PLUGGING INTO THE FUTURE: AN EXPLORATION OF ELECTRICITY CONSUMPTION PATTERNS

CONTENT

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ABSTRACT

Household electricity consumption drivers and profiles of different type of consumers are analysed. They are built upon data gathered from a sample of 230 households with daily electricity consumption from smart meters of InovCity project, the first of its kind in Portugal consisting of a massive smart metering system (31,000 smart meters) with door-to-door 110–question surveys for the same houses in Évora.The survey encompassed information on socio- economic data, equipment's ownership and use and physical characteristics of the dwellings. Ten clusters were derived using Ward's method hierarchical clustering to identify similar types of consumers based on their means and standard deviations, and three of them are deeply analysed and compared. Based on the surveys, a socioeconomic characterization of each cluster was made in order to capture the main similarities and differences within

each cluster and compared to the others. We conclude that three major groups of determinants influence residential electricity consumption segmentation: physical characteristics of a dwelling especially year of construction and total floor area; electrical heating/cooling equipment and fireplaces ownership and use; and occupants profiles (mainly number of occupants and monthly income). Urbanisation levels, bearing structure, type of tariff and contracted power are not variables that distinct the clusters grouping. This consumer profiling allows deriving insights to support utilities for marketing segmentation and policies for effective energy reduction (e.g. tariff design, demand side management strategies, peak shaving). This work is being developed under the EU project InSMART, that involves four European cities targeting innovative methods to integrative city planning, including buildings, transport, and utilities networks.

Introduction

India is the world's third-largest producer and third-largest consumer of electricity. The national electric grid in India has a installed capacity of 370.106 GW as of 31 March 2020. Renewable power plants, which also include large hydroelectric plants, constitute 35.86% India's total installed capacity. During the fiscal year (FY) 2019-20, the total electricity generation in the country was 1,598 TWh, of which 1,383.5 TWh generated by utilities. The gross electricity consumption per capita in FY2019 was 1.208 kWh. In 2015-16, electric energy consumption in agriculture was recorded as being the highest (17.89%) worldwide. The per capita electricity consumption is low compared to most other countries despite India having a low electricity tariff. In light of the recent COVID-19 situation, when everyone has been under lockdown for the months of March to June the impacts of the lockdown on economic activities have been faced by every sector in a positive or a negative way. The dataset is exhaustive in it demonstration of energy consumption state wise. Analysing Electricity Consumption in India from Jan 2019 till 5th December 2020. This dataset contains record of Electricity consumption in each states of India, here we are going to analyse State wise, Region wise and Overall Electricity consumption in India. Greenhouse gases (GHG) emissions will hold steady or might even increase in developed countries effective reduction of energy consumption will not be taken (Lomas, 2010), contrary to policy goals aiming a transition towards low carbon economies. The need for energy consumption reduction is also linked to energy supply security and affordability, and climate change strategies. Therefore, increased search for energy efficiency, greenhouse gases emissions reduction and increased share of renewable energy sources, as established in the new European Union goals by 2030 (EC, 2014) requires more decisive action.

This paper presents results of a study aimed to improve the understanding of how electricity consumption patterns are explained in a Southwest European city. We combine smart meters electricity data for the case study of Évora municipality with a dedicated survey for the same houses in order to identify target groups of consumers through a clustering approach. This will be useful to derive insights to support utilities for marketing segmentation and policies for effective energy reduction The work presented here is being developed as part of the

EU project In SMART, that involves four European urban areas (Évora, Cesena, Trikala and Nottingham) targeting innovative methods to city planning, including buildings, public lighting, transport, waste, water and wastewater networks (Gouveia et al., 2014).

The paper is organized in 4 sections. Section 2 summarizes the methods and discloses the data used. Section 3 presents selected results regarding electricity profiles by consumption clusters and related explaining variables. Section 4 concludes, presents the limitations of the study and further work

Methods and data

Electricity will largely replace petrol and diesel as a fuel for road vehicles. It will also replace the natural gas and oil we burn to heat our homes and run our industries. In short, electricity will grow in importance as a carbon-free energy carrier. Electrification of final demand has huge implications not only for generation, but also for transmission and distribution. So what will the future energy system look like? What challenges must be overcome? And what part will technological innovation play in achieving the transition?

A glimpse into the future

Let's imagine it's 2050. Renewables will be the primary source of electricity generation, much of it from offshore wind farms and solar plants. However, households and businesses will also play a part through rooftop solar generation. There is potential for more than 150 million of these mini power stations in Europe by 2050. As generation becomes more decentralised, it will need to become more collaborative. It's not only generation that will be different. The pattern of consumption will also change. Two things stand out. The first is the electrification of transport – vital if emissions are to be curbed. Tomorrow's vehicles will be electric and there will be millions of them. Even in the short term, numbers are expected to rise rapidly with 13 million zero and low-emission vehicles on the road by 2025, up from fewer than one million today. The second big change is likely to be the electrification of space heating. This matters because heating is the single biggest source of domestic energy demand. Today, 51% of us depend directly on burning gas, oil or coal to keep our homes warm. In 2050, most space heating will need to be done without the help of carbon. More than 100 million European households will need to make the switch from fossil fuels to electricity for heating.

The net-zero challenge

Achieving net zero will require big changes to the energy system. The opportunities are huge, but so are the risks. Industry participants are turning their attention to three key areas – supply security, affordability and sustainability.

Supply security

The quality and reliability of supplies will become even more important as electricity becomes the primary energy carrier. Grids and distribution networks will need to be smarter and more resilient to cater for new loads, increased decentralisation and higher levels of intermittency. Subsea grids and new interconnectors will be needed to promote energy trading and to improve energy security.

Affordability

The energy transition needs to be affordable for everyone: consumers, developers and operators. Renewable energy developers need ways to reduce the cost of implementing new wind and solar infrastructure at scale. Grid and distribution system operators, meanwhile, need cost-effective ways to upgrade, reinforce and extend their networks so generators and consumers can participate easily in the emerging, decentralised energy system.

Sustainability

Increasing electrification will go hand in hand with increasing demand for electricity. This is likely to result in network congestion, particularly in cities. Congestion wastes energy and causes assets to age prematurely. Grid and distribution system operators therefore need ways to reduce system losses and protect grid assets.

Global electricity demand and generation by scenario

In the Stated Policies Scenario, electricity demand grows by 2.1% per year, resulting in over 13 000 terawatt-hours (TWh) more demand in2040 than today (Table 6.1). Developing economies account for almost 90% of demand growth, of which two-thirds is in Asia where demand is rising in particular for electric motors, space cooling and household appliances. About 530 million people gain access to electricity around the world by 2040, mainly in Africa and developing Asia, accounting for 2% of global electricity demand growth. Renewables, led by wind and solar PV provide three-quarters of the increase in electricity supply,underpinned by policy support and declining technology costs. The share generation from renewables increases from 26% today to 44% in 2040, with solar PV and wind together rising from 7% to 24%. The share from nuclear power decreases, but its output nevertheless rises in absolute terms, with growth in China and more than twenty other countries more than offsetting reductions in advanced economies. The share of fossil fuels in electricity supply falls below 50% in 2040, down from two-thirds (where it has been for decades). Coal remains the largest source of electricity, though its share of overall generation declines from 38% to 25%, and its share of generation in advanced economies falls by more than half over the period to 2040. Gas-fired generation grows steadily, maintaining roughly its current share of generation, thanks to the availability of cheap gas in some regions and the role of gas in supporting flexibility.

Table 6.1 ▷ Global electricity demand and generation by scenario (TWh)

			Stated Policies		Sustainable Development		Current Policies	
	2000	2018	2030	2040	2030	2040	2030	2040
Electricity demand[1]	13 152	23 031	29 939	36 453	28 090	34 562	30 540	37 418
Industry	5 398	9 333	11 843	13 525	10 751	12 169	11 998	13 874
Transport	218	377	1 025	2 012	1 374	4 065	725	1 091
Buildings	6 738	11 755	15 198	18 893	14 264	16 606	15 835	20 176
Share of population with electricity access	*73%*	*89%*	*93%*	*93%*	*100%*	*100%*	*93%*	*93%*
Electricity generation[2]	15 427	26 607	34 140	41 373	31 800	38 713	34 988	42 824
Coal	5 994	10 123	10 408	10 431	5 504	2 428	11 464	12 923
Natural gas	2 750	6 122	7 529	8 899	7 043	5 584	8 086	10 186
Nuclear	2 591	2 718	3 073	3 475	3 435	4 409	3 112	3 597
Renewables	2 863	6 799	12 479	18 049	15 434	26 065	11 627	15 485

Note: TWh = terawatt-hours.

There have been a number of significant developments since the WEO-2018. An additional 30 million electric cars, reflecting policy targets, are now projected by 2040, adding to electricity demand growth . For electricity supply, solar PV projections have been boosted by some 20% to 2040, mainly reflecting policy changes: in China, where there has been a partial reversal of a previous decision to reduce subsidies; in India, where an ambition to reach 450 gigawatts (GW) of renewables-based capacity by 2030 (excluding hydropower) has been announced; and in the United States, where state-level policies have been strengthened. Projections for battery storage capacity have been raised by close to 50%, in part due to the increases for solar PV (see section 6.12), and offshore wind projections have been revised upward by some 80% with new policies and technology gains

In the Current Policies Scenario, electricity demand increases by 2.2% per year, and by 2040 demand is nearly 1 000 terawatt-hours (TWh) higher than in the Stated Policies Scenario. This figure hides important differences in the structure of electricity demand growth between the two scenarios; without the implementation of proposed increases in the coverage and stringency of energy efficiency policies, electricity demand in buildings is nearly 1 300 TWh higher, while the difference in industry is 350 TWh, largely due to higher demand related to motor systems. Uptake of electric vehicles continues to accelerate under current policies, although not as rapidly as in the Stated Policies Scenario, as a result, transport electricity demand is nearly 1 000 TWh lower. Without the implementation of proposed policies, the pace of change for the power mix is slower than in the Stated Policies Scenario. Renewables provide half of the increase in electricity supply over the next two decades, though their share of global electricity generation to 2040 remains below 40%. At the same time, under current policies, fossil fuels continue to play a large role to 2040: coal-fired electricity generation still accounts for 30% of electricity supply and gas fired generation for about 25%. Overall, power sector emissions rise by some 20% by 2040. In the Sustainable Development Scenario the share of electricity in final consumption grows faster than in the Stated Policies Scenario, rising from 19% today to 31% in 2040. Increased energy efficiency dampens demand growth, and total electricity demand is just below 35 000 TWh in 2040. Full electricity access is achieved by 2030 and contributes 5% of demand growth. The growth of renewables generation exceeds electricity demand growth by almost 8 000 TWh, raising their share of generation to two-thirds by 2040. Wind and solar

PV together provide 40% of generation in 2040. Solar PV and other renewables also play a critical role in providing electricity access to all, particularly in sub-Saharan Africa (see Chapter 10). Nuclear and power plants equipped with carbon capture, utilisation and storage (CCUS) supplement renewables, raising the global low-carbon share of generation to about 85% in 2040. Generation from fossil-fuelled power plants without carbon capture declines sharply. Coal-to-gas switching provides a bridge to a low-carbon future in the near term, though, in the longer term, the role of gas moves increasingly towards the provision of flexibility.

Results and discussion

(Conclusion and Future Work)

Forecasting energy usage is critical for today's electric power networks to operate efficiently. The planning of future power production systems to meet the expanding needs for electrical energy requires a reliable and accurate assessment of electrical energy consumption. Predicting energy consumption may also help with smart distributed networks, analyzing socioeconomic development, distributed system design, tariff planning, supply planning, power generation plans, and ensuring electricity supply stability by balancing the quantity of electricity generated and consumed. As Saudi Arabia is one of the world's leading countries in electricity consumption, this paper proposed a unified electricity consumption prediction model. The built models utilized new data obtained by the authors from the Saudi Electric Company that contained the monthly total electricity consumption for 18 locations across the Kingdom. The data was preprocessed by normalizing the numerical features within a range between 0−1. Furthermore, the cyclic attributes were transformed into their sine and cosine counterparts. A standalone Artificial Neural Network and a bagging ensemble were used to achieve the goal of the study. The ANN was optimized by using hyperparameter tuning and its results were analyzed and discussed. Furthermore, a bagging ensemble was implemented with the previously optimized ANN as the chosen classifier. The results concluded that the bagging ensemble outperformed the standalone ANN in all evaluation metrics where it achieved a 0.9116 CC, 0.2836 MAPE, 0.4578, RMSPE, 0.0298 MAE, and 0.069 RMSE. For the future work, more machine learning models can be investigated in addition to feature selection techniques. Furthermore, the original dataset contains a breakdown of the electricity consumption based on the sectors, such as governmental, schools, and household consumption. It would be interesting to investigate how well the proposed models can perform while focusing on a certain sector.

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