant contribution to improving equitable and just access to electricity services in Sub-Saharan Africa” (Bazilian et al., 2010; Morgan et al., 2013) (Fatih, 2010). A major challenge in a VPP grid infrastructure is flexibility and unreliability, given the type of architecture which is complex, paving the way for adding or removing members. The reason attributed to this is the willingness of the members to contribute the generated electricity, since a member may wish to contribute any amount of power generated, thus making the member unreliable. This could result in unreliable energy supply to the buyers or the market bidders in the long term. (Rathnayaka et al., 2014) in his goal oriented model, explains and highlights this scenario as prosumers are not goal oriented in VPP, but interconnected members via technical infrastructure. These minor challenges could affect long-term relationships in a VPP due to differing opinions, interests, and preferences. The authors propose a model “goal-oriented prosumer community groups” as a solution to overcome this problem through means of sustainable social aspects with regards to prosumer management. In their proposal to solve, the select prosumers of common interests and targets, solve it in four major steps of (1) obtaining segmented profiles, (2) negotiation process among partners involved, (3) introducing new prosumers during the process and finally ranking the members. Kato et al. (2012), discusses decentralized electricity storage in smart grids. They indicate that excess energy

Figure 2: Operations and functions of virtual power plant



produced by the consumer is a source of revenue and energy that could be harvested by the prosumer from the storage as and when required. This aims to optimize energy distribution significantly by completely being independent of the grid. This storage bank is referred to as clusters by the authors. In a cluster environment energy generated from every prosumer is networked similar to the IT network, called energy network, thus enabling inter-cluster energy transfer thereby effectively utilizing the energy generated. Da Silva et al., (2014) stress the importance of performing accurate forecasts for local energy communities as a whole, to offer service that could become a business model for energy consumption forecasting. They insist that the local energy markets are a more desirable model for generating electricity because of their software management control facilities, efficient resource allocation, and dynamic pricing. Karnouskos (2011) (Karnouskos Stamatis, 5–7 December 2011) indicates the importance of how services will be used by prosumers to their advantage in the future. The author indicates since the system is bi-directional information exchange between production centers and end users is dynamic. They also elucidate How appropriate energy monitoring and consumption habits aid in automated decision making, management of different subsystems and devices, energy brokering strongly related to energy trading in the energy market, real-time analytics and value-added services, community management services of common interests for a group of prosumers, energy application stores. The authors also highlight the importance of interoperability.

SWOT has been applied as a key tool in national sustainable development programs by various public administration offices broadly across different areas as regional development, municipal planning. (Anon., 1999) (Bryson and Roaring, 1987) (Karppi et al., 2001) Ambe in his paper demonstrates a modified version with variants quantitative and qualitative and successfully employs them to assess the sustainability of the sawdust cook stove variant as a cooking device in Sub-Saharan Africa and further explains how it can be put to use in developing regions in general (Ambe, 2017). Liu et al. summarize, define and apply SWOT analysis to diagnose and identify economic, social and environmental impacts from bioenergy production on marginal lands. The results summarize and conclude that the strengths lie in the land, energy crop adaptability, rural economic development with weakness in economic viability, environmental impacts, gender inequality concerns. They also conclude that RE planning will create an external environment to promote bioenergy production on marginal land with concerns on fuel price, labor, natural hazards (Liu et al., 2011). Markovska et al. study the SWOT model for the energy sector in Macedonia. The results pointed to the progressive energy policies in the European Union adopted in Macedonia while addressing the associated problem in the energy sector of scarce domestic resources, unfavorable energy mix, low prices, production inefficiency, insufficient institutional and human resources. They also point out the need for adoption of comprehensive energy strategy on sustainable principles, intensified utilization of natural gas, economical electricity prices, technical, structural changes, promotion of energy efficiency and renewables (Markovska , et al., 2009). Terrados et al. study Jaèn, a Southern Spanish province applying SWOT principles. They present techniques from applying business management techniques as a part of energy plan with a focus on solar and biomass energy. They also discuss associated issues and conclude that multi criteria decision making can be extensively used in energy planning and prove SWOT analysis to be an effective tool as a baseline for diagnosing problems while laying the foundation for future action lines (Terrados et al., 2007). Camille et al. (2013) study Canadian energy policies and show the inconsistencies in the Canadian energy and climate strategies and further proves that the authorities approach amounts to an amalgam of decisions made at a provincial level without cooperation with other provinces or with the federal government (Camille et al., 2013).

3. ENERGY PROFILE IN INDIA AND BOTSWANA

With the depleting fossil fuels, it is crucial that the developing countries utilize other renewable sources and tap the potential for its evolution. The energy demand is expected to grow significantly (Anjan, 2017) in developing countries, and considering the limited resources used for generating electricity using fossils like coal, oil and other fuel sources it becomes a major bottleneck. It is therefore essential to tap the renewable and alternative energy resources to lower the impact on the planet and reduce carbon footprint (Rodríguez-Molina et al., 2014). Thus, it vital that renewable resources act as a catalyst to increase and improve energy access in remote rural areas (Maiga et al., 2008). India and Botswana are fast developing countries with a GDP per unit of average energy use 5.6% and 9.45% (World Bank, 2017). Rapidly increasing energy demands result in emissions. Both the countries are fighting hard, the need to mitigate global warming and mounting pressure to reduce carbon footprint and pollution have led to governments encouraging RE generation by providing subsidies and incentives. Access to energy in rural areas in developing countries is paramount as a means of increasing standard of living and sustainability and tops the agenda in any developing world (Karekezi and Ranja, 1997) (Karekezi and Waeni, 2003) (Karekezi and Waeni, 2002) (Djiby-Racine, 2010). The energy scenario in India and Botswana is comparable. For India to maintain sustainable economic growth rate 8-10% through 2025-30, the power corporations have to increase their production capacity by at least 3-4 times and supply by 5-6 times of their 2003-04 levels. With 2003-04 as the base, India's commercial energy supply would need to grow from 5.2% to 6.1% per annum while its total primary energy supply would need to grow (Deepa and Priya, 2015) at 4.3-5.1% annually. By 2030 power generation capacity must increase to nearly 8,00,000 MW from the current capacity of around 2,78,000 MW inclusive of all captive plants. Similarly, the requirement of coal, the dominant fuel in India's energy mix will need to expand to over 2 billion tons/annum based on the domestic quality of coal. Meeting the energy challenge is of fundamental importance to India's economic growth imperatives and its efforts to raise its level of human development" (Tiwari and Rawani, 2013) (Montek, 2006). As per the annual report of MOP (Ministry of Power, GOI) Table 1, the total energy availability in India stood at about 106.8 billion units. Conventional sources of power, mainly coal accounted for over 60% while in comparison to all other modes of power generation, oil about <1%, RE 12-15% (Wind, Solar, biomass.), natural gas 8%, nuclear at <2%. The total installed electricity generation capacity presently in India is about 278 GW. Out of this about approx. 12-15% (42283 MW) is through renewable generation, mainly wind (29598 MW) and balance are in the form of small hydro (5074 MW), miscellaneous (2114 MW) and PV and solar (5496 MW). India's vast RE resources such as the wind, solar, hydro, biomass, remain untapped in most of the states. Most of the RE capacity is in the renewable potential rich states of Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat, Maharashtra, Rajasthan, Himachal Pradesh and Jammu and Kashmir. These states primarily contribute over 80-90% of total renewable capacity installations in the country (Ministry of Power and Infrastructure, 2013-14) (Ministry of Power and Infrastructure, 2014-15) As per BPC report, energy availability for 2015-16 in Botswana stood at about 4030 GWh. Botswana's supply security in the year 2013 was highly dependent on internal generation, since there were no firm power imports, before the year, the country was roughly importing close to about 80% of national power supply from Eskom in South Africa. However, to meet the growing demand, the contract to Eskom was extended on a non-firm basis for 300 MW up to December 2015. Utilization factors and study pattern, however, shows that 1509 GWh, amounting to 42% of country's requirement was imported as compared to previous years. The Power demand was imported from "Eskom, Electricidade de Mozambique, NamPower of Namibia, ZESCO of Zambia and the day ahead market of the SAPP." Japanese funded Solar Photovoltaic power plant that was commissioned during 2012 could not offer much hope to the growing demand on the energy sector in the country (Botswana Power Corporation, 2015) (Source Data: BPC Annual Report, 2015). Botswana can also explore

Table 1: Energy table (source annual reports MOP and BPC) (Botswana power corporation, 2013) (Botswana power corporation, 2015) (Ministry of power and infrastructure, 2013-14) (Ministry of power and infrastructure, 2014-15)

Years	India			Botswana		
	Energy requirement (MU)	Energy availability (MU)	System (peak demand)	Energy availability (GWh)	Energy consumption (GWh)	System demand
2007-08	737052	664660	72392	3120	2777	473
2008-09	777039	691038	86001	3210	2889	493
2009-10	830594	746644	119166	3369	2917	503
2010-11	861591	788355	122287	3414	3109	553
2011-12	937199	857886	130006	3551	3118	553
2012-13	998114	911209	135453	3590	3198	542
2013-14	1002257	959829	135918	3650	3310	578
2014-15	1068923	1030785	148166	3704	3449	572
2015-16	748676	731445	17231	4030	3495	610

the expansion of the solar plant in the areas of Ghanzi, similar to the North African Solar Project in North African Countries. In comparison to India's energy requirement and availability, a similar situation prevails in Botswana where the demand is higher as in India. With changing times and adapting newer technologies in VPP grid, these challenges can be overcome in the long run to meet the consumer requirement.

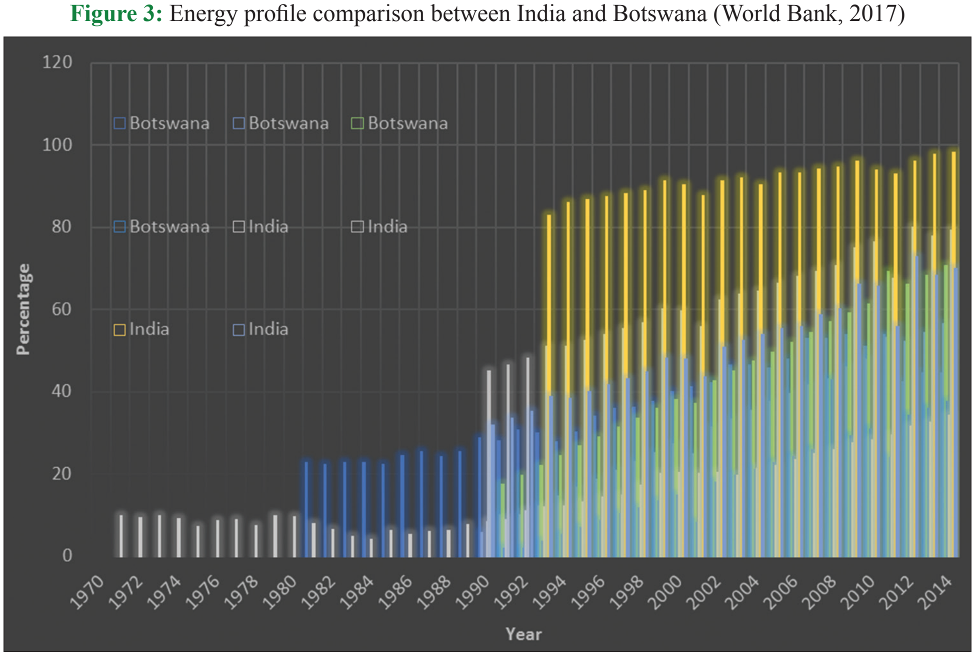
The population without access to electricity in Botswana is about 1 million. According to World Bank data 2014 (Figure 3), the percentage of the population with access to electricity in India and Botswana is 79.16% and 56.58% respectively. The population with access to electricity in urban and rural areas were 70.6% and 37.52% for Botswana while for India it was 98.2% and 70.02% respectively(World Bank, 2017). Though India has doubled its generation capacity; the co untry still faces energy and development challenges. About 240 million people that is one in five Indian citizens have no access to electricity and needs about 140 billion dollars in energy investment per year to 2040 that is more than 110 billion dollars for energy supply and another 30 billion dollars to improve energy efficiency. A major population in both the countries live in rural areas. While India has concentrated on powering up rural areas (70.02%), Botswana has to enhance its access to the countryside which is about half of India's electricity access in rural areas (37.52%). Thus, it is essential to incorporate and implement new technologies to improve the energy profile for both the countries.

4. SWOT PROFILE FOR INDIA AND BOTSWANA

It is essential to understand the function of VPP to study SWOT. The main functionality of the VPP includes planning, operations, and delivery. Optimization is critical to VPP functionality. Figure 4 shows the functionality of the VPP. The business model concepts gained popularity recently, partly due to business interests and partly due to growth and globalization (Wendy, 2004). Definitions of what constitutes business models vary depending on the thought and have not established definition from a scientific literature (Amit, 2001) (Amit et al., 2010) (Wendy, 2004). The business model establishes governance of transactions, content, value creation by exploitation of business opportunities. (David, 2010) defines a business model as a tool that companies use to deliver value to customers for which customers pay thereby converting those payments into profit. There are numerous challenges in a business scenario in the VPP grid due to the disparity among the studied models and introduced models (Rodríguez-Molina et al., 2014).

SWOT analysis considers both internal and external factors (Anon.), and takes into account the hidden factors while minimizing the external effects of weaknesses and threats (Daniel David, 2000 and Peterson, 2000). SWOT has its application in the energy sector in sub domains. (1) Generation, transmission, and distribution, (2) energy technologies, (3) products, (4) energy networks. The main indicators of SWOT are determined by many contributing factors which include internal situation described by its strengths and weakness while the external components portray opportunities and threats. In short, the key areas are: (1) strengths - build strengths, (2) weakness - eliminate, 3) opportunities - exploit, (4) threats - mitigate. The use of SWOT in the energy sector, analyze has strategic advantages as the tool can be focused on to identify changes to improve. Second, a detailed cost-benefit analysis can be performed mainly from an economic view. Third, SWOT if well-structured on internal and external factors can reap rich rewards. When performing a SWOT analysis, it is essential to define internal and external factors clearly before carrying out the analysis. Strengths are positive internal aspects that are controlled by the organization internally, whereas opportunities are possibilities due to external factors that could reduce weakness and improve on strengths, while threats are external factors that could

Figure 3: Energy profile comparison between India and Botswana (World Bank, 2017)

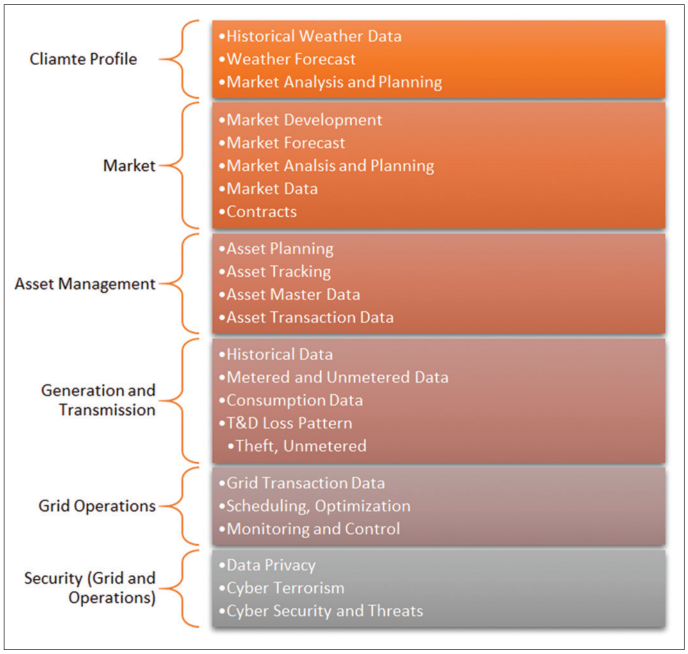


harm or pose problems to the organization either in short term or long terms. This research paper considers three portfolios energy efficiency and security, climatic factors influencing the region, technology and innovation. Figures 5 and 6 shows SWOT profile of India and Botswana respectively. Figure 7 shows a tree profile summarizing various problems associated in the energy sector in the countries of India and Botswana.

4.1. Energy Market, Resources, Planning, and Security

As mentioned earlier Botswana is a land locked country, unlike India. Both the countries have a strategic geographic profile. Botswana is one of the market leaders and strategic partner in the southern belt next only to South Africa and India is viewed as a strategic partner by many countries across the globe. Despite the fact that transfer of technology, information transfer between research institutes and boards could be improved, both India and Botswana are considered a success story by many neighboring countries and strategic partners. It is essential to understand the climate profile of both the countries and both the countries have more or less similar climate profile regarding solar insolation. However, the wind profile of Botswana drastically varies with that of India. Botswana has wind power between 4.5 and 5 m/s (Anon.) (Meteoblue) which is quite low when comparing to India and unsuitable for wind large wind farms. India has substantial RE penetration due to its climate profile, unlike Botswana. Botswana has the highest solar insolation in the world. However, it should be noted there is substantial room for improvement in the Solar PV areas and Wind farming.

Figure 4: Functions of virtual power plant (Martin et al., 2016)



Unlike other European countries or US biomass strategies and policies (Anon, 2005), both India and Botswana lacks an integrated commitment, coordinated approach to research and development in the area although the biomass potential in both the countries is enormous and needs to be tapped. Botswana has one of the largest cattle population (more than the human population) and is the biggest exporter of Beef and Beef products to many countries across the globe. India, on the other hand, is an agriculture economy. This generates huge biomass potential. It is on this basis the countries have intensified the underlying the development of energy systems in their respective countries. The main barrier to the bioenergy market is due to the prices. Bio electricity prices differ greatly between countries due the pricing policies and technology. However, a common advantage and strength in both the countries is the biomass potential which could aid in bringing down the investment costs. It is worthwhile mentioning here that lack of access to technology among the rural masses is a critical

Figure 5: Brief weakness, opportunities, and threats summary for India

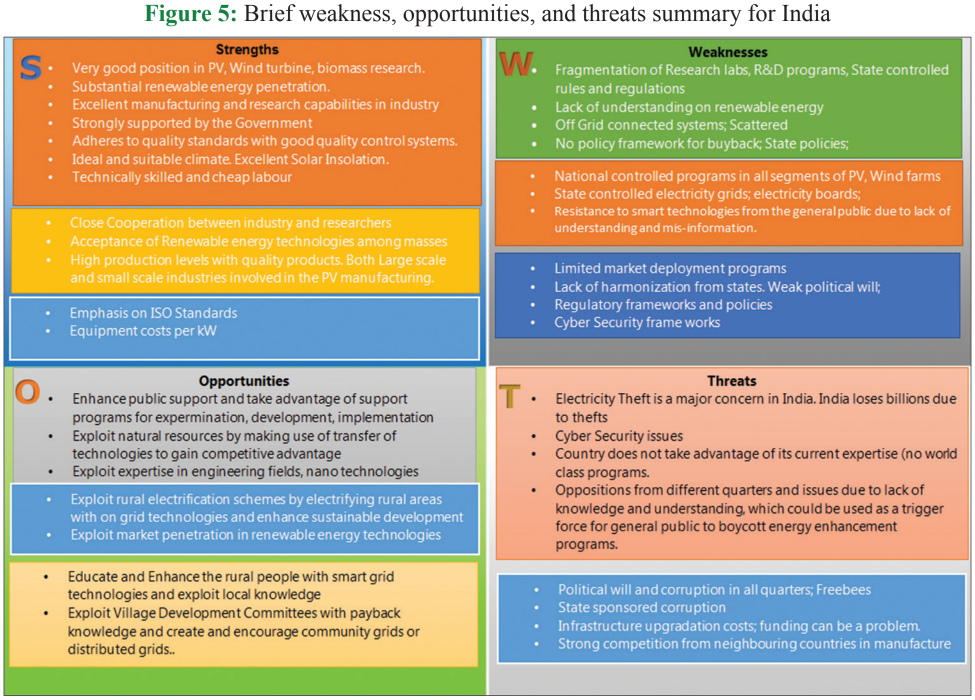
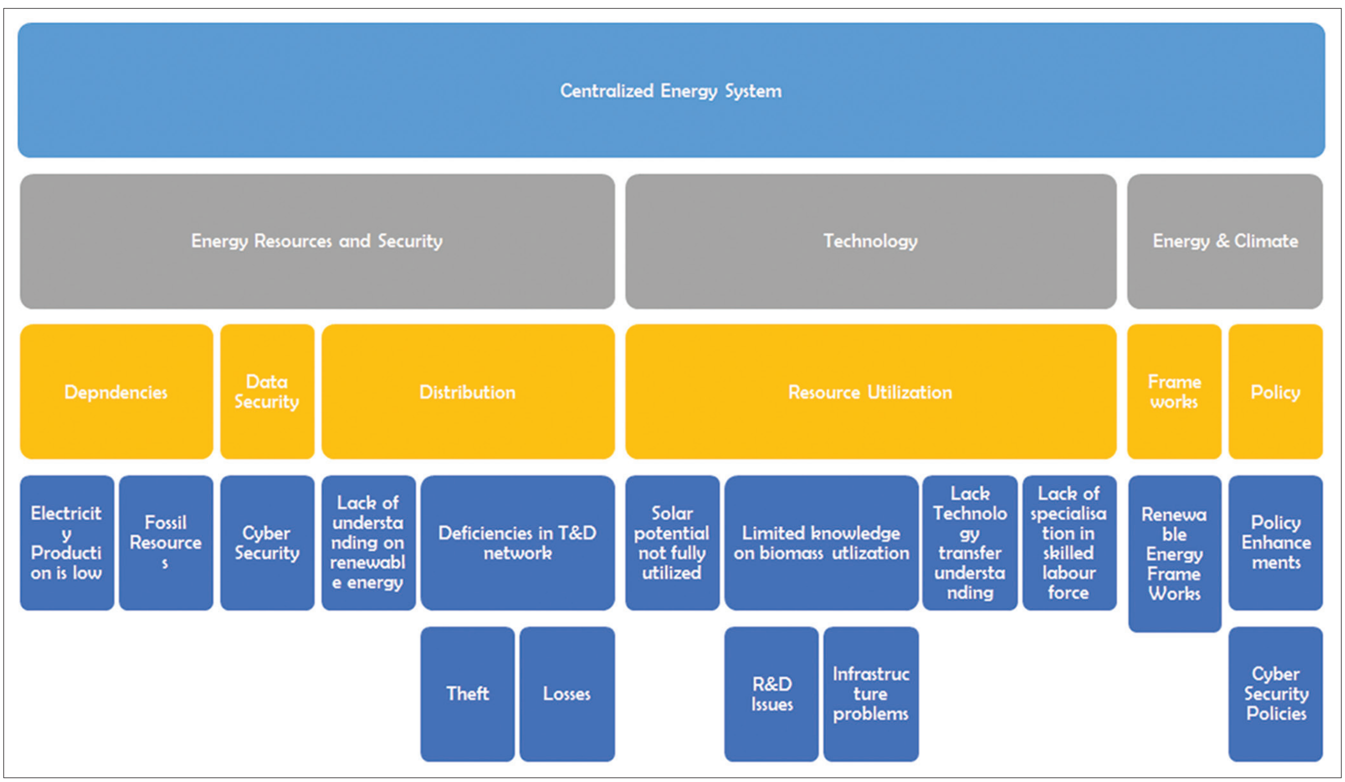


Figure 6: Brief weakness, opportunities, and threats summary for Botswana

Figure 7: Summary of tree profile showing problems in energy sector



challenge and needs to be strengthened with adequate policies and governance.

India exports electricity to its neighboring countries. Therefore it should be backed by adequate laws protecting its interests. Since respective states govern most of the state electricity boards, the absence of frame work will be a potential risk to the regional energy strategy. As the demand for the energy increases on a daily basis internally and externally, decreased imports due to the politically unstable environment in export nations like the Middle East, North Africa could pose a threat to the security of the supply and generation from non-renewable sources. This will impact heavily and put a due strain in the RE segment to cater to demands. Thus the synergies between renewable and the non-renewable power source are imminent. Botswana faces a similar dilemma except for the fact that it imports about 50% of its electricity from the regional SAPP (Botswana Power Corporation, 2013) (Botswana Power Corporation, 2015). Security issue in both these countries is not limited to energy security. With advancement in smart technologies, smart metering, and grid technologies, cyber security, and data protection are critical. Both India and Botswana has very little exposure to cyber threat mitigation. It is therefore essential to put more controls on the cyber security.

Renewable energies have been greatly accepted as a permanent source of energy by the consumers and are inquisitive to have more intricate knowledge of the resources and availability. It is therefore essential that this acceptance is exploited with more innovative schemes and technologies with sound financial support. This acceptance opens up many opportunities for both private industries and entrepreneurs to invest small scale industries, start-ups and large scale manufacturers either at the manufacturing end or at the delivery end.

4.2. Technology and Innovation

India is expanding its base rapidly in solar PV. The total cumulative capacity has quadrupled from 2650 MW to 12.50 GW as of 30.4.2017 (Anon.) (MNRE, 2017). and the installed capacity in Botswana is 12-14% (Botswana Power Corporation, 2015) (Mooiman, 2016). India has also brought down the cost per kW for PV's substantially due to its in-house technology research. Both India and Botswana has got the enormous potential to grow technically with appropriate technology transfer. India and Botswana are expanding its base in research and development in Solar PV with strong support from its Government. In addition to research, the acceptance of RE technologies among the rural masses is highly appreciated. Many private players are playing a key role in technological investment in the PV segment. Anonymous (n.d) BITRI, Botswana's, Energy division is actively involved in PV research and development and is actively participating in technology transfer (Anon.). In addition to the research in PV segments, both the countries are actively involved in research areas of biofuel, the wind, etc. India has doubled its wind energy penetration to a cumulative capacity of 32.28 GW, biopower and bio waste to power with 8.1 GW and 0.114 GW as of 30.4.2017 (MNRE, 2017 (30.4.2017)) respectively in addition to other forms of RE sources, unlike Botswana where this potential needs to be tapped. Bio fuel produced from cellulose materials represent a huge opportunity and can be pursued by both the countries. This could allow the sector to be competitive substitute due to low-cost enzymatic hydrolysis for chemical conversion of biomass. Like their European counterparts, the countries should encourage the establishment of biorefineries, recycle farms in addition to using the traditional knowledge vastly available in both these countries.

Transmission and Distribution losses in both the countries are high due to the grid infrastructure being weak. The T&D losses in India were at 19.42% in 2014 (World Bank, 2017) (CEA, 2016), and GOI is targeting to bring it down to <15% in the current fiscal year. This weak grid profile exposes vulnerabilities and is potential to attack from different sources. Theft is another major problem in both the countries. Though energy theft in developed countries like UK and US, is not a significant problem, in a developing country like Botswana, it poses a far greater challenge. India on an average loses 27% of its generated electricity capacity to theft at various stages (Ministry of Power and Infrastructure, 2014-15) (Ministry of Power and Infrastructure, 2013-14). Theft is especially predominant in distribution. The reason being people have little understanding or no insight of the grid, and with higher poverty ratio, power theft is quite rampant. Mike (Mooiman, 2016) in his blog mentions how it has been a challenge into one of the implemented PV project in Pakhalane, Gaborone in Botswana. It is one area where both countries can improve on with latest technologies like AMI metering, smart grid technologies. This opens up enormous opportunities for sustainable development of the rural electricity market through distributed grids and VPPs. The Governments can enhance their penetration in the countryside through PV schemes at subsidized rates with a payback period. With an on grid proposition, the village communities could be pooled together as a resource and form a community grid. The excess generated electricity in addition to consumption can be put back into the grid. With benefits in the shape of monetary return, the village communities will be encouraged to maintain the equipment and rest assured of sustainable income regularly. This will alleviate the poverty stricken community with a sustainable income and serve the dual purpose of protection of the equipment, minimization of electricity theft while encouraging sustainable living.

4.3. Energy Efficiency, and Climate

Energy efficiency, Climate change together are among priority items in any agenda for achieving sustainable growth. Climate change concerns are the key factors that motivate the growth of RE growth. India is bound by its agreement to reduce emissions target for 2020 and reduce greenhouse gas and carbon foot print. The agreement binding is seen as an opportunity for generating additional revenues. It is a positive step and an opportunity to improve the economic feasibility of sustainable RE projects thus attracting FDI in the energy sector. To achieve this probability a comprehensive long-term energy strategy needs to be in place which will outlay factors influencing climate change mitigation. Therefore, there is an urgent need to strengthen the existing policies on RE and make it more flexible and attractive to investors. There is also need to encourage projects that are low on carbon intensive fuels and associated technologies and practices. Botswana, on the other hand, is a country with least emissions when compared to the India, China or neighboring South Africa. It is however essential that the country actively participates in the reducing the carbon foot print and plan long term for RE investments. It is also vital that both the countries incorporate advanced technologies and optimize the energy sector and improve efficiency and minimize losses on T&D, generation, and other related areas. It is a key factor in controlling emissions to a significant degree. As demand and supply govern market prices, it is essential to enforce and introduce market price strategies that will improve the operational and developmental conditions of energy producers in a VPP environment, as in a distributed environment the consumer is also the prosumer and thus will provide significant motivation to the energy saving consumers. It is also essential to enforce energy efficiency on the demand side and stimulate changes in the industry, favoring less energy consuming industries. As a flexible VPP market, it is essential to educate, provide training and create awareness on the various advantages of the distributed resource and increase efficiency by encouraging energy saving tips and schemes. It is critical to strengthening policies and frame works governing the RE portfolio, environmental standards, institutional standards, quality control, taxes, financing options as a strategy to stimulate RE growth among the masses.

5. RECOMMENDATIONS, DISCUSSION AND CONCLUSION

In this paper, a thorough description of VPP grid has been put forth. The paper highlights SWOT, market factors impacting the VPP/Smart Grids in India and Botswana. A comprehensive explanation of SWOT models has been highlighted and tackled. The paper goes on to explain the strengths and opportunities available in both the countries and how prosumers could benefit from exploiting the resources and be the center focus in a VPP environment, how their roles and decision making will help in energy market value chain. From SWOT analysis, a group of actions is inferred, in some cases with strengths and opportunities combined to compensate weakness and counter threats to ensure sustainability in the measures.

- It is essential to develop long term comprehensive energy strategies accommodating principles for climate change mitigation. In line with the enthusiasm for RE sources among the community as a whole, the governments should actively promote RE sources and projects in the form of community development. There is an urgent need to set priorities in energy projects and include them in the energy strategy review plan.
- Introduce market pricing plan for energy to improve operational and developmental conditions providing the necessary motivation to stake holders in the VPP market. Launch training and awareness programs as a part of VPP model. Stimulate and encourage consumers to be prosumers with attractive incentives in the form subsidies. This will aid in alleviating poverty reduction. Plan financial models, financing schemes to aid in VPP model.
- Enforce energy efficiency plans at the demand side, and generation with optimization protocols, optimization technologies.
- Implement RE strategies which will include quality control, standards, grid connection rules, regulatory commitments, and conditions.

Consumers turned prosumers are key to energy management. Prosumers are the key to the development of the VPP grid and are an integral part of the energy market value chain and are the greatest asset in the business model based on the services in which they take part. The growing demand for clean energy and market needs of organizational evaluation bring forth the necessity of introducing smart technologies and VPP in specific market of Botswana and India. The value proposition of each component of a VPP model generates new business opportunities and aids in the transformation of the electricity market. Since Prosumers form an integral part, VPP model not only saves energy but energy costs to the consumers, and also acts as financial livelihood component, as surplus energy generated is distributed back into the grid or the energy pool. Management of assets such as PV arrays, Wind farms, Bio generators, transmission and distribution lines which have been a bottleneck for many developing nations can be efficiently and reliably addressed by VPP/Smart grid/distributed energy solutions. There are many works in the pipeline of many nations, and several works expected to be performed in the near future. VPP models are scalable models that could be expanded. As long as VPP models are deployed to user's advantage, the scope for expansion into new technologies is tremendous where there is an opportunity for the consumer to take center stage and play an active role in the VPP. In addition to that synergy in VPP business models focus on aggregators and hence there is scope for expanding research into these areas.

REFERENCES

Adrian, R.M. (2016), Innovation and Vertical Upgrading in Global Value Chains: The Case of Philippine Manufacturing Firms. Emit Project. Available from: http://www.emit-project.net/wp-content/uploads/2016/06/4Mendoza_2016up1.pdf. [Last retrieved on 2017 Jul 18].

Ambe, J.N. (2017), The SWOT model's utility in evaluating energy technology: Illustrative application of a modified version to assess the sawdust cookstove's sustainability in Sub-Saharan Africa. Regional and Sustainable Energy Reviews, 69, 313-323.

Amit, R., Zott, C. (2001), Value creation in e-business strategy. Management Journal, 22, 493-520.

Amit, R., Zott, C., Massa, L. (2010), The Business Model: Theoretical Roots, Recent Developments, and Future Research. Pamplona, Spain: University of Navarra.

Anjan, K.S. (2017), Flexible Operation - NTPC's Approach. National Thermal Power Corporation of India. NTPC. Available from: http://www.210.212.126.93:8000/ft/IPS/Session-04A/02.FLEXIBLE%20OPERATION-NTPC's%20APPROACH.pdf. [Last retrieved on 2017 Nov 07].

Anon. (1999), Evaluating socio-economic programmes. Principalevaluation techniques and tools. MEANS-Collection. Vol. 3. E. Communities, Editoon. Luxembourg, Germany: European Communties.

Anon. (2005), Strength, Weakness, Opportunities and Threats in Energy Research. Brussels: European Commission, European Community.

Anon. (n.d.), BITRI Energy Division. (BITRI). Available from: http://www.bitri.co.bw/energy-division. [Last retrieved on 2017 Jul 19].

Anon. (n.d.), Course Hero - SWOT Analysis. (Coursehero). Available from: https://www.coursehero.com/file/21792477/SWOT-Analysis. [Last retrieved on 2017 Jul 19].

Anon. (n.d.), Smart-Grid. (Simens). Available from: http://www.ieema.org/division/smart-grid. [Last retrieved on 2017 Jul 07].

Anon. (n.d.), Weather Base. (Weather Base). Available from: http://www.weatherbase.com. [Last retrieved on 2017 Jun 09].

Anon. (n.d.), Wikipedia - Solar Power in India. Available from: https://www.en.wikipedia.org/wiki/Solar_power_in_India. [Last retrieved on 2017 Jul 18].

Asmus, P. (2017), Honey, I Shrunk The Grids: The Emergence Of Nanogrids - NWPPA. Available from: https://www.nwppa.org/wp-content/uploads/02-NWPPA-Nanogrids-Asmus.pdf.

Balijepalli, V., Khaparde, S. (2011), Smart and Sustainable Energy Systems for Developing Countries: An Indian Perspective. IEEE, Edition. IEEE Power and Energy Society General Meeting. p1-8.

Bazilian, M., Sagar, A., Detchon, R., Yumkella, K. (2010), More heat and light. Energy Policy, 38(10), 5409-5412.

Botswana Power Corporation. (2013), Annual Report. Gaborone: Botswana Power Corporation.

Botswana Power Corporation. (2015), Annual Report - BPC 2015. Gaborone, Botswana: Botswana Power Corporation.

Bryson, J.M., Roaring, W.D. (1987), Applying private sector strategic planning in the public sector. Journal of the American Planning Association, 53(1), 9-22.

Camille, F., Olivier, B., Kathleen, V., Waaub, J.P. (2013), Canadian energy and climate policies a SWOT analysis in search of federal/provincial coherence. Energy Policy, 63(1), 1139-1150.

CEA. (2016), Central Electricity Authority - Report 2016. New Delhi, India: Ministry of Power, Government of India, Central Electricity Authority. Available from: http://www.cea.nic.in/reports/monthly/executivesummary/2016/exe_summary-02.pdf. [Last retrieved on 2017 Jul 19].

Clark, G.W., editor. (2009), What is the smart grid? In: The Smart Grid: Enabling Energy Efficiency and Demand Response. Lilburn, GA, USA: The Fairmont Press, Inc.

Clement, Kevin. (n.d.), Smart Grid Technology. Available from: https://www.smartgridtech.wordpress.com/smart-grid. [Last retrieved on 2017 May 12].

Da Silva, P.G., Ilic, D., Karnouskos, S. (2014), The impact of smart grid prosumer grouping on forecasting accuracy and its benefits for local electricity market trading. IEEE Transactions Smart Grid, IEEE Journals and Magazines, 5(1), 402-410.

Daniel, L.S., David, L.P. (2000), Analytical group decision making in natural resources: Methodology and application. Forest Science, 46(1), 62-75. Available from: https://www.treesearch.fs.fed.us/pubs/1289. [Last retrieved on 2017 Jul 19].

David, J.T. (2010), Business models, business strategy and innovation. Long Range Planning, 43, 172-194.

Deepa, R., Priya, S. (2015), Importance and prospects of renewable energy: Emerging issues in India. International Journal of Art and Humanity Science (IJAHS), 2(4), 11-18.

Djiby-Racine, T. (2010), Renewable decentralized in developing countries: Appraisal from microgrids project in Senegal. Renewable Energy, 35(8), 1615-1623.

Fangxing, L., Wei, Q., Hongbin, S., Hui, W., Jianhui, W., Yan, X., Zhao, X., Pei, Z. (2010), Smart transmission grid: Vision and framework. IEEE Transactions on Smart Grid, 1(2), 168-177.

Fatih, B. (2010), World Energy Outlook 2010. Paris: International Energy Agency, OECD.

Humphrey, A.S. (2005), SWOT Analysis for Management Consulting. SRI Alumni Association Newsletter. p7-8. Available from: http://www.sri.com/sites/default/files/brochures/dec-05.pdf.

IEA. (2014), Africa energy outlook: A focus on energy prospects in Sub-Saharan Africa. World Energy Outlook. Paris: International Energy Agency.

IEA. (2014), World Energy Outlook. Paris: International Energy Agency.

IEA. (2015), India Energy Outlook - World Energy Outlook Special Report. International Energy Agency, World Energy Outlook. Available from: https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf. [Last retrieved on 2017 Jul 03].

IEA. (2016), Wold Energy Investment Outlook 2016. International Energy Agency, Directorate of Global Energy Economics. Available from: https://www.iea.org/newsroom/news/2016/september/world-energy-investment-2016.html. [Last retrieved on 2017 Jul 17].

IEO. (2016), International Energy Outlook: With Projections to 2040. Washington, DC: US Energy Information Administration. Available from: https://www.eia.gov/outlooks/ieo.

Karekezi, S., Ranja, T. (1997), Renewable Technologies in Africa. London: Zed Books.

Karekezi, S., Waeni, K. (2002), Renewable energy strategies for rural Africa: Is a PV-led renewable energy strategy the right approaches for providing modern energy to the rural poor of Sub-Saharan Africa. Energy Policy, 30, 11-12.

Karekezi, S., Waeni, K. (2003), In Collaboration with United Nations and Republic of Senegal. Renewable Energy in Africa: Prospects and Limits in Renewable Energy Development, The Workshop for African Energy Experts on Operationalizing the NEPAD Energy Initiative. Vol. 1. Dakar, Senegal: NEPAD Initiatives. p1-30. Available from: https://www.sustainabledevelopment.un.org/content/documents/nepadkarekezi.pdf. [Last retrieved on 2017 Jun 18].

Karnouskos, S. (2011), Future smart grid prosumer services. In: Proceedings of the 2011 2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies (ISGT Europe). IEEE., Edititon. Manchester, UK: IEEE. p1-2.

Karppi, I., Kokkonen, M., Lähteenmäki-Smith, K. (2001), SWOT-Analysis as a Basis for Regional Strategies Nordregio Working Paper No. 1403. Vol 4. Sweden, Stockholm: Nordregio - The Nordic Centre for Spatial Development, Nordregio.

Kato, S., Nishihara, H., Taniguchi, I., Fukui, M., Sakakibara, K. (2012), Analysis on battery storage utilization in decentralized solar energy networks based on a mathematical programming model. In: IEEE., Edition. Proceedings of the 2012 Joint 6th International Conference on Soft Computing and Intelligent Systems (SCIS) and 13th International Symposium on Advanced Intelligent Systems (ISIS). Kobe, Japan. p651-656.

Kumagai, J. (2012), Virtual power plants, real power. IEEE Spectrum, 49(3), 13-14.

Lai, J., Rosli, Z., Khairulzan, Y. (2014), A conceptual review of engineering consultancy practice (ECP) business model. Archives of Business Reserach, 2(4), 161-173.

Liu, T.T., McConkey, B.G.H., Ma, Z.G., Li, X., Cheng. L.L. (2011), Strength, weaknesses, opportunities and threats analysis of bioenergy production on marginal lands. Energy Procedia, 5, 2378-2386.

Maiga, A.S., Chen, G.M., Wang, Q., Xu, J.Y. (2008), Renewable energy options for a Sahel country: Mali. Renewable and Sustainable Energy Reviews, 12(2), 564-574.

Markovska, N., Taseska, V., Pop-Jordanov, J. (2009), SWOT analyses of the national energy sector for sustainable energy development. Energy, 34(6), 752-756.

Markus, F., Daniel, R., Andreas, K., Antje, D., Andreas, G.S., Peter, L., Hartmut, S., Christof, W. (2012), Impacts of Distributed Generation from Virtual Power Plants, 12, 76131.

Martin, L., Diana, B., Thomas, B. (2016), Economic Assessment of Virtual Power Plants in the German Energy Market - A Scenario-Based and Model-Supported Analysis. Energy Economics, Accepted Manuscript. DOI: 10.1016/j.eneco.2016.12.008.

Meteoblue. (n.d.), Weather and Climate, Climate Botswana. (Meteoblue). Meteoblue Climate. Avilable from: https://www.meteoblue.com/en/weather/forecast/modelclimate/botswana_south-africa_1016666. [Last retrieved on 2017 May 20].

Ministry of Power and Infrastructure. (2013-14), Annual Research Report. New Delhi, India: Ministry of Power and Infrastructure. Avilable from: http://powermin.nic.in/en/content/annual-reports-year-wise-ministry. [Last retrieved on 2017 Jun 18].

Ministry of Power and Infrastructure. (2014-15), Annual Research Report. New Delhi, India: Ministry of Power and Infrastructure, Government of India. Avilable from: http://powermin.nic.in/en/content/annual-reports-year-wise-ministry. [Last retrieved on 2017 Jun 18].

MNRE. (2017), Physical Progress Achievements - MNRE. New Delhi, India: Ministry of New and Renewable Energy. Avilable from: http://www.mnre.gov.in/mission-and-vision-2/achievements. [Last retrieved on 2017 Jul 19].

Montek, S.A. (2006), Integrated Energy Policy. New Delhi: Planning Commission, Government of India.

Mooiman, M. (2016), Grid-Connected Solar Energy Projects in Botswana. Available from: http://www.botswanaenergy.blogspot.com/2016/02/

grid-connected-solar-photovoltaic_14.html. [Last retrieved on 2017 May 19].

Morgan, B., Manuel, W., Deepak, D., David, E., Goran, S., Mark, H., Lawrence, J. (2013), Smart and Just Grids: Opportunities for sub-Saharan Africa. Imperial College, Imperial College of Science, Technology and Medicine. London: Energy Futures Lab.

Ou, Y.C., Verhoef, P.C., Wiesel, T. (2016), The Effects of customer equity drivers on loyalty across services industries and firms. Journal of the Academy Marketing Science, 45(3), 336-356.

Peter, A. (2013), The Energy Cloud: Emerging Opportunities on the Decentralized Grid. Navigant Research. US: Navigant Research. Avilable from: https://www.navigantresearch.com/research/the-energy-cloud.

Rathnayaka, A.J.D., Potdar, V.M., Dillon, T., Hussain, O., Kuruppu, S. (2014), Goal oriented prosumer community groups for the smart grid. IEEE Technology and Society Magazine, 33, 41-48.

Rodríguez-Molina, J., Martínez-Núñez, M., Martínez, J.F., Pérez-Aguiar, W. (2014), Business models in the smart grid: Challenges, opportunities and proposals for prosumer profitability. Energies Open Access, 7(9), 6142-6171.

SAIC. (2011), Smart Grid Around the World. Availble from: https://www.eia.gov/analysis/studies/electricity/pdf/intl_sg.pdf. [Last retrieved on 2017 May 13].

Terrados, J., Almonacid, G., Hontoria. L. (2007), Regional energy planning through SWOT analysis and strategic planning tools: Impact on renewables development. Renewable and Sustainable Energy Reviews, 11(6), 1275-1287.

Tiwari, J.K., Rawani, A.M. (2013), Environmental challenges to thermal power industries: An exploratory study in Indian context. International Journal of Engineering and Management Sciences, 4(1), 75-78.

UNEP, ILO, IOE, ITUC. (2008), Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World. United Nations Environment Programme. Policy Options for Africa. United Nations. Avilable from: http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf.

Wendy, L.C. (2004), Value Creation from E-Business Models: Issues and Perspectives. Burlington, Oxford, UK: Elesivier.

World Bank. (2017), Avilable from: http://data.worldbank.org: https://www.google.co.bw/publicdata/explore?ds=d5bncppjof8f9_&met_y=sp_pop_totl&idim=country: BWA:NAM: LSO&hl=en&dl=en.

World Bank. (2017). Electric Power Transmission and Distribution Losses (% of Output). World Bank., Editor. Avilable from: http://www.data.worldbank.org/indicator/EG.ELC.LOSS.ZS?locations=IN.

Zheng, M., Morten, L., Bo, N.J. (2016), Triple-layer smart grid business model - A comparison between Sub-Saharan Africa and Denmark. In: IEEE., editor. Innovative Smart Grid Technologies - Asia (ISGT - Asia). Melbourne, Australia: IEEE. p374-352.