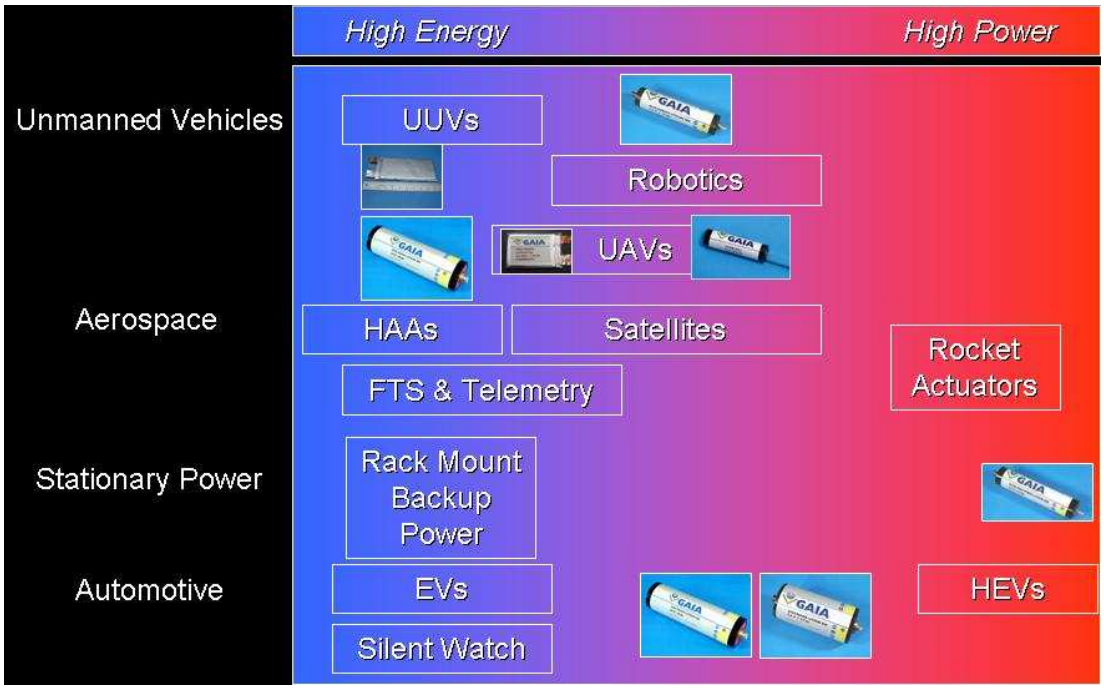
World's Emerging Markets for Safe & Large-Format Li-Ion Batteries (2006 - 2012)& applications overview.

By Tim Schäfer

The emerging world market for large-format, secondary lithium batteries consisting of lithium-ion (Li-ion) and lithium-ion polymer (Li-ion poly) or Li-Powerbatteries is booming, as the chemistries offers improved features compared to the traditional battery chemistries.

Criteria are fulfilled by Li-ion and Li-ion polymer batteries since they provide high-energy capacities and, hence, longer running times, are lightweight and of a compact size and also safe!
Availability and reliability are factors of crucial importance.

The energy and power advantages offered by lithium-ion batteries relative to other chemistries have made lithium-ion a preferred battery in the high–energy and high-power, rechargeable, advanced market segment.



Lithium-ion - the preferred battery in the high–energy and high-power, rechargeable, advanced market segment.

The emerging world markets for safe and large-format Li-ion batteries offer an immense growth potential.

The new EV.age is born!

Global market figures Li-Ion 2007:

- worldwide sales of Li-Ion will exceed 5bn USD 2007 **(Takeshida 2007),**
- more then 2500 Mio Li cells will be raffly shipped in 2007,
- this will be doubeld 2010,
- pot. double digit rated growing 2010 with mobile/Automotive,

----- but depend on safety, economy and absolutely uninterrupted service at the application, dead reliabel systems----

The Li-market is a strong growing one, at double digit rates…

The market drivers for larger format & high power cells:

- new safe an dead reliabel systems for acceptable good price from reliabel vendors

  (safe transport, safe at application, reliabel,service);

- more demand on decentral (regenerative, industrial,military) and mobile/ portable Power (L-EV-HEV) solutions for growing markets,

- reduction of green house gases; “Safe the Climate now!”

Freedonia- the global battery market

The **global battery market is about US-$ 50 billion**, while some US-$ 5.5 billion account for rechargeable (secondary) batteries. The annual **growth** for 2006 is estimated **to be 6 per** cent over all.

The **Freedonia Group, Inc. predicts** a demand for primary and secondary batteries of **US-$ 14 billion in the US by the year 2007**. A new generation of energy-hungry electronic devices, such as digital cameras, camera phones and high-performance portable computing devices will fuel the growth.

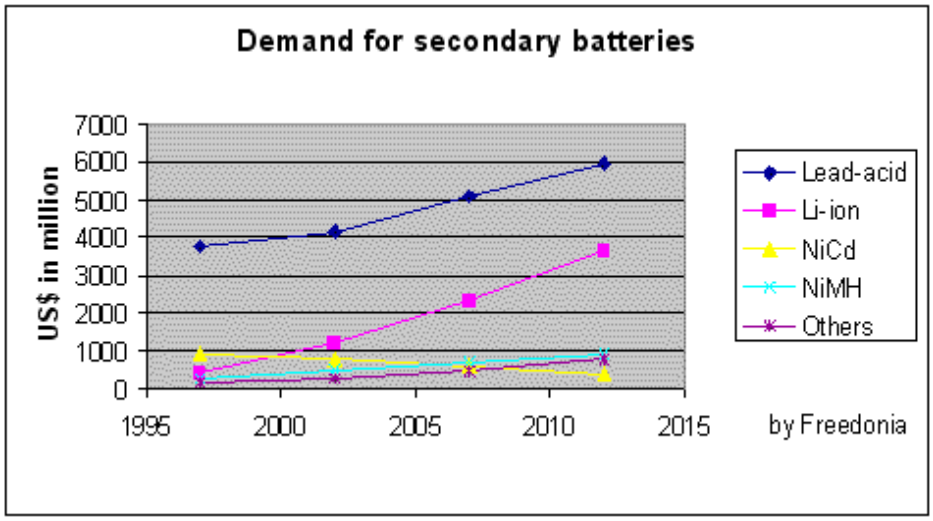


Figure 3: Lead-acid will be the most commonly used secondary battery.

Among portable secondary batteries, lithium-ion shows the most promise.

The tier 1 segment Li-Ion

The **tier 1 segment** of the secondary lithium battery market consists of battery vendors that are global participants operating in more than one region. Common traits include a wide product range that runs across many industries, global manufacturing facilities, a wide distribution network supported by post-sales services, and strong brand recognition. Companies that fall in this tier are **Matsushita** Battery Industrial Company, Limited/Panasonic, **Sanyo** Energy (USA) Corporation, **BYD** Battery Company, Limited, **Sony**, **LG Chem.**

In general, all the battery manufacturers are facing **increasing raw material and energy prices** in 2005-2007! If you consider the fact that increases between January and April 2006 were as follows

- aluminium 21.3 per cent
- copper 59.4 per cent
- nickel 37.4 per cent
- crude oil 21.2 per cent,

this is understandable.

The top Japanese suppliers had a market share of 70 per cent last year, but new competitors from other countries in Asia are catching up. **BYD** Battery Co. Ltd. in China is an example of a **tier 1 major**, new global battery producer.

The **US** and **Europe** will continue to produce specialty batteries, mainly used for defence and industrial application. In comparison to the mass-produced batteries from **Asia**, American and European packs will be more expensive.

World's Emerging Markets- Application Segments an Overview

The following Chart explains the secondary lithium battery market segmentation in detail and also gives the various applications under each segment:

- **Automotive/Transportation,**
- **Defence,**
- **Industrial Tools (wireless), professional appliance,**
- **Medical,**
- **Aviation,**
- **Space,**
- **Marine,**
- **Value-added service,**
- **Motive Power, including HEV-(L)EV,**
- **Industrial + Network Power.**

Automotive/Transportation in various applications:

- SLI 14 V (>),
- SLI 14 V,
- SLI 42 V,
- Dual battery systems,
- Heavy-duty,
- Marine-RV,
- Lawn & Garden,
- Motorcycles,
- ATV & PWC,
- Racing Cars,
- Fuel cell vehicles
- Telematic back-up systems.

Rail & mass transit:

- Braking,
- Starting engine,
- Asset Tracking,
- Emergency backup,
- Lighting
- and Ventilation.

The demand for electrical power provided by batteries is increasing. According to automotive experts, today's large cars can use as much as 2 kilowatts of power**. By 2007 that number is projected to grow to as much as 3.5 kilowatts.** This is because today's vehicles—from passenger cars to heavy-duty trucks—are equipped with more and more electronic equipment to enhance vehicle performance, comfort and safety.

For example, electric power steering (EPS), electromechanical brakes (EMB) and electromagnetic valve operation (EMV) are new developments that save fuel and reduce emissions. Other devices that may require increased levels of power include advanced electrically-controlled heating and air-conditioning systems; on-board communications such as satellite navigation systems; telecommunications systems and wireless Internet access; luxury features such as TVs, video playback units and heated and cooled seats.

Defence in various application:

- Satellites,
- Rockets, missiles, smart munitions
- Space,
- Ground underwater,
- GPS, Communications;
- Target acquisition / Firing systems,
- Portable devices,
- Weapon systems
- Battlefield communications,
- Night vision,
- Sonar buoys,
- Silent watch,
- Personal soldier systems,
- Chemical agent monitoring.

The US and their allies are changing the military landscape. The trend is toward many small, quickly deployed units using extensive, power-intensive electronics.

Application already exists in this market and continues to grow rapidly.
Application requires flexibility in design as application encompasses a wide range of power output, a broad scale of operating temperatures, lower weight and thousands of recharging cycles. Performance is more important than price in this market and the market demand is quickly growing.
Application also requires rapid charging rates and long life in safe, durable high-power storage for HEV and fuel cell powered vehicles. Military and heavy-duty vehicle OEMs have been early adopters of new technology and have become the leader in the use of large-format lithium-ion batteries.

Professional various appliance:

- Pulleys, Hoisting devices,
- Mixer, Soil Compactor,
- Vibrators, Rolls,
- Cleaners,
- Welding apparatus,
- Alarms,
- Radio-controlled models,
- Bar codes, Radio frequency identification,
- RFID-terminals, Supply chain management,
- Sensor-terminals,
- Toll collection tags

- **Medical in various applications:**

  - X-ray equipment,
  - Power box,
  - Monitoring and diagnosis equipment,
  - Special e-wheelchairs,
  - Handheld terminals,
  - Data & information systems for ICU`s,
  - Home dialysis, Infusion pumps,
  - Respirators, wearable monitors,
  - Operating tables,
  - Stair lifts
  - Telemetry systems
  - Automated external defibrillators.

Aviation & Space in various applications:

Aviation:

- Start up,
- Ground checking,
- On-board safety,
- Aircraft safety,
- Emergency lighting,
- Signalling,
- Ventilation.

Space:

- Probes ,
- rovers,
- Launcher control,
- Solar power (satellites..).

Marine in various applications:

- UUV`s,
- AUV`s,
- Science and navigation,
- Buoys,
- Beacons,
- Signalling,
- Lifejacket lights,
- Emergency locator,
- GPS, Radar.

Value-added service:

- Battery rental,
- Recycling,
- Battery handling.

Motive Power with HEV/ (L)EV:

- **Materials handling equipment,**
- **Robots,**
- **Cleaning machines.**

Market boosters of mobile energy

- Growth in world trade,
- Flow of goods velocity,
- Outsourcing,
- Ergonomics and safety,

Materials handling equipment in various applications:

- Reach trucks,
- Counterbalance trucks,
- Pallet Trucks, fork-lift trucks
- Order picking,
- Narrow Aisle,
- Tractors,
- Airside Assistance Vehicles (AAV`s),
- Automatic Guided Vehicles (AGV`s)
- Others.

Robots:

- Industrial,
- Logistics,
- Medicine,
- Military,
- Consumer.

Cleaning machines:

- Polishing machines,
- Vacuum cleaner,
- Scrubber driers,
- Sweeper,
- Others.

LEV:

- Muscle EV,
- Purely electric recreational and sports vehicles,
- Purely electric work assistance,
- Transportation,
- Robots.

The electric bike world report states that, in 2004, **ten Millions LEV will be sold.**
2005 was a good year for the pedelec market in Europe.

The market in Europe for LEV (briefly)

Up to 2010 the market will continue to grow,
players in the EU are Antec-Union and z-bike (more then 40).

99 % of legally sold electric two wheelers are pedelecs.

Market EU LEV –recent figures

- high/advanced NI/D/BE/DK/CH,
- low costs IT/RU/ES/FR/UK

2007 240 K (K= 1000 pcs.)

high 150 K
low 90 K

2008 440 K

high 320 K
low 120 K

HEV:

- Micro hybrid
- Mild hybrid
- Full hybrid
- Plug in (PHET) hybrid.

Estimated Market Hybrids: HEV 2006/7 and 2010

Raffly 400 K per year, up to 3.800 k (2010) estimated HEVs!
(2006).

-since 1997 1 Mio. Units, NiMH, when Li-Ion?

Availability and reliability are factors of crucial importance.

EV: the new EV.age!
In various applications (I):

- Car,
- Bus,
- Fleets,
- Railways,
- Boats…

EV: the new EV-age!
In various applications (II):

- Military vehicles,
- Powered Chairs,
- Lift chairs,
- Scooters,
- Caddies.

Li-Ion Batteries,main developers for EV, LEV:

- Hitachi, NEC Lamilion, ENAX,Sony,Sanyo, (Japan)
- LG Chemical, Kokam, Korea Powercell (Korea)
- GWA, PHET, E-one Moli,GP (Taiwan)
- BYD, Phylion, HYB,Tianjin Lishen,MGL,GEB…(P.R.China)
- A123, Ultralife,Johnson Controls,Exide mobile (USA)
- SAFT (France)
- GAIA Akku and Li-tec, Germany.

Advantages of new mobile solutions:

- new modular based charger technology combined with BMS and state of the art IuK-techology,
- float & high speed charging with conditioning options for batteries,
- data communication direktly to the battery service provider via GMS-moduls on central computer, as an option
- possible to pay via Wh and to rent a battery,
- effective way to analyze data of the systems and to optimize batteries,

The new EV.age is born!

- intelligent charging based on data`s generated at the application,
- analyzed actions, remote control & service.

Industrial + Network Power in various applications:

- **UPS,**
- **Telecommunications,**
- **Renewable,**
- **Railways,**
- **Security.**

Industrial batteries basically fall into two categories: those that supply motive power for vehicles such as fork-lift trucks and those that are available to provide emergency or backup power to critical operations not to be interrupted if the AC or DC power is out.

Anyone familiar with the energy crisis, for instance in California a few years ago, can understand the need for stored reserves of electricity during blackouts and brownouts. All around the world, whenever there is a power outage, network power batteries keep up critical systems that cannot be interrupted—such as data networks, railroad crossing signals, industrial controls and computer systems—and run smoothly and safely.

If the utility power is interrupted, batteries instantly take over the load, providing electricity until utility power is restored or until generators powered by diesel, solar, wind—or fuel cells in the future —can take over the load.
If the power is on, they help electric utilities to shift power from grid to grid. And during spot outages, they help public utilities to shift electric power around substations.

UPS:

- Industrial UPS,
- Traffic control,
- Energy storage,
- Broadcasting stations,
- Information systems,
- Process Control,
- Scientific and medical sites,
- Security installation,

- Measuring devices,
- Electronic systems,
- Toll collect systems,
- Others.

Telecommunications in various applications:

- Fixed networks,
- Cellular networks,
- Fibre networks,
- Switching stations,
- Cable telephony,
- Cable TV,
- PABK,
- Last mile components,
- Subscriber units,
- Wireless networks,
- 3G,
- Broadband,
- Satellite com. stations,
- PVT mobile radio.

Renewable:

- Remote Area Power Supplies (RAPS),
- Remote telecoms, signalling,
- Pur. electrification,
- Wind power, pitch control,
- Solar power (PV): - Standalone/Hybrid…

Energy supply:

- Power plants switching stations,
- Power distribution & control,
- Starting generator,
- Electrical power plants
- Others.

Railways:

- Signalling systems,
- Electrical substations,
- H.Q. to train radio,
- Cash dispensers,
- Others.

Security:

- Acces control, Handheld metal detectors
- Alarm systems,
- Fire alarm, Long life smoke alarms,
- Traffic lights,
- Wireless Transmitters,
- Watching systems,
- Emergency lighting, Carbon monoxide alarms
- Robots,
- Others, Gauges …

Application requires high-reliability power for telecommunications, computers and other mission-critical application. We believe this presents a very large potential market. Growing dependence on electrical power throughout the whole world fuels the demand for high quality and availability of back-up power, standby, remote mobile and renewable power application. The life cycle figure of lithium-ion over lead acid is a key market advantage.

Market boosters are:

- Telecoms infrastructure,
- National safety,
- UPS,
- System integrity,
- Emerging markets,
- Future 3G and broadband,
- Costs of ownership,
- Renewable Energy.

Lithium-ion will lead the demand in powering portable devices. On the other hand, the market for nickel-cadmium is shrinking. This chemistry will be replaced by nickel-metal-hydride. **Nickel-cadmium** still holds a major share to power tools, two-way radios and medical devices. This chemistry is preferred to nickel-metal-hydride for its high durability and reliable service, but some countries **will ban its use by 2006 for environmental reasons**. Exceptions will be made if the substitute is unsuitable.

A research study conducted by Frost and Sullivan and LTC of the rechargeable battery market confirms that the rechargeable battery market for national security, transportation and stationary power advanced applications is predicted to grow from approximately $300 million in 2003 to $2.1 billion in 2011. This represents **a growth of over 700% in an eight-year-period**. The advanced market consists of lithium-ion, nickel-cadmium and nickel-metal-hydride compositions, although **lithium-ion is emerging as the technology of choice.**

But what does it mean for a battery producer?

Market UPS 48V/96V and LEV e-bike & pedelecs based on 10 Ah Li-Ion safe cells are the breakthrough for large-formate Li-Ion today.

Estimated forecasts as example:

Application	Forecast/cells/anno	Remarks
Hybrid	2009 approx. 20 -30 m cells /2006 > 15 m cells 2012 approx. 250 m cells	
LEV	2009 approx. 46 m cells	30% market share
EV	2010 approx. 20-30 m cells	
UPS	2008 8 m cells 2010 25 m cells.	

Li-Ion in the application **Industrial/materials handling equipment and cleaning machines** 200,000 systems globally in 24 V and 36 V
(2007), then annual growth 40% until 2010, then 20 %.

Later, with **EV** and **HEV** application **the new EV.age** comes true.
Li-ion is poised to outperfom NiMH, and, step by step, lead-acid systems in various applications (2008-2025).

With no major breakthrough, the **fuel cell** will play an insignificant role in providing power for future application. Cost, size and performance are the main obstacles. Although continuously in operation by replacing fuel capsules, the fuel cell, as we know it today, still needs a **backup battery** to satisfy the power requirements of modern portable equipment.

Automotive/ Transportation 2006

The **Global Production Forecast** shows for cars **64.4 million units in 2006,** and even 76.4 million units per year for 2012.

The new EV.age is born!

The **US market** for the top OEMs has been showing a downward tendency until May 2006. Fuel costs, prices and a low demand can be given as a reason.

The **P.R. China** is an attractive passenger car market. Compared to 2005 the turnover of the Chinese manufacturers increased by 60.2 per cent (Source: Xiangtong Auto). Due to higher consumption taxes within the premium segment since April, sales boosted at the beginning of 2006. When will a fuel tax be introduced in China?
Thus, Shanghai Volkswagen could increase its sales of the Passat B5 by 36 per cent. Audi at least doubled, Shanghai GM achieved a growth rate of 98 per cent!
Japanese and Korean manufacturers are also very successful. Local manufacturers continued to extend their market shares (Chery, Geely).
Changgang und SAIC GM Wuhing (SGMW) were at the top of the statistics, but they are producers of minibusses (up to 9 seats).
Some Chinese manufacturers are now going directly from the Shanghai Motor Show to the IAA (International Motor Show) in Frankfurt. Here, many makes are shown.
Prospects are also good in Europe; cars are being sold at high prices.
In Europe, the Japaneses as well as the Koreans have made pioneering work for many years.

Today, there are 42 million vehicles in **Germany**; this figure increases by approximately 1.5 per cent a year. According to a public information by the Federal Government the traffic system “Road” has a traffic performance of 720 billion kilometres within the passenger transport. Railways have only 10 per cent thereof. The daily mobility within the German passenger transport comprises routes of 40 kilometres per day.

Approximately 640 cars were alloted to 1,000 habitants; that means about 288 euros (15 per cent of the household spending) are monthly spent on mobility by a household. On working days, about 66 per cent of all passenger cars are used. Due to technical progress fewer pollutants were emitted in the road traffic. **The current situation of German car makers makes a turnaround necessary because of a subdued private demand.** During a period of 5 years, private demand has decreased by 25 per cent. The average age of a car is about 97 months. In order to make the products of the manufacturers more affordable and innovative, new alliances and global sourcing will be reinforced.

Application requires rapid charging rates and long life in safe, durable high power storage for HEV and fuel cell powered vehicles. Military and heavy-duty vehicle OEMs have been early adopters of new technology and have become the leader in the use of large-format lithium-ion batteries.

The electric car: Past dream and nightmare for designers! Is there a market for EV of a new generation?

Electric and Hybrid Vehicles offer a uniquely attractive solution to many of the issues currently confronting the automotive industry, but the technical and marketing challenges are still remarkable.

This question can be answered in the affirmative. The fact that there are electric cars on the market can be given as a simple reason. Sometimes these are quite ambitiously or unusually designed! But the types of well-known manufacturers are often based on famous types, e.g. by Citroen or Peugeot, Smart or VW.
Daimler Chrysler strategically relies on fuel cells.

Did you know that at the beginning of the industrial car manufacturing world-known pioneers had relied on electric cars, many of which can be seen in museums throughout the whole world.

During all the years electric cars have been manufactured while some of them could only be used as advertising medium or sold to environmentalists.

You will probably remember that the Americans wanted to force the automobile industry to sell significant quantities of electric vehicles with no emission at the end of the 1990s. At that time, this was not possible because the batteries available were too heavy and large, and offered insufficient capacity for adequate range or power. The electric vehicles available at that time did not meet customers' expectations in terms of driving pleasure.
In 1996, a fleet of electric cars began to enter the roads in the United States, leased to drivers for about $500 a month. But less than 10 years later, only a few were left. Guests look at the short-lived electric car, and the director of a new film talks about chronicling the vehicle's demise.
After all, you will all remember that the range of electric vehicles, which is the result of the battery, has always been a downfall.
All the experts agree. The car of the future must offer at least as much driving pleasure as today's vehicles or:

If possible, more!

If you take a look at the vehicles with hybrid driving systems which are now available you will find that many are based on this principle. The electric motor is not only used to save fuel. It also often has the effect of an electric turbocharger, supplying the torque needed for acceleration which cannot be provided by the petrol engine because of its low capacity or at low engine speeds.

How to define a new EV?

How to define a new EV?
Proposal: It is a modern vehicle with one or more electric motors for the propulsion of the vehicle, offering a driving range of more than 100 kilometres with the same battery within five years….?!

A manufacturer introducing a new electric car should not only set new standards with regards to driving pleasure, range or lifespan / cost effectiveness, but should also consider some important questions concerning marketing and design.

Preliminary results of an **acceptance survey study on new generations of EV** are shown below in more detail.

It is obvious that the mainstream taste has to be met and the younger generation has to be appealed; perhaps **to create a completely new awareness of life by means of an electric car in a new, beginning new EV-age.**

There are some parallels with the LEV area where new power and mobility are translated into a new awareness of life for people.
An EV of the new generation should of course not have the effect of Ford's Edsel!
It is very interesting to see what there will be offered within two years!

Even the Japaneses have already announced the new EV-generation with Li-Ion inside by 2008. E.g. Mitsubishi, already shown by means of a Lancer Evolution on the occasion of the Motor Show in Tokyo. The Lancer is powered by four wheel hub engines, each providing a performance of 50 kW per wheel, that means 200 kW altogether or a maximum of 270 hp. This car should reach 100 km/h within less than 8 seconds and a maximum speed of more than 180 km/h.

Demand and market potential for new electric cars in Germany – a study

The benchmark figures of mobility and basic data of the market in Germany have been shown above.
If engineers in Germany are asked for electric cars, leading suppliers of the automobile industry say that the necessary components are available.
Electric road vehicles (small cars, fully adequate) of the new generation are by no means only an option of the distant future. Electric vehicles are demanded by:

- Private users,

- Public users,
- Industrial users.

Even the research and development department of the VW group is interested in electric vehicles in the near future, whereas probably Daimler Chrysler is not.

If studies on the purchasing interest of electric vehicles of the old generation are brought in, it can be recognized that approximately 70 per cent of the private users questioned answered that an electric vehicle was disadvantageous. In contrast, only 7 per cent say that today an electric vehicle has already more advantages. Public users are different: The majority of them have positive or neutral attitudes. Industrial users were slightly more negative than public users.

If a small electric car cost approximately 13,000 euros in Germany, 16 per cent of those questioned would be interested in buying an electric car. **However, about 33 per cent of those questioned have generally a positive attitude towards electric cars.**

If an electric car cost 9.999 euros, about 16 per cent were interested in buying one.

Further increases in fuel prices would and will increase the sales prospects considerably.

The most **important properties of an EV** are:

- Security,
- Everyday suitability, longevity,
- Reasonable purchase price and maintenance,
- Range of at least 100 kilometres.

The most **disadvantageous feature** of electric vehicles currently available on the market is the low range, while, in turn, the greeness is a special advantage.
Many do not like the design of electric cars emerging from the old series as the car appears smaller, uncertain and ugly or strange!

It is said that these cars are too angular and a boot was also of importance.

Let us ask for a forecast of new EV`s which can be easily introduced into the German market (only private users) in a realistic scenario:

- Within 24 months approx. 5,000 units,
- Within 48 months 20,000 units.

However, it is suggested to carry out new analyses after having defined an EV, **as the cards are shuffled again.**

Furthermore, it will depend on the fact how the strategy of the market introduction can be materialized.

New Smart-EV / Zytec (GB) project (2006):

The iconic smart fortwo will be available as an electric version. The UK has been selected to run a market trial for the introduction of a fully electric version of the popular two-seater car. The smart ev (electric vehicle) have made its UK debut at the British Motorshow at ExCeL on 18 July this year. The car will be made available on a lease arrangement to selected UK corporate customers with deliveries starting in November.

The smart ev sets a new benchmark in the electric vehicle sector; it has 30kW output and a top speed of 70 mph. It offers even better in-town performance than its petrol powered stablemate, with 0-30 mph in 6.5 seconds. With a range of up to 72 miles, the smart ev is exempt from vehicle excise duty and congestion charge. The drive train for the smart ev is produced in the UK by technology partner Zytek Group who undertake final assembly of the smart ev in Fradley, near Litchfield. Mr. Kelly, Managing Director of the Mercedes Car Group said: "We expect to deliver up to 200 units in this market trial phase and will work with corporate partners, to find suitable applications for the ev, and with green energy suppliers to deliver zero emissions from well to wheel."

Market and Technology Trends

The market for large-format lithium-ion and lithium-ion polymer industrial batteries is an emerging one and has a large growth potential for the future. It is still in a development stage and many manufacturers are testing these battery chemistries and improving their features so that they can withstand industrial conditions of high charge and discharge cycles, extreme temperatures, rugged environment and low maintenance. But in the field of electric bicycles and energy supplies, **deliveries of large scale larger format Li-Ion batteries 10-20 Ah** have already been started on the market. This is the commercial breakthrough for manufacturers of batteries and OEMs because as the example of the bicycle shows much money is earned with Li-Ion in the market.

Availability and reliability are factors of crucial importance.

The old lead-acid battery system is out of date and **supercapacitors**, which have been much appreciated, have a very high output, but their energy storage capacity is very low.

Nanotechnology may probably soon bring some advantages (for instance NCT`s as additives), but then, of course, for all types of energy (storage) devices such as supercaps or batteries. Several new materials are in stage of development for safe and large format Li-Ion batteries. These developments will have a significant impact on the performance and cost-effectiveness of large format Li-Ion batteries.

Lead-acid accounts for the half of the demand for rechargeables until Li-Ion will outperform lead–acid systems. This battery is mainly used for automotive and stand-by application. Because of low costs and a dependable service in case of adverse environmental conditions, **lead-acid will record a final, increasing period until the year 2012**. Lithium-based batteries will start to replace many lead-acid applications if the price can be lowered and the service is prolonged. Later, with **EV** and **HEV** application **the new EV-age** comes true. Li-ion is poised to outperfom NiMH and, step by step, lead-acid systems in various applications (2008-2025).

With no major breakthrough, the **fuel cell** will probably play an **insignificant** role in providing power for future application. Cost, size and performance are the main obstacles. Although continuously in operation by replacing fuel capsules, the fuel cell, as we know it today, still needs a backup battery to satisfy the power requirements of modern portable equipment.

Sources: Frost und Sullivan, Bundesministerium für Verkehr, Frank Jefferson, Extraenergy.org –Hannes Neupert, GAIA Akkumulatorenwerke GmbH a LTC company, VDA Germany, ZVEI Germany, PriceWaterhouseCoopers, DaimlerChrysler, Sanyo, IIT, Degussa AG, Continental AG, R. Bosch GmbH, PSA, Freedonia Group, Xiangtong Auto ,MBI, Exide, Sparta, Kienbaum, Wikipedia, Varta AG, Taipei Int. Cycle Show Intern. Conference 2006 2007,VMI, Der Spiegel,