Investigation Of Development Of Micro Grid With Electric Vehicles To Manage Network Energy To Reduce Costs

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A new concept, known as the microgrid, has emerged in modern power grids due to the increasing penetration of dispersed energy sources into electricity distribution systems, as well as environmental and economic concerns. With the increasing number of electric cars as an environmentally friendly transportation system, it has become possible to use them to store energy in microgrids. Microgrids can use their presence to mitigate the negative effects of fluctuations in renewable energy sources and provide part of the energy needed to operate the island. This study created a model for developing a microgrid of electric vehicles and presented a new AI-based protocol that manages grid-connected alternative energy sources.
In addition to collecting various data on all energy sources connected to the microgrid, using wireless sensor networks, it determines the most cost-effective and environmentally friendly energy source within the network.

Keywords: Electric Vehicle, Micro grid, Cost, Clean Energy, WSN, Machine learning

1. Introduction

Due to advances in technology, government incentives to use clean energy, and concerns about the high and rising price of fossil fuels, scattered energy sources have become a viable approach to producing clean, sustainable and clean local energy. This has led to the tendency to employ micro grids as a set of electric charges and various scattered energy sources. In recent years, much research has been done on micro grids power and their exploitation debate

[1-5]. In [1] the microgrid economic scheduling mathematical model considering the integration of plug-in hybrid electric vehicles (PHEVs) is proposed and the impact of various charging and discharging modes on microgrid economic operation was presented. In [6] designed optimal charging ability for electric vehicle (EV) charging station.

To maximize the benefits of using distributed generation resources in a micro grid, it is necessary to optimize the use of the micro grid and to manage the consumption side to increase efficiency. On the other hand, by increasing pollutions, electric transport system plays a prominent role in advancement system. The development of systems like the EV proposes different chances for next systems. In addition to increasing system efficient and how they are operated, energy consumption and pollutions will be deduced in transportation systems [7, 8].

In recent years, demand response has been extensively studied. The demand response has been investigated in various sources. In [9], a model is provided to show the effects of various demand response systems on the operation performance of a PEV parking complex, utilizing random programming in both cost and incentive based demand response programs and the level of parking complex participation is optimized in any demand response system. It also addresses the uncertainties of the PEVs and the electricity market. In [2], a robust two step optimization model is developed in order to solve the problem of guaranteed robustness against the uncertainties of reproducible distributed generation and demand response. A concurrent two-step micro grid strategy is proposed that adjusts one-day price-demand response and hourly distributed distribution output to maximize profit against system uncertainties.

In researches [10-13] the PVs were used as the energy storage for the Micro grid. In [10], the energy storage scheduling of an intelligent Micro grid was analysed utilizing PVs and seeking to minimize batteries usage. In [3], energy control strategy of a micro grid containing wind turbines, photovoltaic (PV) modules, combined heat and power (CHP), fuel cells, single power units, heating units, electric vehicles and thermal energy storage sources for the supply of electric and heat is provided. To achieve better demand-side management, cost-based and incentive-based demand response programs (DRPs) were employed and their effects on reducing the costs of operating a micro grid in network and island modes are investigated. Also, uncertainties in price, load, wind speed and solar radiation are considered to obtain real results. By dividing the probability distribution functions of per uncertain factor, a set of scenarios is developed.

In [4], a risk-constrained random structure is proposed to maximize the profitability of a micro grid operator with the uncertainties of renewables, load demand and power prices. In the developed approach, the reconciliation between the maximum expected profit of the beneficiary and the risk of low profit in the undesirable scenarios is modeled utilizing the Conditional Value at Risk (CVaR) approach. Impact of consumer participation on Demand Response (DR) programs and their emergency load loss for various amounts of lost load (VOLL) are explored based on requested operating profit, CVaR, demanded energy and scheduled micro grid reserves. In [5], a two-step random optimization is conducted for short-term performance of micro grids with multi-energy carrier network to determine programmed energy and reserve capability. The problem is determined as an integer linear program. The cost function is to minimize the demanded operating price in the short run. By introducing scenarios with relevant probabilities, uncertainties in renewable generation like the wind and solar photovoltaic generation, and electric and thermal demand are considered. In addition, the efficiency of requested response programs to deduce operating costs and amend security factors is measured. In [14], a new random approach with multi uncertainty resources containing load demand variability, PV and wind alternation frequency, location and random demand of Electric Vehicle and market price is introduced. The developed approach helps in minimizing the expected operating cost of an energy collector according to random programming. A case study showed that DR reduces the effect of uncertainties. In [15], using distributed contingency planning, intelligent distribution system scheduling is planned and subscribers participate in energy and reservation planning. A demand response DRP provider combines load reductions to contribute to small and medium loads in the demand response program. In [16] points out the role of demand response DR in power grid smarting. The peak hours of demand can also be changed to off-peak hours by optimizing the performance strategy by setting a dynamic and varied price in the energy management system. In this regard, optimal production planning is based on pricing strategy [17, 18].

2. Electric Transportation

In [19], an optimal robust technique is used to plan short-term operation of the distribution network in the presence of uncertainty in the electricity market price. The effect of EV parking as an energy storage technology on the purpose function of the distribution system is discussed. In [20], renewable energy sources according to a micro grid (RMG) is proposed. The issues of optimal energy management of RMGs with the presence of PEVs are discussed. The goal of the RMG owner is to make a minimum cost by generating energy with its local generators and exchanging energy with the electricity market. In addition, RMG can motivate PEV owners to participate in a Response Plan (DR) as a flexible burden. This can be beneficial to owners of both PEVs and RMGs. The uncertainties in the scenario-based framework are modeled. In [21], a concurrent EV distribution management that extracts the bidirectional power distribution potential between the main network and the EV according to short-term forecasts of network request and RES generation, developed charge control, EV demand over They prioritize the clock with RES surplus and take advantage of the V2G capability to minimize system variance. In [22], an intelligent distribution system operation planning that evaluates renewable energy sources along with electric vehicle parking lots with demand response programs in place. Also considered are the uncertainties of RER and PLs and a proper charge/discharge planning of EVs. Price and incentive based request responses are employed for operational planning. In [23], to accommodate the uncertainties of renewable energy sources, loads, market price signals, and arrival times of the Electric Vehicle in the micro grids operation model, a micro grid based on a robust optimization approach is proposed. Specifically, it focuses on the uncertainties of the arrival and departure of the Electric Vehicle. An energy control strategy is considered for a charge in parking system. In [24], the grid-connected charging park includes a photovoltaic system as well as hybrid EVs connected to electricity. An EV Collector, as an agency between power producers and electric vehicle owners, participates in the Pool and Future market to cater to the needs of the electric vehicle. The problem of optimal decision-making of an automobile picker has been addressed in the medium term under uncertain conditions [25].

The classical longitudinal dynamics equation of the vehicle is used to obtain the required average longitudinal force. This equation, despite its simplicity, is a precise way of describing the straight-line motion of a vehicle.

$$Ft = mgCr + \frac{1}{2}\rho CAV^{2} + ma + mg\sin\alpha \quad (1)$$

In equation (1), the first item represents the power needed to compensate the rolling resistance of the vehicle heel. This power is independent of vehicle speed. The second item represents the aerodynamic force that the car should overcome at a specific speed. This force is proportional to the square of the car velocity. Air resistance is low at low speeds but increases rapidly with increasing speed. The third sentence represents the inertial force caused by the acceleration of the vehicle, which is zero under constant speed conditions.

$$Ftractive = Fa + Faerodynam + Fascend + Frolling \quad (2)$$

$$Fa = (vehicle\_mass + caro\_mass) \times (V - Vpre) / \Delta t \quad (3)$$

$$Fascend = \sin(\arctan(grade)) \times current\_veh\_mass \times g \quad (4)$$

$$Faerodynamic = \frac{(Vavrege)^{2} \times Fa \times Cd \times \rho}{2} \quad (5)$$

$$Frolling = [wh\_1st\_rrc + Vave \times wh\_2nd\_rrc] \times (\cos(\arctan(grade) \times current\_vehicle\_mass \times g) \quad (6)$$

The EV with the status of the state of the charge (SOC) and the required power, based on the longitudinal dynamic force can join to the network to regulate its power.

3. Investigation of Micro Grid Structure

3-1 Micro Grid

The power micro grid is part of the distribution grid and has a set of distributed energy sources and loads, both electric and thermal that can operate in either the main or island mode. The micro grid connects to the main grid via a substation by a transformer, called a common connection point, and serves a variety of loads such as: domestic, industrial, commercial, and so on. Although small standalone grids have been around for a long time, the concept of micro grid was first introduced as a solution to maximize the presence of distributed energy sources in the power grid and utilize their benefits to increase efficiency. The environmental and economic benefits of the micro grid and consequently the expansion of the micro grids are closely related to their energy management, intelligent and optimal control. The primary purpose of a micro grid energy management system is to deliver high reliability electrical power to the consumer and optimize power generation to predetermined targets. An energy management program is performed by a central micro grid controller, local distributed controller, or a combination of the two above. At present, the approach of using local controllers has attracted more attention, leading to the emergence of different hierarchical control strategies. In this strategy, the local controllers are highly intelligent and do not need to communicate with the central controller for some of their decisions. An energy management program must determine the optimal power point with respect to all the constraints of the problem so that power consumption can be appropriately distributed across all generating sources and the micro grid will remain stable during disturbances. Therefore, proper utilization of the micro grid according to the stated objectives is the main task of the energy management program [26-28].

3-2 Micro Grid Structure

The micro grid is usually connected to the main grid by a distribution substation via a common connection point and includes a variety of distributed generation sources, energy storage systems and electrical and thermal loads. Figure 1 shows a micro grid with its usual components. The micro grid usually operates in the grid-connected state, but is expected to be able to independently feed its critical vital loads independently of the grid and remain voltage and frequency stable. Therefore, the micro grid can be isolated from the main grid when errors occur and operate in island-independent mode. For the network user, the micro grid is a controllable system with which it can exchange two-way power. One of the essential features of a micro grid that distinguishes it from a set of distributed energy sources that are not managed is the island's micro grid capability. This unique feature of the micro grid allows the micro grid to be disconnected when the power quality of the main grid is not satisfactory. For this reason, micro grid consumers generally have higher quality electricity [29] [33].

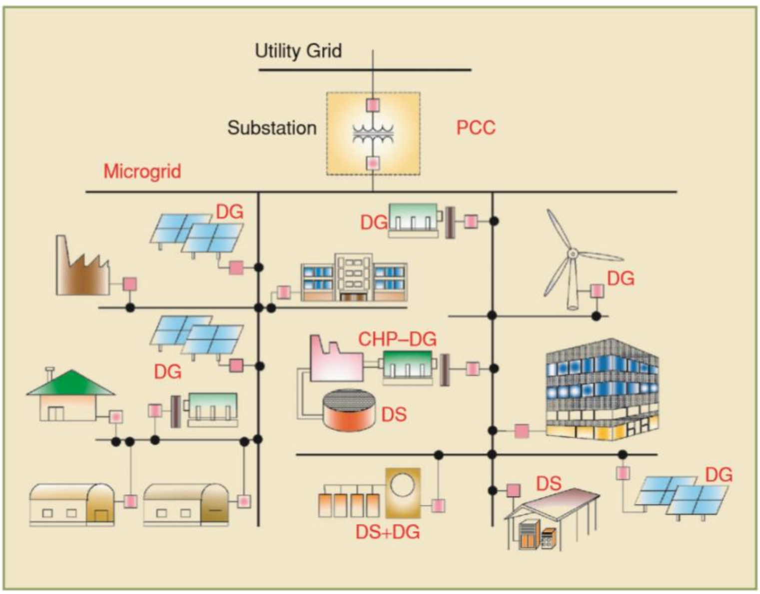

Figure 1: A typical micro grid structure consisting of scattered loads and generating units [33]

Depending on the type and amount of distributed power sources, load characteristics, power quality constraints and market strategies, micro grid management and control strategies can be different from traditional power systems, and the most important reasons for this are:

- Dynamic and steady state characteristics of distributed generation sources with power electronics converter are very different from traditional synchronous generators.
- In the micro grid there is always a great deal of unbalance due to single phase loads.
- A significant portion of the micro grid power supply is of uncontrolled type. For example, the electrical power of a wind turbine or solar cell is completely affected by weather conditions and is highly uncertain.
- Long-term or short-term storage resources can play an important role in controlling and operating the micro grid.
- Economic issues require that the micro grid occasionally cut or plug some energy sources or loads, while traditional systems do not.
- The micro grid is usually responsible for generating heat in addition to generating electricity.

The main components of the micro grid are distributed energy sources including distributed generation (fuel cell, photovoltaic system, wind turbines, micro turbines, CHP, etc.), distributed storage (batteries, flywheels, super capacitors, compressed air storage) and Electrical and thermal loads, including controllable loads and critical loads

3-3 Role of Electric Vehicle in Networking

With increasing the global emissions, electric transportation plays a prominent role in sustainable development. For this purpose, EVs and demand response have inevitable effects on the next intelligent grids. Therefore, the integration of PEVs into the grid is a main factor in achieving sustainable energy process [1]. EVs, as a new emerging electric charge and a fundamental technique to smart grid, have gained more attention worldwide and are stimulated as a next way to energy management problems due to their properties and storage power emerged [25]. It is anticipated that the using of renewable DER and EV techniques will fundamentally improve the requested profile of energy systems and impacts on the way distribution networks are managed and operated [28]. The conventional power grid faces major challenges due to increased demand and aging infrastructure. From an economic point of view, it is not reasonable to increase production capability indefinitely to meet demand. So the smart grid has emerged to increase the power grid's tolerance for future potential demand, namely Electric Vehicle Charging (EVs), and alternating renewables, wind and solar energy. The smart grid allows for the active participation of users through Demand Response (DR), which plays a key role in load planning. With the rapid usage of EVs, vehicles will undergo major changes in the near future. As EVs gradually infiltrate our daily lives, they will consume enormous amounts of electricity [29]. Electric Vehicle may offer potential benefits for operating power systems, depending on their charging schedule [10]. One collector collects the demand for the EV fleet and on the other hand buys electricity from the energy market. A micro grid can also act as a collector and integrate EVs into the system. As is obvious, the EV will become another important element of the future power system, as they can reduce issues regarding energy consumption and emissions [27]. The goal is to reduce emissions by optimally and efficiently utilizing vehicles as loads and energy storage in MG with RESs [30]. The Vehicle-to-Grid (V2G) concept relates to electrical energy storage technology, which is capable of allowing two-way power distribution between an electric power grid and a car battery [31]. Depending on the V2G competency, the charging status of a car storage can be increased or decreased depending on the demands and revenues of the network. The widespread use of EVs collected in [32] is suggested to overcome the low EV storage capacity. EV parking lots are regarded as new players, and their role is to collect EVs to obtain significant storage amount from EVs' small battery capacity in the event of conditions.

3-4 Micro Grid Production Planning

The micro grid production program is an optimization problem, and this optimization problem involves two sub-problems in unit circuitry and economic distribution of load. Solving these issues in the micro grid varies according to its operating modes and the variety of energy sources available, as well as the uncertainty in the ability of renewable energy sources with the traditional power system. Micro grid generation resources are smaller than traditional power systems, which makes switching these resources easier and more flexible in production planning. Power exchange with the main grid, charging and unloading of storage resources is another feature of the micro grid. Due to the micro grid properties, all the issues should be considered in solving the production planning problem in order to achieve economical, safe and reliable operation of the power supply to the consumer. Common objective functions in micro grid production planning include: minimizing costs or maximizing operating income, maximizing use of renewable energy sources, minimizing environmental pollution and power received from the main grid.

3-5 Examination of types of demand response programs (Demand Response)

In restructured power systems, a two-way market is simply an entity that provides a mechanism for the buyer and seller to find each other and carry out energy transactions according to their needs and wants. A market without active consumer input is still a one-way market. Figure (2) represents how a one-way market with inactive and passive demand wanted to get higher prices than a two-way market with request and active production. [34]

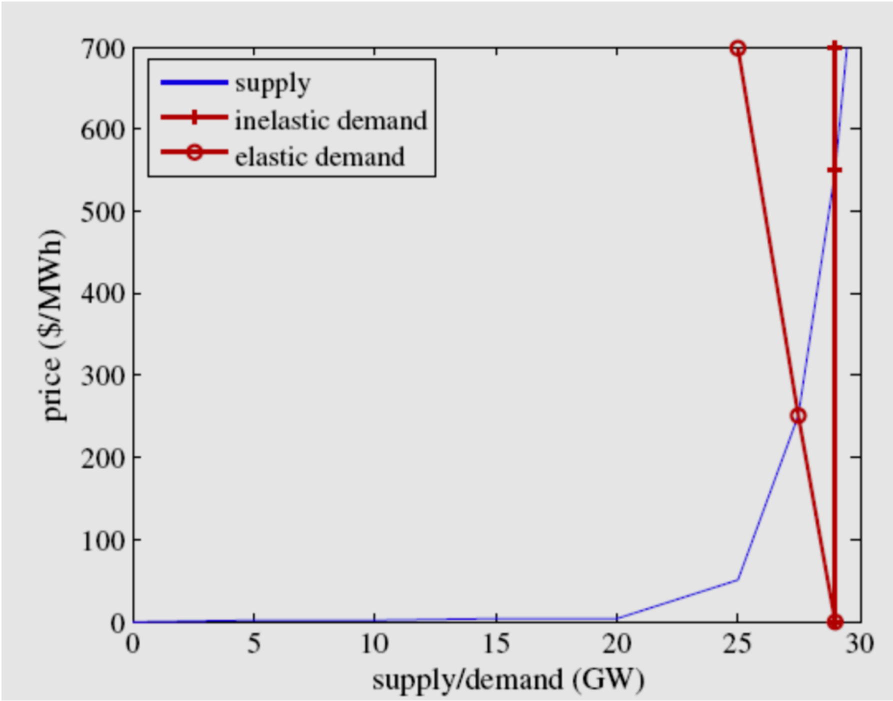

Figure 2: Influence of load elasticity on electricity price (in a bidirectional market)[34]

In general, DR programs can be classified in two main groups:

- Time and Incentive programs

Each of these categories contains several applications, as shown in Figure (3).

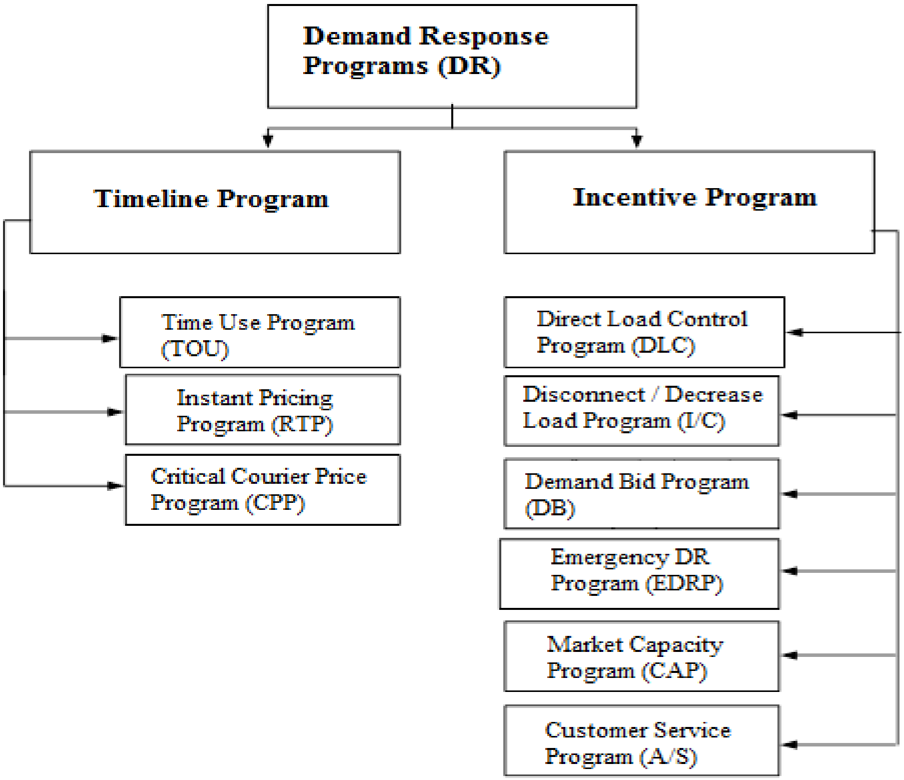

Figure 3: Classification of DR programs

3-6 Electric Vehicle (EV) Model

The concept of micro grid refers to distributed energy sources, various forces and power saving process that are linked to a mean voltage in a geographical area [9]. The micro grid can be used in both island and grid modes by improving the function and reliable system power grids [1]. Electric Vehicle is expected to have a significant percentage of car sales in the coming years. Extra power necessities for charging their batteries may affect network utilization in terms of reliability and reliability, especially when they coincide with peak system demand. This poses challenges for power system users to effectively integrate Electric Vehicle into power systems by discovering their capabilities, such as controllable loads. Modeling of electric vehicle operation is described in Equations (7-12) [30].

$$SOC_{t,s}^{v} = SOC_{t-1,s}^{v} + \eta_{v}^{EV,ch} P_{v,t,s}^{EV,ch} - \frac{P_{v,t,s}^{EV,dis}}{\eta_{v}^{EV,dis}} - P_{v,t,s}^{EV} \quad (7)$$

$$SOC_{\min}^{v} \le SOC_{t,s}^{v} \le SOC_{\max}^{v} \quad (8)$$

$$P_{v,\min}^{EV,ch} \times U_{v,t}^{EV,ch} \le P_{v,t,s}^{EV,ch} \le P_{v,\max}^{EV,ch} \times U_{v,t}^{EV,ch} \quad (9)$$

$$P_{v,\min}^{EV,dis} \times U_{v,t}^{EV,dis} \le P_{v,t,s}^{EV,dis} \le P_{v,\max}^{EV,dis} \times U_{v,t}^{EV,dis} \quad (10)$$

$$P_{v,t}^{EV} = \Delta D_{v,t}^{EV} \ \beta_v \quad (11)$$

$$U_{v,t}^{EV,ch} + U_{v,t}^{EV,dis} \leq 1 \quad (12)$$

It shows energy balances of EVs.   and   are the charge and discharge power modes. The charge and discharge status of   and   are considered as the now - and - here variables, so the charge and discharge status cannot be dependent on the scenarios. In equation (5), the power consumption of the Electric Vehicle ( ) is determined using the linear equation with respect to the distance. Figure 4, illustrates the performance of electric motor model in Advisor/Matlab, also for electric vehicle SOC variation for electric vehicle is presented in the figure 5. For a cycle with 8000 second, the battery SOC has been reduced to its lower limit 0.2 which import power to network as the EV.

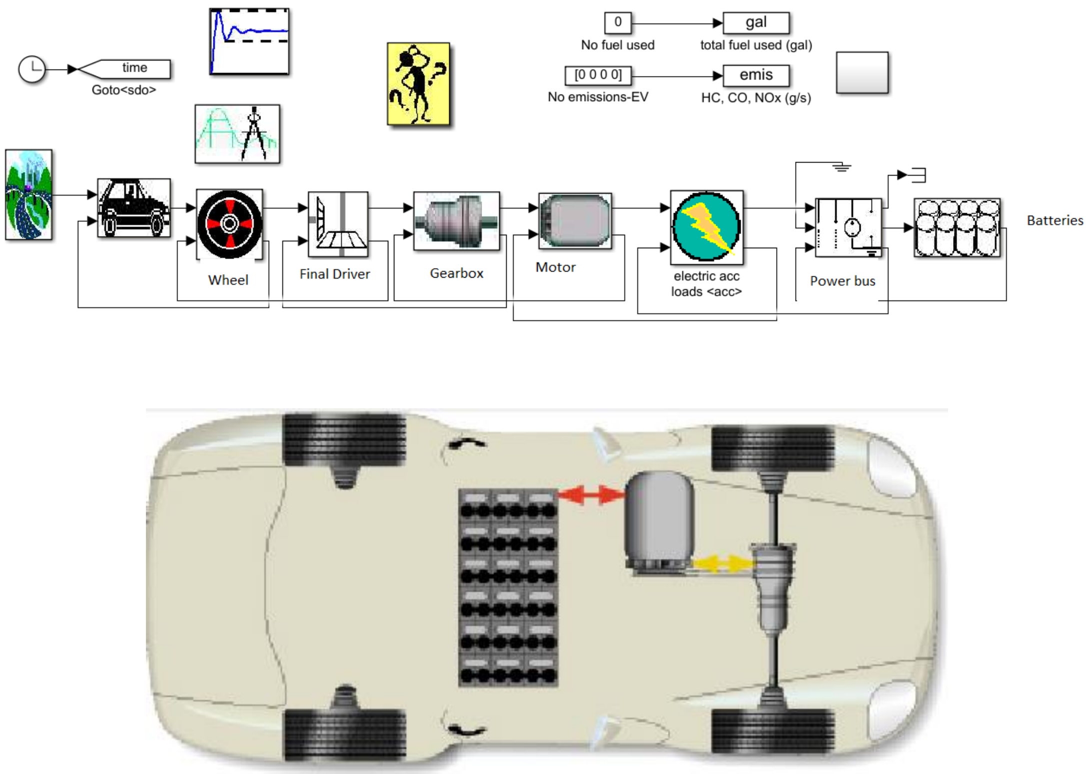

Figure 4: EV model in Simulink

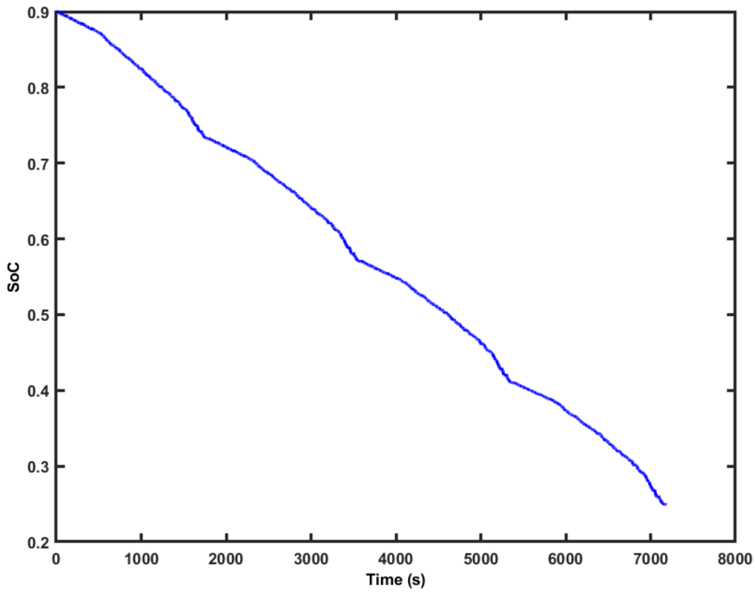

Figure 5: SOC variation

The EV performance regarding the hybridization and sensitivity to the grade of electrification are presented in table 1.

Table 1: Hybridization Effect

Hybridization		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Fuel (mpg)		29.5	32.6	36.7	38.6	41.7	43.4	47.4	53.1	59.2	65.3
Pollution)gas/mile(	HC	0.94	0.98	0.83	0.71	0.57	0.50	0.36	0.25	0.17	0
	Nox	0.82	0.94	0.81	0.71	0.60	0.55	0.51	0.40	0.28	0
	Co	0.18	0.10	0.18	0.17	0.16	0.17	0.15	0.13	0.13	0

The reduction trend of vehicle mass, fuel consumption and emissions are observed by the degree of hybridization increases. Finally, to evaluate the impact of the initial charge level on the performance of the hybrid at three levels of initial charge, 50%, 70% and 90% are considered for a conventional hybrid vehicle.

4. Economic Energy Management Protocol

In addition in this paper we establishing a new Economic Energy Management Protocol(EEMP) to organize and manage the provision of energy sources that are the least expensive and cause the least harm to the environment. This protocol includes three stages: monitoring, conclusion, and recommendation. Monitoring consists of equipping all alternative energy sources available in the microgrid with smart wireless sensor nodes to record and process data.

The conclusion stage represents the calculation and processing of three key factors: the current load of each energy source in the microgrid, the amount of surplus energy, and the amount of pollution. Finally, the recommendation stage refers to the energy source that is least expensive and pollutes the environment.

4.1 Wireless sensor node stage

Wireless sensor network technology has opened promising horizons in monitoring and control operations in many application fields. These networks include communication protocols to perform the tasks of transferring sensor data and controlling commands. It is characterized by its low cost and ease of handling. Figure 6 represents the proposed sensor node for the new protocol. These nodes collect many data points about the alternative energy source, such as the amount of pollution, the maximum amount of energy that the source can supply, the amount of current surplus energy, the cost of the energy generated, the amount of current load, and the timing. Apart from their intelligence, these nodes also reduce their energy consumption by only transmitting data that doesn't surpass the predetermined thresholds for each type of sensor data.

4.2 Conclusions and recommendations stage

The main station receives data from all nodes, processes and compares it simultaneously, and then draws conclusions based on the three main factors for each alternative energy source in the microgrid. These factors include the amount of excess energy, its cost, and the amount of pollution that results. We then subject the data on the main factors for all alternative energy sources to a minimization algorithm to determine the optimal alternative energy source that offers the lowest cost of energy generation and the least pollution to the environment for EV. Figure 7 represents EEMP protocol diagram.

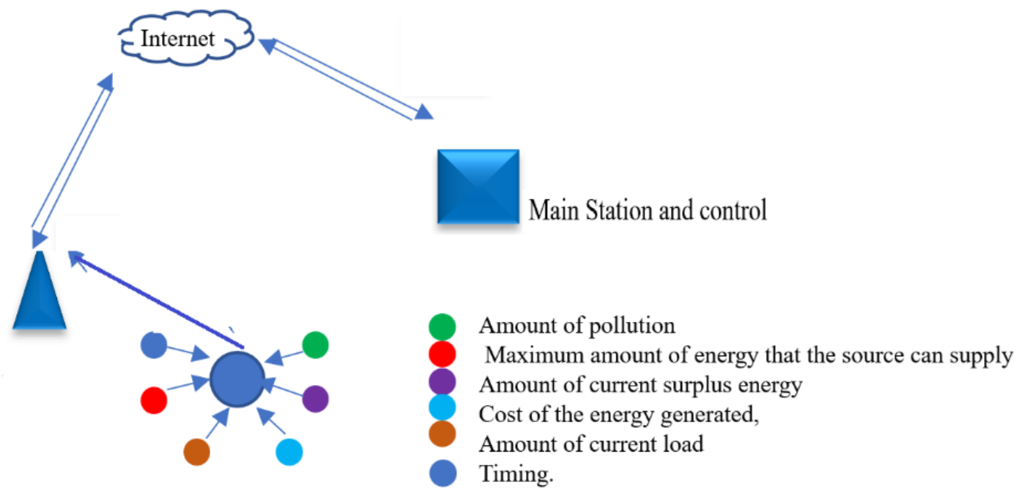

Fig.6. The proposed sensor node for EEMP.

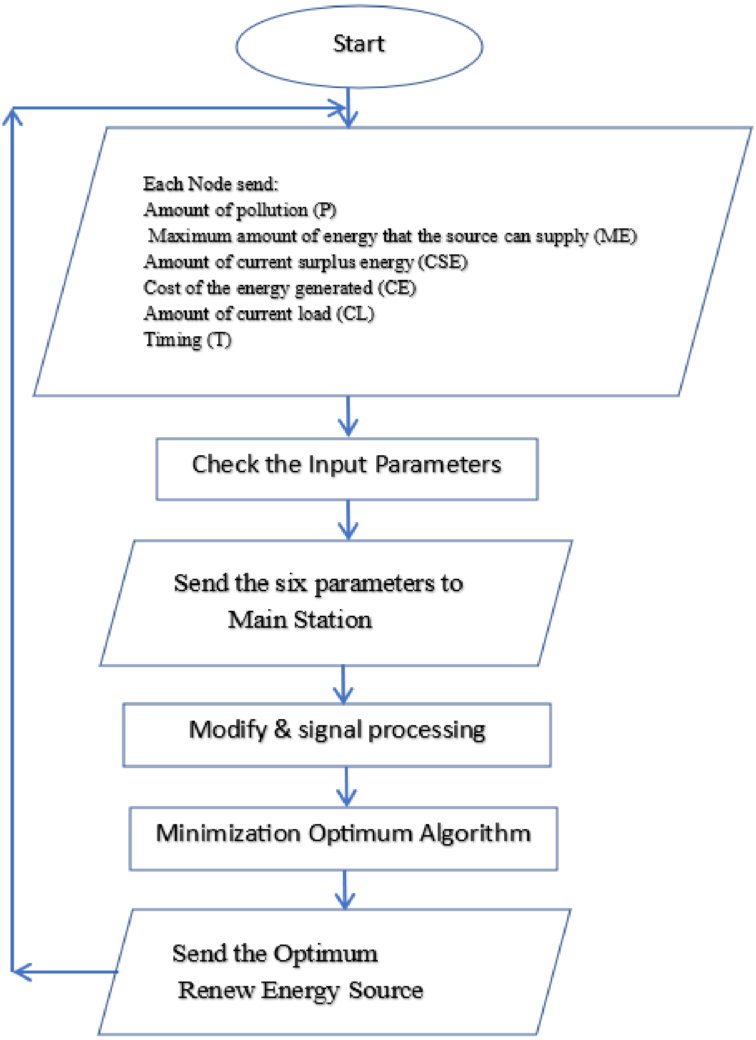

Fig.7. Flow chart of Economic Energy Management Protocol (EEMP).

5. Conclusion

The presence of electric vehicles in a micro grid, taking into account the limitations of the Electric Vehicle night, also to being an electricity consumer, can also be addressed in micro grids by discharging energy from their batteries. It is important to manage the amount and timing of battery charging and discharging, as mobile energy storage systems in micro grids. In addition to the main grid, the network uses distributed generation and storage systems to supply the energy needed by consumers. Electric Vehicle is one of the sources of electricity generation and consumption that can play an important role in network management by connecting to the electricity grid. This paper presents a review and planning analysis for the micro grid with Electric Vehicle and analyzes the use of load response program to overcome the challenges of network management. In addition to developing a new protocol to filter the optimal energy sources available in the network in terms of the least pollution to the environment and the least cost.

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