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Vehicle To Grid Technology

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Abstract:

Battery-electric vehicles and grid-connected hybrid vehicles rely on the power grid for energy – they have to plug in to charge their batteries. With power alerts and blackouts a recent reality, it is easy to conclude that the energy requirements of grid-connected electric vehicles will make the energy crisis worse. Actually, quite the opposite may be true. With a bi-directional grid power interface, virtually any vehicle that can plug into the grid can potentially provide beneficial support to the grid.

Battery electric vehicles can support the grid exceptionally well by providing any of a number of functions known collectively as ancillary services. These services are vital to the smooth and efficient operation of the power grid. A hybrid vehicle can provide ancillary services, and can also generate power. Fuel cells are already being commercialized for small stationary power sources, so a vehicle mounted fuel cell could also serve as a vehicle-to-grid power source. Sharing power assets between transportation and power generation functions can create compelling new economics for electrically-propelled vehicles.

1.Introduction

The development of vehicle-to-grid power systems can accelerate commercialization of battery electric vehicles, hybrid vehicles and fuel cell vehicles. This paper describes the technology of this rapidly evolving concept. Most personal transportation vehicles sit parked more than 20 hours a day, during which time they represent an idle asset. Vehicles that incorporate electric propulsion can be utilized as power sources while parked because their drive systems include the fundamental elements for generating AC power. Utilizing idle vehicles to provide valuable electric power functions can produce a positive net revenue stream and create a powerful economic incentive to own an electrically-propelled vehicle.

The range of services is broad, and includes mobile AC power, backup power for homes or businesses, power generation during peak demand periods, and grid ancillary services such as spinning reserves, regulation, automatic generation control, reactive power, and transmission stabilization. Most of these functions already have established economic value when procured from non-vehicular sources. The economics of vehicle-to-grid are examined.

2.What Is V2g?

Electric-drive vehicles, whether powered by batteries, fuel cells, or gasoline hybrids, have within them the energy source and power electronics capable of producing the 60 Hz AC electricity that powers our homes and offices. When connections are added to allow this electricity to flow from cars to power lines, we call it "vehicle to grid" power, or V2G. Cars pack a lot of power. One typical electric-drive vehicle can put out over 10kW, the average draw of 10 houses. The key to realizing economic value from V2G is precise timing of its grid power production to fit within driving requirements while meeting the time-critical power "dispatch" of the electric distribution system.

3.Conventional View

The conventional view expects battery vehicles to be plugged in to charge their batteries. Hybrid and fuel cell vehicles generate electricity from the fuel in their tanks. Plug-in hybrids can either run from fuel or can charge from the grid. In the conventional view, electricity never flows from vehicle to the grid.

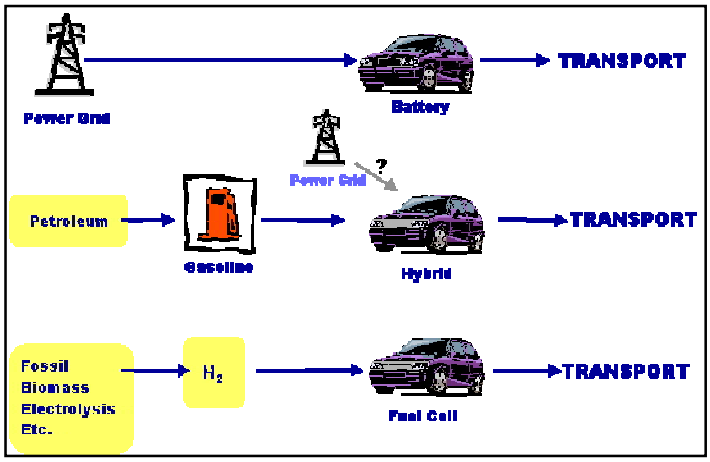

Figure 1

4.V2G Concept

The V2G concept is that battery, hybrid, and fuel cell vehicles all can send power to the electric grid, power that all three already generate internally. For battery and plug-in hybrid vehicles, the power connection is already there. Red arrows indicate electric flow from vehicles to the grid.

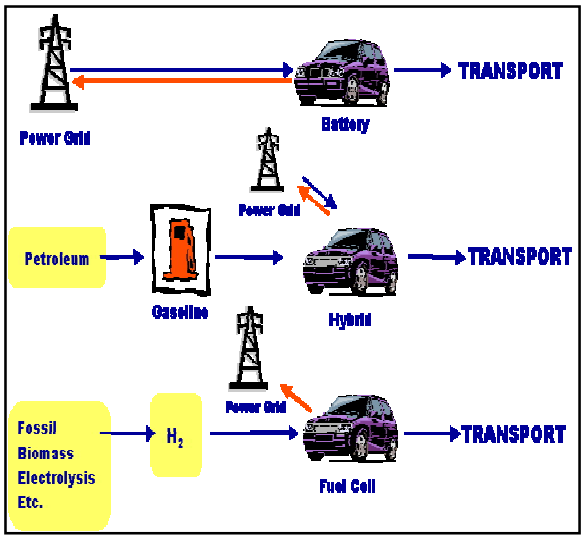

Figure 2

5.DISTRIBUTED GENERATION

Distributed generation is a new trend in the generation of heat and electrical power.

The distributed energy sources(DER) concept permits "consumers" who are generating heat or electricity for their own needs (like in hydrogen stations and micro generation) to

send surplus electrical power back into the power grid - a process also known as net metering - or share excess heat via a distributed heating grid.

AC Propulsion has developed an integrated drive system for electrically-propelled vehicles. The integrated system uses the power switches and motor windings for both propulsion and to provide a bi-directional high-power interface to the electric power grid. In addition to operating as a battery charger to convert AC grid power to DC, the system can operate in reverse to convert DC from the vehicle (from a battery, generator, or fuel cell) to AC at the grid frequency. The AC from the vehicle can power stand-alone loads, and, with a robust safety shut-off to protect against back-feeding the grid when it is down, it can feed power to the grid. This potential for vehicle-to-grid power (V2G) adds new technological, economic, and environmental implications to the concept of distributed generation of electricity.

The theory is basically this: enough cars while parked can be discharged into the grid, as needed, 1) to replace costly standby regulation service from commercial power generators; and 2) to buffer the natural variations in power output from huge solar- and wind-power installations. By providing regulation, ancillary, and bulk services to the power company, electric car owners would be able to use their vehicles to offset their own power bills, or even to earn extra money.

6.The Scope Of V2G

As cars and light trucks begin a transition to electric propulsion, powered by batteries, engines, or fuel cells, there is potential for a synergistic connection between such vehicles and the electric power grid. The aggregate power rating of the US vehicle fleet is much larger than the total US electric generating capacity. If even a small fraction of vehicles are harnessed as generating assets, benefits would accrue both to the electric power grid, vehicle owners, and aggregator/service providers. US passenger vehicles are, on average, parked and idle for about 23 hours each day. During this time, they represent an idle asset and actually create negative value due to parking costs. The advent of electric, hybrid, and fuel cell vehicles, introduces the prospect that parked vehicles can become assets that create value. By connecting such vehicles to the electric power grid, a large scale, dispatch able, electric power generating resource is created.

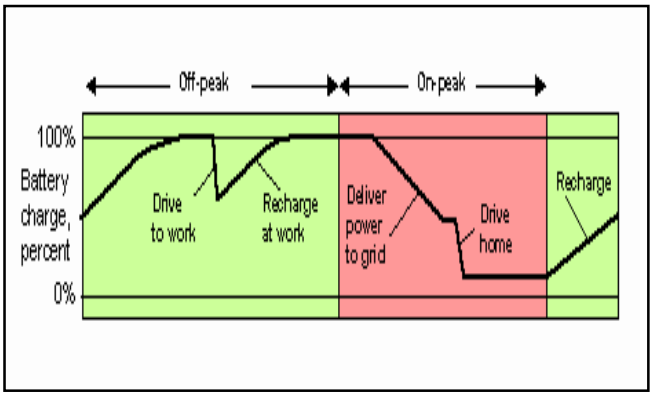

Figure 3

We can charge vehicles during periods of low demand. Drive and deliver power to the grid during demand periods. Driver controls how much energy is available to the grid.

By itself, each vehicle is small in its impact on the power system. But, in aggregate, a large number of vehicles will represent significant generating capacity. For example, five percent of California's vehicle fleet could provide 10 percent of the state's peak power requirement. Power or energy from an electric vehicle could be sold from a vehicle connection point located at the vehicle driver's home or place of work. Such connected vehicles could provide a variety of services.

7.Spinning Reserves

Grid operators maintain reserve generating capacity available for immediate power production. The term 'spinning' derives from the definition that spinning reserves must have generators spinning and synchronized with the grid, ready for immediate power generation. The mass of spinning generators also contributes to grid stability. Vehicles could provide equally-fast power on demand, and could be programmed to appear to the grid as virtual spinning masses, with the added benefit of little or no 'spinning' or idling losses.

For power generation from hybrid or fuel cell vehicles, a connection to low pressure natural gas or hydrogen (in addition to the electrical connection) could be made at compatible parking locations.

8.Uninteruptible Power Source For Business And Homes

Parked vehicles can replace grid power during scheduled or unscheduled power outages. A business could achieve a significant UPS capability with electric or hybrid vehicles

parked and plugged in during the day. This would reduce the risk and cost of a business selecting reduced-rate interruptible power service. Single vehicles could provide a full capability backup power source for homes.

9.The Economics Of V2G

The economics of vehicle-to-grid power flow are complex but appear to be robust. The costs and values of grid support functions vary greatly by vehicle, time of year, time of day, region, and utility. In general though, the magnitude of value is more than enough to offset the costs of battery wear out, equipment wear and tear, energy losses, and other related costs.

10.Micro-Transactions Capture V2G Value

Creating transactional systems to capture vehicle-to-grid value will become a fundamental element of the electric propulsion business. The propulsion system will provide motive power for the vehicle's primary function as transportation. The technology for feeding power from the vehicle to the grid is a feature that creates added value. Since every energy transaction can be recorded and valued, the way phone calls are today, the technology supplier for this beneficial feature may extract a fee in proportion its usage. This pay-for-use approach allows separating the value of the propulsion function from the value of the vehicle-to-grid function. In this way, the propulsion system supplier can earn returns for proprietary technology while still selling to the auto industry at commodity prices.

11.Advantages

- Electric vehicle charge stations serve as grid connection points for power delivery
- Vehicles can provide
    - Extra power during demand peaks
    - Grid regulation(automatic generation control AGC)
    - Uninterruptible power source for businesses and homes
    - Demand charge reduction- monthly cost saving.

- Increases reliability and efficiency of the power system
- Profit for car owner.

- V2G technology takes cheap and abundant off-peak power and allows it to be brought back into the system to meet daytime peak power demands in the place of extra daytime fossil fuel generators.

12.Future Vision Of V2G

- All new passenger vehicles come with grid power connection standard
- Emissions from cars are no longer a problem
- Most of peak load needs are met with vehicle-based generation
- Vehicles provide valued ancillary services to the grid, offsetting the cost of ownership

There has been an increasing interest among some famous companies towards Some of them are- Ford, DaimlerChrysler, Honda, EPRI, AC Propulsion.

13.Conclusion

By deploying the vehicle's power systems to perform ancillary services for the power grid operator, there is the potential for economic value to be created. With the value created through vehicle-based grid services, partially offsetting purchase and operating costs, electric drive vehicles may have a lower net ownership costs than conventional vehicles. This would invert the cost vs. emissions benefit tradeoff; there could be a cost benefit together with the emissions benefit. Vehicle based grid services may prove to be instrumental in overcoming market and cost barriers in the adoption of electric and other advanced technology vehicles.

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