Edition 3 | 2022

# SWAP

A Newsletter by INFRADianba

CAR Symposium, Source: ©INFRADianba

Battery Swap Taxi, Source: ©INFRADianba

Dear Readers,

On June 6, 2022, the EU Parliament decided to ban new registrations for internal combustion vehicles in the EU starting 2035. Since the maximum level in global temperatures of 1.5 degrees Celsius, as set by the WMO in Paris in 2015, has now been forecasted for 2026, this decision seems compelling. Unfortunately, climate change is not geared to the schedules and interests of our species.

In 13 years, the mobility turnaround must be tackled at its core – the focus needs to be on infrastructure and vehicles.

The VDA has long known that there will be no sufficient plug-in infrastructure in Germany by 2035. But that is no drama if we rethink now!

We still have more than 12,000 service stations, almost all of which - in addition to the charging piles - can be quickly converted to battery swap 4.0. It enables e-mobiles to receive a freshly charged battery within 20 seconds. Brand-neutral, battery and grid protecting. With up to 1,000 swaps per day, a throughput of 50 MWh and more can be achieved. This ensures large user numbers, high power purchase discounts and hidden storage reserves for small battery storage power plants in the service of the smart grid. Yes, with battery swapping, 2035 as a caesura is a solvable, future-proof task.

Prof. Dr. Dieter Flämig and Alexander Yu Li
Founders of INFRAMobility-Dianba GmbH

## IN THIS ISSUE

# EU Parliament decides to phase out combustion engines

European Parliament, Source: ©shutterstock, Leonid Andronov

We believe that nobody thought of this in Paris 2015! The Paris climate agreement had the goal of permanently stopping the global temperature rise at 1.5 degrees Celsius in the following decades - with 2 degrees Celsius as the final firewall.
Rises above 2 degrees, as Nobel laureate Prof. Schellnhuber warned, would be the "no-go zone for humanity from a climate scientific point of view", the zone of irreversible tipping effects for all the main climate guarantors of our highly sensitive biosphere.

Now, however, the UN weather organization WMO reports that there is a 50% probability that the 1.5 degree Celsius target will be exceeded as early as 2026. The 2 degrees firewall is thus already in sight! Changes in the jet stream, El Niño, monsoon, polar ice, coral reefs, rainforests to the thermohaline circulation of the Atlantic and methane seeps in oceans and from permafrost soils are signaling with increasing intensity the rapid approach of a global climate catastrophe.

The EU Parliament's decision of June 6, 2022 to ban internal combustion engines in new passenger cars and light commercial vehicles from 2035 onwards must be seen against this background of urgently needed greenhouse gas containment. This decision is intended to reduce the CO2 emissions of newly sold vehicles in Europe to zero. The European economies and mobility companies now have 13 years left to finally reduce the high contribution of "fossil-fueled" mobility to the greenhouse gas problem (up to 20% of the total burden) in a way that has an impact on the climate.

Can 2035 be achieved? Our answer is: Yes, if the automotive industry and politicians everywhere now follow suit and do not unilaterally rely on completely new charging infrastructures, which technical progress has already exposed as being too slow, too complicated, too expensive and too bureaucracy-prone in comparison.

We are convinced that the acceleration of the mobility-related energy turnround must take place at the following levels:

- Conversion of existing service stations to service stations offering battery swap, storage plug-in and hydrogen refueling, instead of relying on millions of charging piles and the nationwide expansion of local networks (900 local networks in Germany alone).

- Expansion of these service stations to energy storage stations for the smart grid instead of the unproductive construction of 2 battery worlds for mobility and grid.
- Open mind of Europe's top 10 car manufacturers for a 4-building block concept: battery swapping with dual use, plug-in and hydrogen refueling. In Asia, we already partner with BP and SINOPEC; 18 OEMs use battery swapping, 16 of those use the Aulton/INFRADianba technology.

## Follow-up CAR Symposium 2022 in Bochum

The INFRADianba team had the opportunity to personally present the great potential of the battery swapping technology to a very experienced audience of experts at the CAR Symposium of Prof. Dr. Ferdinand Dudenhöffer in Bochum (31.05.-01.06.2022).

On the 2nd day, VW CEO Herbert Diess presented the mobility turnaround concept of his company. When asked by Prof. Dudenhöffer about his interest in the battery swapping technology of INFRADianba he answered that VW observes the topic with interest but was currently focusing on 4-minute fast charging. Also with reference to this INFRADianba stated in its follow-up: "The 20 seconds battery swap in INFRADianba stations is not only faster than any plug-in, but may be the key to solve the storage problem of the German smart grid (100 GW in 2050), to quadruple the battery life before 2050 and to save more than 350 000 t of lithium p.a. nationwide before 2050. By decoupling battery placement and recharging, we can achieve a battery life of 20 years or more, taking into account certain "adjusting screws".

In our presentations, we were able to demonstrate that our approach can ensure the highly efficient integration of the two systems of mobility and energy supply. We see express battery swapping as a central component of future dual service station concepts: normal e-service stations can be additively transformed into energy stations or hubs of a flexible and decentralized renewable energy supply infrastructure.

Battery swap stations with 1,000 swaps and 50 MWh of energy supply per day have sufficient silent reserves, in order to ensure, together with a smaller auxiliary storage unit, the operation of coupled battery power plants (10-20 MW).


CAR Symposium, Source: ©INFRADianba


CAR Symposium, Source: ©INFRADianba

With such 10-12,000 energy stations for mobility and grid could fully cover the future German electricity storage demand (up to 100 GW with more than 1000 TWh electricity demand p.a.). They do not need any complicated site planning but can be installed at proven locations through a renewing of the service station network.

We would like to thank Prof. Dudenhöffer for the invitation and thank the participants for their interest in our pilot e-taxi (MG SAIC) and for visiting our booth on site!".

## Battery swap for a logistics of sustainability

Logistics is the science that helps us optimize flows of persons, resources and information. Sustainability is the term that reminds us that this optimization must not take place at the expense of the natural balances, which are also vital for us, and future generations.

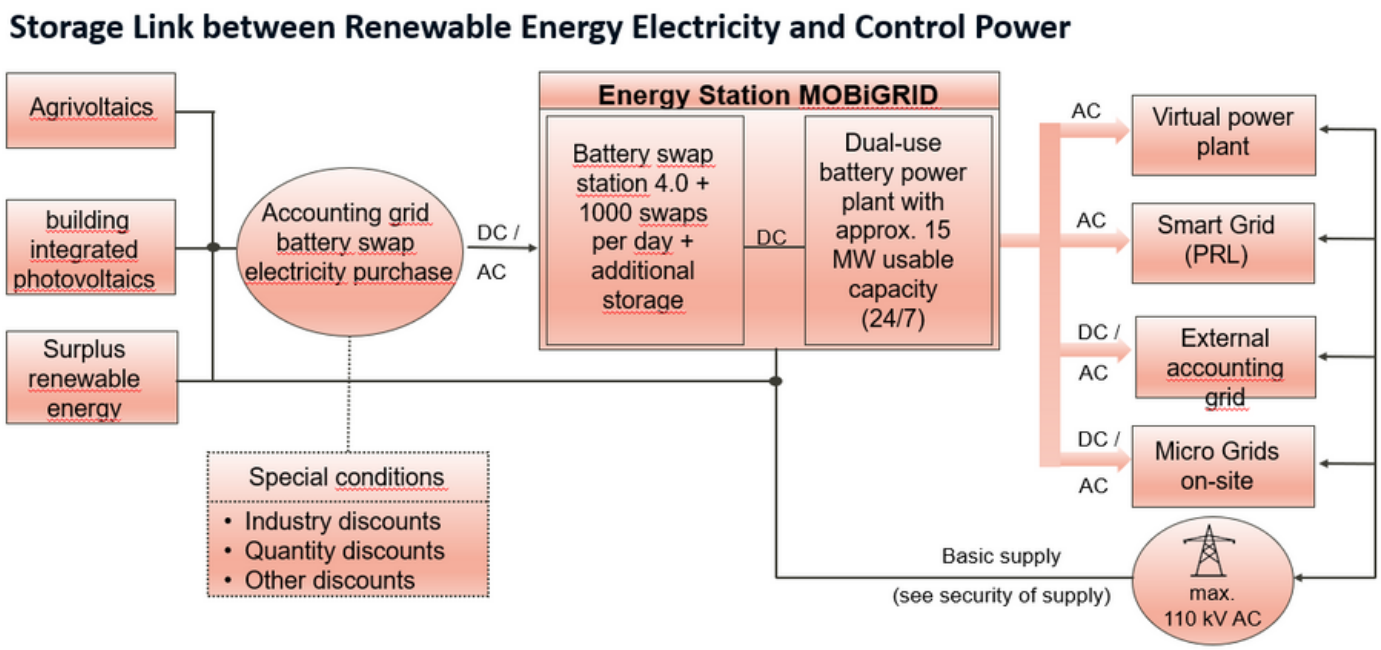
INFRADianba's battery swapping, in combination with renewable energy purchasing through price minimizing balancing groups and with battery power plants for primary control power and peak shaving, is the Archimedean point for a fast, efficient dovetailing of mobility and energy turnaround, for a logistics of sustainability. Specifically, this implies:

- For instance, in Germany, the existing service stations simply need to be equipped with battery swap stations (10 kV connections); the time- and resource-consuming renewal of the 900 local networks and the installation of up to 30 million charging points is largely unnecessary (complexity reduction: factor 3,000).

- With battery swapping, e-car drivers will get a freshly charged battery in 1-1.5 minutes (20 seconds technical swapping time). This will never be achievable with plug-in fast charging! This provides more useful time sovereignty and reduces the often stressful constraints of mobility. Overly long routines of refueling and driving will be significantly reduced through the speed of swapping.

- With up to 1,000 swaps per day, an optimal operating size is created for sustainable electricity purchasing (e.g. PV power, wind power surplus power), for other filling station services and for a battery storage potential (50 MWh throughput per day), which locally enables the economically attractive operation of battery storage power plants. Supported by auxiliary storage units, the silent storage reserves of the battery swap station can keep power plants of 10-20 MW running, primarily to provide reliable and highest-value primary control power for the smart grid. This will also provide a sustainable integrating contribution to the abolition of two expensive battery worlds for the for grid and mobility.

- Battery swapping with battery leasing takes away the main part of the risk, the often time-consuming stress (see among others operational safety or disposal) and the costs associated with an installed battery from the individual consumer. Battery leasing requieres the operator to assume the main responsibility, who is then compensated by the fact that he can optimize the battery in dual use as an available valuable production resource and derive a sustainability-supporting entrepreneurial benefit from the now possible quadrupling of its service life (see also chapter "Sustainability target" in this issue).






## Perspective 2050: 100 million battery swap vehicles in Europe

The further development and rethinking of the European mobility turnaround must first be based on 250 million vehicles currently on the roads in Europe. In a "worst case" scenario, we believe that the number of people switching to public transport or car sharing will be no more than 20 % by 2050. In particular, low noise, zero emissions and perspectives such as semi-autonomous driving will tend to increase the acceptance of e-vehicles as meaningful mobile individual habitats.

We believe, that if the European mobility turnaround is to succeed quickly, it should not be overloaded with operative models that only insufficiently take into account the needs, interests and requirements of many people, coined by upbringing/socialization. This applies to long standby-times at the charging point as well as to the general permanent renunciation of owning a car. From this point of view, too, a one ton of CO2 per person and year in Europe seems to be achievable more quickly than a car-free Europe or even a filling station-free Europe. After all, the filling station as a modern oasis and logistics hub caters to age-old preconceptions in many people's minds.

Battery swap at e-filling stations with handling times of 1-1.5 minutes (quote "Welt am Sonntag" / 28.11.2021 "Faster than FUELING") is therefore not a break with the usual for the end customer, but cultivates cherished habits with the innovative, time-giving added value of quick completion. Added to this are the facilitations of battery leasing. A further, very strong argument in favor of the Europe-wide battery swap will be the low kWh prices for end customers. This is made possible by bundling tasks at e-filling stations, the high numbers of users, high volume discounts on electricity purchasing (purchasing via low-cost electricity balancing groups), significantly lower investment costs and, incrementally, additional contribution margins possible through dual use revenues. **The goal is kWh end prices that are stably 50% below the real prices of conventional fast charging.**

In Europe, a strategically prepared collaboration with major mineral oil groups would enable the use of an infrastructure that is already largely in place and logistically proven in Europe. The European mobility turnaround is thus possible on the basis of 40-50,000 e-filling stations with battery swap stations by 2035! By 2050, most of these service stations can also be expanded to energy stations that help to significantly secure the storage requirements of the European renewable energy grid of up to 500 GW (2050).

Since this expansion is in the interest of mobility customers (contribution margins) and electricity customers (cost-reducing storage solution for the volatile smart grid), it will find broad acceptance. Against this background, INFRADianba expects that in 2050, approx. 50% of the approx. 200 million CO2-free vehicles in Europe will use battery swapping technology. **These 100 million battery swap vehicles will then include the mobiles of e-fleets, car rental, car sharing and frequent drivers, but also normal e-cars of customers who are simply convinced by the easy going of battery swapping.**

## Sustainability goal: "quadruple battery life"

The importance of the rechargeable battery will increase exponentially in the coming decades. The mobility turnaround as a global task is just at the beginning: At present, the share of e-vehicles in the total number of cars is around 3 %. This figure must triple in the next 3 years if the life-threatening global warming is to be stopped.

This will have a massive impact on battery raw material demand. E.g. since 2020 the price for a ton of lithium carbonate has already nearly tripled from $29,800 at the time. Similar trends are expected for cobalt and nickel. Major lithium producers such as Albemarle (Chile) or the Chinese world market leader Ganfeng Lithium are already warning of delivery problems and further cost increases.

German research institutes (e.g., AGORA Verkehrswende, Jülich) foresee a Herculean task for Germany in this regard. Not only e-mobility requires hundreds of thousands of tons of battery raw materials per year, but also the German energy system. For 2050, electricity demand is expected to exceed 1,000 TWh p. a., indicating a storage demand close to 100 GW in the case of a volatile RE supply. In this overall context, a lithium demand of 500,000 t and more in 2050 (estimated current equivalent: over $50 billion) is realistic for Germany, if two strategic steps are not being taken:

- The reduction of raw material demand through a longer service life of the rechargeable batteries.
- The use of these batteries for efficient dual use: as energy storage in e-vehicles and for power supply in the smart grid (via battery swapping/battery leasing).

In the event that it is possible to quadruple battery life (compared to battery wear and tear by extreme fast charging), the demand would be reduced from 500,000 t to 125,000 t in 2050. The additional effects of an extended, at least dual use of the same exchangeable battery for e-mobility demand on the one hand and a system-integrated use as battery storage for the smart grid on the other hand will further minimize the use of raw materials in a cost-reducing way (no 2 battery worlds).
INFRADianba's dual-use battery swap system provides the technological basis for solving the Herculean task of future battery raw material supply in an operationally and economically viable way. INFRADianba relies on 4 levers:

**Lever 1**: By separating battery charging from battery placement, charging times of up to 2 hours are possible (at 20 degrees Celsius). This cautious charging (target value: 0.5 C) protects batteries and grids; in its technological context, it increases battery life by a factor of 2-2.5.

**Lever 2**: Systemic energetic restitution of up to 1,000 car batteries in the course of 24 hours provides an ideal basis for quality control and assurance of the battery stocks used. Using a patented control technology (FFM Fiber Functionality Measurement), all cells, modules and packages are continuously checked for 100% functionality in real time. Non-functional batteries are immediately discarded, which has a positive effect on the efficiency of the overall system as the process progresses. We foresee a factor of 1.1 effect.

**Lever 3**: The service life of batteries defined via partial cycles depends on certain factors, in particular the extent of the respective discharge and storage duration and conditions when the charged/partially charged battery is temporarily not in use.
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If a new battery has 4,000 partial cycles, it can be fully recharged 4,000 times without loss. However, if this battery is always only half discharged (SOC Status of Charging: 50%), then this number of partial cycles may double. This is precisely the effect used by the INFRADianba system: with kWh bonuses, we reward the customer everytime he swaps his battery with a higher status of charging (e.g.: 40 %, 50 %, 60 %).

Since the check-in/ turn-around process only takes 1-1.5 minutes, he has plenty of time sovereignty to make the most of such price incentives. This makes the "battery" as a means of production more durable and thus more economical for the operator. The win-win service life effect of the SOC optimization is cautiously set at a factor of 1.3.

**Lever 4**: At this point, dual use of the battery helps. The fact that the storage of the battery swap station (up to 50 MWh throughput and more per day) provides three hidden/silent reserves that can be used, e.g., by a battery storage power plant co-using an auxiliary storage for the smart grid, offers a solid foundation:

- Silent storage reserves due to the average high Status of Charging of the batteries introduced into the storage system to be recharged.

- Silent storage reserves due to organized pauses in the provision of already recharged swap-batteries to e-mobile customers. These pauses are based on the one hand on a high inventory of charged batteries due to the high frequency of use in preceding peak periods, and on the other hand on kWh pricing that makes swapping during these intermediate periods with few customers additionally unattractive. For example, from 2 p.m. to 4:30 p.m., approximately 300 fully charged batteries can be used dual use, which can then offer 15 MWh (300 x 50 kWh) for 2.5 hours for the storage needs of the smart grid, etc.

- Silent storage reserves due to the fact that the recharging process begins immediately after the technical battery swap of 20 seconds, so still in the turn-around time of 1-1.5 minutes. As a result, 40 seconds of immediate charging time can be extracted per swapping customer. With 1,000 swaps per day, that is approx. 11 hours of charging time, resulting in further dual-use energy reserves in the MWh range.

These silent reserves of highest quality and charged car batteries are ideal for the very high demands of the Renewable Energy System in terms of Primary and Secondary Control Power (highly reliable stabilization of the 50 Hertz frequency to which all electrical appliances in Germany are calibrated).

Laboratory tests at the Fraunhofer Institute and at INFRADianba's test facilities show that batteries are subjected to such fine-frequency throughout their use for Primary Control Power that this process acts as a kind of fitness program for them. This additionally increases the battery service life and, depending on the extent of this special use, make a factor of 1.2 - 2.0 appear conceivable and possibly feasible.

**Together, these various factors result in a lifetime extension factor for the correspondingly used batteries of over 4 and are also strengthened by the fact that the battery is continuously challenged in intelligent dual use without being overstressed. Fatigue of the battery due to overly long periods of storage in permanently fluctuating temperatures does not take place. The INFRADianba storage system permanently maintains operating temperatures of 20 degrees Celsius.**

Battery Swap Station 4.0, Source: ©INFRADianba

Pilot Swap Station/ Berlin, Source: ©INFRADianba

## New renewable energy alliance: AGRO PV and battery swapping

In May 2022, AgroSolar Europe GmbH and INFRAMobility-Dianba GmbH (INFRADianba) GmbH signed a Memorandum of Understanding in Berlin to establish a permanent common basis for the use of AgroSolar Europe's solar energy yields for the electricity needs of INFRADianba's battery swapping stations. The concept of double harvesting has been verified by the latest research results of Fraunhofer ISE (see Agri-Photovoltaic project) as an economically viable and forward-looking approach.

AgroSolar is working with a major European eco-investor who is willing to pre-finance larger AgroSolar plants that are capable of providing daily PV power in the MWh range to RE customers. customers on a daily basis.

"Solar power or wheat, that used to be the question. But it is also possible to have both... For this purpose, the PV system is elevated, with more distance between the module rows than with conventional plants. This way grains and plants receive sufficient light and there is enough space for harvesters and tractors to operate underneath" (Schrot & Korn 06/22).

AgroSolar-plant, Source: ©AgroSolar Europe GmbH

**INFRAMobility-Dianba GmbH**
Fürstenbrunner Weg 99, 14050 Berlin
Tel. +49 (030)2309784-46
info@infradianba.com
www.infradianba.com

**CEO**
Alexander Yu Li
**Handelsregister:**
Nr. HRB 204169
B – Amtsgericht Charlottenburg

**Communication**
Dr. Katharina Flämig
Can Sekertekin
Bernd Stumpf