

The Feasibility of using V2G to Face the Peak Demand in Warm Countries

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Abstract: As a result of the very difficult weather in Saudi Arabia during the summer, there is too high power peak demand in the grid and this is expected to increase in the next decade. To fix this problem, power consumers should participate in the power production. Vehicle-to-grid (V2G), one of the efficient sustainable technologies, can offer this opportunity. It is defined as a concept where electric vehicle (EV) provides electric to the grid when parked. This investigation looks at the feasibility of using V2G to mitigate the problem of highest electricity peak demand in the summer period in one of the warmest countries of the world (Saudi Arabia). We conduct a survey in order to serve this issue and we use information from Saudi Arabia electricity authority. We found that, V2G is a promising solution to the peak demand challenge in the summer in Saudi Arabia since there is about 80% of the sample interested in using V2G technology. Moreover, 90% of the participants used their vehicles less than 4 hours daily. Furthermore, in the summer period, most of the participants park their vehicles for the longest time between 13:00 to 18:00, which is the peak demand period.

1 INTRODUCTION

The massive increasing in the electricity peak demand at the summer period is one of the most important issues should be considered by the electricity companies around the world, specifically in the warmest countries. Electricity & Cogeneration Regulatory Authority (ECRA) state that the electricity peak demand is too high in the summer in Saudi Arabia and they expect that to increased massively in the next decade (ECRA, 2011). One of the most promising solutions that can be used to support the grid to face this problem is Vehicle-to-grid (V2G) technology. It is defined as a method whereby electric vehicles (EVs) provide electricity power to the smart grid when not being used. The majority of the vehicles are used just 10% of the time, so they can be used to offer the power electricity to the grid during this time when they parked (Kempton and Tomić, 2005). Specially, if the EV drivers know about that, they might gain money because of the contributing in V2G systems, about 2500 3000 \$ annually (Tomas, 2013).

As ECRA report, the daily load consumption curve is increased massively through the summer periods in Saudi Arabia. Thus, one of the suggested solutions which has been provided by ECRA is that a cost of energy in the summer seasons should be dou-

bled that cost in winter seasons. Thus, it can be concluded that, the peak demand in Saudi Arabia is very high in the summer period and this issue is a difficult challenge for the Saudi Electricity Company that should be considered. On the other hand, as we mentioned in the V2G definition, there is a chance to support the power grid by the EV when it parked so we inspired by this idea and we conducted a survey that investigate the feasibility of applying V2G in Saudi Arabia in order to support the grid to face the very high peak demand in the summer period. This matter is becoming more important if we know that, ECRA predicts that to increase significantly in the next decade. The rest of the paper is organised as follows. The related work will be discussed in Section 2. Next, the research methodology will be described in Section 3. Then, Section 4 provides the Results and Discussion. Finally, the findings and conclusion of our study will be discussed in section 5.

2 RELATED WORK

Before we discuss the results of our survey, we have to clarify that we choose to use vehicle usage behavior instead of drivers behavior since the drivers behavior

frequently use to define the drivers emotional which is not discussed in our study.

Additionally, nowadays, the EVs on the street are very rare. Therefore, it is difficult to collect the real EV vehicle usage behavior consequently we assume the V2G drivers behave like any other vehicle drivers and this assumption has been used broadly in the studies that review EV drivers such as (Wu et al., 2010).

Moreover, our study is consistent with (Matar et al., 2015) study which is aiming to reduce the fuel consumption cost in Saudi Arabia without increasing at the end customers costs side. In more details, their work discusses the problem from the service providers sides but it has not considered how the sustainable technologies such as V2G could help in this issue. Indeed, our work could be used as one of the robust evidences for the efficiency of applying new policies that encourage the consumers in Saudi Arabia to use sustainable technologies and specifically V2G in order to face the predicting massively increasing in the power demand and without effect the power economy.

There are many researches in the literature that review the travel behavior matter. For instance, there is a published dataset of the National Household Travel Survey (NHTS, 2016), Danish National Travel Survey (Christiansen and Skougaard, 2015), the Traffic Choices Study dataset collected by the Puget Sound Regional (Council, 2011), and the University of Winnipeg data (Danny Blair, 2011).

To the best of our knowledge, none of the abovementioned datasets are appropriate for our study goal since none of them are considered the feasibility of applying V2G in a warm country, specially, in the summer season when the electricity peak demands being very high and the drivers parked their vehicles for long period because of this difficult weather.

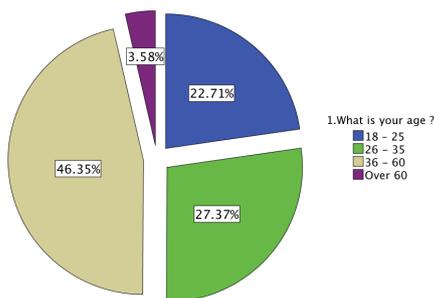


Figure 1: The participants' age.

3 RESEARCH METHODOLOGY

This section describes the survey that has been used in this study. After that, the study limitations are discussed.

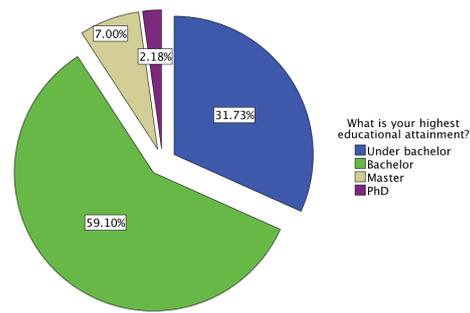


Figure 2: The participants' highest educational attainment.

3.1 Study Overview

We divide the survey into two sections. Firstly, we ask the participants about their demographic information. Afterward, we ask the participants about their cars battery usage preferences (fuel in the conventional cars) but we are not going to discuss this part here because it is out of this paper scope. However, this part will be the core of our future work. Finally, we examine the feasibility of applying V2G in Saudi Arabia. In this study, online-based survey is used. Participants are invited through social networks, and e-mails and are offered with a web link to the survey. Any individual has a Saudi driver license considered a proper participant in this study. About 699 participants answered this survey. Further, the participants are chosen randomly.

3.2 Study Limitations

This study is investigating the feasibility of applying V2G to support the smart grid in the peak time in the warm countries. It has some strengths points, however, it has some weaknesses.

The first weakness point is that, the participants are only the men and this since we consider the people they have a driver license in Saudi Arabia and till now only the men can drive officially in the Saudi Arabia. Furthermore, we cannot capture the entire population since this survey is an online survey therefore we may miss some kinds of individuals such as the elderly men who have not used the Internet.

4 RESULTS AND DISCUSSION

Now, we are going to discuss the results in this section. Firstly, Figure 1 illustrates, the majority of the drivers who participate in this study are between 36 - 60 years old, 46.35%. On the other hand, the minority is over 60 years old, 3.58% and this sensible

since the individuals over 60 are less than the others in term of using the social network where we distribute our study.

Moreover, in the highest educational attainment for the participants we found that, as the Figure 2 shows the highest number of the participants is the individuals got the Bachelor degree. Afterward, the students who are under bachelor. Next, with the significant different of number, the individuals who got the Master degree, and the minority are the participants got the PhD. Actually, we believe this is a reasonable distribution for educational attainment for the sample in a normal social. Furthermore, about the half of participants work in the public sector, and 20.37% work in the private sector, and the rest of them do not work.

In terms of the daily trips number that the drivers make we found that, as Figure 3 illustrates the drivers who make 3 - 4 trips daily are the highest number of the participants for about 40.07%. Additionally, the second highest number is the individuals who make 1- 2 trips, about 37.94%. Afterward, the drivers who make 5 - 6 trips are only about 16% of the sample. To capture the fourth option and by applying thematic analysis technique, the most repeated response is greater than or equal to 10 times. Thus, we count that as a fourth option.

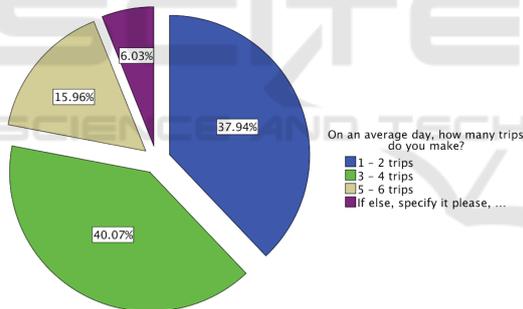


Figure 3: The number of trips the participants make daily.

Also, as Figure 4 shows about the half of the sample park their vehicle for the longest period between 00:00 to 6:00, and we think this is since the individuals sleep on this time. The second highest is between 07:00 to 12:00 where the participants are in their workplace or their school in this period. Lastly, on the very close percentages, the individuals who park between 19:00 to 23:00, and those who park in other periods which have not been described in this study.

Additionally, As Figure 5 shows, there are 40% of the participants who have more than one vehicle which make the V2G technology more efficient and this will be discussed in the finding section (Section 5).

Ultimately, to examine the feasibility of applying the V2G in Saudi Arabia, we asked twofold questions

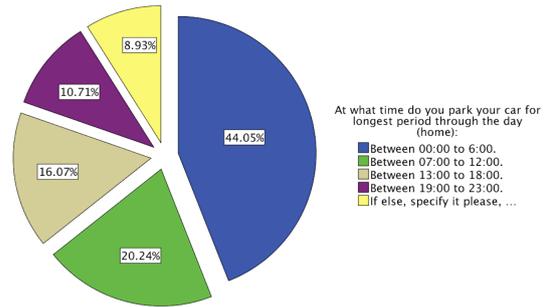


Figure 4: The longest period through the day the participants park their cars.

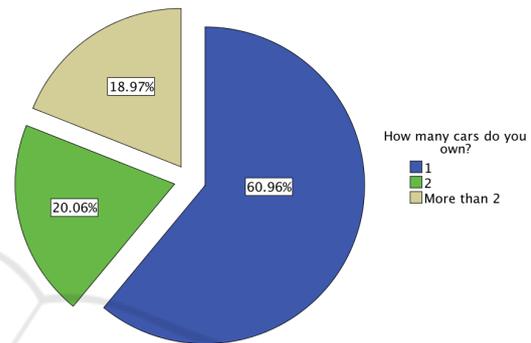


Figure 5: The number of cars the participants own.

at the end of the study.

- Are you interested to using the EV instead of the fuel vehicles if you receive some economic and environmental advantages?
- If you will receive more economical advantages from using V2G, are you interested to using the V2G?

The majority of the participants chose to drive EV, about 85% , as Figure 6 shows, which is good indication. For the remainders, by using the thematic analysis technique, these responses are the most repeated response for the reason of the sample selects to do not use the EV. The first reason is that, the participants think that the EV is less than the conventional cars in

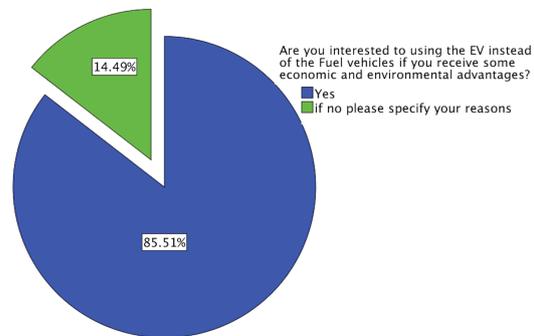


Figure 6: Choosing between EV or conventional vehicles.

terms of performance. Furthermore, it requires long time to recharge. Further, the EV until now is very expensive if we compare it with the conventional cars. Finally, the existing Saudi Arabian infrastructures do not support this kind of technology.

Before we discuss the study findings and provide the conclusion, we will briefly analyze the power data that confirms there is a peak demand problem at the summer in Saudi Arabia. As Figure 7 illustrates, which is typical daily load curve during summer, the peak demand at Friday is more than the other days because it is the social day in the Saudi Arabia and other Muslim countries where the people gathering more than other days. In a weekday, at 1:00 the curve is decreasing steadily until 7:00, where the curve is increasing gradually with some fluctuations until 18:00. Then, the peak curve is decreasing until the end of the day. From this figure, we can conclude that the peak demand period at the summer in Saudi Arabia is between 7:00 and 18:00. Further, we got figure 9 from the Saudi Electricity company which is an updated version for the current peak demand, it is for 4 days in August 2017, as the figure shows, it is almost same as the figure 7 which is for 2015. In the following section we will discuss the study findings and conclusions.

5 STUDY FINDINGS AND CONCLUSIONS

In this section, firstly we will discuss the study findings as points, then we will provide our conclusions and future work.

- About 40% of the sample has more than one vehicle, this gives a chance to them to use the spare vehicle to trade in the power market with more relaxed conditions. Accordingly, we expect the V2G technology might play a crucial role in the Saudi power market.
- Most of the participants (about 90%) are used their vehicles less than 4 hours (1 - 2) or (3 - 4) which means the vehicle are not being used about 83% of the time. Thus, we can use this time to trade with the power market without disturbing the drivers, if we apply the V2G concept in a clever way.
- About 85% of the participants are interested on using EV generally and V2G technology specifically which is a promising results if we consider that happens in a society has not has any awareness about these technologies. Consequently, based on these results we believe if we encourage the



Figure 7: Typical daily load curve during the summer.

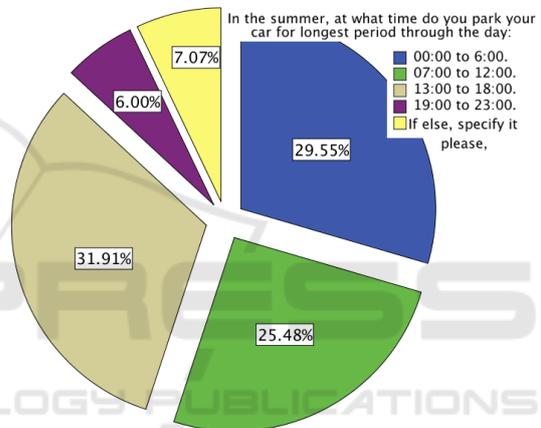


Figure 8: The longest period through the day the participants park their cars during the summer.

people and educate them about these technologies these numbers might be increased.

- In the figure 7 we use the information that has been provided by ECRA (ECRA, 2015) for the typical daily load curve during summer and we reflect the information that we collect from the participants for the longest period they parked their vehicles in the summer. As the figure 7 shows, the most interesting finding is that the longest period time the drivers park their vehicles during the summer (between 13:00 - 18:00 and between 7:00 -12:00 which represent about the 60% of the sample as figure 8 illustrates) is the same period of the peak demand. Thus, we can claim that, using V2G in the Saudi Arabia could support the grid to face the predicting peak demand at the summer period in the next decade.

In conclusion, this study considered the feasibility of using the V2G to face the electricity peak demand

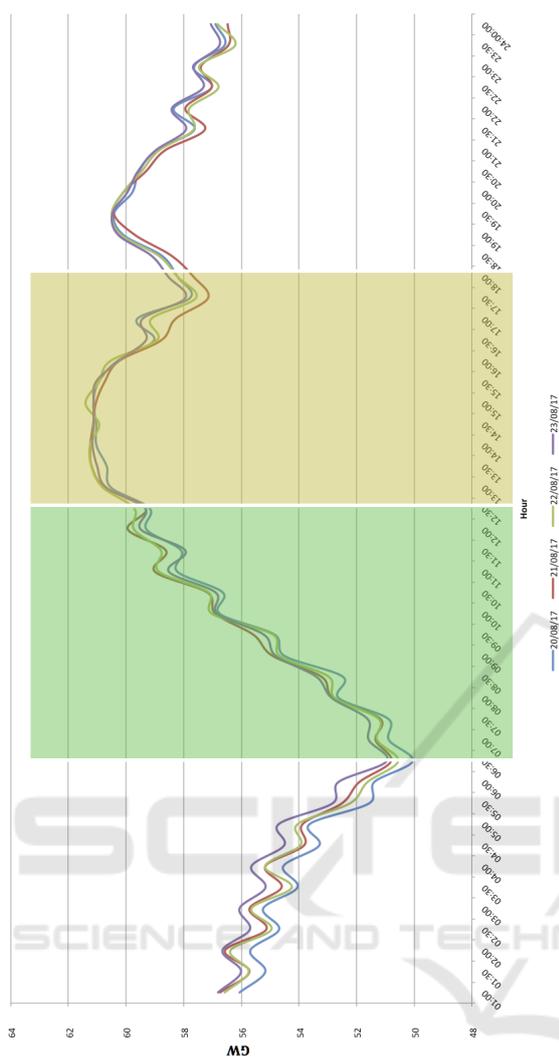


Figure 9: Peak demands for 4 days in August 2017.

in the summer season in the warmest countries. As we discussed earlier, ECRA states that, nowadays, in the summer the power peak demand is very high in Saudi Arabia, and they predict that to rise greatly in the following ten years. Based on the survey results, we believe there is a promising opportunity to the V2G technology to support the smart grid in the high peak demand in the summer.

For future work, we will develop an algorithm to trade with the power market on behalf of the V2G drivers in aim of maximizing their profits by understanding their vehicle usage behavior. To do so, we are going to deal with two types of uncertainties, which are the vehicle usage uncertainty and the power market price uncertainty. Moreover, we are planning to quantify the benefits of using V2G to support the grid at the peak demand in the summer in Saudi Arabia as a second phase of this study.

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