

INVESTMENT OPPORTUNITIES

Green Mobility



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Foreword by Miroslav Křížek

General Director, CzechInvest



There is no doubt that demand for electromobility is rising worldwide and the Czech Republic is no exception in this context. Furthermore, electric vehicles have a long tradition in our country, with the first use of electric motors dating back to the 19th century. Current development of electric vehicles in the Czech Republic enables conversions of existing models which are being carried out on Škoda Auto platforms by EVC Group, for example. Modifications are also performed directly by manufactures such as SOR (electric buses). With regard to automobiles that are designed from the ground up as electric vehicles, there are currently only a few one-off units in the Czech Republic. A range of research and development centres are in operation here at technical universities in Prague, Plzen, Liberec, Brno and other locations, which closely cooperate with companies in the automotive sector, such as Škoda Auto a.s., Porsche Engineering Services, Mercedes-Benz Technology and Honeywell. These centres offer firms the necessary know-how and skilled workers which are highly valued by automobile manufacturers.

I am convinced that the Czech Republic, as a traditional player in the automotive sector and as a country with great innovation potential, will not fall behind other countries. And CzechInvest is ready to contribute as much as possible to ensuring our country's success in this endeavour.

Foreword by Martin Jahn

Managing Director of Volkswagen Group Fleet International



In today's automotive world, it would be hard to find a topic that is discussed more than alternative fuels. The previous wave of interest in compressed natural gas, hydrogen and biofuels helped to start the extremely necessary debate on ecological fuels. However, all of these are encountering problems which limit their use and proliferation. Development in practice has thus shown that electricity is the alternative fuel with the greatest potential. Practically all automobile manufacturers are rolling out new models of electric vehicles, and this no longer involves only small city cars. An example of this is the new electric Golf recently unveiled by Volkswagen. Electric vehicles are playing a key role in programmes implemented by European metropolises such as Amsterdam, London and Helsinki which are aimed at reducing vehicle emissions. For example, within a carbon-reduction programme introduced by U.S. President Barack Obama, electric versions of light freight vehicles manufactured in Prague by Avia Ashok Leyland Motors are headed for the American market.

At technical universities, teams of students are being established in order to focus on the issue of electromobility – Brno University of Technology offers a good example of this on the domestic front. The fact that this does not involve only the enthusiasm of theoreticians is evidenced by the active support from significant players in the electricity market. For example, the Czech power company ČEZ earmarked CZK 500 million over two years for its Electromobility programme. This funding is intended primarily for a pilot project involving the construction of charging stations.

Substantial growth in sales of electric vehicles can be expected over the next several years. I would be pleased if the Czech Republic had a hand in a success in this new segment. Correctly focused investments in research, development and innovation and intensive cooperation between all interested parties can significantly help to achieve this.

History of Electric Vehicles in the Czech Republic

"František Křižík thus preceded Thomas Edison, who presented an electric vehicle in 1913."

Electric vehicles have a long tradition in the Czech and Slovak lands. In fact, the world's first electric vehicle was built by Štefan Anián Jedlík around 1828 in an area of Hungary which is now part of Slovakia. This was the first use of an electric motor with an electromagnet and mercury commutator. Jedlík was also the first to use line electrodes in his galvanised cells and accumulators. His first battery-powered electric tramway preceded the first electric rail vehicle offered by Siemens.

In 1895 the Czech engineer František Křižík gradually constructed several practically usable electric vehicles with 3.5 kW motors located directly in the rear wheels. Křižík's third electric vehicle was a plug-in hybrid with a small internal-combustion engine to increase acceleration. František Křižík thus preceded Thomas Edison, who presented an electric vehicle in 1913. During the first world war, the Škoda factories in Plzeň turned out several electric-powered freight vehicles for the city's breweries. In the 1930s, Josef Sousedik, owner of an electrical-engineering plant, built an electric vehicle, again with the motors placed directly in the wheels. Sousedik drove his electric automobile daily to work and on excursions.

Beginning in 1934, engineer H. Fügner conducted extensive trials with an electric-powered bicycle. Fügner's work was continued by J. Kolínek, who became a contemporary proponent of electric vehicles and, along with Jiří Janda, was a founding member of the current Electromobily civic association.

In 1970 the Brno-based VÚES, in cooperation with the Brno Technical University constructed two functional prototypes of the EMA1 compact city car and a year later two prototypes of the EMA2 utility vehicle on Barkas chassis. One of the EMA1 models is now on display at the Brno Technical Museum. In 1979, Jasoň Hampl of the Institute of Highway and Municipal Transportation was the leader of the F127 conversion project, in which components from the aforementioned EMA2 were used. The interesting Kujebák vehicle which was created in the apprentice workshops of Karosa Vysoké Mýto was equipped with an electric motor designed by Střílek of Opava.

The Plzeň-based designer V. Mužík later modified a Škoda 1000 MB sedan with an electric engine using an energy-accumulating flywheel. An auxiliary power unit based on a Babeta moped engine was used here for generating electric current. Other endeavours in this area included the conversion of a Trabant, (ing. Novák, ing. Sedláček), Favorit Bela Elektro (Bělonohý jr. and sr.) and Prinz NSU (Jindřich Burian). These vehicles were successfully registered for highway operation.

Dozens of such conversions were carried out at the beginning of the 1990s. One of the first of these was the Škoda ELTRA built on the Škoda Favorit platform in Ejpovice from 1991 to 1993. Several hundred of these cars were built, and some of them are still in use in various countries around the world. The company Elis Plzeň converted an Opel Corsa, and Belcanto, a firm owned by Luboš Zahradník of Prague, modified a Mazda pickup and several Multikar M24 utility vehicles, which have been in service since 1991. The following year, the Czech automaker LIAZ built the prototype of its clean electric-powered 01.02 XGJ. This was followed in 1994 by the PROTOEL2 prototype from the company TES. Today electric buses built in cooperation with the Faculty of Electrical Engineering at the Brno Technical University (BTU) are a common sight on the streets of Znojmo.



Edison electric car
1913

The Current State of Electromobility in the Czech Republic

In the Czech Republic, as elsewhere in the world, electromobility stands before a renewal of growth. Though demand is rising, the supply is still in preparation. There are currently three paths of electric-vehicle development:

- Conversions of existing vehicles are being carried out in the Czech Republic by, for example, EVC Group on Škoda Auto platforms, in Italy by MicroWett on Fiat platforms, and in England by Smith on AVIA and Ford platforms. Conversions can be undertaken with the consent of the manufacturer, though the provider of a conversion assumes responsibility for the warranty of the vehicle, which is made more expensive by the conversion. The vehicles were usually not designed to use electric drive and modifications are thus complicated. Modern vehicles with downsized internal-combustion engines already use electric heating and electronic power steering and, exceptionally, power brakes, which reduces the number of maintained assemblies. However, it is necessary to replace the internal-combustion engine's control unit and to find a suitable place for the batteries. It usually suffices to place the batteries in the engine compartment and in the fuel-tank space. The spare-tire compartment is used only in exceptional cases.
- In the Czech Republic, modifications are also performed directly by manufacturers such as SOR (electric buses), and AVIA is preparing to do so. Foreign vehicle manufacturers involved in this area include, in particular, Renault, Citroen and Peugeot of France, Germany's BMW Mini, Smart and VW, as well as Iveco. Modifications from original manufacturers offer the advantage of prior knowledge of the given vehicle's design, control units, load-capacity limits and safety features, while the customer receives the added benefit of having a full warranty.
- There also exist automobiles that are designed from the ground up as electric vehicles, such as the Norwegian THINK, the Italian Pininfarina BlueCar, which for the time being will be available in France, and the German Mercedes B-Zero and Smart, whose design was based on electric drive from the beginning. Factory modifications are worthwhile in larger series production. However, the advantages of electric vehicles can be applied in the design, the ideal distribution of battery weight and arrangement of space, while offering greater safety. Currently there is no such series produced electric vehicles in the Czech Republic, though there are several individual one-off production units.



Advantages of Electric Vehicles



Electric vehicles have a range of advantages, some of which they have in common with hybrid vehicles, which represent an excellent transitional stage on the path to full electrification.

- Zero local emissions. Of course, production and distribution of electricity causes emissions (80g CO₂/100 km in the Czech Republic), though emissions from mining, manufacturing and motor fuels, including CNG, exist in comparable amounts. Indirect emissions from production in the Czech Republic amount to roughly 80g CO₂/100 km and are continually being reduced.
- Low energy costs (CZK 0.25 – CZK 0.50/1km)
- High reliability and long service life of electric motors. Besides the rotor, no other moving parts are needed in an electric motor. Low maintenance and energy costs offset the disadvantage of the higher price after approximately seven years of operation.
- Inexpensive charging infrastructure. Electric vehicles can be charged wherever there is electricity from commonly dimensioned sockets without enhancing the installed wiring.
- Elimination of problems associated with the various types and quality of fuel, simplification of fuel taxation and reduction of fuel-related tax evasion.
- Elimination of the risk of theft of fuel from company vehicles.
- Significant reduction of noise pollution. In cities such as Prague this is an interesting argument in favour of introducing electromobility.
- Attractiveness of electric vehicles as a clean means of transportation.
- Marketing advantage in comparison with other alternatives such as LPG and CNG.

Disadvantages and Inconveniences of Electric Vehicles

- Conversion of a standard combustion-engine vehicle is complicated and expensive. The price of a conversion is roughly equivalent to the original price of the vehicle being converted, thus doubling the overall acquisition price.
- Production costs of large series will not be different from those of combustion-engine vehicles, but there are high development costs, which significantly encumber small series production. Thus there is a problem with high demand and low supply.
- The maximum range of today's commercially available lithium-based batteries is between 200 km and 400 km on one charge. Batteries with a range of 150 km are commonly used to reduce the price. An advantage is the possibility to start out with a fully charged battery and charge it at one's home, at work or when shopping and therefore in practice the range corresponds to the convenience of the greater range of ordinary fuels and gases which must be replenished "on the road". However, today it is difficult to find in every city a sufficient and publicly available socket for rapid three-phase charging without ordering in advance.

Earlier Deficiencies of Electric Vehicles which Have Been Eliminated



- Short service life of batteries. Thanks to progress in the production of LiFePO₄ batteries and the introduction of a system for controlling individual cells (battery management system – BMS), up to 400 charging cycles for 100-250km can be achieved. The service life of batteries thus exceeds 500,000 km.
- Bulky and weighty heavy-current regulators. Modern semiconductors are smaller and more efficient, and their capacity is constantly increasing.
- Changing of carbon brushes and the disruption of DC motors belong to the past. Most modern drive units use frequency converters and AC electric motors.
- Extremely heavy lead batteries were replaced with lighter but safer NiCD batteries and, later, with lightweight lithium batteries. Today the weight of batteries is due especially to copper electrodes, which are getting ever smaller thanks to new technologies.
- Battery prices are falling progressively by approximately 10% per year, though they remain high despite technological advances. Current prices are in the area of CZK 1,000/1 km of range.
- The advantage of quiet operation can be a hazard for pedestrians in cities. Today this is not only a problem of electric vehicles and hybrids, but also of quiet modern internal-combustion engines and pedestrians' use of music-player headphones. Active safety features such as audio and light signals and vehicle-surroundings sensors are being introduced.



Prerequisites for the Successful Development of Electric Vehicles

- Dense public infrastructure for rapid charging using 3x32A or 3x63A sockets.
- Low price of vehicles, e.g. leasing of batteries from leasing or energy companies or electric-vehicle vendors.
- Support for users, political support, parking lots with chargers, toll-free driving in cities, tax breaks, waiving of road tolls and fees, possibility of using lanes reserved for taxis and buses.

Charging-infrastructure Suppliers



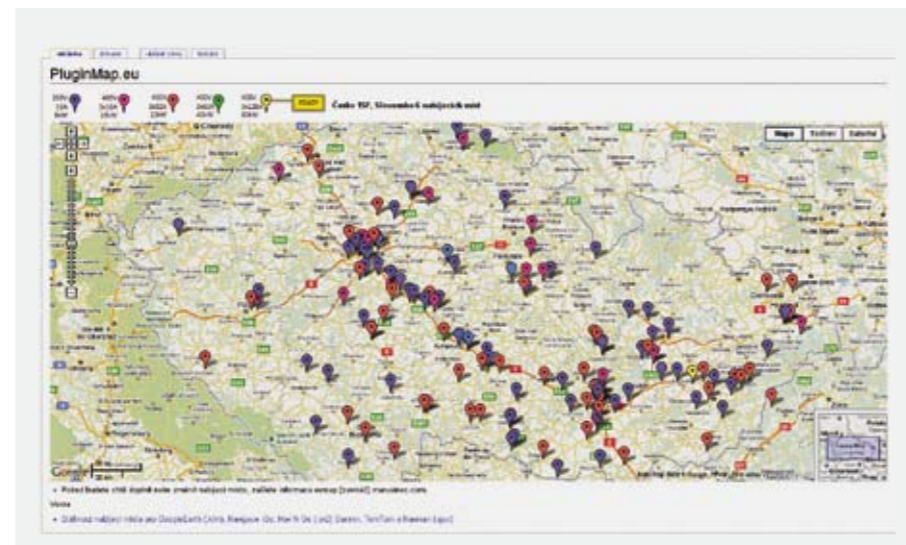
With the preparation of investments in the Czech infrastructure by ČEZ, E.ON, PRE and RWE, the structure of charging stands and stations is also taking shape. Suppliers are beginning to specialise for various customers. Charging stations are being offered to filling-station networks, thus allowing full integration with filling stations' existing payment and information systems provided by the company PhGIA. For many filling stations, the main source of income is no longer fuel sales, but rather sales of goods and restaurant services. Therefore, it is advantageous to sell cheap electricity, thus enticing the customer to spend more time and money at the station. Customers on the road are willing to pay significantly more per kWh than via their own connection.

Shopping centres, restaurants, museums and parking lots are being offered universal stations which either provide charging free (at paid parking lots or supermarkets) or accept coins, cards or contactless RFID/MIFARE chip cards which energy companies will issue to electric-vehicle users. Various companies including Rittal, Elnico, Molaris, Micos, Proautoma, TILI and Ensto are offering such stations in the Czech Republic.

Charging Infrastructure Map

Since 2008 a European charging-infrastructure map (www.pluginmap.eu) has been drawn up and it currently contains 136 charging points in the Czech Republic. Charging points can be stored in navigation units. In future, the map will be supplemented with European charging points and will communicate online with modern rapid-charging stands. A point in the middle of the map symbols indicates that the given station has charging capability.

Charging in the form of exchanging batteries is not used in the Czech Republic and it is not considered effective due to cultural and technical reasons. The more likely option is very rapid charging using either a maximum 40kW (3x400V 63A) integrated charger or direct-current charging. The company Eprona of Rokytnice nad Jizerou operates a direct-current stationary charger for EVC electric vehicles at its Hulín factory.



Map of Czech charging infrastructure



CNG in the Czech Republic

Compressed natural gas (CNG) has become a fully-fledged and accessible alternative to oil-based fuels and is currently the most promising alternative motor fuel in environmental, economic and safety terms. Furthermore, it is a technically well-developed solution that is easy and quick to implement in practice. In transport, compressed natural gas has huge potential, which should be exploited to the full in an effort to achieve savings of liquid fuels and a significant reduction in harmful emissions. The programme for CNG use in transport is a major project, which is being carried out in the Czech Republic in line with the EU's strategy. Under COM (2001) 370 (EU's white paper on transport policy), the target is to achieve an at least 10% share of natural gas in overall consumption of transport fuels by 2020.

The programme for natural gas use in transport has been running in the Czech Republic since 2005. A Government Resolution has helped to professionalise the approach, and the subsequent implementation of the objectives set out in the respective Agreement between the government and the gas industry on support for CNG has boosted companies' awareness and interest in this fuel, attracting new foreign manufacturers of OEM vehicles powered by CNG and also manufacturers of refuelling station equipment into the Czech Republic. The Czech Republic is currently a promisingly developing market with an expanding offer of new CNG vehicle models and rising numbers of these vehicles on roads. The number of public refuelling stations is also growing every year while the whole infrastructure is being rolled out, offering drivers more convenient travelling across the country, greater comfort as regards CNG refuelling, including the self-service option, and payments using the CNG CardCentrum client cards or VISA and EC/MC cards, or cash. Most of the dispensers are in non-stop operation. In particular the gas companies RWE Plynoprojekt, s.r.o., E.ON and Pražská plynárenská, a.s. and equipment manufacturers Bonett Gas Investment, a.s. and Vítkovice Cylinders, a.s. are helping to run the CNG programme in the Czech Republic.

To inform about the latest trends in the world, enhance expert circles' awareness of the benefits of CNG, which is currently the least expensive, safe, and environmentally the least harmful alternative fuel, and offer a platform for discussions of issues related to the further developments in CNG and biomethane in transport in the Central and Eastern Europe region, the Czech Gas Association is therefore preparing the fourth edition of the Prospects for the Development and Use of CNG in Transport, an international conference held in Prague, Czech Republic, on 9 and 10 February 2011. NGV conference will offer a unique opportunity to all businesses operating in road transport, company managers, state administration and local governments, mayors and councillors and all those who are interested in CNG use in transport.

The statistical data in the table below confirm the positive development of CNG in the Czech Republic; in the light of the situation in other countries, the data also indicate that we are going in the right direction. >>

| Indicators | Public CNG refuelling stations | Total number of vehicles | Passenger cars | Buses | CNG sales, in million |
|------------|--------------------------------|--------------------------|----------------|-------|-----------------------|
| 2004 | 9 | 250 | 150 | 100 | 2.773 |
| 2005 | 9 | 450 | 280 | 165 | 3.010 |
| 2006 | 11 | 580 | 400 | 180 | 3.584 |
| 2007 | 17 | 900 | 680 | 195 | 5.790 |
| 2008 | 17 | 1,200 | 950 | 215 | 6.758 |
| 2009 | 23 | 1,800 | 1,465 | 270 | 8.082 |
| 3Q 2010 | 30 | 2,275 | 1,900 | 295 | |

Czech economic indicators

CNG in the Czech Republic

>> As it is a much cleaner alternative to oil-based fuels, CNG is used in the Czech Republic especially in municipal transport. This is the reason why manufacturers such as IRISBUS, IVECO, SOR Libchavy, Ekobus, TEDOM and others CNG-powered EURO5 municipal and intercity bus models. All of the CNG buses produced by the above-mentioned companies fulfil EURO5 emission standards and are thus in the category of Enhanced Environmentally Friendly Vehicles (EEV). As a result, many municipalities in the Czech Republic have declared a plan to partially or even fully incorporate CNG buses into their public transport fleets.

CASE STUDY – IRISBUS IVECO

Iveco Czech Republic a.s. acquired the Czech company Karosa in 1993 and continues to manufacture buses in the town of Vysoké Mýto. Besides other commercial vehicles and buses in particular, Irisbus Iveco manufactures a CNG-powered minibus model called the DAILY and a full-size CNG bus called the CITELIS. The CITELIS model range is equipped with the new Cursor 8 CNG engine, which delivers greater efficiency and lower emissions than required by both the EEV and even the future EURO6 standards. Compared to the EURO6 standard, the Cursor 8 engine's emissions are up to 60% lower than the set limits. Irisbus Iveco's line of CNG buses ranges from 10.5-meter to 12- and 18-meter vehicles with capacity ranging from 86 to 148 passengers. The company's total annual output of CNG buses is between 1,200 and 1,500 units and its main markets are Belgium, the Czech Republic and Greece. Markets such as Italy, Spain and France are also dominated by these safe and reliable CNG buses.



CASE STUDY – SOR Libchavy

The Czech company SOR Libchavy s.r.o. is the second-largest bus manufacturer in the Czech Republic. In 2010, it achieved the largest share of the domestic market and is aiming to become a European leader in bus production. SOR Libchavy offers a wide range of middle-category municipal, intercity and touring buses, urban trolleybuses, electric buses and hybrid buses with capacity from 25 to 51 seats and total capacity of up to 177 passengers. The producer places emphasis on high quality and a high level of customisation. This is also true of SOR's four CNG bus models of the company's own design. Customers can choose among various versions, each adjusted to meet particular requirements (short-distance, city, low-floor and full low-floor). All of the company's CNG models are 12 meters in length, have two or four doors depending on the model and are powered by either Iveco Cursor 8 CNG or Cummins CGe 280 engines, which are in compliance with EURO5 emissions limits. The quality of SOR Libchavy buses was confirmed in 2001, when the company was awarded ISO 9001 quality certification.

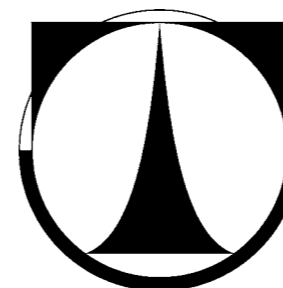


Liquefied Petroleum Gas (LPG)

LPG, also known as autogas or auto propane, has a long tradition in the Czech Republic. Introduced in the 1940s, the use of LPG has been rising significantly since the 1990s and plays a key role in the Czech alternative fuels market. Of the Czech Republic's 6,500 fuel stations, 850 offer LPG refuelling and related services. There are roughly 150,000 to 200,000 motor vehicles (especially passenger cars) in the Czech Republic that use this economical and environmentally friendly fuel and that number is rising every year. While the use of CNG is backed by the Czech Gas Association, a member of NGVA Europe, LPG is supported by the Czech LPG Association and by the LPG Club. Various carmakers, such as Fiat, Hyundai, Mercedes-Benz, Opel, Škoda Auto, VW and others, have recently announced their intention to produce LPG or CNG models, thus acknowledging the importance of the gas segment.

Green Mobility at the Universities

Alternative Fuel Engines at the Technical University of Liberec



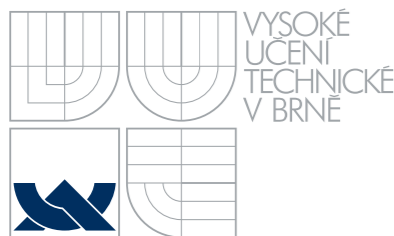
LPG, CNG and bio-fuels can currently be considered as the most frequently utilized alternative fuels for automobiles and hydrogen is offering very good prospects as well. Research workers at the Technical University of Liberec are paying special attention to the research, development and application of these alternative fuels in transportation in view of the environment pollution and diminishing resources of fossil fuels.

The main line of the research conducted by the Department of Vehicles and Engines at the Faculty of Mechanical Engineering at the Technical University of Liberec is focused on the application of alternative fuels and the development of gaseous fuel engines, fuel mixture formation, combustion process optimization and exhaust emission reduction. Another area of the research deals with the strength and stress-strain analysis of components, groups of engines and vehicles, new concepts of engines and vehicles and characteristics of vehicles with the active directional control.

The reciprocating internal combustion engine laboratory houses several test stands for the testing of spark ignition and diesel engines. For many years, the university specialists have been working on the use of alternative fuels, in particular the gaseous ones. The laboratory conducts the experimental research on the LPG, CNG and hydrogen powered engines. The Department of Vehicles and Engines cooperates closely with Škoda Auto a.s. Mladá Boleslav to develop the LPG and CNG fuelled engines. As far as the alternative fuels are concerned, the university specialists are also actively involved in modifications for running a diesel engine on vegetable oil. The most up-to-date testing and measuring equipment enables to analyze both performance and emission parameters of engines, visualize the processes inside the combustion chamber (by means of the VISIOSCOPE system) or measure and analyze all significant parameters of the engine's working cycle (combustion pressures, behaviour...).

One of other goals the laboratory wants to achieve is the implementation of a functional prototype of a hydrogen powered internal combustion engine featuring extremely low emissions discharged into the atmosphere as defined by the future ZEV regulations (Zero Emission Vehicle) and actively controlled chassis. To develop a hydrogen powered engine a test stand has been built where experimental studies are being conducted to establish and calibrate a program for control functions of the electronic management (performance parameters, on-line pressure measurements inside the engine cylinder and fuel system, exhaust gas component measurements...). In the final stage of the research the functional prototype will be built into a passenger car and the complete car will undergo emission light-duty chassis dynamometer in stable as well as transient driving modes in view of performance and emission characteristics.

Brno University of Technology



Brno University of Technology (BUT) has a tradition dating back more than 110 years. According to the prestigious THE-QS World University Rankings, in 2009 BUT was the world's 254th best university in the fields of engineering and IT. BUT receives funding from a range of significant research centres, while a key aspect for the university and its further progress is its involvement in the Central European Institute of Technology (CEITEC) project.

Particularly the faculty of Electrical Engineering and Communication Technologies and the Faculty of Mechanical engineering are focusing on the subjects of alternative propulsion and ecological transportation, whereas to some extent research in the environmental area falls within the interest of the scientists at the Faculty of Chemistry (development of textile solar cells, among other things). The Energy, Processes and Ecology Division of the recently established NETME Centre (New Technologies for Mechanical Engineering) is focusing on the development of new combustion systems and devices intended for reducing harmful emissions and the use of energy produced from biomass and waste as well as, for example, improvement of the thermal comfort in vehicle cabins and building interiors with regard to the energy, ecological and economic aspects (e.g. development of a new generation of personalised ventilation systems in aircraft cabins).

However, beyond research centres, the European Personal Plane project will deal with designing an aeroplane that is more environmentally friendly, including reduction of noise and emissions. On the part of the Czech Republic, the Aerospace Institute of the Faculty of Mechanical Engineering is participating in the project alongside twelve other partners from various European countries and Israel. Another project of the Faculty of Mechanical Engineering involves the development and implementation of a prospective propulsion system using hydrogen fuel cells and batteries as a source of energy for an electric motor powering a propeller.

The Centre for Research and Use of Renewable Energy Sources is being established at the Faculty of Electrical Engineering and Communication Technologies. Research will be conducted within three programmes – “Optimisation and Control of Electromechanical Conversion of Energy”, “Chemical and Photovoltaic Energy Sources” and “Optimisation of Energy Conversion and Use in Systems with Ecological Energy Sources”. The university is cooperating with a range of companies such as První brněnskou strojírenskou, Škoda Auto, and LET Aircraft Industries, among others, on projects in the area of alternative propulsion and ecological transportation.

Conversion of a Škoda Superb into an electric vehicle

This project was developed by a team of students and employees from three faculties at BUT. The conversion of the vehicle was technically realised by EVC Group s.r.o. and serves to promote electric vehicles for the general public. The aim of the project is to publicise the conversion process and brief technical information so that the conversion can be repeated after purchasing the necessary components. BUT is currently developing a high-speed charger which will be able to charge the vehicle's batteries from 10% to 90% of capacity in 30 minutes.



Electrical Engineering Faculty, Czech Technical University in Prague



ČESKÉ VYSOKÉ
UČENÍ TECHNICKÉ
V PRAZE

Laboratory for researching power transfer to vehicle drive wheels

At the Department Electric Drives and Traction, the Faculty has an electric propulsion and traction laboratory equipped for researching power transfer in series, parallel and serio-parallel automobile systems. Special research is dedicated to systems with an electronic power divider. Detailed research focused on recouping kinetic energy in the supercapacitor has been conducted. The results of theoretical works are being verified through experimentation and published in prestigious journals.

A range of studies and projects have been prepared in cooperation with industrial firms, including Škoda Auto, PAL International, Stavus, Satrema and Porsche Engineering, among others.

In a separate part of the laboratory at the Department of Electric Drives and Traction, experimental measuring is performed with a focus on, among other things, verifying the parameters and dimensioning of propulsion in the following areas:

- verification of the methodology for measuring the mechanical characteristics of drive units
- verification and implementation of temperature testing for the selected stable load regime
- verification of the methodology for determining the moment of inertia of the motor including the wheels (rims and tires) through retardation testing

The aim is to build a facility at the Department of Electric Drives and Traction for model testing of complete electric-vehicle drive assemblies.

Light, ecological vehicles comprise another focus of the Department of Electric Drives and Traction. The aim is to verify properties and to gain experience with the operation and driving characteristics of two- and four-wheel vehicles. Work in this area was commenced in 2004.

Development and experimental construction of electric vehicles

The Department of Electric Drives and Traction is developing its first true electric vehicle, which is equipped with two modern synchronous motors with permanent magnets from the firm Perm Motor, a member of the Heinzmann Group. The vehicle's concept derives from two independent motors for driving the rear wheels, which are not connected by a differential, but are rather driven only electronically. Due to financial considerations, standard lead batteries are being used to power the drive units in the initial phase of development. The electric-vehicle project is aimed at developing an electric racing car in the “formula-student electric” class. Within this project, the department is cooperating with the Faculty of Mechanical Engineering at the Czech Technical University, where a group of students and young instructors was formed in order to participate in the worldwide formula-student competition, within which teams of students from 250 universities around the world are represented. The entire electric-vehicle project is financed with grants and financial aid from sponsors.



ŠKODA



Skoda Auto

Mobility for people and clean cars for the environment: these are Škoda's commitments. Environmental protection and sustainable development are integral parts of Škoda Auto's corporate policy, involving both environmentally friendly products and environmentally friendly production. Octavia GreenLine cars, based on the GreenLine technology, minimise environmental impacts and offer each driver an opportunity to show his or her willingness and determination to support environmental protection efforts.

A second generation of GreenLine models has already been developed and shown at the Paris Motor Show. Modern direct-injection Diesel engines (1.2 TDI CR 55kW and 1.6 TDI CR 77kW), the Start-Stop system and braking energy recuperation are the technological pillars of the GreenLine models. Other features include engine control unit adjustment, the use of low rolling-resistance tyres, changes to streamline the car's body and chassis, or gear changing recommendations displayed on the dashboard.

In 2008, with the first generation of the GreenLine version, Škoda Auto set out on the path of continuous reduction of its cars' fuel consumption. GreenLine is a combination of various modifications and improvements of the car and its driving unit. Škoda Auto is developing this technology on a continuous basis.

Škoda Auto also introduced in Paris its Octavia Green E Line concept – its very first study of a car with all-electric drive. With its Octavia Green E Line concept, Škoda shows its innovative capacity and technological competence in this high-potential field. A test fleet is planned to be launched already in 2011.

The Green E Line concept is based on the Škoda Octavia Combi model. With the modular structure of its floor, the series-production model is ideally fitted for the mounting of a battery, an electronic driving unit and an electric motor. The motor is capable of a constant power of 60 kW and max. 85 kW. The peak torque of 270 Nm is available immediately when the motor is started. Octavia Green E Line accelerates from 0 to 100 km/h in twelve seconds. Its maximum speed is limited to 135 km/h.

Škoda Octavia Green E Line takes electricity from a state-of-the-art ion-lithium battery. With its driving range of 140 km, Octavia Green E Line meets the needs of most commuters in Europe. The battery consists of 180 lithium-ion cells (diameter 150 mm, length 650 mm). Its capacity is 26.5 kilowatt hours and its weight is about 315 kilograms.

Maximum importance is also attached to reduction of the environmental impacts of the manufacturing processes. The company complies with all statutory limits and in many respects the values are far better than required. All activities in Škoda Auto are fully secured against environmental damage and the company is successfully removing the adverse consequences of the environmentally inconsiderate industrial activities from the central planning era (before Škoda joined the Volkswagen Group). The company removed more than 80% of the previous environmental damage (the costs being CZK 587 million) by the end of the year 2009.



History of Avia Ashok Leyland Motors

Avia is a traditional brand, which has been on the world vehicle market for ninety years. Production under this brand has been focused on lighter trucks over the last forty years. In 2006, Avia became a member of the Hinduja Group, joining the second largest motor works in India. Backed by a strong partner, Avia – now named Avia Ashok Leyland Motors (AALM) – is returning to the world truck market and is working intensively on expanding its product range. In the Czech Republic, Avia is a leader in the truck market and its products are popular because of their high quality and reliability.

Avia – Ashok Leyland

Electric trucks with Avia's looks

In recent years, Avia has proved to have a say in the market for alternative-drive vehicles. Cooperation with Smith Electric Vehicles (SEV), manufacturer of fully electrically powered vehicles, is a significant project that has extended Avia's product range. Avia is the sole supplier of chassis and cabins for Newton trucks and Smith equips them with electric driving units. This year the delivery of these electric truck components for the US market accounts for as much as a third of the planned output of the Avia truck maker.

Last year the cooperation with Smith culminated with the delivery of electric vehicle components for customers such as Coca Cola, DHL or TNT. For 2010, Avia is delivering (against orders) another three hundred frames and cabins for the US market. At the beginning of this summer, the Smith works were visited by US President Barack Obama, who confirmed that there is long-term interest to expand the use of electric vehicles in the USA. During the ceremony that took place on this occasion in the Smith Company's Head Office, the company announced its plan to increase output to ten electric trucks a week, starting in September. AALM has successfully tested the Smith electric trucks on Czech roads – for example, during the Electromobility Day with PRE (electricity distributor). These "clean" vehicles will most probably appear in routine traffic within two years.

Parameters of Smith electric vehicles

Electric trucks represent a global landmark in green transport. They can be used with advantage in utility services, foodstuff distribution, parcel delivery or electricity distribution network servicing in city centres. They may be able within several years to replace the traditional utility vehicles, because many European cities are starting to restrict access to the historic core for vehicles with traditional petrol or Diesel engines. The riding distance at one charge is about 160 kilometres. Electric trucks produce no emissions and almost no noise. The Avia cabin is compact and streamlined in its shape, which is an advantage in the narrow streets of city centres. The chassis is specially adapted for the installation of batteries that accumulate electricity to drive the vehicle. Insufficient infrastructure of charging points and the absence of direct support to electric vehicles are the greatest hindrances to greater expansion of electromobility in the majority of the countries of Central and Eastern Europe.

Outlooks in the field of alternative drives

Avia does not exclude that it may develop cooperation schemes with focus on other alternative drives. This year the brand has entered the market in Argentina, the country with the greatest number of vehicles powered by compressed natural gas (CNG) in the world. AALM is therefore examining the possibility to make use of the synergies from merging with Ashok Leyland, which has developed the first CNG bus for the city of Delhi. AALM plans to continue this trend on a long-term basis, expanding environmentally friendly production of both electric trucks and CNG-powered vehicles.





EVC Group

You could count the number of companies like EVC Group in Europe on one hand. EVC Group is engaged in non-traditional manufacturing, converting standard vehicles to run on electricity. During its three years in existence, EVC Group has already converted more than twenty vehicles to run on a set of lithium batteries. The company's work involves the installation of new batteries in existing PSA electric vehicles and installation of supplementary sets for increasing the range of Toyota Prius hybrids, as well as installation of complete electric-propulsion equipment in new cars. This involves a broad range of vehicles, from individual projects, e.g. deliveries of components for go-karts, to conversion of all-wheel-drive off-road vehicles and cars for everyday use. EVC Group offers such vehicles in small-series production using the Smart Fortwo, Škoda Roomster and Praktik, and even the luxury Škoda Superb.

The company delivers battery sets to foreign customers and has developed battery sets for SOR, a domestic manufacturer of electric buses. Its vehicles are in operation in Prague, for example, where they are used by the municipal authorities and in courier and taxi services. The company's first customer in Prague has been successfully operating an electric vehicle from EVC Group for three years. The company also delivers the compact Alke utility vehicle to the domestic market. The vehicle was tested for use on ecological farms, for transporting cargo at airports in Prague and Brno and for landscape maintenance, among other uses. The Alke is resistant to winter weather and is delivered with a snowplough attachment for clearing sidewalks. EVC also offers a model for municipal waste removal.

EVC focuses primarily on deliveries to foreign partners in countries where electromobility is supported by government subsidies. The company is able to adapt to customers' individual requirements and has recently received interest in electric freight vehicles as well as passenger cars.

Even though electric vehicles are currently not suitable for long journeys due to the lack of charging infrastructure, their use is very economical in shorter distances. Despite the higher acquisition cost, the initial investment can be recovered in only a few years thanks to the low operating costs.

Example: Model derived from the Škoda Roomster

EVCR7 with a range of 150-200 km on one charge

| | |
|--------------------------------|---|
| Power source | Batteries |
| Driving characteristics | |
| Rotary electric motor | LiFeYPO4 |
| max. speed | 130 km/h |
| rated power | 30 kW |
| consumption | 17 kWh/100 km |
| max. power | 70 kW |
| charging time | 11 hours from 230V to 90% of capacity |
| 305V | when ordering a high-speed charger, 3.5 hours |
| | from 400V to 90% of capacity |
| service life | 500,000 km |



Gordeon



Automobile fans' hearts skip a beat and their eyes are popping – but wait! This retro-style beauty is far from being a veteran; it's a brand new electric model with the very latest modern technology packed under the hood.

The prototype of this totally electric vehicle, the EHR 10, was built by a six-member team from scratch in only 150 days. Three of the team are from the Faculty of Mechanical Engineering at the University of West Bohemia in Pilsen and the other three are from Czech auto manufacturer Auto projekt centrum s.r.o. The open-topped, long nosed design recalls the classic style of the 1930s, which enhances the pleasure of driving and offers a comfortable drive for two. The sporty character of the vehicle is emphasized by the minimalist interior and exceptionally quiet ride. All its dimensions comply with road safety regulations for use on public highways.

The performance of the vehicle is designed with a calm and relaxing drive in mind, as preferred by all real motoring enthusiasts, but this doesn't mean that the HER 10 is a dawdler – far from it! It's up to the driver if the needle on the speedometer stays at 100kmh or if they want to really let rip and enjoy the wind in their hair.

"The stimulus for building the EHR 10 was a competition which announced 'Construct an electric vehicle and win a million!' So we built one, and not only have we got a lot of pleasure out of it, but also everybody who has driven in it too," smiles chief constructor Josef Formánek from the University of West Bohemia. The EHR 10 passed its technical control with flying colours on 9 June 2010 and with the homologation of all the components, it is ready for the road.

Technical information:

Dimensions
 length: 4,000mm,
 width: 1,600mm,
 wheel base: 2,700mm ± 10%,
 curb weight cca. 900kg ± 20%.

Its name EHR 10 stands for 'Electric Hot Rod 2010', and because the vehicle was built in Pilsen, the sharp-eyed observer will notice that some of the details are completed in the town colours.

The drive system uses variable direct current from 48V to 84V and the dashboard and control elements use a standard 12V supply. The main drive is provided by an electric traction motor with gearbox. The power source is a lithium iron phosphate battery which can be completely recharged in anything from half an hour to six hours depending on the kind of charger used. 90% of the EHR 10 is 'Made in Czech', including the main drive unit, control system and silencer. The only imported component is the battery, which is from China. The electric motor is situated at the back and drives the rear axle.

Traditional and innovative technologies were used in the construction of the EHR 10. Traditional materials (steel, aluminium alloy) are combined with the very latest composite materials, with a strong emphasis on ecological liquidation of waste and recyclability of the maximum number of components used in the vehicle. Priority was also given to the production planning, which favoured simplicity of manufacture, total assembly and consideration of future maintenance and repairs.

The creators of this unique and low-cost project are now preparing documentation for potential investors, the first of which have already expressed their interest.



TriHyBus: Triple Hybrid Hydrogen Bus

TriHyBus is a modern and highly efficient bus with hydrogen fuel cells as the main energy source. Thanks to its triple hybrid conception, it can achieve optimal operating parameters with a relatively small installed power of the fuel cell (42 kW).

The hydrogen fuel cell is an energy converter that uses hydrogen's chemical energy to produce electricity, with a high overall efficiency of 50%. Hydrogen fuel cell-propelled vehicles are therefore entirely environment-friendly.

At first glance, the TriHyBus resembles any other bus and the passengers may not notice anything unusual – that is until it pulls away. Then the absence of vibrations and noise typical for diesel engines becomes apparent. The bus was manufactured in Plzeň by Škoda Electric using Iveco Irisbus Citelis chassis. A 42-kW Proton Motor membrane fuel cell is used as the main power-source for its electric traction motor. Additional traction accumulators and ultracapacitors are engaged while the bus accelerates or ascends, working alongside the fuel cell, allowing for energy recuperation while decelerating. The bus uses a hybrid design that increases efficiency of its propulsion system.

Key Project Partners

| | | |
|----------------|---------|---|
| NRI Řež | CZ | Project coordinator, owner of the bus and filling station, safety and legislation issues, MMI |
| Škoda Electric | CZ | Electric drive, control system, bus finalization (assembling) |
| Proton Motor | Germany | Fuel cell development and fabrication, fuel tanks, hydrogen infrastructure within the vehicle |

Innovations

Advanced technologies utilized in the bus allow optimizing of energy flows. The main energy is an electricity generated by fuel cells (manufacturer Proton Motor - Germany, power output 42 kW), other key parts are Li-ion accumulator (22 kWh) to support the fuel cell and for energy recuperation, and a bank of ultracapacitors (2 kWh) to carry over the current peaks during acceleration and braking. Hydrogen is stored as a gas under pressure of 35 MPa in pressure vessels (20 kg of H₂), which are mounted on the bus roof. The driving range is about 300km, the H₂ consumption aprox.7 kg of H₂/100km.

Market Position

Although the market for alternatively fueled buses is not fully developed, there are ongoing preliminary trade negotiations with transport operators particularly of northwestern Europe (Norway, Germany). In the near future, the significant development of the market is expected in relation to gradual growth of a hydrogen infrastructure, and increasing prices of petroleum fuels.

Impact on the environment

Presented solution has a positive impact on the environment. CO₂ savings is achieved primarily by increasing the efficiency of energy use in the bus. This is achieved both by higher efficiency of fuel cell - an electric motor compared to combustion engine and the use of a hybrid energy recovery during deceleration. Another advantage of using hydrogen technologies in transport is zero emissions of further pollutants (generally produced by combustion engines). These include nitrogen oxides, carbon monoxide, hydrocarbons and particulate matter. Another advantage is the reduction of noise exposure.



The hydrogen fuel cell is an energy converter that uses hydrogen's chemical energy to produce electricity, with a high overall efficiency of 50%. Hydrogen fuel cell-propelled vehicles are therefore entirely environment-friendly.



Project Intuo – Pearl of Czech Design

The Intuo Bioconcept is a vision of a new type of small car.

The automobile's bionic concept reflects the endeavour to join technology with nature as harmonically as possible. The egg-shape is not only the result of seeking out new aesthetic forms; it also has its own structural, functional and philosophical significance, whereas the aim is to learn as much as possible from nature.

Every person feels safe where they began life – in the womb.

Nature favours the spherical shape as a safe form in terms of sturdiness and as a form for the safest and most seamless frustules in a range of animal species. This can be positively perceived intuitively by a person using an automobile. The ovoid car-body also has very favourable aerodynamic properties (measured at C_x = 0.19 for a model in the wind-tunnel at the Czech Technical University) and thus enables economical operation with a lower-volume drive unit. At the same time, the basic shape makes it possible to ensure by natural means the necessary rigidity and stability of the body, which is very important for the safety of the driver and passengers.

In comparison with ordinary small cars, the automobile gives its driver and passengers an extraordinary feeling similar to that which one might experience in a motorless glider, for example. The panoramic view from the vehicle is advantageous particularly for better orientation in dense city traffic and enhances the pleasure of driving. The body and glass are made of modern high-strength materials comprising a combination of carbon and kevlar with high-impact plexiglass. The vehicle's drive unit can be variable, consisting of an electric motor or a low-volume, low-power internal-combustion engine, which provides sufficiently dynamic properties in light of the vehicle's low weight.





CZECHINVEST HEADQUARTERS

Stepanska 15, 120 00 Prague 2
Czech Republic
PHONE: +420 296 342 500
FAX: +420 296 342 502
E-MAIL: fdi@czechinvest.org
WEB: www.czechinvest.org

www.czechinvest.org



CZECHINVEST WORLDWIDE

UK & IRELAND
PHONE: +44 20 7221 9663
E-MAIL: london@czechinvest.org

GERMANY
PHONE: +49 211 25056190
E-MAIL: germany@czechinvest.org

CHINA
PHONE: +86 21 61413845
E-MAIL: china@czechinvest.org

JAPAN
PHONE: +81 3 3486 0329
E-MAIL: tokyo@czechinvest.org

USA WEST
PHONE: +1 (408) 524 1690
E-MAIL: california@czechinvest.org

USA EAST
PHONE: +1 347 216 93 55
E-MAIL: newyork@czechinvest.org

SCANDINAVIA
PHONE: +46 721 602 196
E-MAIL: scandinavia@czechinvest.org

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