VOLUME 4

Green Solutions to the Auto Crisis

From Auto Makers to Mobility Service Providers

A strategy paper by **Weert Canzler** and **Andreas Knie**

HEINRICH BÖLL STIFTUNG
ECOLOGY

GREEN NEW DEAL

GREEN SOLUTIONS TO THE AUTO CRISIS

The authors

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PREFACE

"Auto Industry Production and Sales Figures Plunge Dramatically During First Quarter of 2009" – "Daimler Acquires 10% Share of Californian Electric Auto Startup Tesla Motors" – "Obama Ends the Gas Guzzler Era" – the headlines of the recent past suggest that automobile manufacturers are not just suffering from the economic downturn. They are also experiencing a structural crisis that will require a profound transformation of the industry. Climate change, the dwindling availability and increasing price of oil, the intense pressures of traffic in many cities and the new mobility needs of many people will bring about a major change in the demand for cars worldwide. The industry's proven recipe for success – building ever larger, more powerful cars – has now become an outdated model. In light of the auto industry's present crisis, the Heinrich Böll Foundation commissioned Dr. Weert Canzler and Prof. Andreas Knie of the Social Science Research Center Berlin to outline mobility concepts for the future. This strategy paper analyzes the current crisis and illustrates how demand for mobility will be changing in urban regions. Its verdict: firstly, we need climate-neutral cars that no longer depend on oil, a finite resource, in their production and operation. Secondly, it will not be enough to merely replace the internal combustion engine. The "green car of the future" must be embedded in intermodal transportation concepts that will permit effortlessly changing modes of transportation. Thirdly, the "green car of the future" must be associated with new patterns of use. The automotive industry is not alone in facing a deep transformation. New actors will also be entering the scene. In addition to the automotive industry, utility companies, the IT sector and public transportation authorities will be called upon to shape the evolution of new transportation services. Governments will also need the courage to create forward-looking frameworks to promote such development. With this strategy paper, we would like to contribute to the debate surrounding the transformation of the auto industry and mobility concepts of the future. We see the current crisis as an opportunity to question the industrial and political strategies of the past and to set the course for developing the vehicles and services of the future.

Berlin, May 2009

Ralf Fücks
President
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SUMMARY

The automotive industry is not only suffering from the economic downturn, it has also been in a structural crisis for some time. Overcapacity and years of ignoring medium and long-term challenges such as climate change, the finite nature of fossil fuel resources and the fading symbolic value of cars in urban areas are contributing to the industry's troubles. It will not be possible to stay the course. Government props such as lax emissions limits, the nature of vehicle taxes, the privileged status of company cars in Germany and the overeager provision of bailouts have all contributed to the structural crisis. The diagnosis is utterly clear: we not only need different cars, but also a new understanding of automobility. The industry isn't finished, but a fundamental transformation will be crucial for its survival. Governments must also create new, forward-looking legislative frameworks to that end.

In future, traffic in the world's urban centers will be different from what we know. Unparalleled qualities of use could arise if utility companies, public transportation authorities and the automotive industry were to join forces: all of the forms of transportation needed in day-to-day life would be powered by electricity and provided to users as a single integrated service. That presupposes a change in perspective, however. Alternative drive technologies alone are not enough – the focus must be on comprehensive mobility concepts for urban regions. A wealth of innovations is conceivable – not only new technologies, but also lucrative supplementary services and genuinely groundbreaking new applications. E-mobility is thus a formula for a new, technically sophisticated dimension of utility that will render the concept of mobility based on vehicle ownership a relic of the past. The value creation of intermodal urban e-mobility not only encompasses the vehicle hardware itself, but also traffic services and the provision and storage of energy from renewable sources. Catering to such comprehensive e-mobility will become a leading market worldwide.

1 Crisis as opportunity? A turnaround in automobile use

The diagnosis is clear: Cars are no longer merely an environmental and traffic policy issue. The auto industry's overcapacity and plunging sales figures also make them an economic problem.

The exhaust and noise emissions, space requirements and detrimental effects on the climate of the growing worldwide automobile fleet have been the subject of considerable criticism over the years. Yet the steadily increasing registration figures seemed to indicate that the automotive industry was on the right track in catering to the ongoing worldwide demand for cars. The automobile as an icon of the modern age, as a mobility machine that enables a way of life unfettered by time and distance, remained a virtually continuous success story over the course of a hundred years, and with it, auto manufacturing rose to industrial leadership.

This strategy paper[1] analyzes the current crisis of the automotive industry and proposes green solutions to its problems. It focuses on products for passenger traffic in urban areas; goods traffic and the special issues of traffic in rural areas[2] are not covered in this analysis.

Big loses, small wins

The global financial crisis has had a draamatic impact on the production and sales figures of auto manufacturers. Since October 2008, only around half the number of vehicles, averaged across all makes and models, were sold in comparison to the year before. A pickup in demand could not be made out in the first two quarters of 2009.

Yet the development of the sales figures varies considerably from one model to the next. While premium products were hit by massive drops in demand, smaller vehicles are almost unaffected by the crisis. Sales figures for small cars

1 We received numerous helpful comments in the course of presenting this strategy paper. We would especially like to thank Jürgen Resch for his critical remarks.

2 It can be deemed certain that traffic in rural areas will tend even more toward cars in future as a result of demographic change. The ways in which those cars and the provision of the remaining public transportation services in peripheral regions will be subject to different requirements than today would be the subject of a dedicated study.

worldwide appear to remain stable. The reason for this is almost certainly the fact that the bulk of large and mid-size vehicles are sold in fleet deals – as company cars for large businesses, or for use as rental cars. In Germany, for example, those channels account for around 90 percent of BMW 5 and 7 series, Mercedes S and E class and Porsche sales.

Compact and subcompact-class vehicle sales profited significantly from the *Umweltprämie* – Germany's cash-for-clunkers program – while fleet sales have been virtually nonexistent since Q4 2008 due to the collapse of automobile financing.[3]

A temporary lull in sales?

The central question in the current crisis is whether this is a temporary drop in sales due to the current woes of the finance sector, or a worldwide trend shift that reflects broader changes in the use of automobiles. That, in turn, raises additional questions: How will the rising oil price and awareness of the detrimental effects of road traffic on the climate affect worldwide demand for cars? What kind of cars will people want to drive in future?

Aside from rational matters such as the rising price of fuel, the cultural significance of the car is a central consideration in its use. Will large luxury automobiles remain status symbols for their owners? Or are attitudes toward conspicuous consumption changing in the face of climate change? Have clothing, home furnishings, travel, education and the use of telecommunications technologies become the latest status symbols? Is driving a large SUV or luxury sedan being reduced to a mark of lower social strata? "Small is beautiful" was first heralded as a trend in the 1970s and has been identified as the next big thing repeatedly since then. The concept of use without ownership was its logical extension in the 1990s. The significance of such trends would fade whenever the economy recovered, however.

Overall findings tend to be mixed and provide little reason for post-automotive euphoria. The trend in which significant numbers of people are intelligently combining all available modes of transportation according to practical considerations is an exclusively urban phenomenon. This has long been true of extremely dense cityscapes such as Tokyo and New York, but it is also becoming increasingly the case in Paris, London and Berlin. However, this cannot be construed as a fundamental rejection of the automobile – as is frequently hoped for by environmental activists and progressive urban planners. Generally, users' personal relationships to cars and their individual mobility requirements depend on whether they live in an urban, suburban or rural environment. Cars will remain indispensable in suburban and rural areas; social inclusion and day-to-day family life depend almost entirely on access to a car, as the large number of households with two or three cars documents. This holds true regardless of the

3 See Rother 2009

values and political views of their users; suburban Green voters are also frequent and enthusiastic drivers, using their cars for shopping trips to organic farmers or weekend canoeing trips.

In one regard at least, things today seem to be different than in the past decades. Experts agree that young people in urban areas are exhibiting a more differentiated approach in their use of cars. This is characterized by their rejection of large, prestigious vehicles and a great affinity to intermodal traffic solutions supported by modern communications technology[4]. While many regard cars as an option, they are but one of several. Considering the steady worldwide move toward urbanization[5] and the fact that today's urban youth are often trendsetters and the potential power elite of the future, the auto industry cannot afford to ignore this development. If it intends to continue satisfying demand for individual mobility in future, it must develop products that meet urban dwellers' needs for intelligently integrated modes of transportation.

This represents no small challenge for the automotive industry. Firstly, it means catering to new demand for integrated transportation in urban areas in which the car no longer plays a dominant role. At the same time, there is also a need for new options for suburban and rural regions, as rising oil prices and stricter CO_2 emissions standards in the foreseeable future will boost demand for fuel-efficient, climate-friendly cars. This confronts the auto industry with the new task of developing different product ranges for urban centers and less densely populated regions. This challenge goes well beyond a further diversification of its model range.

It will be impossible for the industry to fall back to its pre-crisis business-as-usual. The trend shift in worldwide demand outlined above not only calls for "green cars" with new drive technologies; such cars must also be an element of a comprehensive "green mobility" – a systematic view in which all of the available modes of transportation mesh with one another.

In light of this background, the current buzz surrounding electric mobility takes on its special significance. If cities such as Paris, Beijing, Shanghai, Los Angeles and London were to announce that their inner cities will only be open to zero-emissions vehicles in future, it would lend a certain plausibility to the German government's idea of fostering a "leading market for electric mobility" with half a billion euros from its stimulus programs.

Indeed, the new drive technologies – from fuel-efficient hybrids to electric cars – offer great opportunities to develop innovative, future-oriented mobility products and services. This should not mean simply replacing the drive techno-

4 This refers to the combined use of multiple modes of transportation, as well as the natural use of traffic information – in real time wherever possible – via the Internet and wireless devices. User studies have also shown that young people in particular take advantage of new intermodal offerings such as public bike systems and integrate them in their routine mode choices; cf. Maertins 2006.

5 According to UN forecasts, over 60 percent of the world's population will live in megacities by the year 2030.

logy, however. The new "green car" should become an integral part of a comprehensive public transportation program. It would then no longer be the autistic artifact of decades gone by, but an element of a new network structure. Yet it remains to be seen whether we will seize this chance to innovate and use this crisis as an opportunity. It will depend not least on whether we succeed in developing attractive new transportation systems in the near future and launching them on the waiting market.

What is needed is no less than an innovative product offensive. The core elements of such an offensive: include

- putting transportation on a foundation of renewable energy sources (breaking the dependence on oil);
- integrating the various available individual modes to innovative new transportation systems (intermodal services);
- developing new forms of shared use, from car sharing and car pooling to virtual fleets (mobility services).

The starting point of such a campaign would be a broader understanding of modes of transportation. That would mean less individual property and more shared use in order to reconcile diversity, suitability and resource conservation. The current questions are: which forces will be driving or impeding "tomorrow's green mobility" – and which business and legislative frameworks will be required to pave the way for the mobility of the future?

2 The auto industry: an economic or structural crisis?

Car production in Europe, Japan and the United States was 20 to 40 percent lower in the first quarter of 2009 than in the same period the year before. The decline especially affected the premium segment, with nearly all manufacturers cutting production by more than 50 percent since the end of last year. Uneasy private customers are not the only ones holding back on their purchase decisions. Business purchasers in particular have been as reserved as never before since the end of last year, with the worldwide financial crisis bringing procurement virtually to a standstill. Depending on the market segment and make, fleet operators such as large companies or auto rentals make up a total of 40 to 90 percent of the overall market in Germany.

The various cash-for-clunkers programs designed to provide incentives for purchasing new cars implemented by a number of European countries since the end of 2008 were the sole reason that the shortfall in private demand has been less pronounced than expected. Small and mid-sized models of French, Japanese and Korean makes have especially benefited from these measures. However, the purchase incentives mainly led to buyers moving already-made purchase decisions forward, which will result in a lack of demand next year[6].

The effects of the financial crisis and faltering economy are especially glaring in the premium segment that is so important to the German automotive industry. In recent years, manufacturers in North America and Europe have succeeded in marketing large vehicles only by offering special leasing terms. These are based on especially favorable residual values – in effect, optimistic assumptions about the prices that the returned vehicles will command on the used-car market. However, the sales channels in Eastern Europe, the Middle East and Central and East Asia vital to this market have also shrunk dramatically, making it necessary to recalculate residual values across the board, reducing the value of existing fleets. Therein lies a grave performance risk – especially for the German manufacturers Daimler, BMW and Porsche – which will have a significant impact on manufacturers' 2009 financial statements.

6 Germany's cash-for-clunkers program did not provide auto manufacturers with the slightest incentive to focus on research and development for alternative drive or storage technologies. The program was intended to deliver swift benefits, and so stipulations related to ambitious drive technologies were ruled out; the (Japanese) vendors of hybrid technology were not to be given an advantage.

Yet the auto crisis was not triggered by the turmoil on the financial markets. It has its roots years earlier. This is especially apparent on the U.S. auto market.

Thanks to cheap fuel and generally low taxes on energy, U.S. manufacturers had little incentive to develop fuel-efficient vehicles and drive technology. The industry focused its entire innovative power on increasingly lavish extras, safety features and an overall up-sizing of the models. By the late 1990s, the registration figures of heavy SUVs and semiprofessional trucks had outpaced those of traditional sedans. Such vehicles were generally designed exclusively for the U.S. market, creating a segment of off-road vehicles and light trucks unparalleled elsewhere in the world. These vehicles were unusually heavy and had poor fuel economy. This special path taken by the United States, which evolved over many years and culminated with the dominance of sport utility vehicles and pickups until the summer of 2008, appears to have reached its end. The cost of fuel reaching four dollars and more per gallon in the early summer of 2008 was already enough to dent the sales figures of such vehicles. During the crisis of the financial markets in autumn 2008, sales plunged by up to 80 percent. Even aggressive discounting did little to improve matters.

Yet German and European manufacturers have also ignored important trends, as shown by the success of Toyota and Honda in selling around 2 million hybrid models worldwide since 1997. German car makers long viewed the hybrid concept with disdain and belittled it as poor engineering; instead, they focused exclusively on optimizing the diesel engine. Nearly all of them have now belatedly made developing their own hybrid drives a priority. With its recently-unveiled S 400 Hybrid, Daimler has now put a model of its own on the market – in the luxury segment of all places, and years after its competitor Lexus.

Above all, however, the crisis in the financial sector and the recession have made significant overcapacities throughout the worldwide auto industry in recent years painfully apparent. Nearly all manufacturers and market segments – and especially the premium makes – have been hit hard. Many suppliers are also suffering. Their margins are under considerable pressure, and a number have come under the sway of private equity firms in recent years. The suppliers are now in even greater danger of bankruptcy than carmakers. After the insolvencies of TMD Friction, Edscha and Karmann, the disappearance of further German SME automotive suppliers is anticipated. Above all, major suppliers such as Bosch and Continental are attempting to diversify and are stepping up their research in the automotive technologies of the future. Bosch, for example, is investing heavily in the production of photovoltaic cells and is intensifying its R&D.

The battles over the future of General Motors and Opel have shown that unused production capacities require adaptation strategies and are an increasing source of stress for manufacturers. Even if they manage to address the crisis successfully in the short term, the industry as a whole will not be out of the woods for some time to come. Further stress factors exist which are completely unrelated to the economy:

- Climate change and the finite nature of fossil fuels are two factors that will inevitably aggravate the crisis in the medium and long term. The latest forecasts of the international climate research community indicate that industrialized countries would need to curb their greenhouse gas emissions by 95 percent relative to 1990 levels by the year 2050. Yet according to the latest European Commission figures, traffic-related CO_2 emissions in the EU-27 countries rose by 36 percent from 1990 to 2006[7]. Most energy price forecasts come to the conclusion that prices for fossil fuels are set to increase dramatically as soon as the economy picks up. It is likely that the oil price spiral – which came to a halt in the late summer of 2008 after hitting 150 dollars a barrel – is not over, but merely dormant due to the crisis. The International Energy Agency (IEA) predicts that the price of crude oil could reach 150 dollars a barrel again already in 2010 when worldwide demand once again rises significantly as the economy recovers. The IEA is anticipates a barrel price of 200 dollars in real terms by 2030.
- Patterns of use and the symbolic value of automobiles are evolving: The current trend is to own a car, but to drive it less in favor of other modes of transportation[8]. This pattern is becoming increasingly prevalent for urban dwellers in Europe. Declining interest in acquiring a driver's license has also been observed among urban youth[9]. At the same time, however, OECD countries have long had such high motorization rates that, with the exception of insignificant fringe groups, virtually all of their inhabitants have access one or more cars. Differences between genders and generations with regard to holding driver's licenses are disappearing. Despite some changes in perspective in urban areas, holding a driver's license remains a basic qualification comparable to competence in digital media or even literacy for those aged 21 and over. Driving has thus become a matter of course, and the air of exclusivity once attached to it has long become a thing of the past. Luxury vehicles and company cars still serve as status symbols and their drivers still engage in conspicuous consumption. Yet in that function, the automobile has been facing considerable competition lately. The car has lost a great deal of its symbolic value and actual importance for day-to-day mobility among the younger generation and the urban middle class. Having its symbolic – and actual – value put into perspective like this indicates a relevant trend. It does not, however, represent a broad rejection of the automobile. The figures published in June 2009 in the most recent *Mobilität in Deutschland* survey indicate slight gains for both public transportation and bicycle traffic (each

7 http://ec.europa.eu/transport/publications/statistics/doc/2009_energy_transport_figures.pdf

8 This has long been the case in Japan; on average, private cars there clock little more than 5,000 km per year, while in Germany, private cars are still driven around 12,000 km annually; see Bungsche 2009 and MiD 2008.

9 See Beckmann et al. 2006; regarding the relationship between communications technology and automobility cf. Tully/Baier 2006.

about one percent growth in the modal split) in Germany over the reference year 2002. Private motorized transportation remains dominant, however, with a share of around 80 percent of total traffic[10].

In summary, the automotive industry is not only suffering from the economic downturn, it has also been in a structural crisis for some time. Overcapacity and the years in which it ignored medium and long-term challenges such as climate change, the finite nature of fossil fuel resources and the fading symbolic value of cars in urban areas are contributing to the industry's problems. Continued reliance on its previous strategies is no longer an option. Government props such as lax emissions limits, vehicle taxes, the privileged status of company cars in Germany and the overeager provision of bailouts have all contributed to the structural crisis.

The diagnosis is utterly clear: We need different cars and a different kind of mobility. The industry isn't finished, but a fundamental transformation will be crucial for its survival. Governments will also need the courage to create forward-looking legislative frameworks to promote such development.

2.1 A fresh impetus for alternative drives: the state of the art

The range of potential alternative drive technologies is broad, each with its own strengths and shortcomings and widely differing time and development horizons[11]. Conventional engines also offer considerable scope for improvement. After more than a century of refining the internal combustion engine, major leaps can no longer be expected, however. Even with improved efficiency, burning hydrocarbons remains relatively uneconomical, not only because a substantial share of energy is wasted as heat, but also due to the air pollutants that require treatment with costly end-of-pipe technologies such as catalytic converters, particulate filters and deNOx systems. Biofuels are not the solution to the internal combustion engine's relative inefficiency and may lead to new problems. Increasing demand for palm oil and soy for biodiesel is leading to the further destruction of natural resources, for example. Many biofuels also offer only insignificant greenhouse gas savings potential.

Electromobility is conceivable in a number of variations. Electric motors can be powered by fuel cells or batteries, for example. Two scenarios currently exist for the electrification of drive technology, which are evolving in parallel. The traditional fast, long-range sedan[12] will become increasingly hybridized. Small, light urban cars will already be arriving on the market in the coming years as

10 See MiD 2008.

11 For an overview see: Deutsche Bank Research 2009: 15.

12 The fast, long-range sedan is the dominant design which embodies the two historical focal points of automotive development – racing and long-distance travel. It encompasses the four essential characteristics of a car: acceleration ("0-100 km/h"), maximum speed, range ("at least 500 km per tank") and capacity ("four passengers and their luggage").

purely electric vehicles. Due to the still relatively low storage densities of batteries, ranges in excess of 150 kilometers are not ecologically or economically viable from today's outlook, however[13]. How the electricity is generated is also decisive. Only renewable sources of power have a long-term perspective.

Hybrid technology includes a wide range of approaches and degrees of implementation. It starts with the micro hybrid, which initially involves nothing more than a start-stop system and regenerative braking. The BMW Group was the first German manufacturer to introduce automatic start-stop systems throughout its model range – from the Mini to the 7 series – under its Efficient Dynamics label already in 2007. Mild hybrids, such as the Honda Insight and Mercedes S 400, offer additional, limited electric support drive. They do not feature an electric-only mode, however. Full hybrids include parallel hybrids, in which the internal combustion engine and electric motor both apply power to the drive train, and the electric motor and battery are powerful enough to permit electric-only driving over short distances. The Toyota Prius is based on this design principle. A plug-in hybrid (or plug-in hybrid electric vehicle, PHEV) combines the above technology with a larger battery and the option of plugging the vehicle into an electrical outlet for charging, thus increasing its electric-only range.

Another form of the full hybrid is the series hybrid. In this version, the internal combustion engine only powers a generator that charges the on-board battery. The vehicle's wheels are driven using electric power only. The advantage of this technology is that the internal combustion engine can be run at its maximum efficiency at all times and the range of the electric drive is increased dramatically[14]. The advantage of hybridization is that it permits the new – electric traction – to gradually supplant the old – internal combustion[15].

Regardless of the drive design, numerous options are available for increasing efficiency and significantly reducing the CO_2 emissions of passenger cars[16]. Potential efficiency gains through lightweight construction (using materials such as carbon fiber), tires optimized for minimal rolling resistance and further reductions of vehicle drag coefficients (C_d value) must be fully exploited at last.

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13 Higher ranges call for larger batteries. This would make the vehicles even heavier and thus less efficient. It would also make the battery block even more expensive (cf. for general information on battery concepts: Naunin 2007).

14 Series hybrids are also known as "range extenders", and the GM Chevy Volt – which, assuming Opel overcomes its current crisis, is scheduled to arrive on the European market in 2011 as the Opel Ampera – is based on this principle.

15 Gradually replacing conventional drive technology in this manner would be conceivable, the state of development permitting. This approach would not suffer from the classic chicken-egg problem (first hydrogen filling station infrastructure, then fuel cells, or vice versa). In terms of corporate culture, it should also not be underestimated that electrical engineers will not need to radically sweep aside the entrenched internal combustion engine technology and the mechanical engineers defending it. It will also provide more time in which to write off the billions in development costs that have been spent on internal combustion technology.

16 See Zimmer/Fritsche 2008: 8 ff.

2.2 Electric mobility – déjà vu or the base of a learning curve?

What does that mean for the chances of alternative drives and vehicle concepts? The unpleasant struggle over CO_2 emissions limits seems to have already been forgotten in the year 2009. The media are now abuzz with "green cars" that use environmentally friendly electric drive technology. Electric cars are being portrayed as the saviors of both the planet and the auto industry. Opel is betting its future on such vehicles, and even Abu Dhabi's stake in Daimler seems to be dedicated primarily to electric cars. The electric power industry is also on board. Virtually all major utility companies have announced the operation of small test fleets. In the spring of 2009, the German government also gave the green light and earmarked EUR 500 million from the second phase of its economic stimulus package for a full range of industrial, municipal and scientific activities. According to government forecasts, over one million electric cars will be on German roads by 2020. If RWE's predictions prove to be true, there will be no less than five million.

Creating jobs while doing something to save the climate – who could object to that? With intelligent grid management and the certified use of green power, electric cars would indeed be a big step forward in environmental terms and a major breakthrough in innovation policy: the internal combustion engines that have been used almost exclusively for the past 100 years convert the bulk of the energy stored in their fuel into waste heat, while an electric motor converts 95 percent of the power it consumes into mechanical energy[17].

Failed attempts at innovation

However, experience with radical innovation in automobile design mainly provides grounds for skepticism: the finite nature of oil and gas reserves did not just come to the world's attention during the high-price phase in 2008. The Club of Rome already pointed out the urgency of the problem in the early 1970s. The 1973 oil crisis then revealed the political dependencies that oil consumption entails for all to see when the German government banned driving on Sundays. Auto manufacturers then urgently initiated research and development projects. Daimler and Volkswagen even went as far as to establish an R&D company – *Deutsche Automobilgesellschaft* – to focus exclusively on designing electric vehicles. The prototypes, however, remained under tight wraps in the halls of the development departments. None of the new vehicles made it into mass production. The springtime of automotive innovation was indeed very brief.

17 The efficiency balance of internal combustion engines vs. electric motors is naturally influenced by the upstream electricity generation process. The greatest overall efficiency is attained when using green power. Using electricity generated by wind turbines, for example, reduces the CO2 emissions of electric cars to approx. 5g per kilometer. Yet even using electricity from a diesel-powered cogeneration system is over twice as efficient as burning the same fuel in the most economical diesel engine available.

The idea of electric cars experienced a renaissance in the late 1980s, when smog-choked southern California responded to the auto industry's many empty promises with a law that would require three percent of new vehicles registered in the most populous U.S. state to have an electric drive as of 1998. This triggered a long battle between the state government in Sacramento and representatives of the auto industry who wanted the law repealed or at least its enforcement postponed. The Clean Air Act nevertheless prompted General Motors to heights of innovation yet to be matched. The auto maker, which up to that point had had a relatively conservative reputation, took the lead in developing an electric car for the first time[18].

Meanwhile in Europe, Nicolas Hayek, the Swiss inventor of the Swatch wristwatch, was making the rounds of the leading auto manufacturers with the idea of an electric urban car. In short, his formula called for enough room for two people and a case of beverages, a colorful exterior, and integration with other modes of transportation in a mobility concept. He wanted to take the successful concept of the Swatch – simple, cheap and colorful – and apply it to the transportation market. Hayek received a mixed response from executives at Volkswagen and Daimler. After expressing initial sympathy, Volkswagen was not ready to depart from the fast, long-range sedan concept. Daimler was not convinced until its own development department had gradually evolved the initial Swatch Car idea into the Smart, a subcompact with a proper internal combustion engine, the usual range and a top speed of no less than 135 km/h. Little remained of the alternative drives in Daimler's Micro Compact Car (MCC) subsidiary, which has built the Smart in a dedicated factory in the Alsatian town of Hambach since 1997. The development of an electric drive was put aside with the start of series production.

The idea of mass-produced electric vehicles had thus been buried for the time being[19]. And for good reason – or so the auto industry claims: battery technology is still not up to the task of delivering the 500 to 700 km range typical of vehicles with an internal combustion engine. A variety of programs are in place to promote R&D so that electric vehicles might one day also cover long distances without charging stops, but this is likely to take many years and be very costly

18 With the EV1, General Motors developed a futuristic car that was available under an extremely costly lease from a very small number of selected dealers in southern California. With its claim to be faster and cleaner than conventional vehicles, the minor revolution soon faltered. Without a suitable charging infrastructure, the EV1 was like a fish out of water, unable to fulfill its promise of being a superior alternative to the internal combustion engine in the eyes of potential customers (cf. Shnayerson 1996).

19 Also not to be underestimated is the aftermath of a failed experiment in electric mobility on the German island of Rügen. In the early 1990s, a total of 60 electric vehicles – ranging from 3-series BMWs to tour busses – were tested there. The results were disappointing in every respect, leaving the skeptics thoroughly vindicated. The e-vehicle scene has since dropped from the public's attention. Nevertheless, the *Deutsche Gesellschaft für elektrische Straßenfahrzeuge* (DGES) still stages an annual convention which is popular among experts and covers the latest developments and research findings in the field (www.dges.de).

– an electric drive that emulates the performance of an internal combustion engine will always be more expensive by a factor of two, even when produced in large numbers.

The heralded world of e-mobility

Despite past setbacks and concepts lacking in technical performance, the high oil prices of summer 2008, the economic slump and the climate crisis have created opportunities for new vehicle concepts and alternative drives. The window for innovation has not been open this wide for a long time. After a lengthy phase devoted purely to optimizing the internal combustion engine, research and development related to alternative drives is now experiencing an enormous thrust forward.

Three major economic and technological forces are currently driving this new development.

1. Since 1997, Toyota and Honda have demonstrated that cars that rely partially on electric drives can be realized successfully in large-scale production. The decisive factor in this regard is the interaction between the internal combustion engine and electric motor used in all such vehicles, from mild to plug-in hybrids.
2. Progress in electrochemistry has yielded massive growth in battery storage density, significantly improving the ratio of stored energy to weight. A modern lithium-ion battery has several times the storage density of the lead-gel batteries that were still in use in the late 1990s.
3. Newcomers are entering the auto market with new vehicles. These include a sports car by Tesla, a Californian manufacturer, which is being built in small numbers and sold mainly to VIPs and a select few technology enthusiasts. With its impressive acceleration figures, the two-seater quickly achieved cult status. The durability of the Tesla – and especially the service life of its lithium-ion batteries – remains to be seen, however. The batteries must now demonstrate that they can remain functional over extended periods in practical use[20].

Since 2008, nearly all auto makers have given high priority to developing electric drives and performing field tests to determine their practical value and reliability. Daimler sent several dozen electrically powered Smarts onto London's streets to gain experience with the new drive and gauge the responses of their users. BMW is renting out over one hundred converted Minis in California and on the U.S.

20 The fact that Daimler acquired 10 percent of Tesla in May 2009 would suggest that it is currently the best the market has to offer, however.

east coast with the same objective[21]. The cars are also set to make their appearance on the streets of Berlin before the end of 2009. Public charging stations will be set up by then. As the new partners of the auto makers, the major utility companies – in the case of Berlin, RWE and Vattenfall – will be responsible for realizing them. Renault is working on a small production run of an electric car with quickly replaceable batteries for Better Place, a U.S.-Israeli company. The associated battery replacement stations are scheduled to be realized in Israel and Denmark in 2010. The stations will generate electricity using wind and solar energy to reduce dependence on fossil fuels.

Despite the new driving forces behind the electric car, a further setback could threaten it still, namely the completely unrealistic expectation of replacing cars with internal combustion engines 1:1 with vehicles with electric drives. The cost of an electric car with the same performance characteristics of a traditional fast, long-range sedan would be much too high for most users to accept. In any case, the initially high costs per unit could prevent a broad market with economies of scale and falling prices from ever becoming established. Such a conventional perspective also neglects the opportunity for a truly innovative partnership between the automotive industry and utility companies.

21 It should not be forgotten that a "long-term test" of electrically powered Citroen and Peugeot compact cars has been taking place in La Rochelle for nearly the past 15 years. It started in 1995 with 25 cars; currently, seven rental stations hire out a total of 50 electric cars in the small town on the French Atlantic coast. The vehicles also entitle their users to drive in the center of town, which is closed to conventional cars, and park there free of charge. Small-scale fleet tests of electric cars are therefore by no means new or spectacular. They have not received a great deal of attention over the years, however. Manufacturers have thus neglected to develop prototypes and build small preproduction runs for testing.

3 Automobility 2.0: The "green car" as an element of sustainable mobility

As important as electric drives and new post-fossil-fuel cars may be, concentrating on drive technology alone will not be enough to achieve a true paradigm shift. The space and noise problems in urban centers remain unsolved. The demands placed on modern, high-performance transportation systems are immense. Integrated systems that combine the strengths of a variety of modes of transportation while compensating for their respective shortcomings are the only perspective that offers adequate efficiency and flexibility. Transforming the automobile into one element of a comprehensive range of mobility options is crucial in this regard.

Partial solutions for integrating transportation systems have been realized in the past, including networks of busses, light railways, subways, trams and regional train services. Yet intermodal offerings that include cars and bicycles and which are marketed as a single seamless service are still in their infancy. Their chances have never been better, however, as demand is also undergoing a transformation. Public rental bicycles are currently experiencing a boom in the world's major cities. In Paris, users log over 200,000 rides a day on around 20,000 public bicycles. Even car sharing is slowly attaining the growth figures long expected of it after years of being shunned. Over 200,000 users are currently active in car sharing programs in Germany, while the U.S. can now boast well over one million organized members. Still missing, however, is *the complete integration of all modes* – offering transportation that is ubiquitous, clearly recognizable, immediately accessible, suitable for dropping off anywhere, and all part of a zero-emissions public transportation landscape powered by renewable sources of energy.

3.1 The integrated public vehicle in urban areas

In the past, the car has served as *the* private mode of transportation of universal utility. Designed for speed and transportation over short and long distances alike, cars have been built according to the template of the traditional fast, long-range sedan for more than one hundred years. The essential characteristics of this template have been used as a benchmark for all potential alternative drives. Many alternatives, including electric motors, have not lived up to it due to their

insufficient range[22]. If one does not attempt to use the traditional fast, long-range sedan as a standard, however, the electric car can certainly serve as part of an integrated transportation landscape. Such scenarios open countless potential uses for electric vehicles. The 50 to 100 km range that can be easily achieved at present would be quite adequate, making it unnecessary to drive the demands placed on battery technology to artificial, costly heights. The supposed technical handicap can thus be seen as a characteristic that invites integration, with the electric car becoming a further facet complementing the public transportation system.

How can electric vehicles serve as "integrated cars"? They can be very useful in regions not served by busses or trains. When operated with electricity from certified renewable sources, these vehicles provide quiet, comfortable and environmentally-friendly access to places beyond the reach of regular, route-bound public transportation services. Electric vehicles are ideal for deployment in such situations, their technical range limitations making them a perfect fit for a comprehensive transportation system.

Like busses and trains, public electric cars would be accessible to virtually anyone. They would be available at public parking lots and public transportation hubs. For example, Paris intends to follow the successful introduction of its *Velib* bicycle fleet by issuing a request for proposals for a public car fleet consisting of several thousand electric vehicles. Modern car sharing technology would grant easy access to the vehicles using a card or cell phone. With its Car2Go program in the German city of Ulm, Daimler is testing a new car sharing concept – albeit currently with a fleet of conventionally motorized Smarts – in which the cars are billed by the minute and can be dropped off anywhere in town[23]. The cars can be used at any time without advance booking and can be returned in any free parking space. Additional terms would apply for electric vehicles in car-sharing fleets: cars would remain locked if their charge level is critical, and the maximum booking period would limited to 48 hours, guaranteeing wide availability.

Electric cars with a range of 100 km are therefore not a technical problem, but virtually a precondition to solving serious public transportation problems. It would be essential for such systems to develop a comprehensive product range. A single card could then provide equal access, use and billing for the full range of electric public transportation services – including city busses which are currently powered by internal combustion engines. At the same time, the system can satisfy the desire for modern, high-performance individual transportation. It therefore seems strange that public transportation companies did not begin promoting the introduction of such vehicles much sooner. From that vantage point, the electric

22 Electric cars with limited ranges have been used in niche applications for some time, however. Experience has shown that not a potentially long range, but the reliability of the specified range is the decisive factor. If a vehicle promises a range of 80 or 100 kilometers, then they must be available, even in cold weather or if the route involves long uphill sections (cf. Knie et al. (1999).

23 See http://www.spiegel.de/auto/aktuell/0,1518,624828,00.html

car is a domesticated version of modern automobility: an attractive complement that does not compete with – and certainly does not cannibalize – other modes of transportation.

This world of mobility appears quite unlike anything that has gone before, with entirely new options arising when utility companies, public transportation authorities and the auto industry join forces. New transportation services with significantly reduced emissions that previously did not even exist in niches – including electric cars – become feasible. This presupposes a change in perspective, however. The focus must not only be on the new drive, but also on comprehensive mobility concepts for urban regions. A wealth of technical and product innovations are conceivable – not only at the technological level, but also in lucrative supplementary services and genuinely groundbreaking new applications. E-mobility is more than simply providing attractive electric cars and an adequate number of clean charging stations. The value creation of intermodal urban e-mobility encompasses the vehicle hardware itself and the integration of its infrastructure into the cityscape, as well as traffic services and the provision and storage of energy.

New industrial partnerships

Good, pragmatic reasons speak for the intermodal e-mobility concept proposed here. Yet this complex innovation path will be anything but a self-starter. It will be necessary for extremely diverse cultures to cooperate closely. Partnerships will be required that will not be able to draw from previous experience. The greatest hurdles for realizing the mobility concept including electric cars outlined here are not primarily technical, but are related to differences in organizational structures and cultures of innovation: Industries that have not done so in the past will need to communicate with one another and adapt their business development.

It must be quite clear that the consequences of the path proposed here to attaining tomorrow's mobility are not trivial. The centrally involved industries and the companies within them which operate according to rational business principles must be open to new relationships that will require a certain degree of initial coordination. At the same time, however, those partnerships will generate new opportunities and business fields:

- *Auto industry*: Auto makers must let go of the concept of the universal car. Its value creation will shift from manufacturing cars and offering financial services to its customers to providing comprehensive mobility services. Already before the current crisis, the financing arms of the German manufacturers Daimler, Volkswagen and BMW contributed up to 70 percent to the consolidated results of their respective groups. It has not been possible to make money with building cars alone for some time now; financing their sales has become the cash cow. This idea is not new: in the early 1990s, Daimler-Benz was already referring to "seat kilometers" as a product it intended to sell in future. The seat kilometer is a label for a mobility service that is no longer

tied to a specific vehicle. Auto makers will continue to build and sell traditional fast, long-range sedans. Outside of urban areas, resource-optimized internal combustion engines with low emissions will remain the de facto standard. In future, however, such conventional business will depend on successfully catering to the leading market for modern mobility in urban areas. In other words, The auto makers will continue building cars in future, but will increasingly sell them in an intermodal package.

- *Public transportation companies*: The transformation in this sector will also be profound. Public transportation companies will need to supplement their traditional offerings with new service modules. In Germany they will no longer be able to blame their unwillingness to innovate on the tight restrictions of a public transportation law dating back to 1934. Competition over operating concessions – which may be profitable, but stifle innovation – must also become a thing of the past. In addition to trains and busses, public transportation companies will also operate car fleets and public bicycle systems. At the same time, this will mean devoting more attention to their customers and their increasingly differentiated needs. Such a transformation in services and customer orientation will not be possible without cooperating closely with the automotive industry – an old competitor – as well as public utility companies and the IT sector. Public transportation companies would thus take big steps away from their sheltered existence as public service providers and toward a future in which they cater much more to the demands of their customers.
- *Utility companies*: Interest in new sales opportunities and business fields is the driving force behind the e-mobility activities of utility companies. They also anticipate greater flexibility and a wider range of options for smart grid management. Such decentral power generation and supply increases grid management requirements. Higher shares of renewable energy, especially the peaks to be expected from offshore wind turbine systems, call for additional storage that can also serve as a load management buffer (vehicle-to-grid)[24]. At the same time, new tariff philosophies and business models will be required. The use of electricity from renewable sources is reinforcing the trend toward merging energy and transportation networks. The energy sector will depend on the expertise of the transportation sector in this new field, and specifically also on the technical components of e-mobility. It cannot serve the transportation market by itself and needs to partner with the vendors of electric transportation technology.
- *IT industry*: While the IT sector is not the most important player in the new alliance for future e-mobility concepts, it is nevertheless essential as an inter-

24 This refers to batteries being charged during power generation peaks or at times of low overall demand. Ideally, they would also be able to return power to the grid. Car batteries would thus become an element of the intelligent load management that will become increasingly important as the share of electricity from renewable sources grows. Considerable uncertainty still exists in this respect, however, as it would subject batteries to frequent charge and discharge cycles.

disciplinary technology. Integrating multiple modes of transportation and efficient load management will call for extensive deployment of information and communication technology. In the same way that the Internet is well-suited to mapping the "smart grid" right down to its most finely branched structures, mobile communications combined with positioning and network access technologies such as WLAN are economical prerequisites for integrating various modes of transportation in a customer-friendly manner.

3.2 The regulatory framework for tomorrow's mobility

As an element of sustainable transportation concepts, the "green car" will need a suitable framework to help it become established on the mobility market. At this point, the government will be needed to prompt the market and its actors to choose ecological solutions through regulation and incentives.

The "green car" needs rules

Despite the opportunities available for better integration of modes of transportation, the car will remain the dominant mode in Germany in the medium term. We therefore need legislation to improve the ecological soundness of conventional cars. At the same time, we also need a framework that strengthens public transportation as a central element of intermodal concepts. Primarily, that will require:

- *Strict emissions standards*: Consistently-applied emissions standards are essential to promoting greater dynamics in the mobility of the future. Ambitious emissions limits and strict quotas for fuel consumption and pollutants ("zero emissions") are powerful stimulants for innovation. Sustainable industrial competitiveness has been strongest wherever limits and environmental standards are the strictest. That applies all the more when the internalization of external costs of environmental and resource consumption is pursued with greater consistency. Strict environmental regimes are therefore, as a rule, successful innovation regimes. Now that China – and after some delay, the United States – are entering this global race for efficiency and thus innovation with ambitious national emissions standards, it has become all the more important for Germany to assert a leadership role within Europe. Traditional pollutants have been reduced dramatically since the 1980s thanks to strict emissions standards, and now regulation will be required to address the problems of noise and CO_2 emissions, as well as the long-term issue of particulates, in the coming years. A gradual tightening of the standards already adopted at the European level will be essential for environmental and public-health reasons, and also in the interests of fostering innovation. The next European CO2 standard in the year 2020 must therefore be significantly more ambitious than the limit for 2012, which was eased and delayed several times.

- *Internalization of external costs*: The pivotal issue for promising innovation policy related to transportation is the gradual internalization of previously-external costs. This includes using an eco-tax – possibly modified as a carbon tax – to put a price on damage to the environment. It would also require making users bear the costs related to infrastructure use. This could be realized via general road tolls based on precise distances traveled, or by universal parking charges.
- *A new regulatory and competition framework for public transportation*: The transition to user financing of public transportation is also an important step toward an effective regulatory framework. Experience in financing public transportation has shown that flat subsidies such as those realized via the regionalization funds of the German *Länder* result in "local public transportation as ordered", but not necessarily better customer orientation. The main clients for local transportation services are currently the public authorities, which guarantee them exclusive rights to adequately manage a "service area" over long periods. User interests only play a role in such situations if the client is aware of them and formalizes them in the regulatory framework. This is only the case in rare exceptions, however. As long as the client orders transportation kilometers and pays well for them, the service provider has no incentive to offer innovative transportation services. The relevant regulatory framework defined in Germany by the Passenger Transportation Act (*Personenbeförderungsgesetz*, PbfG) and General Railways Act (*Allgemeines Eisenbahngesetz*, AEG) still considers public transportation to be primarily a matter for the government and gives local and regional authorities the exclusive right to define service offerings.

Successful innovation will require strict emissions limits, the transition to user-financed transportation services and a completely new regulatory and competition framework for public transportation. Only then will it be possible to balance public interest with the intrinsic motives of business.

"Green mobility" as an object of support policy

In addition to defining suitable regulatory and competition frameworks and monitoring compliance, the role of the state here is to establish suitable incentives through support measures. Experience gained with the German Electricity Feed Act (*Energieeinspeisegesetz*, EEG), in which long-term and calculable market launch assistance resulted in the accelerated establishment of a new industry, is central in this regard. Measures to promote the introduction of Automobility 2.0 would be conceivable at a number of levels:

- *At the municipal level*: Municipalities and communities have a resource that they have often not exploited fully, which they can leverage to enable and support green mobility projects – public space. Integrating cars as a transportation service requires, above all, public parking spaces and a public charging

infrastructure. Communities thus have an important instrument with which they can vigorously promote the cooperation of vehicle manufacturers, utility companies and local public transportation authorities while actively shaping the urban planning aspects of the project.

- *At the* Länder *level*: The *Länder* receive federal regionalization funds and have a relatively free hand in determining how those funds will be spent on regional transportation projects. A number of options would be conceivable within the framework of relevant EU regulations and federal laws for creating spaces for entirely new entrepreneurial possibilities. As budget constraints due to increasing public debt are likely to make the annual EUR 7 billion in regionalization funds untenable, those funds should be earmarked for new uses as soon as possible. A conceivable first step would be to require both integrated mobility elements and the use of energy from renewable sources by law.
- *At the federal level*: Under pressure to provide an economic stimulus, the German federal government has launched a request for proposals for integrated transportation models at the municipal level. At this point, however, the various support programs still need coordination and measures to ensure that their benefits are mutually reinforcing. This will require a roadmap or Automobility 2.0 master plan to integrate industrial and innovation policy components into a future-oriented program for public transportation. Its central element would be a market incentive program for e-mobility to compensate for technology-specific additional costs during the market launch phase. Germany's 100,000-roof solar electricity program and renewable-energy legislation – which offers degressive support as green energy gradually reaches market viability – could serve as models for such a plan. On the other hand, simple purchase incentives – such as Germany's cash-for-clunkers program designed to promote the replacement of cars older than nine years with new models – are completely counterproductive. Such measures merely perpetuate supply structures that are in need of reform.
- *At the EU level*: Impulses for a paradigm shift in transportation and innovation policy can also be provided at the European level. A green mobility initiative modeled after the Joint Technology Initiatives – and which would take the actual requirements of the actors even more closely into account when allocating funds – could be set up within the context of European research support.

A wide range of initiatives are also conceivable that would fall under "ecological procurement". Procurement regulations at all levels can – and should – be designed to establish the most efficient technology as the minimum standard that must be observed for all public purchases. Public procurement is also an instrument that can be wielded creatively. An incentive effect can be generated by invitations to tender that define efficiency requirements beyond those currently available that, if attained, would result in a guaranteed minimum purchase (technology improvement by tendering).

It is therefore essential to use the tendering process more effectively to establish sustainable transportation services. Procurement policy is already being used as an instrument to that end in many places. In London and Paris, for example, preparations for public requests for proposals for both public bicycle and automobile systems are currently in advanced stages.

3.3 The next steps

The trends outlined in this paper will be difficult to address for the worldwide auto industry. Yet the industry cannot continue as it did in the past. It needs a new orientation and partnerships that will be unfamiliar to it. That will not be simple for an industry that operates in long, inflexible planning cycles. It will be especially difficult for German car makers because of their unique record of success. German manufacturers have succeeded in steadily enhancing their positions in the world's automobile markets over the past decades and have profited from the traditional image of the fast, long-range sedan. German cars have a reputation for high quality and technical maturity.

Despite its increasingly challenging overall situation, decisions about the future direction of the automotive industry have therefore not been made at this point. Every movement toward the outlined trends and each new project initially generates costs that need to be legitimized vis-à-vis existing program lines.

Will the alternatives be capable of generating the necessary profits? Are threats to the conventional lines truly substantial and do the forecast developments actually jeopardize the viability of the traditional business model? Those are the questions that are currently being debated hotly at various executive levels of the car makers. Strategic decisions have not yet been made; without the appropriate incentives and regulations, there has not been the necessity. The danger of ending up with undertakings that merely provide the industry with an easy way out – such as the Rügen project of the 1990s – is still very real. However, the difference to earlier years not only lies in the inevitably higher sensitivity to the consequences of climate change, but also in the fact that with the public utilities and public transportation companies, two other major industries have discovered the topic for themselves. This "coalition of the willing" will nevertheless require external reinforcement. In that regard, it will be necessary to continue applying existing regulatory pressures. Restrictions on the functional space of conventional cars must be applied consistently and the commitment to using energy from renewable resources must remain high. Changes in the competitive situation have made winning new customer groups a strategic goal for public transportation operators. This must not be undermined by issuing long-term concessions guaranteeing them a comfortable business outlook.

Making Automobility 2.0 a reality will call for a master plan coordinated between relevant government ministries that uses a mixture of support and regulation to provide the industry with a consistent framework for the long term. Furthermore, meshing various industry interests and ensuring that the develop-

ments are followed by a critical public will ensure that the process becomes irreversible. If public utilities, the auto industry and public transportation companies become interdependent and carefully monitor their new alliances, a truly new basis will have been established.

The tipping point, after which the development becomes stable and intrinsic, has not yet been reached, however. Public pressure to actually realize the announced transformation must be maintained. As plausible and vital as the heralded trends may be, a new Automobility 2.0 will not simply drop into our laps.

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The production and sales figures of the auto industry plunged dramatically during the first quarter of 2009. Yet the current automotive crisis is not merely the result of an economic downturn. It has revealed structural flaws within the industry itself. Climate change and dwindling fossil fuel resources, but also evolving mobility requirements in urban areas call for different cars – and a different kind of mobility. Integrated transportation systems that combine the strengths of a variety of modes of transportation while compensating for their respective shortcomings will be the only perspective for adequate efficiency and flexibility. Transforming the automobile into an element of a comprehensive range of mobility options is crucial in this regard. Mobility researchers Andreas Knie and Weert Canzler have produced a strategy paper on behalf of the Heinrich Böll Foundation analyzing the current crisis and outlining their vision of the "mobility products of the future".

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