INSTITUTE OF ENERGY FOR SOUTH-EAST EUROPE

Electric Mobility Update

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THE GLOBAL MARKET FOR ELECTRIC VEHICLES (EVs)

According to the International Energy Agency (IEA), the global fleet of electric cars rose to 3.1 million vehicles (Fig. 1) in 2017, showing an increase of 57% from the previous year, 40% of which, exceeding 1 million, are to be found in China.

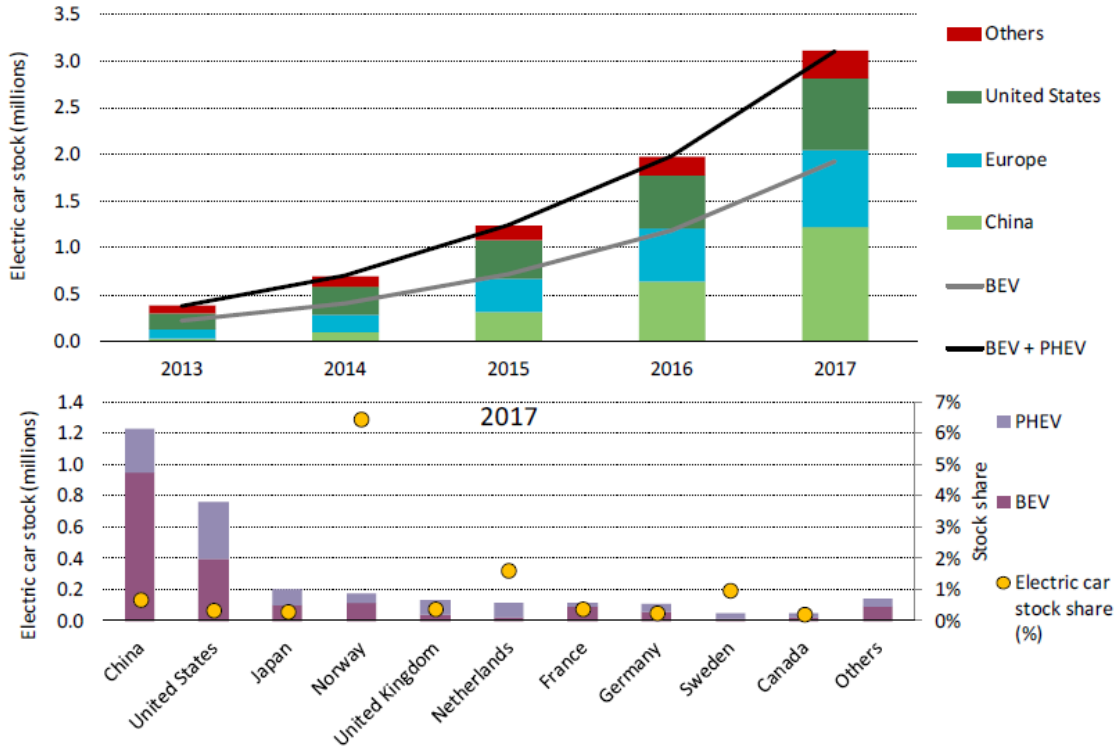


Figure 1 Evolution of Global EV fleet (Source: IEA)

A most important trend in the EV market is that the dynamics of the adoption policies for electric vehicles are now reflected in the activity of car manufacturers. The automotive industry now aspires to move towards the age of electric mobility with frequent announcements of new electric models and important investments which correspond to ambitious transition targets. Hence, the targets announced by the automotive industry exceed market expectations, indicating the industry's commitment to promote EVs. This is further reinforced by the significant decrease in the popularity of the market competitive diesel-powered vehicles in the wake of the diesel-gate emission scandal and by the automotive market's drive to promote the next low carbon mobility technology.

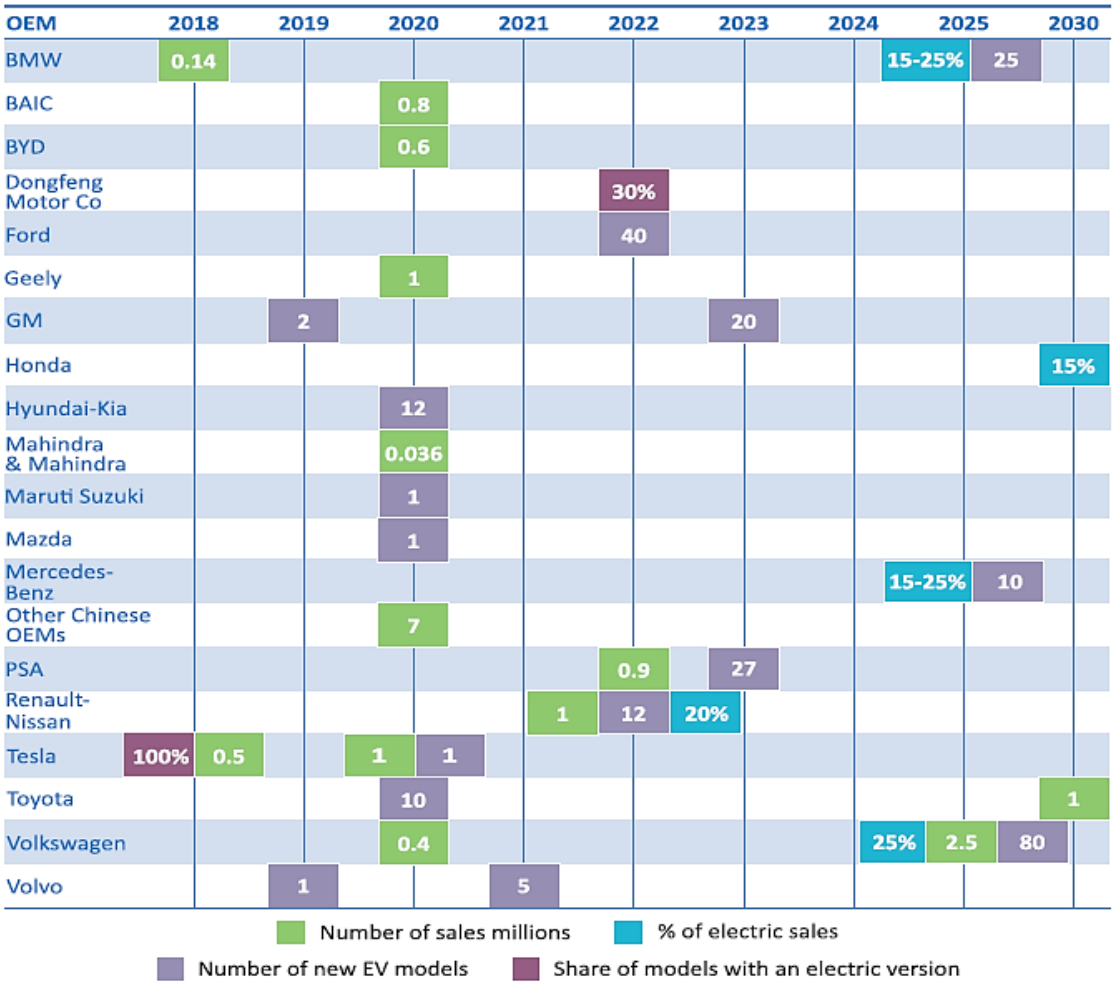


Figure 2 Announcements of the automotive industry related to electric cars (Source: IEA)

Toyota: Toyota announced its target for 4.5 million sales of hybrid (HEV) and plug-in hybrid (PHEV) cars by 2030. The company also announced that it will release more than 10 EV models worldwide in the early 2020s. Such a goal could require that the manufacturer expands its corporate partnerships beyond its only partnership with Panasonic for the joint development and supply of batteries. Reuters reports that an investment of more than $ 13 billion will be needed to develop and produce batteries to achieve an annual sales target of about 1 million of pure electric vehicles (BEVs) that the company has set for 2030. Moreover, the stricter regulations on global vehicle emissions require a sharp increase in production capacity for more powerful batteries. So Toyota, the world's second largest automaker in terms of sales, will need to accelerate its battery development. As part of the expansion of its production towards BEVs, Toyota is expected to introduce its new models initially to China, and later to Japan, India, the United States and Europe.

In addition, the Toyota-Panasonic consortium is considering developing the next generation EV batteries. Towards this direction the consortium is examining the development of solid-state batteries, and consequently, has entered into partnerships with Mazda and Suzuki. Shigeki Terashi, the Executive Vice President of

the company, told Reuters that Toyota- Panasonic's battery production capabilities may not be enough to meet its battery needs by 2030, and that's why Toyota is open to additional collaborations.

CHINA: Given the high market absorption of China's EV production, its automotive industry targets are purely responsive to its productive potential which is subject to government policies. Hence, companies such as BJEV-BAIC, BYD and Geely are expected to significantly increase their production capacity to 800 thousand, 600 thousand and 1 million electric cars, respectively, by 2020.

Renault-Nissan: Renault-Nissan has announced that 20% of its sales will come from zero-emission vehicles in 2022, while 30% of the same year's sales are expected to come from hybrid and plug-in hybrid vehicles. In addition, Renault is planning investments of $ 1.2 billion for the development and production of plug-in EVs in France. These investments include the introduction of a new electric platform in Douai's plant to create a second EV production site, the doubling of domestic production capacity for its ZOE EV and the launch of a new ZOE model at Flins' plant. Renault plans to triple the production capacity of its electric motor plant at Cleon as well as develop its new electric motor that is expected to be introduced in 2021. Finally, the company plans to invest significantly in its Maubeuge plant to produce its next generation electric utility vehicle, Kangoo ZE. It should be noted that Renault saw its EV sales increase by 38% in 2017, while the company estimates that its market share in the European market reached 23.8%.

The group's latest strategic plan includes the introduction of 8 new "electric" models with its model availability on the market amounting to 12 in 2022. "The acceleration of our investments in France for electric vehicles will increase the competitiveness and attractiveness of our French industrial sites," said Renault/Nissan CEO Carlos Ghosn. "Within the framework of its drive the future strategic plan and with the Alliance, Groupe Renault is giving itself the means to maintain its leadership in the electric vehicle market and to continue to develop new sustainable mobility solutions for all."

GERMANY: The German government has announced € 50 million ($ 58 million) in new funding for 31 municipal electric mobility projects under the "Clean Air 2017-2020 Emergency Program". Under this fourth phase of the program, municipal vehicle fleets (e.g. waste disposal vehicles and buses), as well as taxi and car-sharing companies will receive subsidies from 40% to 90% to support the plug-in vehicle market. Overall, a total of 420 cars, 100 electric buses, 110 special and commercial vehicles and 425 new charging points are expected to be purchased as a result of this phase of the program. Finally, government sources estimate that the previous phases of the specific program resulted in, the introduction of 650 new EVs and the creation of 425 additional charging points.

THE IMPACT OF ELECTRIC VEHICLES ON OIL DEMAND

COLUMBIA SIPA - **Center for Global Energy Policy (CGEP)**: Passenger cars accounted for a quarter of world oil demand (27%) in 2017. According to a study by the Center on Global Energy Policy (CGEP), forecasts of global organizations, governments and the oil industry for global oil demand, all agree that there will be no increase in oil demand by passenger cars after 2025. Oil demand is expected to remain at steady levels (small increase) in the next decade, while it is expected to decline after 2030, when it is anticipated that EVs will achieve a high market penetration. However, the magnitude of the decrease in oil demand differs significantly between the different forecasts (see Fig. 3).

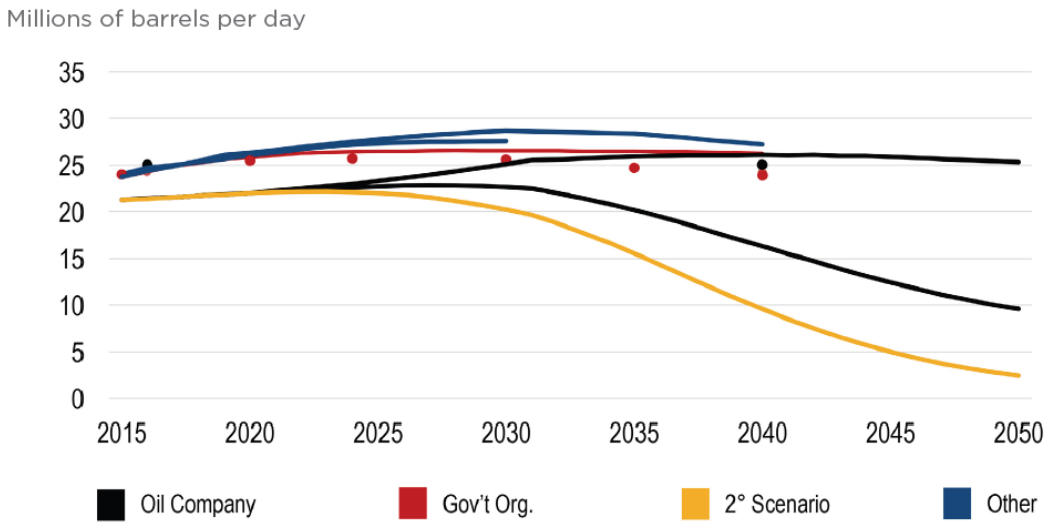
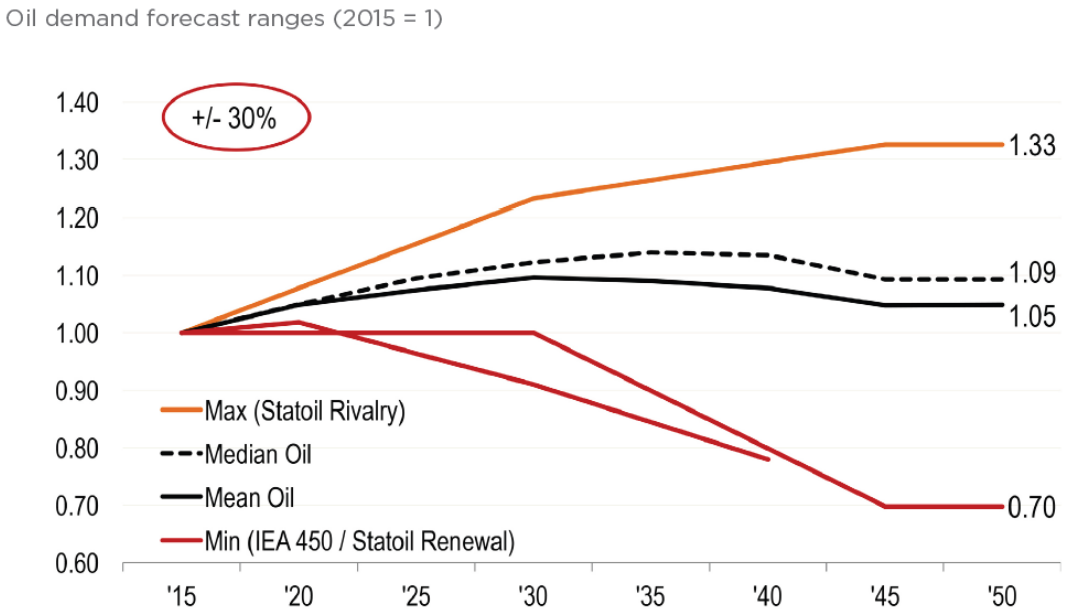


Figure 3 Forecasts for Global Oil Demand for Passenger Vehicles (Source: CGEP)

Due to the plurality of government policies aimed at reducing oil use and transport emissions, the passenger sector is not considered an area where growth is expected in the coming decades, although many people are buying vehicles for the first time in developing countries. However, reducing the demand for oil consuming cars does not necessarily mean that overall oil demand will be reduced. There may be strong growth in petrochemical sector caused by demand in aviation and heavy duty vehicles, which may offset any demand reduction by the passenger car sector.

The following figure shows industry projections for total oil demand by 2050 as published in 2017 compared to oil demand of 2015. The range of forecasts is projected to be from 30% reduction in demand by 2050, up to an increase of 30% by the same year (see Fig. 4). This means that there is the same uncertainty about the downside risk and upside risk of global oil demand, which is inconsistent with the downward market expectations for the demand for conventional oil consuming vehicles.



Source: BP, Exxon, Carbon Tracker (3 scenarios), Statoil (3 scenarios), EIA, IEA (3 scenarios), OPEC, 2017

Figure 4 Global Oil Demand Forecasts (Source: CGEP).

Carbon Tracker: Although most international organizations estimate that EVs will eventually reduce global oil demand, the uncertainty about when this will occur and what will be the magnitude of demand reduction is troubling global markets. Although large oil companies are predicting a gradual decades-long process, some prominent analysts predict a significant downturn in oil demand as early as 2030. A new report by Carbon Tracker examines many of the factors that affect oil demand as a function of penetration of EVs in the automotive industry. Significant findings of this study are that the size of the global vehicle fleet is the most important parameter that will affect oil demand, although the mileage per EV per year and the improvement of the energy efficiency of internal combustion engine are also important factors. Carbon Tracker concludes that the EV adoption could fully offset annual oil demand growth as early as 2027, and could lead to the much-anticipated peak oil demand by the end of the next decade. Moreover, analysts estimate that a sharp drop in oil prices due to oversupply is likely to arise due to the oil industry's inability to predict the rapid global adoption of EVs.

ELECTRIC VEHICLE TECHNOLOGY

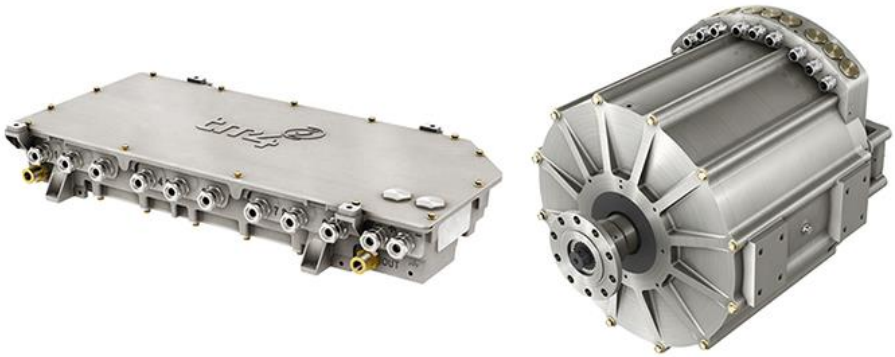
ZapGo develops Carbon-ion batteries with nanomaterials: Williams Advanced Engineering has selected ZapGo, a spinout of Oxford University, to join a consortium working to develop next-generation battery systems for EVs (part of the UK government's Faraday Battery Challenge). ZapGo's Carbon-Ion technology, based on carbon nanomaterials including graphene, is intended to combine the power density of supercapacitors and the energy density of rechargeable batteries. The C-Ion cells work in a similar way to supercapacitors, but use different carbon and electrolyte

materials that ZapGo says are safer and easier to recycle, and enable the devices to operate at higher voltages, resulting in higher energy density.
ZapGo argues that the C-Ion battery it develops can provide specific power characteristics between one and two orders of magnitude higher than those of a Li-ion cell. It is designed to be classified as non-flammable and non-hazardous for transport. "It's an important validation of our technology to be invited to work with the Williams team," said CEO and founder Stephen Voller. "We want to demonstrate the viability of a hybrid battery management system that goes beyond what's currently available to EV manufacturers. The time is right to demonstrate that our Carbon-Ion technology can deliver safe, fast charging."

General Motors and Honda partner to develop next generation battery: GM and Honda have agreed to a multi-year agreement to conjointly develop new battery chemistry components in order to hasten their plans for future all-electric vehicles. They seek to improve power density, packaging size, and charging capabilities for their up-and-coming EVs. Honda intends to source the new modules from GM in the future. This is not their first partnership; they are currently working on new hydrogen fuel cell technologies set to be released around 2020. Both companies seek to establish a major foothold in the future North American EV market.

ON Semiconductor develops new automotive diodes SiC: ON Semiconductor has introduced a robust line of automotive-grade silicon carbide (SiC) Schottky diodes. The AEC-Q101 diodes can handle high surge currents and are meant to operate from -55° to 175° C. There are several reasons why SiC diodes are ideal for automotive applications. They are smaller and cheaper compared to alternatives, have higher power densities, and create less electromagnetic interference (EMI). Also, SiC diodes have temperature-independent switching performance and no reverse recovery current. ON's FFSHx0120 1,200 V Gen1 and FFSHx065 650 V Gen2 diodes have the added benefits of lower leakage currents, faster switching, and as a result, smaller magnetic components. They are offered in several surface-mount and through-hole designs, including TO-247, D2PAK and DPAK.

"By expanding our Schottky diode range with AEC qualified devices, ON Semiconductor is bringing the significant benefits of SiC technology to automotive applications, allowing our customers to achieve the demanding performance requirements of this sector," says ON's Senior Director Fabio Necco. "SiC technology is a perfect fit for the automotive environment, where it delivers greater efficiency, faster switching, improved thermal performance and high levels of robustness. In a sector where saving space and weight are critical, the greater power density of SiC, which helps reduce overall solution size, along with the associated benefit of smaller magnetics, is most welcome."



Dana and TM4 collaborate to offer a range of powertrain technologies: Drivetrain technology supplier Dana has announced a joint venture with TM4, a subsidiary of Hydro-Québec. TM4 will become Dana's source for electric motors, power inverters, and control systems, and Dana will become a majority shareholder of TM4 in exchange for $165 million Canadian ($127 million US). TM4 manufactures EV motors, power inverters, and control systems, complementing Dana's electric gearboxes and thermal-management technologies for batteries, motors, and inverters. TM4 operates a manufacturing facility in Boucherville, Québec. Its management team and 130 employees will remain in place.

This transaction is expected to strengthen Dana's position in China, where TM4 and Prestolite Electric Beijing have a joint venture that offers electric mobility solutions throughout China and the ASEAN region. "This joint venture brings together a world leader in mechanical power conveyance and thermal-management technology with an experienced manufacturer of electric motors and inverters to offer a broad range of hybrid and electric vehicle solutions for our customers across all three of our end markets," said Dana CEO Jim Kamsickas.

ELECTRIC VEHICLE CHARGING TECHNOLOGY

Benefits of Increased Investments in EV Charging Infrastructure finds M.J. Bradley & Associates: A new analysis from the nonprofit organization Ceres and M.J. Bradley & Associates finds that the benefits of increased investment in EV charging infrastructure outweigh the costs by more than 3 to 1. "Accelerating Investment in Electric Vehicle Charging Infrastructure" evaluates the need for charging infrastructure – including both private and public chargers – in 12 of the largest utility service territories in 7 US states. In these utilities' territories, which include 42 million residential customers and 80 million vehicles, an infrastructure investment of $17.6 billion would yield benefits of $58 billion by 2035, the analysis found. Moreover, after 2035 annual net benefits will increase faster than additional investments, therefore the cumulative net benefits will continue to increase over time.

The report recommends various pro-EV policies, including: vehicle purchase incentives; rebates, grants and tax credits for both private and public charging

infrastructure; and utility-based programs such as consumer outreach and education, special charging rates and investment in charging infrastructure. "The benefits of transportation electrification would be shared by EV owners, electric utility customers, and society at large," said Dan Bakal, Director of Electric Vehicles at Ceres. "Utilities are in a unique position to help build awareness among their customers. They are also well situated to significantly reduce the financial risk to charging station developers – especially in the short term as the PEV market develops – by providing special rate structures for commercial charging stations."

"Properly designed PEV market incentives can advance diverse state and local policy goals at the same time – including energy independence and security, climate change mitigation, air quality improvement, and local economic development," said Michael Bradley, President of M.J. Bradley & Associates. "State and local policymakers should prioritize these policies and programs in the near term to aid in the transformation of the transportation sector."

HUBER + SUHNER develops EV fast-charging solutions with integrated cooling system: Faster charging means higher power, and equipment manufacturers are already preparing for the future charging needs that industry observers believe are just around the corner. One company working to enable higher power is HUBER+SUHNER, which started looking into fast charging solutions when car manufacturers turned to the company for its connectivity experience.

To build a faster charging cable, there are two options. The first is simply to increase the size of the cable by increasing the cross-sectional area of copper wire. The bigger this area, the more current the cable can handle without overheating. Unfortunately, for the 400 A of current required for next generation fast charging, a cross-sectional area of 180 mm^2 or more would be required, which is simply too big and unwieldy for consumer applications. The second option for a faster charging cable avoids the need to increase the cable size by instead managing the temperature of the copper wire at high currents. To achieve this, it's necessary to make a cable with a built-in cooling system.

HUBER+SUHNER's solution, the RADOX HPC High Power Charging System, supports up to 500 A and 1,000 V, for a total of 500 kW. Even with this high power, because of its built-in cooling system, the RADOX has a cross-sectional area of only 25 mm^2. To keep the cable cool during high-power charging, RADOX uses a non-conductive coolant combined with temperature sensors placed throughout the system. The cooling liquid, which cools down the contacts at the connector, circulates directly onto the power lines back to the charging station. In the charging station there is a small container with a pump installed to enable the coolant's circulation. The coolant itself is cooled with a ventilating system or heat exchanger. The heat exchanger option needs a cooling circuit with a central cooling unit and thus it is only used for bigger charge parks.

Even though the EVs available today aren't equipped to handle RADOX's high power levels, HUBER+SUHNER and other EVSE manufacturers recognize the need to promote the charging technology of the future, prompting the automotive industry to develop EVs that support high-power charging. The HUBER+SUHNER RADOX HPC system was approved by Intertek according to UL and IEC standards in April of 2018. The company now plans to sell the system (connectors, conductivity, cooling, and all) to charging station manufacturers, while is expected to present the complete fast-charging system at the international exhibition "Electric & Hybrid Vehicle Technology Expo Europe 2018".

ITT Cannon supplies Efacec with liquid-cooled 350 kW EV charging tech: ITT's Cannon brand has signed an extended contract with Portugal-based EV charger manufacturer Efacec Electric Mobility. The two companies have a long-standing partnership, and now Efacec plans to use Cannon's High-Power Charging (HPC) solution, comprised of a connector, cable and cooling unit, to power highway charging stations in the US and Europe.

Cannon's liquid-cooled DC charging technology delivers 350 kW of power. It uses a dielectric cooling liquid that runs from the cable throughout the connector's contact system. Cannon says its dielectric fluid is extremely safe with minimal environmental impact, and that the weight-optimized cable design and minimized cable diameter make it ergonomic, light and easy to use. The charger is available in CCS1 and CCS2 variants for North American and European markets. In addition, Cannon and Efacec are currently testing a 500 kW solution.

BP acquires Chargemaster's charging network in the United Kingdom: BP has agreed to purchase Chargemaster, which builds charging stations and operates a network of over 6,500 public charging points across the UK. Unlike some oil giants, BP is taking a proactive approach to the coming transition to electric transport. The company estimates that there will be 12 million EVs on UK roads by 2040, and therefore Tufan Erginbilgic, CEO of BP Downstream, stated that "the development of

convenient and innovative EV charging technologies and networks is a key part of BP's strategy to advance the energy transition."

A key priority for BP Chargemaster will be the rollout of ultra-fast charging infrastructure, including 150 kW chargers. BP Chargemaster chargers are to be installed at BP locations over the next 12 months. Overall, such a business move is expected to help diffuse the EV charging know-how in the company in order to accelerate research and development of fast chargers, with ultimate goal, BP becoming the leading provider of energy to low-carbon vehicles in the UK.

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3,Alex. Soutsou st. 106 71 Athens, Greece
tel: (0030)-210-3628457, 3640278, fax: (0030)-210-3646144, e-mail: marketing@iene.gr, site: www.iene.eu