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The Role of Electric Vehicles to Enable Large-scale Renewable Energy Integration

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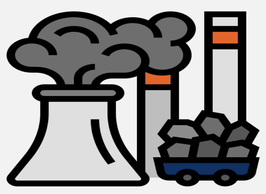
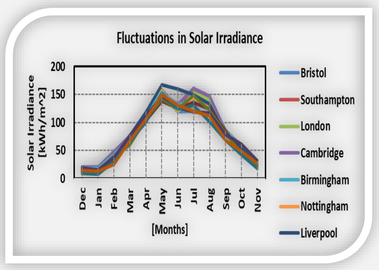
Introduction:

Electricity demand has been increasing due to rapidly developing technology and increasing population. On the other hand, the environmental policies of the developed countries and progression on the electric vehicle (EV) technology will lead to rapid penetration of EVs and therefore a high amount of additional electricity demand.

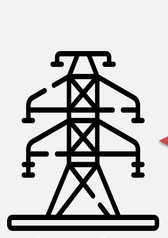


One of the biggest concerns is that adding such a demand without control to the already increasing energy demand can cause overloading to the national grid systems causing blackouts. Fossil-based energy sources, which are widely used today to meet the energy demand, have been causing serious pollution in the atmosphere because they produce CO_2 when burnt [1].

Therefore, renewable energy sources (RESs) are fast becoming a key sustainable instrument in covering this growing electricity demand. However, a quick transition to large-scale RES applications may not be possible because of the intermittent nature of RESs, resulting in power quality and power flow problems in the grids. Therefore, the dilemma of expanding existing power generation capacity and decarbonising of the transportation and the grid using EVs can be addressed sustainably by using EVs technology as an energy carrier, charging these during the low load, and discharging them during peak load conditions.



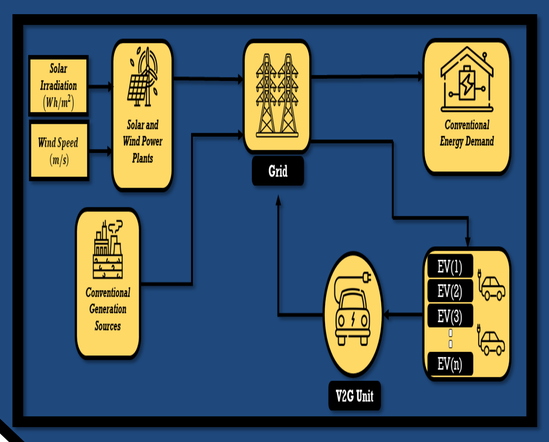
In essence, using the EVs as an energy storage medium is referred to as Vehicle-to-Grid (V2G) technology. With this technology, it is likely that the batteries of EVs will be able to meet the owners' daily trips and support large-scale RE integration at the same time.



Researches show that the daily mileage consumption of most vehicles in the United Kingdom (UK) is approximately 20 miles and that the vehicles are in the park mode for about 90% of the daily hours [2,3].

Methodology:

The study consist of two case study models. The models covers solar and wind energy generation systems, conventional energy generation systems, conventional energy consumption systems, EV charging processes, EV discharge processes with V2G and the UK's grid.

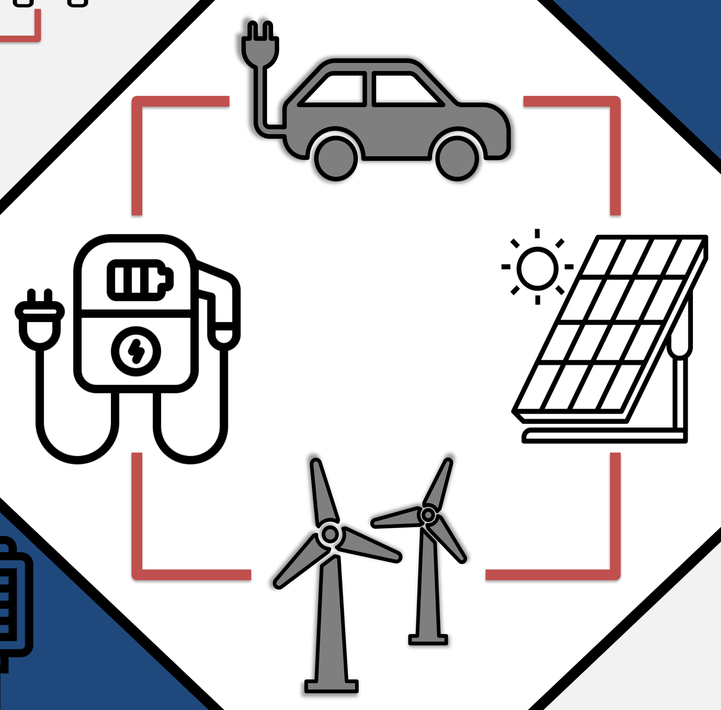


The first case study considers the UK system on a national basis and examines the monthly national energy balance, the impact of EVs on the national grid, and the relationship between the charging demands of EVs and the energy generation from RESs. This case study is also designed to compare the two charging frameworks such as uncontrolled charge and V2G and to explore why V2G is more effective in the large-scale RESs integration.

The second case set out to investigate a regional energy network of the UK to develop a better understanding and focuses on the hourly regional energy balance, the effect of EV charge and discharge operations on this network and large-scale RE integration.

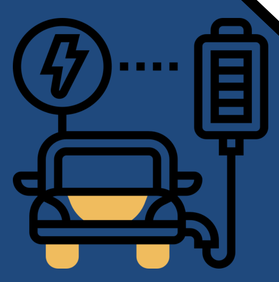
The computer programs, HOMER, MATLAB and MATLAB Simulink are used to obtain the outputs of this project.

MATLAB HOMER Pro



Aim and Objectives:

The main aims of this investigation are to explore maximum interaction between EVs and RESs and to analyse the potential usage of EVs to reduce the impact of large-scale RE integration on the UK grid.



The some of the specific objectives of this research are:

- To explore potential methods of reducing the impact of large-scale renewable energy integration into the grid
- To demonstrate the potential patterns of EV charging/discharging cycles and how this may impact or enhance RES integration into the grid.
- To develop a computer model to investigate the impact of the varying EV operational characteristics on the grid-connected renewables system.
- To predict the energy load that may be required for the increasing number of EVs under existing and future UK's power grid.
- To achieve the maximum number of EVs that can be plugged in at any time of the year on the national and regional scale

Initial Results:

The review show that the usage of EVs will increase in the near future as both transportation and energy storage devices. Additionally, it is clear that the effects of EVs on the network will be seen more clearly in the near future. The initial model of the study showed that the excess renewable energy generated in the UK has the potential to charge large amounts of EV under current UK's power generation systems.

Future Works:

The model will be developed to make a monthly and hourly energy analyses by using the charging and discharging operations of the vehicles in the created EV dataset.

References:

[1] K. Chen, R. C. Winter, and M. K. Bergman, "Carbon dioxide from fossil fuels: Adapting to uncertainty," Energy Policy, vol. 8, no. 4, pp. 318-330, 1980.

[2] A. Colmenar-Santos, A.-M. Muñoz-Gómez, E. Rosales-Asensio, and Á. López-Rey, "Electric vehicle charging strategy to support renewable energy sources in Europe 2050 low-carbon scenario," Energy, vol. 183, pp. 61-74, 2019.

[3] DFT, "Annual Mileage of Cars by Ownership and Trip Purpose: England", [Online], [Accessed at 16.03.2022], Available:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/906055/nts0901.ods

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