Sector: Energy
Sub-Sector/Technology Option: Smart Grids
Technology Application: Introduction of Smart Grid Phasor Measurement Units (PMU).

Introduction

The Guyana Power & Light Inc. (GPL) is the Guyana's main producer of electricity using mainly heavy fuel oil. The company's operation includes the generation, transmission and distribution of electricity and is continuously challenged by significant technical and non-technical electricity losses from the transmission and distribution network, which is estimated between 28-30.3%[58]. Technical losses account for about 14% and non-technical losses (commercial losses through faulty equipment or illegal connections, tampered meters) account for 17%[59].

One approach to reduce losses in the transmission and distribution network is through a system upgrade to 'smart grids'. Smart grid is not a single technology but a combination of several technologies that can potentially contribute to increasing efficiency of the electrical system (generation to end use by consumers) promote energy conservation and renewable energy integration, as well as, facilitate electric vehicles charging infrastructure.

In order to integrate renewable energy into the national grid, a grid system upgrade would be required to accommodate the additional sources of energy generated and supplied. IRENA (2013) suggests it is more cost effective to incorporate smart grid technologies[60] instead of only using conventional technologies.

Smart grid as defined by the Electric Power Research Institute (2008) is *"a modernization of the electricity delivery system so it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their devices"*[61].

A smart grid system essentially allows for the integration of information and communication technology at each stage of the system – power generation, transmission, delivery (distribution) and consumption – in order to reduce environmental impacts, increase markets, reliability and service, reduced costs and improve efficiency. This means that sensors to gather data (such as power meters, voltage sensors, fault detectors etc) are outfitted on each device on the network. The data gathered from each device are fed through the two (2) way communication and information system (from the field to the utility network operation centre) to allow for automatic adjustment and control of the devices from a central point.

Eight smart grid technology areas span the entire electricity grid system and these are (i) wide area monitoring and control, (ii) information and communications integration, (iii) renewable and distributed generation integration, (iv) transmission enhancement applications, (v) distribution grid

[58] GEA November 27, 2015; GPL(2011& 2016).
[59]GPL 2011 :Development and Expansion Programme 2012 – 2016
[60] The smart grid technologies to be used are usually system specific and would require detailed assessment of the state of the current and future electric system (IRENA, 2013).
[61] As sourced by www.climatetechwiki.org/technlogy/smart-grid

management, (vi) advance metering infrastructure (AMI), (vii) electric vehicle charging infrastructure, and (viii) customer-side system[62]. A number of hardware and software applications are associated with each smart grid technology area across the electricity generation and use spectrum. However, many of these are at various stages of maturity in terms of development and application. Wide area monitoring and control allows for real time monitoring over the generation and transmission side of electricity production. It helps operators to protect, control and automatically respond and resolve disturbances in the power system. One key sensor device that is installed at this stage is the Phasor Measurement Unit (PMU). PMU can be installed as single devices at strategic points in the generation and transmission chain or in a network called wide-area measurement system (WAMS). This factsheet focuses on introducing smart grid through the installation and use of PMU. However, it is important to point out that for a smart grid to function effectively and to ensure a fully optimized electricity system all the smart grid technology areas must be deployed.	
Technology Characteristics	
Features	Phasor Measurement Units (PMU) are high sped sensors used to monitor the quality of the electric grid and measures voltage, current and frequency of the transmission lines about 25-120 times per second (IRENA, 2013). Phasors, short for "phase vector", are depiction of waveforms of alternating current where the unit is used to detect and automatically respond to disturbances or errors in the grid. Global positioning system (GPS) is used to coordinate measurements from the PMU to provide a real-time picture of the system. Measuring phasors simultaneously at strategic positions in the grid and at synchronized time is called synchrophasors. A network of PMU is called a wide-are measurement system (WAMS) and this provides real-time monitoring at various scales.
Capital Investment Cost	Each PMU cost approximately USD 2000-3000. However, investment costs must also include the communication and data processing systems. The precise costs for the synchrophasor data processing systems are unknown at the moment since the technology is still in development (IRENA, 2013).
Operating Cost	Operating costs are currently not available since PMU's are not fully deployed on large commercial scale.
Maturity	Although PMUs were introduced in the 1980's, it was not until the 1990's that the technology was deployed in experimental systems and has emerged to early commercial scale in recent years. According to IRENA (2013), the technology is still developing and in the research and development and demonstration phase.
Country Specific Applicability	
Status of technology in country	Smart grids and PMU are new to Guyana. Currently and to a limited extent, some aspect of smart grid is evident with the solar power integration at the Guyana Energy Agency (GEA) and the Protected Areas Commission (PAC) buildings allowing renewable and distributed generation integration. However, there is no known application of wide area monitoring and control technology application using PMU at the power generation and transmission phase of the system.

[62] www.climatetechwiki.org/technlogy/smart-grid

Market potential	According to IRENA (2013), the market penetration for phasor measurement units is scarce at the moment since the technology has only recently emerged on the market.
Scale of application and time horizon	Medium to long-term.
Institutional and Organisational requirements	The institutional and organizational requirements to increase efficiency of the national grid and integrate renewable sources of electricity generation are within mandate of the Ministry of Public Infrastructure and the GEA along with GPL. Specific policies, regulations and standards will be required before deployment.
Operation and maintenance	Institutional capacity building would be a critical component for the application of technologies in the sector.
Scale/size of beneficiary group	The main beneficiaries are those customers connected to the national grid.
Acceptability to local stakeholders	The level of awareness of smart grids, in general, and PMU, in particular, is limited in Guyana which therefore impacts the acceptability of the technology.
Endorsement by experts	There is a strong international push to advance the development and installation of PMU.
Barriers and Disadvantages	▪ Current PMU devices on the market ("off-the-shelf") are more suitable for transmission grids and can have performance challenges if applied to the distribution networks. ▪ High cost associated with PMU and synchrophasor systems, especially, since these are emerging technologies. ▪ Although synchrophasor systems can enable high renewable energy integration without having to upgrade the transmission system, the cost for synchrophasor data processing systems are not known since the technology is still in development. ▪ There is a lack of standardization across the PMU communications systems and data models. ▪ Lack of awareness of the technologies to be deployed across the electricity generation and use spectrum, as well as, smart grid technology areas between different stakeholders.
Mitigation Benefits	
Greenhouse gases abatement potential	Smart grid system in general could contribute, indirectly, to greenhouse gas emission reductions through application of technologies to increase efficiencies in the system and incorporate renewables. Consequently, less fuel oil will be used for electricity generation.
Potential Development Benefits: Economic, Social, Environmental	
▪ PMU application allows for the monitoring of the overall state of the power system. ▪ Synchrophasor systems enable high renewable energy integration without having to upgrade the transmission system. ▪ PMU in the smart grid allows for the monitoring of power systems and automatic response to disturbances that can consequently, reduce blackouts. ▪ PMU monitoring increases accuracy and high reporting rates and has a digital communication interphase.	

▪ Smart grids in general allows for the integration of renewable sources of electricity generation and by extension, facilitates electric vehicles charging infrastructure, reduces operating cost for electricity and increases efficiency and energy conservation. ▪ Smart grids are considered 'self healing' as these systems can resist attacks and natural disasters and respond to disturbances.

References:

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6. www.climatetechwiki.org