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Fully electric free-floating car sharing – challenges, chances and solutions identified by car2go with Stuttgart, Amsterdam and Madrid as examples

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Abstract

One-way carsharing pioneer car2go is managing fleets with hundreds of purely electric vehicles since more than five years. Today car2go operates purely electrical fleets in three cities with 1,400 vehicles. Fully electric one-way car sharing poses special challenges for operators as well as cities and other stakeholders. Based on its experiences, car2go has developed two fundamental solutions for its fleet management: On-street charging and hub charging.

Urban mobility concepts, mobility as a service (incl. electric car sharing), fleet management

1 Fully electric free-floating car sharing: Challenges and chances identified by the pioneer and market leader

car2go is the market leader and pioneer in free-floating car sharing and operates the biggest fully electric car sharing fleet worldwide. Today, car2go operates purely electrical fleets in three cities with 1,400 vehicles. Based on over-5-years experiences in managing such fleets in even more cities worldwide, car2go was able to identify central challenges, chances and solutions. These unique, first-hand insights are summarized in the following sections.

1.1 Electric carsharing improves quality of living within cities

Electric car sharing has great benefits for cities and their inhabitants: Purely electric car sharing fleets improve the air quality in city centers significantly [1]. With tightening emissions targets the urge to take appropriate measures to improve air quality rises significantly. Therefore electric mobility increasingly becomes an important component in cities' emission reduction strategy. Hence, governments and cities are already encouraging and promoting electric mobility and appropriate incentives while increasingly imposing restrictions for vehicles with conventional drive systems, such as temporary or permanent traffic bans. Electric free-floating car sharing can also have advantages for the car sharing operator – for example, in respect of municipal parking regulations, taxation, fuel savings and other operating costs of the vehicles. Given these benefits the question rises, why the adoption rate of electric vehicles is still fairly slow. The special challenges for car sharing operators as well as cities and other stakeholders are investigated in detail in the next section.

1.2 Charging infrastructure expensive and therefore missing

As with most innovations, electric mobility and electric carsharing in particular faces many new challenges. Limited ranges, long charging and downtimes, insufficient charging infrastructure any many more aspects come to mind, resulting in higher personnel, time and financial expenditures for fleet management in comparison with conventional vehicles. In the following two main aspects are identified and discussed.

On the one hand, electric vehicles are very costly compared to a similar combustion engine vehicle. Although electric vehicles are more efficient and electricity is cheaper than fossil fuels required for driving the same distance, the high initial costs still lead to a higher Total Cost of Ownership (TCO) for electric mobility. However, further decreasing battery prices are expected to narrow the gap in future. When exactly this tipping point is reached is subject of intense discussion and a great uncertainty within the automotive industry.

On the other hand, the unsatisfactory charging infrastructure in most cities, with only some exceptions is a big challenge. This is a great hurdle, both for private car ownership and carsharing. The reason for the reluctance of investments in charging stations is its small financial attractiveness from a return on investment point of view. The utilization of charging stations is usually too low to generate profits. Compared to a combustion engine vehicle, electric vehicles have significantly lower ranges and longer fueling or charging times, respectively. The fastest charging vehicles on the market today have charging rates of just over 1 C, which means a full recharge takes almost one hour. Therefore at most, 24 full charging operations can take place each day. Experience shows however, that this is not realistic and therefore not achieved, as it would mean seamless consecutive charging operations, even during night. Assuming a more realistic 12 % effective utilization, the time a vehicle is actually charging and not just blocking a charging point, a 22 kW AC charging station can sell ca. 63 kWh per charging spot each day. Also assuming a EUR 0.05 margin per kWh, a charging spot can generate ca. EUR 1,150 per year per spot, and 2,300 per station, respectively, as today's common charging stations have two outlets. Since a 22 kW AC charging station approximately costs EUR 10,000 in hardware and installation costs plus yearly maintenance and other operating costs, an amortization period would be more than four years. Financially this seems not very attractive, especially when also considering the omitting of parking spaces for non-electric vehicles and the thereby generated parking revenues. While fast charging stations with higher charging power can generate higher revenues, it must be noted that they also have far higher investment costs. Therefore a separate analysis of different types and stages of charging power might be required, which is not part of this analysis.

The relevance of electric carsharing will arguably grow further in the years to come, due to the importance of low emission mobility solutions. car2go has early invested and moved in this direction, making it the global leader in free-floating electric carsharing. Insights from the broad experiences in facing the given challenges as well as suggestions are formulated and discussed in the following chapter.

2 Fully electric free-floating car sharing at car2go

car2go is the market leader in the free-floating car sharing sector and is a wholly owned subsidiary of the Daimler AG. With the car2go car sharing concept, smart fortwo and Mercedes-Benz vehicles can be rented anywhere and anytime at affordable per minute prices. The vehicles can be found, booked, opened and paid for via smartphone app. The car2go car sharing service has been operating since 2008. It is internationally available in 26 locations in Europe, North America and Asia. Purely electrical fleets with a total of 1,400 smart fortwo and Mercedes-Benz B-Class electric drive vehicles are available today in the three cities; Stuttgart, Amsterdam and Madrid. Hence, car2go ensures that the electric mobility experience is available to an ever increasing number of people: In the three locations, car2go has 300,000 customers who thus come into direct contact with electric mobility, thereby overcoming their inhibitions and become enthusiastic about the new driving experience. Catchphrase: "learning by driving". This has led to more than 10,000 electric rides each day, and more than 60 Million electrically driven km in total as of today.

Relying on practical experiences and exclusive insights with electric car sharing fleets in six cities in North America and Europe, car2go developed two fundamentally different solutions for the management of the purely electrical fleets in its current fully electric locations Amsterdam, Stuttgart and Madrid. Whilst in Amsterdam and Stuttgart both the service personnel and the members can recharge the vehicles at publicly available charging stations ("on-street charging"), Madrid has charging stations which are not open to the

public ("car2go hubs") and can only be accessed by the service personnel from car2go. Both solutions are described in more detail below.

2.1 On-street charging: Stuttgart and Amsterdam

In Amsterdam, the car2go fleet currently comprises 350 smart fortwo electric drive vehicles. Stuttgart's fleet has 550 such vehicles. These vehicles are charged at public charging stations which are also available to other electric vehicle owners. In Amsterdam's business area, there are around 650 charging stations offering 1,300 charging points, in the Stuttgart business area there are approximately 350 charging stations with 700 charging points available with 22 kW AC (semi-fast charging) each. In Stuttgart, the state capital authorities commissioned the energy supplier EnBW to install the charging infrastructure whilst in Amsterdam, the city authorities carried out the installation themselves.

The vehicles in Stuttgart and Amsterdam are charged both by the car2go service employees and the members themselves. Members receive suitable incentives to motivate them to plug the vehicles onto a charging station after use – for example, in the form of free minutes should the charge status drop below a certain level at the end of the rental period.

2.2 car2go hubs: Madrid

In Madrid, car2go operates a very different and innovative model. It operates its own charging stations, which are not open to the general public, providing a total of 45 charging points with 22 kW AC (semi-fast charging). At these so-called "hubs", the vehicles are not only charged, but also cleaned and serviced at the same time. The charging of the vehicles is therefore only carried out by service employees, while car2go members are not involved in the charging process in any way.

2.3 A comparison of car2go hubs and on-street charging

Both systems are very different in their setup and operation and therefore have different advantages and drawbacks. An overview of success factors and challenges identified by car2go in the past years are listed in Table 1.

Table 1: A comparison of car2go hubs and on-street charging

	On-street charging	**car2go hubs**
Success factors	Density / walking distance	Fast-charging infrastructure
	Distribution / locations	Fast-charging vehicles
	Availability / accessibility	100% exclusive hubs
	Parking rules enforcement	Locations / accessibility
	Technical functionality	Synergies in operations
Challenges	Enticing customers to charge	Personnel costs
	Legal basis / political will for parking rules enforcement	Identification and contracting of suitable hubs

The two approaches show fundamental differences during setup and operation. From an initial investment point of view, the on-street charging approach has one great disadvantage compared to the hub model. The required investments in public charging infrastructure are rather high in this case. With several hundred required charging stations of ca. EUR 10,000 each, the upfront investment quickly reaches millions of Euros. For the same number of electric vehicles, the investment necessary for the handful number of hubs is significantly lower. This can be reached via a high utilization rate of each charging spot over 50%. On the operational side however, the hub model has great disadvantages. Since customers cannot charge the vehicle themselves when ending a rental, a service team has to perform the charging tasks. Each time a vehicle is empty, a service team member has to approach the vehicle, bring it to a hub and redistribute it across the city once charged. This leads to high personnel costs compared to the public charging system, where car2go members can charge the vehicle, receiving an incentive for doing so. Finding an economical and sustainable solution is the next step to make electric carsharing competitive compared to non-electric carsharing. car2go already has identified and implemented measures to do so, which are described in the following.

2.4 Carsharing as an efficient transition into the new world of electric mobility

With the great experience in operating fully electric car sharing fleets, car2go can be an important partner for cities for the market penetration of electric mobility. The knowledge from the actual mobility behavior of its carsharing fleet, it is possible to identify when and where the demand for mobility occurs. Thereby grounded advice can be given to cities in the selection of optimal locations for charging stations. This enables optimal utilization of charging stations, overcoming the previously stated challenge of financially unattractiveness of investments in public charging infrastructure. car2go has created a simulation model that identifies the amount and location of minimally required charging stations, suitable for good operation. It has already successfully advised cities in this regard.

As an example the required charging stations in car2go's operating area of Hamburg for a fully electric fleet is calculated. In this case further ca. 300 charging stations are required in addition to the 250 existing charging stations. The exact locations can also be identified as seen in Figure 1.

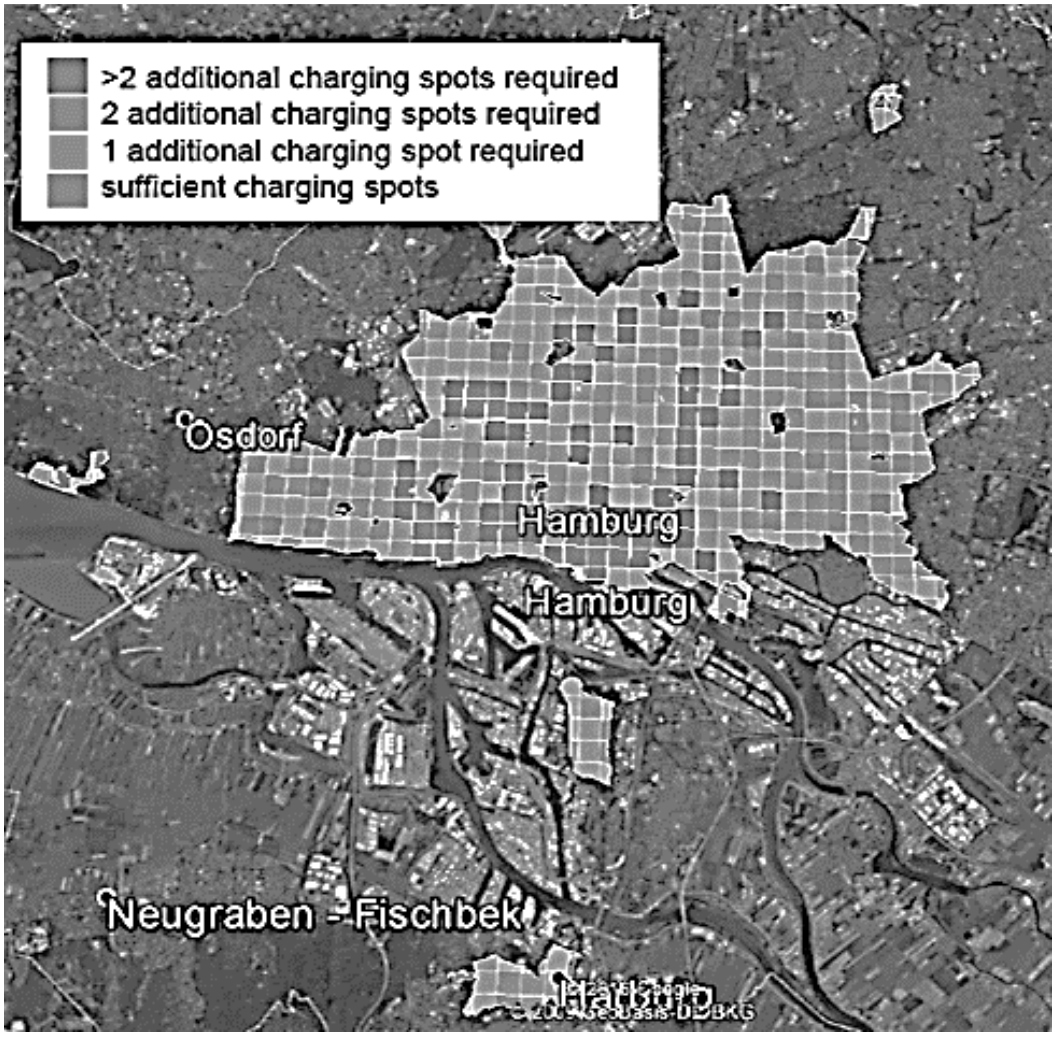

Figure1: Simulation results for Hamburg optimal charging infrastructure

Thereby, a sustainable expansion of the charging infrastructure can be achieved, as this enables the highest possible utilization of charging stations, increasing the financial returns for the investor. This subsequently also benefits other owners of electric vehicles. By expanding the charging infrastructure, providers such as car2go thus help overcome the widely cited "chicken-egg problem".

In future a parallel approach of both systems is also possible. Not every city is willing or able to invest in public charging infrastructure as Amsterdam did for example, in particular today when electric vehicles are still in a niche. Nonetheless, already a small amount of public charging stations can have a great impact on

the operation, if placed in optimal locations according to the simulation. This allows a gradual transition towards electric mobility with the help of electric car-sharing. Thereby the amount of hubs decreases while the amount of public charging stations increases over time.

3 Perspectives: The future of free-floating car sharing is fully electric

Electric carsharing will be an important part in the transition towards a low emission mobility solution. As an early adopter character, carsharing can lead the path to efficient implementation. The great amount of experiences and insights rapidly generated with many customers enables quick learning and adoption. In particular in the implementation of optimal charging systems, cargo's approach and simulation models can give important advice for cities and investors.

This will be increasing relevant as cities worldwide benefit from car sharing and will not be able to do without it in the future: According to The World Bank [2], approximately 1.5 times more people will live in cities by 2045 than today – that is a total of six billion people. Mobility with private cars with conventional drive systems has now already reached its limits in cities with traffic jams, lack of parking spaces and pollution being the result. Growing urbanization, progressive digitalization and the desire of the younger generation to use rather than own ensures that car sharing is already growing rapidly and will continue to grow. Today, about every 1.3 seconds one of the over 2 million car2go members starts a rental with one of the 14,000 car2go cars around the globe – with numbers still rising. And this is just the beginning: A recent study by the Frost & Sullivan management consultancy [3] even predicts that the number of car sharing users worldwide will increase five-fold from the current 7.9 million to 36.7 million by 2025.

Fully electric car sharing fleets will be a central, sustainable part of mobility in the future and improve the quality of life in cities all over the world. As the pioneer and market leader in free-floating car sharing, car2go will continue to pave the way and is glad to share its unique, first-hand insights from lost-lasting experiences in different locations around the globe with cities and experts and the EVS30 Symposium

References

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Authors

Thomas Beermann became managing director of car2go Europe GmbH in 2013. Since then, he has been responsible for the entrepreneurial leadership of the world's largest station-independent car sharing provider, which currently has 14 locations in Germany, Italy, the Netherlands, Austria and Spain. Thomas Beermann studied business administration at the University of Paderborn. Before starting at car2go, he worked from 1994 to 1997 in the financial consultancy sector and from 1997 to the end of 2012 for Europe's biggest car rental company, Europcar, as a product manager, regional manager and lastly as director of strategy and business development

Thorsten Sobe is working for car2go since 2016 in a cross-divisional function as an expert for electric mobility as a Business Development Manager. Before, he was a doctoral candidate in the Powertrain Strategy for the Daimler AG. Prior to his doctoral studies at the École Polytechnique in Paris, Thorsten Sobe completed his industrial engineering degree at the RWTH Aachen and Imperial College in London.