GRID TO VEHICLE

(G2V)

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Introduction

- During the 20th century two massive but separate energy conversion systems were developed
  - the electric utility system
  - the light vehicle fleet

Dimensions of the Power

- In the India, for example, there are over 1500 electric utility generators with a total power capacity of 147,402.81 MW.
- These generators convert stored energy (chemical, mechanical, and nuclear) to electric current, which moves through an interconnected national transmission and distribution grid.

Dimensions of the Power (Contd.)

- The second massive energy conversion system is the fleet of 15 million light vehicles (passenger cars, vans, and light trucks), which convert petrochemical energy to rotary motion then to travel.

- With a shaft power capacity averaging 100 hp, or 75 kW_m per vehicle (kW_m is kW mechanical), the Indian fleet's 15 million light vehicles have a total power capacity of about 1,000,000 MW_m, which is 7 times the power capacity of the entire electric generation system.

Relevance of Comparison

- Why is it relevant to compare the power of the light vehicle fleet with the power of the grid?
  - The automotive industry is beginning its shift to electric-drive vehicles (EDVs)
  - The utility industry is beginning its shift to renewable energy.
- The economics and management of energy and power in the light vehicle and electric systems will make their convergence compelling in the early decades of the 21st century.

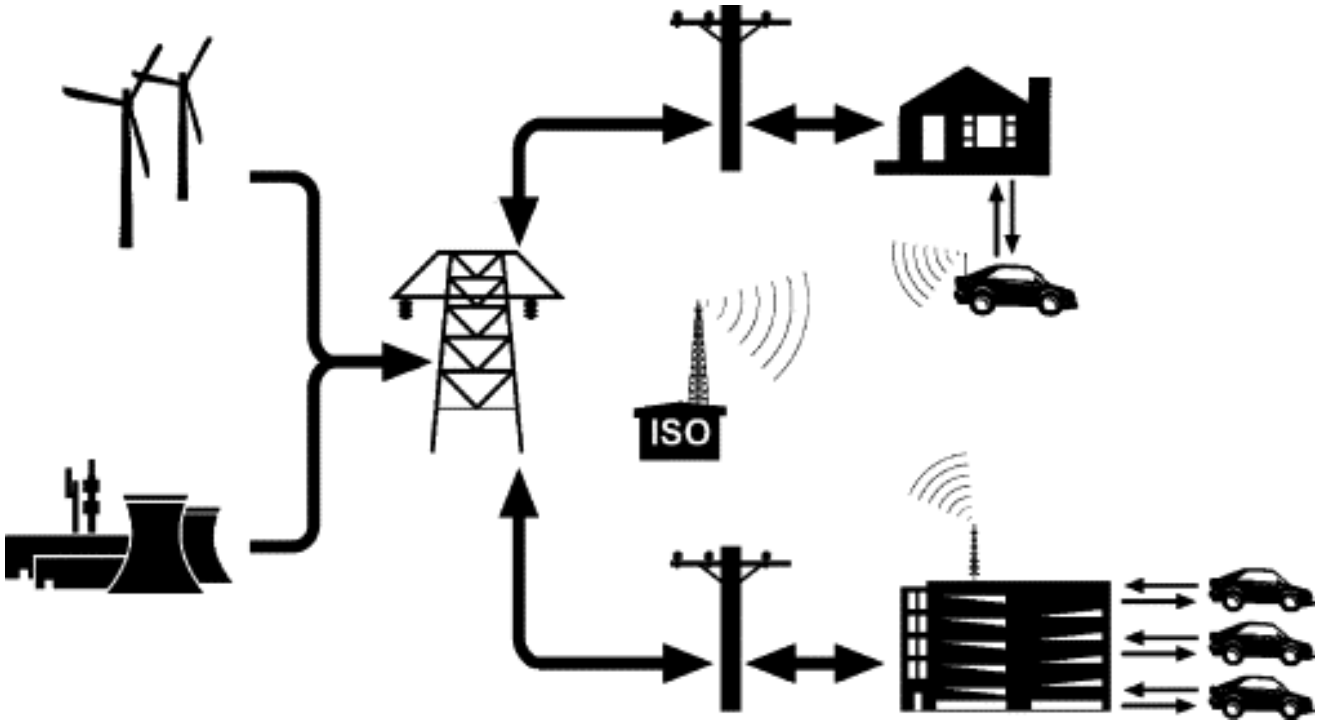
Convergence Vehicle and Electric Systems

- There will be three possible forms of convergence
  - The vehicle fleet will provide electricity storage and quick-response generation to the electric grid
  - Electricity will complement or displace liquid fuel as an energy carrier for a steadily increasing fraction of the vehicle fleet
  - Automated controls will optimize power transfers between these two systems, taking into account their different but compatible needs for power by time-of-day

Grid to Vehicle Concept

- The basic concept of vehicle-to-grid power is that EDVs provide power to the grid while they are parked.
- The EDV can be a battery-electric vehicle, hybrid, or a fuel cell vehicle connected to the grid.
- Each vehicle must have three required elements for V2G
  - A power connection to the grid for electrical energy flow
  - Control or logical connection necessary for communication with grid operators
  - Precision metering on-board the vehicle

Grid to Vehicle Concept (Contd.)



Grid to vehicle system (Tomic et.al. , Journal of Power Sciences, vol.168)

Why Grid to Vehicle Make Sense

- In order to schedule dispatch of power, a grid operator needs to rely that enough vehicles are parked and potentially plugged in at any minute during the day.
- An average personal vehicle is on the road only 4–5% of the day, which means that a great majority of the day the vehicles are parked.
- At least 90% of personal vehicles are parked even during peak traffic hours.

Economic Sense of G2V

- The electricity from V2G is not cheap when compared to bulk electricity from large power plants.
- This electric energy can be competitively used for ancillary services because of the two parts that make up the price of power in the ancillary service market
  - capacity price
  - energy price.
- When a generator, in this case a battery-vehicle, provides ancillary services it is paid a capacity price for being available to respond on a minute's notice, and an energy price for the actual energy output.

Economic Sense of G2V (contd.)

- The energy output may be quite small, making the cost to produce each kWh of little consequence for the overall economics. The more important factors are:
  - the capital cost of generation or storage equipment
  - ability to vary output quickly
  - ability to operate in these modes without serious maintenance penalties
- Vehicles are better than central generators on all three counts.

Benefits of G2V Vehicle Owners

- Consumers may profit from the use of electric vehicles (Evs) because electricity is cheaper than petrol for equivalent distances traveled.
- EVs in a V2G configuration could provide additional revenue to owners who wish to sell power back to the grid.

Benefits of G2V to Utilities

- The electric utility system may also benefit from implementing the V2G concept, not only by supplying electricity to the new vehicles, but by drawing power from them to maintain ancillary services.
- Except for periods of peak use, the power system could generate and deliver a substantial amount of energy needed to fuel the nation's vehicles at only the marginal cost of fuel.
- The V2G cars can serve as distributed generators that supplements to utility power plants and provide valuable generation capacity at peak times
- V2G PHEVs can further reduce emissions and air pollution in the electricity sector by providing storage support for intermittent renewable-energy generators.

Potential Hurdles to G2V Concept

- The technologies required for V2G systems have rarely been combined. Unforeseen technical difficulties may arise when these systems are applied together on a large scale, although there may also be unanticipated beneficial spillovers and synergies.

- Critical for the diffusion of V2G technologies is also likely to be the communication and grid regulation systems required to manage dispatch, recharge and regulation up and down.

- The smaller scale of generation from each vehicle may lead to difficulties in compatibility with existing systems based around large generation units.

Conclusions

- V2G systems may have the potential to transform both energy and transport systems in profound ways, by promoting the deployment of alternative vehicle technologies; reducing inefficient investment in conventional generation; and supporting the installation of renewable electricity sources.
- There are of course numerous obstacles in such an epochal transition.
- The building of a new recharging network involves fresh investment, and not the dismantling of some existing networks.

Conclusions (Contd.)

- The long-term case for V2G and sustainable energy production boils down to a choice:
  - To keep the electric system and vehicle fleet separate. This in turn increases increase the cost of renewable energy because we have to build storage to match intermittent capacity.
  - Or, to connect the vehicle and electric power systems intelligently, using the vast untapped storage of an emerging electric-drive vehicle fleet to serve the electric grid.

Thank You