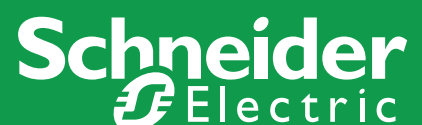


# The electric vehicle: plugging in to smarter energy management

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Make the most of your energy



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# Executive summary

## The electric vehicle: driving the growth of the smart grid

The electric vehicle is emerging as a key solution to one of our energy future's biggest challenges: the impact of transportation on our environment. The smart grid will be one of the keys to a cleaner transportation future; and whether or not tomorrow's smart grid becomes a reality could hinge upon widespread adoption of electric vehicles by consumers and the construction of the charging stations these plug-in cars will require.

## The key success factor: energy management solutions

Today, we are at a pivotal moment; one that will lay the foundations for tomorrow's energy landscape. Mainstream consumer adoption of the electric vehicle is just over the horizon. This new mode of mobility and the infrastructure that will sprout up around it will require reliable, safe, and convenient energy management solutions that meet users' charging and availability needs while helping facility managers and utility operators optimize resources.

Energy management solutions are key to ensure that the electric vehicle and the charging infrastructure are safe, convenient, economical, and energy efficient for drivers and facility managers while ensuring that utility operators are able to manage the impacts of electric vehicle charging on the grid.



### What is the smart grid?

The smart grid is an intelligent energy distribution system that leverages the power of information technology to align energy production with demand and to optimize use of all energy sources, including renewable energies.



This white paper discusses the technological, economic, and safety issues involved in linking massive numbers of plug-in electric vehicles to the grid and what it all means to consumers, facility and vehicle fleet managers, and electric utilities.



Energy management solutions are key to meet users' charging and availability needs while helping facility managers and utility operators optimize resources.

# Introduction

## Smarter energy management: the response to an uncertain energy future

Today's global energy environment is fraught with challenges. The specter of rising energy costs, a shifting regulatory landscape, and competition among emerging energy-efficiency technologies have given rise to uncertainty for all stakeholders, from consumers and equipment manufacturers through to facility managers and electric utility operators.

**Despite an uncertain energy future, there is one thing we do know: transportation will be a major target for future energy savings.**

Regulators and manufacturers are today joining forces to design more energy-efficient, less-polluting vehicles and inventing ways to link them to smarter energy infrastructures.

Regardless of how we ultimately address tomorrow's energy challenges, more efficient transportation is a must, and smarter energy management will be the key to reaping all of the potential environmental and economic benefits new, greener forms of transportation can offer.

# 30 %

Transportation is responsible for 29% of CO<sub>2</sub> emissions in the 27 EU Member States<sup>1</sup> and 33,1% in the US<sup>2</sup>.

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<sup>1</sup> CO<sub>2</sub> emissions from transport in the EU27. An analysis of 2008 data submitted to the UNFCCC. European Federation for Transport and Environment (T&E). August 2010.

<sup>2</sup> <http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html>

# The electric vehicle: linking energy consumers and producers via the smart grid

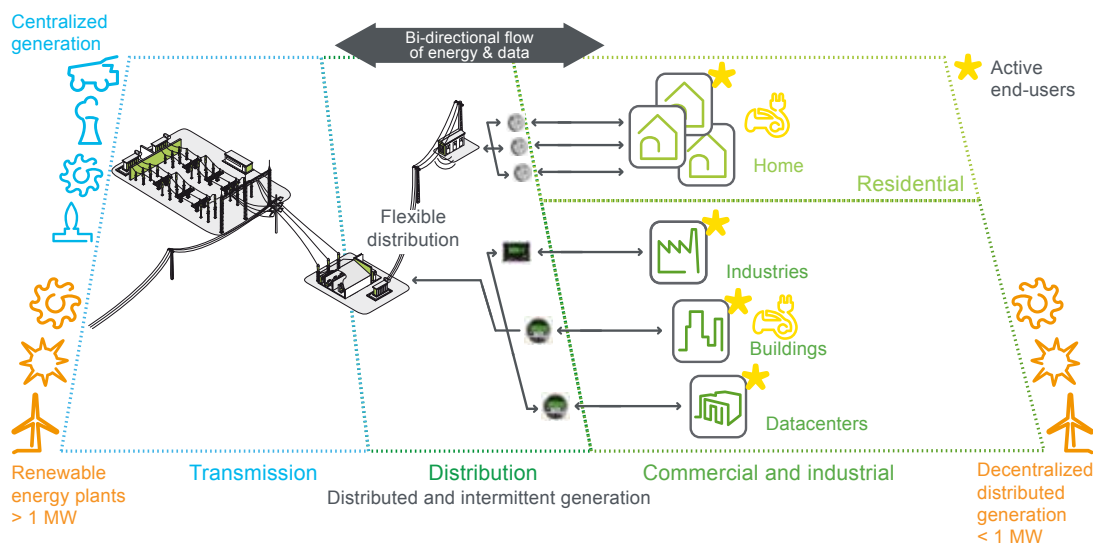
## Motor vehicles: a major contributor to our energy challenges

Old nations are home to at least one motor vehicle for every two inhabitants. The barriers to changing our car-intensive lifestyles appear insurmountable. Underdeveloped public transportation, urban sprawl, long commutes, and consumers' demand for convenience at all cost mean that abandoning our cars is simply not a realistic option.

## With challenges come opportunities: enter the electric vehicle

Cars are here to stay. So, we must find ways to lighten the environmental impact of all the driving we do. Electric vehicles (EVs) are more economical and environmentally-friendly than traditional combustion-engine-powered cars, making them an ideal real-world solution to this dilemma. A Greenpeace study pointed out that, in Europe, the EV is more sustainable than even the best-performing combustion-engine-powered vehicles<sup>3</sup>.

With zero gas and no particle emission, extremely quiet operation, and a readily-available fuel (electricity), electric vehicles offer a promising alternative for tomorrow's transportation sector.



### From top-down grid to interactive Smart Grid

<sup>3</sup> Green power for electric cars - Harvesting the climate potential of electric vehicles. A study by CE Delft commissioned by Greenpeace, Friends of the Earth Europe and Transport and Environment. January 2010.

# Getting consumers, manufacturers and regulators to work together to build the smart grid

## Moving the supply side through public policy and private investment

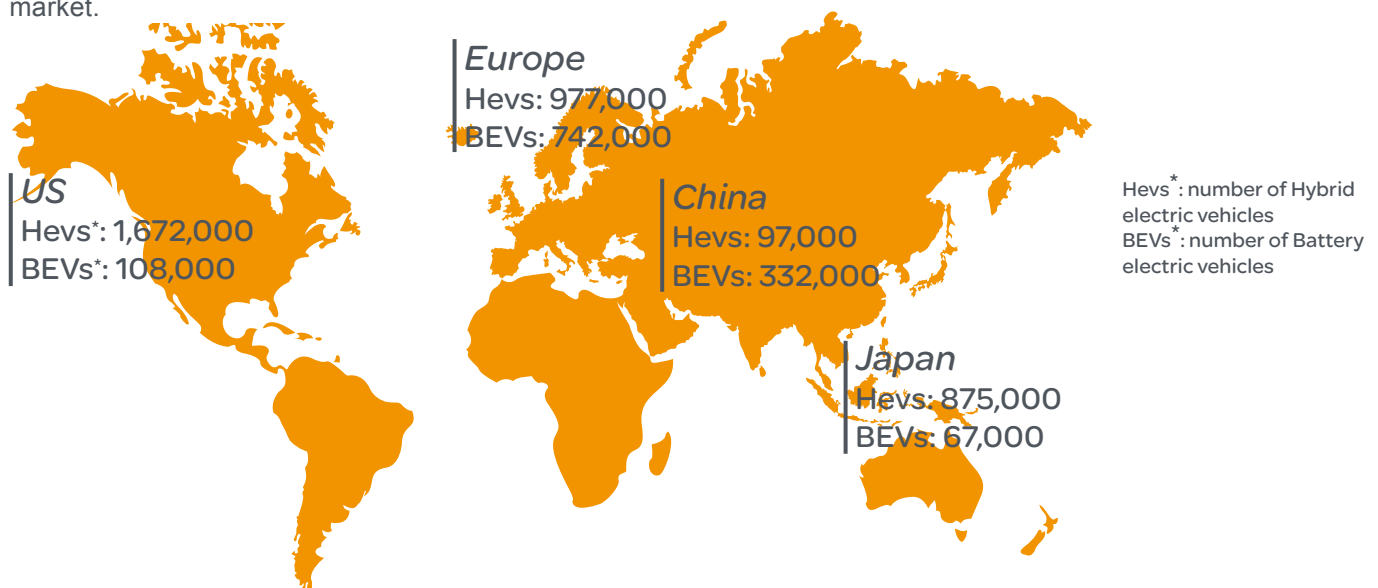
The electric vehicle is at a turning point. Investment in EVs has gone mainstream: Warren Buffet famously bought a 10% stake in Chinese EV company BYD and Google's RechargeIT program has been investing massively in green car technologies.

Major world leaders are following in the wake of business: to break the nation's oil dependency, President Obama, said the United States should aim to be the first country to have one million electric vehicles on the road by 2015<sup>5</sup>. Governments in the US, France and the UK are rolling out large-scale initiatives to equip government agencies with EVs and build vast EV charging networks. Chinese Science and Technology Minister Wan Gong, a former engineer at Audi, recently announced a plan to support NEVs (New Energy Vehicles) in China, the world's largest car market.

## Preparing the demand side for plug-in electric vehicles

On the demand side, early hybrid electric vehicles like the Toyota Prius have received a warm reception from consumers, paving the way for future consumer acceptance of plug-in electric vehicles. The latest editions of the North American International Auto show and big European motor shows confirmed this trend, with all major manufacturers exhibiting EV or hybrid prototypes.

The standards and architecture battle is currently being waged, with large-scale EV and charging infrastructure deployment just around the corner. 2012–2020 is gearing up to be a crucial period in the construction of tomorrow's cleaner, smarter transportation system.

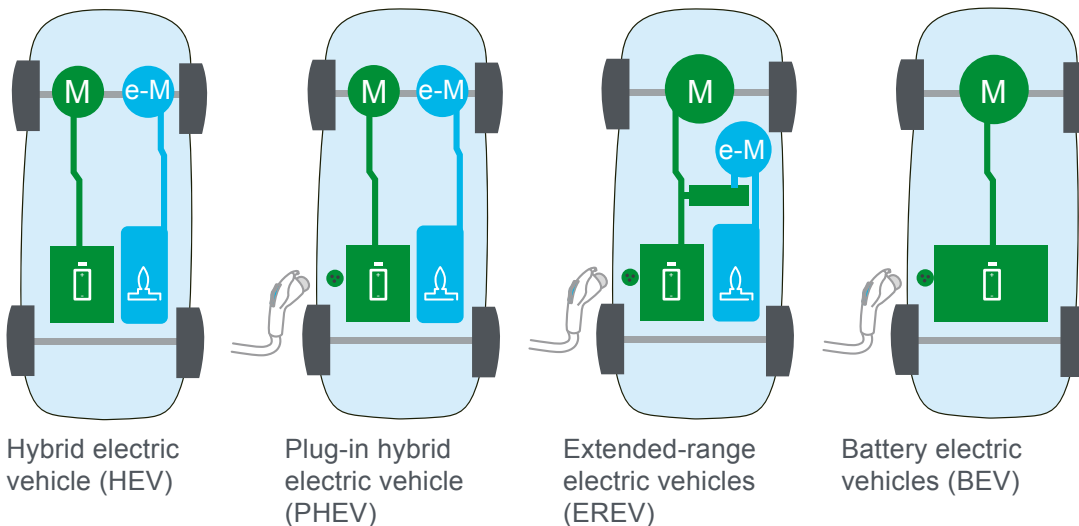


*The Global Alternative-Energy Vehicle Map: 2020<sup>6</sup>*

<sup>5</sup> [http://apps1.eere.energy.gov/news/news\\_detail.cfm/news\\_id=16693](http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=16693)

<sup>6</sup> Source: J.D. Power and Associates

## From hybrid to plug-in to the smart grid



### The electric vehicle landscape

Of the four types of potential EV solutions (see sidebar), hybrid electric vehicles like the Toyota Prius are currently the most common. While it does not offer the same short-term potential as the classic hybrid, the grid-enabled plug-in hybrid electric vehicle (essentially a hybrid that plugs in to an electrical outlet) offers the greatest capacity to drive the development of tomorrow's smart grid, an intelligent system that will link power generation, homes, and the transportation infrastructure.

The smart-grid-enabled plug-in electric vehicle landscape will include fully-connected vehicles on a smart grid where power consumption is optimized and users can give or sell power back to the grid (for backup or peak power for example) when not needed. Tomorrow's intelligent grid-enabled vehicles will also feature mobile applications to monitor the engine, charging status, traffic, trip planning, and other driver activities.

### Barriers to massive adoption of the grid-enabled plug-in electric vehicle

To get from where we are today to this ideal of smart-grid-connected, electric-powered mobility, we must overcome a number of barriers.

- **Infrastructure:** Without infrastructure, consumers have no reason to purchase EVs; and without EVs there is not much reason to build an infrastructure.

- **Regulatory:** Utilities must be encouraged to make innovative investments and be allowed to set appropriate rate structures for optimizing consumption through a smart grid and grid-enabled EVs. Auto and equipment manufacturers must be given incentives to build, and consumers incentives to buy.

- **Standards:** For drivers to want to adopt EVs, they need the reassurance of standardized, safe, convenient charging points everywhere.

Whatever roadmap electric vehicle deployment ends up following, widespread EV use will require powerful energy management solutions that meet consumers', manufacturers', facility managers', and utility operators' needs for safety, convenience, availability, and cost-effectiveness.



The IEC 61851-1 standard "Electric vehicle conductive charging system" defines the different charging modes.

The IEC 62196-2 standard "Plugs socket-outlets, vehicle couplers and vehicle inlets-conductive charging of electric vehicles" guarantees maximum safety to users while charging their electric vehicle.

And a standard is being written on the communication modes between the vehicle and the grid.



# Managing the future electric vehicle charging infrastructure for all stakeholders

Like most energy efficiency solutions just over the horizon, the rise of the EV will require innovative, safe, reliable, and cost-effective energy management solutions.

Schneider Electric, a global specialist in energy management, will play a major role in promoting the electric vehicle and the charging infrastructure. This includes putting Schneider Electric's extensive energy management expertise to work to develop the charging solutions needed to make broad deployment a win-win proposition for consumers, manufacturers, facility managers, and utility operators.

“The rise of the electric vehicle will create a host of new energy-management challenges for end users, car and equipment manufacturers, facility managers and electric utilities.”

## Energy management: the key to reaping the full environmental benefits of EVs

Whether or not society is able to reap the full environmental benefits of EVs will depend largely on how the energy that feeds EV batteries is produced and on when the batteries are charged.

In Europe, for instance, part of the electricity is generated by CO<sub>2</sub>-free nuclear power plants. In China, however, coal-burning power plants are still common.

If users charge their EV batteries during the day or during peak demand hours, utilities will have to compensate for the increase in demand with polluting thermal power plants, the only form of power generation currently able to respond quickly to surges in demand. However, if users charge their EV batteries during off-peak hours, utilities can respond to demand using cleaner or more sustainable sources of power like wind farms, hydroelectric power, or nuclear power, for instance.

Furthermore, slow charging at night could help reduce fluctuations in demand. Surprisingly, nuclear-dependent countries like France often face nighttime overproduction. Nighttime EV charging could help absorb this excess supply, which would otherwise be wasted.



### Setting standards for a safe, cost-effective EV charging infrastructure



**Electric Vehicle Plug Alliance**, an industry association whose mission is to develop a certificate of compliance with the future IEC Type 3 plug and socket standard. The goal is for all electric vehicle charging equipment to meet safety standards for residential and commercial use while optimizing cost. For more information visit: [www.evplugalliance.org](http://www.evplugalliance.org)

# Challenges and opportunities for EV stakeholders

The future widespread adoption of the plug-in EV will present some unique opportunities for consumers, auto manufacturers, facility managers, and utility operators. However, responses to the different stakeholders' questions and concerns must be found for the EV to truly take off. Effective energy management solutions will be needed to make the EV an attractive alternative to traditional combustion-engine-powered vehicles.

## Addressing car owners' concerns about safety, cost, and convenience

Purchasing an electric vehicle is a major decision for many consumers. Industry partnerships, public programs, and consumer education from electric utilities, vehicle manufacturers, and energy professionals will be essential to ensuring that drivers have access to the information, equipment, and trained professionals they need to enjoy their electric vehicles safely, cost-effectively, and conveniently.

**Safety** is perhaps the biggest question in consumers' minds. Consumers need to be informed about how to charge their vehicles at home safely, avoiding electrical hazards and other dangers like falls caused by stray power cords. With emerging standards like those promoted by the EV Plug Alliance (see page 8), charging equipment will meet tough safety requirements developed and tested to avoid these dangers.

**Cost** is another concern in the minds of consumers, who may wonder about the impact of EV charging on their home energy bill, the cost of any necessary equipment upgrades, and who is responsible for financing these upgrades. Away-from-home charging is another issue. How much will it cost? How will consumers pay? There are utilities in US actively working on promoting an incentive to own an electric vehicle by offering an EV rate, examples include Detroit Edison<sup>7</sup>, Southern California Edison<sup>8</sup>.

**Convenience** is not to be underestimated as a major factor in consumers' EV purchasing decisions. "Range anxiety" has long been cited as a stumbling block to EV adoption. Consumers need to know how far they can go on a charge, where to recharge (At home? At work? In public places like shopping centers?), and how long it will take.

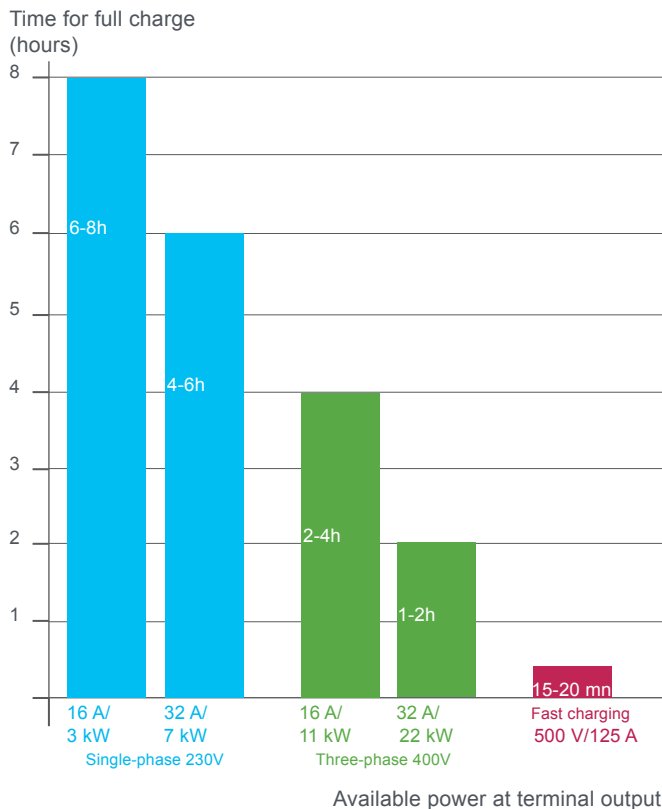
# 2 €

The electricity bill for the recharge of an Electric Vehicle battery should not exceed 2€ in France (Source: EDF, French utility).

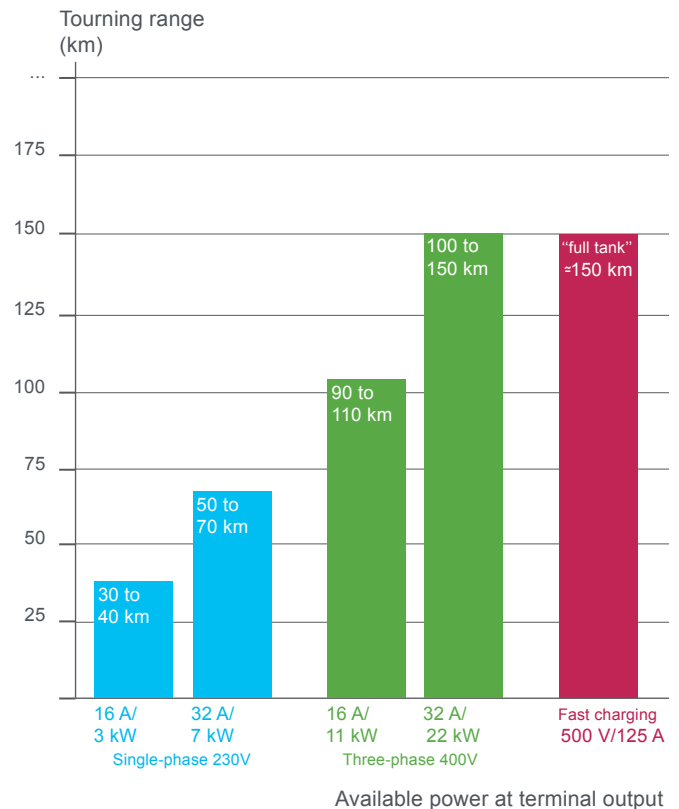
<sup>7</sup> <http://www.dteenergy.com/residentialCustomers/productsPrograms/electricVehicles/pevRates.html>

<sup>8</sup> <http://www.sce.com/PowerandEnvironment/PEV/plug-in-ready.htm>

## How long does it take to charge EV? (for “all-electric” car)



## One hour's recharging for how many km travelled? (for “all-electric” car)



Once consumers overcome these barriers to EV adoption, they can begin to reap the benefits of cleaner, quieter, cheaper transportation without sacrificing safety or convenience.

### Strasbourg, France launches broad-scale electric vehicle pilot program

The city of Strasbourg, France has teamed up with Toyota and a slate of partners from industry to run a three-year plug-in electric hybrid vehicle pilot program. A fleet of 100 Toyota Prius plug-in hybrids has been leased out to participating businesses and government agencies for professional and personal use by employees on a volunteer basis.

The charging points provided include advanced safety features like an automatic power cutoff if the cable is unplugged or the car battery is

completely charged. Drivers and fleet managers can also access real-time information on available charging points nearby and current battery charge level.

The Strasbourg project will enable car manufacturers to leverage the results of testing in real-world conditions for future product development work and will give utilities valuable information on user behavior to envisage optimal solutions for managing the potential impact of EV charging on the grid.

## Giving facility and fleet managers comprehensive solutions to optimize use and control costs

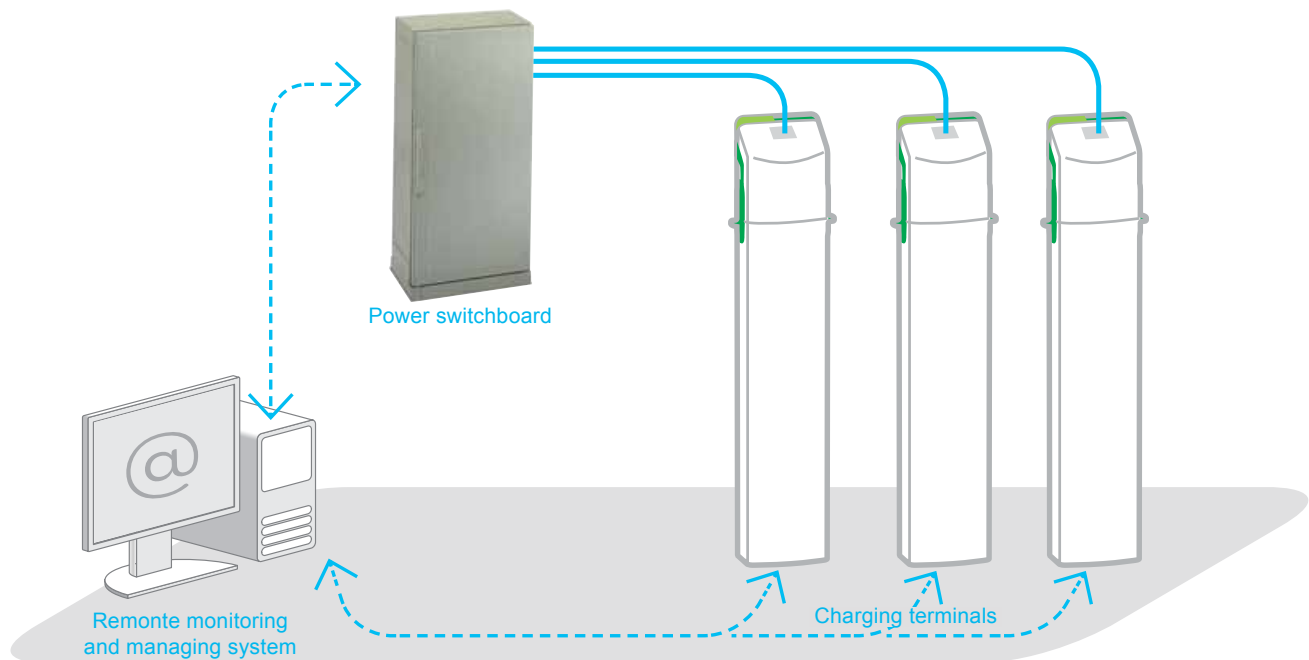
Facility and fleet managers of all sizes have one thing in common: They must ensure that employees have safe, convenient access to the vehicles they need, when they need them, and keep their organizations' energy bills as low as possible.

The charging infrastructure must enable facility and fleet managers to meet their business objectives. Linking a network of communicating charging points to a supervision or remote monitoring system can give managers the detailed information they need to optimize vehicle use, charging, and energy costs.

For example, charging can be programmed to make sure vehicles are ready at a

specific time (like the start of a delivery route), or certain vehicles can be given charging priority. Charging stations can also be set to stop charging when there is enough power to drive a predetermined distance. Or, the entire fleet can be programmed not to exceed a predetermined demand threshold for a certain period of time.

In addition to managing vehicle charging, the supervision or remote monitoring system should also provide managers with the information they need to track and optimize their energy bills.



*Station with three terminals, charging architecture model including Power availability and protection and energy management and remote control*

## Helping electric utility operators manage increased stress on the grid

For utilities, the large-scale deployment of EVs will create a number of obstacles to be overcome depending on when and how the electric vehicles are charged.

The **regulatory environment** will have to evolve so as not to discourage utilities from making innovative investments in EV-related and smart-grid technologies and to ensure that they can integrate the consumption of these infrastructures into utility load curves.

**Infrastructure upgrades** may also have to be made. If drivers can be encouraged to charge during off-peak hours, it is likely that the existing utility infrastructure will be sufficient to absorb widespread adoption of the EV. However, utilities may need to invest in equipment like local transformers and service drops.

**Demand-response management** will be another major requirement that utilities will need to meet. From a technical standpoint, widespread EV charging will increase energy demand, putting the grid under substantial stress.



### Spain's Cenit Verde project explores how electric charging stations can be integrated into the grid

In Spain, partners from government, industry, research, and academia are teaming up to explore EV charging. The €40 million Cenit Verde project, which has mobilized partners like automobile

manufacturer Seat and utilities Endesa and Iberdola, will examine the impacts of EV charging on the grid and will search for the most effective ways to integrate future EV charging points into the grid.

The EV also presents a number of opportunities for utilities, not least of which is increased flexibility preventing problems on the grid. For example, the integration of EV and PHEV charging could be leveraged to build a grid that is adaptable to varying conditions, with vehicle-to-grid discharge and demand-side (pricing) management.

Vehicle-to-grid discharge capabilities would be a boon to utilities in a number of scenarios. If demand on the network reaches a critical peak, for instance,

utilities could use the energy available in EV batteries to prevent blackouts. Such use would have to be short-term and very occasional, however, as EV batteries were designed to power vehicles, not supply the grid. A more likely scenario would be using EV batteries to power individual homes in the event of storm outages.

For electric utilities, the smart grid, with its advanced energy management capabilities, is a crucial step on the pathway to managing the EV interface with the grid.

**Non-peak load / Evening**  
Grid to vehicle and second life battery backup



**Peak load / Midday**  
Second life battery and vehicle to grid (V2G)



*Peak vs. non-peak charging*

## Giving electric vehicle manufacturers access to skilled energy professionals

The hybrid electric vehicle (HEV) has now gone mainstream, as evidenced by the Toyota Prius' groundbreaking success since it was launched in the United States in 2000. The plug-in hybrid electric (PHEV) vehicle is more reliant on electricity, and therefore presents automobile manufacturers with a new set of challenges.

**Technical mastery:** Car makers will need to master skills not traditionally needed to produce combustion-engine-driven vehicles. From power electronics to the management of high voltage, automotive professionals will have to learn the ins and outs of electricity.

**Customer education:** Another challenge for car makers will be to make it easy for drivers and fleet managers to opt for plug-in hybrids by offering them complete information and access to trained professionals who can inspect their existing electrical networks and, if needed, make upgrades or install new equipment.

## Key take-aways

Widespread adoption of the plug-in electric vehicle is just over the horizon.

The arrival of massive numbers of these vehicles on the grid will raise regulatory, technological, economic, and safety hurdles to overcome for consumers, facility and vehicle fleet managers, and electric utility operators.

The smart grid—and effective energy management systems to link individual energy consumers to the smart grid—will play a crucial role in reaping the full economic and environmental benefits electric vehicles can offer.

Energy management specialists like Schneider Electric will help drive the smart grid movement, working alongside government, automobile manufacturers, electric utilities, and consumers to find safe, reliable, convenient, and cost-effective electric vehicle charging solutions.

New regulations will be needed to encourage utilities to innovate; standards are needed so that manufacturers can build safe, interoperable EV equipment; and infrastructure is needed to make using EVs convenient and cost-effective.

By getting all stakeholders to work together, we can help transform our energy-hungry motor-vehicle-driven lifestyle into a cleaner, quieter, cheaper mobility landscape in which the electric vehicle will play a key role.

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