Energy for Sustainable Development 36 (2017) 16–21

Contents lists available at ScienceDirect

Energy for Sustainable Development

An analysis of the effects of residential uninterpretable power supply systems on Pakistan's power sector

Naveed Arshad *, Usman Ali

Department of Computer Science, LUMS, Sector U, DHA, Lahore, Pakistan

ARTICLE INFO

Article history:
Received 12 September 2015
Revised 20 August 2016
Accepted 17 September 2016
Available online xxxx

Keywords:
Uninterpretable Power Supply System
Load Shedding
Energy Efficiency
Measurement
Power Sector

ABSTRACT

For the past many years Pakistan is facing electricity shortfall. The gap between demand and supply of electricity is as much as 6000 MW during the peak summer months. This has resulted into scheduled power cuts that range between 6–12 h in a day. To reduce the effect of these power cuts or load shedding, consumers have installed alternate energy sources such as Fossil Fuel Generators and Uninterpretable Power Supply Systems (UPSs). While Fossil Fuel Generators use energy sources such as oil and natural gas, the UPSs are charged from the electricity grid that is already under stress. Some sources estimate the UPSs penetration to as much as 40% in Pakistan. With this penetration rate the UPSs are a solution for individual consumers but it exacerbates the problem at the National scale. Moreover, the low quality of UPSs further strains the electricity system. In this paper presents a study to investigate the effects of UPSs in Pakistan's electricity system. By carrying out measurements of sample UPSs we estimated the amount of electricity the UPSs consume in Pakistan's electricity market. Our results show that depending on the number of power cut hours, the UPSs consume between 2%–7% of electricity at any given time. We further provide ways and measures to reduce the UPS charging load on the overall electricity system.

Introduction

Pakistan is facing demand and supply shortfall in its power sector. The total electricity requirement of the country peaks to approximately 20,000 MW during the summer months. Of this peak demand, the country faces a shortage of around 5000 MW due to inadequate supply (Nayyar et al., 2014). This results in load shedding of up to 12 h per day (Amer and Daim, 2011). To mitigate the effects of this load shedding many people in the country use alternative measures such as Uninterrupted Power Supply (UPSs) and fossil fuel generators. Generators use gasoline, diesel or natural gas to generate electricity but UPSs are charged from the same electricity distribution grid. The efficiency of UPS is up to 94% depending on the load, battery-type, inverter and its usage style (Gurrero et al., 2007). Some UPSs are reported with even higher efficiencies (Moura et al., 2015). However, this high efficiency is for branded UPSs which are designed with state-of-the-art components.

In Pakistan, the UPSs available off the shelf and being bought and used in the residential and small scale commercial sectors do not have this efficiency level. This inefficiency of the UPSs put extra load on the grid and creates more problems for it. A large number of people, with access to credit and the market have bought UPSs for running essential electrical devices during the times of power unavailability. Although this is a legitimate use of UPSs, it is limited to the more affluent section of society due to high upfront cost of purchase (Pasha and Saleem, 2013). But the most common UPS (1–3 kVA) typically used in households are highly inefficient. The losses of such UPSs are accumulated due to the inversion, storage and rectification losses of charging and discharging cycles

In this study we undertake such an exploration with the hope that the evidence produced leads to the promotion of alternative sources of energy for backup power, thus reducing the load on a National Grid in crisis. In our quest we bought five random UPSs from the market and measured their efficiency. Following this we used approximations of the number of UPSs used in Lahore, the second largest city of Pakistan, to estimate how much power is wasted due to use of inefficient UPSs. To show possible national level impact, we also extrapolate these results to the whole country. Towards the end we discuss alternate solutions to the uncontrolled use of UPS and discuss how alternate energy sources such as solar and wind can be used to reduce the load on National Grid.

Introduction to Pakistan electricity system

Pakistan, with an area of 796,095 km^2, is the second most populous country in South Asia after India and sixth in the world with population of 177.1 million according to official estimates. The population growth rate in Pakistan is around 2% per year. With current population growth rate it will become the fifth most populous nation by 2050 (Ahmed

* Corresponding author.
E-mail addresses: naveedarshad@lums.edu.pk (N. Arshad), usman.ali@lums.edu.pk (U. Ali).

http://dx.doi.org/10.1016/j.esd.2016.09.004
0973-0826/

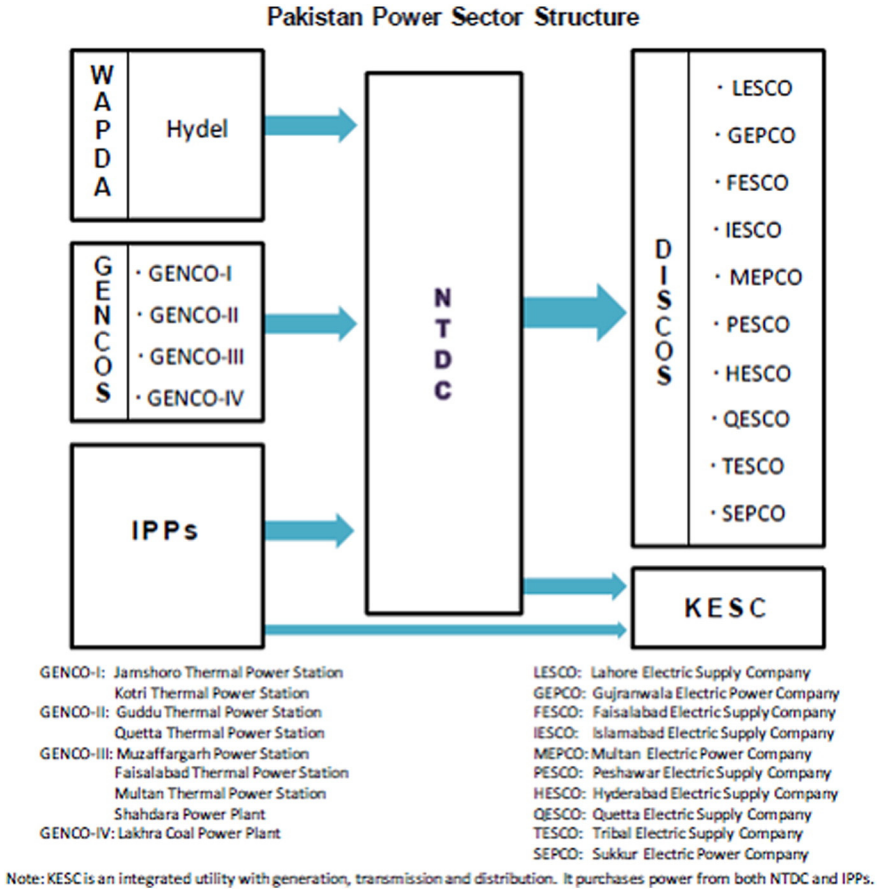

Fig. 1. Pakistan Power Sector Structure.

et al., 1992). Due to population growth there has been an unprecedented increase in demand for energy during the last decade. During this time the supply has failed to match this growing demand (Dar et al., 2013).

According to the Economic Survey of Pakistan (2014) the total installed systems of the PEPCO[1] generated 22,797 MW out of which 14,635 MW were obtained from fossil fuel including 35.2% oil and 29% gas, 6611 MW from hydro production (29% of total) and 1322 MW (5.8% of total) from nuclear sources (Economic Survey of Pakistan, 2014-15).

Under PEPCO there are four major power producers in Pakistan:

(1) Water and Power Development Authority (WAPDA)
(2) Karachi Electric Supply Company (KESC)
(3) Independent Power Producers (IPPs)
(4) Pakistan Atomic Energy Commission (PAEC)

WAPDA is responsible for a total power generation of 11,272 MW from thermal and hydroelectric sources. Depending on the flow of water, hydel electricity generated by WAPDA varies between a minimum of 2414 MW and a maximum of 6761 MW. KESC generates a total of 1756 MW. IPPs share in power generation is 7070 MW while PAEC generates 852 MW of electricity. By combining all four power producers, Pakistan's maximum power generation capacity is 21,143 MW. Of course not all the generation capacity is available all the time. The effective generation capacity in peak summer months is close to 20,000.

Pakistan experiences extreme shortage of electricity during both summers and winters. During the summer the demand increases at higher rate than supply due to increased use of high power consumption devices, such as air conditioners (over 5000 MW of power demanded), while in the winter low hydel availability drastically reduces the supply.

PEPCO also manages 10 Power Distribution Companies (DISCOs) and one TransCO (NTDC). The ten DISCOs are responsible for power distribution to end users. KESC meets its overall demand with its own generation plus purchase from NTDC, IPPs and from Karachi Nuclear Power Plant (Anon., nd-b). Fig. 1 shows the current structure of power sector.

Energy crisis and alternative sources

The increase in power outages and load shedding in Pakistan spurred the demand for generators and UPSs, with a majority of commercial buildings and significant percentage of residential buildings

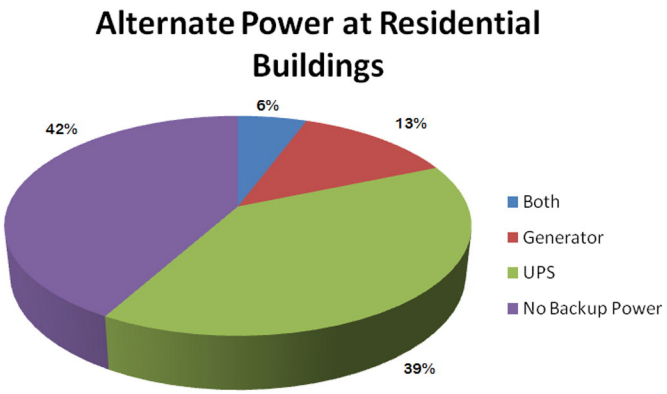

Fig. 2. Alternate Power Usage in Pakistan (Anon, 2012)

[1] Pakistan Electric Power Company (PEPCO) is the governmental agency in Pakistan that coordinates the generation, transmission and distribution of electricity.