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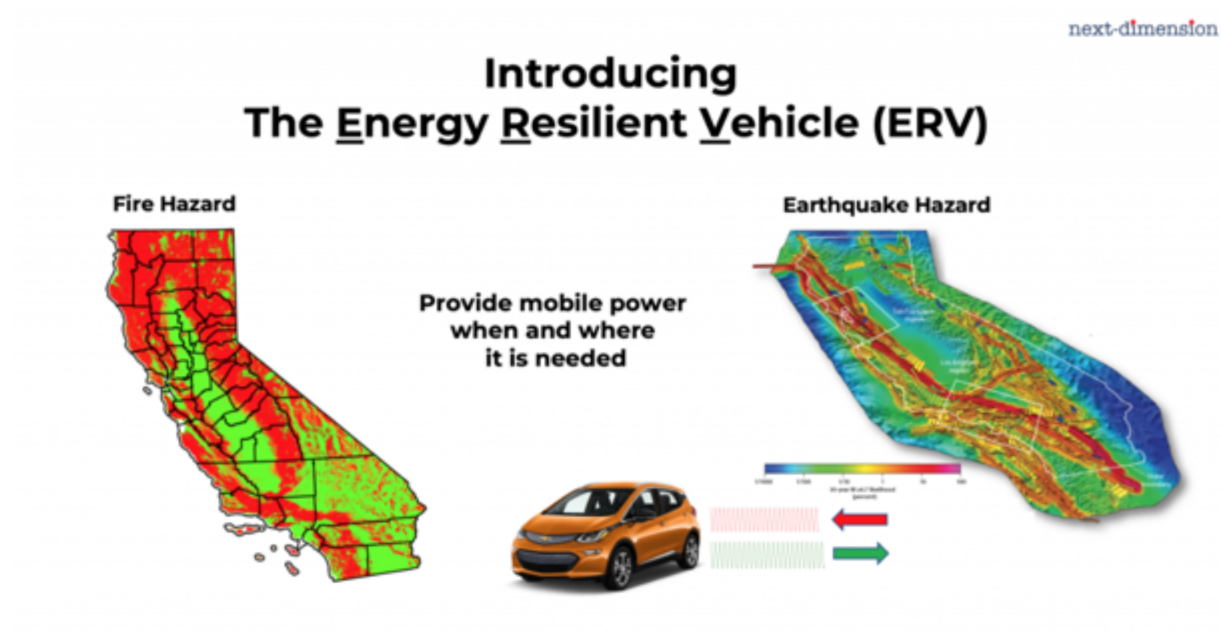
Energy Resilient Vehicle - Using to ZEV to enhance energy resilience

Additional submitted attachment is included below.



Now is the time for car manufacturers to step up and help California mitigate the effects of wildfires and earthquakes (1).

[Leave a Comment](#) / [V2G](#), [Vehicle Grid Integration (VGI)](#) / By Bjoern E Christensen

A "new normal day" in a Californian's life Autumn 2019.

Last Friday we received a call from our electricity provider Pacific Gas & Electricity (PG&E). They told us that they would cut the power to the area where we live outside San Francisco because of high wind and dangerous fire conditions. It turned out that we were not alone – all in all they cut the power to almost 1 million customers affecting almost 3 million people that may be without power for 1 to ? days. This happens to prevent wildfires and is part of the PSPS system (Public Safety Power Shutoff).

So our family convened to prepare: Make sure that all cell phones and the EV is fully charged, buy enough water and non-perishable food to last a week without power, start using the contents of our fridge and freezers to limit the amount of food that we have to throw away, make sure we have all our flashlights, what should we do about our son's school, what about our teleconferences for work from home etc. etc.

In the end we did not end up losing power, but we got a preview of what it would be if we had lost power.

And this was a "good" scenario where the power cut was planned. What about a big earthquake that is certainly not planned?

We started to think about how we could cope with future power shutoffs. Since we have a 75kWh Tesla in the garage it was obvious that would be a good place to start. Our Tesla would easily be able to supply our house with emergency power for 5-7 days.

Now I have worked in the E-Mobility/Vehicle-Grid-Integration (VGI) field for almost a decade and am aware that there are two type of EVs.

The uni-directional power EV that can only charge. The energy charged can only be used for transport.

The other type of vehicle is the bi-directional power EV. This vehicle is capable of charging the vehicle battery, but the energy in the battery can be used for more purposes like: transport, emergency power, cutting the electricity bill and supporting the electric grid.

Since a vehicle is typically only used for 2-3 hours a day for transport and needs a relative short time to charge it would be obvious to use the remaining time for something that could bring value to the owner of the car like emergency power.

My Tesla does not provide the capability of powering my home as is also the case with most EVs sold today. Only the Japanese car manufacturers Nissan and Mitsubishi provide this capability in their series EVs, and this was a result of the lessons learned during the great earthquake and following tsunami in 2011.

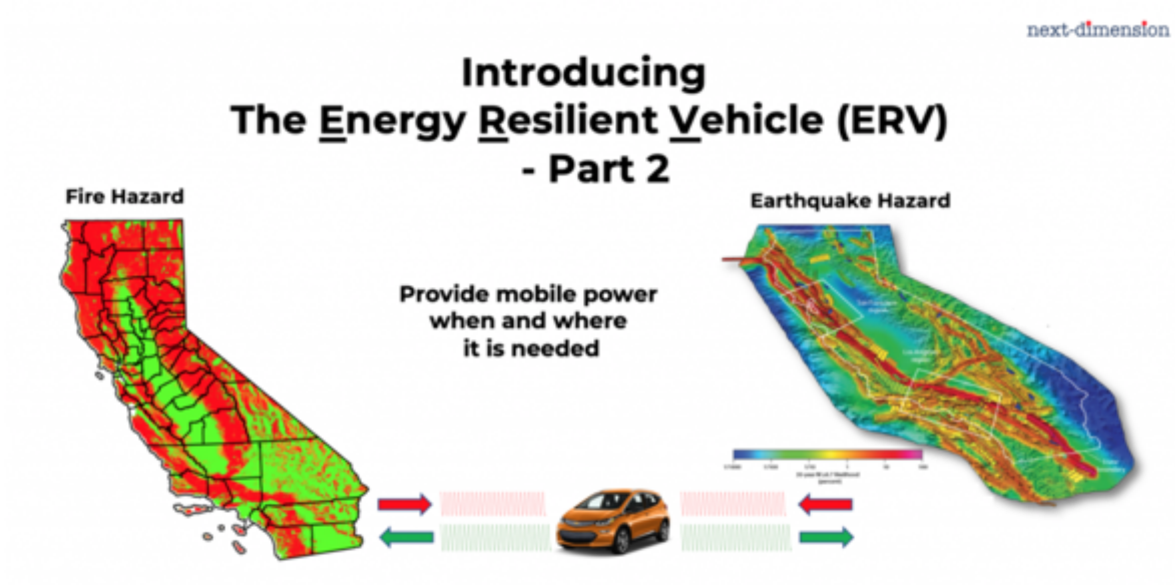
So, if an EV could provide critical emergency power for families and communities to cope with the effects of a PSPS wildfire situation in California,

why have not more car manufacturers introduced bi-directionality (V2G) in their EVs?

The typical concerns mentioned by the car manufacturers are:

- added cost
- added volume
- added weight
- potential battery wear
-

We will explore these issues in the next blog – stay tuned.



Now is the time for car manufacturers to step up and help California mitigate the effects of wildfires and earthquakes.

Leave a Comment / EV MARKET, V2G, Vehicle Grid Integration (VGI) / By Bjoern E Christensen

The Energy Resilient Vehicle (Part 2)

California has always been on the forefront of helping car manufacturers to introduce climate friendly technology in their vehicles.

A. The Story of smog and the Catalytic Converter in California

The first episodes of 'smog' occurred in Los Angeles in the summer of 1943. It got worse the following decades to the point where it was outright dangerous to your health to be outside when the bad smog events occurred.

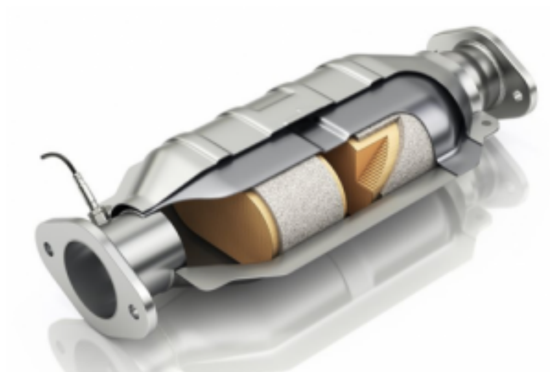
California then in 1966 established the first tailpipe emissions standards in the nation. In 1967 the California Air Resource Board (CARB) was established, to attain and maintain healthy air quality; and to provide innovative approaches for complying with air pollution rules and regulations.

City Center Los Angeles in 1948

Los Angeles – Skyline of Downtown 1975

Los Angeles Airport in 1980

The catalytic converter became standard equipment on most new vehicles starting in 1975 and was mandatory by 1981, when it was fitted to vehicles for sale in the United States, enabling them to meet newly introduced emission regulations.



The Catalytic Converter mandated in 1981

The car manufacturers originally objected to the:

1. cost ($thousand+)
2. weight
3. volume
4. performance (reduced miles per gallon)

added to the car but eventually rose to the challenge and incorporated the catalytic converters.

B. The Story of CO2 emission and the Zero Emission Vehicle (ZEV) in California

The Zero Emission Vehicle program was first adopted by the California Air Resources Board (CARB) in 1990. The purpose of the ZEV program was to meet California's health-based air quality standards and greenhouse gas emission reduction goals and move the cars away from petroleum-based fuel. This would reduce smog-causing pollutants and greenhouse gas emissions of passenger vehicles in California.

The ZEV regulation is designed to achieve the state's long-term emission reduction goals by requiring auto manufacturers to offer for sale specific numbers of the very cleanest cars available. These vehicle technologies include full battery-electric, hydrogen fuel cell, and plug-in hybrid-electric vehicles. The ZEV regulation is part of the broader Advanced Clean Cars package of regulations, a set of tailpipe regulations put in place to limit smog-forming and greenhouse gas (GHG) emissions and combat climate change.

The following is a quote from the CARB homepage:

"**How the ZEV Regulation Works**
Auto manufacturers are required to produce a number of ZEVs and plug-in hybrids each year, based on the total number of cars sold in California by the manufacturer. Manufacturers with higher overall sales of all vehicles are required to make more ZEVs. Requirements are in terms of percent credits, ranging from 4.5 percent in 2018 to 22 percent by 2025. Auto

manufacturers are to produce vehicles and each vehicle receives credits based on its electric driving range. The more range a vehicle has, the more credit it receives. Credits not needed for compliance in any given year can be banked for future use, traded, or sold to other manufacturers. CARB releases annual credit bank balances each year, as well as the total number of vehicles produced for that model year, as well as the total number of ZEVs and plug-in hybrids."

Carmakers that didn't comply could be fined $5,000 per credit not produced, though CARB has yet to levy a penalty.

The ZEV program is largely credited for incentivizing the car manufactures to introduce Zero Emission Vehicles (battery, fuel cell, hybrid plug-in) in California.

The car manufacturers have introduced ZEV in California – there are currently around 750,000 ZEVs – even in the light of the following issues:

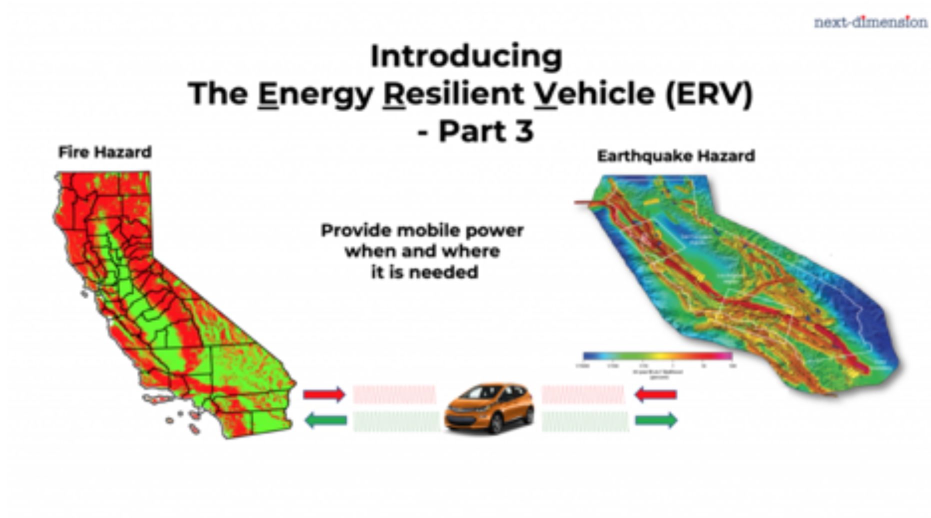
1. cost ($ten thousands+)
2. weight (EVs are heavier than similar ICEs)
3. volume (batteries taking up a lot of space. but also reducing space because no ICE drive train)
4. performance (reduced range per fuel stop)

.

C. To Sum It Up

The car manufacturers adopted their cars to help California cope first with reduction of smog with the incorporation of the catalytic converter and are now helping California in its efforts to meet its climate goal of carbon neutrality by 2045 by the introduction of Zero Emission Vehicles.

In the next blog (3) we will explore how the car manufacturers should help California mitigate the effects of wildfires – The Energy Resilient Vehicle.



Now is the time for car manufacturers to step up and help California mitigate the effects of wildfires and earthquakes (Part 3)

Leave a Comment / Energy Resilient Vehicle (ERV), EV MARKET, V2G, Vehicle Grid Integration (VGI) / By Bjoern E Christensen

The Energy Resilient Vehicle (Part 3)

This is the 3rd of a series of blogs that explains the concept of the Energy Resilient Vehicle. This blog goes into some details about what the ERV is and how the EV manufacturers can make ERVs. The next blog will take a view of the advantages to the state of California if ERVs become the mainstream.

1) Use cases

Public Safety Power Shutoffs / Wildfires

When PG&E announces that a PSPS event is upcoming the driver has time to fully charge the EV. When the actual power is cut the EV can provide emergency power to the home for 3-5 days. This will avoid that the homeowner has to discard food contents of fridges and freezers often in the amount of $300-$500 per PSPS event. And in October we had 3 PSPS events!. Furthermore, the homeowner has the peace of mind that there will be light in the house, power to charge critical medical devices and power to charge the cell phones (so they can be used if the cell towers have power).

Earthquakes

Earthquakes occur spontaneously and charging of the EV cannot be planned before an earthquake occurs. However, if power is cut and the EV is at home and charged or partly charged it can still provide power to the house as described above.

Camp Fire: $16.5 billion (2018)

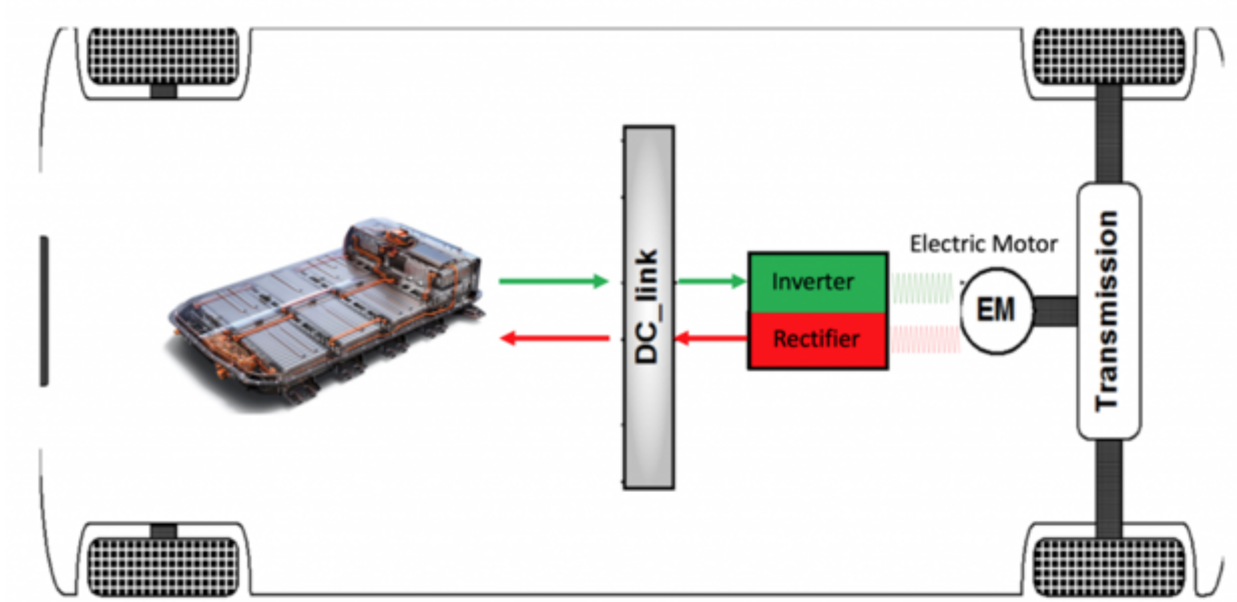
Northridge: $15 billion (1994)

2) All electric vehicles are born to "bi-directionality" internally

When you depress the accelerator in an EV DC energy is flowing from the battery to the electric motor (EM) – the green arrows. However, before it reached the EM it has to be converted to AC, this is done by the inverter. See simplified diagram below.

When the foot is taken off the accelerator the EM will break the car by reversing the energy flow which flows back to the battery in form of regenerative energy – the red arrows.

However, before the energy can be returned to the battery it must be converted from AC to DC. This is done by the rectifier. Voila, every EV is born to bi-directional power flow. Battery -> Electric Motor (outgoing power flow from DC to AC through inverter). Electric Motor -> Battery (incoming power flow from AC to DC through rectifier/charger).



Electric Vehicle Battery and Electric Motor System

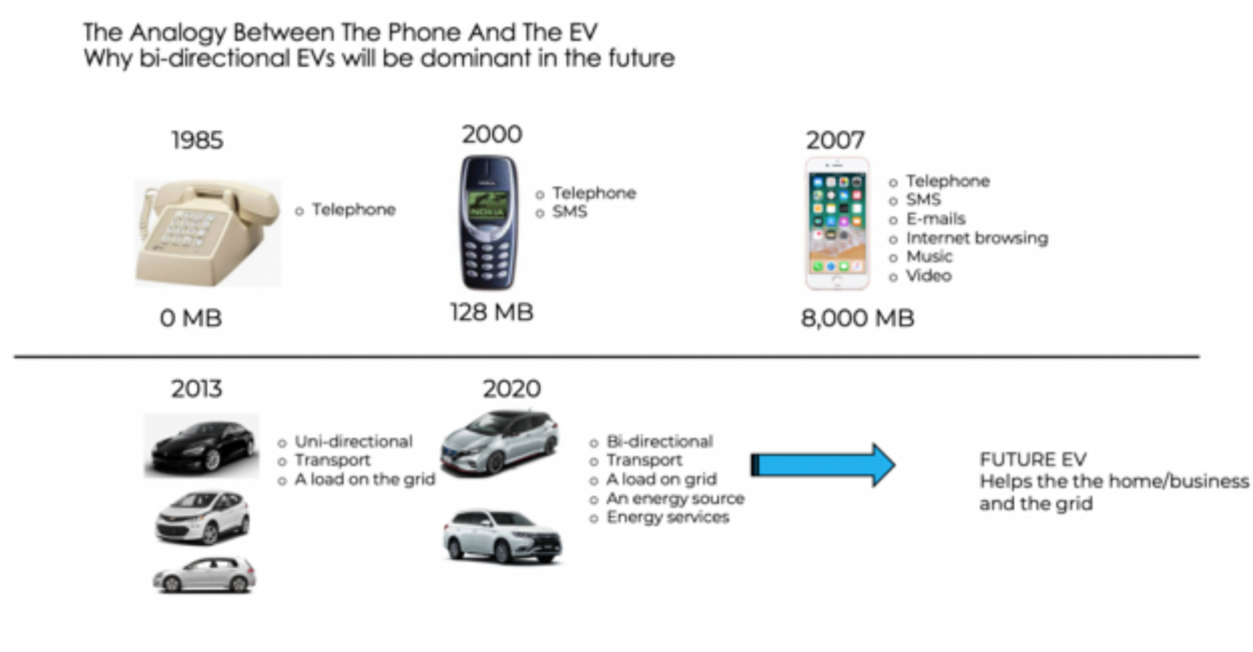
The diagram below shows a typical power flow of a Tesla Model S. As can be seen by the orange and green curve the power is bi-directional.

Bi-directional Powerflow in a Tesla Model S

3) The analogy between the car and the phone

The good old-fashioned AT&T telephone was invented for making telephone calls. With the invention of the car phone and later the cell phone it was possible to move around with the phone. Later the first smartphones were introduced – spearheaded by Nokia, these could add text messages and simplified internet connections for limited internet browsing via the WAP (Wireless Application Protocol). With the introduction by Apple of the iPhone in 2007 that all changed. The telephone had become mobile and could be used for many functions: telephony, texting, browsing, emails, video, photography, music etc. (see figure below).

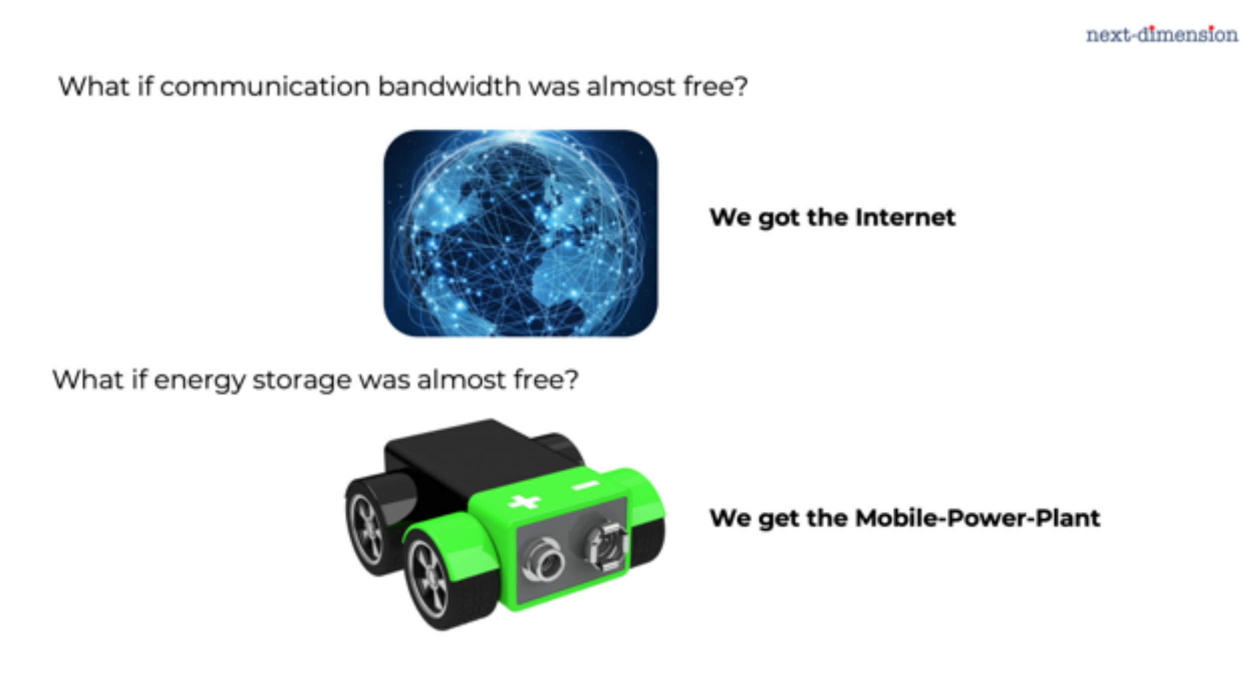
Up till now the ICE (Internal Combustion Engine) vehicles fulfill one single purpose: transportation. With the introduction of the EV this has not changed. The EV can be charged and the energy can only be used for transport. So to say, the energy is trapped in the battery for one purpose only. With the bi-directional ERV this changes in analogy to the telephone – the ERV becomes multifunctional. The energy in the battery can be used for transport, emergency services, mobile power, energy services serving the business, home or stabilizing the grid. The energy is no longer trapped in the battery for transport but can be used for a multitude of value adding services.



4) The analogy between the Internet and the E-Mobility (ERV)

The key word during the internet revolution was: **bandwidth, bandwidth, bandwidth**, and the internet required a lot of it. However, the internet could only scale to what it has become now, if technology could drive the cost of bandwidth to almost zero.
The keyword now – in the transition to renewable energy and increased electrifications – is **energy storage, energy storage, energy storage**. But how can we make the cost of energy storage almost free or at least much lower costly?

The owner of an EV will buy the EV including the battery with the purpose of driving the EV. However, it is only driven for a few hours every day. Why not share the battery between transport and energy services? This would drive the marginal costs of using the battery for emergency power services dramatically down. For the state of California, the cost of providing emergency power to households would also go dramatically go down.



5) What it takes to make an EV bi-directional externally

For DC charging the inverter is located in the EVSE (Electric Vehicle Supply Equipment). The EV manufacturers Nissan and Mitsubishi have already shown that is is possible to implement DC bi-directionality in their EVs even in "low cost" EVs.

For AC charging there are principally two ways to make the EV bi-directional to the outside:

A. Integrated solution. Use the existing internal EV inverter/rectifier system already on-board inside the EV.

B. Separate solution. Change the existing on-board charger to a bi-directional charger/inverter.

Option B is pursued by Honda. Actual Honda cars are operating in the CEC (California Energy Commission) funded INVENT project (Intelligent Electric Vehicle Integration) at the UCSD campus.

Both case A and case B requires relative low-cost components and some engineering efforts. Considering that the larger EV manufacturers are typically producing many hundred thousand EVs in a series the engineering costs can be amortized over many EVs. The total costs should be considerably less than what it cost to put catalytic converters on the cars in the 90ties.

Just in November 8, 2019: “BMW has just announced Bidirectional Charging Management – BCM research project brings together companies and institutions from the automotive, energy and scientific sectors. Electric mobility in tomorrow’s world – a question of give and take. Green light for the Bidirectional Charging Management (BCM) consortium research project led by the BMW Group: electric vehicles enable more efficient use of green energy while also boosting power supply reliability. Testing of the first 50 BMW i3 cars equipped with bidirectional charging technology (i.e. that are capable of back-feeding) is expected to start under real-world everyday conditions in early 2021.”

6) The ultimate ERV – The California school buses

There are over 25,000 school buses in California. In the USA there are 480,000 compared to 70,000 transit buses.

Electric school buses would be examples of perfect ERVs. They are large and have room for large batteries (+100 kWh), are driven only 180 days a year, for 4-8 hours a day, non-operation for long time (summer, holidays, weekends and nights) and have predictable routes every day. They could provide substantial community emergency power in case of power cuts for example 10 school buses could provide 1 MWh+ emergency power to critical community functions.

Trials have already been underway in California since 2014.

In July 2014, the California Energy Commission approved a $1.4 million grant for the deployment of six V2G school buses. These buses were 1996 model-year diesel Blue Bird buses, EV-converted with 96 kWh batteries, 150 kW EPC Power Corp on-board inverters and Nuvve 22 kW bidirectional chargers. In June 2019 a new vehicle-to-grid (V2G) pilot for 10 electric school buses was approved with a budget of $1.7 million. CPUC noted that it would be the first V2G pilot in the California Independent System Operator (CAISO) market utilizing 25 kW bi-directional chargers.

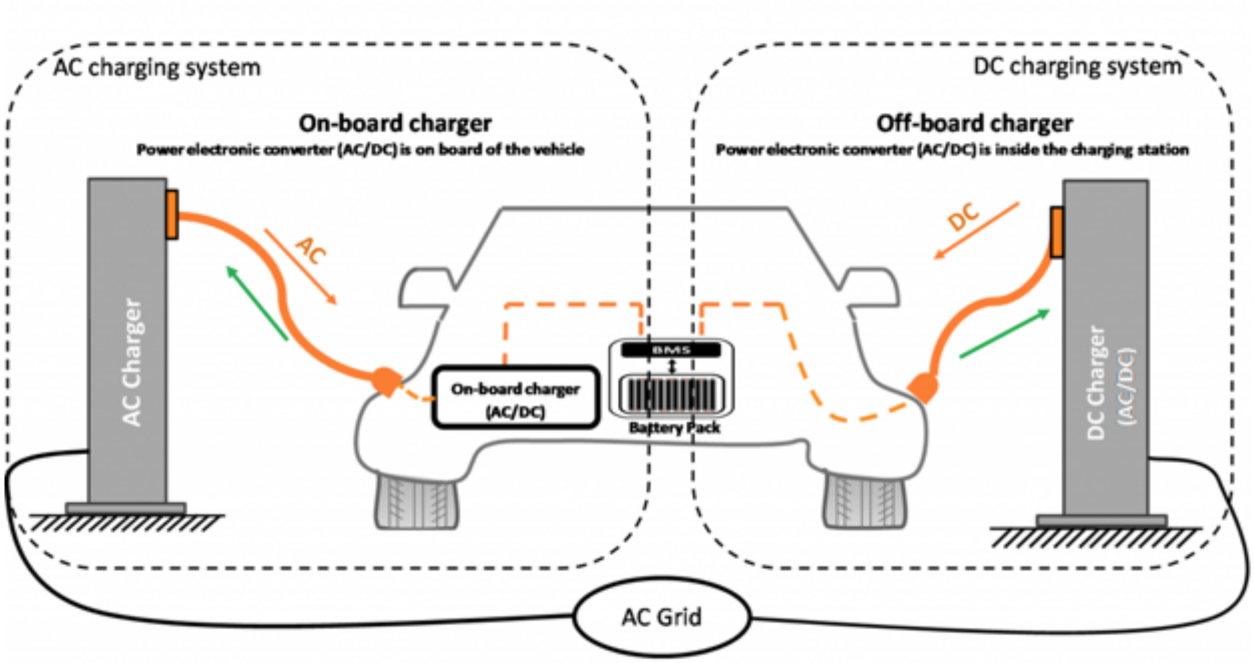
7) The cost of the bi-directional EVSE

It is not enough that the EV is bi-directional the EVSE must support bi-directional power flow as well. The figure below shows the two different ways to charge an EV (orange color). In the AC charging system, the EVSE provides AC power to the on-board charger which in turn converts the AC to DC and via the Battery Management System (BMS) feeds the energy into the battery.

In the DC charging system (on the right) the AC to DC conversion is built into the EVSE and as such can be shared by many cars.

In case of bi-directionality (the green arrows) an inverter must convert DC from the battery to AC to the grid. The inverter can be located in the EV (on-board) or in the EVSE (off-board).

Locating the inverter in the EVSE (off-board) transfers the cost to EVSE. This cost is today quite high. For example, typical bi-directional EVSEs cost upward of $8,000.



Source: Modelling analysis and performance evaluation of power conversion unit in G2V/V2G applications – a review. https://www.mdpi.com/1996-1073/11/5/1082

Using the already integrated inverter in the EV used for feeding power to the electric motor (on-board) reduces the additional cost for the EV substantially. But more importantly the cost of the bi-directional AC EVSE is much lower – in the range of $1,000+. Such technology is already commercially available today e.g. the Nuvve Powerport charger that provide up to 99 kW (3 phase) at low cost.

So, the way to achieve a low-cost bi-directional solution is to go AC and as is show later the international standards to support this will be available in 2020.

8) Why EV manufacturers should implement external AC bi-directionality

Cost: In quantity this will only add some few hundreds $ per EV for ; less than the cost of a catalytic converter. However, the cost of a bi-directional AC EVSE will go down dramatically. Example: today a bi-directional DC charger @10 kW typically sells for $8,000+. The cost of AC bi-directional EVSE today is in the range of $1,000+!

Weight: Integrated solution – Case A: the added weight will be negligible; **Separate solution – Case B:** This may increase the weight with 5 – 10 kg, but with maturing charger/inverter technology and increased integration this weight should go substantially down.

Volume: Integrated solution – Case A: the added volume will be negligible; **Separate solution – Case B**: This will increase the volume, but with maturing charger/inverter technology and increased integration the volume should substantially decrease.

Performance: For emergency use (energy resilience) in case of cutting power or earthquake this will only be activated few times per year and have no effect on battery health and will make sure local grid is protected (anti-islanding). However, it will greatly help California in its preparedness for mitigating natural disasters.

9) The international standards

The CHAdeMO protocol between the EV and the EVSE already supports bi-directional power flow to-day. However, the support for CHAdeMO is dwindling as the CCS (Combined Charging System) spreading and the IEC 15118-20 standard protocol is emerging.

The IEC 15118-20 standard communication protocol supported by the European and North American car manufacturers will support bi-directional power flow functionality and be released in 2020.

The Energy Resilient Vehicle (ERV)

The year is 2030 and California has successfully reached its goal of 5 million EVs. Average cost of an EV has fallen to $25,000; battery capacity is 60 kWh; charging capacity 10 kW. The consumers have invested 5M * $25,000 = $125 B of their money in a distributed battery capacity of 300 GWh. An EV needs ~3,000 kWh per year and 5M EVs 15 GWh. If all the cars charged at the same time 50 GW of extra grid capacity would be required (max CA peak was in 2006 @ 50 GW!).

These EVs could put substantial strain on the electric grid.

Two hypothetical scenarios:

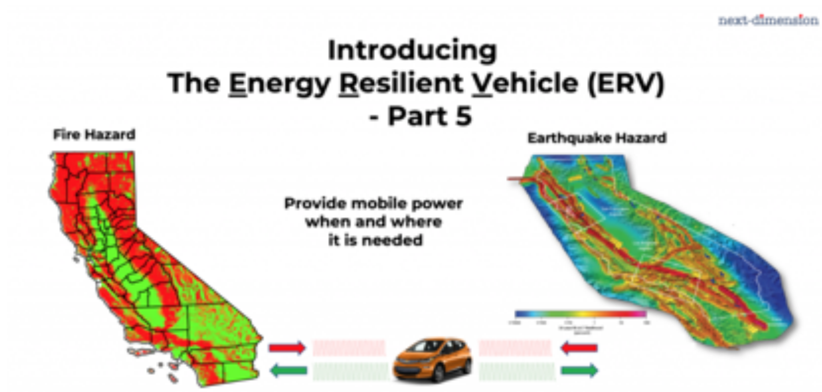
Scenario 1: EVs are all uni-directional

The energy in the batteries is "trapped" and can only be used for transport. The EVs may pose a problem for the grid, which can only be partly mitigated by programs such as Demand Response and Smart Charging despite a $125 B investment.

Scenario 2: EVs are all bi-directional (ERV) at low marginal extra cost per EV.

Additional 300 GWh distributed storage would be available for multiple purposes resulting in increased flexibility. The stored energy could be used for emergency power, energy arbitration, stabilizing the grid or cutting down on demand charges.

Which scenario would you prefer?



Now is the time for the IOUs and Regulatory Bodies to step up and meet the EV manufacturers to help California mitigate the effects of wildfires and earthquakes (Part 5)

Leave a Comment / Energy Resilient Vehicle (ERV), EV MARKET, V2G, Vehicle Grid Integration (VGI) / By Bjoern E Christensen

The Energy Resilient Vehicle

This is the 5th of a series of blogs that describe the concept of the Energy Resilient Vehicle (ERV). In previous posts I have explained how the car manufacturers must step up to the table and help California deal with the wildfire and natural disaster threats through producing so-called ERVs.

1. Blog #1: Introduction to the Energy Resilience Vehicle
2. Blog #2: The story of GHG emission and California
3. Blog #3: Why the car manufacturers should step up to help CA
4. Blog #4: California 2030 – A scenario

This article describes what the IOUs (Investor Owned Utilities) and the regulatory bodies can do to step up and together with the EV manufacturers meet the challenge of making the California electric grid more resilient.

1) A hypothetical PSPS (Public Safety Power Shutdown) scenario

Mrs. and Mr. Jones hear on the TV in October 2019 that there may be a proactive power shutoff the next day that may affect the area where they live in their house. The PSPS – PG&E explains – may be necessary because of dry hot weather, strong winds and vegetation that is bone dry from a scorching summer and to avoid that the electric grid ignites wildfires, which have been the case in previous years. The next day afternoon the Jones receives a call from PG&E saying that their area actually will be cut off from power starting at 8pm and that the power outage may last up to 5 days!

The next day's turns into a nightmare for the Jones. After the first 24 hours the food in the fridge has to be discarded. The same goes for the food in the freezer after 48 hours. Since there is no power to their house and the telephone system is down as is the cell towers Mr. Jones cannot work from home as he normally does and has to commute to his work 4 driving hours away (assuming that his workplace has power). Since he does not want to spend up to 8 hours driving to and from work he decides to book into a hotel close to his workplace.

After a week without power the power returns and the Jones decides to take stock of the costs. The food that was discarded amounts to $500. The hotel costs and meals outside the home to another $400. So, the total cost is in the neighborhood of $900 for this PSPS event, not to mention the discomfort of being without communication and Internet services, no light and heat and security system not working since battery is empty.

Let's use this hypothetical example to estimate the aggregated costs to the California population living in the PG&E area just focusing on the discarded food cost:

Monetary costs alone: 800,000 households affected @ $500 = 800,000 * 500 = $400 million!

And what about the people relying on grid power for their medical equipment and the old folks' homes, and the lost work income….. And many of these people are economically disadvantaged making the burden even more disproportional.

2) Some are more equal than others in a PSPS

However, not everybody are affected by the power outage in the same way. Hospitals use their Automatic Transfer Switches (ATS) to switch to backup diesel/gas generators (required by CA law), cell towers have battery backup power to last 24-48 hours, large computer centers switches to backup power (UPS) and large organizations such as university campuses can disconnect from the electric grid and operate in island mode. This is widely known as forming their own island microgrids.

Now if hospitals, cell towers, computer centers large U campuses can "microgrid", why can residential customers and small businesses not do the same? If they had an ERV it could provide power from its battery to provide emergency power to essential functions in the house.

3) The need for microgrids – safe, flexible and easy to create/manage

In 1987 the telecommunication network was changed forever with the Final Modified Judgement that set the scene for competition in the marketplace. One important influence was a report by Peter Huber with the title "The Geodesic Network". One statement summed his position up: "Networking is contagious". The development of the Internet certainly has proved that he was right.

In the same way distributed microgrids may revolutionize the electric grid with the emergence of the "prosumer", who produces and consumes his/her own generated electricity without the need for a centralized electric grid. However, as simple as it sounds it is facing the dilemma: if more and more households and business goes "microgrid" who will pay for the public network? (Analogy to the debate of private schools versus public schools). It would also challenge the economic interests of the IOUs, which have sunk trillions of dollars into their distribution grids.

However, if allowing safe "microgridding" only in case of a PSPS event and if the IOU's could be in control of the disconnect and reconnect of the customer to ensure safe disconnect, operation in island mode and safe reconnect, it would be difficult to argue against such a solution. All the consumer would need would be an ERV (and/or PV panels and/or a separate battery).

A major issue for microgrids is that rules prohibit private-utility customers from selling electricity "over the fence" — on the public market — because they are not regulated by the state.

The ability to do so would make the economics far more feasible for neighborhoods, community groups and private customers interested in building microgrids, especially in rural areas, as a backup to the increasingly unreliable utility-provided electricity. One compromise would be to allow some private microgrid electricity sales only during blackouts, a step other states have taken.

ERV as part of a home microgrid (Source: Nissan)

Even a Tesla Cybertruck may be used as an ERV

4) Flexible certification of ERVs (on-board and off-board)

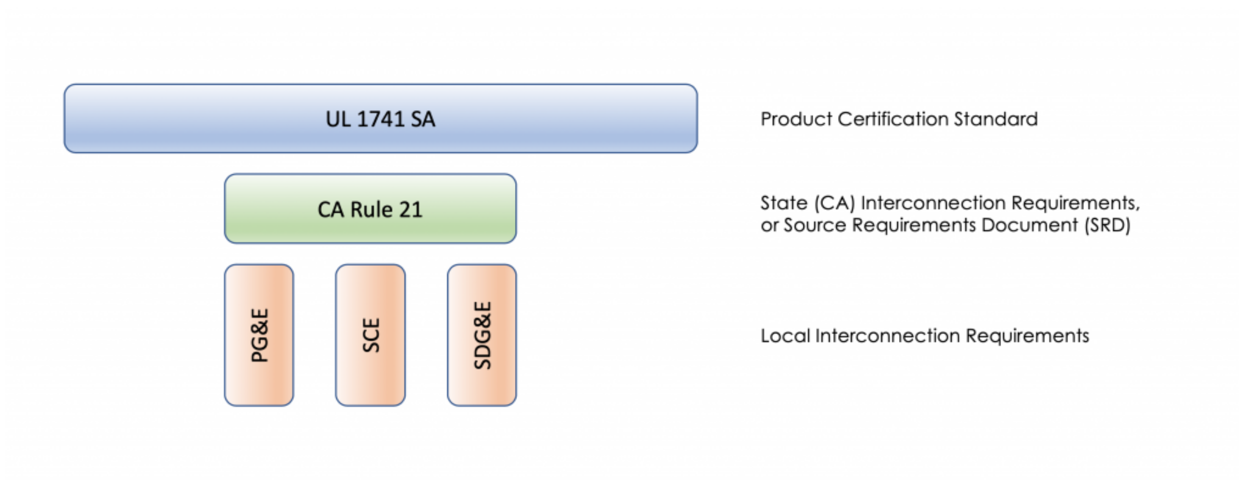
As the number of distributed energy resources incl. ERVs grows it is necessary to define rules of how they can be added safely to the grid and improve the reliance and stability of the grid. These grid rules are set by national US bodies and tested by national recognized labs (NRTL) and administered by the local utilities. They are codified in rule sets known as **UL 1741 SA** and **Rule 21** (California) to describe how power exporting entities (wind turbines, solar panels, batteries) must react in case of voltage or frequency anomality's.
UL 1741 SA is a standard for inverters, converters, controllers and interconnection system equipment for use with distributed energy resources, in essence, the test standard by which inverters are certified for interconnection to the grid, with particular respect to: grid voltage and grid frequency.

5) Streamlined and easier site interconnection approvals

An important issue to address is how to speed up and streamline the site Interconnection approval process. In order to connect to the electric grid any site that is capable of exporting power to the grid (or even to a grid connected building) must adhere to strict approval processes administered by the IOUs.

The regulatory bodies and the IOUs must continuously improve, streamline and shorten this process to make it easier to get approvals.

The figure below shows the taxonomy of the certification:



Interconnection – Taxonomy
Rule 21 – a quote from the CPUC: "Electric Rule 21 is a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system, over which the California Public Utilities Commission (CPUC) has jurisdiction."

If the inverter is located in the EVSE (off-board) it is straight forward – the car manufacturer can rely on the inverter in the EVSE is UL 1741 SA certified. However, if the inverter is located in the EV (on-board) and the EV delivers AC power back to the EVSE, then we enter a domain where the EV manufacturers will have to go through a UL 1741 product certification in order to sell their ERVs in California. This UL certification will most likely not be acceptable to the EV manufacturers since they already have their own equivalent safety industry standards like J3072 that addresses mostly the same safety issues as UL 1741 and is based on the same international standard IEEE 1547. This issue still needs to be resolved with priority.

However, in the case of the single meter / customer premises microgrid, everything is "inside the fence" like it is at a datacenter or generator backed site.

Generators and other power sources "inside the fence" used for backup / islanded (non-parallel) operation are not ever electrically connected to the utility's distribution system, and therefore aren't subject to the interconnection certification & listing standards (UL 1741) and utility interconnection rules (21 in CA). This means that an ERV could be used to power a microgrid in a PSPS emergency without that added cost & complexity.

Note: The state of Delaware has passed a Grid Integrated Vehicle (GIV) law in 2019 to make SAE J3072 qualify for interconnection and net metering! CA could choose to follow the same route or at least allow the car manufacturers to choose their own industry accepted 3rd party organization to test and certify.

If the regulatory bodies do not act fast the people will come up with their own solutions which may jeopardize the safety and even lead to new fire hazards in case of using gas powered generators. As an example, from the CA city of Arcata have demonstrated: "*When the power went out those with generators started them, creating fire risks of their own. On Arcata's central square, where the bead shops, cannabis oil vendors and vintage clothing stores attract a steady flow of tourists, owners of the Big Blue Cafe turned on their generator in the minutes after the power went out for the second time in October. A few hours later, the popular diner was in flames, the generator later found to have vibrated across the floor to a wall, where the hot exhaust sparked the fire. The restaurant and its two neighbors are still closed*" (source: Washington Post).

7) International standards

In order to reduce the cost of making ERVs happen we would need international standards. Fortunately, they are on their way. The most prominent is the IEC 15118-20 standard expected to be released end 2020. It covers the communication interface between the EV and the EVSE. It supports CCS (Combined Charging System – AC as well as DC) and support bi-directional power flow.

The interface between the EVSE and the backend is under work in the standard bodies and known under the name IEC 63110 (Protocol for Management of Electric Vehicles charging and discharging infrastructures) and is expected to be released late 2020.

8) Example of a CA microgrid – Blue Lake Rancheria

The following is an excerpt from a Washington Post article:

“BLUE LAKE, Calif. — After months of wildfires, an essential question in a warming, windy California is this: How does the state keep the lights on? A tiny Native American tribe, settled here in the Mad River Valley, has an answer: ***Build your own utility.***
The Blue Lake Rancheria tribe has constructed a microgrid on its 100-acre reservation, a complex of solar panels, storage batteries and distribution lines that operates as part of the broader utility network or completely independent of it. It is a state-of-the-art system — and an indicator of what might be in California’s future.

In early October, Pacific Gas & Electric cut power to more than 2 million people across Northern California, including all those who live here in rural Humboldt County, where redwood forests fringe the wild edge of the continent. The shut-off aimed to reduce the risk of wildfire, and as the region sat in darkness, the tribe’s multimillion-dollar investment in its power system glowed.

Responding to public needs, the tribe transformed a hotel conference room into a newsroom so the local paper could publish. It used hotel guest rooms to take in eight critically ill patients from the county’s Health and Human Services Department. The reservation’s gas station and mini mart were among the only ones open, drawing a nearly mile-long line of cars.

The Blue Lake Rancheria Casino

The Blue Lake Rancheria gas station and mini mart

The Blue Lake Rancheria served more than 10,000 people during the day-long outage, by some estimates, roughly 8 percent of Humboldt's population. And for a government that had largely ignored the tribe for more than a century, the tribe suddenly became a vital part of its emergency response.

“The irony was not lost on us,” said Jason Ramos, a member of the tribal council who ran emergency operations during the blackout. “When these power cuts started, we looked like geniuses for what we had done. But in truth, we didn’t really see them coming when we made our decision.”

California, a hive of rapid private-sector innovation, is adjusting slowly to the accelerating changes in its climate. The sharp transition between heavy rains and hot, windy weather has primed the landscape for wildfires, which have burned larger and deadlier in recent years than at any time in history.

After an autumn of power cuts and economic losses, the reliability of California’s electricity grid and of its three largest investor-owned utilities is among the most pressing public policy issues facing Gov. Gavin Newsom (D). The state lags behind some on the East Coast, where Tropical Storm Irene swamped towns in 2011, causing blackouts and a rethinking of how to strengthen a vulnerable electrical grid.”

9) California is not the only place suffering from wildfires

As this article is written Australia is having its worst wildfires in history. More than 200 wildfires continue to rip through the nation’s eastern states, prompting the largest peacetime evacuation in the country’s history. At least 19 people are dead and 28 more are missing after hundreds of fires scorched more than 12.35 million acres of land, destroying at least 1,400 homes in three states. All these wildfires are of course not ignited by the electric grid; however, the effect is still that many million people is without electric power for extended period of time.

And Australia is not alone. Indonesia experienced their worst fire season and their Forestry and Environment Ministry, has estimated that by the end of September 2019 a total of 2.12 million acres had been burned.

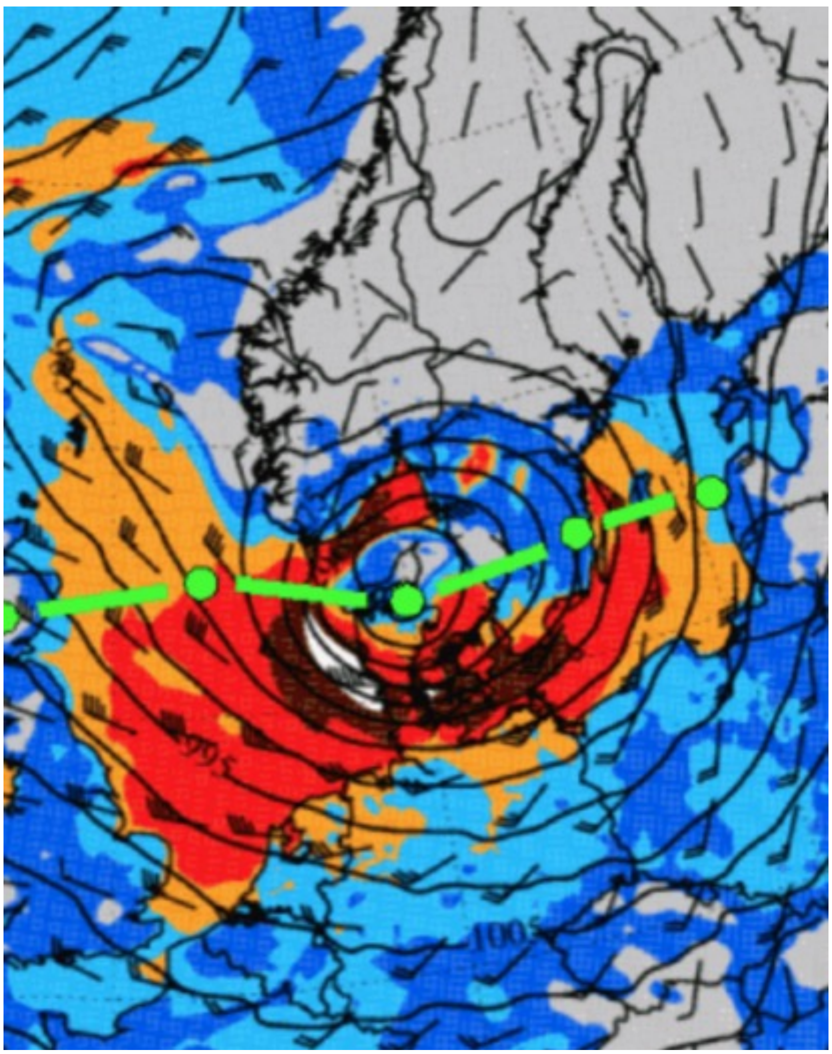
Australia is burning

Worst wildfires in decades in Australia

10) Reducing the risks to/from the electric grid – example Denmark

20 years ago, a Category 4 hurricane swept over Denmark and brought death and destruction with it. Seven people were killed and 800 injured. The electricity grid was also severely hit on December 3, 1999. The wild hurricane toppled high voltage lines and created the most extensive power cuts in recent times. This was followed by a category 3 hurricane that struck Denmark in 2005 and caused disruptions however not as severe as in 1999.

1999 Category 4 hurricane strikes Denmark



Category 4 hurricane in 1999 in Denmark

As a result of these events Denmark decided to bury most of the distribution grid underground at large costs. This activity was largely completed this year. Since the hurricanes in 1999 and 2005 Denmark has not experienced large power outages and Danish families and businesses have received electric power 99.99 percent of the time.

California must consider going the same route and bury the most vulnerable distribution grid sectors underground even if this will be quite expense and take time.

11) Summary

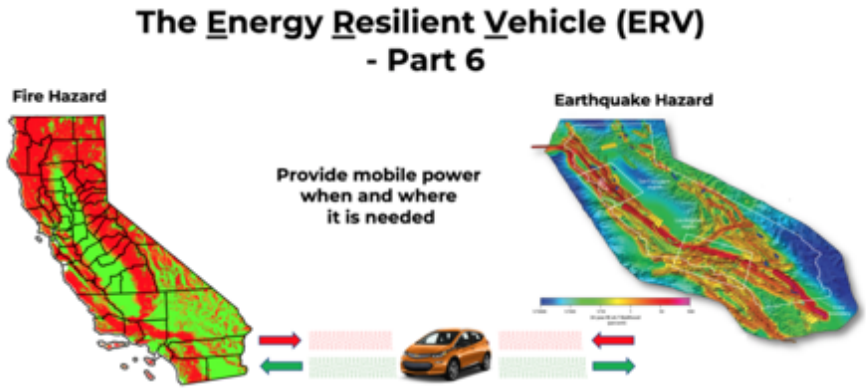
The technology is here today to make ERVs and allow for flexible "microgridding" in case of PSPS events to make the California grid more resilient. We don't even need expensive solutions such as solar panels and wall batteries. It is now up to the regulation to show same flexibility and innovation and move into the modern area of supporting e-mobility to allow the technology to help California cope with the existential threat of seasonal wildfires expected to increase in strength and frequency as a result of the global climate change.

By 2030 we will have a 5 million EVs on the roads in California and if we are not moving fast enough on the regulation they will pose a big problem for the grid instead of being a part of the solution to move into the the California grid into the future just as we did with the transition from the centralized telephone network to the distributed Internet.

In summary the state of California regulatory bodies and the IOUs should accelerate the rule makings, streamline processes and lower the barriers to:

1. Enable microgrids (safe, flexible, economically) in case of power emergencies – for consumers as well as for business
2. Device interconnection certification flexibility meeting car manufactures midway (Rule 21, UL vs SAE)
3. Site interconnection administration and ease of approval
4. Better grid maintenance and bury underground for most vulnerable part of the grid

The next article will look at how to incentivize the EV manufacturers to introduce Energy Resilient Vehicles in California.



California has to step up to the plate to get Energy Resilient Vehicles on the road and lead the world to more resilient energy infrastructures. Coping with wildfire and PSPS scenarios requires all hands-on deck.

Leave a Comment / Energy Resilient Vehicle (ERV), V2G, Vehicle Grid Integration (VGI) / By Bjoern E Christensen

This is the 6th of a series of blogs that describe the concept of the Energy Resilient Vehicle (ERV). In previous blogs I have explained how the car manufacturers and the regulatory bodies must step up to the table and help California deal with the wildfire and natural disaster threats through producing so-called ERVs:

1. Blog #1: Introduction to the Energy Resilience Vehicle
2. Blog #2: The story of GHG emission and California
3. Blog #3: Why the car manufacturers should step up to help CA
4. Blog #4: California 2030 – A scenario
5. Blog#5: What regulatory bodies can do to foster Energy Resilient Vehicles

This article describes what the State of California can do to incentivize the car manufacturers to introduce Energy Resilient Vehicles into the California market.

California has to step up to the plate to get Energy Resilient Vehicles on the road and lead the world to more resilient energy infrastructures. Coping with wildfire and PSPS scenarios requires all hands-on deck.

In previous articles we have argued that the EV manufacturers should do their part on start producing bi-directional EVs. We have also argued that the regulatory bodies should step up and make it easier to form microgrids with ERVs to mitigate power shutoffs, events to be expected to increase as we move forward.

Now it is time to look at the economic incentives that California should be offering to the EV manufacturer to incentivize them to make ERVs available in California.

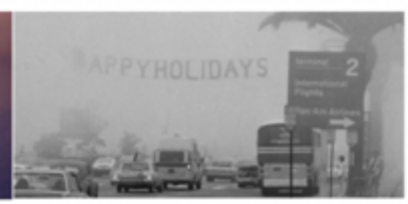
A short history

1). The Story of smog and the Catalytic Converter in California

The first episodes of ‘smog’ occurred in Los Angeles in the summer of 1943. It got worse the following decades to the point where it was outright dangerous to your health to be outside when the bad smog events occurred. California then in 1966 established the first tailpipe emissions standards in the nation. In 1967 the California Air Resource Board (CARB) was established, to attain and maintain healthy air quality; and to provide innovative approaches for complying with air pollution rules and regulations.

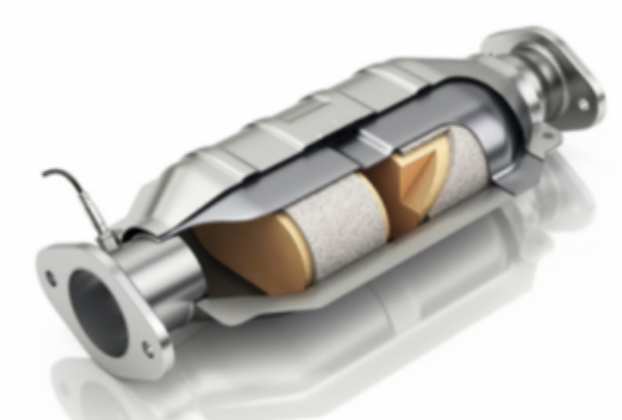
City Center Los Angeles in 1948

Skyline of Downtown 1975



Los Angeles Airport in 1980

The catalytic converter became standard equipment on most new vehicles starting in 1975 and was mandatory by 1981, when it was fitted to vehicles for sale in the United States, enabling them to meet newly introduced emission regulations.



The Catalytic Converter mandated in 1981

The car manufacturers originally objected to the:

1. cost ($thousand+)
2. weight
3. volume
4. performance (reduced miles per gallon)

added to the car but eventually rose to the challenge and incorporated the catalytic converters.

2). The Story of CO2 emission and the Zero Emission Vehicle (ZEV) in California

The Zero Emission Vehicle program was first adopted by the California Air Resources Board (CARB) in 1990. The purpose of the ZEV program was to meet California's health-based air quality standards and greenhouse gas emission reduction goals and move the cars away from petroleum-based fuel. This would reduce smog-causing pollutants and greenhouse gas emissions of passenger vehicles in California.

The ZEV regulation is designed to achieve the state's long-term emission reduction goals by requiring auto manufacturers to offer for sale specific numbers of the very cleanest cars available. These vehicle technologies include full battery-electric, hydrogen fuel cell, and plug-in hybrid-electric vehicles. The ZEV regulation is part of the broader Advanced Clean Cars package of regulations, a set of tailpipe regulations put in place to limit smog-forming and greenhouse gas (GHG) emissions and combat climate change.

The following is a quote from the CARB homepage:

"**How the ZEV Regulation Works**

Auto manufacturers are required to produce a number of ZEVs and plug-in hybrids each year, based on the total number of cars sold in California by the manufacturer. Manufacturers with higher overall sales of all vehicles are required to make more ZEVs. Requirements are in terms of percent credits, ranging from 4.5 percent in 2018 to 22 percent by 2025. Auto manufacturers are to produce vehicles and each vehicle receives credits based on its electric driving range. The more range a vehicle has, the more credit it receives. Credits not needed for compliance in any given year can be banked for future use, traded, or sold to other manufacturers. CARB releases annual credit bank balances each year, as well as the total number of vehicles produced for that model year, as well as the total number of ZEVs and plug-in hybrids."

Carmakers that didn't comply could be fined $5,000 per credit not produced, though CARB has yet to levy a penalty.

The ZEV program is largely credited for incentivizing the car manufactures to introduce Zero Emission Vehicles (battery, fuel cell, hybrid plug-in) in California.

The car manufacturers have introduced ZEV in California – there are currently around 700,000 ZEVs – even in the light of the following issues (sounds familiar?):

1. cost ($ ten thousands+)
2. weight (EVs are heavier than similar ICEs)
3. volume (batteries taking up a lot of space. but also reducing space because no ICE drive train)
4. performance (reduced range per fuel stop)

3). Bi-directional EV/EVSE

A number of Japanese car manufacturers have already shown that it is possible to produce an EV that is capable of bi-directional power flow in the lower cost EV segment. For example, the Nissan 2020 Leaf sells for $31,600, but with Federal Tax Credit it comes down to $24,100!.

The charging station must of course also be bi-directional and until recently they have been selling at quite high prices making bi-directional solutions out of reach for most people. However, this is about to change with a number of startups announcing lower cost bi-directional chargers for the US market. The Spanish startup Wall Box has announced a 7.4kW bi-directional charger at the price of ~$4,000.

4). EVs are born bi-directional (power flow)

EVs are born with bi-directional power flow internally. Press the accelerator and power is flowing from the battery to the electric motor. Remove the foot from the accelerator and the power is flowing from the electric motor back into the battery (regenerative braking).

All that is required to make this bi-directional power flow available outside the EV. Nissan and Mitsubishi Motors have shown is feasible at low cost.

5). CARB like regime to get EV manufacturers to add bi-directionality to their EVs.

Car manufacturers are already spending billions of dollars to make their cars self-driving and add more entertainment and vanity features to their cars. They should be able to spend a small amount of this money making their EVs energy resilient.

This is where a CARB like mechanism could work. Why not change the charter of CARB slightly as shown in the figure below. Add a sentence after "climate change" to say, "including making communities more energy resilient".

And in the ZEV program description below add the definition of what is an Energy Resilient Vehicle as shown in the light blue box. Carmakers that don't comply to the ERV mandate could be fined $5,000 per credit not produced in line what is the case for the ZEV program.

The ZEV program is largely credited for incentivizing the car manufactures to introduce Zero Emission Vehicles (battery, fuel cell, hybrid plug-in) in California and the ERV program could likewise help Californian citizens cope with PSPS events, wildfires and natural disasters.

The Zero Emission Vehicle (ZEV) program is a California state regulation that requires automakers to sell electric cars and trucks in California and 9 other states. The exact number of vehicles is linked to the automaker's overall sales within the state.

The program's objective is to ensure that automakers research, develop, and market electric vehicles (EVs), which generate fewer global warming emissions than gas-powered cars, and which don't produce tailpipe pollution (hence the term: "zero emission vehicle").

The California Air Resources Board (CARB) manages the ZEV program, although it has also been adopted by nine other states (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont). By directly requiring that automakers invest in clean technology, the ZEV program is considered one of the nation's most forward-looking climate policies, and a driving force behind an expanding market with a current offer of over 30 zero emission models available to the U.S. public.

What is a zero emission vehicle?
Under the ZEV regulation, three distinct vehicle designs are considered "zero emission," though to varying degrees.

Plug-in hybrid vehicles combine a conventional gasoline-powered engine with a battery that can be recharged from the electrical grid.

Battery electric vehicles run entirely on electricity and can be recharged from the electricity grid.

Hydrogen fuel cell vehicles run on electricity produced from a fuel cell using hydrogen gas.

.. Add ERV - Energy Resilient Vehicle

What is an Energy Resilient Vehicle?

Under the ERV regulation distinct vehicle designs are considered "energy resilient" if the vehicle can provide emergency power in case of natural disasters like earthquakes or wildfires or as a result of power cuts to prevent wildfires.

6). Summary

California should take the bold step to incentivize the car manufacturers to introduce ERVs into the California market. This would go a long way to help CA citizens cope with effects of wildfires, PSPS and other natural disasters.