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The “start-up” powertrain for electric cars: the Bosch e-axle offers greater range

August 2017

PI 9780 BBM FF/af

- ▶ New development: more efficient and affordable than other electrical powertrains
- ▶ All-in-one principle speeds up automakers’ development times
- ▶ Bosch board of management member Dr. Rolf Bulander: “Economically speaking, the e-axle may turn out to be a major coup”

Gerlingen, Germany – It’s now common knowledge that a more powerful battery will increase an electric car’s range. But can a new powertrain have a comparable impact? In the case of the Bosch electric axle drive, or e-axle, the answer is a definite yes. What’s so special about it is that Bosch has combined three powertrain components into one unit. The motor, power electronics, and transmission form one compact unit that directly drives the car’s axle. This makes the powertrain not only far more efficient, but more affordable as well. “With its e-axle, Bosch is applying the all-in-one principle to the powertrain,” says Dr. Rolf Bulander, member of the board of management of Robert Bosch GmbH and chairman of the Mobility Solutions business sector. It is precisely for this reason that the new powertrain is a potentially huge business opportunity for Bosch. The components are very flexible, which means the e-axle can be installed in hybrids and electric cars, compact cars, SUVs, and even light trucks – a huge market.

A powertrain that also speeds up development times

“Economically speaking, the e-axle may turn out to be a major coup for Bosch,” Bulander says. The novel electrical powertrain is playing a key role in the company’s drive to be the global mass-market leader for electromobility from 2020. On the world’s roads, there are already well over 500,000 electric and hybrid cars fitted with Bosch components. Bosch thus has many years of experience in the manufacture of electric motors, axle drives, and power electronics. The expertise it has gathered in the process is now bearing fruit in its newly developed electric axle. With this component alone, Bosch is hoping to generate sales running into

the billions. “The e-axle is the ‘start-up’ powertrain for electric cars – also at established automakers. It allows them to save valuable development time and to get their electric vehicles to market considerably faster,” Bulander says. As Bosch customizes the powertrain to each automaker’s requirements, customers no longer have the time-consuming task of developing new components. Samples of the electric axle have already been tested with customers. The start of mass production is planned for 2019. Bosch already has a flexible, globally applicable manufacturing concept for this component. The concept guarantees that each customer will get a customized solution that can be quickly integrated into its manufacturing operations.

Up to 6,000 Newton meters of torque and 300 kilowatts of power

The e-axle’s USP is its high level of versatility, which means it can be adapted to many types of vehicles. “Instead of reams of specifications, a few parameters are enough for Bosch to customize the e-axle,” says Dr. Mathias Pilin, the executive vice president for electromobility. All the customer has to do is state what performance, torque, and installation space they require, and Bosch then optimizes the rest of the powertrain to fit these parameters. In this way, a complete, customized powertrain can be delivered directly to an automaker’s assembly line. This is a further reason why the Bosch electric axle is the next logical step for powertrain engineering.

The powertrain can deliver between 50 and 300 kilowatts, and is therefore also capable of powering large vehicles such as SUVs completely electrically. Torque at the vehicle axle can range from 1,000 to 6,000 Newton meters. When installed in hybrid and electric vehicles, front- and rear-axle drive is possible. An electric axle delivering 150 kilowatts weighs roughly 90 kilograms, and thus far less than the combined individual components used so far. Compared with competing products, the distinguishing feature of the Bosch electric axle is an especially high peak performance combined with a high level of continuous performance. In other words, the electrical powertrain can accelerate better and maintain a high speed for a longer period. To achieve this, Bosch has not only redesigned the system as a whole, but also improved the motor and power electronics components.

Q&A – Additional information about the Bosch electric axle

What makes the electric axle more efficient than previous electrical powertrains?

Highly efficient individual components are the basis for a high level of overall efficiency. In this respect, Bosch has the benefit of years of experience in the market. In addition, efficiency losses are minimized by reducing interfaces and components such as high-voltage cables, plugs, and cooling units. One of Bosch's strengths is its ability to combine individual components to form systems, to use the interactions in the system, and in this way to arrive at an overall optimum. In the case of the e-axle, this relates not only to efficiency, but also to things such as acoustics and electromagnetic compatibility.

When will the e-axle be available in the market?

Bosch has had electric axle drives in the market since 2012 (in the Peugeot 3008 and Fiat 500e, for example), but the power electronics was not fully integrated into them. With the new generation of the electric axle, Bosch is in the development phase, and is in contact with automakers from around the world. More precisely, samples of the electric axle are ready for use, and are currently being tested. Start of production is planned for 2019 at the latest.

What vehicles can it be used in?

The Bosch electric axle is designed so that it can be adapted to many types of vehicles. When installed in hybrid and electric vehicles, front- and rear-axle drive is possible. This applies to any vehicles up to a total weight of 7.5 metric tons, and thus to light trucks as well as passenger cars.

Why is the e-axle less expensive than the powertrains used up to now for electric cars?

Since the e-axle combines power electronics, electric motor, and transmission in a single component, fewer parts are needed. For example, the new electric powertrain does completely without thick and expensive copper cables linking the components. In addition, the cooling system can be simplified, and there is no need for bearings for rotating components. This reduces the powertrain's cost while increasing its efficiency. Placing the transmission close to the motor saves valuable installation space, which is always an important factor in the auto industry.

How deeply is Bosch involved in electromobility?

On the world's roads, there are already well over 500,000 electric and hybrid cars fitted with Bosch components. In its efforts to make a breakthrough in electromo-

bility possible alone, the company invests 400 million euros annually. The company has already won more than 30 electromobility-related orders from international automakers.

Press photographs: #1156595, #1152529, #1152530

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EXPERIENCE BOSCH AT THE IAA 2017 in Frankfurt: Bosch believes the mobility of the future will be accident-free, emissions-free, and stress-free. On a technological level, Bosch wants to achieve the objectives of zero accidents, zero emissions, and zero stress through automation, electrification, and connectivity. At the IAA 2017, Bosch will be presenting its latest solutions in each of these three spheres – solutions that make driving safer and more efficient, and turn cars into a third living environment.

BOSCH PRESS CONFERENCE: From 13:15 to 13:40 local time on Tuesday, September 12, 2017, with [Dr. Volkmar Denner, chairman of the board of management of Robert Bosch GmbH](#) and [Dr. Rolf Bulander, chairman of the Mobility Solutions business sector](#), at the Bosch booth A03 in Hall 8.

FOLLOW the **Bosch IAA 2017** highlights at www.bosch-iaa.de and on Twitter: #BoschIAA

Mobility Solutions is the largest Bosch Group business sector. In 2016, its sales came to 43.9 billion euros, or 60 percent of total group sales. This makes the Bosch Group one of the leading automotive suppliers. The Mobility Solutions business sector combines the group's expertise in three mobility domains – automation, electrification, and connectivity – and offers its customers integrated mobility solutions. Its main areas of activity are injection technology and powertrain peripherals for internal-combustion engines, diverse solutions for powertrain electrification, vehicle safety systems, driver-assistance and automated functions, technology for user-friendly infotainment as well as vehicle-to-vehicle and vehicle-to-infrastructure communication, repair-shop concepts, and technology and services for the automotive aftermarket. Bosch is synonymous with important automotive innovations, such as electronic engine management, the ESP® anti-skid system, and common-rail diesel technology.

The Bosch Group is a leading global supplier of technology and services. It employs roughly 390,000 associates worldwide (as of December 31, 2016). The company generated sales of 73.1 billion euros in 2016. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. As a leading IoT company, Bosch offers innovative solutions for smart homes, smart cities, connected mobility, and connected manufacturing. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source. The Bosch Group's strategic objective is to deliver innovations for a connected life. Bosch improves quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is "Invented for life." The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiaries and regional companies in some 60 countries. Including sales and service partners, Bosch's global manufacturing and sales network covers nearly every country in the world. The basis for the company's future growth is its innovative strength. At 120 locations across the globe, Bosch employs some 59,000 associates in research and development.

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New hybrid battery from Bosch – 48 volts is a recipe for success

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- ▶ Short development times: Bosch is an incubator of electromobility
- ▶ New 48-volt battery systematically designed to save fuel
- ▶ Michael Budde: “We are confident that this will position us as a market leader for 48-volt batteries.”

Gerlingen, Germany – Bosch’s new 48-volt battery for hybrids is in demand by automakers across the globe. Similar to the Bosch e-axle, this innovative 48-volt battery is standardized for easy integration into new vehicle models. Established manufacturers and start-ups alike can thus eliminate long and expensive development processes. “Bosch is an incubator of electromobility. We help manufacturers reduce their development times and launch their products faster,” says Dr. Rolf Bulander, chairman of the Bosch Mobility Solutions business sector and member of the board of management of Robert Bosch GmbH. This means that installation of the lithium-ion battery will benefit not only compact cars, but mini- and microcars as well. Production of the battery is scheduled to start in late 2018. Anticipating a large market for entry-level hybrids, Bosch offers other powertrain components for these models in addition to the 48-volt battery. The company estimates that some 15 million 48-volt hybrid vehicles will be on the road by 2025.

The art of the battery: standardized and easy to use

Automakers everywhere – whether in China, Europe, or North America – are all striving to cut CO₂ emissions, which in practice means reducing cars’ fuel consumption. Bosch has systematically designed its new 48-volt battery to do precisely that. For instance, the lithium-ion cells Bosch uses are as compact as possible while still achieving a reduction in CO₂. The 48-volt battery is in high demand, particularly among Chinese manufacturers, and the lithium-ion unit is poised to become a global success. Bosch is already in talks with over a dozen customers and has secured a considerable number of production projects.

The secret of the battery's success is its sophisticated concept, which offers a comparatively inexpensive way to help reduce vehicle CO₂ emissions. This is also due to the product design, as the battery requires no active cooling and its housing is made of plastic, not metal. Both these factors bring costs down still further. The plastic housing presents a real challenge, as lithium-ion cells expand when the battery is charging and over the course of the unit's service life. As a result, the housing must withstand a certain amount of stress. Bosch engineers rearranged the cells in the 48-volt battery so that even plastic housing can bear the pressure.

"We at Bosch have long been making upfront investments in electromobility. Now those investments are gradually starting to pay off," says Dr. Mathias Pillin, head of electromobility at Bosch. On the world's roads, there are already well over 500,000 electric and hybrid cars fitted with Bosch components. The company invests 400 million euros a year in electromobility. Bosch has years of experience from more than 30 production projects, including in the manufacture of batteries, and that expertise is now bearing fruit. As Michael Budde, head of Bosch Battery Systems, puts it: "We are demonstrating that there is more to a battery than making it perform faster, stronger, farther; instead, there is an art to finding a suitable user-friendly solution."

With its new battery, Bosch is playing a key role in making the 48-volt hybrid affordable for the mass market. This would make it possible for the powertrain to quickly become a hybrid for everybody – and not only in China: as the mass market for hybrids expands, Bosch expects its battery to find success in Japan and Europe as well. "We are confident that this will position us as a market leader for 48-volt batteries," Budde says.

Q&A – More information about the 48-volt battery

How does a 48-volt hybrid save on fuel?

A 48V hybrid can considerably cut its fuel consumption through the use of a boost recuperation system (BRS). Here's how it works: a conventional car loses energy whenever the driver brakes. The BRS stores this braking energy in a 48V battery and applies it later when the driver accelerates (electronic boost). This requires less fuel – and produces less CO₂ in the exhaust.

Why is China seen as an e-mobility pioneer?

With more than half a million models sold, China is by far the world's largest market for electric vehicles. It is a world leader in e-vehicle production, too. Electric vehicles and hybrids are set to take over still more of the Chinese market, especially with government support.

Why is the new battery efficient when it comes to CO₂?

No other country in the world emits as much CO₂ into the atmosphere as China. It has set itself a fleet target of 117 g/km by 2021, and China's automakers are looking to the 48-volt hybrid system to help them achieve this goal. Bosch's new and less expensive 48-volt battery will make the system more affordable for a broader market, and will thus help Chinese automakers considerably reduce CO₂ emissions.

Press picture: 1138662

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The Bosch Group (www.bosch.com) is a leading global supplier of technology and services. It employs roughly 375,000 associates worldwide (as per December 31, 2016). The company generated sales of 73.1 billion euros in 2016. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. As a leading IoT company, Bosch offers innovative solutions for smart homes, smart cities, connected mobility, and connected manufacturing. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source. The Bosch Group's strategic objective is to deliver innovations for a connected life. Bosch improves quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is "Invented for life." The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiaries and regional companies in some 60 countries. Including sales and service partners, Bosch's global manufacturing and sales network covers nearly every country in the world. The basis for the company's future growth is its innovative strength. At 120 locations across the globe, Bosch employs some 59,000 associates in research and development.

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A world-first: The powertrain for the electric long-haul truck

Nikola Motor Company and Bosch develop the commercial vehicle powertrain of the future

September 20, 2017

PI 9811 BBM IEh/af

- ▶ Development partnership will bring to market fuel cell and commercial vehicle eAxe for Nikola class 8 hydrogen-electric truck
- ▶ Bosch offers automotive-grade hardware and software for aggressive launch schedule - production by 2021
- ▶ Electrification incubator: Bosch's expertise and portfolio help start-ups go from concept to execution

Salt Lake City, Stuttgart – Electrification is becoming bigger than you imagined. By 2021, Nikola (pronounced Neek-oh-la) Motor Company will bring to market the Nikola One and Two, a class 8 hydrogen-electric truck lineup that will deliver more than *1,000 horsepower and 2,000 ft. lbs. of torque* – nearly double the horsepower of any semi-truck on the road – all with “zero local emissions,” as previously announced by Nikola.

At the heart of the Nikola truck lineup is a new commercial vehicle powertrain achieved thanks to a development partnership between Nikola and Bosch. The organizations re-imagined the powertrain from the ground up. Bosch's eAxe expertise has enabled Nikola to move quickly on an aggressive path to bring its electric truck to market.

“Bosch is an incubator of electromobility solutions. No matter whether at established OEMs or start-ups, Bosch is accelerating development and helps achieve fast breakthroughs on the market,” said Dr. Markus Heyn, member of the Bosch board of management responsible for the Commercial Vehicle Organization.

“We have been aggressively pursuing our goal of bringing the most advanced semi-truck ever built to market,” said Nikola Founder and CEO Trevor Milton. “The powertrain requires an innovative and flexible partner able to adapt quickly to the speed of our team. Bosch has empowered us to come to market quickly with automotive-grade hardware and software so our vision can become a reality.”

The eAxle developed by Bosch is a scalable, modular platform with the motor, power electronics and transmission in one compact unit. This makes it suitable for vehicles of all kinds, from small passenger cars to light trucks. Nikola and Bosch will use this know-how to commercialize the world’s first true dual-motor commercial-vehicle eAxle for a long-haul truck.

The eAxle will use proven commercial vehicle electric machine technology and SMG (separate motor generator) motors from Bosch. The technology vision of Nikola and integration expertise from Bosch will enable the Nikola trucks to realize unprecedented targets for e-machine efficiency.

The eAxles will be paired with a custom-designed fuel cell system – also being developed jointly between Nikola and Bosch – designed to deliver benchmark vehicle range. The overall vehicle controls will also be jointly developed based upon Bosch’s vehicle control software and hardware. The Nikola Bosch zero local emission powertrain is designed to achieve segment-leading performance at a competitive total cost of ownership to traditional powertrains.

“Breakthrough mobility technology requires visionary targets, speed to-market and disciplined structure to ensure long-term success,” Heyn said. “Together with Nikola we are pushing ourselves to realize new levels of technological achievement and market penetration.”

Bosch and Nikola will also jointly develop the overall powertrain system for the Nikola lineup, which will include the safety concept and vehicle electrical architecture. By utilizing advanced simulation technologies throughout the whole development process, from system layout to testing and validation, the Nikola One and Two will launch with one of the most optimized and state-of-the-art system designs and vehicle controls in the mobility sector.

For complete product details on the Nikola lineup, visit www.nikolamotor.com.

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About Nikola Motor Company

Nikola Motor Company designs and manufactures electric vehicles, vehicle components, energy storage systems, and electric vehicle drivetrains. NMC is led by its visionary CEO Trevor Milton (twitter: @nikolatrevor), who has assembled one of the most talented teams in the country to bring the Nikola products to market. The company is a privately-held Delaware corporation registered as Nikola Corporation. For more information, visit nikolamotor.com or Twitter: @nikolamotor.

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Bosch is putting small electric vehicles on city streets

Presentation by Dr. Markus Heyn,
member of the board of management of
Robert Bosch GmbH,
at the Bosch Mobility Experience
in Boxberg, July 4, 2017

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Whether transporting goods or making the daily commute in a crowded metropolis: small electric vehicles are the backbone of mobility in the Asian conurbations, as well as the number one form of mass transportation. Over the past decade, electric scooters have taken Asia's urban roads by storm: in 1998, a modest 58,000 were sold. Now, more than 30 million of them are sold each year. Some 200 million such scooters are already purring along China's roads alone.

For the local population, they are usually the only chance of making any headway in the congested cities – past cars and buses stuck in traffic jams. Nonetheless, there is no denying that it is not only in small vehicles such as e-scooters that e-mobility is on the march on the streets of the world's conurbations. Electric SUVs are also an ever more frequent sight there. Indeed, especially in China, there are even long-wheelbase versions of electric vehicles sold in Europe.

Nonetheless, we firmly believe that urban electromobility is not solely about the quest for greater size and range. In cities, neither are absolutely necessary. How? The distances traveled in cities are only short, usually no more than 40 kilometers a day. In addition, small vehicles make it easier to weave quickly through traffic, as well as to park in the smallest available space.

We can currently see a new wave of pragmatism among city-dwellers. Their rallying cry is back to basics, with mobility having to offer one thing above all: it has to get them reliably and as quickly as possible from A to B. Especially city-dwellers want a simple and affordable alternative, without stress and emissions. Mr. Bulander talked about this earlier.

But can this form of electromobility that depends on small vehicles such as e-scooters also work outside countries such as China, Taiwan, and Vietnam? At Bosch, our answer is clear: yes, it can. Small electric vehicles have a bright future, worldwide. We believe that it is especially in this segment that urban

electromobility will take off. According to estimates, some 100 million light electric vehicles will be produced worldwide by 2020 – these include scooters and small four-wheeled cars roughly the same size as a Smart.

We have brought along two prototypes of this new urban mobility with us today. The small e.GO four-seater, and the electric makeover of the Schwalbe scooter. Both are powered by a Bosch solution. Especially for urban mobility, we have developed an integrated system including motor, control unit, battery, charger, display, and app – for two-, three-, and four-wheelers.

- The powerful 48-volt drive unit converts the energy from the battery into maximum boost.
- The control unit is the powertrain's brain, and ensures perfect handling.
- The lithium-ion rechargeable battery provides high energy density.
- The charger enables fast recharging at regular household power sockets.
- The display clearly presents all information about the system. There is a choice of different driving modes.
- In addition, the system allows communication between the vehicle and the driver via a Bluetooth interface and an app.

One further advantage is that these small vehicles not only reduce emissions, but noise as well. All these elements mean that the system isn't just about efficient mobility in cities. Rapid acceleration from a standstill makes for a "wow" factor. We expect that this 48-volt system will generate annual internal growth of well over 100 percent.

As the system is made up of off-the-shelf automotive components, manufacturers will have the benefit of production-tested parts and minimal development expense. This gives both established OEMs and new players in the market the opportunity to launch vehicles within a very short timeframe of 12 to 18 months. Thanks to simple scalability, multiples of the system's components can be combined, depending on vehicle class and the desired

level of power. Adding a second battery pack, for example, doubles the vehicle's range. This reduces complexity, variants, and cost – for manufacturers and thus also for anyone who wants to drive electrically through their city.

In order to get around more flexibly in a small electric vehicle in urban traffic, people no longer have any absolute need to have a vehicle of their own parked outside the house. Sharing is the new trend. With Coup, our e-scooter sharing service, we are making urban mobility simpler and less stressful. In addition, as a sharing service provider, we receive direct feedback from our customers, both about the service itself and the technologies used. This gives us an opportunity to constantly improve and launch new developments, since we now know what people expect of sharing services.

To sum up, we firmly believe that electromobility will take off much more rapidly in small-vehicle segments. And with our modular 48-volt system and our Coup e-scooter sharing service, we have the right solutions.



Bosch: shaping the transformation of the powertrain New division pools expertise

February 7, 2017
PI 9554 RB EMR

- ▶ Electromobility is an area of future importance
- ▶ Combustion engine remains important part of the mix of different powertrain types
- ▶ New Powertrain Solutions division with 88,000 associates
- ▶ Bosch is actively shaping the change in mobility, and taking advantage of all its opportunities

Stuttgart, Germany – Bosch estimates that nearly 20 million hybrids and electric vehicles will be produced in 2025. Bosch regards electromobility as an area of future importance. For this reason, the supplier of technology and services is now setting up an operating unit specifically for electromobility. The unit will be part of the new Powertrain Solutions division. From the start of 2018, this will include the company's electromobility activities as well as today's Gasoline Systems and Diesel Systems divisions. In the future, therefore, Bosch will supply existing and new customers with all powertrain technologies from a single source. As well as expanding electromobility, Bosch will work intensively on further improving combustion-engine technology. In addition to the 20 million new hybrids and electric vehicles on the world's roads in 2025, there will be some 85 million new gasoline and diesel-powered vehicles.

“Whether in diesel technology, gasoline technology, or electromobility, Bosch is the number-one engineering and technology partner for automakers. We are strategically well prepared for the shift to electric driving,” says Dr. Rolf Bulander, chairman of the Bosch Mobility Solutions business sector and member of the board of management of Robert Bosch GmbH. “Whether fuel or electricity, Bosch will drive the powertrain in the future as well. As it is still unclear which powertrain or which combination of the various types will dominate when, we are taking a two-pronged approach, and continuing to

extend our expertise and knowledge in both electromobility and combustion engines,” Bulander adds. As the technology and market leader for powertrain, Bosch is playing an active role in shaping the transformation of mobility concepts. In the future, the new Powertrain Solutions division will offer a wide-ranging portfolio of technologies that will make getting from A to B more efficient, economical, and eco-friendly for people around the world.

Heavy investments in innovative powertrain solutions

Each year, Bosch spends several billion euros on further improving powertrain solutions. In the quest to achieve a breakthrough in electromobility alone, the company invests 400 million euros annually. Most of this has gone into battery research and development. Worldwide, Bosch is the only classic automotive supplier researching into both current and future cell technologies. The company has already won more than 30 electromobility-related orders from international automakers. Some 1,800 Bosch experts are working on the electromobility of the future.

Closer to the market and customers

With its new Powertrain Solutions division, Bosch wants to be able to offer its customers powertrain-related support from a single source, and to increasingly offer complete systems solutions in addition to individual components. “Increasingly, our customers’ requirements are going beyond the combustion engine. This dynamic shift toward electrification will play a leading role in shaping the new division. In this transformation process, we will be there to support our customers with knowledge and technology,” Bulander says.

Strategically speaking, Powertrain Solutions will focus on three core segments: passenger cars and trucks with combustion engines and hybrid powertrains, and electric vehicles. This involves wide-ranging challenges. “We see huge growth potential in electromobility and commercial vehicles. When it comes to passenger cars with combustion engines, our main focus will be on improving efficiency,” Bulander says. Technical innovations will be needed for all powertrain solutions. In the end, only companies which market products that further reduce fuel consumption and emissions will remain competitive over the long term.

Changes in the market

In the years ahead, Bosch will develop all these technologies in parallel. Only in this way will the company be able to react quickly and flexibly to changes in the market, and this across all areas relating to the powertrain. There is currently no doubt that mobility will be electric in the long run. At present,

however, it cannot be reliably forecast when and how quickly the change will come, and what form it will take.

Powertrain Solutions will bring together roughly 88,000 associates at more than 60 locations in 25 countries around the world. Even today, associates from Gasoline Systems and Diesel Systems are successfully working together. This collaboration will be intensified in the new division from 2018. Headcount will remain practically unchanged as a result of the reorganization.

The details of the future organization will be worked out in close consultation with the employee representatives. The plan is for the new division and its three units to start operations at the beginning of 2018.

Press photos:

#536167, #546138, #949352, #955727, #955730, #955731

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Mobility Solutions is the largest Bosch Group business sector. According to preliminary figures, its 2016 sales came to 44.0 billion euros, or 60 percent of total group sales. This makes the Bosch Group one of the leading automotive suppliers. The Mobility Solutions business sector combines the group's expertise in three mobility domains – automation, electrification, and connectivity – and offers its customers integrated mobility solutions. Its main areas of activity are injection technology and powertrain peripherals for internal-combustion engines, diverse solutions for powertrain electrification, vehicle safety systems, driver-assistance and automated functions, technology for user-friendly infotainment as well as vehicle-to-vehicle and vehicle-to-infrastructure communication, repair-shop concepts, and technology and services for the automotive aftermarket. Bosch is synonymous with important automotive innovations, such as electronic engine management, the ESP anti-skid system, and common-rail diesel technology.

The Bosch Group is a leading global supplier of technology and services. It employs roughly 390,000 associates worldwide (as of December 31, 2016). According to preliminary figures, the company generated sales of 73.1 billion euros in 2016. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. As a leading IoT company, Bosch offers innovative solutions for smart homes, smart cities, connected mobility, and connected industry. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source. The Bosch Group's strategic objective is to create solutions for a connected life, and to improve quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is "Invented for life." The Bosch Group comprises Robert Bosch GmbH and its roughly 450 subsidiaries and regional companies in some 60 countries. Including sales and service partners, Bosch's global manufacturing, engineering, and sales network covers nearly every country in the world. The basis for the company's future growth is its innovative strength. At 120 locations across the globe, Bosch employs 59,000 associates in research and development.

Additional information is available online at www.bosch.com, www.iot.bosch.com, www.bosch-press.com, www.twitter.com/BoschPresse.



Car Symposium 2015

Bosch CEO Denner “Electric cars are good, but connected electric cars are better”

February 4, 2015

PI 8803 BBM FF/af

- ▶ Dr. Volkmar Denner: “Electrification will take combustion engines to new heights”
- ▶ Falling battery prices will halve costs by 2020
- ▶ E-bike as model: Europe’s most successful electric vehicle is about enjoyment

Powertrain electrification is picking up pace. The currently low oil price will not change that fact. This was the message underlined by Dr. Volkmar Denner, chairman of the board of management of Robert Bosch GmbH, at the Car Symposium in Bochum, Germany. Bosch expects roughly 15 percent of all new cars built worldwide to have at least a hybrid powertrain by 2025. For the Bosch CEO, advances in battery technology are the key to lower vehicle prices. Denner, whose responsibilities on the board of management include research and advance development, believes that by 2020 batteries will deliver twice as much energy density for half the present cost.

Electrification enhances the attractiveness of combustion engines

The EU has set strict fleet CO₂ targets for 2021. For this reason alone, Bosch expects hybrid powertrains to become the standard for SUVs. This will give diesel and gasoline engines an extra boost. “Electrification will take combustion engines to new heights,” Denner said. With electric support, the combustion engines of the future will consume significantly less fuel and be even cleaner. And the additional torque from the electric motor will add to driving enjoyment. Moreover, falling battery prices will make hybrids considerably more affordable.

Denner used the example of China to show how important it is in a mass market for electric cars to be suitable for everyday use. There are already more than 120 million electric scooters on China’s roads. And in China, Bosch sells the electric wheel hub drive for such e-scooters. With a top speed of 40 kph, this popular form of transport is fast enough for the traffic conditions in megacities.

And their range of roughly 50 kilometers is sufficient for everyday journeys. “The reason these two-wheelers are such a success is that they are a perfect match for Chinese commuters’ needs,” Denner said. And because they are designed to meet these needs, many models are less expensive than two-wheelers with combustion engines. According to Denner, the task now is to make such tailor-made solutions possible for cars as well.

One app to recharge the battery, nationwide

The main factor helping to make electromobility convenient will be connecting vehicles with the internet of things. “Electric cars are good but connected electric cars are better,” Denner said. At the moment, recharging vehicles is complicated. But this is expected to become much more convenient. Bosch Software Innovations, the Bosch Group’s software and systems unit, has developed an app that makes it significantly easier to reserve the charge spots of different providers and pay for the electricity. Up to now, doing this would have required a different customer card for each provider. Now all drivers need is a smartphone, the app, and a PayPal account to recharge anywhere in Germany. Bosch also complements this with a software platform that links 80 percent of all charge spots in Germany. As this example shows, Bosch no longer sees itself solely as a supplier of automotive components. The company is now combining its expertise in all three mobility domains – automation, electrification, and connectivity – and will in the future be offering its customers integrated mobility solutions.

Fun as a reason to buy: e-bikes show the way

However, rational arguments alone are not enough to win drivers over to electric powertrains. In Bosch’s view, emotion and fun play a decisive role. The example of e-bike drives illustrates this. Bosch’s “electric tailwind” makes riding a bike a joy – for serious athletes as well as recreational cyclists. Bosch is now the European market leader in this area, and its e-bike drives feature in more than 50 bike brands. “The e-bike is the most successful electric vehicle in the EU,” Denner said, adding that customers pay considerably more on average for e-bikes than they do for classic ones. “For more than 100 years, riding a bike was a mechanical process. No one saw any reason to change it. Then along came the e-bike, and completely redefined a market everyone thought would never change,” Denner said. The same could be true for the auto industry, he added. The Bosch CEO stressed that the supplier of technology and services will be using its comprehensive systems and connectivity know-how to take electromobility a decisive step forward.

Press photos: 1-EB-19739, 1-RB-20741, 1-UBK-20832, 1-RB-20590

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Electromobility at Bosch
Facts about battery technology for hybrid and electric powertrains

February 2015
PI 8807 BBM FF/af

How range is increasing, why a battery has more than one lifetime, and how automated driving could change battery technology

Long service life, top quality, the highest degree of safety – we expect an enormous amount from high-voltage batteries in vehicles. That’s why today’s lithium-ion batteries, for example, have to be designed to run for at least 150,000 kilometers and to last up to 15 years. Even then, after spending all this time in the car, the battery still has to possess 80 percent of its original storage capacity and performance. “Developing a high-voltage vehicle battery that is cost-efficient, powerful, and reliable at the same time – this is the proverbial rocket science,” says Stefan Seibert, president of the Gasoline Systems division of Robert Bosch GmbH responsible for electromobility. Within the next five years, Bosch intends to offer high-voltage batteries that are twice as powerful. At the same time, the company is exploring new battery technologies.

Development: the path to the next generation of lithium-ion batteries

Lithium-ion technology: In the years to come, lithium-ion technology still has plenty of potential to offer. Today’s batteries have an energy density of approximately 115 W h/kg, but have the potential to go as high as 280 W h/kg. To research the next generation of lithium-ion batteries, Bosch has joined forces with GS Yuasa and Mitsubishi Corporation in a joint venture called Lithium Energy and Power. “The goal of this joint venture is to make lithium-ion batteries up to two times more powerful,” Seiberth says. In pursuit of this goal, the partners have pooled their strengths. GS Yuasa can apply its experience in cell optimization to creating a battery with a higher energy density and increased range. Bosch contributes its expertise in complex battery management and systems integration.

Post-lithium-ion batteries: Bosch’s corporate research department is working on post-lithium-ion batteries, such as those made using lithium-sulfur technology,

which promises greater energy density and capacity. Bosch estimates that the earliest the lithium-sulfur battery will be ready for series production is the middle of the next decade.

Progress: battery management results in 10 percent more range

Cell chemistry: There are several ways to improve battery performance. For example, the material used for the anode and cathode plays a major role in the cell chemistry. Most of today's cathodes consist of nickel-cobalt manganese (NCM) and nickel-carboxyanhydrides (NCA), whereas anodes are made of graphite, soft or hard carbon, or silicon carbon.

Cell voltage: High-voltage electrolytes can further boost battery performance, raising the voltage within the cell from 4.5 to 5 volts. The technical challenge lies in guaranteeing safety and longevity while improving performance.

Battery management: In terms of high-performance batteries, Bosch is focusing on driving forward the monitoring and management of the various cells as well as the overall system. The challenge is managing a high-voltage battery reliably, since up to ten microcontrollers regulate energy flow in the cells by means of a CAN bus system. Sophisticated battery management can further increase the range of a car by up to 10 percent – without altering the cell chemistry.

Infrastructure: automated vehicles have an effect on battery technology

Rapid-recharging charge spots: If there are lots of places where you can quickly charge your electric vehicle, then this will have a major impact on battery technology. The faster an electric vehicle's battery can recharge, the less important its range becomes.

Automated driving: Fully automated vehicles make charging much more straightforward, since they can search for charge spots without any assistance from the driver. How this works is demonstrated by V-Charge, a project spearheaded by Bosch, VW, and a number of European universities. The idea is that within a parking garage, for instance, the driver would be able to use a smartphone app to direct their electric vehicle to a charge spot. When the driver comes back, the car returns to the pick-up spot by itself. Other variations on this theme are also possible; for example, a driver could request a vehicle from a car-sharing fleet by cell phone and have it come right away to a designated spot. Fleets are in fact another area where demands on the battery – such as those regarding its service life – are changing, since fleet vehicles are often in service for fewer than the 15 years estimated for vehicle batteries.

Three lifetimes: for a high-voltage battery, the car is just the first step

Different stages in the life of a battery: A fleet vehicle, which drives many kilometers in a short space of time, requires a new battery with full performance and capacity. In contrast, a slightly used battery can work just as well in cars that are driven only occasionally for short routes. That would reduce the overall cost of an electric car. Even after twelve years – the average service life of a car – the battery still retains 80 percent of its original performance and capacity. This means its components can still be useful, for example as a power storage unit.

“Second Life” project with BMW and Vattenfall: In Hamburg, used batteries from electric vehicles are being joined together to form a large power storage system. It can provide energy within seconds and helps stabilize the grid. With this project, Bosch, the BMW Group, and Vattenfall are working together to drive electromobility and energy storage forward.

Press photo: 1-RB-20741, 1-UBK-20832, 1-UBE-20209-d

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Expertise in innovative drive technology **An electrifying combination: hybrid technology from Porsche and Bosch**

May 12, 2015

PI 8928 GS FF/af

Stuttgart - With the 918 Spyder, the Panamera S E-Hybrid and the Cayenne S E-Hybrid, Porsche was the first car manufacturer in the world to offer three plug-in hybrid models. Among the suppliers Porsche relies on for the innovative drive system is Bosch. The possibilities offered by the combination of an internal combustion engine and an electric motor will impressively be demonstrated by the Porsche hybrid vehicles at the 62nd International Automotive Press Briefing at the Boxberg test track, starting May 19.

"We promised to redefine driving pleasure, efficiency and performance with the 918 Spyder. We kept our word, and in so doing repositioned hybrid technology", says Wolfgang Hatz, Member of the Executive Board - Research and Development at Porsche AG. The Porsche 918 Spyder¹⁾ was the first globally road-legal car to complete the 20.6 kilometre lap of the North Loop of the Nürburgring in less than seven minutes. At exactly six minutes and 57 seconds, this super sports car with plug-in hybrid drive beat the existing record by 14 seconds. Porsche also integrated the knowledge gained from the development of the technology demonstrator into the electrification of the rest of its model range. The Panamera S E-Hybrid²⁾ and Cayenne S E-Hybrid³⁾ round off the product range and make Porsche the global market leader for hybrid cars in the premium segment.

"Porsche and Bosch have teamed up to bring electrification to electrifying sports cars together. Electricity gives added driving pleasure and efficiency", says Dr. Rolf Bulander, Chairman of the Business Sector Mobility Solutions at Bosch. For the three plug-in models made by Porsche, Bosch supplies the power electronics, the battery pack, the electric motors for the Cayenne and Panamera and the electric motor installed on the front axle of the 918 Spyder.

918 Spyder: a unique combination of performance and efficiency

The project definition for the 918 Spyder's development team was to build the super sports car for the next decade with a highly efficient and high performance hybrid drive. The completely new development, which logically started from scratch on a blank piece of paper, allows a new concept without having to make any concessions. The whole car was designed around the hybrid drive. The 918 Spyder thus highlights the potential of hybrid drives, i.e. the simultaneous increase in efficiency and performance, without one coming at the expense of the other. Thanks to the SMG 180/120 electric motor developed by Bosch, the Porsche 918 Spyder has an additional 210 kW (286 hp) of driving power. The electric motor on the front axle of the 918 Spyder delivers a torque of 210 Nm right from the start, while the motor on the rear axle delivers 375 Nm. The result is a total system output of 652 kW (887 hp) with a maximum torque of up to 1,280 Nm, allowing the 918 Spyder to accelerate from 0 to 100 km/h in a mere 2.6 seconds. The super sports car's fuel consumption, on the other hand, is an amazing 3.1 litres per 100 km, making it more efficient in the NEDC test than most of today's small cars.

Panamera S E-Hybrid and Cayenne S E-Hybrid: fuel consumption of a small car

The driving experience of a sports car combined with the consumption of a small car – the Porsche Cayenne S E-Hybrid and Panamera S E-Hybrid prove that these two are not contradictory to each other. The world's first plug-in hybrid amongst the premium SUVs with a system output of 306 kW (416 hp) achieves an NEDC fuel consumption of just 3.4 l/100 km. The plug-in hybrid model of the Porsche Gran Turismo, which also has a system output of 306 kW (416 hp) stands out thanks to its weight advantage, rear-wheel drive and low drag, giving it a fuel consumption of just 3.1 l/100 km.

In the plug-in hybrid models of the Porsche Cayenne and Panamera, Bosch's IMG-300 electric motor provides additional electrical propulsion. It gives a boost of up to 310 Nm of additional torque and provides 70 kW (95 hp) of additional power. The central interface between the electric motor and the battery is the INVCON 2.3 module made by Bosch. The power electronics are the control centre of the electric powertrain, because the system converts the direct current stored as energy in the battery into three-phase alternating current for the electric motor and vice versa. The traction battery stores the electricity in the powertrain. It is made up of prismatic cells with an energy capacity of 9.4 kilowatt hours in the Panamera S E-Hybrid and 10.8 kilowatt hours in the Cayenne S E-Hybrid that can be fully charged from a normal household power socket in less than four hours. Using a high current power supply, the charging time is almost halved to a good two hours.

GO

Note: Photographs are available to accredited journalists on the Porsche Press Database at <https://presse.porsche.com>.

¹⁾ Porsche 918 Spyder: combined fuel consumption 3.1 l/100 km; combined CO₂ emissions 72-70 g/km; combined electricity consumption 12.7 kWh/100 km; efficiency class: A+

²⁾ Porsche Panamera S E-Hybrid: combined fuel consumption 3.1 l/100 km; combined CO₂ emissions 71 g/km; combined electricity consumption 16.2 kWh/100 km; efficiency class: A+

³⁾ Porsche Cayenne S E-Hybrid: combined fuel consumption 3.4 l/100 km; combined CO₂ emissions 79 g/km; combined electricity consumption 20.8 kWh/100 km; efficiency class: A+

Press photos: 1-GS-21198, 1-GS-21199, 1-GS-21200, 1-GS-21201, 1-GS-21202

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The Bosch Group is a leading global supplier of technology and services. It employs roughly 360,000 associates worldwide (as per April 1, 2015). The company generated sales of 49 billion euros in 2014. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiary and regional companies in some 60 countries. Including its sales and service partners, Bosch is represented in roughly 150 countries. This worldwide development, manufacturing, and sales network is the foundation for further growth. In 2014, Bosch applied for some 4,600 patents worldwide. The Bosch Group's strategic objective is to create solutions for a connected life. Bosch improves quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is "Invented for life."*

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*The sales figure disclosed for 2014 does not include the former joint ventures BSH Bosch und Siemens Hausgeräte GmbH (now BSH Hausgeräte GmbH) and ZF Lenksysteme GmbH (now Robert Bosch Automotive Steering GmbH), which have since been taken over completely.



Bosch cooperates with BMW and Vattenfall **Batteries from electric vehicles for a stable power grid** Second Life Batteries project

January 21, 2015
PI 8780 RB Res/SL

- ▶ Connecting electromobility and energy storage systems
- ▶ More than 100 vehicle batteries to stabilize power grid
- ▶ Storage systems a core element of the move to alternative forms of energy

What to do with valuable batteries once they have reached the end of their life cycle in electric vehicles? A project involving three partners is connecting old batteries in Hamburg to form a large-scale storage system to keep the power grid stable.

Stuttgart – Electromobility and power storage are two core elements of the move to alternative forms of energy. A project is bringing Bosch, the BMW Group, and Vattenfall together to drive progress on both technologies by interconnecting used batteries from electric vehicles to form a large-scale energy storage system in Hamburg. Its energy is available within seconds and can help keep the power grid stable.

Bosch, BMW, and Vattenfall believe in this concept and as a result have launched the Second Life Batteries alliance. BMW is supplying batteries from its ActiveE and i3 electric vehicles, while Vattenfall has agreed to operate the massive storage system at its site for a period of ten years. Bosch is in charge of integrating the batteries and managing the system. The storage solution will become part of an already existing Vattenfall virtual power plant. This allows the partners to combine various small, decentralized power generating systems to market them as a shared power plant.

Still valuable

Lithium-ion batteries still have high storage capacity at the end of their life cycle in electric vehicles. As a result, they are still very valuable and can be used extremely efficiently as stationary buffer storage for many years to come. The project allows the three partners to gain numerous new insights into potential

areas of application for such batteries, their aging behavior, and their storage capacity. Bosch's management algorithm is intended to ensure maximum service life and performance as well as other benefits.

The company has already gained its first experiences in the field. In Braderup, located near the German island of Sylt, Bosch has built one of Europe's largest energy storage systems to temporarily store the energy generated by a wind farm if needed. To do so, the company has connected thousands of small lithium-ion batteries to form a large-scale network. In Kelsterbach, a community close to Frankfurt, Bosch has installed a similar lithium-ion storage system at a housing complex. This knowledge is also making a difference in the Second Life Batteries project.

"The project is important because it combines two strategically significant goals," says Bosch CEO Dr. Volkmar Denner, who believes in the future of the electric drive. "In electromobility, we see a future mass market accompanied by many new business models and solutions," the physicist adds. "Stationary energy storage systems that enable people to continue making good use of used batteries are part of this. Such decentralized storage systems allow us to make a major contribution to a secure power supply."

Core element of the move to alternative forms of energy

Energy storage systems are considered to be a core element of the move to alternative forms of energy. They can absorb solar power during the daytime and release it at night – or secure wind power for moments when the wind is calm. By doing so, they help better integrate the often fluctuating supply of renewable energy into the power grid. Electromobility can also benefit from this development by making it possible to charge vehicles with solar power at night along with a host of other options. In addition, a storage system can supply its energy rapidly to stabilize power grids as part of a virtual power plant, for example.

Two megawatts of capacity

The current plans call for the construction of a storage unit with an output of two megawatts (MW) and an installed capacity of two megawatt hours (MWh) in Hamburg. The energy will be fed into the energy balancing market to balance out short-term fluctuations in the power grid. More than 100 vehicle batteries will be interconnected to achieve these targets. The entire system is compact enough to fit in a small building. It provides enough output in mathematical terms to supply 30 four-person households with power for seven days. The partners expect the storage unit to be operational by the end of 2015.

Internet

BMW homepage:

<http://bit.ly/1zZQifK>

Vatenfall newsroom:

<http://bit.ly/1I1Kf0s>

Bosch stationary energy storage solutions:

<http://bit.ly/1sOKZ5g>

Energy storage system in Braderup:

<http://bit.ly/1BUP0W0>

Energy storage system in Kelsterbach:

<http://bit.ly/1wCbpmo>

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The Bosch Group is a leading global supplier of technology and services. In 2013, its roughly 281,000 associates generated sales of 46.1 billion euros. (NB: Due to a change in accounting policies, the 2013 figures can only be compared to a limited extent with the 2012 figures). Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. The Bosch Group comprises Robert Bosch GmbH and its roughly 360 subsidiaries and regional companies in some 50 countries. If its sales and service partners are included, then Bosch is represented in roughly 150 countries. This worldwide development, manufacturing, and sales network is the foundation for further growth. In 2013, the Bosch Group invested some 4.5 billion euros in research and development and applied for some 5,000 patents. This is an average of 20 patents per day. The Bosch Group's products and services are designed to fascinate, and to improve the quality of life by providing solutions which are both innovative and beneficial. In this way, the company offers technology worldwide that is "Invented for life."

The company was set up in Stuttgart in 1886 by Robert Bosch (1861-1942) as "Workshop for Precision Mechanics and Electrical Engineering." The special ownership structure of Robert Bosch GmbH guarantees the entrepreneurial freedom of the Bosch Group, making it possible for the company to plan over the long term and to undertake significant up-front investments in the safeguarding of its future. 92 percent of the share capital of Robert Bosch GmbH is held by Robert Bosch Stiftung GmbH, a charitable foundation. The majority of voting rights are held by Robert Bosch Industrietreuhand KG, an industrial trust. The entrepreneurial ownership functions are carried out by the trust. The remaining shares are held by the Bosch family and by Robert Bosch GmbH.

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Boost recuperation system

Bosch is making hybrids affordable

Electric components provide a ten kilowatts boost while lowering CO₂ emissions by up to 15 percent

June 2013

PI 8152 SG Hn

- ▶ Recovery of braking energy and torque boost
- ▶ Silent and zero-emissions coasting for up to 30 percent of the journey
- ▶ Easy integration into vehicles of any class

The new Bosch boost recuperation system (BRS) is set to close the persistent and sizeable gap between start-stop systems and hybrid drives. "BRS represents the affordable electrification of compact cars," says Wolf-Henning Scheider, member of the board of management of Robert Bosch GmbH. "We are serving the needs of the mid-price segment by providing tailored components such as a lithium-ion battery with a capacity of 0.25 kilowatt-hours." BRS can lower a vehicle's fuel consumption and CO₂ emissions by up to 15 percent thanks to electrical components that provide the engine with up to ten kilowatts of additional power. This opens up another way to meet more demanding CO₂ emissions restrictions in Europe, China, and the United States.

This innovative Bosch drive component combines four functions within one system: recuperation and torque boost together with comfortable start-stop and coasting functions. The centerpiece of this new hybridization is a highly efficient generator that has been upgraded from 12 to 48 volts using new power electronics, making the electric motor up to four times more powerful than before.

This 48-volt electrical system offers drivers a range of benefits. Increasing the voltage allows vehicles to be fitted with new comfort and security systems. And as mechanics do not need special high-voltage training before they can service BRS, it is easier to maintain than current hybrid systems.

BRS charges during braking and delivers additional torque when accelerating

As its name suggests, the boost recuperation system performs two main functions: it uses recuperation to recover energy and then uses that energy for vehicle acceleration. In detail, it works as follows: any surplus energy from braking is sent via the 48-volt vehicle electrical system to the 0.25 kilowatt-hour lithium-ion battery. When required, this energy is fed back to the BRS, which then functions as an electric motor. This means BRS provides additional torque – a boost effect that is particularly important for achieving dynamic handling with small, turbocharged engines and at low engine speeds.

The new system also expands the familiar start-stop system to enable coasting. If neither the accelerator nor brake pedal is depressed while coasting to a stop or going slightly downhill, BRS automatically stops the internal combustion engine. The vehicle coasts along driven solely by its momentum, producing no emissions and no noise. Freeways and highways that slope gently downward provide ideal driving conditions for BRS coasting. Under real conditions such routes offer the chance to coast for 30 percent of the journey.

The comfort of a start-stop function and silent starting

The boost recuperation system also takes the start-stop function to the next level by rapidly starting the vehicle's engine with no noise or jolts, even when restarting the combustion engine during coasting. Once again, the 48-volt battery helps by reliably bridging these driveless periods to provide power to all comfort and safety functions.

New vehicle electrical system architecture with DC/DC converter

With its additional functions, the 48-volt electrical system is a particularly attractive solution for midsize and luxury vehicles, as it permits electrification of vehicle functions that could not be supported by a system with lower voltage and energy. It can, for example, increase the functionality and reduce the CO₂ emissions of air-conditioning compressors, turbochargers, engine-cooling fans, and auxiliary heaters. A bidirectional DC/DC converter – known as the power conversion unit, or PCU for short – connects the new 48-volt electrical subsystem to the conventional 12-volt system with a high degree of efficiency and reliability. The PCU's main job is to supply this 12-volt electrical system with electrical energy produced and stored on the 48-volt part of the system. The PCU is compact and can be flexibly installed in the vehicle, even the engine compartment.

Press image: 1-SG-19206

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Automotive Technology is the largest Bosch Group business sector. In 2012, its sales came to 31.1 billion euros, or 59 percent of total group sales. This makes the Bosch Group one of the leading automotive suppliers. Its roughly 177,000 Automotive Technology associates worldwide mainly work in the following areas of business: injection technology for internal-combustion engines, alternative powertrain concepts, efficient and networked powertrain peripherals, systems for active and passive driving safety, assistance and comfort functions, technology for user-friendly infotainment as well as car-to-car and Car2X communication, and concepts, technology, and service for the automotive aftermarket. Bosch has been responsible for important automotive innovations, such as electronic engine management, the ESP® anti-skid system, and common-rail diesel technology.

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More information is available online at www.bosch.com and www.bosch-press.com



Bosch power electronics

The command center of the electrical powertrain

June 2013

PI 8113 UBK FF/Na

- ▶ Central interface between electric motor and battery
- ▶ Bosch generation 2.2 and 2.3 systems for hybrid and electric cars
- ▶ Key component of electric powertrains and recuperation systems

Power electronics are an indispensable part of every electrical powertrain. The aluminum housing with its electronic components is often barely larger than a shoebox, yet it functions as the central interface between the electric motor and battery. The system converts the direct current stored as energy in the battery into alternating current for the electric motor. “The more efficiently the power electronics work, the greater a vehicle’s electric range,” says Dr. Joachim Fetzer, member of the executive management of the Bosch Gasoline Systems division. “Our current powertrain systems have an efficiency rating of 92 percent, which allows car owners to make the most of their batteries’ capacity.” It is no coincidence that Bosch power electronics will be installed in the extremely fuel-efficient VW XL1. Versions of the system can also be found in the VW Jetta Hybrid and e-up!. Other cars including the Fiat 500e, Porsche Panamera Hybrid, and PSA diesel hybrid make use of the technology as well.

These various examples show how versatile the Bosch power electronics system is. The latest generation 2.3 model has a pulse inverter, and is designed to work within a voltage range of 150 to 430 volts. “Our power electronics can be just as easily installed in a small, everyday hybrid as they can in a purely-electric sports car,” Fetzer says. The components can power a motor with an output of up to 100 kW.

Along with the voltage range, the form is also variable: Bosch offers both rectangular and flat versions of the system. In addition, the 2.3 model is about a third smaller than previous generations. This enables it to be installed even where space is at a premium – for example in hybrids that

have both an electric motor and an internal-combustion engine under the hood.

Pulse inverter and inverter for modern electrical powertrains

In addition to a pulse inverter, the generation 2.3 model also contains a DC-DC converter. The combination of these two elements in one system allows a particularly compact design. The pulse inverter transforms the direct current stored in the battery into alternating current for the electric motor. The reverse happens during braking: it converts the alternating current generated by recuperation into direct current. This is the only way energy released while braking can be stored in the battery.

The DC-DC converter transforms high voltage into power for the 12-volt vehicle electrical system. This system encompasses power consumers such as the radio and headlights. The DC-DC converter also supplies power from the lithium-ion battery to comfort and safety systems such as electric steering and ESP, as well as to all the control units in the vehicle electrical system. When headlights, on-board electronics, and driver assistance systems are all in use simultaneously, more than 150 amperes of current flow through the compact electronics.

Press photos: 1-GS-19214, 1-GS-19215

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Electronic horizon from Bosch **Predictive navigation data lower fuel consumption and emissions**

September 2013

PI 8277 BEG Fi

Powerful networking of vehicle systems

- ▶ Innovative functions reduce fuel consumption by up to 15 percent
- ▶ Cross-systems networking of powertrain, driver assistance and braking systems with the electronic horizon
- ▶ Individualized solutions to suit brand-specific driving behavior and the features of different vehicle models

It is common knowledge that driving with foresight can significantly reduce fuel consumption. A system called the electronic horizon greatly extends the driver's range of view by creating a detailed preview of the road ahead based on enhanced digital map data, including topographical data such as the grade of inclines and the radius of bends, together with information derived from infrastructural features such as road signs indicating maximum speed limits. "By linking automotive systems with electronic horizon data, it is possible to reduce fuel consumption by up to 15 percent," says Bernhard Bihl, president of Bosch Engineering GmbH.

Data from the electronic horizon are already being used to provide driver assistance functions such as recommending gear changes, alerting drivers to upcoming bends, and automatically adapting the inclination of headlamps when entering a curve. In future, when the electronic horizon is linked to the navigation system, it will be possible to distribute these data to other control devices via the vehicle communication bus using the standard ADASIS v2 (Advanced Driver Assistance System Interface Specification) interface protocol. By logically linking such data with the ACC adaptive cruise control and engine management systems, it will be possible to implement new functions that reduce the driver's workload and cut fuel consumption.

ACC with “foresight”

The adaptive cruise control functions available today already simplify the driver’s task by regulating the speed to a preset value defined by the driver, and automatically maintaining a safe distance to the vehicle in front. Bosch intends to widen the scope of these functions by integrating electronic horizon data in the ACC. A control unit calculates the vehicle’s future velocity curve using the data from the electronic horizon, which provides information on the route ahead extending well beyond the next bend. It is not necessary for the navigation system’s route guidance function to be activated. If it is, the electronic horizon uses the route data calculated by the navigation system. If the route guidance function is not active, a control device repeatedly calculates the vehicle’s probable route. When the ACC function is activated, it now automatically regulates the vehicle’s speed, reducing it if necessary when approaching bends and road signs indicating speed restrictions or built-up areas, as well as when it detects obstacles or slow-moving vehicles ahead. This enhanced functionality means greater comfort and safety because it allows the driver to concentrate on steering the vehicle and observing the traffic.

Predictive engine management

In future, Bosch integrates data from the electronic horizon in the operating strategy and energy management functions of vehicles with internal combustion engines and hybrid or electric drives. The potential to improve efficiency by configuring the driving strategy on the basis of predictive data, thereby reducing fuel consumption by up to 15 percent, is particularly high in the case of hybrid vehicles. The engine management system can use the route preview to calculate how much energy the powertrain will need and control the dynamics of the internal combustion engine and/or electric motor according to the anticipated requirements.

“For instance, when the system identifies a segment of the route in which a hybrid vehicle will be able to recuperate more energy than it expends, it can engage the electric motor to discharge the battery before reaching this point,” explains Bihr. Different methods can be employed to reduce the vehicle’s speed depending on the operating strategy: using the engine brake, or recuperating more energy from the electric motor, or coasting. The operating strategy can be configured to different settings ranging from an eco mode that emphasizes fuel efficiency to a sport mode that emphasizes dynamic performance.

Press photos: 1-BEG-19458, 1-BEG-19459, 1-BEG-19460, 1-BEG-19461

Links for further information:

- Footage with narration networking with the electronic horizon:
http://videoportal.bosch-presse.de/clip/_/na/BEG/bosch-engineering-gmbh?category=motorpresse-kolloquium-2013
- Film footage networking with the electronic horizon:
http://videoportal.bosch-presse.de/clip/_/na/BEG/bosch-engineering-gmbh-7?category=motorpresse-kolloquium-2013

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Bosch Engineering GmbH is a wholly owned subsidiary of Robert Bosch GmbH and is headquartered in Abstatt, Germany. Since 1999, Bosch Engineering has been offering engineering services for automotive, industrial and marine applications, railway and commercial vehicles, off-highway applications, as well as powersports – independent of the actual production numbers needed.

More information is available online at www.bosch-engineering.com

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