A Simulation-Based Analysis of Electricity Access in Uganda

Donna Lillian Namujju, College of Engineering, Design, Art & Technology, Makerere University, Kampala, Uganda

Gönenç Yücel, Department of Industrial Engineering, Bogazici University, Istanbul, Turkey

Erik Pruyt, Faculty of Technology, Policy and Management, Delft University of Technology, Delft, Netherlands

Richard Okou, College of Engineering, Design, Art & Technology, Makerere University, Kampala, Uganda

ABSTRACT

Access to power is tied to a country's development. It facilitates improved social welfare, education, health and income generating opportunities. Uganda's economy is stifled by its low electrification rates - 16% nationally. This study builds a working theory on the internal setup of Uganda's power sector utilizing this theory to surface influential behavior modes as they pertain to power generation and supply and how these ultimately affect electricity access. Based on this working theory a System Dynamics simulation model is built. The model simulations show how Uganda's power sector is expected to evolve over 80 years in terms of power supply and demand given existing market structure and prevailing conditions. The study finds major problems in the nature of power accessed specifically an insufficient and unreliable power supply. The root cause is found in the nature of the existing capacity planning process in terms of how future capacity requirements are determined and the agreements made with generators as to how and when they fulfill their investment obligations.

Keywords: Economy, Low Electrification Rates, Power Sector Investment Dynamics, System Dynamics Model, Uganda, Uganda Electricity Access

INTRODUCTION

Uganda is endowed with a variety of energy resources including plentiful woody biomass, solar, wind, geothermal and hydrological resources. Presently the primary energy source is hydro resources along the Nile providing electricity through a national grid utilizing ~20% of the available hydroelectric potential. The other sources have remained largely untapped contributing less than 2% of Uganda’s total energy consumption. Total installed capacity is ~630MW large hydro, 53MW mini hydro and 15MW co-generation (Mudoko, 2013)

Uganda’s electricity sector has problems, among which, an ageing infrastructure resulting from years of under investment, high distribution losses averaging 30% (Parsons BrinckerhoffAfrica, 2011a) and very low electrification rates. Although 40% of the country’s population lives in the area covered by the grid (Umeme, 2014), the electrification rate is quite low with a

DOI: 10.4018/IJSDA.2015010101
national grid access of only 15%; 7% of which in rural areas (IEA, 2013). Only about 1% sources power using diesel and petrol gensets, car batteries and solar PV systems. ‘Access’ is defined here as a physical feed-connection to a central or decentralized power grid as well as sufficient electricity supply from that grid.

Uganda’s relatively low electrification rate could be due to many reasons including insufficient extent of the transmission network coverage so that this constrains and makes it impossible to set and achieve reasonable grid connection targets; and/or insufficient power supply/generation capacity so that even though the grid connection rate may be high there is not enough power to meet all the connected demand. With 40% national grid coverage and only 15% corresponding grid access; 2 critical points stand out: First, grid access does not directly translate to electricity access. Second, the extent of the grid network is not the immediate pressing problem. Hence, we (1) investigate possible generation side capacity constraints and how they contribute to Uganda’s low power access levels (2) identify potential problems arising from the current policy framework and market design.

SIGNIFICANCE OF THE PROBLEM

Access to power is tied to any country’s development. It provides opportunities for increased social welfare, education, health and income generating opportunities all of which Uganda needs. Uganda’s small but significant economic development of ~6% 5-year compound growth (The Heritage Foundation, 2014) is being stifled by power inaccessibility. Critical power shortages have been constraining GDP growth by an estimated 1% to 2% per year undermining Uganda’s efforts toward accelerating industrial development, creating employment and alleviating poverty (Alstom, 2013, p. 16; SITHE GLOBAL, 2014). Uganda’s population split is 20% urban and 80% rural (Electricity Regulatory Authority, 2011). The lack of access to electricity is most felt by Uganda’s substantial rural population with access at only 7%(IEA, 2013). While Uganda’s aggregate development figures look very promising; development in rural areas has lagged well behind that of urban areas. Poverty remains pervasive and extensive and much of Uganda’s rural population remains isolated with limited access to basic modern goods and services among which is electricity. The result is a vicious cycle whereby the potential for rapid and broad-based economic growth is severely constrained by the lack of access to electricity while on the other hand the consequent poverty levels inhibit infrastructure investment potential. If Uganda is to continue growing economically, increasing its overall net productivity, the level of electricity access must be ramped up to keep pace and even better begin to drive the development and key to this is obtaining a good understanding of the factors limiting the needed growth in power access.

SYSTEM DYNAMICS METHODOLOGY

Uganda’s electricity sector is complex - it is tightly coupled to other sectors i.e. commercial, industrial etc. and governed by feedback between itself and these sectors. An example is how increased power access fuels development of the coupled sectors, which development in turn contributes to growing the power sector through increased demand and improved purchasing power. The problem of electricity access by extension is similarly quite complex. It involves many relevant and interconnected sub-systems – highly technical functions (power generation, transmission, and distribution). Because of the physical nature of electricity, the entities performing these functions are not isolated but interconnected meaning that they make simultaneous and dependent decisions which have widespread effects on all consumers. To effectively study a problem of this magnitude requires a systematic study of each subsystem at a time but this fails to take into account the feedback effects between the different subsystems. In addition, the various methods and tools most commonly used for management problems...
Related Content

Improvement of 2-Partition Entropy Approach Using Type-2 Fuzzy Sets for Image Thresholding
[www.igi-global.com/article/improvement-of-2-partition-entropy-approach-using-type-2-fuzzy-sets-for-image-thresholding/136068?camid=4v1a](www.igi-global.com/article/improvement-of-2-partition-entropy-approach-using-type-2-fuzzy-sets-for-image-thresholding/136068?camid=4v1a)

Knowledge Mining Wikipedia: An Ontological Approach
[www.igi-global.com/article/knowledge-mining-wikipedia/53045?camid=4v1a](www.igi-global.com/article/knowledge-mining-wikipedia/53045?camid=4v1a)

Statistical Analysis of Computational Intelligence Algorithms on a Multi-Objective Filter Design Problem
[www.igi-global.com/chapter/statistical-analysis-computational-intelligence-algorithms/38456?camid=4v1a](www.igi-global.com/chapter/statistical-analysis-computational-intelligence-algorithms/38456?camid=4v1a)
The Cybernetics of Innovation and Knowledge: The Viable Systems Model Applied to the Silicon Valley Index and China


www.igi-global.com/article/the-cybernetics-of-innovation-and-knowledge/110910?camid=4v1a