MITIGATING ELECTRICAL VEHICLE CHARGING CHALLENGES WITH MICROGRID AND SOLAR SYSTEMS IN BANGLADESH

A thesis is submitted in partial fulfillment of the requirements for the award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DECLARATION

We hereby declare that this project "**MITIGATING ELECTRICAL VEHICLE CHARGING CHALLENGES WITH MICROGRID AND SOLAR SYSTEMS IN BANGLADESH**" represents our work which has been done in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. In order to perform this research safely and ethically, we have made an effort to identify all potential dangers. We have also acknowledged our responsibilities and the rights of the participants while obtaining the necessary ethical and/or safety approvals.

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APPROVAL

The project entitled “MITIGATING ELECTRICAL VEHICLE CHARGING CHALLENGES WITH MICROGRID AND SOLAR SYSTEMS IN BANGLADESH” submitted by Md. Zahid Hasan (191-33-5073) & Md. Motiur Rahman (191-33-5034) has been done under my supervision and accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering in January, 2023.

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Dedicated

To

Peoples of Bangladesh

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LIST OF ABBREVIATIONS

NDC	Nationally Determined Contributions
V2G	Vehicle to Grid
CO2	Carbon Dioxide
kWh	Kilowatt Hour
Mtoe	Million Tonnes of Oil Equivalent
GHG	Green House Gas
GW	Giga Watt
BSREA	Bangladesh Solar and Renewable Energy Association
EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PEV	Plug-in Electric Vehicle
CNG	Compressed Natural Gas
PV	Photovoltaic
STC	Standard Test Conditions
AC	Alternating Current
DC	Direct Current
TOU	Time of Use
DPDC	Dhaka Power Distribution Company
ISO	Independent System Operator
AMI	Advanced Metering Infrastructure
HVDC	High Voltage DC
MG	Microgrid
HTS	High-Temperature Superconductors
DLR	Dynamic Line Rating
SCADA	Supervisory control and data acquisition
BEV	Battery Electric Vehicle
PSMP2016	Power System Master Plan 2016
LDC	Least Developed Countries
EVCS	Electric vehicle charging stations
SPP	Solar Power Plant

CHP	Combined Heat and Power
RTO	Regional Transmission Organization
GIS	Geographic Information Systems
RTU	Remote Terminal Unit
VAT	Value Added Tax
FACTS	Flexible AC Transmission System

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ABSTRACT

Power outage has become the biggest problem in the current scenario in Bangladesh. And one of the major reasons for this is that energy is decreasing in Bangladesh and energy has to be imported from outside. In light of the challenges with demand, it is therefore impossible to produce electricity. Besides, noise pollution, air pollution, and global warming are increasing in our country due to oil and gas-powered vehicles. Moreover, due to the increase in oil and gas prices and the increase in air pollution, and noise pollution in the environment, electric vehicles have become our basic need. But to increase the use of electric vehicles, it is very important to solve its challenges. Through this thesis, we have tried to solve the challenges of electric vehicles in Bangladesh using microgrids and proposed possible solutions. In addition, we have tried to solve the national electricity problem by using solar panels to charge our vehicles as well as meeting our own electricity needs and using some of the electricity from the National Grid. if necessary, we can also take electricity from the National Grid. We compared solar-powered electric vehicle charging combined with vehicle-to-grid (V2G) technology with battery and solar-powered electric vehicle charging combined with vehicle-to-grid (V2G) technology without battery and found which one is more acceptable for Bangladesh. We have also proposed some agreements between the government and the consumers in providing and receiving this electricity. Finally, we have shown that we can meet our electric demands using solar systems.

Keywords: microgrid, smart grid, solar panel, battery, electric vehicle, V2G.

CHAPTER 1
INTRODUCTION

1.1 Introduction

Bangladesh is an emerging economy. Every day we have to face different kinds of problems. These are issues that require solutions. Sometimes we can find solutions to these problems and sometimes we can't. Sometimes we research in hopes of a better solution. Bangladesh is currently facing various problems. One of the biggest problems is the power problem. In our country, load shedding is since the amount of electricity generation is less than the demand. There can be no new power generation so long as fossil fuels are depleting at an ever-faster rate. Fossil fuels must be imported from other countries. Again, due to the increase in oil and gas-powered vehicles and Burning fossil fuels (such as coal, natural gas, and oils), solid waste, plants, and other biological materials release carbon dioxide (CO_2). As a result, the concentration of anthropogenic greenhouse gases, such as CO_2, in the atmosphere has significantly increased, contributing to both global warming and climate change.

Low rainfall, changing seasons, and an increase in temperature all contribute to a decrease in worldwide agricultural productivity. the amount of carbon dioxide is increasing, increasing global warming, and causing various problems including climate change. On the other hand, due to the decreasing amount of fossil fuels, there is a need to increase the reliance on electric vehicles instead of oil and gas-powered vehicles. But the production of electricity in Bangladesh is already less than the demand. So,

- How do we get extra electricity to charge electric cars?
- How can we solve the problems related to our electrical production?
- We have tried to solve these problems in this thesis paper.

To solve these problems, we have considered different types of natural fuel sources. But the energy obtained from the sun seems much more acceptable to us. So, we tried to solve some of our electrical problems by using solar energy to charge our cars as well as some power from the national grid.

1.2 Problem Statement

Why do we think solar energy is more acceptable for Bangladesh? Generally, in Bangladesh, we find three types of renewable electricity sources: 1. Wind power 2. Hydropower3. Solar energy

- Wind energy: The amount of wind energy in Bangladesh is very less. Moreover, generating electricity using wind power is very expensive. A developing country like Bangladesh can't bear such expenses.
- Hydropower: Bangladesh is a riverine country. But even if the volume of water flow is very high, we cannot utilize hydropower because it is a costly process.
- Solar energy: Bangladesh is a summer-dominant country, sunlight exists more or less in all seasons. Moreover, we can easily store the energy obtained from sunlight by using solar panels and generating electricity. The cost is also very low.

Finally, we can say that generating electricity using solar energy is a much more acceptable and rational decision for Bangladesh.

Overall energy use: Per capita annual energy use is 0.28 toe, with electricity use accounting for 489 kWh (2020). The nation's overall energy consumption has been rising significantly since 2010 (4.5% annually), propelled by the nation's brisk economic expansion (6.9% annually). Before biomass (17%), coal (13%), and oil (12%), gas accounts for 57% of all energy production (2020). Consumption trends by energy source, (Mtoe) [1].

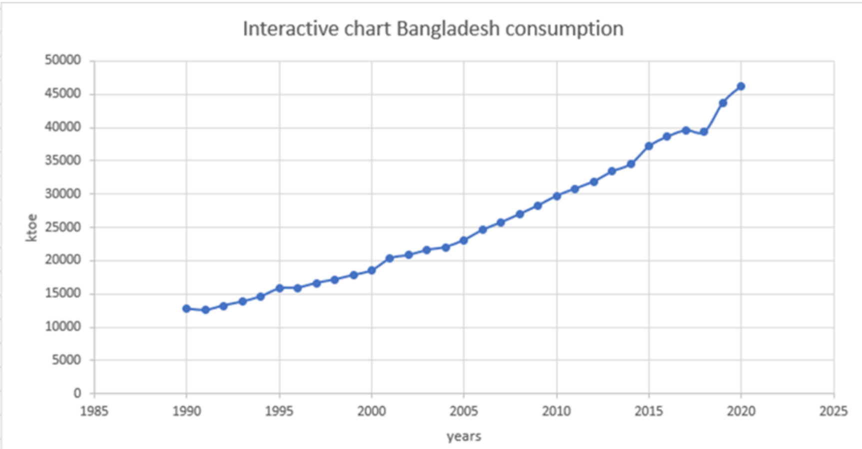

Figure 1. 1 Overall energy use of Bangladesh till 2020.

Production of Crude Oil: As of 2020, the country had imported almost 1.3 Mt of oil, or more than three times as much as it had produced (in that year, it produced 0.4 Mt of oil). The nation's total refining capacity is 35.5 kb/d (2020), which will be split between the two refineries in Chittagong and Mongla. Only one-third of the consumption of oil products is met by domestic production. Since 2010, imports of oil-related goods have surged by 50% [1].

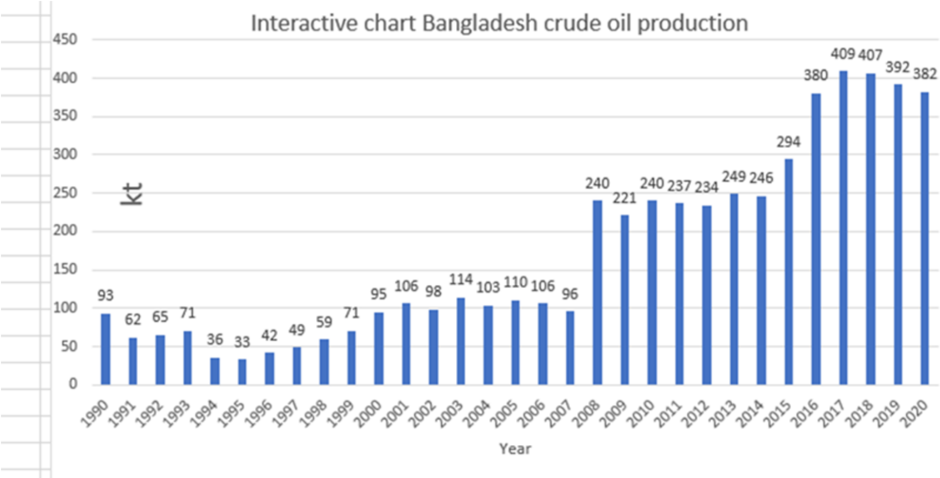

Figure 1. 2 Crude oil production in Bangladesh

Fuel Burning and CO2 Emissions: Bangladesh amended its NDC in August 2021, establishing an unconditional target of a 6.7% reduction in GHG emissions by 2030, resulting in emissions of 382 MtCO2eq in 2030, or -28 MtCO2eq relative to the BAU scenario. The additional 15% conditional reduction objective (or 21.85%, or -89 MtCO2eq in) would keep the level of absolute GHG emissions at 320 MtCO2eq. The reduction goals in the prior iteration were 5% and 10%, respectively. Energy-related CO2 emissions have risen 6.8% year on average since 2000, reaching 99 MtCO2 in 2020[1].

Renewable Energy Production as a Percentage: By 2030, Bangladesh plans to have a total renewable capacity of 4.1 GW, with solar power contributing around 2.3 GW of that total. The previous PSMP (PSMP 2016) set the goal for 2041 at 3.9 GW, therefore this is an increase. Clean Energy Industries Alliance (BSREA), a marketplace for companies that produce renewable energy, was established in the nation in 2012. All of the renewable energy goods and services offered for sale in Bangladesh are being standardized and subject to quality control thanks to the efforts of BSREA[1].

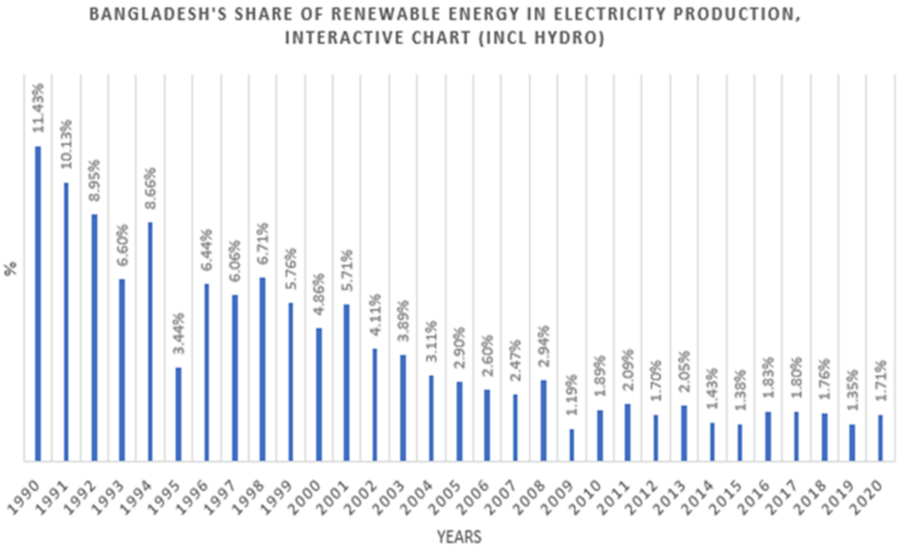

Figure 1. 3 Bangladesh's power generation as a percentage of energy from renewable sources.

Charging an EV with solar: It is more cost-effective than using grid electricity or public EV chargers. Using solar energy to recharge an electric vehicle is 51% less expensive than using grid electricity, 80% less expensive than using public charging stations, and 81% less expensive than fueling a 30-mpg vehicle with $4 a gallon.

Table 1 shows the savings that may be made by using solar energy to charge an electric vehicle as opposed to alternative fueling options.

CHARGING METHOD	**MODEL 3 ON HOME SOLAR**	**MODEL 3 ON GRID ENERGY**	**MODEL 3 ON PUBLIC CHARGER**	**30 MPG COMBUSTION CAR**
Miles per unit of fuel	3.33 miles/kWh	3.33 miles/kWh	3.33 miles/ kWh	30 miles/gallon
Distance per year	13,476 miles	13,476 miles	13,476 miles	13,476 miles
Fuel per year	4,047 kWh	4,047 kWh	4,047 kWh	450 gallons
Cost of fuel per unit	$0.08 per kWh	$0.166 per kWh	$0.40 per kWh	$3.96 per gallon
Total fuel cost per year	$323.75	$671.77	$1,618.40	$1,777.04

Table 1. 1 Table 1 shows the savings from using solar energy to charge an electric vehicle compared to other fuel types [2].

table ref. [2]

The only consistent factor in solar energy for the home is the price. You may lock in a rate of around 6 to 8 cents per kWh for the life of your solar-powered electric vehicle charging system when you purchase and install the two together [2].

Different nations are turning to solar to meet their electricity needs. Here, in the first table, we've displayed statistics for seven countries, including Bangladesh, and the global capacity of renewable energy and solar energy.

country	Energy type	2016	2017	2018	2019	2020
World total	All renewable	5883206	6211866	6590943	6955886	4768058
	solar	325725	437320	561716	690310	843855
Bangladesh	All renewable	1250	1313	1198	1149	1175
	solar	220	253	275	328	389
Norway	All renewable	145180	145519	142923	131401	151203
	solar	24	40	47	91	126
Sweden	All renewable	89127	95058	91153	98933	112143
	solar	143	230	407	679	1051
Finland	All renewable	30412	31475	32139	31883	35610
	solar	22	49	90	147	218
Japan	All renewable	151523	168066	175129	185549	197851
	solar	45761	55068	62668	69381	79087
India	All renewable	190238	209262	237057	273081	299905
	solar	10182	18128	31064	43870	54666
China	All renewable	1522405	1648541	1810864	1986041	2149534
	solar	67874	118267	178071	224542	261659

Table 1. 2 Different countries' solar and renewable energy capacities in MW [3].

In the second table, we have displayed statistics for seven countries, including Bangladesh, and the global production of renewable energy and solar energy.

country	Energy type	2017	2018	2019	2020	2021
World total	All renewable	2184464	2357959	2541478	2808273	3068297
	solar	395273	488801	591000	717211	854795
Bangladesh	All renewable	423	449	477	522	567
	solar	185	201	239	284	329
Norway	All renewable	33251	34396	35912	57999	39801
	solar	45	68	120	160	225
Sweden	All renewable	28179	29180	31156	31951	34558
	solar	244	428	714	1107	1610
Finland	All renewable	7512	7563	7890	8774	9629
	solar	82	140	222	318	404
Japan	All renewable	84187	91309	99272	106858	111856
	solar	49500	56162	63192	69764	74191
India	All renewable	105253	118195	128428	134455	147122
	solar	18252	27453	35203	39385	49684
China	All renewable	620856	695463	758844	899625	1020234
	solar	130832	175262	204971	253964	306973

table ref. [3] Table 1. 3 Different countries' total production in GWh [3].

1.3 Aims/ Objectives

The global auto industry is steadily but gradually transitioning to electric vehicles, primarily in the transport industry. In the past, the most common method of propulsion was the internal combustion engine; however, this has now given way to electric cars. The three primary varieties of electric cars (EVs) that are now available on the market are plug-in hybrid electric vehicles (PHEV), hybrid electric vehicles (HEV), and battery electric vehicles (BEV). Bangladesh uses BEV the most frequently out of these EVs. Electric motors in BEVs employ battery power to move the vehicle forward. In comparison to HEVs and PHEVs, BEVs emit fewer emissions and don't require any fossil fuel[4].

Not just in countries with a high standard of living, but also in nations that are still in the process of growing and those that have a lower standard of living, as electric vehicles become more mainstream. Because large quantities of electricity are required for massive EV adoption, the power grid and distribution networks are placed under a significant degree of pressure as a result. In Bangladesh, batteries power almost all-electric vehicles, including Easy bikes, autorickshaws, and electric bikes. According to a survey, Bangladesh is home to more than 0.5 million EVs that consume 450 MW of power every day from the national grid[5].

Originally manufactured in China, this kind of battery-powered EV is presently being developed in Bangladesh. Such vehicles are being developed by numerous small, medium, and big enterprises. Additionally, this vehicle is currently available at a lower price than it was previously roughly 2 lakh takas. As the number of electric vehicles on the road continues to increase at a breakneck pace, so does the need for electric vehicle (EV) accessories and charging stations. According to the level of interest shown by customers, it would indicate that the charging station, which is an essential factor, is insufficient. As a direct consequence of this, the owner of an electric car is required to make use of the residential rate in order to recharge the vehicle's batteries inside the confines of their own residence. In this way, the power sector has experienced system failure despite producing a substantial quantity of revenue[6]. There are no precise figures on the EV in Bangladesh. So, the government is unable to take appropriate action on this matter. In Bangladesh, the adoption of electric vehicles (EVs) is being followed by a number of different components. For instance, inadequate electric vehicle charging systems (EVCS), battery technology, a lack of power supply, expensive charging, environmental pollution, and so on are only some of the potential issues. On the obstacles to EV penetration in various countries, numerous types of research have been conducted. But no studies have been discovered on " MITIGATING ELECTRICAL VEHICLE CHARGING CHALLENGES WITH MICROGRID AND SOLAR SYSTEMS IN BANGLADESH". It is the main driving force behind the authors' decision to conduct this research.

1.4 Brief Methodology

Through this thesis, we have tried to discuss in detail the challenges and solutions of the electric vehicle. We have also discussed vehicle-to-grid connection and through the smart grid, we have tried to solve the shortage of power in the national grid by providing additional electricity to the national grid. We compared the two scenarios of energy storage with batteries and direct energy to the national grid without batteries and discussed which is most likely to be better and proposed solutions. We have also drawn a diagram and discussed how it works. In addition to charging the battery, we have discussed in detail how we can meet our energy needs through solar systems and contribute residual energy to the national grid. We also show how each device works. We have proposed a solution through an agreement on how both the government and consumers will benefit from this solar system. Finally, we conclude our main objective by discussing the challenges of electric vehicles and proposing possible solutions.

1.5 paper outline

In the first chapter, we have written the introduction of our research paper. Explain why we are doing this thesis, what are our objectives, and a brief methodology. We reviewed the literature in the second chapter. We have discussed and compared the work done so far related to our thesis. In the third chapter, we describe the materials used and discuss the working procedures and propose some agreements that establish the relationship between the consumer and the government. In Chapter Four, we have written a discussion and results. Among these, I have discussed different types of challenges and proposed solutions. Finally, in Chapter Five, we wrap off by speculating on potential future directions for similar research.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

By reading various research papers/thesis papers we can learn about what research has been done in the past on electrical vehicles. We found out after the papers that the topic we were doing a thesis on had never been done before. So, we are motivated to research this topic. We have gained knowledge by reading various studies done in the past which has helped us a lot in our research.

2.2 Related Works

In recent years, there has been a study trend toward the deployment of EVs in smart cities since EVs allow the reduction of urban carbon dioxide (CO2) reduction strategies. As a result, few researches have been conducted to enhance the widespread adoption of EVs by people in a flexible and effective manner [7]. Although Bangladesh, is one of the lowest polluters in the world, more than 75% of gasoline/CNG cars in Bangladesh release CO under the 1%(v) limit, while 85% of all CNG vehicles meet the 1200ppm HC emission level, according to an analysis of emission data, this emission testing study revealed the greatest polluters in the automobile sector in Dhaka city as being motorcycles and all varieties of diesel vehicles. It was discovered that 78% of motorbikes and 77% of diesel automobiles did not meet their respective limit levels as specified by the government[8]. One of the least developed nations with the highest rates of success is Bangladesh (LDCs). The nation has made such advancements that by 2021. Over the last two decades, a high demographic dividend, sizable exports of ready-made garments (RMG), consistent inflows of remittances, and stable macroeconomic conditions have all contributed to rapid economic progress. Strong recovery from the COVID-19 pandemic persisted through FY22 [9], [10]. As a result of the city's rapid growth of vehicles over the past two or three decades, the air quality in Dhaka would have been intolerable by now. According to the most recent source apportionment research, automobiles, 10.4%, and dust, 15.3% [8]. But Bangladesh confirmed at the Glasgow climate conference that it will reduce carbon emissions by 89.47 million tons, or 21.85% of carbon dioxide, by 2030 [11]. On the other hand, to develop Bangladesh in a way that it would be among the developed nations by the year 2041, as stated by the government of Bangladesh, is the main goal of VISION 2041. Creating 24,000 MW of power by 2021, 40,000 MW by 2030, and 60,000 MW by 2041 are the power generation goals for achieving Vision 2021, SDGs, and Vision 2041, respectively[12]. already with on-grid and off-grid PV systems, helps to satisfy the energy demand in two distinct ways. According to Table 3, which details the current state of on-grid and off-grid PV systems and their combined installed capacity until 2020, Bangladesh has an excellent chance of supplying all of its energy needs through the use of various solar energy technologies[13].

Technology	Off-grid (MW)	On-grid (MW)	Total (MW)
Solar Park	0	38.4	38.4
Rooftop Solar	14.21	27.56	41.76
Net Metering Rooftop Solar	0	17.02	17.02
Solar Irrigation	43.15	0.02	43.17
Solar Home System	251.64	0	251.64
Solar Mini grid	5.65	0	5.65
Solar Nano grid	0.001	0	0.001
Solar Charging Station	0.262	0.016	0.278
Solar Street light	10.59	0	10.59
Solar Power telecom (BTS)	8.06	0	8.06
Solar Drinking Water System	0.095	0	0.095
Total	333.66	83.02	416.68

Table 2. 1 Bangladesh will have a combined installed solar energy capacity of both on-grid and off-grid systems by the year 2020[14].

Table Ref. [14].

Since fully electric cars (EVs) have no exhaust emissions, they are substantially better for the environment. In wealthy nations, public investment in EV subsidies and incentives nearly quadrupled to USD 30 billion in 2021 [15]. The 2022 study from the Energy Agency claims that this feature of EVs makes them more energy efficient than ICE cars. A medium-sized electric automobile also generates far less pollution than the typical internal combustion engine car[15]. Braun et al. conducted research that was published in 2017 that examined the amount of energy that was used by two different types of passenger automobiles, one of which was powered by batteries and the other by an internal combustion engine, while being driven under a range of different scenarios. Evaluating the fuel economy of different types of automobiles on urban, extra-urban, and highway routes, each of which has its own set of characteristics that set it apart from the others. When it comes to energy efficiency, electric cars (EVs) perform much better than internal combustion engine (ICE) vehicles. In particular, while taking into consideration the urban route, an electric vehicle has an energy consumption of 0.158 kWh/km, whereas an internal combustion engine vehicle has an energy consumption of 0.678 kWh/km [16]. An electric vehicle has a huge capacity battery for running the car over long millage, this battery capacity can be used to store electricity on overcapacity or low electricity prices time. When there is a surge in demand or when prices are very high, this electricity may be sent back into the grid. V2G has the potential to increase both the dependability of the system as well as its security by supplying electricity to buildings in the event of an emergency such as a power outage [17]–[26]. Studies conducted more recently have validated these results. The author of this paper investigates the viability of the V2G concept and whether or not it is suitable for the expansion of Morocco's national grid and the electric vehicle market. Electric vehicles (EVs) have the potential to function as power storage devices for the grid, allowing for the integration of renewable energy sources in a seamless and stable manner [27].

2.3 Compare and Contrast

If several EV chargers are connected at the distribution end, the voltage drops and causes overloading on the transformer and the distribution line, increasing power loss [6] and the demand exceeds the grid's capacity, it will cause a fall in system frequency, and voltage, eventually resulting in brownouts or blackouts. With incorporate of solar power plant to maintain a consistent voltage level across the distribution network by integrating the effects of the solar power plant and EV charging stations on the grid's voltage control. It was able to restore the voltage while keeping it well within the specified limits in each scenario. Even though the voltage was stabilized by the solar power plant power production, the voltage level was still affected by the dynamic and randomly selected EV charging processes [28]. In their analysis, Gielen et al. 2019 showed that renewable energy can provide two-thirds of the world's energy needs and help to reduce greenhouse gas emissions most significantly between now and limiting the rise in world average surface temperature to less than 2 degrees Celsius by 2050

[29]. To meet the enormous demand of that rapidly developing nation for power, renewable energy sources must be included as well as nonrenewable ones. Solar energy is one of the most readily available forms of free energy from renewable sources. it has developed into a tool to improve the economic position of emerging nations and to help the lives of many disadvantaged people because it is now free as a consequence of the rigorous research being done to speed its expansion. The solar sector would undoubtedly be the best option for supplying future energy demands because it surpasses other renewable energy sources in terms of availability, cost, capacity, and efficiency [30] Similar findings were found in a research conducted by Mojumder et al. 2022, who found that the micro grid system makes efficient use of renewable energy sources such as solar, wind, hydropower, geothermal, and biomass. There are several opportunities for grid-connected and island microgrids as a result of the possible renewable shift [31]. The authors of[32] describe microgrids, which can be constructed in both DC and AC modes. the advantages of establishing DC Microgrids over AC grids Microgrids are advantageous owing to their ease of control and the decrease of conversion steps. Consequently, EVs can enhance the economics of the sector that produces renewable energy. Future power grids will be greener and more sustainable with effective energy management between EVs and renewable energy sources [33]. A hybrid heuristic technique is presented to approximate the global ideal for the optimization issue. *Tu et al. 2020* sought to reduce GHG emissions from charging EVs by substituting simulated annealing for the selection phase in a typical genetic algorithm This study highlights the implementation of the charging infrastructure in terms of the quantity and quality of plugs, which has the potential to greatly reduce the amount of GHG emissions from power generation[34]. Increased participation in smart charging and vehicle-to-grid can increase the uptake of zero-carbon generation by up to 5.2% and 11.1%, respectively, as shown in a different study by Tarroja et al. 2021, who investigated the value of consumer acceptance of controlled electric vehicle charging in a decarbonizing grid for the state of California. Smart charging has a value of up to $2,850 year per car, but only reaches $87 annually. This is a significant difference from vehicle-to-grid charging, which has no limit. Encouragement of the usage of smart charging may need the use of non-monetary incentives [24]. B. Anthony Jnr in his study proposes energy as a service business model to explore how EVs can contribute to achieving sustainable energy in smart cities. Additionally, this study explores the emerging role of energy informatics, the role of smart grids and sustainable

energy systems, the benefits of integrating EVs within the energy grid as flexibilities, and EV‘s implications for providing incentives to its users[35].

Electric vehicle (EV) sales will have more than quadrupled by 2021. In 2012, 120 000 electric cars were sold, breaking the previous year's record of 6.6 million EV sales. By 2021, each week Almost 10% of all cars sold globally were electric. As a result, there are already more than 16.5 million EVs on the road worldwide. With 2 million sold in the first quarter of 2022, global sales of electric cars increased rapidly, up 75% over the same period in 2021 [36]. El-Zonkoly 2014 in his publication introduced the number of dispersed generations to be allotted, as well as their ideal locations and sizes were all established using the suggested method. When it came time to figure out how to best allocate the system's resources for energy use, a rule-based expert system was called upon to do the heavy lifting. The disclosed method aimed to cut down on the energy consumption of the system as a whole. The topic was framed as an optimization issue, and the artificial bee colony (ABC) algorithm addressed it by considering constraints imposed by the power grid and plug-in hybrid electric vehicle (PHEV) operations. A 45-bus distribution network in Alexandria, Egypt, successfully used the suggested method [37] Passenger EVs are commonly recharged at home, hence Muratori 2018 focused on how EV charging affects household power usage. He used 10-minute home power consumption and EV use models for a bottom-up investigation of consumer energy use and real-world vehicle utilization. This helped him assess the global and local implications of uncoordinated EV charging. The results show that EV adoption, particularly Level 2 charging, does not significantly affect residential power consumption. In terms of energy usage, EV charging has little influence on home power demand. If Level 2 charging is considered, bringing a single EV to a domestic distribution network with six homes may raise the distribution transformers' peak load factor and shorten their lifespan [38]. another research found They provided a dispatching model for organizing the recharging of a fleet of 50 electric cars, and the same number of residences are catered to by a residential microgrid. Results show that the simultaneous recharging of all the cars prevented a peak in the load curve, that consumption was dispersed evenly throughout the night, and that all the vehicles were recharged by the owners' deadline. The risk of power infrastructure overload is decreased by reducing consumption peaks and coordinating battery recharge for electric vehicles [39]. Value of regulated charging at or below 50% is required to make use of the micro grid and boost efficiency. Based on previous work linking high-resolution mobility and grid dispatch models, this study explores potential futures for the renewable energy grid and plug-in adoption up to California's 5 million electric vehicle goal. 0.95–5 million "smart" charging PEVs mitigate renewable energy curtailment by up to 40% and save the California grid $120–690 million in annual operating costs (up to 10% of total costs) compared to unmanaged plug-in electric vehicles, even after accounting for practical charging and grid constraints [40].

2.4 Summary

In this chapter, we have given various information regarding many papers related to the electric vehicles of Bangladesh. As a result, we have highlighted the current need for electric vehicles in Bangladesh. We have compared the information related to electric vehicles in different countries. So that it is convenient to do our thesis. Based on the material reviewed above, we may conclude that integrating renewable energy into the grid is the best approach available.

CHAPTER 3
MATERIALS AND METHODS

3.1 Introduction

In this chapter, we will discuss in detail all the tools we will use in this thesis. Because to do the thesis we must have detailed knowledge about the equipment. If we have no idea about machinery, we have to face many problems to do our thesis. In this chapter, we will discuss solar panels, batteries, inverters, microgrids, smart grids, etc.

3.2 Methods and Materials

Solar panels: The usual yearly power density of solar radiation is between 100 and 300 W/m2 (on a horizontal plane). As a consequence, a region of 3 to 10 square kilometers roughly one-tenth the size of a sizable coal or nuclear power plant—must be made accessible to create an average energy production of 100 MW with a PV efficiency of 10%. 4.36 kWh/m2 is the estimated monthly average daily radiation for Bangladesh[41]. Direct electricity generation from sunlight is possible with photovoltaic solar panels. Energy is obtained from the sun by it. PV modules are connected collections of PV solar cells that come in a variety of voltages and wattages. A photovoltaic system uses photovoltaic modules to create and provide solar power for industrial, institutional, and domestic purposes.

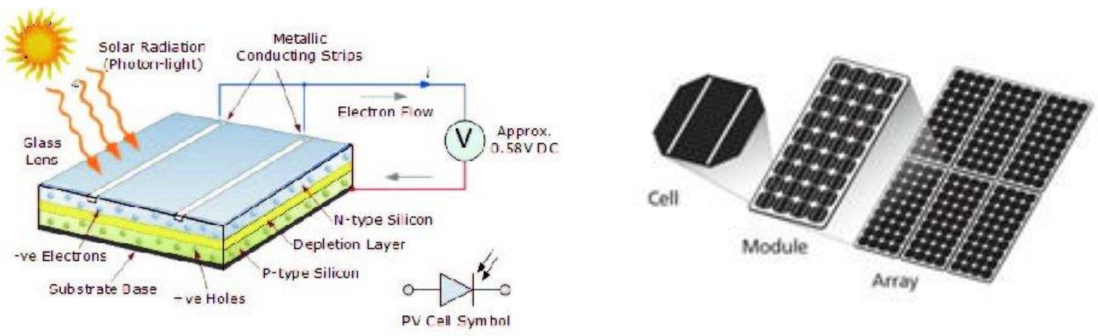

Figure 3. 1 basic diagram of photovoltaic solar cell [42] and solar panel figuration, cell, module, array [43]

Image ref. [42], [43].

How much power does an equivalent number of solar panels generate?

Solar panels are used throughout the day to generate electricity. Solar panels generate more power when the sun is directly overhead. On July 11, 2020, when there was continuous sunshine, and on July 13, when there was a mix of sun and clouds, the Figure depicts the PV generation in watts for a solar PV system.

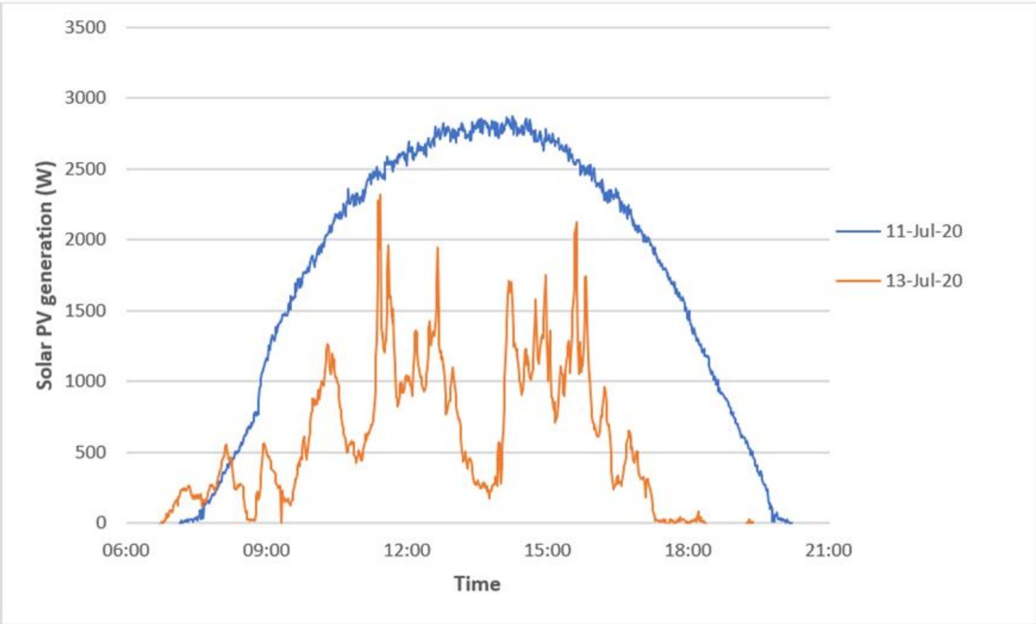

Figure 3. 2 PV production measured in watts for a solar PV system on the 11th of July, 2020 [44].

Image ref. [44].

Theory and construction: Photovoltaic modules convert the light energy from the sun into usable power via a process known as photovoltaic reaction (photons). The vast majority of modules are constructed using cells that are either built from wafers or thin films containing crystalline silicon. The structural component of the module may be the module's top layer, its back layer, or both. Moisture and mechanical harm are protected by cells. While thin-film-based semi-flexible cells are also available, most cells are rigid. Electrical connections are made between the cells first in parallel to boost the amperage and then in series to connect them at the correct voltage. The module's wattage is calculated by multiplying its voltage by capacitance. The interface for the output is a PV junction box that is fastened to the solar panel's back. for the most part, external connections.

History: Alexandre-Edmond Becquerel experimented with and studied a variety of materials in 1839 that may generate electric charges when exposed to light[45]. But back then, solar panels weren't effective enough to power typical electrical appliances. However, it served as a simple measurement device[46]. Becquerel did not repeat the observation until 1873. Willoughby Smith discovered at this time that light stress may charge selenium. William Grylls Adams and Richard Evans Day published the "Action of Selenium on Light" in 1876 as a result of Smith's finding. They discussed the experiment that was conducted to confirm Smith's findings[45], [47] Charles Fritts created the first solar panel for commercial use in 1881[48]. However, compared to coal-fired power plants, these solar panels were significantly less sophisticated. Russell Wohl created the solar cell concept utilized in many contemporary solar panels in 1939. His design was patentable in 1941[49]. Bell Labs used this idea to create silicon solar cells that were commercially viable for the first time in 1954[45]. The silicon surface transition method via thermal oxidation was created in 1957 by Mohammad M. Atalla at Bell Labs[50], [51].

Efficiency: Each module is rated according to the power of its DC output under standard test conditions (STC). The typical power ranges from 100 to 365 watts. Given the same rated output, the module's area is determined by its efficiency. Some solar modules that are on sale in the market are more efficient than 24%[52]. This new unfocused world record was achieved by a team of engineers at the University of New South Wales, who developed a novel solar cell configuration that enhanced the efficiency of converting sunlight into power by 34.5% [53]. Photovoltaic modules can generate electricity from various light frequencies depending on the design. nevertheless, cannot usually cover the entire solar range (in particular, ultraviolet, infrared, and low or diffuse light)[54]. Only a certain quantity of energy may be produced by a single solar module. The majority of installations are made up of several modules linked together via cables and PV systems using voltage or current. An array of photovoltaic modules, an inverter, a battery pack for energy storage, charge controllers, interconnecting cables, circuit breakers, fuses, disconnect switches, voltage meters, and optionally a solar tracking device are all common components of a photovoltaic system.

Battery: A device that stores energy for later use and is charged by a connected solar system is referred to as solar battery storage. The stored electricity is used during power outages, at night or during peak energy hours. Most usually seen on buildings such as residences or businesses.

Figure 3. 3 BATTERY.

Image ref. [55].

Solar battery storage breakdown: A few outside aspects need to be considered for us to properly comprehend solar storage battery systems and the pertinent advantages of owning one.

Types of battery: two types of battery are commonly used so we are discussing only them**.**

I. Lithium-ion: In comparison to other battery kinds, lithium-ion batteries, the most widely used storage batteries, have the longest lifespan and are incredibly small and light. However, despite all of these advantages, they are the most expensive.

II. Lead acid: Despite being among the least expensive, these batteries have the lowest capacity and longevity. These are an excellent choice if you're on a tight budget but will cost you more in the long term because you'll have to replace them more frequently.

Inverter: An inverter is a piece of electrical equipment that changes DC voltage, which is typically obtained from batteries, into regular home AC voltage so that ordinary appliances may utilize it. An inverter essentially changes direct electricity into an alternating current. Many pieces of small electrical equipment, including solar power systems, rely on direct current because solar cells can only generate DC. Additionally, they are utilized in locations that require or create very little voltage, such as power batteries that solely output direct current (DC). In addition to these, other power sources such as fuel cells also produce DC.

Figure 3. 4 Simplified layout of a common grid-connected (on-grid) solar power system [55].

Image ref. [56].

Why should you use an inverter?

The question that then arises is, however, why it is necessary to convert direct current to alternating current. The answer to this query is the most straightforward. We are all aware that power plants primarily provide our houses with alternating current, which has a voltage of 220 volts. That is one of the primary reasons why electrical equipment that requires high voltages and currents is made to operate on AC since it is provided to our homes. Aside from this, AC power is extensively used because most appliances need more power than DC can provide. After all, DC electricity is made to operate at low voltages.

Basic Inverter Types: Voltage is also raised throughout the conversion process. However, because of Ohm's Law, which states that a rise in voltage causes a fall in current, the overall output current is reduced when a DC signal is changed into an AC one.

There are two primary categories of inverters based on how they function: I. Independent Inverters, II. Grid-connected inverters.

Below is a summary of these inverters so that you can understand the fundamental differences in how they operate. They would be described in the greatest depth feasible in our upcoming tutorials.

I. Independent inverters: These are the fundamental types of inverters that, in addition to inverting DC to AC, also raise voltage amplitude and, as a result, change frequency. Normally, the output of these sorts of inverters is a sine wave, but occasionally, for a variety of reasons, the output becomes distorted and takes the shape of a modified sine wave or a square wave.

II. Grid-connected inverters: As its name suggests, Grid connected inverters supply the output AC power to a grid-like network or a larger supply unit. The power is then further distributed via this device. They feature complicated internal circuitry and structure as a result of having to coordinate with the grid network[57].

Rectifier: A rectifier is a piece of electrical equipment that employs one or more P-N junction diodes to convert AC power to DC power. Diodes are like one-way valves in that only electricity flowing in one direction may pass through them. The term "correction" is used to describe this process. Rectifiers may be implemented using a wide variety of physical structures, such as solid-state diodes, vacuum tube diodes, mercury arc valves, silicon-controlled rectifiers, and a wide variety of other silicon-based semiconductor switches.

The Various Forms of Rectifiers: Rectifiers may be split into two categories: First, an unregulated rectifier; second, a controlled one.

I. In the case of a rectifier, the term "uncontrolled" refers to the fact that the voltage output cannot be adjusted. The following subcategories of unregulated rectifiers exist:

Half-wave rectifier: In contrast to full-wave rectifiers, which convert the whole AC cycle into DC, half-wave rectifiers only convert half of the cycle.

Full-wave rectifier: The AC's positive and negative half cycles are converted via a full-wave rectifier. An example of such a device is the bridge rectifier. The bridge rectifier consists of four diodes connected in a Wheatstone bridge configuration.

I. Controlled rectifier: The controlled rectifier is a form of rectifier that can adapt to changing voltage requirements. SCRs, MOSFETs, and IGBTs are used to regulate an uncontrolled rectifier. Controlled rectifiers are preferred over their unregulated equivalents. Different types of controlled rectifiers include those that can only rectify half of a wave and those that can rectify the complete wave. The design of the half-wave-controlled rectifier is identical to that of the half-wave uncontrolled rectifier except that an SCR is used in lieu of the diode.

Microgrid: A micro grid is a small-scale energy system with the ability to be controlled. Therefore, it does not need connection to the broader grid in order to function [58]. To meet the electrical demands of its customers, a micro grid must have access to a reliable source of generation. Because micro grids are a relatively new concept, their power has often come from "behind the meter" fossil fuel generators like gas-powered generators. Due to the dropping cost of solar and the environmental benefits of shifting away from fossil fuel production, many of the micro grids being built today use solar + battery storage to provide power [59].

Microgrids offer numerous advantages, including these: Offer clean, affordable, and efficient energy. Enhance the regional electric grid's performance and stability. infrastructure that is essential for boosting dependability and resilience. Reduce peak loads and grid congestion. enabling extremely effective CHP, lowering carbon footprint, line losses, and fuel use. Adaptive systems and building controls, renewable energy, thermal and electric storage, and CHP should all be integrated. Increase competition in RTO markets. offer the grid ancillary, energy, and capacity services. In times of regional crisis, assist first responders. Employ local labor and energy sources.

risk diversification as opposed to risk concentration. When combined with its electric and thermal storage capabilities, a micro grid facilitates local control of fluctuating renewable energy, most notably on-site solar. When built properly, a regional power system that includes both large-scale central plants and smaller, more distributed micro grids may provide reliable service to a wide area.

What Applications Microgrids Are Used For: As a result of the grid's ability to link houses, businesses, and other establishments to a network of power plants, we have access to a wide variety of electrical devices and systems. Due to this interdependence, however, the consequences of repairing one part of the grid affect the whole system. This is a situation where a micro grid may be handy. In normal circumstances, a micro grid functions while connected to the larger grid; but, in times of crisis, such as power outages or storms, it is able to disengage and function autonomously utilizing local energy generation. Micro grids have the ability to become isolated from the grid electrically in the case of a breakdown. When the power system goes down, whether from a natural disaster or a fallen telephone pole, you will need to be "islanded" from the grid in order to keep generating and utilizing energy. Therefore, the capacity of a micro grid to continue operating even while the main grid is down is essential [58]. Microgrids would be useful in situations like the recent Californian wildfires. To prevent powerlines from being damaged and starting additional fires, many of the power outages in California are intentional outages. A microgrid would be a solution for many people's power issues because it would allow them to generate their power using solar panels and store it for usage during crises. These homes might cut off from the main grid and function independently until the main grid is operational again.

Rates for Time-of-Use (TOU): A time-of-use rate plan can be available to you depending on your utility. Thus, the rates at which you utilize your energy will vary based on the time of day. Electricity prices are at their highest after work into the evening, when electricity demand is at its maximum. The quantity of electricity you would typically purchase during peak hours can be reduced with the use of a solar battery system. Your solar panels' excess energy produced during the day can be stored and used at more expensive times. The difference between peak and off-peak TOU rates can be up to twice as great. A solar battery storage system can therefore soon earn back its investment.

Net metering: Numerous utilities are discontinuing their net metering programs and no longer give full credit for the electricity you return to the grid. It happens frequently that you sell your electricity at a lower wholesale price and later purchase it from the grid at the full retail price. If your utility is in this scenario, it is more advantageous to store your electricity for use later.

Smart grid: The term "smart grid" refers to a digital power network that employs digital communication in both directions to provide energy to consumers. This system allows for the comprehensive monitoring, analysis, control, and communication throughout the whole energy supply chain, which in turn increases efficiency, lowers costs, and increases both transparency and dependability. The supply chain can now be tracked, analyzed, controlled, and communicated with thanks to this technology. To address the problems with conventional power networks, the smart grid was developed using smart net meters. Since smart grids may be used to monitor and solve global warming, emergency preparation, and energy independence, they have garnered backing from many governmental groups throughout the globe.

Explain about smart grid: Smart grid technology is a development of analog systems that permits bidirectional communication for the management of electrical appliances. Most households now have Internet connectivity, which facilitates the deployment of the smart grid. Smart grid devices broadcast data in real time, allowing regular users, operators, and automated equipment to instantly respond to fluctuations in the smart grid's condition systems. Smart grid technology is useful for many different types of enterprises, including large corporations, small shops, hospitals, colleges, and even multinational corporations. Power consumption data is collected and analyzed automatically throughout the whole smart grid system. An organization's projected energy consumption and associated expenditures may be calculated with the use of energy management software and grid design. In broad terms.

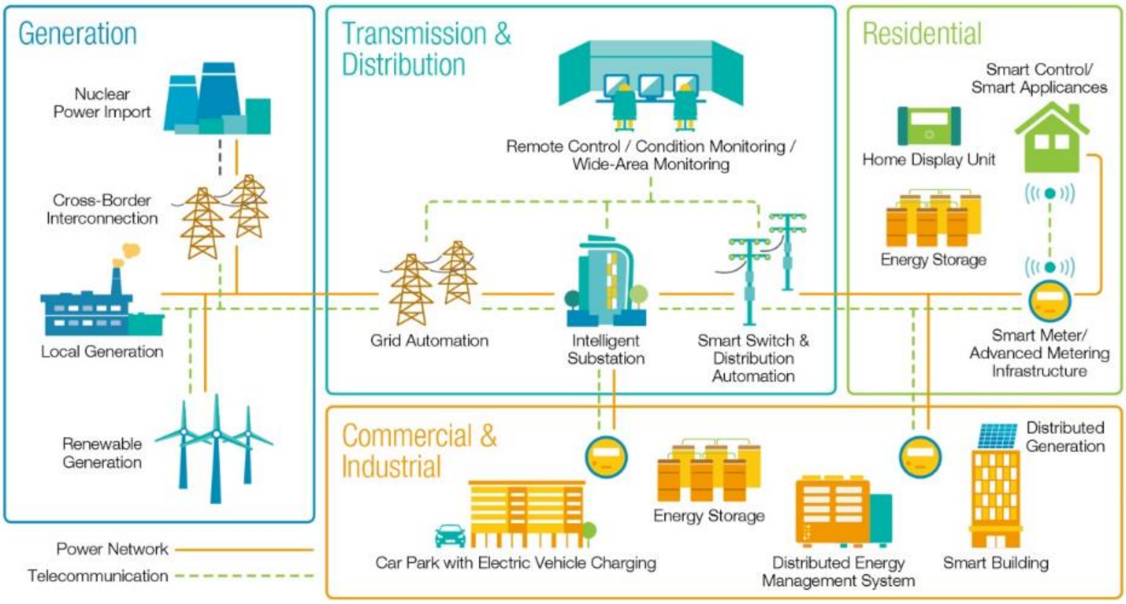

Figure 3. 5 Smart Grid Technology [60].

Image Ref. [60].

Technical Benefits of a smart grid: The following diagram illustrates how the traditional technical condition compares to the smart grid[61].

Bangladesh's power production is centralized.	There will be both dispersed and centralized power generation.
If there is a problem with the transmission and distribution system, it can be found without human intervention, but it can't fix itself.	The issue can be automatically repaired thanks to smart grid technology. It may result in fewer transmission lines.
The system of distribution is not atomized.	For fault identification, automated feeder reconfiguration, and reactive power and voltage optimization, it is atomized and analyses real-time data from sensors and meters.
No contemporary technique exists to lessen transmission loss.	A smart grid can increase the quantity of real power and decrease the flow of reactive power to reduce transmission losses.
Although load shedding occurs for several reasons, one of them is that not enough circuit breakers are automatically radio-controlled inside the distribution network.	Digital radios were necessary for the smart grid's wireless distribution network control. According to this approach, the territory will be split into two extremely small zones, so if a fault develops, the entire area won't be harmed.

The majority of meters are electromechanical, and their security systems are very shoddy and ineffective.	The meter is mostly digital. It can identify bypassed meters and inoperative meters.
Only dispersed sources can merge.	It can combine distributed energy sources and renewable energy.
Billing issues are a serious concern. Meter readers are significantly more worried about customer exploitation and corruption than they are about bill collection.	It can automatically correct billing information, identify customers who have failed to pay, and remotely cut off service to such customers before re-establishing service after payment has been received.
Because of technology, many transformers are stolen each year and never found by the authorities.	It is possible to detect theft of transformer level.
There is no communication, or if there is, it is only one-way and not in real-time.	Real-time and two-way.
Limited and one-way power flow control is available.	There are numerous, automated, and complete power flow pathways.

Table 3. 1 Technical Benefits of a smart grid: The following diagram illustrates how the traditional technical condition compares to the smart grid.

Key characteristics of a smart grid include:

Handling loads: In general, the demand placed on the power system fluctuates throughout time. In the event of peak demand, a smart grid might suggest that users temporarily cut down on their energy usage. To help reduce power costs, Demand Response encourages consumers to run less important electronics during off-peak hours when prices are lower. Individuals connected to a decentralized grid are free to utilize whatever method they see fit to produce electricity on their own premises [62].

Why smart grid is a special solution for Bangladesh?

The pollution produced by diesel generators used as a backup during grid failures will be eliminated when the smart grid enhances grid performance. A smart grid is a two-way system. The consumer can give energy and also take energy from the grid. So, it is the best solution to reduce energy lacking. It gives benefits a total of 1,141,000 people. Additionally, by eliminating an annual accumulation of 104,000 tons of CO2 emissions, the project aids in the fight against climate change. Overall, the smart grid solution has significant operational value and goes beyond the collaboration with the DPDC. It allows for maintenance to be performed before failures and for equipment used to be optimized (power transformers, circuit breakers, etc.). Real-time algorithms that continuously assess the data enable this[63].

Vehicle to grid(V2G): With the help of self-renewing resources like the sun, wind, soil, and plants, renewable energy technologies promise to produce clean, plentiful energy. The flexibility required to balance supply and demand is a problem for renewable energy sources like solar, wind, and tidal energy. Demand and supply in electrical energy systems must match at every time point, which is a need that is very pronounced[64]. Energy storage, which can be expensive, is essential to balancing the supply and demand dilemma. Vehicle-to-grid technology comes in handy here. it provides a decentralized type of storage, V2G might potentially benefit—or be coupled with—independent and decentralized power sources, therefore it need not simply benefit traditional energy sources or grid operators. Suppliers like those that use solar power to produce electricity. Here, V2G can help renewable energy producers and improve overall sustainable grid management[65]. Grid offers two-way data communication and electrical flow. A better way to include distributed renewable energy sources, including solar and wind, is through two-way electricity. energy, which benefits the averting of the energy problem as well as environmental preservation[66]. One of the crucial components of the smart grid, along with the home area network, is the vehicle-to-grid (V2G) network[67]. The fundamental idea behind vehicle-to-grid power is that electric vehicles (EVs) power the grid while they are parked. The EV can be a plug-in hybrid, a fuel cell vehicle, or a battery-electric vehicle. Battery EVs can charge when there is little demand, and discharge as soon as you require power. Fuel cell EVs use gaseous or liquid fuel to produce electricity. Both modes are functional in plug-in hybrid EVs. The grid serves as a one-way conduit for power to travel from generators to consumers. When using battery-powered EVs, electricity can flow both ways back to the grid. The grid operator (abbreviated ISO for Independent System Operator) may transmit the control signal via broadcast radio, a cellular phone network, a direct Internet link, or a power line carrier. In any event, a huge number of cars receive requests for power from the grid operator. Each car might get the signal directly, or it may go to the office. the power of a fleet operator, which in turn manages vehicles in a single parking lot or via a third-party aggregator of scattered individual automobiles[68].

3.3 schematic diagram and working procedure

PV converts solar energy to electricity, which is then sent to a battery through an inverter. The battery stores the energy and provides it to the house as needed, as well as to the EV charging station. The inverter transforms DC electricity into alternating current and feeds it to the smart grid. A smart grid is a network or system that develops direct data interchange between providers and consumers to ensure efficient use of power. It is digitally controlled, allowing home power consumption to be tracked. Minor mistakes are avoided, and blackouts are considerably reduced. It enables manufacturers and consumers to work together. Additionally, anyone may create power using solar energy and utilize it via net metering. The customer will utilize solar energy as their primary source of energy, and the rest will be fed into the national grid. If more power is required, it can also be sourced from the National Grid. In this situation, a consumer serves as both a consumer and a producer. Since our EV usage has a big capacity battery that may be utilized as an energy storage system for cars connected to grid technology, we have two storage systems with this microgrid system[28], [69].

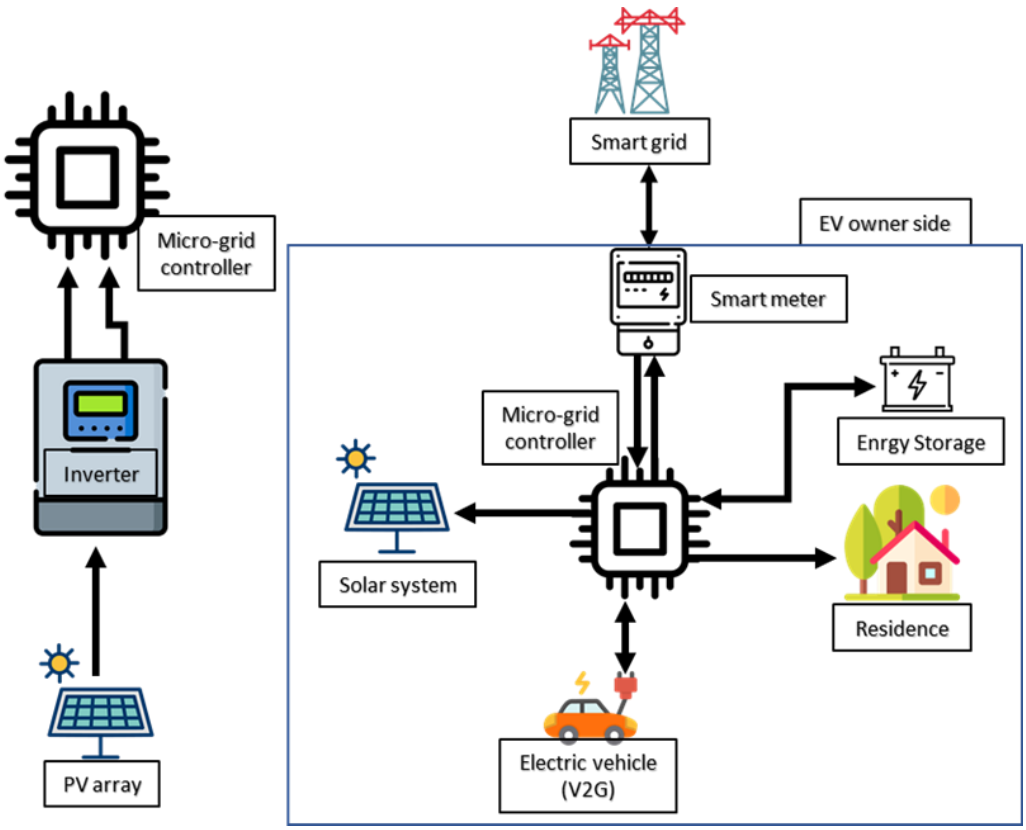

Figure 3. 6 Combined solar-powered electric vehicle charging with vehicle-to-grid (V2G) technology with battery.

Therefore, we will be able to provide the national grid with energy during the day through the smart grid and charge vehicles from the national grid during off-peak hours, which begin at 11 pm and end at 8 pm [19] The vehicle owner will specify the charging time, and the automobile will charge itself at the appointed time. The energy storage battery system will charge itself in the meantime to prepare for increased energy delivery during peak hours. as Energy at peak times is more expensive per unit than energy at off-peak times, thus the stored energy will be sold to the national grid at a set price[70]. Using an extra battery as illustrated in figure 3.5 cost a huge amount of investment for this reason we can avoid the extra use If we use an additional battery as storage, our loss will be more than our profit because battery technology is not cheap yet, so we have to pay a relatively large initial investment here! On the other hand, we can just use the battery that comes with our electric car as our battery storage without using extra batteries which are shown in figure 3.6. Because most car users use the car during the day and return home after work at night or in the evening, the extra electricity can be supplied to the grid from the car's battery, which can then be supplied to the national grid through vehicle-to-grid technology.

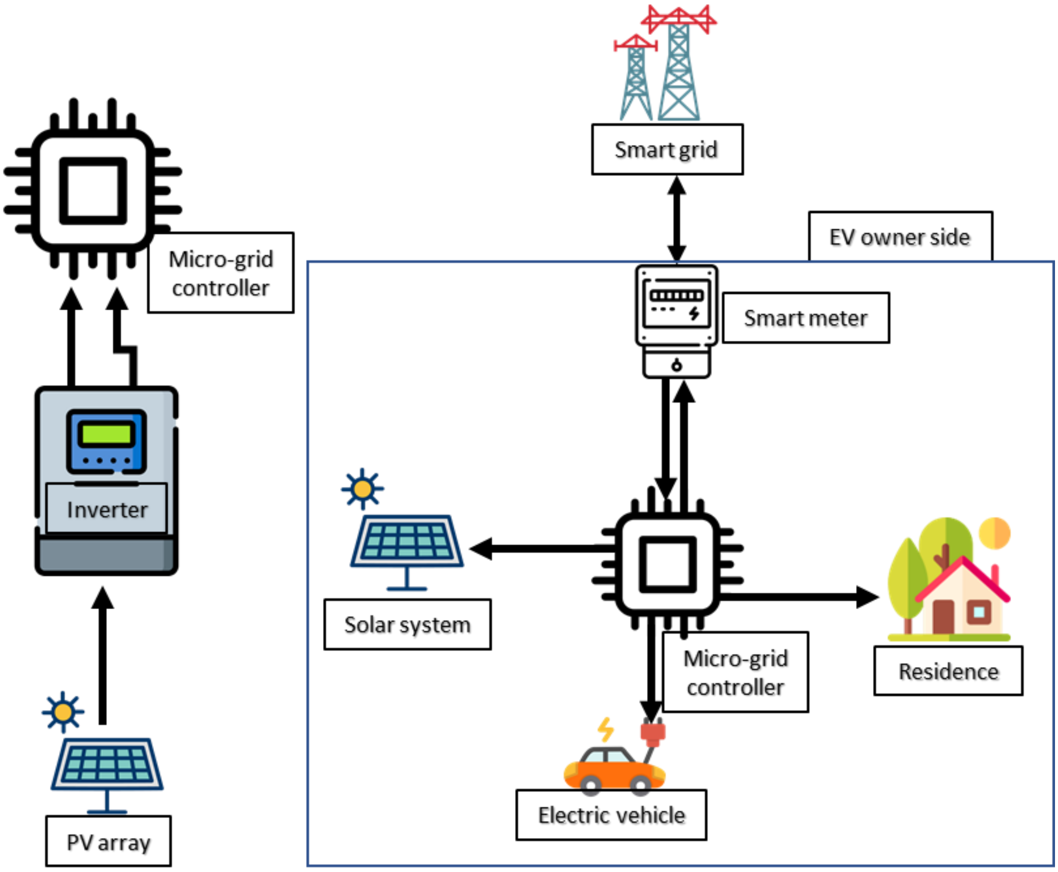

Figure 3. 7 Combined solar-powered electric vehicle charging with vehicle-to-grid (V2G) technology without battery.

3.4 suggested policies

1. The government should free or reduce the VAT and tax of electrical vehicles so that everyone can buy solar with the money of that VAT and tax to meet their own needs as well as provide some electricity to the national grid.
2. The government must buy electricity from the consumer at a fair price.
3. If the consumer wishes, he can use the entire electricity to fulfill his other needs.
4. Consumers can purchase additional electricity from the National Grid at a fair price.
5. The more electricity the consumer gives to the National Grid, the more the price per kilowatt will have to be paid by other consumers. So that everyone is interested in paying more electricity to the National Grid.
6. Everyone who buys an electric vehicle must buy a solar system.
7. The consumer must buy solar systems for more power than he needs.

Having these agreements will benefit both the government and the consumer. Because tax and VAT are free or reduced, consumers will be interested in buying electric vehicles and because of more profits, they will buy more power solar systems, which will supply more electricity to the national grid. As a result, our national grid power deficit will be met. On the other hand, the number of diesel vehicles in our country will continue to decrease and the number of electric vehicles will continue to increase. As a result, carbon dioxide emissions will decrease and environmental pollution will also decrease.

3.5 Summary

In this chapter, we describe all the equipment related to our thesis and describe the working procedure by drawing the diagrams we need. we also Discussed about solar systems with and without batteries, which one we think is best and why. at the end of this chapter We have proposed a possible regulation policy for taking and supplying energy between the government and consumers through some agreements.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Result

As stated before, each user would build their solar microgrid system to accommodate their EV charging needs. Here, we're assuming that solar energy is produced for six hours every day, 2,500 hours per year. Since no user will be able to utilize all of the solar energy generated by their installed MG system. The extra energy will either be consumed by household appliances or provided to the grid each day. As the number of users grows, solar energy production will also grow accordingly, supporting the national grid will also grow.

EV type	Installed solar system	Owner-generated electricity per day	Annually supplied electricity
for the small models	2-5KWh	12-30kWh	5000-12500kWh
for the medium-large	4-7KWh	24-42kWh	10000-17500kWh
for the high performers,	10-15KWH	60-90kWh	25000-37500kWh
for the sports models	5-15KWh	30-90kWh	12500-37500kWh
for the Chinese sports models	3-10KWh	18-60kWh	7500-25000kWh

Table 4. 1 Installed solar energy system according to user vehicle battery size.

4.2 Discussions

Key challenges we are facing with our proposed system are V2G, Challenges for Monitoring and Design of Grid Networks, Problems with the advanced metering infrastructure (AMI), Security Challenges, Control of frequency droop, Loss of transformer power, Voltage regulation

Challenges with vehicle-to-grid technology: renewable energy technologies promise to produce clean, plentiful energy. The flexibility required to balance supply and demand is a problem for renewable energy sources like solar, wind, and tidal energy. Demand and supply in electrical energy systems must match at every time point, which is a need that is very pronounced [64]. Energy storage, which can be expensive, is essential to balancing the supply and demand dilemma. Vehicle-to-grid technology comes in handy here. it provides a decentralized type of storage, V2G might potentially benefit—or be coupled with—independent and decentralized power sources, therefore it need not simply benefit traditional energy sources or grid operators. Suppliers like those that use solar power to produce electricity. Here, V2G can help renewable energy producers and improve overall sustainable grid management [65]. Image Ref. [71].

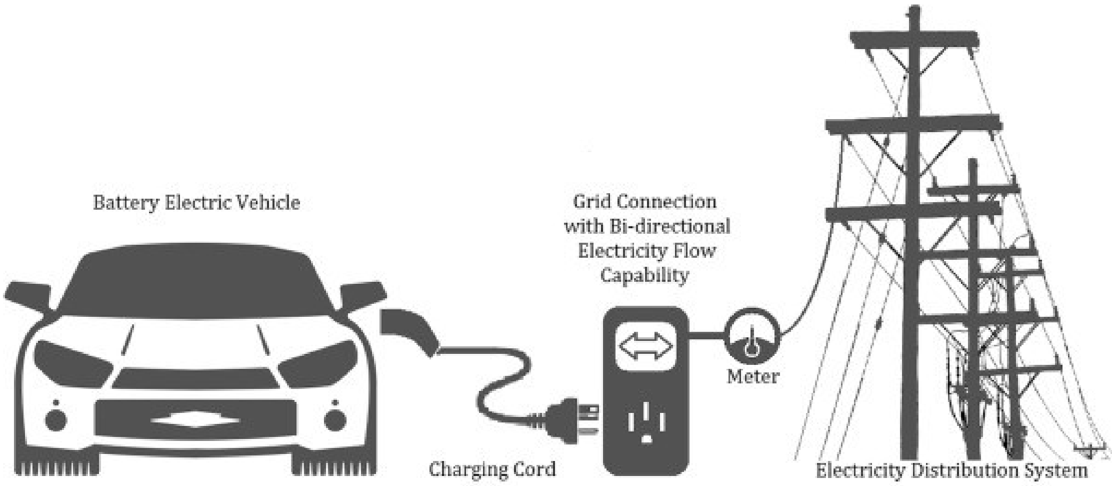

Figure 4. 1 V2G is represented simply in a schematic diagram [62].

Grid offers two-way data communication and electrical flow. A better way to include distributed renewable energy sources, including solar and wind, is through two-way electricity. energy, which benefits the averting of the energy problem as well as environmental preservation [66]. One of the crucial components of the smart grid, along with the home area network, is the vehicle-to-grid (V2G) network [67].

Vehicle-to-grid power is predicated on the concept that parked electric cars (EVs) can provide energy to the grid. Plug-in hybrids, fuel cell vehicles, and battery-powered electric vehicles are all viable options for the EV. Battery EVs can charge when there is little demand, and discharge as soon as you require power. Fuel cell EVs use gaseous or liquid fuel to produce electricity. Both modes are functional in plug-in hybrid EVs. The grid serves as a one-way conduit for power to travel from generators to consumers. When using battery-powered EVs, electricity can flow both ways back to the grid. The grid operator (abbreviated ISO for Independent System Operator) may transmit the control signal via broadcast radio, a cellular phone network, a direct Internet link, or a power line carrier. In any event, a huge number of cars receive requests for power from the grid operator. Each car might get the signal directly, or it may go to the office. the power of a fleet operator, which in turn manages vehicles in a single parking lot or via a third-party aggregator of scattered individual automobiles [68]. On the other hand, As the need for ancillary services (including frequency control, peak shaving, and load leveling) continues to grow, vehicle-to-grid (V2G) technology is being developed to facilitate the connection of electric car batteries to the power grid [23], [72]. The range of these vehicles is proportional to the size of the battery they use. Their average single-charge range is between 100 and 250 kilometers, with the most premium models reaching 300 to 500 kilometers. All BEV models use lithium-ion battery packs. Power ranges from 12 to 90 kilowatt hours (12 to 30 kilowatt hours for compacts, 20 to 42 kilowatt hours for midsize cars, 60 to 90 kilowatt hours for high-performance sedans, 30 to 90 kilowatt hours for sports cars, and 18 to 61 kilowatt hours for Chinese vehicles). It has been determined that between 78% and 95% of a battery's total energy capacity is utilized, allowing it to last for a lengthy period of time. Maximum voltages may reach 600-700 V in high-performance sports vehicles with battery weight to curb ratios of 13%-37%. Typical nominal voltages range from 300-400 V. Most proportions fall around between 15% and 25%. Ranges of 50,000, 60,000, and 100,000 miles (80,000, 130,000, and 180,000 kilometers) are common [73]. When using V2G technology, the electric vehicle (EV) batteries are charged, and, when the car is parked and linked, energy is also returned to the grid. Battery deterioration is the primary issue with the adoption of V2G [74]. A battery's level of charge concerning its capacity is known as its "state of charge" (SoC) [75]. the SOC is often expressed in percent, 100% means fully charged and 0% means fully discharged. And A battery cell's current health (or a battery module's or a battery system's) is measured using the state of health (SOH) concept and compared to the ideal circumstances for that particular battery[76]. On the other hand, a battery that is 100% charged is considered to be new. The capacity and internal resistance of the battery, as well as other battery characteristics like AC impendence, self-discharge rate, and power density, might be used to determine the SOH. Consider the capacity as an example. SOH might be defined as the difference between the existing capacity and the manufacturer's rated capacity [77]. Battery aging and degradation are the main causes of a battery cell's SOH deterioration[78]. Understanding the mechanism and modeling of battery degradation is essential for the effective study of V2G services on battery deterioration. Lithium-ion batteries have benefits in terms of energy density, power density, environmental friendliness, and charging capabilities when compared to other battery technologies, such as lead acid and nickel metal hydride batteries [78]. Generally speaking, calendar life (measured in time) or cycle life is used to describe battery life (in cycles). To assess battery deterioration, the remaining usable life (RUL) concept is established [79] The fraction of capacity lost during storage that cannot be recovered is called calendar aging. In other words, it refers to the deterioration brought on by battery storage [80]. And when describing batteries, "cycle life" refers to the total number of charges and discharges that a certain battery may undergo before becoming less effective. To a large extent, Li-ion battery cycle life is affected by the depth of discharge. The amount of a battery's storage capacity that is discharged is measured in terms of its depth of discharge [81].

According to a thorough study by Bui et al. 2021, semi-empirical aging models that have been developed and verified to capture the battery's degradation behaviors about both calendar and cycling aging may be used to estimate the energy capacity decline of electric car batteries. Before starting vehicle-to-grid operations, five charging methodologies for battery state-of-charge pre-conditioning have been devised to test the effectiveness of battery aging mitigation. These charging procedures have been used in simulation research on battery deterioration under two distinct operational profiles and the analytical findings demonstrate that the suggested charging strategies do not hasten battery deterioration and are capable of reducing the overall aging process from 7.3 to 26.7% during the first 100 days of operational life to 8.6 to 12.3% during one continuous year of operation in comparison to the reference standard charging approach [25]. Discharging 40%-8% of the battery's state of charge to the grid may minimize capacity fade by around 6% and power fade by 3% over three months, according to another research by Uddin et al. (2017), assuming a daily driving cycle uses between 21% and 38% state of charge. Battery pack capacity fade in EVs may be reduced by up to 9.1% and power fade by up to 12.1% with the help of the smart-grid formulation [18].

Challenges for Monitoring and Design of Grid Networks: Poor maintenance has been one of the main contributors to Bangladesh's electricity infrastructure's epileptic nature over the years. This is true even in the face of increased generation capacity and the introduction of the Smart grid, whose use is constrained by the infrastructure's transmission and distribution system's malfunction. It is common knowledge that electricians only do emergency repairs, and that no preventative or routine maintenance is performed to ensure the smooth running or prolonged lifespan of the nation's power grid [82]. In this small South Asian nation, daily electricity production ranges from 25,700 MW [83], but in the lack of a sophisticated monitoring system, theft of electricity from power lines without remuneration has been commonplace in recent years. A good way to reduce systemic losses would be to combine green energy with intelligent grid infrastructure. Apart from theft from the electrical system, the issue is that more than 10% of daily generation is wasted on aging transmission lines[84]. A smart grid system by itself cannot reduce system losses if these lines are not altered.

Developing a power grid is greatly aided by the use of geographic information systems (GIS). Many utilities have found that GIS's ability to query databases spatially and execute searches is a practical and economical option. State estimators, which are based on data from SCADA systems and remote terminal units, are now used in the monitoring system at a control center in Bangladesh (RTUs). There is a single inefficient national load dispatch center and a second, equally ineffective distribution load dispatch center. Even while the present state of bus visualization allows for connections to be made to specific buses, these connections are not always geographically accurate [85].

Transmission of electric power quality and efficiency: The national grid of Bangladesh runs at 132 kV, 230 kV, and 400 kV and spans the whole nation. The 400-kV lines at Bheramara connect the nation's transmission network to India's national grid. To further improve the power network, the 400 kV transmission lines from Meghnaghat to Aminbazar and Ashuganj (North) to Bhulta are now operating. Two more 400 kV transmission lines are being built: Biyana-Kaliakoir and Mongla-Amin bazar[86]. But high-capacity transmission corridors will be connected to the primary territorial linkages in the smart grid transmission network's ultra-high voltage, or voltage greater than 800 kV. So, it is a big problem [85].

Utilizing high-capacity, governable AC and DC systems, long-distance transmission can be established. The smart transmission grid will also make use of a distinctive digital platform for quick and dependable communication, sensing, computing, control, security, visualization, and maintenance of the entire transmission system [85].

Problems with the advanced metering infrastructure (AMI): The smart meters or AMIs will be the main components of the future intelligent grid system since they will give energy users the ability to monitor their power usage in real-time and intelligently adapt to demand. But integrating smart meters with the current systems is a significant hurdle. The AMI system is required to achieve a high level of data interchange without being dependent on a single vendor and to allow for technological advancement [85]. Image Ref. [87].

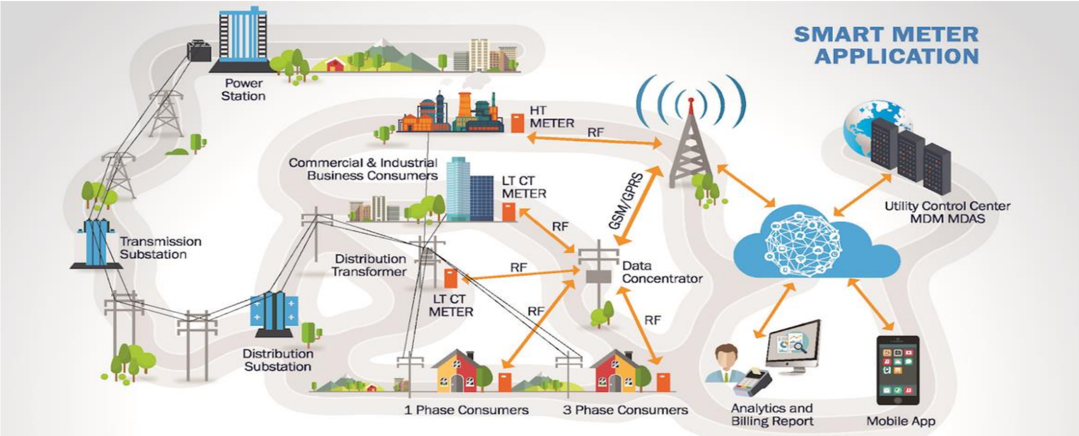

Figure 4. 2 An example of advanced metering infrastructure's schematic layout.

Adopting standards will aid in resolving this problem. Pilot projects have been set up throughout Europe to get ready for the major rollout of smart meter installations [88]. Utility firms have been dispatching employees to Bangladesh for many years to gather the necessary electrical statistics. Workers check meters, searching every area and location for damaged equipment. Smart metering makes it possible to accomplish this in a lot less time and with a lot more dependability. Although there hasn't been much commercial advancement in smart meters in this South Asian nation, several prototypes are being developed in academia, and their performance and reactions are being studied [85].

Integration Challenge of Distributed Energy Resources: Intelligent integration of dispersed energy production is possible via the use of sensors and two-way metering. Several renewable power sources, advanced metering systems, and enhanced lines of communication will make this a reality. As the share of renewable energy in total production increases, more nuanced regulation will be required to ensure the reliability of the power grid. Therefore, modifications are needed to accommodate the shifts brought about by the amalgamation of different generations [85].

There are numerous ready-made and specialized solutions to integrate generation from renewable energy sources into the system in Bangladesh. The integration of these green sources has been planned by numerous private enterprises, but policy issues rather than technical ones were delaying their implementation throughout the nation. Once more, the supply of energy from Renewable sources fluctuates greatly. While it is not always possible to run renewable energy conventionally, it is possible to foresee its behavior, and a smart grid must use this information to increase system efficiency. The nation's current electricity system is unable to anticipate and identify such fluctuation, and as a result, cannot sustain or regulate this. Therefore, a sensitive control system is needed to utilize transmission and distribution, as well as demand response and energy storage systems, more effectively[85].

Security Challenges: One of the primary concerns with any control system is security. There is a layer of control and communication systems in the smart grid at some points. Any control system that is linked to a communication system requires very high cyber security to ensure safe control[85].

These days, remote access to SCADA systems is possible. An attack on the SCADA system could result in a power outage in the current electrical infrastructure since the SCADA system regulates the power flow on the bus. In addition, there is a chance for issues when establishing two-way communications for AMI. It will not be difficult for any skilled programmer (hacker/cracker) to gain access to any specific equipment in today's ultrafast globalizing, internet-connected world, whether on accident or purpose[85].

Loss of transformer power: EV charging in clusters has the potential to overload transformers, increasing power loss. Table 2 depicts the overloading scenario of a distribution transformer with various EV loads. The harmonic current causes heating losses in the transformer core, increasing the overall power loss and lowering the transformer's kVA rating[89].

Output kVA under Rated current	Output kVA under Rated Harmonic current
200	191.80(1EV)
200	186.75(3 EV)
200	181.85(5 EV)

Table 4. 2 Transformer loss with various vehicle loads [89]

table ref.[89]

The loss of power in the transformer caused by harmonic effects can be by choosing a transformer with a greater k-factor. Adding more EVs to the distribution transformer the efficiency of the system will decrease due to higher losses. system power dropped[89].

Control of frequency drop: frequency drop is the main problem for the V2G system. When we give the power from the vehicle to the grid the frequency may vary. For this reason, we have to control the frequency.

Through frequency drop control and the measurement of active (P) and reactive power, the hybrid microgrid is controlled and shared power (Q). The following voltage amplitude equations and reference frequency are maintained via the frequency drop control:

Fi=fi*-pir2

Fi=fi*-miX(Pi-Pi*)

Vi=Vri*-niX(Qi-Qi*)

where fi is the reference-rated operating frequency for the micro grid and Vri is the reference-rated voltage of the DC bus. Real and reactive power is measured as Pi and Qi, respectively, whereas their rated values are P and Q, respectively. The droop coefficients for the load's maximum ratings are represented here by m and n[90].

Voltage regulation: Cables are typical in a low-voltage grid, and the resistance R is significant in comparison to the reactance X. The voltage amplitude in this grid will be affected by changing the active power flow.

The voltage regulation preserves the voltage within the boundaries established by the obligatory standard EN50160[91]. The charger may include this voltage control. When the voltage at the grid connection drops too low, the vehicles' charging will halt.

The discharge of an active power unit may also be considered in a subsequent stage to raise grid voltage[92].

There is potential for the implementation of new technologies and applications inside the transmission system. Flexible AC transmission systems, also known as FACTS, are deployed to improve the controllability of transmission networks while simultaneously increasing the capacity for the transfer of electricity. It is conceivable to boost efficiency while deferring the need for additional investment if this technology is used for lines that are already in operation. Offshore wind and solar farms may be linked to big power areas via the use of high voltage direct current (HVDC) technology. Because of this, energy sources that are geographically far from load centers may be efficiently harnessed. Technology advancements in high-voltage direct current (HVDC) have led to better system management and lower losses overall. DLR, or dynamic line rating, is a system that use sensors to instantaneously identify the maximum current that may be carried by a specific section of a network. DLR has the potential to maximize the use of existing transmission assets without running the risk of overloading those assets. High-temperature superconductors (HTS) have the potential to significantly cut transmission losses and allow more cost-effective fault-current limitations, although there is a dispute regarding whether the technology is ready for the market.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this research, we want to show that it is possible to reduce CO2 emissions by incorporating technology such as electric cars and others. Employing this thesis, we have put forward the idea that the issue of charging electric cars might be remedied by the use of solar energy. We suggested that we might help alleviate Bangladesh's energy crisis to some degree by delivering excess electricity to the national grid during peak hours. This would be accomplished by meeting our own need for electricity using solar power, which would then result in a surplus of electricity. We plan to use a solar power system that is connected to the grid rather than installing any additional batteries. We have offered, via the agreement, a solution to the issue that customers and the government had with electric cars, and we have also advocated that this solution would make people interested in purchasing electric vehicles. We have endeavored to structure the agreement in such a manner that it would be beneficial to the customer as well as to the government. In addition, we explore some of the potential obstacles that may arise during the installation of solar systems in Bangladesh and offer alternative solutions.

5.2 New Skills and Experiences Learned

While researching and writing this thesis, we learned about global and other national electricity production and consumption data. We also study the historical to the current growth rate of Electric Automobiles. we developed our reading comprehension skills. In the literature review section, we outline their contributions. For more information and to discuss our work, we must consult our academic advisors, teachers, course fellow students**,** and seniors while writing this paper. Their problem**-**solving skills are also improved. If we find that an argument is not entirely persuasive and we need to rethink our strategy, for example, it shows that we have the flexibility to change course if necessary and the self-awareness to know when we are pursuing the wrong goal. Further, we have learned to make the decision,

5.3 Future Recommendations

Because solar energy, microgrids, and electric automobiles are relatively new in Bangladesh, there is a lack of sufficient data and information about their usage in our nation. In the near future, through simulation and additional scientific research, it will be possible to achieve substantial improvements in both the entire EV sector of Bangladesh as well as the Bangladesh electric network system. This will be made possible by the growing number of EVs in Bangladesh as well as the increased availability of data.

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