Overcoming the Energy Efficiency gap in Pakistan's Household Sector

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***Abstract*—Energy efficient household appliances ensure substantial financial savings while at the same time ensure better environmental quality. Despite these benefits, historically developing countries like Pakistan have not taken advantage from such opportunities and instead overwhelmingly concentrated on increased energy production. Likewise households are a major consumer of electricity and contribute, to a large extent, to the total electricity use of the nation. At present, the share of direct electricity use of households in Pakistan is about 42.15 % of the total. This paper identifies potential areas in the household sector of Pakistan where employing efficient technologies will result in substantial energy saving and hence financial saving to consumer and society as a whole. The study especially focuses on household electricity consumption patterns to identify the areas where there is room for achieving high efficiency goals. It also identifies the barriers that are preventing from achieving energy efficiency goals and appraise government's policy to overcome such barriers.**

I. INTRODUCTION

Energy consumed by households represents a considerable percentage of the energy consumed in the world [1-2]. Patterns of domestic energy use are closely linked to agro-climatic, socio-economic conditions, such as the level of the user's living standards, family size, education, farm area per rural household and forest area per household [2-8]. It is also influenced by government policy, which affects the inequity in fuel and equipment availability among different income groups [2, 9]. A key consideration in approaching electricity consumption is that people do not consume electricity directly; rather, they consume services powered by electricity, such as television, lighting, warming and cooling [10]. In other words, to overcome energy efficiency gap, electricity consumption should be studied in terms of electrical appliance, their applications and efficiency. An efficient device give more light, heat, and mobility from less energy and is the most simplest and direct way of increasing the sustainability of the energy system.

In some end-use services of electricity like lighting, electricity is the only possible source for such services while in the production of other services, for instance cooking, there are substitutes for electricity. Therefore, identifying the various components of electricity demand is important in analyzing energy consumption patterns and for policy analyses [11].

In Pakistan the household electricity consumption growth is driven largely by the increase in number of consumers due to expansion of electric network to villages and other areas[12]. Literature also suggest that rise in household incomes also increases the rate of appliance ownership which is also a one of the major driver for the growth of residential electricity consumption. [13].

To achieve sustainable energy system, it is imperative to reduce energy requirement of society. The society can limit or reduce energy consumption through improving the energy efficiency and also by changing consumption patterns. However, for an efficient consumer energy policy, it is important to know how the energy consumption pattern is established and why some households require more energy than others. Energy efficiency accentuates the positive attributes of energy (the services it provides) and diminishes the negative aspects (the pollution and financial costs) associated with producing and delivering energy [14].

II. PAKISTAN: ENERGY INTENSIVE GROWING ECONOMY

Pakistan is also an energy intensive growing economy and its energy needs are met by large quantities of imports. The statistics for last 10 years shows that the rise of gross energy demand has by far exceeded the growth rates of population. During last ten year energy use growing at 4.95 per cent every year, while the Pakistan's population increased by less than 2.26 percent [12]. This suggests consumption growth as the driving force for the rise in energy demand in household sector. Also the number of electricity consumers is on a rise due to expansion of electric network to villages and other areas [12]. The Policy makers are particular interested in reducing demand during the morning and evening peak periods. Such reductions would help to postpone a portion of the required investment in increased capacity and thereby lower the long-run marginal cost of electricity. Still, to meet the raising energy demand, Pakistan has to expend capital to increase generation capacity and reduce system losses. Similarly, the impacts on electricity demand of an increase in electricity tariff also depend on the composition of electricity consumption for various end uses as the elasticity rates varies over end uses.

TABLE I.
FUEL UTILIZATION BY END-USE IN THE RESIDENTIAL SECTOR

End Use	Natural Gas	Electricity	Oil
Lighting		•	
Cooking	•		•
Space heating	•	•	
Water heating	•		
Other appliances	•	•	

III. DEMAND-SUPPLY GAP

The electricity demand was projected to grow with an annual compound growth rate (ACGR) of 7.9% during the Medium Term Development Framework 2005–2010 of the Government of Pakistan [15]. The per capita electricity consumption stands at 469kWh per capita, which is less than one-fifth of the world average of 2465kWh per capita and just about 5% of the consumption in the OECD countries [16]. The peak electricity demand in Pakistan is 21835MW while total generate capacity varies between 17523MW in summer to 14640MW in winter due to seasonal variations of reservoir levels and consequent reduction in Power outputs from hydel projects. As a result the supply- demand gap also varies with session and is between 3500-4310 MW. The lack of investment in existing plants, outdated grids/ distribution system and widespread electricity theft causes line losses of 19.1 Million Kilowatt Hours which further increases the demand–supply gap.

At present demand–supply gap is filled through planned power cuts (euphemistically termed "load-shedding"). In cities, the scheduled power cut last for 6-8 hours, while cuts are much more prolong in rural areas. These scheduled cuts supplemented by unscheduled cut due to faulty and overloaded transmission lines (line failure) often trigger violent street protests by consumers who block main roads, burn tyres and throw stones at police. The industries remains closed down during peak hours in the evenings. Export sector often failed to fulfill the target and commitments resulting loss of international customers and good will. Overall the load shedding has created a negative impact on the economy of Pakistan.

IV. HOUSEHOLDS ARE A MAJOR CONSUMER OF COMMERCIAL ENERGY IN PAKISTAN

The residential sector in Pakistan consists of over 24 million households that account for 20% of the total commercial energy consumption in the country. Electricity is available to about 70% of the households, and accounts for 34% of the total energy consumption in the residential sector. Domestic sector consume 42.15 % of total electricity produced [12]. Table I indicates fuels consumed by the end user in residential sector [14]. Table II identify energy realizable energy savings and investment requirements for replacing and upgrading household electricity appliances.

According to CRCP survey lighting and space cooling are two major electrical end using categories amongst household in Pakistan. Bulbs and tube lights are generally used for lighting, whereas fans, air coolers and air conditioners are used for space cooling. These two basic end uses account for two third of the total household electricity consumption [17].

V. LIGHTING

According to EEIP baseline domestic lighting survey there are presently approximately 117.4 million residential points in the country, 36% of which are fitted with incandescent bulbs (IBs), 42% with compact fluorescent lamps (CFLs) and 22% with linear fluorescent tube lights. The survey suggest that IB and CFL light points are used for an average 2.9 hours daily and FTL light points are used for an average of 3.3 hours daily.

According to Household Energy Strategy Study (HESS) survey finding, residential lighting accounts for 14% of total electricity delivered and for approximately 35.7% of household electricity consumption. The study conducted by Consumer Rights Commission of Pakistan in 2004 showed that on average an inefficient incandescent bulb consumes extra energy equivalent to 2.3watts/8-hours [17]. Hence significant savings in electricity consumption can be achieved by replacing existing IBs in the domestic sector with energy efficient CFLs that provide the same lumen output at lower electricity consumption. In addition, CFLs have a longer lifetime as compared to IBs

ADB in its technical assistance report has suggested inject of large volume of efficient compact fluorescent lamps into the market at a low price to expedite their use by domestic consumers. This approach has been successful in several countries where it has immediately reduced customer's monthly power bills. ADB report also suggests that the introduction of 15 million high-quality compact fluorescent lamps into Pakistan's domestic market would save customers $78 million over the lifetime of those bulbs (approximately 2 years). In addition, 880 MW of power demand would be avoided. The cost of such additional new generation capacity would be $1.15 billion (at $1.3 million per MW) [18]. Government, in same lines, is also plans to free distribution 30 million CFLs.

VI. FANS

It was estimated that every household in Pakistan own a minimum of two to three fans and based on this figure, the total strength of fans was over 40 million. In 2004, a comparative study conducted by the Consumer Rights Commission of Pakistan (CRCP) [17] with support from the Global Environment Facility (GEF)/UNDP showed that none of the ceiling fans tested met efficiency standards, and they consume on an average extra 12.67 watts/8 hours. Same report has also suggested that the quality of copper wire and silicon steel being used and manufacturing of motors should be increased by reviewing the standards developed by the PSQCA.

VII. Changing electricity behaviors

Country has witnessed numerous campaigns over the years on print and electronic media to motivate consumers to switch off the light when leaving a room, switch off light used for illuminate outside of the house, keep a moderate indoor temperature during summer, switch off electronics devices like TV and computer while not in use rather than keeping them on standby and turn off the tap while brushing our teeth. Literature suggest information about energy problems as conveyed by mass media campaigns tends to result in increases of knowledge and of conservation behaviors, but little is known about the effects on actual energy saved [19]. However, literature suggests energy savings were achieved by giving households tailored information through home energy audits [20, 21]. Literature also suggests that it is difficult to make people change their routines but behavior can and does change [22].

Electricity consumption behaviors are actions which are directly linked to electricity consumption at the point of usage. These actions include user's behavior in using electrical appliances including televisions, computers, washing machines and personal electronics. It also includes using lighting and setting the thermostat level.

Literature suggests providing households with frequent feedback has proven successful intervention in reducing energy consumption [23]. However, exceptions exist [24]. Literature suggests differential effect for high and low consumers of energy, the former reducing energy use and the latter increasing energy use as a result of feedback [21]. Above finding form an important policy perspective, in the sense that policies aiming to reduce energy use may especially want to target high users of energy, because of a higher energy-saving potential. Feedback on energy consumption can take several forms and measures like giving respondents daily/weekly/monthly feedback on their energy consumption usage pattern through e-mails, messages on their mobiles, comparative monthly bills, or technologies such as direct displays or smart meters (Meters that record the time varying character of electric service to the premise) [25].

Smart meters will help in achieving the Policy makers are particular interest in reducing demand during the morning and evening peak periods. The underlying theory behind feedback is that once people receive information on their energy behaviors, they are likely to form attitudes on those behaviors and act accordingly. Continuous feedback can also make people aware of their routine behaviors.

In Pakistan, majority of people in the cities and towns are 'locked-in' to poorly build and inefficient houses. The majority of existing housing stock is old and inefficient, and hardly meets average energy efficiency standards. However, the usage of electric home appliances (such as fans, bulbs, tube lights, irons, lamps, etc) in these areas has also increased substantially due to rapid urbanization, population growth, and changing consumption styles. Almost all 7.7 million appliances have been connected to national grid last year only and unfortunately most of the low cost brands available in the market do not fulfill energy efficiency standards. Furthermore, appliances used in the home are rarely switched off – rather in routine they are leaved on standby consuming electricity even when they are not in use.

In village connected with national grid, load factor is very low in these areas. Here houses are mostly of the "kachcha hut" (made from mud) type, consisting of one or two rooms only. Poor people use electricity for lighting, battery charging, and running small domestic appliances only [26]. Light is the major requirement for these houses and electricity provides the best and most efficient form of lighting [27].

VIII. Government's sweeping measures to save electricity

In April 2010, Government has introduced sweeping measures to save electricity. New measures include an extra day off for government offices and turning off half the lights in government offices. Shopping centre has been ordered to close at 8 pm while advertising agencies has been directed to switch off lighted billboards, neon signs and other decorative commercial lights. Only top government officers are allowed to use air-conditioners in their offices after 11 am. New measures also restrict power supply to marriage halls for three hours a day only and power cut to agricultural connections during peak hours.

All above measure can be categorized as curtailment measures. Some researchers argue that curtailment behaviors initiate actual behavioral changes, which can potentially be sustained for long-term [28]. However Abrahamse et al., 2005 [25] has suggested that efficiency behaviors are in fact generally more effective in obtaining actual and larger energy savings.

As discussed earlier, majority of existing new and old housing stock is inefficient and does not meets average energy efficiency standards. Government should also focus on formulating and enforcing the improved efficiency standards. A Standard bans product that do not fulfill minimum efficiency requirement from the market. Such measures have unique advantage of increasing the number of customers served by existing generation while reducing the investment necessary to meet increasing demand. Such measures will provide the government the required cushion to re-allocate capital resources to other sectors of the economy.

IX. Conclusion

The challenge for policy makers and utilities in the Pakistan remains over which intervention measures will provide long term behavioral changes. A combination of smart meters and display units and more innovative billing for example could provide households with better feedback on their energy consumption, raise awareness of households' energy consumption, possibly form new habits and thus create potential for behavioral change. For improving the efficiency of appliances, the most effective measures are the mandatory energy-efficiency standards applied to manufacturers.

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TABLE II.
ENERGY CONSUMPTION, ATTAINABLE SAVINGS AND INVESTMENT REQUIREMENTS FOR REPLACING AND UPGRADING HOUSEHOLD ELECTRICITY APPLIANCES [18]

Energy Type	Energy Consumed, FY2008		Energy Consumption Forecast, FY2019		Energy Efficiency Potential			Attainable Savings, FY2019		Investment Required ($ Million)
	(GWh)	(TOE)	(GWh)	(TOE)	Technical	Attainable	Effective	(GWh)	(TOE)	
Lighting	5,641	459,433	13,156	1,071,410	54%	80%	44%	2,455	199,938	191
Refrigeration	4,524	368,424	10,550	859,176	67%	80%	54%	2,425	197,475	304
Water Pumping	1,258	102,422	2,933	238,852	50%	80%	40%	503	40,969	465
Air Conditioning	5,845	476,024	13,631	1,110,102	40%	80%	32%	1,870	152,328	149
Fans	10,105	822,950	23,565	1,919,143	0%	0%	0%	-	-	-
Total	27,373	2,229,253	63,835	5,198,683				7,253	590,710	1109