

EV Charging in Future

16th Anniversary of PQSynergy

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Qianlu Yan

Beijing Joint Harvest S&T Co., Ltd.

qianluyan@vip.sina.com

EV increase worldwide

- Beijing 14th (2016) Auto Show; April 25th – May 4th
- 147 new energy cars exhibited (79 new energy cars in 2014 Beijing 13rd Auto Show)



EV increase in my residence district

- The 1st one I bought EV last year



EV increase in my residence district

- 18 electric cars up to now.



EV increase in my residence district



EV increase in my residence district



EV increase in my residence district



EV Charging Stations near my home

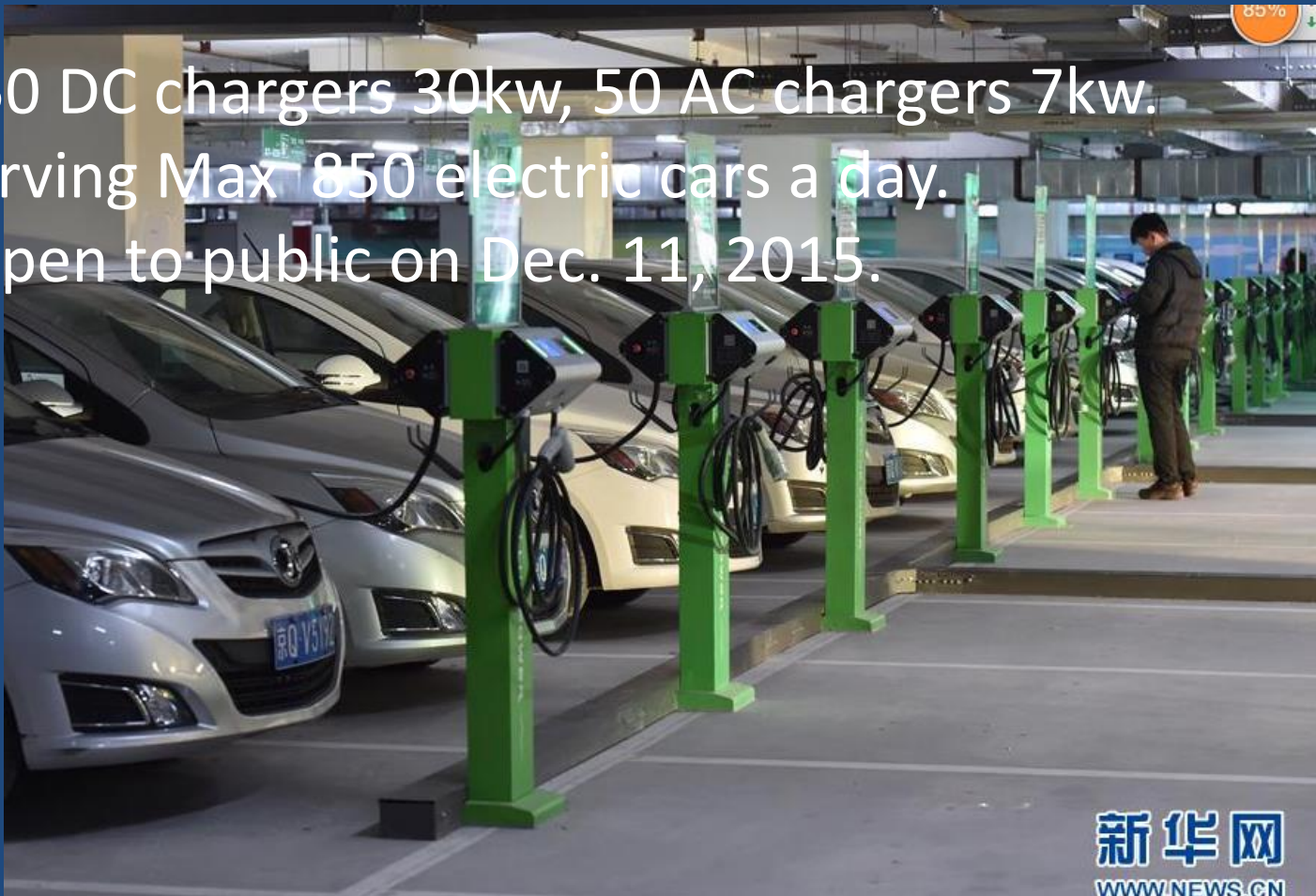


New EV Charging Stations in Beijing

- Hua Mao Mension, 100 Chargers (20 DC chargers 45kw, 20 DC chargers 22kw, 60 AC chargers 7kw)
- Beijing Capital Airport, 12 DC chargers 37.5kw, 24 AC chargers 7kw

Charging Station at Beijing West Railway Station, 100 Chargers 37.5kw/7kw

- 50 DC chargers 30kw, 50 AC chargers 7kw. Serving Max 850 electric cars a day.
- Open to public on Dec. 11, 2015.



On Apr 21, 2016, Beijing Government published planning for EV charging infrastructure 2016-2020

关于印发北京市电动汽车充电基础设施专项规划（2016-2020年）的通知

75%

京发改[2016]620号

2016年04月21日

各有关单位：

为贯彻落实国务院办公厅《关于加快电动汽车充电基础设施建设的指导意见》（国办发[2015]73号）、国家发展改革委等4部门《电动汽车充电基础设施发展指南（2015-2020年）》（发改能源[2015]1454号），我们编制了《北京市电动汽车充电基础设施专项规划（2016-2020年）》，经市政府批准同意，现予以印发，请贯彻落实。

特此通知。

北京市发展和改革委员会
北京市科学技术委员会
北京市规划委员会
北京市住房和城乡建设委员会
2016年3月30日

Beijing EV charging infra-structure 2016-2020 Summary (1)

- 35900 EV cars in use by the end of 2015 (in Beijing)
- 23500 EV cars sold in 2015
- 234 public charging station built with 3700 chargers by 2015
- 12000 chargers by private use by 2015
- Publically charging with a radius of 5km public EV serving network by 2015

Beijing EV charging infra-structure 2016-2020 Summary (2)

- Forecast by 2020
 - 600,000 EVs in use
 - 450,000 EVs private, 150,000 EVs public (including 15000 Taxi)
 - 435,000 chargers will be built between 2016-2020
 - EV Chargers : EV cars ratio; 1:7
 - Public chargers; 65000, Private chargers; 360,000

Beijing EV charging infra-structure 2016-2020 Summary (3)

- Regulating
 - Chargers installed more than 10% parking places in public car parks.
 - Chargers installed 100% car places for new residence buildings (apartment buildings).
 - Chargers 25% car places for new office buildings.
 - 20% for new commercial buildings (Department stores, supermarkets, etc.)
 - 15% for hospitals, schools, stadiums, etc.

My question

- Is this a correct and efficient plan?

3 Charging Models, Advantages & Disadvantages

- AC Chargers for home use, factory employees, government locations, etc.
- DC Charging Stations for public users
- EV Swapping Stations

AC chargers for home use, factory employees, government locations, etc.

3kw to 7kw AC chargers.

Advantages;

- Convenience ?
- Peak-Valley electricity usage?
- Low cost ?



AC chargers for home use, factory employees, government locations, etc.

- Advantages;
- Convenience ?
- Partly true.
 - Charging time; 6 to 8 hours for my EV200 (30kwh). 16-20 hours for BYD e6 (60kwh).
- Only when you do it at home.
- Only when the EV fully charged.
- But
 - How about you need to use when it is only partly charged?
 - How about if you go a long ride.

AC chargers for home use, factory employees, government locations, etc.

- Advantages;

- Peak-Valley electricity usage?

Partly true.

For home use, yes if charging during night.

But for at factories, government locations, increase peak loads.

AC chargers for home use, factory employees, government locations, etc.

- Advantages;

➤ Low cost?

Partly true.

- Parking place not shared.
- Capacity usage.
- Construction fee.
- Maintenance fee.



AC chargers for home use, factory employees, government locations, etc.

- Disadvantages;
 - Long charging time;
 - Location must be available, not easy in central city.



AC chargers for home use, factory employees, government locations, etc.

- Disadvantages;
 - Electricity capacity;
 - In future EV will have more KWh battery. Chargers may need to be with more charging KW.
 - For home use, charging may be once a week but chargers capacity with high KW always needed. Low efficiency for transformers.
 - For at factories, government locations, charging may be only work days, not during night and weekend. But capacity still needed.
 - Huge demand for kw in residence area.
 - No easy to manage power usage.
 - No easy to manage Power Quality issues.

AC chargers for home use, factory employees, government locations, etc.

- Disadvantages;
 - Car places reserved, not be shared.
 - Built conditions (road reconstruction, weather-resistant)
 - Maintenance cost; location dispersed, more maintenance personals needed.

DC Charging Station for public users

- 30kw to 60kw or more in future

- Advantages;

➤ Quick charging ?

Partly true.

Now for a 30kw charger,

my car EV200 needs 1.5 hours charging.

(charging current will reduce after first 30 min).



DC Charging Station for public users

- Chargers now with 30kw to 60kw, or more in future
- Advantages;

- Quick charging ?

No matter how the battery or charger technology improved, the shortest charging time calculated (the law of energy conservation);

- My EV200 battery; 30kwh
- Charger; 30kw
- The shortest time; 1 hour

DC Charging Station for public users

- 30kw to 60kw or more in future
- Advantages;

- Quick charging ?

If you want to finish charging in 3 min in future, the shortest charging time calculated;

- My EV200 battery; 30kwh
- Charger; $30\text{kw} * (60\text{min}/3\text{min}) = 600\text{kw}$
- If a charging Station has 10 chargers, total capacity = 6,000 kw !!!

EV battery improving

- By new tech or materials in future;
 - More capacity
 - Quick charged
 - Less expensive
 - Less weight
 - Less size
 - Wireless charging

DC Charging Station for public users

- Disadvantage
 - Still long charging time
 - High power capacity needed
 - New land required for charging station
 - High cost for DC chargers
 - High cost BPM in EV (Battery Management System including charging, up to 20% of the battery cost)
 - High construction fee
 - Not helpful to peak-valley usage/Smart grid

EV Swapping Station

- The Best Solution in Future!

EV Swapping Station

- Advantages;
 - Finishing in less than 3min like gas car.
 - Charging battery during night, averaging peak – valley load
 - Easily manageable – energy storage can be part of Smart Grid. – Social benefit.
 - Locations easily available – use gas stations.
 - Easily maintenance, including safety.
 - Low electricity cost – charging during night.
 - High efficiency for battery usage.
 - PQ problems easily control – harmonics mitigation.

EV Swapping Station

- Advantages;
 - Finishing in less than 3min like gas car.
 - Taxi drivers don't want to wait, do I want to wait? Are we less busy than taxi drivers?
 - Will our next generations want to wait?
 - Charging battery during night, averaging peak – valley load
 - Easily manageable – energy storage can be part of Smart Grid.
 - For my EV car, electricity fee is 120% of my home electricity fee. How about millions of homes in future?
 - » Now in China, 20 millions of cars are in use.
 - » In 2020 in China, 5 millions of EV will be in use
 - More important than home appliance to be integrated to smart grid.

EV Swapping Station

- Advantages;
 - High efficiency for battery usage.
 - Professional charging at charging station
 - Less requirements to BMS in EV
 - Prolong life time of battery (until 80% used)
 - Recycle using battery
 - EV life time 15 years (regulated by Chinese government).
 - Battery 80% of capacity
 - Written off battery for PQ mitigation
 - » Sag compensation equipment
 - » UPS battery
 - » Substation energy storage

EV Swapping Station

- Doubt 1
 - What if swap a new battery with an old battery.
 - Life time of battery
 - For my EV200, 80% capacity remains after 3000 charging. EV 200 allows 200km per charging. So the battery can be used more than $200\text{km} * 3000 = 600,000\text{km}$.
 - A car's life time; 300, 000km. So battery life time is double the car life time.
 - Battery has been protected from over-discharging.
 - You may swap an old one with a new one next time.
 - You won't spend money on new battery.
 - If you really mind a few miles difference, Swapping station may think about to manage battery stock to swap battery according to number of charged times.

EV Swapping Station

- Doubt 2
 - Standards? How Swapping Station deal with different batteries of different brands of EV.
 - No need. By stock management. Treat them like car tires.
 - Manage battery stock for different brands of cars.
 - In future, battery capacity information (Internet of Vehicles) can be sent to Swapping Station remotely, so Swapping Station can prepare for stock.
 - Large auto factories can help for stock.
 - Reservations by users .
 - Less requirement to build battery charging standards (Safety standards, etc.)

EV Swapping Station

- Doubt 3
 - Do gas stations have enough capacity for charging battery?
 - A solution is to build “Battery Charging Stations” in suburb of large cities, and transport batteries from “Battery Charging Stations” to “Swapping Stations”.
 - Gas stations provide available places for swapping, may remain profitable business.
 - Quota of Petro-Chemical companies to reduce carbon emission. Petrol-chemical companies eager to cooperate.

EV Swapping Station

- Doubt 4
 - More batteries needed means high cost?
 - Yes. But think about below;
 - Cost is decreasing due to quantity, new tech, and will continue in future.
 - Social benefit from energy usage.
 - Saving time and convenience to daily life.
 - More sales of EVs.
 - Less places or lands needed.
 - Batter life time prolonged and recycled.
 - High efficiency to centralized management to power and equipment. Less maintenance. 10kv battery charging station?

EV Swapping Station

- Doubt 5
 - Dynamic balancing after swapping?
 - This is a small problem of designing – Technology of mechanical design and manufacture is not an obstacle nowadays.
 - Beijing Auto Company shows a good example (later).

EV Swapping Station

- Question 1
 - Why Swapping has not been promoted?
 - Auto companies want to quick profit and save money with their available designs and manufacturing.
 - Auto companies can quickly release EV.

EV Swapping Station

- Question 2
 - What government should do for Swapping?
 - Regulate Auto companies to make battery swapping, a.s.a.p.
 - Like in US regulates auto companies to make EV in a percentage of all gas cars. Now auto companies has benefited from the regulation and developed EV pro-active.
 - Subsidize to EV swapping station instead of to EV charging station.
 - Developing necessary standards for battery charging.

EV Swapping Station - A true case in Beijing

- First EV Swapping Station in BJ, for taxi only.
- Opened to taxi EV200 on April 26th, 2016.



EV Swapping Station- A true case

- Located in a gas station (Sino-PEC).
- Robot swapped battery in 134 second – my witness on 2016/5/20.



EV Swapping Station- A true case

- 400 kw total charging capacity
- 28 DC charging modules , 15kw each
- 28 batteries
 - 41kwh each





EV Swapping Station- A true case

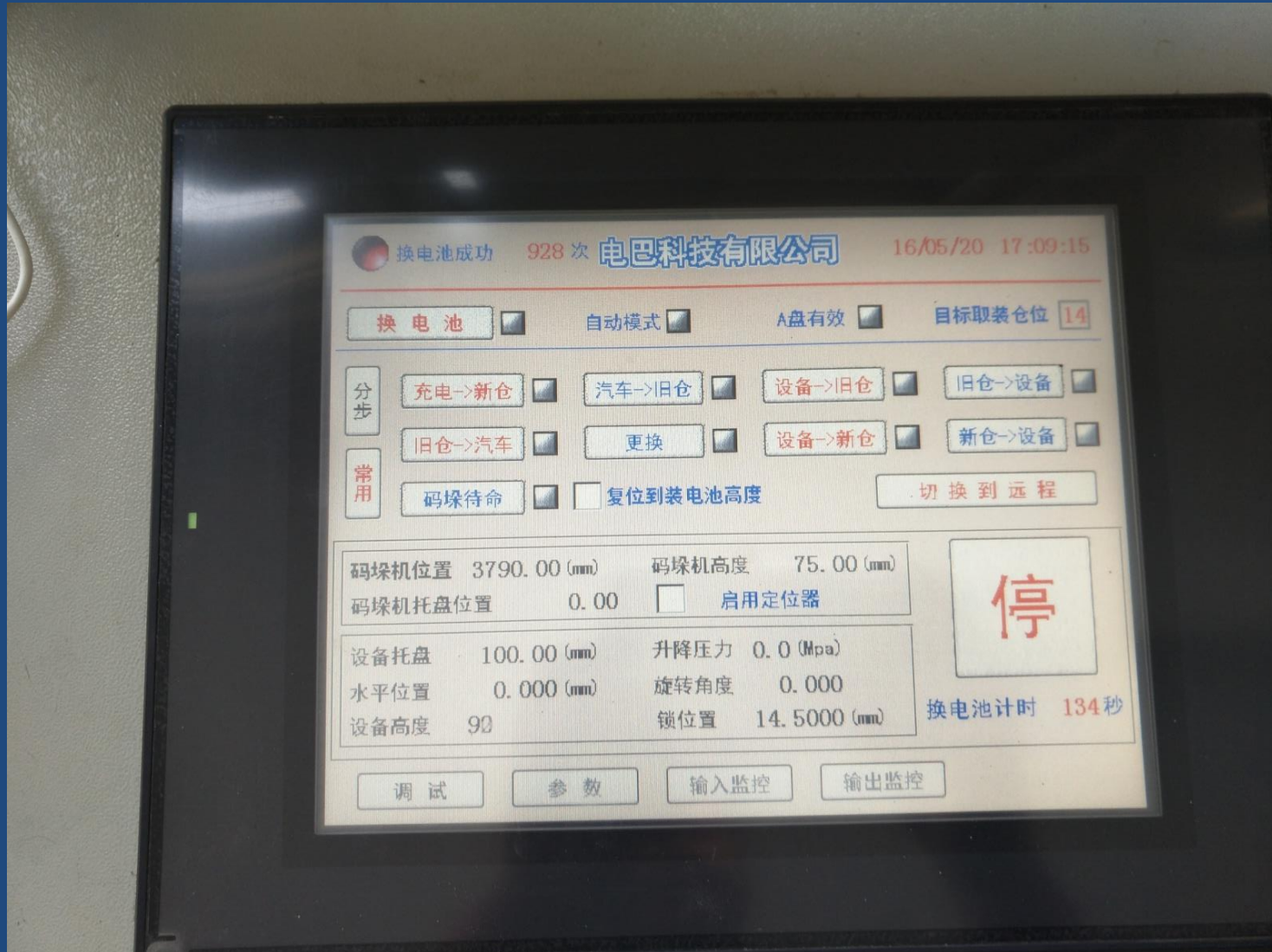
- Floor area; 220 m² (22m L * 10m W)
- Investment; RMB 3.6 millions



EV Swapping Station- Control Room



EV Swapping Station- Control Panel



EV Swapping Station- Control Panel

- Charging fee
 - Now is free, sponsored by Beijing Auto, Sino-PEC, and Swapping Station investing company.
 - Future; RMB 1.6 * 40 = RMB 64
 - Allows 260 km per swapping

Power Quality Issues

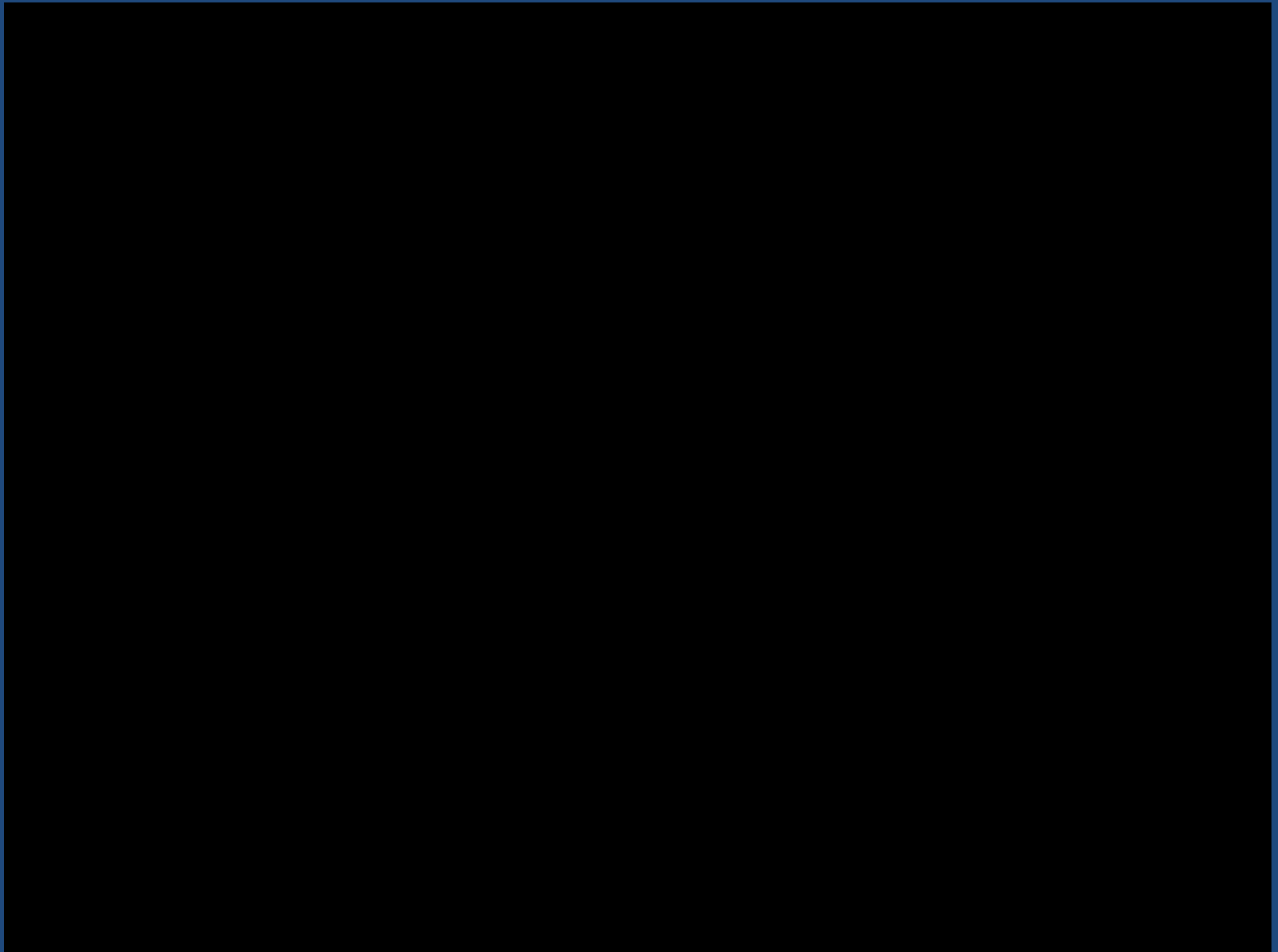
- Harmonics filters to battery charging station.
- Battery charging station as energy storage, sag compensation solution, etc?

EV charging in Future

- **Swapping Station + Battery Charging Station**
 - The best solution in future.
 - Be part of smart grid.



Video - Beijing Bodalu Swapping Station



More discussion (1) – Better Place

- **Better Place** was a venture-backed international company that developed and sold battery-charging and battery-switching services for electric cars. It was formally based in Palo Alto, California, but the bulk of its planning and operations were steered from Israel, where both its founder Shai Agassi and its chief investors resided.
- Opened its first functional charging station the first week of December 2008 at Cinema City in Pi-Glilot near Tel Aviv, Israel. The first customer deliveries of Renault Fluence Z.E. electric cars enabled with battery switching technology began in Israel in the second quarter of 2012, and at peak in mid September 2012, there were 21 operational battery-swap stations open to the public in Israel.
- Better Place filed for bankruptcy in Israel in May 2013 (Lost \$850m). The company's financial difficulties were caused by mismanagement, wasteful efforts to establish toeholds and run pilots in too many countries, the high investment required to develop the charging and swapping infrastructure, and a market penetration far lower than originally predicted by Shai Agassi.

-- From Wikipedia

More discussion (1) – Better Place

- Reasons for failure of Better Place

An old Chinese saying; (to success;) right timing, right location, and right people

- Timing:

- Financial crisis in 2009.
- No international agreements on reducing CO emission.
- Few E cars and E auto companies.
 - Only Renault supported.
 - Promised order 100,000 Fluence ZE, final sales 1400.
- Battery was expensive
-

More discussion (1) – Better Place

- Reasons for failure of Better Place
 - Location:
 - Few countries involved. US, Israel , Denmark, Japan.
 - People:
 - Business model;
 - High cost of building Swapping Station; U\$2m – 5m, later U\$0.5m in Israel and Denmark.
 - High cost of maintenance and personnel.
 - » Service fee U\$60-80 per charging.
 - Spread too fast.
 - Tried to do everything itself causing huge investment.

More discussion (2) – China State Power Grid

- In 2011, swapping recommended.
 - State Power Grid wanted to be operator of battery business (battery business mode).
 - Battery purchase & own by State Power Grid.
 - Auto companies don't sell battery.
 - Users don't pay for battery.
 - Auto companies didn't accept
 - Most profit goes to State Power Grid.
 - Monopoly by State Power Grid.
- In 2012, charging decided
 - Criticized by many parties.

More discussion (3) – DC charging stations along highway in China

- One hour for coffee/meal break after long ride.
 - The only choice you have.
- Swapping allows more choices.
 - Whenever you like to go.
 - Choice to restaurant away from the station.
 - No worry about peak travel time before holiday.
 - Limited number of chargers, 5 – 10 per station.
 - Efficiency of power usage, low cost of electricity.

Thank you!