36th International Electric Vehicle Symposium and Exhibition (EVS36)
Sacramento, California, USA, June 11-14, 2023

BANULA – A novel DLT based approach for EV charging with high level of user comfort and role specific data transparency for all parties involved

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Executive Summary

The core goal of the BANULA research project is to combine customer oriented and grid compatible *charging* of electric vehicles. It addresses the current challenges of the e-mobility ecosystem from the perspective of grid operators and charging *infrastructure* users and creates added values for every *mass market* role involved. In the project, the idea of a virtual balancing group based on blockchain technology is implemented. Thereby, it enables an extended *data acquisition*, a real time data exchange between grid and market, proper balancing and grid node specific load flow determination and thus *load management.*

Keywords: charging, infrastructure, mass market, data acquisition, load management

1 Initial situation

One of the major challenges on the way to a high penetration of electric vehicles (EV) is the ramp up of a widespread and reliably available charging infrastructure. Due to the need to expand the number of charging stations, the construction of public charging stations has been strongly promoted in Germany and Europe in recent years. In this context, various publicly funded programs such as "Publicly accessible charging infrastructure for electric vehicles in Germany" [1] have been established to create incentives for the errection of charging infrastructure. As a result, the number of charging points in Germany has steadily and significantly increased over the course of recent years. Quantitively, the number of public charging points has increased from 17,108 in 2018 to 77,191 in 2022. In 2022 alone, over 28,000 charging points were installed, corresponding to over a third of the publicly available public charging points. The strong expansion of public charging infrastructure affects both AC charging as well as DC fast charging stations. Some 20% of the expansion of charging stations in 2022 in Germany were DC fast charging stations [2].
Despite this growth in the number of public charging points, great efforts still have to be made to further increase the amount of accessible charging points in order to meet the increasing demand from the sharply rising number of electric vehicles in the German market. Estimates for the required number of public charging

points range from 350,000 [3] to one million charging points [4] in 2030. Similar developments with respects to the need for charging stations and groth of the latter as well as the EV market can be observed in other European countries, such as France and the Netherlands [5, 6]. The US is also planning a significant expansion of charging infrastructure in the coming years [7].
In addition to a high number of charging points, easy and most of all reliable access to charging infrastructure for end customers is an absolute requisite for the success of e-mobility as a whole. In order to be able to use public charging stations, consumers currently conclude charging contracts with e-mobility providers (EMP) thereby gaining access to all available charging stations within their direct charging network. Most providers offer roaming contracts, so that their customers can additionally charge their electric vehicles using the charging infrastructure of other providers [8].
However, there is potential to improve the current charging and billing processes between various market participants. Users often lack certainty about the exact roaming and billing conditions for charging stations of other providers and whether they can use their charging contract on a specific charging station at all. In addition, users are forced to conclude specific charging contracts – just like gasoline charge cards nowadays– and can't use their household electricity contract. Beyond, the lack of usage of forecast data places a disproportionate burden on charging station operators (CPO) regarding the acquisition of the correct amount of energy for their charging stations. In line, the existing synthetic standard load based balancing is not a feasible pattern for a full scale market penetration of EVs.
Last but not least, distribution grid operators (DSO) need full transparacy in terms of location, power and energy with regards to occuring charging processes in their grids, which is not given at the moment. This requirement will gain importance dramatically, as millions of charging points are to be hosted by power grids.
This paper proposes a solution to the issues raised before hand which is based on a block-chain approach building upon distributed ledger technology and yielding solutions to the challenges of all players involved: costumers, charging point operators, distribution as well as transmission system operators, e-mobility providers and balancing group managers.

1.1 Past and ongoing research activities

Within the BANULA project the authors are particularly addressing the development and applicability of a new innovative e-mobility ecosystem from the perspective of a multitude of stakeholders. It also focuses on the applicability of communication and control of charging points of the current system in the BANULA ecosystem via blockchain. From today's perspective, the charging electricity is allocated on balance to the supplier of the charging infrastructure operator. In this model, the charging station of the charging infrastructure operator fills the role of the ultimate consumer. However, completely removing the e-mobility provider from responsibility for the balancing and forecasting of charging processes is not goal-driven for a correct balancing group management. The first, as yet imperfect, approaches to a solution are offered by the German E-Mobilty network usage contract [9]. In essence, this involves the allocation of the electricity quantities drawn from the grid to the balancing group of the respective e-mobility provider rather than to the balancing group of the charging infrastructure operator in accordance with MaBis[1]. In addition to the costs of the charging current, this also affects the network charges, in particular the provision of corresponding power, as well as the costs of construction, maintenance and upkeep of the actual infrastructure. The research work of this project includes the creation of transparency for the availability of measurement and billing data in real time, the reduction of contractual complexity with roaming providers or in the context of roaming, the simple passing on of costs for the construction and operation of the infrastructure as well as the network charges, and the allocation of costs according to the source.
Much has been developed and accompanied by research projects in this regard in recent years, but the challenge of a comprehensive and user-friendly charging infrastructure has so far only been inadequately solved, if one considers the course of the expansion of the charging station network in Germany (Triebke et. al. [10]). Kihm and Trommer [11] model the future market for electric vehicles as well as the associated substitution of conventional energy sources with respect to the use of electric vehicles. The authors have emphasized that both the charging infrastructure and a coherent regulatory framework for corporate customers are important elements for the diffusion of electromobility. However, the study merely considers financial aspects from the user's perspective and thus does not address either local or systemic effects of the diffusion of electric vehicles. The use of electric vehicles for load management is widely viewed positively.

[1] Market rules for the execution of balancing group settlement electricity

Lopez et al. [12] simulated the load shifting of individual electric vehicles and the resulting load smoothing with the help of minimizing the purchase costs for electricity. By doing so, they demonstrate the suitability of electric vehicles for load management. Babrowski et al. [13] analyzed the load shifting potential of electric vehicles and additional implications due to the availability of charging infrastructure at the workplace. The authors concluded that load shifting potentials exist and discuss the consequences of load management deployment of electric vehicles on electricity generation. However, specific system-wide impacts are not analyzed and quantified in detail. Also, the applicability and possible potentials for load shifting using decentralized technologies are not considered and compared to centralized technologies.

Other projects focus on a large variety of aspects with regards to charging station rollout (LamA – Laden am Arbeitsplatz [14]), charging pattern optimization (eFlotten- und Lademanagement [15], Shared E-Fleet [16], eMobility-Scout [17], ChargeLounge [18], InFlott – Integriertes Flottenladen [19]), inclusion of smart meter gateways into the charging IT landscape (LamA-connect [20]), various boundary conditions of charging (C/sells [21], SPARCS [22], IMEI - Erforschung integrierter Mobilitäts- und Energieinfrastrukturen [23], GeMo – Gemeinschaftliche Mobilität [24]) and charging infrastructure as a component of a smart grid (Charge@Work [25]).

In the referenced projects the existing roles, actors and systems of electromobility have been used and the functions have been embedded in the current ecosystem. Now, this existing ecosystem is to be expanded and combined with the ecosystems of the energy grids and markets. For this purpose, new roles, processes, responsibilities and systems will be defined and developed, and a new approach – based on the blockchain technology - will be tested to carry out charging processes. The topics of balancing group management (both technical and legal aspects) and the consideration of flexibility have also not yet been integrated in the electromobility ecosystems nor implemented in blockchain approaches so far. Finally regulation has to be adapted, very much the way the German regulator has recently put thoughts into this process of "Netzzugangsregeln zur Ermöglichung einer ladevorgangscharfen bilanziellen Energiemengenzuordnung für Elektromobilität" [26].

2 BANULA's concept

The concept of the BANULA research project is a holistic approach to combine energy economic processes and energy balancing with the commercial processes in the e-mobility ecosystem to make them more efficient in favor of the end customers and the electricity market roles. The approach provides correct accounting between all parties involved as they have to implement a new common communication network.

Within this new ecosystem, charging point operators provide their infrastructure to e-mobility service providers and don't need to procure the charging electricity. The e-mobility providers have to procure the necessary charging electricity for their own customers, but are able to create better energy procurement forecasts than charging station providers. This decreases the overall energy grid imbalances as the correct amount of energy can be purchased. Distribution system operators can use this approach to gain full transparency of the charging loads within their grid, reduce imbalances within balancing groups and improve overall energy grid stability.

To meet the current energy industry's regulations, a virtual grid area is implemented in which all charging points relevant to an EMP are aggregated by charging processes of its customers. BANULA acts as the operator of this virtual grid area and is in direct exchange with the distribution system operator in order to coordinate grid operator processes directly with each other. The management of the charging current (balancing) is carried out by any number of EMPs and not by a supplier who supplies the physical grid connection point to which the charging infrastructure is connected.[2] Thus, an EMP always balances the charging current withdrawals of its customers by performing an ad-hoc change of supplier at the charging station based on the authentication (e.g., by means of RFID) in the sense of a different accounting allocation. Against the background of this approach, it becomes necessary for the EMP to ensure correct balancing group management - with regard to the charging processes of its customers. This is a contribution to continue to ensure system stability despite increasing charging capacities of electric vehicles through a proper allocation of balancing responsibility. By shifting the balancing responsibility to the EMP, the costs

2 An example from the concrete application would be a charging process at a LamA charging point on the campus of a Fraunhofer institute by any EMP. This EMP now manages this charging point in the virtual grid for the charging time of its customer, even if the charging point is located on the Fraunhofer campus.

of balancing errors are eliminated for the grid operatorIn this way, costs and risks can be allocated appropriately. The EMP's designated balancing group is assigned the withdrawals of a large number of charging points depending on the usage behavior of its customers. To implement the new ecosystem, blockchain technology is used to provide a data architecture that all participants in the ecosystem can use and build upon.[3] This corresponds to a back-end system of market communication in order to be able to allocate charging energy quantities to the supplier or suppliers of charging electricity within the 15-min period relevant for balancing. The blockchain technology as a decentralized medium manages and regulates the interaction of the different actors. It enables a timely, accurate, tamper-proof and transparent allocation of the charged energy quantities per charging pole, the customers to the balancing groups, the balancing areas, the duration of use as well as the data necessary for the billing of the grid usage. It also offers the opportunity to integrate information about the network status into the charging management of the EMPs. For grid operations, it offers opportunities to balance the provision of flexibility on a plant-by-plant basis, to assign these to corresponding market roles, and also to assign the intended use of the flexibility usage. The coupling of the grid (transmission system operator, distribution system operator) and the market (electric mobility provider, balancing group coordinator) thus provides a data and information interface to communicate grid events and restrictions directly to the market in accordance with German regulation (§ 13(2) EnWG). The overall system with the interfaces and information to be exchanged is shown in Figure 1.

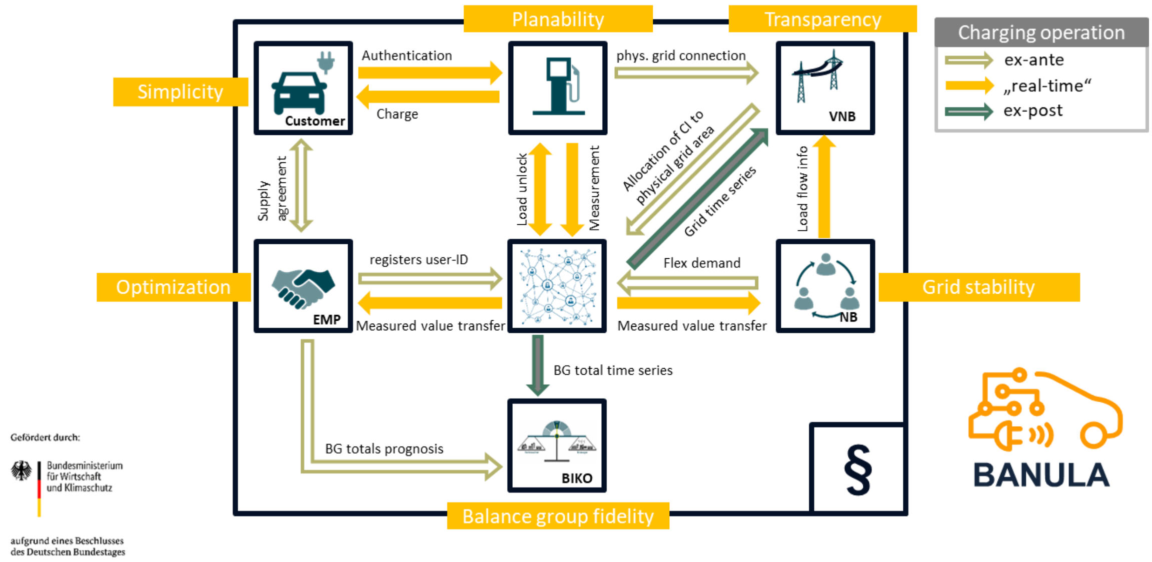

Figure1: Brief overview of the EV charging ecosystem and the operational steps carried out during charging processes. Within the context of the BANULA project, these processes are enhanced using a block-chain based approach employing distributed ledger technology for the benefit of all participants of the system.

So how can customers of an arbitrary EMP charge at any charging infrastructure of a given CPO? In the future BANULA ecosystem, a charging process could look like this:

1. A given client establishes a contract with fixed terms (i.e. cost per kWh) with an arbitrary EMP. The client’s authentication dataset is assigned to its respective EMP in a decentralized DLT/blockchain network. The client is now capable and eligible of using any charging point, which is part of the decentralized virtual grid area.
2. In order to start a charging process, the client carries out the authentication process either via presenting an RFID, registering in a mobile app or through plug and charge building upon the ISO 15118 protocol. Through the DLT network the client’s authentication and eligibility of being granted access to the charging point in question are verified. If all criteria are met, the

[3] For more properties that distinguish a blockchain, see Section 3.

charging process is enabled, and the respective kWh are assigned to the EMP's energy economic balancing sheet.

3. The charging process starts, in parallel, the BANULA-DLT network aggregates all relevant data (charge detail records) for other participants in the ecosystem such as charged energy, time stamps, etc. The respective EMP as well as distribution system operator (DSO) in whose grid area the event takes place are both provided with the time series data of the charging process. The CPO whose charging point was used is provided with the data which is need in order to bill the use of the charging infrastructure.
4. Following this process, the DSO has complete knowledge about all charging processes within his grid. Moreover, this information is available for each charging point in real time, which in turn enables the DSO to gain better understanding about load flows in the grid.
5. In order for this concept to work, all charging points are to be balanced in a so-called virtual grid, although physically they are part of a DSO's real distribution grid.
6. In complete analogy to existing processes in Germany's energy economic regulatory framework the virtual system operator establishes a summarized load time series on a monthly basis for each EMP in a temporal resolution of 15 minutes. This time series data is used for an exact ex-post balancing of the charged kWh for each EMP. Where applicable, upstream as well as downstream grid operators can tap the same kind of summarized load time series data for their balancing purposes.
7. Due to the fact that real time charging information is available, grid congestion can be determined in time, further developments using i.e. artificial intelligence will also allow for predictive grid management e.g. by establishing incentives to charge at different times or locations.

2.1 Respective perspectives of each market participant

2.1.1 End costumer

Customers are free to choose an EMP, but they cannot charge with certainty after finding a charging point at a previously agreed price; even at the same charging point, the costs of a comparable charging process can differ significantly depending on the EMP. In practice, users would have to check before each charging process whether they want to accept the price or continue the quest for the next charging point. If the user has explicitly concluded a contract with an EMP that includes, for example, 100% green power for charging, the guarantee of this power quality cannot, under the current regime, be mapped independently in the roaming case. In addition, it is currently not possible for customers to reliably use all available charging stations with just one charging contract.

Addressed need for action from the customer's perspective:

- Removal of access barriers and creation of price transparency
- Sourcing of advertised and purchased "quality" charging power, e.g. regional, green, etc.
- Reliable access to all available charging stations with just one charging contract

2.1.2 E-Mobility Provider

EMPs that enable their customers to charge on the basis of a peer-to-peer contract with a CPO or in the context of roaming have not sufficiently been involved to date in the balancing of charging processes. Particularly in the case of roaming, there is no need for the EMP that enables its customer to charge at charging infrastructure to make an accurate forecast under the current regime. Suppliers who supply electricity to charging stations of CPOs balance these withdrawals for annual withdrawals of up to 100,000 kWh using synthetic load profiles (SLP). However, proper SLPs that sufficiently take into account the various use cases of the charging infrastructure and, in particular, the frequently spontaneous charging, do not yet exist.

Addressed need for action from the EMP's perspective:

- Enable access to any charging infrastructure under transparent and simple conditions.

- Establishment of a system that solves the access deficits of today's roaming
- Introduction of a central energy balancing group forecast of all customers across Germany or a control zone by the EMP (establishment of reliable forecasts of charging energy to be procured)

2.1.3 Charge Point Operator

The charging energy is currently assigned to the supplier of the CPO in the balance sheet. In this picture, the charging station of the CPO fills the role of the final consumer. However, completely removing the EMP from responsibility for the balancing and forecasting of charging processes, as has been the case to date, is not expedient and is the subject of heated debate within the industry. The first, as yet imperfect, approaches to a solution are offered by the E-Mob network usage contract [9]. In essence, this involves the allocation of the electricity quantities drawn from the grid on a balancing group basis according to the MaBis not to the balancing group of the CPO, but to balancing groups designated by the respective EMP. However, neither essential points have been specified yet, nor are technical solutions available. In addition to the costs of the charging current, this also affects the network charges, in particular the provision of corresponding power, as well as the costs of the construction, maintenance and repair of the actual infrastructure.

Addressed need for action from the CPO's perspective:

- Creation of transparency for the availability of measurement and billing data in real time
- Reduction of contract complexity with roaming providers
- Simple passing on of costs for infrastructure construction, operation as well as network charges
- Allocation of costs according to the originator, e.g. for load peaks
- Procurement and balancing of charging electricity in line with the polluter-pays principle

2.1.4 Distribution System Operator

DSOs bear a significant balancing group deviation risk of their network groups due to the current balance sheet mapping of charging processes and have to expect high consumption peaks in distribution network strands that are currently only inadequately measured. Furthermore, distribution grid operators do not know the charging load at certain grid points and install sensor technology to operate the grid safely.

Addressed need for action from the DSO's perspective:

- Exploiting synergies and creating transparency: what happens where in the grid, in real time (so that grid stability measures can be initiated to minimize balancing group deviations and the necessary risk capital)
- Form appropriate aggregation points that can be forecasted and managed
- Create incentives for EMPs to make withdrawals predictable and avoid power peaks

2.1.5 Transmission System Operator

If the existing system is continued, the TSOs will also be increasingly exposed to uncontrolled and hard-to-predict use of balancing energy in the physical balancing of their networks. This would result as a direct consequence of schedule deviations in the downstream distribution networks.

Addressed need for action from the TSO's perspective:

- Increase in balancing group reliability
- Supporting system security through the systemic use of flexibility by managing the load in the distribution network and its IT-based proof of delivery

3 Aims

The research project develops a blockchain-based data platform that enables a tamper-proofed and german-regulated billing of charging processes for all market participants. The overall purpose is to establish a new ecosoystem, which will be of the benefit of all players involved. The question as to who will eventually operate the system is part of our research.

The main objective of the project is to make public charging points accessible to all end consumers in the most transparent terms and to best prepare all players involved for the mass market penetration of electric cars. For this purpose, the ecosystem proposed aggregates charging points of a charging station operator in a specific grid area into a virtual charging point network. It integrates all involved market roles and enables trustworthy data exchange. Blockchain technology manages and regulates the interaction of the various players. In addition, EMPs, CPO, DSOs and TSOs gain transparency. This provides an accurate, tamper-proof and transparent allocation of the charged energy per charging point, per customers and balancing group, per usage period as well as the data required for the grid fees. Within our contribution to EVS 36, we would like to discuss this approach with specialists from around the world. Within the project team we raised the following five questions to answer during the project duration and to create guidelines for the technical implementation.

3.1 Reasoning for blockchain based approach

As an underlying communication platform, the blockchain as a distributed ledger offers security, full transparency and auditable traceability over all interactions of the participants. In addition, the blockchain is not operated by a single party, but rather operates in the form of a distributed network that "belongs" equally to all stakeholders and to rules that all stakeholders have jointly defined (governance model). New participants (market actors) can join at any time, but they can only use the system if they submit to the common set of rules (based on the rights defined by the stakeholders, e.g., by means of previously defined rights for the individual roles). By introducing digital market roles (identities), blockchain technology can be used to include market players in their role deposited by an authority in an automated as well as standardized manner via an "authority" model. Based on the best fitting governance model for the ecosystem – which form is part of the research – a blockchain based approach delivers the technological aspects for each role to interact with each other.

3.2 Is a blockchain performing well enough to deliver real-time results even with a high number of participants?

Depending on the use case, different blockchain technologies and concepts are available. Permissioned Blockchains are only accessible to consortia and also offer transaction times for high performance requirements that enable almost real-time processing (a few milliseconds) compared to previous matching mechanisms (approx. 15 minutes). However, depending on the project requirements, the use of public blockchains may also be appropriate, e.g., to ensure easy access by the public (the end users). Deciding which blockchain concepts (or combinations of them) are suitable for operational use is part of the knowledge we want to gain with this project. As for now, the current plan is to implement a blockchain based approach where the blockchain itself only holds a limited set of data but offers an up-to-date lookup table for each role of the system. The blockchain – let it be called BANULA Data Hub (DHB) for now – knows all the application programming interfaces (API) for each party in the ecosystem and also the necessary rights to interact with this party, as indicated in the figure 2 below:

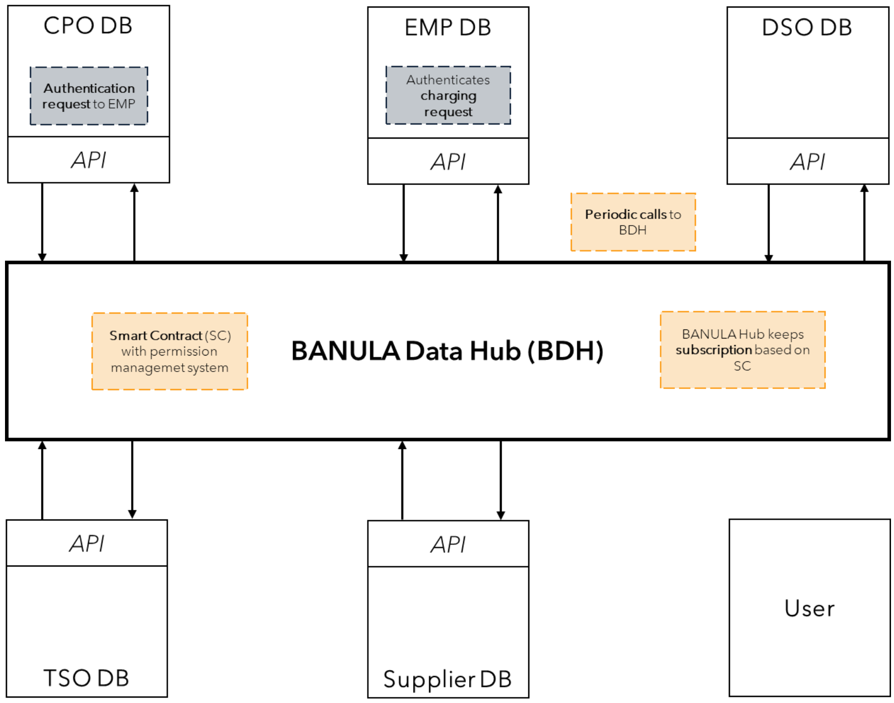

Figure 2: A schematic description of the blockchain based approach for a DLT-based platform as lookup table and gatekeeper

The DHB orchestrates the rights of all parties in the ecosystem and is responsible for the parties' API-lookup table. If one party A wants to obtain data from another party B and has the rights to to so, the DHB delievers the endpoints and datastructure for party B, so that party A knows how to get the data and how to understand the response. As the blockchain is only used as lookup table and permission management system and does not store all data of the ecosystem, no performance issue is to be expected.

3.3 Can all data in the blockchain be viewed by all actors and how do we ensure the data protection and privacy?

Depending on the blockchain technology used, there are various options for protecting sensitive data. Following the governance model mentioned above and the associated different roles, access to the data available in the D network and its processing options can be comprehensively regulated. For example, in Hyperledger Fabric, it is possible to separate different parts of the distributed ledger network for different use cases. In addition, encryption can be used to secure the transmission of data within these sub-areas. The project also investigates the possibilities for controlling access to the protection and its suitability for the different use cases. In any case, it is important that market players or all participants are only allowed to see the data in plain text for which they have authorization (e.g., EMP A only sees the measurement time series of its assigned customers and EMP B does not see this data in plain text, but only as an encrypted value for consensus building, which cannot be deciphered by EMP B). As shown in Figure 2, the blockchain works as gatekeeper and permission management system with the suitable smart contracts programmed by the government organisation in the ecosystem.

3.4 What is the strategy for existing hard- and software systems?

The project will develop an integration concept for existing charging points as well as new charging hardware to be set up by the Fraunhofer charging network "LamA" and the Lidl/Schwarz Group as a blueprint for the scalability of the project architecture solutions. In total, the participating project partners can so far integrate up to 10,600 charging points into the BANULA network. The solution explicitly aims to make further inventory (outside the partners charging networks) integrable. Overall, there are two starting points here.

Top-down: On the one hand, regulatory requirements are needed for later implementation, e.g. on the part of the reglation authorities ("Bundesnetzagentur"[4]) with regard to virtual network areas concerning the network connection of charging stations. Discussions are planned here on the part of the transmission system operators. Furthermore, the topic is to be discussed within the framework of the European TSO-DSO cooperation. In the next few years, the network code flexibility is to be developed at the European level. Basic elements of our question can be directly incorporated here.

Bottom-up: Parking operators and large employers can already participate in the network today in order to achieve fair and equitable treatment of the workforce with regard to mobility subsidies (no free fuel for e-drivers) and the charging of guests.

3.5 Transfer strategy for Europe

A decentralized solution (like DLT) also offers more flexibility than a centralized platform for onboarding additional regions (or environments). A DLT network is not subject to the sovereignty of a single provider and, due to its decentralized orientation, by definition offers more openness for the onboarding of new stakeholders. Due to the (within the framework of the project initially Germany-wide) implementation on a national level, overarching solutions for simple loading in the virtual grid area must already be developed within the project for four TSO control areas. These processes are scalable across Europe, since the European TSOs are galvanically as well as information-technically coupled and the concept of the balancing group management is analogously structured. The model requires an expansion of the German (and potentially also the European) regulatory framework by extending and thus improving the existing balancing system for charging processes. The virtual grid approach is easy to integrate into the existing balancing system, as it is based upon it - comparable to the e.g. traction current system or balancing between two grid operators. However, it is also easily transferable to all other EU countries, as they have a balancing system that is comparable to Germany's in the main points. In this respect, the EU makes hardly any particular specifications. A European rollout is therefore possible. Specifically, a coupling or interoperability of the platforms of the company Elia (EnergyBlocks) and BANULA is already being considered. Elia is very interested in the results from the BANULA project, since both concepts are based on a virtual grid area. The company Elektromaps from Spain, which provides information about charging points throughout Europe, has expressed interest in participating in the project.

In a further step, BANULA will be presented by TransnetBW and 50Hertz in entso-e in the context of the established TSO-DSO cooperation. Currently, the managing director of TransnetBW is chairman of the working group for coordinated cooperation with the new European DSO association "EUDE". This provides the best conditions for coordinating processes between the two associations throughout Europe with regard to a virtual grid area. Against this background, on the one hand we carry the concepts to Europe, on the other hand we also want to actively accompany European developments (e.g. FlexHub, Equigy) in order to derive possible synergies for BANULA.

In summary, the technology is thus transferable to other countries. On the operator hand, the Schwarz Group is a project partner that operates many hundreds of charging points not only in Germany, but across many other European countries. It is interested in a solution for all of its charging points, so it also has a great intrinsic interest in developing an international solution.

4 Practical applications

To proof and validate the project's underlying concepts, a pilot of the entire system and all players involved is implemented. For each role mentioned above there is at least one organization necessary to adapt and implement the idea to make the ecosystem applicable in the current German energy market. Therefore the project is composed of a multitude of entities in order to be capable of proving the concept end-to-end. As the approach of the system shall eventually be rolled out in the real world's energy market, the pilot is applied on the infrastructure of two large German charging networks and not only in a laboratory setup. For this reason, the new ecosystem is based on the current German and European regulations of the energy and e-

[4] German federal network agency

mobility market. In the German energy market a voluntary regulation system for CPOs to create a transaction-based energy balancing group was implemented in 2020 (BK6-20-160 [27]) but is not widely used from CPOs in Germany due to the lack of adequate incentives. For the pilot project, this regulation system is analysed, the flaws are exposed and practicable improvements are made. Hence the pilot project focuses especially on improvements which create benefits for the CPOs to participate in this voluntary regulation system but also integrates into the current technical market solutions. Furthermore the new ecosystem shall include the application of bidirectional charging and decrease the administrative burden as charge points – in Germany – so far are not considered as energy market locations but as energy metering locations. To fulfill the ecosystem's transparency objectives, the pilot project evaluates the usage of distributed ledger technologies and implements the best fitting solution into the pilot implementation. Therefore the pilot will be splitted in multiple implementation and testing stages. In the first stage a prototype – called the minimal viable product (MVP) – is implemented and tested. Therefore the technical feasibility of the project is shown by implementing the necessary roles for a limited set of use cases and and charging stations. For this approach only the least features of the roadmap are implemented and tested in a friendly environment with known drivers, CPOs, EMPs, grid operators and – if necessary – with a shadow balancing. Thus we can implement and test the MVP, even if the current regulations are not fully satisfied. The roadshow across Germany – from Freiburg to Berlin – shall demonstrate the cross-regional approach across the four balacing zones operated by the German TSOs.

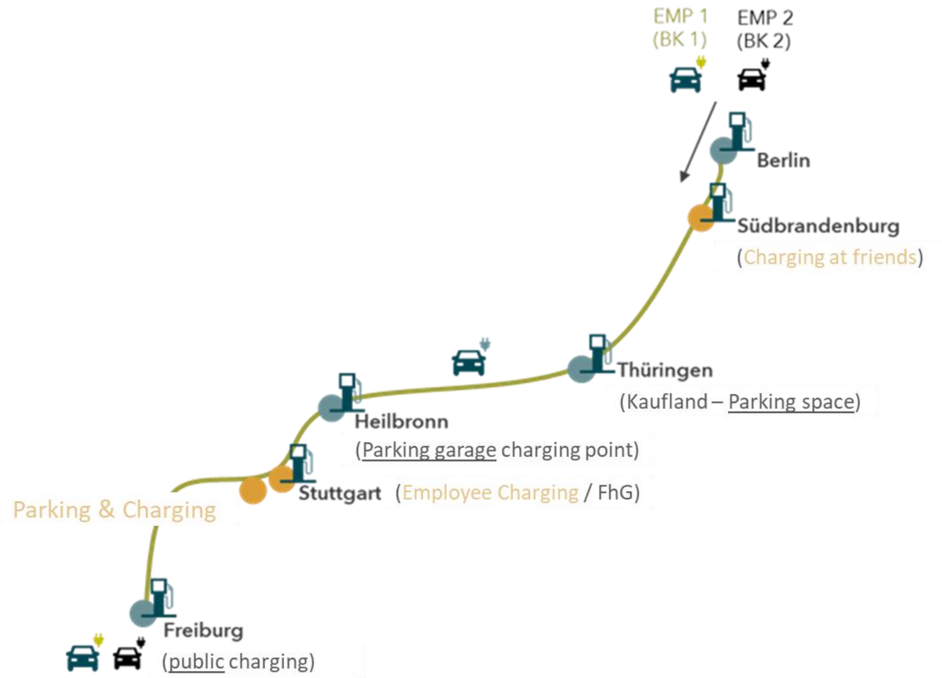

Figure 3: Overview of the planed roadshow across Germany – from Freiburg to Berlin – to demonstrate the MVPs important use case.

The use cases to demonstrate in this roadshow include the most important roles for the combination of the e-mobility ecosystem and the energy market ecosystem. The goal of the roadshow is *to make charging at any charging point - system & grid compatible.* In the roadshow two electric vehicles with charging cards from two different EMPs will start the journey from Freiburg to Berlin. They will charge simultaneously at charging points – even at charging points of the same charging station – and the charging quantities will be allocated to the respective balancing group of the respective supplier and will appear in the correct balancing group bookings. So there will be no change of the charging station supplier, despite the fact that different suppliers will deliver the energy for the charging quantities. After the MVP is implemented and tested successfully, the next stage of the project with more users, charging stations and use cases will be implemented. For testing the ecosystem under real life conditions in Germany, a large number of charging stations will be integrated into BANULA and the functionality will be proven and validated within a one-year fleet trial with at least 40 vehicles. The vehicles will be handed over to different groups of test subjects which vary in terms of their user patterns and the provided charging possibilities. The results of the testing groups shall create the basis to evaluate the application of the ecosystem to end users and improve the pilot project. In addition, a roadshow across Germany – from Freiburg to Berlin – shall demonstrate the cross-regional approach across the four balacing zones operated by the German TSOs. During the lifetime of the pilot, a series of workshops with experts in the field of energy and mobility is held and a new expert community will be founded. The feedback of the expert rounds will be integrated into the pilot and the interim results will be published to the community.

Acknowledgements

We gratefully acknowledge the financial support of the German Federal Ministry of Economics and Climate (BMWK) as well as administrative support by German Aerospace Center (DLR-PT). Furthermore we thank the entire project consortium for their cooperation: Our full partners Badenova AG & Co. KG, Becker Büttner Held PartGmbB, OLI Systems GmbH, smartlab Innovationsgesellschaft mbH, TransnetBW GmbH, Universität Stuttgart (IAT and IEH) as well as our associated partners Schwarz Immobilien Service GmbH & Co. KG, Netze BW GmbH, 50 Hertz GmbH, Amprion GmbH, ZSW e.V., Stadtwerke Stadtroda GmbH, Stadtwerk am See GmbH & Co. KG and e-clearing.net GmbH.

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Presenter Biography

Dr. Daniel Stetter holds a masters degree in physics from Karlsruhe Institute of Technology, Germany, and a diploma for graduates in economics from LSE London, UK. He received his doctorate in engineering with emphasis on energy economics from the university of Stuttgart and the German Aerospace Center DLR.

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Since 2015 lecturer at different universities. Recently since 2019 in the context of replacement of a professorship of energy economics and engineering at HfT Stuttgart, Germany.

Since 2016, he works for Fraunhofer IAO, Stuttgart, Germany focusing on novel energy infrastructures with special emphasis on the electricity sector, renewable energy as well as e-mobility grid integration.

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