HYBRID CARS: CONCEPT OF V2G AND LOAD EQUALIZATION

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1. INTRODUCTION

"V2G and Load Equalization" acronym for vehicle to grid and load equalization, an unconventional method of load curve equalization by using electrical and connected hybrid electric vehicle by energizing or de-energizing in a manner corresponding to requirement with respect to time and place.

Here in our project we are going to see the actual concept and idea by a prototype model which consists of conventional and unconventional generating points, storage unit, comparator, DC and AC loads.

Mainly dc loads here are PHEV's and EV's which are acting as dc load during valley hour or time and there is also a port for discharging vehicle for bidirectional flow of energy to equalize the load response/duration curve flat.

As conventional we have shown a simple transformer connected to ac loads directly and battery bank by converter solar and wind plants are shown as unconventional dc power production units directly connected to the battery bank which is controlled by potentiometer as a comparator. According to the load variation we are shifting our load and also charging our PHEV during valley hour of demand and giving it back while there is a peak period to the battery bank by discharging efficiently.

2. NEED OF PHEV FOR LOAD EQUALIZATION

As we know load equalization is always beneficiary from economic, reliability and efficiency point of view because it reduces the installed capacity requirement and leads to economic energy. The peak load reduction results into grid security that is reliability as well as efficiency.

PHEV is an unconventional way of storage element which is mobile and beneficiary at two stages transportation as well as storage it has higher efficiency than pumped storage plant and other peak load suppliers. In smart grid integration with conventional sources like solar, wind it can be a large interface because conventional sources like solar generally generates dc and our grid is ac so for the peak load supply as well as equalization PHEV can be easily charged from solar/wind and give power back to the grid by discharging stations leading to an efficiency of 80% much higher than conventional peak load suppliers.

3. OBJECTIVES

1. To increase reliability of power grid.
2. To provide continuous power supply.
3. To make the power grid eco-friendly.
4. Increasing consumer participation to power grid especially residential consumer through PHEV.
5. Working of smart grid in smooth way by doing Load Equalization.
6. Grid Security.
7. To make the grid decentralized and intelligent one.

4. LITERATURE REVIEW

4.1. Early Developments in V2G and Load Equalization

Electric vehicles (EVs) and module half and half electric vehicles (PHEVs),numbered around 1 million, are relied upon to be being used by people and armadas by 2015 (United States Department of Energy 2011). Unorganized charging of EVs will add to top network stack and would require extra production limit (Kiviluoma and Meibom 2011; Kintner-Meyer et al. 2007). Charging must be booked keenly keeping in mind the end goal to abstain from over-burdening the grid at pinnacle hours and to exploit off- pinnacle charging benefits. EVs can likewise serve as a energy asset by vehicle-to-grid (V2G) operation by directing electricity once again into the network, in this way anticipating or delaying load shedding. V2G administrations and charging must be improved for network stack while ensuring proprietor timetable and range necessities are met. A framework incorporating EV proprietor input by means of a versatile application, a conglomeration middleware, a charge booking, and V2G operation calculation, and radio-frequency identification (RFID) peruse, is presented

4.2.Recent Developments in V2G and Load Equalization

Late mechanical advances in electricity conveyance and load administration, alluded to as "smart grids," guarantee to encourage the incorporation of EVs into electricity stack and to reduce costs. Electric uses have as of now sent keen framework advancements to better oversee business and residential stack utilizing wise metering and interchanges frameworks with a specific end goal to spare vitality, cut emanations, and lessen top burdens. More far reaching arrangement would empower EV charging to be booked wisely.

Moreover, it could in any event on a basic level empower the capacity limit of the batteries in

EVs to be utilized as a supplementary wellspring of power now and again of pinnacle load; the remaining charge in those batteries could be encouraged once again into the system amid the night crest and the battery revived during the evening. There may likewise be degree for abusing this stockpiling potential to make up for the changeability of electricity transmission from variable renewable energy sources, for example, wind and sun powered. Along these lines, keen frameworks and EVs could be commonly valuable: EVs could both advantage from and drive forward interest in smart grids.

In this research is exhibited the innovation street mapping of a savvy battery charger for EVs or PHEVs, pointing their combination into smart grids. The battery charging procedure is controlled by a proper control calculation, intending to safeguard the battery life expectancy. The fundamental elements of the hardware are the alleviation of the power quality devaluation and the bidirectional operation, as grid to- vehicle (G2V) and as V2G. The V2G method of operation will be one of the principle elements of the brilliant grids, both to work together with the electrical power framework to expand strength and to work as a conveyed Energy Storage System (ESS).

Subsequently, EVs could assume a focal part in de-carbonizing street transport sooner rather than later. To set up the fitting procedures is required for its research and development. As indicated by Phaal et al., innovation street mapping is an appropriate instrument to develop vital and long haul arranging by evaluating possibly problematic advances and market changes. As needs be, the target of this paper is to build up an innovation guide for smart grids innovation. Specifically, this exploration concentrates on the utilization of keen grids in the EV charging for the home.

5. CONCEPT AND THEORY

Electrical grid is an interlinked system for conveying electricity from sellers to buyers. It comprises of creating stations (like warm, atomic, hydro, renewable sources and so forth.) that deliver electrical power, high-voltage transmission lines that convey power from far-reaching sources to request focuses, and dispersion lines that associate individual clients/buyers/loads.

5.1. Concept

The culmination of the aforementioned development constitutes Energy and fuel efficiency, Reliability, National economy and security, Environmental friendliness, providing consumer with choices pertaining to buying and selling of electricity is called smart grid.

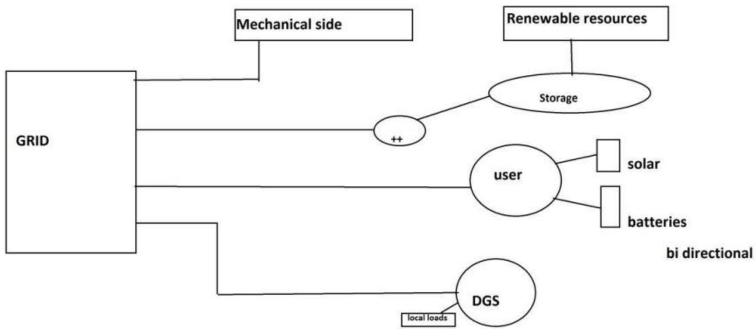


Figure 5.1 Block diagram of Bi-directional smart grid

The way by we make our load profile almost flat so that we can utilize our base power plant installed capacity efficiently is called load equalization. When our load is in valley then we should store the energy by using various storage techniques which provide energy during the peak demand so as to flatten the load profile.

5.2. Construction of Smart Grid

A Grid when connected in such a way that we can send or collect power from any end of the system and in which the facility of Distributed generation(DG) , renewable and non-renewable Interface are connected synchronously as well as asynchronously in intelligent way. The smart grid has more focus on increasing consumer participation, interaction and responsiveness would pave way for more decentralization and hence smart grid become more reliable. Smart grid role is not just to PHEV and DSM etc. but to keep environment clean. With the advent of PHEV a unique opportunity is available for residential consumer to directly participate in market operation.

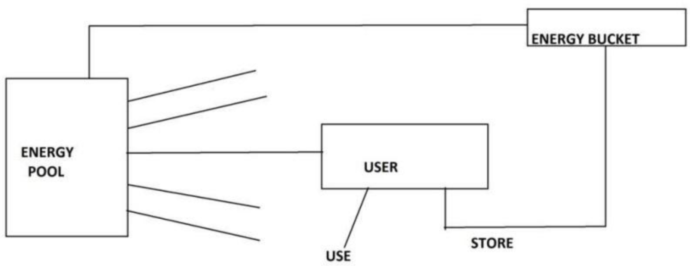


Figure 5.2 Consumers as GENCOS

Smart grid is the integration of electrical and digital technologies, information and communication system. Smart delivers electrical power to the consumers using two way grid technologies and Monitors the supply to the consumers and measurements.

5.3. Theoretical Background

The components used in smart grid are nuclear power plant, thermal power plant, solar, wind, hydro and other renewable resources. The devices used for storage are PHEV, fly wheel levitation, compressed air energy storage, batteries etc.

5.4. Nuclear Power Plant

The reason for an atomic power plant is not to create or discharge "Atomic Power." The motivation behind an atomic power plant is to deliver electricity. It ought not shock, then, that an atomic power plant has numerous similitude to other electrical creating offices. It ought to likewise be obvious that atomic power plants have some critical contrasts from different plants.

In splitting procedure, the cores of substantial radioactive atoms are broken into two almost a balance of. Amid this breaking of cores, tremendous amount of energy is discharged. This arrival of energy is because of mass defect. This implies, the aggregate mass of beginning item would be lessened amid splitting. This loss of mass amid splitting is changed over into heat energy according to well known condition E = mc. The fundamental guideline of atomic power station is similar to steam power station

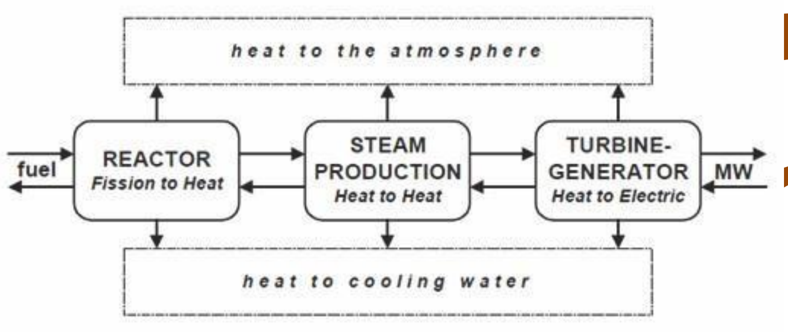


Figure 5.3 Basic block diagram of Nuclear Power Plant

5.5. Thermal Power Plant

Thermal power station or a coal fired thermal power plant is by a wide margin, the most traditional strategy for producing electric power with sensibly high effectiveness. It utilizes coal as the essential fuel to heat up the water accessible to superheated steam for operating the steam turbine. The steam is then mechanically coupled to an alternator rotor, the revolution of which results in the production of electric power. For the most part in India, bituminous coal or cocoa are utilized as fuel of evaporator which has unpredictable substance running from 8% to 33% an fiery debris content 5% to 6% . to improve the thermal proficiency of the plant, the coal is utilized as a part of the evaporator in its pummeled shape

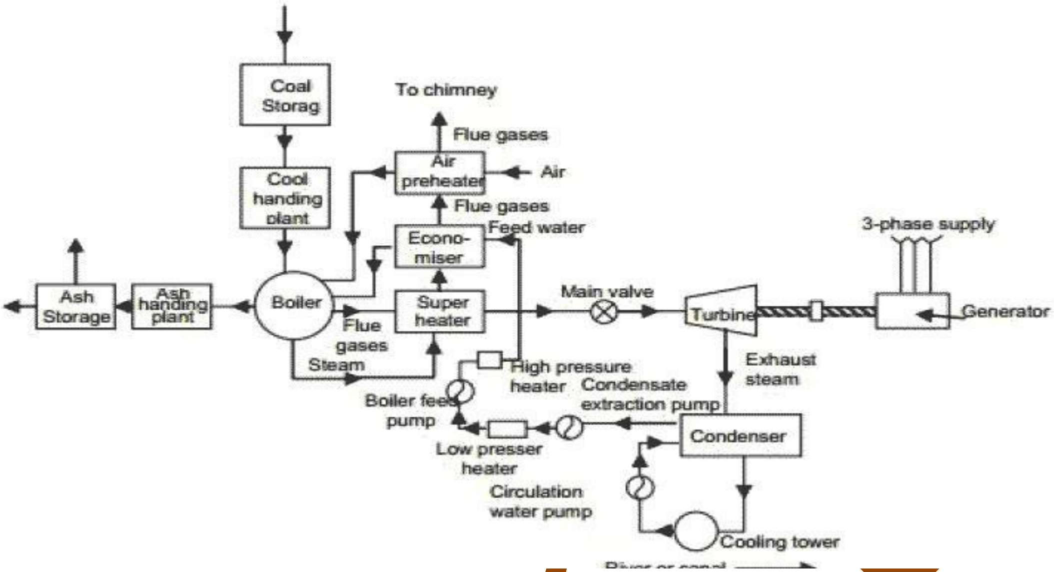


Figure 5.4 Layout of thermal power plant

Inside coal fired thermal power plant, steam is acquired in high weight inside the steam evaporator by blazing the pounded coal. Then this steam is super -warmed in the super radiator to outrageous high temperature. This super warmed steam is then permitted to go into the turbine, as the turbine cutting edges are pivoted by the weight of the steam. The turbine is mechanically combined with alternator in a way that its rotor will turn with the pivot of turbine cutting edges. In the wake of going into the turbine, the steam weigh all of a sudden falls prompting relating increment in the steam volume. In the wake of having granted energy into the turbine rotors, the steam is made to go out of the turbine sharp edges into the steam condenser of turbine. In the condenser, cool water at encompassing temperature is coursed with the assistance of pump which prompts the build-up of the low weight wet steam. At that point this dense water is further supplied to low weight water radiator where the low weight steam expands the temperature of this nourish water, it is again warmed in high weight. This framework is the fundamental working technique of a warm power plant.

5.6. Water Power Plant

Inside water power plant we utilize gravitational drive of liquid water to operate the turbine which is combined with electric generator to create power. This power plant assumes an imperative part to ensure our fossil fuel which is constrained, as the produced power in hydro control station is the utilization of water which is renewable wellspring of vitality and accessible in loads of sum with no cost. The enormous favorable position of water power is the water which the fundamental stuff to deliver electricity in water power plant is free, it does not have any kind of contamination and after produced electricity, the cost of power is normal not all that much high.

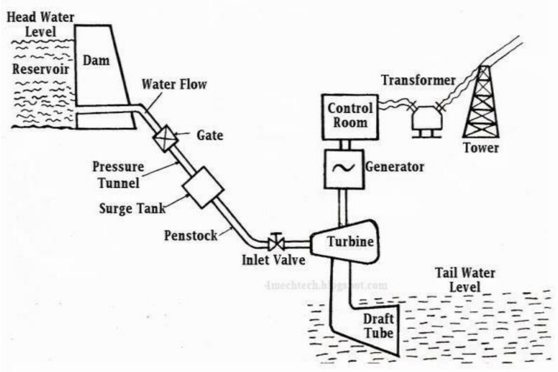


Figure 5.5 Basic Hydro Power Plant Layout

For development of water power plant, initially we pick the range where the water is adequate to hold and no any emergency of water and appropriate to manufacture a dam, then we build the dam. The primary capacity of dam is to stop the stream of water and hold the water in repository. Predominantly dam is arranged at a decent stature to build the compel of water. Stocking of heaps of water, which is utilized to create control by method for turbines, is done by reservoirs. After that Penstock, the pipe which is associated amongst dam and turbine cutting edges and the most vital reason for the penstock is to broaden the kinetic energy of water that is the reason this pipe is comprised of to a great degree well- manufactured material which carries on the weight of water.

5.7. Solar Power Plant

A grid-associated photovoltaic power framework or grid associated PV framework is electricity producing solar PV framework that is associated with the utility matrix. A grid associated PV framework comprises of sunlight based boards, one or a few inverters, a power moulding unit and network association gear. They run from little private and business housetop frameworks to expansive utility-scale sun oriented power stations. Not at all like stand- alone power frameworks, has a grid associated framework infrequently incorporated a coordinated battery arrangement, as they are still extremely costly. At the point when conditions are correct, the network associated PV framework supplies the overabundance control, past utilization by the associated load, to the utility grid.

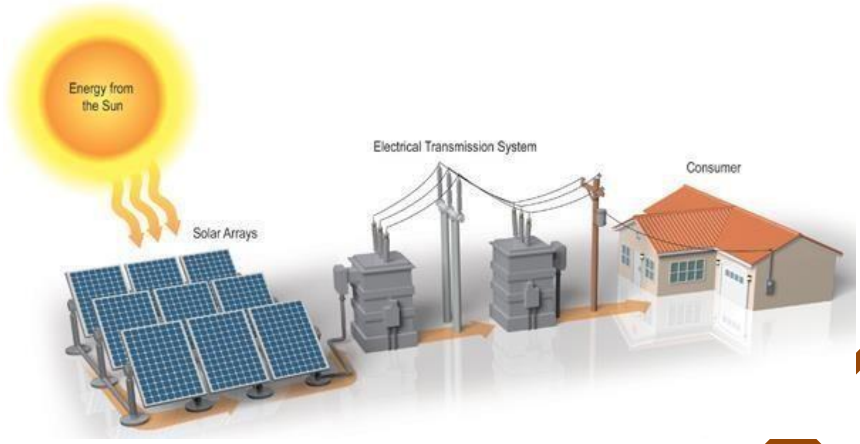


Figure 5.6 Basic layout of generating unit of Solar Power Plant

Household, grid associated housetop frameworks which have a limit more than 10 kilowatts can meet the heap of generally buyers. They can nourish over-abundant energy to the grid where it is devoured by different clients. The input is done through a meter to screen control exchanged. Photovoltaic wattage might be not as much as normal utilization, in which case the purchaser will keep on purchasing network vitality, yet a lesser sum than beforehand. On the off chance that photovoltaic wattage significantly surpasses normal utilization; the energy delivered by the boards will be much in abundance of the request. For this situation, the overabundant power can yield income by offering it to the grid. Contingent upon their concurrence with their nearby grid energy organization, the shopper just needs to pay the cost of power devoured less the estimation of power created. If more power is created than devoured then this will be a less than zero number. Also now and again, money motivations are paid from the network administrator to the purchaser. Association of the photovoltaic power framework should be possible just through an interconnection understanding between the customer and the service organization. The assertion subtle elements the different security measures to be taken after amid the association.

5.8. Wind Power Plant

Wind energy is presently immovably settled as a develop innovation for power era and more than 13,900 MW of limit is currently introduced, around the world. It is one of the quickest developing power creating advances and elements in energy arranges over each of the five mainland, both in the industrialized and the creating scene. WT change over wind energy into electrical energy, which is encouraged into power supply frameworks. The association of WT to the provision frameworks is conceivable to the low voltage, medium voltage, high voltage and to the additional high voltage framework. While the vast majority of the turbines are these days associated with the medium voltage arrangement of the network future extensive seaward wind homesteads will be associated with the high and additional high voltage level.

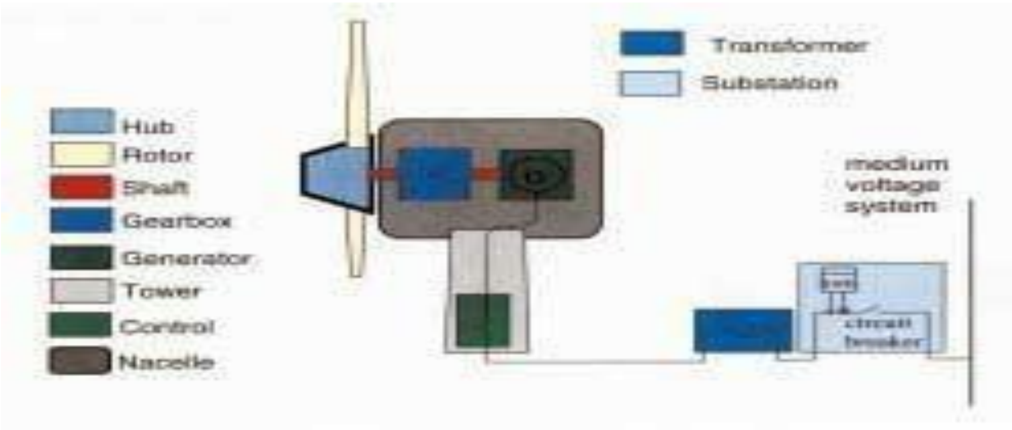


Figure 5.7 Components of Wind Power Plant

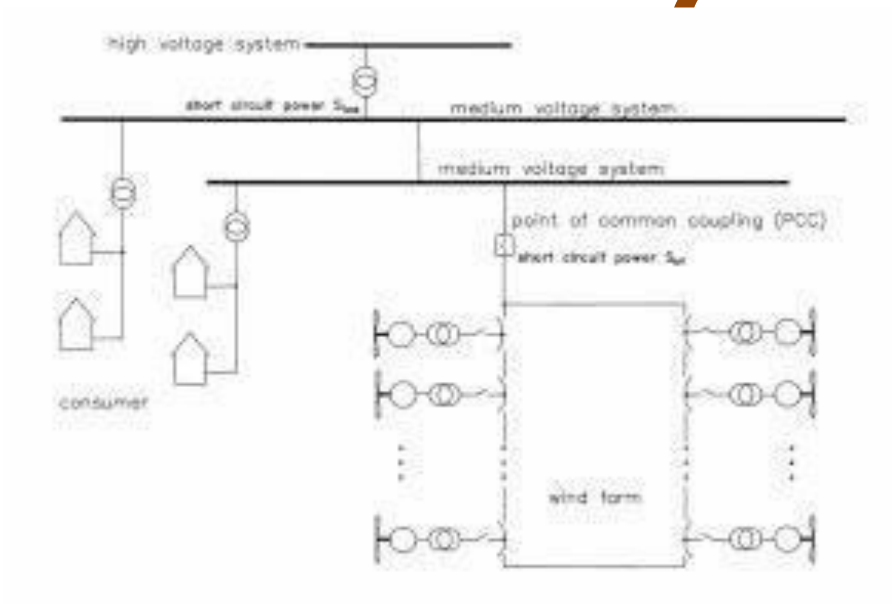


Figure 5.8 Connection of Wind Power Plant to Grid

5.9. Vehicle

Any means in or by which someone travels or something is carried or conveyed, a means of conveyance or transport. A conveyance moving on wheels, runners, tracks as a cart, sled, automobile, or tractor.

Types of Vehicle:

I. Mechanical vehicle: Those type of vehicles which only uses the principle of internal combustion engine(IC Engine).

II. Electric vehicle: An electric vehicle (EV), also referred to as an electric drive vehicle, is a vehicle which uses one or more electric motors for propulsion. EVs utilize a battery to preserve the electric energy which powers the engine. The batteries are charged by connecting the vehicle to an electric power wellspring. EVs are some of the time alluded to as battery electric vehicles (BEVs).

III. Hybrid electric vehicle: - The combination of an internal combustion engine (ICE) with one or more electric motor/generators battery pack is called plug in hybrid electric vehicle. It is a combined propulsion system which results in a better fuel economy.

HEVs are basically controlled by an inside burning motor that keeps running on customary or option fuel and an electric engine that utilizes energy put away in a battery. The battery is charged by a regenerative braking and through the inward burning motor and is not connected to charge.

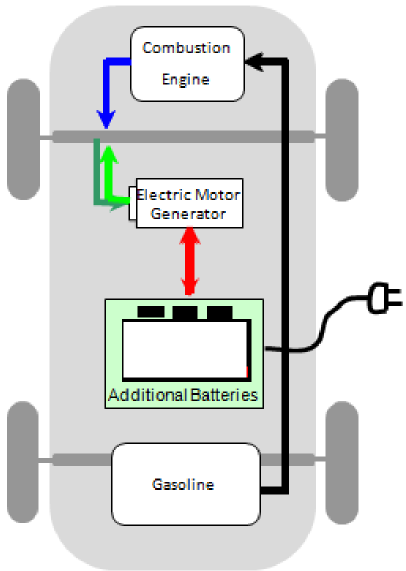


Figure 5.9 Block Diagram of a Hybrid Vehicle

PHEV (connect to hybrid vehicle):- PHEVs are controlled through an inner burning motor that can keep running on routine or option fuel and an electric engine which utilizes energy put away in a battery. The vehicle can be connected to an electric power source to charge the battery. A few sorts of PHEVs are likewise called extended range electric vehicles (EREVs).

Generally we classify PHEV on the basis of fuels –

Fuels	PHEV
Diesel	Diesel PHEV
Petrol	Petrol PHEV
CNG	CNG PHEV

LPG	LPG PHEV

Advantage of electric vehicle over mechanical vehicle

1. Gives more interior space.
2. Greater Fuel Economy.
3. Improved Traction and directional stability on snowy, mud, wet roads etc.
4. Weight shifting limits the acceleration of affront-wheel-drive vehicle.
5. Weight: Fewer components usually mean lower weight.
6. Low cost.
7. Improved drive train efficiency.

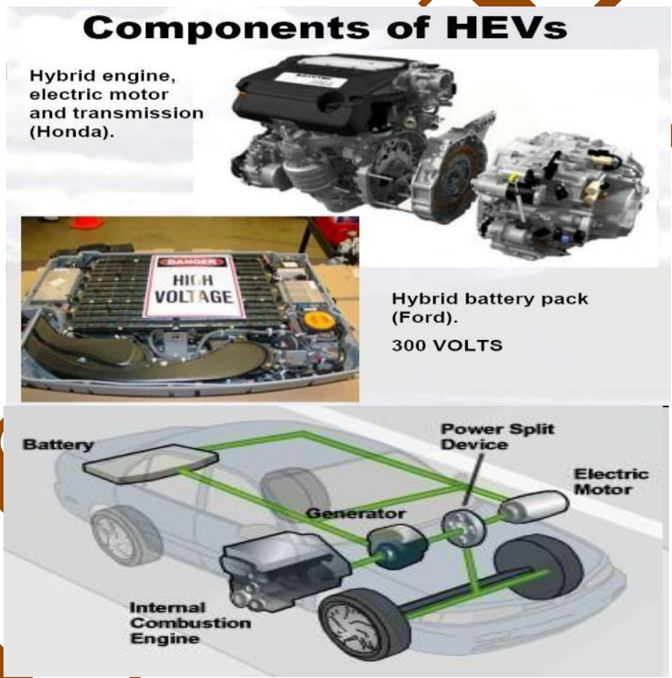


Figure 5.10 Components of Hybrid Electric Vehicles

5.10. Load Profile

Load profile is a diagram of the variety in the electrical load versus time. It will differ as per client sort (average illustrations incorporate private, business and industrial), temperature and occasion seasons. Control makers utilize this data to arrange for how much power they should make accessible at any certain period.

Some important FACTORS definitions:

a. Load Factor (LF): The LF is measured as the degree of variation of load [L (t)] over a period of time, and could be illustrated by the proportion of average load (L av) over the maximum load (L max):

LF= average load/ maximum load

b. Capacity Factor (CF): The CF is the extent of use of the generating units in the Power Plant (PP), and can be defined as:

CF= average load on power plant/ rated capacity of power plant

c. Utilization Factor (UF): The UF can be defined as:

UF= maximum load/ rated capacity of the power plant

d. Demand Factor (DF): Each device (equipment, appliance, and apparatus) has maximum power absorption. If all devices are run up to their fullest extent simultaneously, the maximum demand of consumer will reach his connected load that has been prescribed (assessed, evaluated) by the electric company. So, the DF can be defined as:

DF = consumer actual load/ maximum load

e. Group Diversity Factor (GDF): Experience shows that it is highly unlikely that maximum load of individual consumer in the same group occur in the same time, but spread over the time. Therefore, the GDF measure the extent of diversification within the consumers of the similar group and can be defined as:

GDF= sum of maximum individual loads within the group/ maximum load of system

f. Peak[74 Diversity Factor (PDF): The peak load (maximum demand) of the electric power system (electric company) is made up of the individual demands. It is seldom (rarely) that the different group (residential, commercial, industrial, etc.) will occur at the same time. The PDF is defined as:

PDF = sum of individual maximum load of each group/ maximum load of each group

5.10.1. Load Duration Curve

Load Duration Curve speaks to the assortment of a particular load in a diving structure with the true objective that the biggest load is diagramed in the left and the littlest one in the right side. On the time rotate, the time term for which a particular load keeps in the midst of the day is given.

There are a few certainties about the LDC that can be condensed as:

1. The LDC is a course of action of all load stages in a plunging request of extent.

2. The region under the LDC speaks to the energy requested by the framework (expended).

3. Can be utilized as a part of financial dispatching, framework arranging and unwavering quality evaluation.

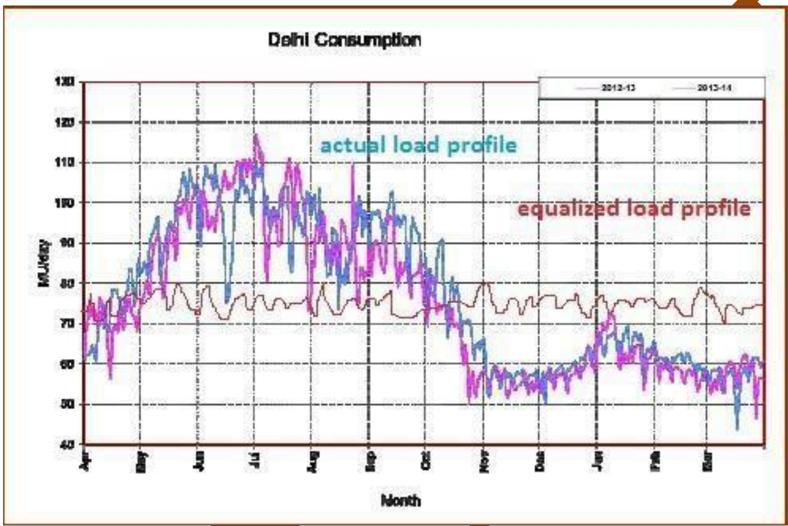
It is more helpful to manage than the load curve.

Load duration curve (LDC) is utilized as a part of electric power production to delineate the relationship between producing limit necessities and limit usage.

LDC is like a heap bend yet the request information is requested in plummeting request of extent, as opposed to sequentially. The LDC bend demonstrates the limit use necessities for every addition of load. The stature of every cut is a measure of limit, and the width of every cut is a measure of the use rate or limit consider. The result of the two is a measure of electrical vitality (e.g. kilo watt hours).

5.10.2. Load Equalization

The way by we make our load profile almost flat so that we can utilize our base power plant installed capacity efficiently is called load equalization. For ex- this is annual load profile of Delhi before and after equalization.



Installed capacity= maximum demand + reserve

From the load profile we can easily see the maximum or peak demand is almost reduce to 65%.

In general reserve which is of 2 types spinning and non- spinning are kept 20% of total maximum demand. So now from these data we are going to show the benefits of load equalization.

Before equalization-

Let maximum demand= x (118 mu) Reserve= 20% of maximum demand= 0.2x

Installed capacity=maximum demand +reserve= x+ 0.2x= 1.2x After equalization-

Maximum demand= 65% of maximum demand before equalization

= 0.65x(76.70 mu)

Reserve = 20% of maximum demand= 0.2 * 0.65 *x= 0.13x

Installed capacity= maximum demand +reserve= 0.65x+ 0.13X= 0.78x Saving in installed capacity due to equalization

Saving= installed capacity requirement before equalization- installed capacity requirement after equalization

= 1.2x- 0.78x= 0.42x

% saving= 0.42x/ 1.2x* 100 %= 35%

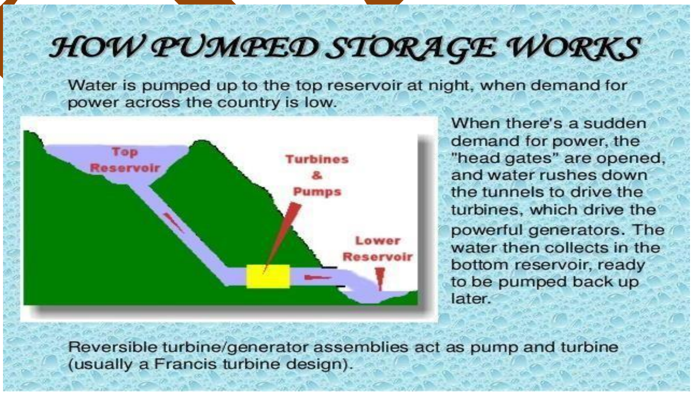
= 41.30 mu are saved

And it is huge amount of energy and the capital requirement is proportional to installed capacity which is also going to reduce by 35% means in place of 3 power plants we can open or start 4 power plants with same facility.

5.11. Various Storage Units

5.11.1. Conventional Way

In the conventional energy can be stored during valley by using pump storage plants (mechanical battery). These types of plants can be used as peak load plants during peak load .this types of plant are used across the world. Injected hydroelectric storerooms preserve energy as water in upper supply, injected from another repository at a lower height. Amid time of load request, the upper store is energized by utilizing lower cost electricity from the framework to grid the water back to the repository.



These plant are ordinarily profoundly effective (round trip- efficiency eighty percent) loads and can demonstrate extremely helpful as far as adjusting inside the overall system. Pump storage offices can be exceptionally temperate because of pinnacle and off peak prices differential and there potential to give basic auxiliary grid administrations.

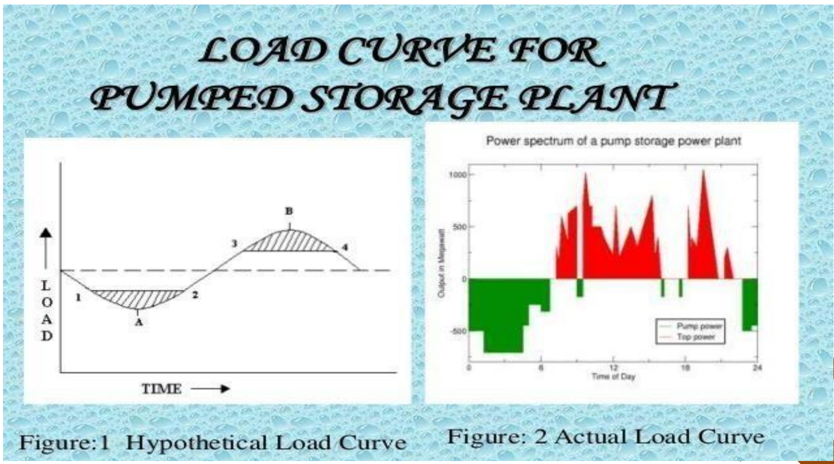


Figure 5.12 Load curve for pumped storage plants

5.11.2. Modern Way

a. Consumers as GENCOS. Plug in hybrid vehicle.

b. Fly wheel levitation

We can store kinetic energy into flywheel during valley hour and by using generation principle we can convert and feed it back to the grid.
Its efficiency is 95-97% in NASA Lab.

We can also use it as an interface between renewable and non-renewable.

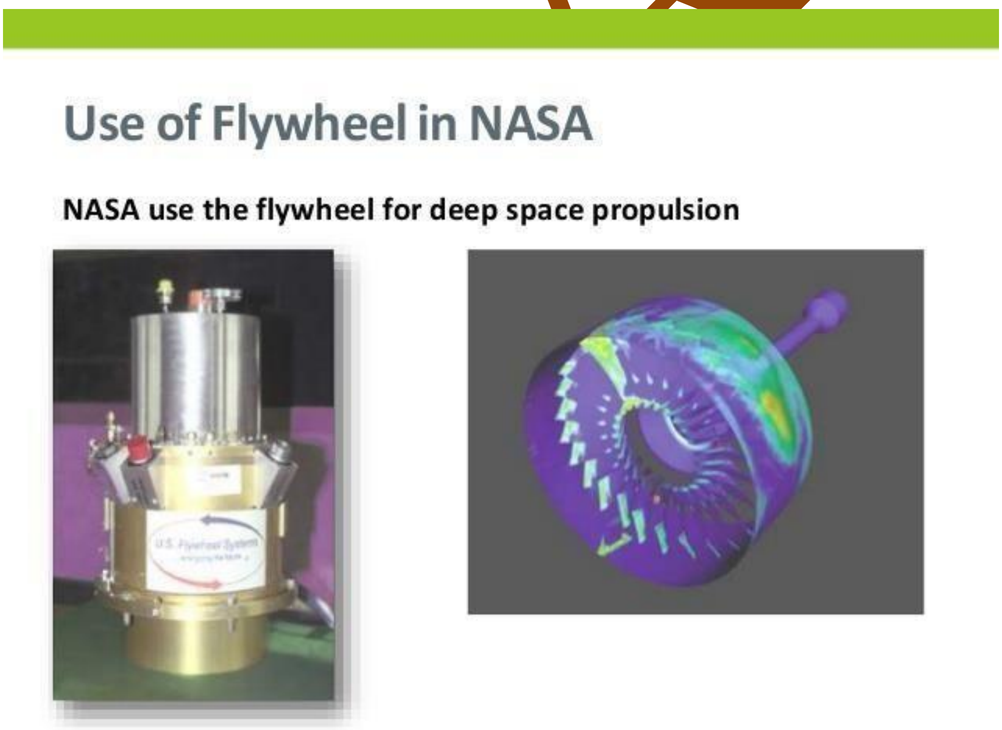


Figure 5.13 Diagram of Flywheel

c. Compressed air energy storage and thermal
In compressed air energy storage method we can compress air during valley and give it back during peak.

Efficiency- 87-90%

Flow battery is simply in our chemical batteries at home level by inverter and during peak we can give it back by a local colony bidirectional substation.

In thermal we can heat fluid or solid and cool according to our requirement.

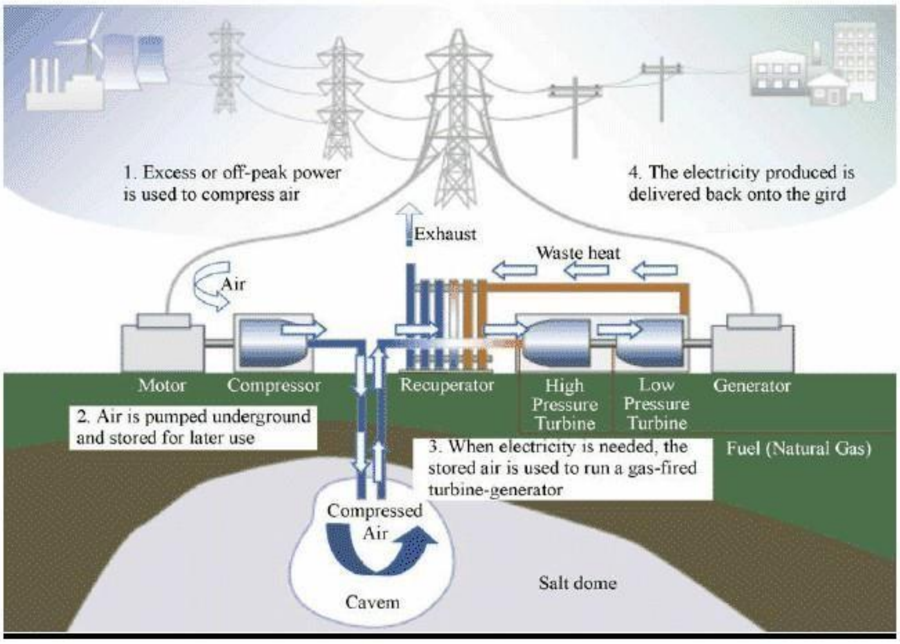
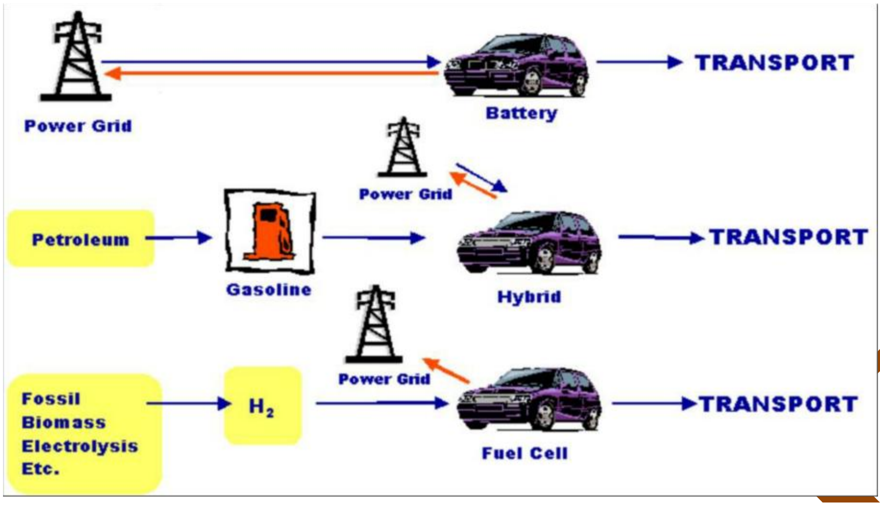


Figure 5.14 Layout for compressed air energy storage

5.12. Vehicle to Grid (V2G)

Electric-driven vehicles, whether fuelled by Batteries, FCs, or gas half breeds, have inside them the energy source and power hardware equipped for delivering the 50 Hz AC electricity which powers our residents and workplaces.

At the point when associations are added to permit this electricity to spill out of autos to electrical cables, we call it "vehicle to framework" control, or just V2G.



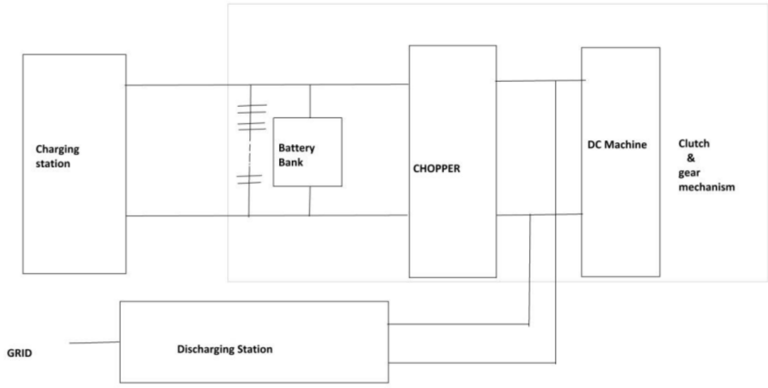


Figure 5.15 Actual View of V2G

5.12.1.Advantages of V2G

a. Electric vehicle charge stations serve as grid connection points for power delivery

b. Vehicles can provide

I. Extra power during demand peaks

II. Uninterrupted power source for businesses and homes

III. Demand charge reduction – monthly cost saving

IV. Enhances dependability and proficiency of power framework.

5.12.2.Disadvantages of V2G

a. Decreases Battery life

b. Additional cost

c. Extra weight

d. New infrastructure

5.12.3. Prototype Block Representation of PHEV2G

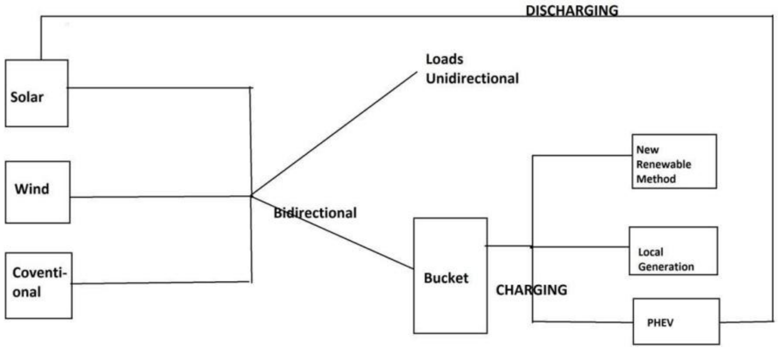


Figure 5.16 PHEV interconnection with grid

Here PHEV is a modern storage unit. It is interconnected with conventional and non – conventional generating units with charging and discharging sub stations for the purpose of grid security, reliability, efficiency and load equalization.

6. PERFORMANCE ANALYSIS

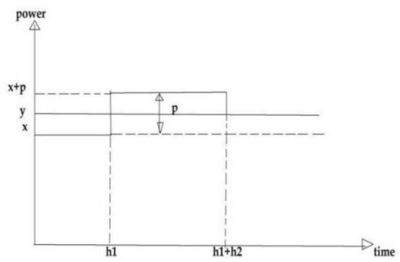


Figure 6.1 Typical Load Profiles for Equalizations

We are doing performance analysis of Load equalization by PHEV through comparison with load equalization

Pumped storage plant

During valley period during storage) Pumping motor efficiency = 85% Mechanical Output = (y-x)* h1*0.85 during peak period

Electrical Requirement =(x+p-y)*h2 Efficiency of generator turbine = 80%

Mechanical storage requirement $=(x+p-y)*h2/0.8$ Now according to law of conservation of energy $(y-x)*h1*0.85 = (x+p-y)*h2/0.8$

$(X+p-y)*h2 = (y-x)*h1*0.85*0.8$

$h2 = (y-x)*h1*0.85*0.8/(x+p-y)$ …..(1).

Load equalization by PHEV During valley

Shift PHEV on solar (100% efficiency from fuel point of view) during discharging efficiency becomes 48% Now average efficiency= 0.5*(100+48)%= 74%

Storage = $(y-x)*h1'$

<u>During peak</u>

Output of PHEV = $(x + p - y)/0.74$

According to law of conservation of energy $h2' = (y - x)*h1'*0.74/(x + p - y)$ ……
(2)(From equation 1&2)

h2' h2

Efficiency comparison

Efficiency of conventional plant= 30 to 35%

Pumped storage plant= overall 80%

Total efficiency= 0.3* 0.8= 0.24 or 24%

PHEV during charging= 100%

PHEV during discharging= 48%

Overall = 74% efficient (if connected to solar only)

Otherwise if charged by conventional overall efficiency becomes 50% of 74%= 37%

Net saving= 37%- 24%= 13%

If charged by solar saving= 74%-24%= 50%Much more saving which is exactly going to make our grid very smart, reliable, secure and efficient.

7. RESULT & DISCUSSION

a. We hope to do no less than one year of research.
b. At the present time, we take a gander at two classifications while assessing the PHEV and Wind Turbine
   - I. Category One: Did the Wind Turbine give required electricity to the greater part of the operating done amid charging at WMU?
   - II. Category Two: Did the Wind Turbine give required electricity to the PHEV

for the majority of the driving done consistently, amid in PHEV mode?

c. When charging at WMU, the Wind Turbine has given all electricity to charge
d. In nutshell, we are demonstrating an overflow of electricity produced (used to charge the PHEV) over the course of the examination extend.

Because use of PHEV we have some disadvantage also

1. Increases transformer losses
2. Thermal loading on distribution transformer which reduces the transformer life
3. Increase in voltage deviation
4. Increases harmonics

8. CONCLUSION AND FUTURE SCOPE

a. Reliability of the power grid increases
b. Environment remains clean because of eco-friendly nature of PHEV
c. Grid security increased due to reduction in peak demand
d. Efficiency increases
e. Large scale grid integration and system became intelligent one
f. Grid become decentralized and cleaner and consumer interactive
g. Because of PHEV unique opportunity is available for residential consumer to directly participate in market operation

9. APPLICATIONS

a. Load equalization
b. Grid security
c. Storage
d. Grid integration

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