Freedom of Charging:
Opportunities and Challenges of Blockchain Technology for seamless Electro-mobility

EURELECTRIC Blockchain platform interim report

November 2017

EURELECTRIC is the voice of the electricity industry in Europe.

We speak for more than 3,500 companies in power generation, distribution, and supply.

We Stand For:

***Carbon-neutral electricity** by 2050*

We have committed to making Europe's electricity cleaner. To deliver, we need to make use of **all low-carbon technologies**: more renewables, but also clean coal and gas, and nuclear. Efficient electric technologies in **transport and buildings**, combined with the development of smart grids and a major push in **energy efficiency** play a key role in reducing fossil fuel consumption and making our electricity more sustainable.

***Competitive** electricity for our customers*

We support well-functioning, distortion-free **energy and carbon markets as** the best way to produce electricity and reduce emissions cost-efficiently. Integrated EU-wide electricity and gas markets are also crucial to offer our customers the **full benefits of liberalisation**: they ensure the best use of generation resources, improve **security of supply**, allow full EU-wide competition, and increase **customer choice**.

***Continent-wide** electricity through a coherent European approach*

Europe's energy and climate challenges can only be solved by **European – or even global – policies,** not incoherent national measures. Such policies should complement, not contradict each other: coherent and integrated approaches reduce costs. This will encourage **effective investment to** ensure a sustainable and reliable electricity supply for Europe's businesses and consumers.

EURELECTRIC. Electricity for Europe.

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Disclaimer:

This interim report has been drafted by members of the EURELECTRIC Blockchain platform and in particular the e-mobility workstream. It aims at taking stock of current developments with regard to the blockchain technology, as one of the various possible digital solutions in developing e-mobility. In so doing, the report aims at mapping out the challenges and opportunities linked to the use of this technology. Through this report, the EURELECTRIC Blockchain platform would like to initiate further, long-term debates on the role of blockchain and other distributed ledger technologies for the future of the energy sector. To this aim, it provides a preliminary, fact-based, assessment of existing initiatives that would allow the forward-looking energy consumers and utilities to better understand and navigate the potential offered by the blockchain technology. The report does by no means represent a formal EURELECTRIC position and should be treated as a White Paper, merely marking the direction and scope of the platform's future work on the topic.

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Executive Summary

In today's digital age, customers expect a high quality, effortless experience of every service or product they pay for. Proactive users flock towards those providers that offer the smoothest and most frictionless solutions in supporting and improving their day-to-day activity. The rise of electro-mobility uncovers the insufficiently developed service offerings that currently exist in both the mobility and energy sectors, with challenges related particularly to the financial transactions involved in this process. While issues of compatibility and interoperability of services do not discourage some early adopters of e-mobility, the lack of a truly simple and seamless customer experience prevents electro-mobility from spreading around and propelling as much and as fast as it could. Blockchain might be the missing piece of this puzzle and become the stepping stone towards the widespread adoption of new e-mobility services.

This interim report seeks to critically explore the potential value locked in this digital solution and compare it to other, known alternatives in customer experience with the primary goal of identifying clear use cases for the blockchain technology in e-mobility. It seeks to explore if and how blockchain technology could improve the quality, usability, and scope of services currently offered while demystifying some of the main challenges related to its integration. It also explores the next wave of digital innovation, which would most likely include the integration of financial transactions and transfer of title to tangible (currency or energy) or intangible (data) assets.

The EURELECTRIC Blockchain platform engages key electricity industry stakeholders in identifying and co-developing the potential sources of value stemming from the deployment of the blockchain technology in the energy sector:

- **Customers** can benefit from seamless mobility services, full transparency of the availability of chargers and of their prices, and other services. This could decrease the total cost of owning electric vehicles (EVs) and tackle the 'range anxiety', which remains among the most limiting factors for EV deployment;
- **Mobility service providers**, who work on improving the customer experience of EV users, can benefit from streamlined back-office operations and interoperable, scalable IT tools based on open standards and common procedures for asset access, sharing, and control, decreasing costs and avoiding vendor lock-in;
- **Charging pole operators**, who manage the infrastructure, can benefit from standardised integration of modern payment systems with hardware, and from novel revenue streams resulting from coordination with grid operators;
- **Grid operators** can benefit from accessing additional granular data and sources of flexibility which are of indispensable value when it comes to triggering demand response via price signals capable of ensuring grid stability and optimisation. Through flexibility, grid operators will also have the added benefit of being informed about the power demand situation and forecast in specific nodes of the grid;
- **Vehicle manufacturers** can reduce the cost of ownership for customers and can market their products better by unlocking novel revenue streams, for example by choosing to implement next-generation features, such as Vehicle2Grid (V2G), to enable EV owners to benefit from more pronounced price signals and provide related grid services when feasible and needed;
- **Blockchain technology developers** can see their solutions widely adopted if they solve some of the issues identified in the current, early versions of the technology;
- **Policy makers** will have a crucial role to play in allowing the full potential of this technology by streamlining rules and legislation, ensuring open standards, and supporting the adoption and technology development through targeted funding, while guaranteeing the security, stability, and reliability of energy services to end-customers. The role of the

European Union and its institutions in this process is critical as it is expected to take the lead in developing political, legislative, and regulatory frameworks ensuring that national administrations and relevant EU institutions are equipped to respond to the novel challenges and opportunities that would be posed by the deployment of blockchain.

The EURELECTRIC Blockchain platform will continue to investigate and assess the viability of blockchain and of distributed ledger solutions in electro-mobility, trading, flexibility, and other use cases as they emerge. It will investigate how the blockchain value proposition and benefits to customers compares to other available alternatives with the primary goal of inspiring future development of various digital solutions that improve customer experience.

The platform's objectives include analysing the potential of blockchain technology to bring value to customers and energy businesses by improving the customer and user experience, promoting open standards and interoperability, and inviting novel services to the energy sector and related industries by leveraging blockchain technology to create customer driven, low-cost and high trust business models and applications. The platform will also engage in a cross-sectoral and cross-institutional dialogue with industry representatives and blockchain developers', activity - essential to understanding and resolving the challenges and opportunities related to blockchain applications in the energy sector.

Prologue

Blockchain technology has become a mainstream innovation topic for many European energy start-ups and utilities. The participants in the EURELECTRIC Blockchain platform see the opportunities this technology can bring about for customers and energy companies. We also understand the need to critically evaluate the scope of its potential, how it compares to other available digital solutions where such a comparison can be made, as well as the risks that a widespread blockchain technology deployment in the utilities sector could create, with the primary goal of inspiring beneficial future development of any such solution.

In order to illustrate the future potential of blockchain deployment for the electro-mobility and electricity sectors, we would like to introduce the subject with the following "science fiction" scenario:

> *"In 2025, electric vehicles have become a widespread mode of transportation in Europe, with annual sales of 2 million EVs[1] in the European Union and sustained growth of sales worldwide. Renewables generation has increased to more than 30% of generated electricity, digitalisation was embraced by energy service providers, which has led to the development of the transactive grid[2], enabling power producers to transact directly with consumers and prosumers, using highly automated systems.*
>
> *Michèle is a European citizen with a French passport living in Colmar, France and works for an industrial design agency in Freiburg, Germany. She commutes to work each day and crosses the border twice, driving a total of 100km in her electric car. At home, she has solar panels and a home battery, which enables her to accumulate electricity and charge her car when she returns home at night. At work, she is able to use the car chargers made available by her employer. She loves driving her silent but speedy EV. When travelling across Europe, she particularly enjoys being able to use her own home energy when stopping at the super charger - such a seamless user experience!*
>
> *Even better: her home energy supplier and that of her employer have teamed up with her car manufacturer's bank to offer a flat fee for a lot of costs related to the use of her EV. These include the lease of her energy assets (car, battery, PV panels, heat-pump, smart home), insurance and maintenance, relevant taxes, the electricity used for charging the car (both at home and at the office) and for supplying the remainder electricity to power her home, and even the highway toll fees. On rare occasions she receives a notification on her smart-phone reminding her to plug in her car or alerting her about special offers for shifting the load of her heat-pump by agreeing to adjust her smart thermostat.*
>
> *At the end of each month, she gets a detailed report informing her how 'green' her energy consumption was for that month, and she can accumulate points entitling her to customised offers for greener appliances to be used at home. Each time, she recalls how complex it once was to finance, own, and operate a car, and to heat the home.*
>
> *In order to enable this effortless and seamless user experience, in 2022 utilities joined a Europe-wide and cross-industry consortium to define the common digital standards for handling complex transactions, named 'European Mobility Chain (EMC)'. This consortium was part of a wider effort in the European electricity sector to optimise and simplify processes and*

[1] https://about.bnef.com/electric-vehicle-outlook/

[2] The concept of transactive grid could be linked to transactive energy, which the staff of the California Public Utility Commission indirectly references as "an internet-enabled free market, where customer devices and grid systems can barter over the proper way to solve their mutual problems, and settle on the proper price for their services, in close to real time" in their report "Transactive Energy: A Surreal Vision or a Necessary and Feasible Solution to Grid Problems?"

services for users through interoperable digital solutions. Following various demonstration projects, car manufacturers, electricity companies, grid operators, electro-mobility infrastructure providers, financial institutions, highway operators, public authorities, regulators, academic institutions, and other parties teamed up to enable a common European personal mobility market. This was based on a decentralised multi-layer IT architecture which made use of the latest advances in quantum computing[3], mobile IoT, big data, machine learning and blockchain technologies.

Over the course of this European-funded "Horizon 2050" program, the implementation of a common European market for energy and mobility data was instrumental. The core innovation stemmed from defining so-called distributed apps (DApps[4]), which are accessed through smartphone apps, data and algorithms to provide physical and virtual services, with growing share of machine-to-machine (M2M) communication and transactions. The DApp-concept was initially successfully and globally adopted by the first truly distributed app, Bitcoin[5], which had already been invented 17 years previously, back in 2008.

The scope of the Agency for the Cooperation of Energy Regulators (ACER) was extended in 2023 to include a division focused on digital energy infrastructure regulation which was tasked to monitor, through specialised blockchain robots, the wide range of Distributed Apps (DApps) made available to business users and (more selectively) customers of the European Mobility Chain. DApps, which are valid according to and compliant to national and European rules and regulations, include:

- *ChargingPointDApp, allowing EV charging points to operate seamlessly in the grid;*
- *CarBatteryDApp and HomeBatteryDApp, enabling customers to optimise storage assets based on various forecasts;*
- *HomePVDApp, enabling management of residential PV assets, including the personalised energy production forecast;*
- *GridDApp, handling grid fees but also grid ancillary services, at any geography the car is charging;*
- *ElectricityMarketDApp, facilitating the purchase of energy on the European energy market;*
- *HeatDApp, managing home temperature and warm water through a heat pump system;*
- *GreenConsumptionPointsDApp, incentivising customers to change their energy consumption behaviour and facilitating cheaper new and low-energy home appliances;*
- *InvestorDApp, allowing customers to directly fund e-mobility related projects.*

Many other distributed apps are used in order to integrate with non-energy service providers and regulators, including for instance the CarLicenseDApp, CarMileageDapp, ParkingDApp, HighWayTollDApp, LeasingDApp, CarInsuranceDApp, CarMaintenanceDApp, ValueAddedTaxDApp, DriversLicenseDApp - and unfortunately also: the SpeedingTicketDApp.

[3] Fully fledged quantum computers are expected to be built sometime after 2025, affecting protection of data encrypted with current cryptographic systems, as recent research by Eindhoven University of Technology and partners indicates at https://www.tue.nl/en/university/news-and-press/news/13-09-2017-the-dark-side-of-quantum-computers

[4] A DApp is very similar to an iPhone App like Uber or Facebook. However, as it runs on IT-systems which are distributed amongst many users, it cannot be controlled by a single party.

[5] The Bitcoin system is based on a blockchain as data store, which can be used to transact Bitcoin - the currency DApp - and also to run DApps based on specific smart contracts (e.g. "coloured coins"-Dapps).

In view of the success of this new system, the largest European grid operators and utilities are currently looking into transforming their existing legacy processes towards a fully digitalised blockchain-based system in the following years.

Michèle cannot wait to benefit from the additional revenue stemming from monetising the flexibility of her French battery and EV on the German market when she charges at her office!"

"Prediction is very difficult, especially about the future" - Niels Bohr

Nobody, not even the most knowledgeable blockchain experts, knows which blends or mixes of technologies will prevail. Notwithstanding such uncertainty, this interim report is the collection of our current understanding of the topic and of the key initiatives which could potentially lead to the digital utopia described above. One thing is certain: the future role of blockchain and distributed ledger technologies will most likely enliven the debates about the digital transformation of the European energy industry in the coming years.

Introduction and purpose of this paper

The EURELECTRIC blockchain platform was established as a trusted collaboration and co-creation space in which partners could share experience on use cases across the value chain, investigate potential regulatory issues, and explore possibilities for joint pilot projects within EU public tenders and upon their own private initiative. It is a forum for frank discussions with technology solution developers as well as with other key partners and stakeholders en route to exploring blockchain potential in the energy sector.

In certain ways the platform is similar to various open source initiatives established by the digital industry in the past 20 years, whose purpose is to explore, foster, and guide tools, standards, and methods of working which would be beneficial to concerned sectors and the society at large.

As the initial product of this interaction, this Interim Report seeks to provide answers to the following questions regarding the potential use of blockchain technology for electro-mobility.

Why? To improve customer experience in mobility and energy services

Energy and mobility are essential to the daily life of people, communities, and their activities. Both industries are being reshaped by novel technologies and as McKinsey notes[6], the border between industrial sectors disappears due to digital technologies. This creates a new industry, an ecosystem that can cater to the vital needs of customers and businesses in an improved way, with potential for substantial benefits but also the risk of amplifying existing or even creating new inequalities.

The authors of this report believe in a world where novel solutions can be created to the benefit of society in a reliable, sustainable, and affordable manner for all. At the same time, the emerging services will create novel business and operational opportunities also for vehicle manufacturers, grid operators, and other service providers as well as and above all for the customers that we all are.

How? By exploring emerging digital technologies and exploring regulatory and legal limits

Digital technologies are reshaping the way society and economies operate, putting stress on the rules inherited from the past.

Europe has pioneered digital innovation before, even though it does not boast its own world-famous Silicon Valley. One notable example is GNU Linux, open source free software which originated[7] in Finland as a university student's initiative in 1991. Customers today, most often unknowingly, use Linux whenever they use the Android operating system, which relies heavily on the Linux kernel for the enforcement of its security model[8]. Android is installed on more than 2 billion devices[9] around the world today, democratising access to information and thereby bridging social and economic inequalities. In a rare display of infrastructure scalability, Linux also powers all 500 of the world's most powerful supercomputers[10] as of November 2017. The world's

[6] https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/competing-in-a-world-of-sectors-without-borders
[7] http://www.bbc.com/news/technology-18419231
[8] https://android-developers.googleblog.com/2016/07/protecting-android-with-more-linux.html
[9] https://www.nytimes.com/2017/05/17/technology/google-io-conference.html
[10] https://www.top500.org/statistics/details/osfam/1

largest cloud computing provider, Amazon Web Services, leverages its open source modularity to offer multiple Linux operating system versions for free[11].

Blockchain and distributed ledger technologies have been compared to Linux, for example by BCG in their Thinking outside the blocks[12]. Today, the concept of blockchain has been explored, or is being explored, by supranational entities such as the European Parliament, the European Commission, the European Central Bank and the International Monetary Fund. Tests of blockchain solutions are supported, for example, by the governments of Estonia, Sweden, and the UK. In the commercial sphere, blockchain has been in the focus of major companies such as IBM, Microsoft, McKinsey, BCG, EY and a host of leaders in various industries. These activities are explored further in this report.

Similarly to Linux, blockchain might equalise the playing field in the energy sector by making the same kind of innovation accessible to the smallest and the largest, the poorest and the wealthiest, the followers and the first movers. However, in order to make such digital services enter the lives of European citizens, some rules will need to be updated to unleash these new opportunities and ensure that they can be introduced in a manner consistent with the principles of providing secure, reliable and affordable energy service. Specifically in electro-mobility, regulatory challenges for example in relation to charging licenses and taxation were identified. Further investigation of other use cases of blockchain might identify additional regulatory provisions that may not align with a future adoption of blockchain and other innovative digital services for customers.

What is next? Engaging stakeholders and exploring opportunities for cooperation

Blockchain in the energy and mobility sectors is no longer a theoretical subject, it calls for productive coordination to prevent fragmentation and incompatibility, active collaboration to create positive network effects, and joint engagement of stakeholders to improve the experience of customers.

Blockchain initiatives by their very nature benefit from network effects, which is why some projects seek partners from their early stages. A notable example at the intersection of electricity and mobility is the complex of initiatives OMOS, Oslo2Rome, and Share&Charge, which will be explored in more detail in this report. In trading, similar initiatives include Ponton Enerchain and BTL Interbit. There are also an increasing number of research and demonstration grants for blockchain use cases from governmental agencies and EU funds and institutions, such as Horizon 2020 and the European Innovation Council[13]. Furthermore, as the technology matures, blockchain could also bring solutions in other innovative areas, such as Vehicle2Grid.

However, there are also potential obstacles and challenges on the road towards adoption. Most notable is the lack of compatibility and interoperability, an issue observed in debates on EV charging standards. A preferred solution seems to be an open source standard with industry-wide adoption, as argued further in this report. A second best solution would be free operational compatibility that would not discriminate against services of various kinds. Other issues related to technology and the regulatory and legislative framework will surely arise as current pilot projects mature.

[11] https://aws.amazon.com/mp/linux/
[12] https://www.bcg.com/blockchain/thinking-outside-the-blocks.html
[13] https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/eic_pilot_factsheet_2018-2020_0.pdf

Customer and user perspective

Customers of nascent electro-mobility services face difficulties due to the complexity and relative immaturity of the service. The broad range of related activities, expected by customers, indicates a missing piece: the need for an open, digital interconnection of the various activities beyond energy, mobility, and financial services, towards communities and the society.

A vision of seamless mobility

Mobility services will undergo substantial improvement in the upcoming years, similar to the past decade which saw the rise of mass use of satellite navigation and ride hailing services. This vision provides guidance as well as a tangible potential development platform. Therefore, imagine the following scenario:

'Bob lives in Munich and is planning to visit his mother in Amsterdam, so he purchases a door-2-door ticket via his preferred mobility app. He is picked up by an autonomous taxi, which brings him to the train station. Arriving in Amsterdam, Bob picks an electric scooter to cover the last two miles to his mother's house. Bob is able to rent the e-scooter without driving license identification due to the secure legitimation with Bob's personalised digital mobility wallet. In the meantime, the autonomous taxi has re-charged at the cheapest charging point in the neighbourhood. The overall bill is split between all the mobility service providers (taxi, train, e-scooter) and asset owners (charge point operator). Payments are transferred instantly and directly to the according wallets (including the tax authorities), thus showcasing the benefit of a common European mobility market.'

Such vision is proposed by OMOS[14], Open Mobility System, an initiative by a trio of partners: MotionWerk, Fraunhofer Institute for Applied Information Technology, and TÜV Rheinland. MotionWerk, a spin-off from Innogy Innovation Hub, has also implemented Share&Charge[15], commercial peer-to-peer EV charging service available in Germany and California, one of the earliest blockchain-based customer services worldwide. Another element from this family of initiatives is Oslo2Rome[16], a joint cross-European EV charging pilot undertaken by several European utilities and charging pole operators, expanding the Share&Charge system to establish a Europe-wide charging network based on blockchain.

OMOS proposes a number of additional use cases, some of which are already being developed:

- **Seamless EV charging**, an "AirBnB of charging poles", similar to existing Share&Charge, and available as a service for charging pole operators and electro-mobility service providers;
- **Zero congestion platform**, using blockchain as a data source and incentive tool for traffic management in cities;
- **Identity platform**, using a mobility wallet to securely store personal legitimation, such as a driving licence;
- **Mobility credits**, allowing companies to solve their employee mobility needs while creating more flexibility for individual preferences;
- **Virtual toll gates**, collecting fees without a need for multiple registrations, with instant settlement;
- **Usage-based direct taxation**, similar to toll, and also relevant in cross-border charging.

[14] http://omos.io/
[15] https://shareandcharge.com/
[16] http://www.oslo2rome.com/

Further development, outlined in the OMOS White Paper[17], can deliver services such as *digital product memory*, which allows for example representation of physical objects and their data, such as cars and their mileage or maintenance information, protected from tampering by the virtue of immutability of blockchain. *Decentralised marketplace for driving data* can, for example, empower car owners to share data about their cars, rides, and surrounding environment, preventing misuse and unintended sharing. *Delivery tracking* can augment existing tracking of goods to benefit from new models of mobility. *Crowdfunding of autonomous cars in a machine economy* can enable financing and operation of self-governing fleet of vehicles.

This vision is essentially consistent with external perspectives. Bloomberg New Energy Finance and McKinsey shared their *Integrated perspective on the future of mobility*[18], which outlined four trends that are rapidly changing passenger transport: electrification, autonomy, connectivity, and sharing. McKinsey followed up with *Urban commercial transport and the future of mobility*[19]. Meanwhile BCG explored some of these trends in *Self-Driving Vehicles, Robo-Taxis, and the Urban Mobility Revolution*[20].

Global, centralised digital corporations are already actively designing and patenting novel solutions in EV charging. For example Amazon applied for a patent on flying drones that might recharge an EV, obtaining the US patent in October 2017, as The Washington Post reports[21]. While it does not necessarily mean that Amazon will use drones to serve EV drivers, it indicates that Amazon is actively engaged in developing EV charging solutions.

Daily customer journey

Customers increasingly expect companies to respond swiftly to inquiries, to customise products and services seamlessly, and to provide easy and secure access to the information they need, when they need it. In mobility services, the key focus for most customers is to get "from A to B" conveniently, cheaply and on time. If electro-mobility is to scale up quickly, it needs to prove its benefits over traditional combustion engine powered mobility.

Digital experience already solves many customer needs and permeates most of the everyday activities surrounding mobility: navigation (Google Maps, Waze, real time traffic updates), smartphone apps for public infrastructure and service, app-based shared mobility services, car rental and other services.

Some centralised services, such as Google Maps, aim to integrate most of these activities, with a preferred ride hailing app, such as Uber, occupying a prominent place among other options on display. Electro-mobility changes the traditional operations in mobility, creating uncertainties for some users. Psychological concerns of customers are range and time anxiety, caused by several reasons:

- **Limited size of batteries**, requiring frequent charging;
- **Wait times** while charging, caused by limited capacity of chargers;
- **Interoperability** among charging networks;

[17] https://www.omos.io/wp-content/uploads/whitepaper/OMOS_concept_paper.pdf
[18] http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/an-integrated-perspective-on-the-future-of-mobility
[19] https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/urban-commercial-transport-and-the-future-of-mobility
[20] https://www.bcg.com/en-cz/publications/2016/automotive-public-sector-self-driving-vehicles-robo-taxis-urban-mobility-revolution.aspx
[21] https://www.washingtonpost.com/news/tripping/wp/2017/10/11/amazon-patents-drones-that-might-give-your-electric-car-a-boost-someday/

- **Reliable availability of chargers** when needed, issue of booking and parking, particularly on-street charging.

Advances in battery research and manufacture will impact these concerns by reducing the wait times, size, and price of batteries. Several new technologies and materials, such as graphene and carbon, promise to substantially improve key parameters of lithium-ion batteries. The speed of their adoption is subject to their successful transition beyond laboratory tests, field trials, and ability to compete in commercial environment. Their success would further strengthen the benefits of electro-mobility.

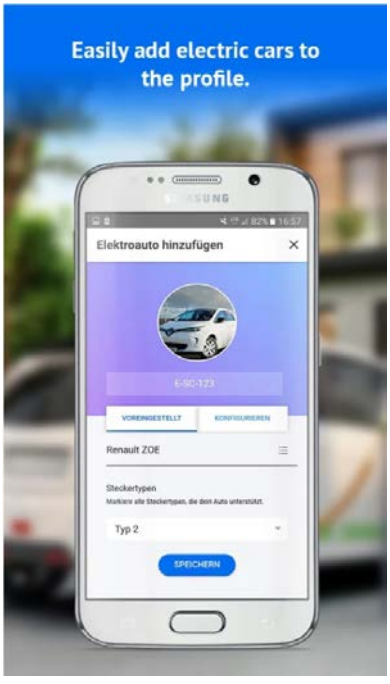
Another issue relates to payments for EV charging, which are more frequent than fossil refuelling and more complex due to the immaturity of the service. Specifically, the following issues are fairly common:

- **Transparency and clarity of rates** and charges before they are incurred;
- **Ability to pick-and-choose best rates** and location of available charging points on the go;
- **Ability to request priority charging** and pay for it, when other EVs do not need priority;
- **Ability to select a supplier or source of electricity**, which would also enable greater competition and increase trust of customers;
- **Preferences for various types of payment**, such as post-paid, pre-paid, or one-off payment.

Finally, the typical transaction value is substantially lower for EV charging than for fossil refuelling, and owners of chargers can charge their own EVs outside of their home. Such factors create an environment for peer-to-peer services, as long as there are zero or near-zero transaction fees (several orders of magnitude smaller than credit card fees), otherwise the money in the system would be gradually siphoned off to payment processors.

Many of these issues are common across Europe and around the world, and could be potentially solved by a shared transaction infrastructure. An example of such infrastructure is the *Share&Charge* service (Figure 1), available in Germany and California, which enables direct payments for EV charging to the owners of chargers, both private and public, and vice versa, who can therefore earn revenue by renting the chargers to others.

Exhibit 1: *Share&Charge app with peer-to-peer payments*



Longer journeys, particularly cross-border ones, are probably where shared transaction infrastructure could add the most value, especially if multiple implementations in different countries are able to somehow interoperate. An example of such cooperation is the *Oslo2Rome* initiative, which builds on the Share&Charge infrastructure to bring more partners to share in the emerging benefits of the technology, and to potentially extend the original peer-to-peer EV charging offer to those customers who prefer the simplest service without the integration and comfort of additional services.

Other use cases could then build on this initial, shared platform, and expand beyond utilitarian EV charging transaction infrastructure in order to enable true cooperation using shared infrastructure, while preserving competition. This is the goal of OMOS, an Open Mobility System, which aims to deliver seamless

mobility (such as parking, car sharing, tolling, etc.) with its members and partners on a shared, open infrastructure.

Purchasing vehicles, building infrastructure

The decision to purchase an electric vehicle (EV) is influenced by several rational reasons, but also by perceived electro-mobility weaknesses, such as range anxiety and the ability to charge at home, which could be addressed in meaningful ways.

For example, EDP is addressing range anxiety by currently developing a mobile app that compares the user's current driving patterns and car usage with the equivalent usage on an EV, and potentially recommending the minimum battery capacity suitable to the user's usage pattern. Making EV charging points (and the distance to them) visible on the app at all times, in addition to showing traditional fuel pumps as a means of comparison, is expected to ease anxiety and contribute to the further electrification of mobility.

The substantial investment required to purchase an EV and secure associated charging infrastructure could be offset by opening new revenue streams to the owners of EV charging points. Examples include:

- **Easy participation in EV-charging marketplaces**, connecting one's home charger to a network and benefiting from community sharing/renting. Examples include Share&Charge in Germany, California, and via Oslo2Rome and OMOS in other European countries, operating on blockchain; ELbnb in Sweden[22]; and youcharge[23] in Austria;
- **Automatic and instant settlement of accounts**, which would help with offsetting daily costs of own EV charging by renting the charger to others;
- **Increased utilisation of chargers**, which would lower the high initial investment burden;
- **Using own production surplus**, generated e.g. by solar panels, explored by Alliander and partners as one of the ideas behind the Joulliette project at De Ceuvel in Amsterdam, operating on blockchain;
- **Vehicle2Grid and Vehicle2Home packages** which also incentivise EV users to provide storage services to the grid, with solutions explored by Alliander and its partners in the Amsterdam Vehicle 2 Grid[24] project.

Vehicle-to-Grid, Vehicle-to-Home[25]

V2G technology can be defined as a system in which there is capability of controllable, bi-directional electrical energy flow between a vehicle and the electrical grid. The electrical energy flows from the grid to the vehicle in order to charge the battery. It flows in the other direction when the grid requires the energy, for example, to provide peaking power or "spinning reserves". Subsets of V2G technology include vehicle-to-home (V2H; when the electric vehicle is at a residence) or vehicle-to-building (V2B; when the electric vehicle is at a commercial building). In these cases, the battery power is used to supplement the local building electrical load without transfer to the electrical grid. Note that this still effectively displaces building load from the grid,

[22] https://cleantechnica.com/2016/07/08/swedens-elbnb-like-airbnb-ev-chargers/
[23] http://www.youcharge.org/
[24] http://www.amsterdamvehicle2grid.nl/
[25] Source: *"Vehicle-toGrid (V2G) Power Flow Regulations and Building Codes Review by the AVTA", Idaho National Laboratory, US Department of Energy*

which effectually provides a load-shed function. Alternatively, if there is a power outage from the grid, this permits emergency backup power to continue building processes.

There are also new commercial opportunities for service providers, given the higher costs of EV, lower fuelling costs, and the opportunity for decentralised energy infrastructure. The services, sought by some segments of customers, include:

- **Installing EV chargers on customer premises**, and making it available to other EV users;
- **Integrating EV charging** with local energy production, delivery, and consumption, including PV panels, home batteries, heating and appliances, and the grid;
- **Crowdfunding** of the charging infrastructure. This is explored by Wien Energie which offers[26] **€**250 vouchers, enabling the holder to earn **€**55 p.a. over 5 years, or even more if already a loyal customer of Wien Energie or partners;
- **Vehicle management**, including car rental, car sharing, and fleet management.

Many of these investment activities and business services could potentially benefit from an open, transparent, and decentralised ledger of transactions (blockchain) or in some cases they already do.

Communities and the society

From families and associations to municipalities, regions, and countries, we share the costs of infrastructure in mobility, energy, and transactions. Investments range from acquiring cars and other means of transport, to building roads and other transport infrastructure, operating energy grids and other assets, and setting standards in banking and other transactions.

At the intersection of electro-mobility and associated services from the energy sector and other sectors is an emerging opportunity to establish a platform which develops shared transaction infrastructure using blockchain. Its potential seems to lie in the ability to link both individual customers and business partners, who could then use the shared infrastructure to develop attractive solutions for their customers. Notable initiatives of this platform initiated by the Innogy Innovation hub include:

- **Share&Charge**, a fully operational service of sharing EV chargers on a peer-to-peer basis in Germany;
- **Oslo2Rome**, a joint effort of European utilities and charger operators to streamline cross-border charging, improve the utilisation of charging infrastructure, and develop shared understanding of other potential services benefiting customers;
- **OMOS**, an open, shared transaction infrastructure enabling partners to deliver better service to customers in electro-mobility.

The need for interoperability and shared open standards is voiced by many members of the EURELECTRIC Blockchain platform. Some members also stress the importance of introducing the principle of 'portability', i.e. the right to relocate your assets in the same way as in telecommunications, as a possible solution to overcome standardisation and regulation challenges.

Other actors are also exploring the use of decentralised digital solutions in electro-mobility.

[26] https://www.tanke-wienenergie.at/das-stromladenetz-fuer-e-autos-in-wien-wird-massiv-ausgebaut-und-sie-koennen-sich-beteiligen/

Hubject[27], the centralised digital Business2Business marketplace for services related to the charging of electric vehicles, with more than 300 partners in Europe and around the world, considers blockchain as an important topic for future market growth in this space, due to the large number of operators, and has been developing a Proof of Concept. Their biggest concerns are the ability to implement the solution at scale and to avoid fragmentation of standards, which happened before in the hardware specifications of chargers, leading to incompatible standards of CHAdeMO[28] and others.

EY recently launched[29] Tesseract, "an integrated mobility platform underpinned by blockchain technology. The platform facilitates fractional vehicle ownership, shared use and seamless multimodal transport. It will help lay the groundwork for how autonomous vehicle fleets can be owned in the future and provide access to a variety of on-demand mobility options."

In a more localised manner, a number of communities combine electro-mobility and renewables, for example **We Drive Solar** in the Netherlands[30].

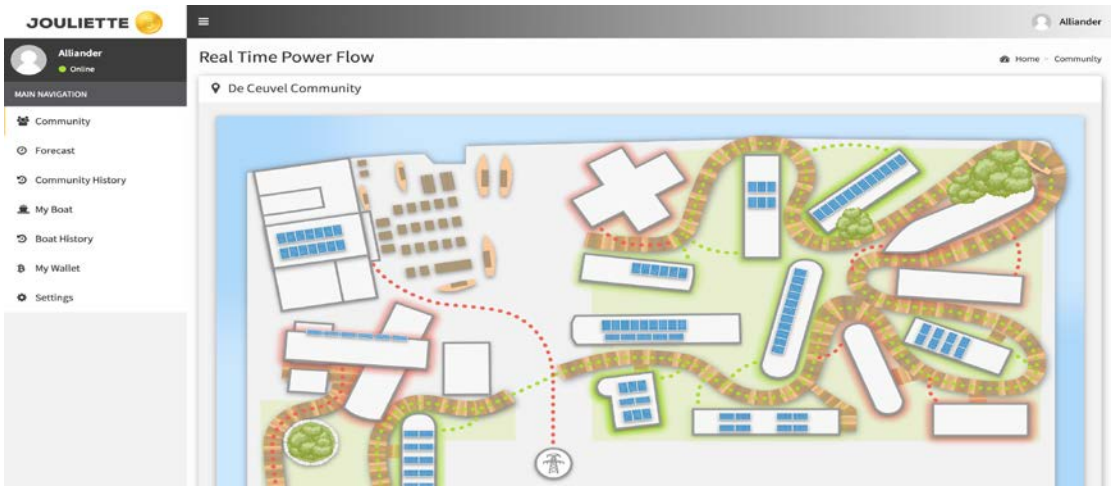
Specifically, in the energy sector, there are emerging communities of customers and prosumers who are interested in trading with their peers and who wish to be informed about the source of their energy. These communities are typically built either on the shared locality, or on a common interest, for example in understanding the specific source of their renewable energy. These initiatives are also connected with concepts of smart cities, smart grids, and related operations. Examples of energy communities using blockchain technology include:

- **Jouliette**, an experimental blockchain pilot launched at the De Ceuvel community in Amsterdam, in cooperation with Alliander, illustrated by Exhibit 2;
- **Conjoule**, a blockchain-based peer-to-peer energy retailer spun off from Innogy Innovation Hub, with a pilot in Germany;
- **Sonnen Community**, linking customers, residential energy storage, PV, and other renewables and indirectly providing flexibility to the TSO;
- **Vandebron**, linking customers with renewables and indirectly providing flexibility to the TSO.

These trading and flexibility initiatives are the focus of other workstreams of the EURELECTRIC blockchain platform and will be examined in detail in future analysis.

[27] https://www.hubject.com/
[28] https://en.wikipedia.org/wiki/CHAdeMO
[29] http://www.ey.com/gl/en/newsroom/news-releases/news-ey-advancing-future-of-transportation-with-launch-of-blockchain-based-integrated-mobility-platform
[30] http://www.wedrivesolar.nl/

Exhibit 2: *Real-time power flow among the buildings of the De Ceuvel community blockchain pilot in Amsterdam. Image courtesy of Alliander.*



The rise of autonomous technologies could also help improve the utilisation of existing infrastructure in the long term, such as roads, parking, and other services, improving the quality of life of the communities.

In order for society to benefit from these solutions, it could learn from the evolution of the digital economy, improve the Internet as we know it, and aim for transparent governance which would benefit both the customers and service providers, building on the core principles of:

- **Democratic Governance**: blockchain technology that is governed by democratic mechanisms instead of a centralised party or even oligopoly;
- **Open Portability**: The idea that assets are owned by their owner and should not be locked in by a blockchain ecosystem, but rather freely transferrable between blockchains;
- **Social Incentives**: A design philosophy where blockchains are not run by a purely monetary incentive but also by an incentive that stems from social contribution principles;
- **Antifragility**: A learning mechanism that allows communities of blockchain developers, users, and customers to learn from experience and evolve towards greater resilience.

These societal concerns are not necessarily at odds with commercial opportunities, as existing examples in the open source software environment show: Red Hat[31] sponsors and helps the community which develops Fedora Linux, a freely available open source operating system. At the same time Red Hat provides premium service to enterprise customers, which contributed to Red Hat revenues of $2.4 billion in 2016.

In blockchain use cases the driver of commercial adoption could be the cost efficiency of operations, which could also lower cost per transaction. This hypothesis, along with the notion that open source platforms may unlock services and markets that were not even imagined at the stage of early adoption, needs to be tested in order to provide guidance to developers and ensure the desired result.

[31] https://www.redhat.com/

Society and its policymakers could work with companies and help customers in their transition to clean mobility. EURELECTRIC and its Blockchain platform partners are ready to work with the European Commission and other national and European stakeholders to continue developing the necessary infrastructure and test the potential of blockchain. In this context, the platform is prepared to partner with institutional actors to assess the agility and preparedness of legislative and regulatory frameworks at EU and national level to allow for the increased use of blockchain, should it be validated by early use cases as a reliable, customer-friendly, and cost-efficient solution.

Electricity and the mobility sector perspective

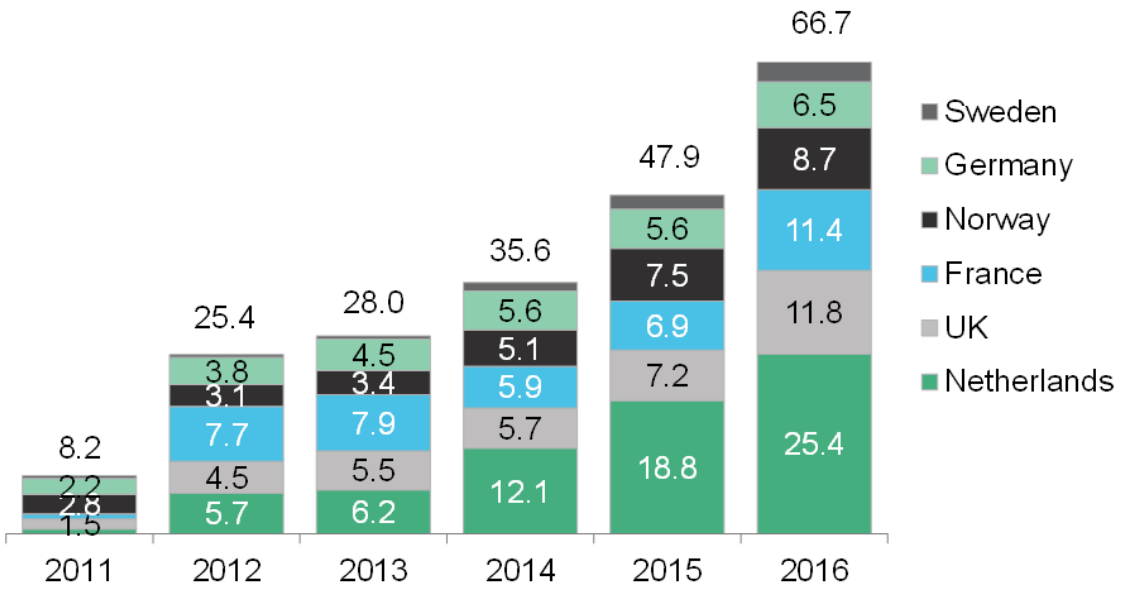
Electric mobility seems to be at its tipping point before mass uptake for various reasons, some of which are listed in a recent article[32] by EV-box. Combined with other factors, such as customer experience of EV driving, green public procurement, financing products helping customers to purchase an EV, and corporate fleet initiatives, this creates a situation which will foster the widespread deployment of electric vehicles.

The challenge of growth of electric vehicles

The electricity sector will face challenges due to the future growth of the market share of electric vehicles and the location of their power demand, which current charging solutions do not solve. Without smarter infrastructure the growth of electro-mobility could incur significant additional costs or remain limited, and fail to live up to its potential. This is the challenge which blockchain holds the promise of solving.

Finding a publicly accessible EV charger is easier than it was just a few years ago. Streets and parking lots in many European towns are budding with dedicated charging poles, and enthusiasts are offering their private power sockets to EV drivers in need almost anywhere.

Exhibit 3: *Charging stations in Europe, 2011-2016, (thousands of stations)*



Source: Bloomberg New Energy Finance, data.gouv.fr, BDEW, NOBIL, National Charge Point Registry. Note: selected countries only.

Figure courtesy of Bloomberg New Energy Finance.

However, as Bloomberg New Energy Finance notes[33], the path towards charging infrastructure is still not clearly solved. The amount of public EV chargers has grown significantly in the last five years, as Exhibit 3 indicates, but more is needed to foster the adoption of EV. Even when EVs themselves reach cost parity with internal combustion engine vehicles, the lack of home charging will be a significant barrier to their adoption and will restrict EV sales from reaching 100%.

[32] http://blog.ev-box.com/tipping-point-electric-mobility/
[33] https://about.bnef.com/electric-vehicle-outlook/

The expansion of simultaneous home charging would strain the grids and may incur additional costs. National Grid, in its thought piece[34], quotes a pilot project called My Electric Avenue, which identified voltage issues in a specific distribution grid cluster supplying 134 residential dwellings and five EV chargers of modest size (3.5 kW) operating at the same time. The project concluded that across Britain 32% of low voltage circuits will require reinforcing when 40-70% of customers have EVs based on such 3.5 kW chargers, with problems exacerbated when 7 kW chargers are used. National Grid proposes that "perhaps one potential solution would be to build a few thousand super-fast charging forecourts of over 3 MW capacity rather than carry out a large scale rebuild of the domestic electricity infrastructure. It may well be that the charging from home option may not be in the long term interest of the consumers even with smart chargers."

The 2015 EURELECTRIC paper on EV smart charging[35] quotes a calculation made by ERDF in France, which indicates that for every 1 million of EV globally travelling, the cost of low voltage grid reinforcement to enable EV charging in single houses would be **€**200 million, with even higher costs for multiple EV charging in multi-dwelling or business buildings and for the public charging spots in the streets and parking lots. Fortunately, the calculation also indicates that smart charging could reduce the incurred costs by almost 100% in the case of single house charging, by 70% in the case of larger buildings, and by 50% in the case of charging in public spaces.

The expansion of charging infrastructure, needed to sustain long-term growth of electric mobility, might be made cheaper by a more sophisticated and digital approach to EV charging.

The opportunity for smart charging

Customers, their vehicles and their appliances, could optimise electricity consumption based on price signals provided by energy markets, grid constraints, and other factors, such as parking fees and the need for fleet operation. This service of "smart charging" could help in optimising power demand and thus grid operation, leading to lower additional grid costs (compared to other options) and better customer experience for EV users, while bringing more flexibility and information about future power consumption for grid operators. EURELECTRIC called for smart charging in its 2015 paper, and now individual companies, such as Alliander or MotionWerk of Innogy, are exploring and developing it using blockchain concepts and technology.

The efficient exchange of information would prevent information asymmetry, improve utilisation of assets, enhance trust, and potentially decrease further investment and operational costs. The concept of distributed ledgers and crypto-token payments enables multiple parties to share information, optimise and automate operation of their assets, enter into contracts, and settle the transactions. The parties which could be involved include:

- **customers**, who can lower their costs by optimising the use of their assets, based on asset parameters and availability, and who can also benefit from new revenue streams and higher utilisation of their assets, such as electric vehicles;
- **charging pole operators**, who can increase utilisation of their assets and improve the customer experience for EV users;
- **electricity suppliers**, who can facilitate provision of wholesale power and additional, novel services responding to demand needs in specific geographies or time zones through information available on the distributed ledgers;

[34] http://fes.nationalgrid.com/insights/forecourt-thoughts-mass-fast-charging-of-electric-vehicles/
[35] Smart charging: steering the charge, driving the change, EURELECTRIC paper, 2015

- **aggregators**, providing the forecast and information flow between supply and demand (not yet viable for all European countries, but quickly appearing across first adopters in Europe and the US) and executing the demand response commands requested from distribution and transmission grid operators;
- **distribution grid operators**, who can benefit from information about future power demand, indicate grid constraints and nudge aggregators, customers, and their assets into change in behaviour, and use price signals to customers in order to optimise grid operation, instead of resorting to control signals to limit the grid load, prevent extreme situations, and avoid grid upgrade costs;
- **transmission grid operators**, who can facilitate provision of wholesale power, balancing, and ancillary services, while improving stability of the grid and receiving information about future power demand;
- **EV manufacturers**, who could bundle energy costs and new energy revenue streams into transport service offering.

All parties can also decrease their transaction costs by using instant settlements offered by certain types of blockchain technology, which could enable economic operation even in situations involving micro-transactions and real time transfers. Furthermore, the concept of coordinated and automatically executed agreements, *smart contracts,* and of decentralised data feeds, *oracles*, could also help in automating the transactions, lowering back-office costs and the need for operational capital.

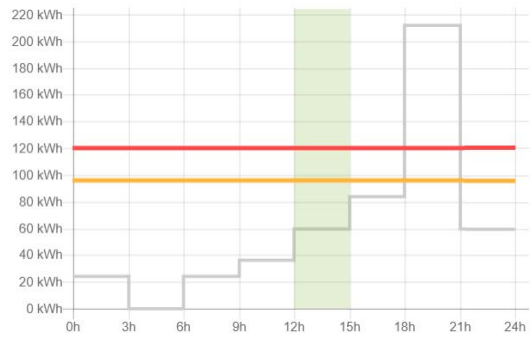
In this way the parties involved could prevent the "tragedy of the commons", which in this case means depleting the available grid capacity to power EV charging in peak times, and avoid it by working together to lower system costs. Elements of these concepts have been already developed by several companies.

Alliander demonstrates this blockchain use case in their Alva Energy Consortium concept[36], where the 6:00pm evening peak of EV charging in the base scenario is avoided using dynamic price signals composed of the base price, flexible transport tariffs, and congestion surtax, as Exhibit 4 illustrates.

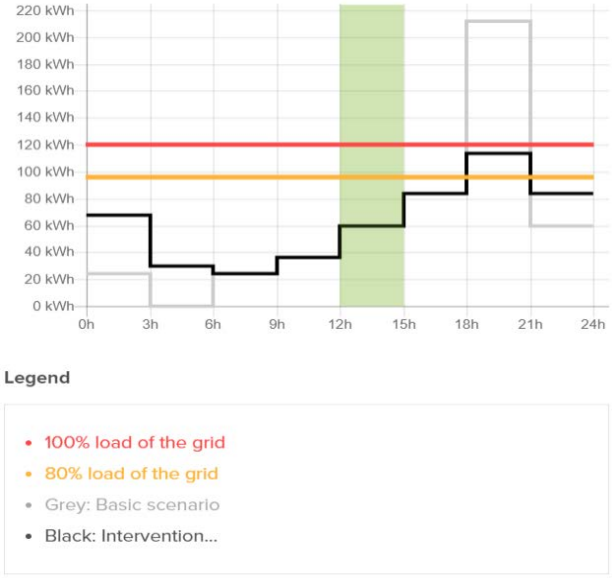
[36] http://blockchain.alliander.com/

Exhibit 4*: Alliander Alva project*

a) basic scenario



b) optimized scenario



Ponton, a software supplier for the European energy industry and developer of the *Enerchain* blockchain trading platform, is also developing *Gridchain*[37], a blockchain-based coordination platform for DSO and TSO processes. The communication also involves aggregators and generators, aiming to shorten the entire process to request, deliver, and settle balancing power to 45 minutes, composed of three 15-minute intervals for each step.

The emerging solution of smart charging, based on nascent decentralised ledgers, could balance the market approach and the co-operative optimisation nature of decentralised transaction systems. This would help preserve the competition which improves customer experience, helping with integration of renewables into energy markets and systems, building on open standards, and laying foundation for shared mobility infrastructure available across Europe and around the world.

Novel revenue streams for electric vehicles

As electric mobility matures, the associated services are unlocking new sources of revenue for customers, fleet operators, vehicle manufacturers, and also electricity sector actors.

Some manufacturers are already equipping EVs to perform *Vehicle2Grid* (V2G) services, supplying electricity from mobile batteries back to the system, in addition to *smart charging*, which optimises the timing of battery charging to help in balancing the system. Nissan is developing partnerships to leverage its V2G technology, with more than 100 cars in trials across Europe, as Bloomberg reports[38]. In Denmark, Nissan and partners implemented a solution which enables EVs to earn money by feeding power back into the grid. There, fleet operators collected about

[37] https://enerchain.ponton.de/index.php/16-gridchain-blockchain-based-process-integration-for-the-smart-grids-of-the-future

[38] https://www.bloomberg.com/news/articles/2017-08-11/parked-electric-cars-earn-1-530-feeding-power-grids-in-europe

€1,300/year using the two-way charge points, according to a Nissan representative interviewed by Bloomberg.

In the UK, Nissan partnered with Ovo Energy, which is proposing free energy for customers who take up their new V2G service. The Times quotes[39] the CEO of Ovo Energy as saying, "If we can use our customers' batteries to discharge and power the grid at peak times, it should more than cover the cost of the energy required to fill the battery up. They shouldn't have to pay to fill up ever again."

As an added benefit, other legacy solutions, such as backup diesel generators, could be improved or replaced by low-carbon solutions leveraging EV assets as well as stationary storage.

The benefit of electric vehicles goes beyond lower emissions compared to fossil fuel cars. Car manufacturers who equip their vehicles with V2G and similar technologies could help their customers unlock new revenue streams to counteract the higher costs of EVs, and see their vehicle market share expand even at the expense of single use EV manufacturers. Blockchain is being piloted as a coordination tool in some of these use cases already today, and the EURELECTRIC blockchain platform will continue exploring opportunities in this space.

[39] https://www.thetimes.co.uk/article/how-to-run-an-electric-car-without-any-charge-nissan-ovo-energy-rhzv6cthw

Blockchain technology perspective

Blockchain, an emerging technology solution, is expected to deliver improvements in many areas of public life and the economy, including the energy and mobility sectors. This chapter aims to outline basic properties of blockchain technologies, a list of platforms in development and use, and initial identified issues which should be solved to enable adoption of blockchain in the energy sector to improve customer experience, resilience, sustainability, and affordability of energy services.

Blockchain technology essentials

Quoting a McKinsey article[40], "*Blockchain is a shared, public ledger of records or transactions that is open to inspection by every participant but not subject to any form of central control. The Economist newspaper has described it as a machine for building trust. In the case of the virtual currency bitcoin, arguably its most famous application, it tracks transactions and facilitates money transfer, while preventing double-spending, without the need for a bank. But blockchain lends itself to many other systems for keeping static records (of land titles, for example), for registering dynamically the exchange of assets, and for making payments such as ticket purchases. It is also a platform for 'smart contracts' - computer programs that automatically initiate certain actions when predefined conditions are met."*

Criteria for blockchain use case can help identify real applications where blockchain technology could add value over traditional relational databases, and vice versa, where traditional database may suffice. The following guidelines build on thinking[41] published by Gideon Greenspan, CEO of Coin Sciences:

1. **Use of a database:** blockchains, or distributed ledgers, are technologies for shared databases, structured repositories of information, which are modified using transactions;
2. **Multiple writers**: more than one entity is expected to enter transactions, otherwise a standard centralised database would be sufficient;
3. **Absence of trust**: the writers do not necessarily trust each other (e.g. due to cybersecurity concerns or different economic incentives); trust can be absent even inside a single organisation;
4. **Disintermediation**: there is no need for a trusted intermediary who would control the database and have centralised power over transactions, which are instead verified independently according to the agreed rules of the blockchain implementation.

Characteristic benefits of blockchain

Ponton, developer of the Enerchain blockchain-based trading platform, proposed also the following characteristic benefits:

Instantaneous settlement: blockchain transactions are typically settled immediately and could be further extended to mitigate the counterparty risk for the selling party

Potential for cost reduction: blockchain nodes can be operated at a low cost, estimated by Ponton at 10-20 EUR/month; a permissioned blockchain can be expected to operate with 4-20 nodes, which would imply annual hosting cost as low as 1.000-4.000 EUR

High technical availability: even if individual blockchain nodes operate at relatively low availability (e.g. 99%), with the consensus algorithm tolerating outages of up to N nodes the overall availability could remain close to 100%, diminished only by the possibility of N+1 nodes simultaneously disconnecting

[40] https://www.mckinsey.com/industries/financial-services/our-insights/the-promise-of-blockchain
[41] https://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/

Transaction interaction brings additional benefits when more than two parties are involved in a transaction, for example EV charging involves customers, charger operators, DSO, TSO, and power markets, as would other flexibility use cases. Energy trading could involve two transaction parties, but also the regulator, grid operators, banks providing guarantees etc.

Set the rules, pick your validators outlines an imperative for blockchain governance, which includes basic checks on transactions, such as access rights or preventing duplication of assets, as well as more advanced rules as defined by the blockchain implementation. Equally important are *validators*, who form a specific subset of participants, authorised to confirm transactions on behalf of the entire blockchain.

Depending on the design there are several types of blockchain segmented by permission model, as illustrated by the table in Exhibit 5, reprinted from the *Global blockchain benchmarking study*[42] published by the Centre for Alternative Finance, University of Cambridge.

Exhibit 5*: Blockchain types and associated access rights*

			Read	Write	Commit	Example
Blockchain types	Open	*Public permissionless*	Open to anyone	Anyone	Anyone*	Bitcoin, Ethereum
		Public permissioned	Open to anyone	Authorised participants	All or subset of authorised participants	Sovrin
	Closed	*Consortium*	Restricted to an authorised set of participants	Authorised participants	All or subset of authorised participants	Multiple banks operating a shared ledger
		Private permissioned ('enterprise')	Fully private or restricted to a limited set of authorised nodes	Network operator only	Network operator only	Internal bank ledger shared between parent company and subsidiaries

** Requires significant investment either in mining hardware (proof-of-work model) or cryptocurrency itself (proof-of-stake model).*

Source: *Global blockchain benchmarking study,* Cambridge Centre for Alternative Finance, University of Cambridge

The above criteria can be complemented by five key criteria for blockchain, outlined by McKinsey in *Blockchain Technology in the Insurance Sector*[43]. Four of the criteria correspond to the previously introduced thinking: *Distributed ledger*, *Remote independent writers, Existence in absence of trust,* and *Causing disintermediation.* A fifth criterion, *Economic benefit for participants*, indicates another important issue which may prove crucial for the long-term viability of blockchain solutions.

[42] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3040224
[43] https://www.treasury.gov/initiatives/fio/Documents/McKinsey_FACI_Blockchain_in_Insurance.pdf

An article[44] by Sebastien Meunier lists several *decision models* which help to better understand the real opportunities enabled by blockchain solutions, and vice versa identify situations in which alternative solutions would be more helpful.

Overview of blockchain and distributed ledger technologies in energy and mobility

Given the early stage of blockchain technologies there is a number of evolving platforms. This short overview has no ambition to provide an exhaustive list, and aims primarily at platforms which are already used in real pilots in the European energy sector. The platform will explore the technologies in subsequent Modules.

Ethereum[45] is relatively widely used in the energy sector, including electro-mobility by OMOS, Oslo2Rome, and Share&Charge; by Conjoule from innogy; by the Energy Web Foundation; by the US-based Consensys Grid+; by the Australian Power Ledger; by the Spanish multisectoral infrastructure Alastria, and by other initiatives.

Hyperledger[46] underpins e.g. the initiative[47] of TenneT, sonnen, Vandebron, and IBM.

BTL Interbit[48] supports a multi-stage trading pilot with BP, Eni Trading & Shipping, and Wien Energie, in cooperation with EY[49].

Openchain[50] is used in Jouliette[51], blockchain-based energy token launched by Spectral and Alliander in the De Ceuvel community in Amsterdam.

Moreover, blockchain-inspired technologies have been developed for the banking and insurance industries, most notably Corda[52] from the R3CEV consortium, and for specialised use-cases, like IOTA[53]**,** which is a blockless distributed ledger for large-scale Internet-of-Things use cases.

These platforms focus on different aspects of blockchains and distributed ledgers. The main use cases include crypto-currencies, crypto-tokens, smart contracts, tokenisation of assets, deep integration with IoT devices, etc. It is possible that multiple blockchain platforms will mature, solving needs in various types of use cases, similar to centralised database technologies. It is important to promote cooperation, so that the solutions are interoperable while market dominance by a single provider and fragmentation are prevented. Regardless of the technology used, the ambition of new solutions is to make the process of value exchange ('transfer of titles' in all its forms) easier than today.

Future Work

Blockchain technology is still in its early stages of development: its most visible initial application, the Bitcoin public network, was launched in 2009, another public network, Ethereum, was launched in July 2015, and Hyperledger Fabric reached its version 1.0 in July 2017. This section aims to address some of the outstanding issues with the technology, which should be addressed in order to accelerate adoption in areas where blockchain might bring added value. It builds on the

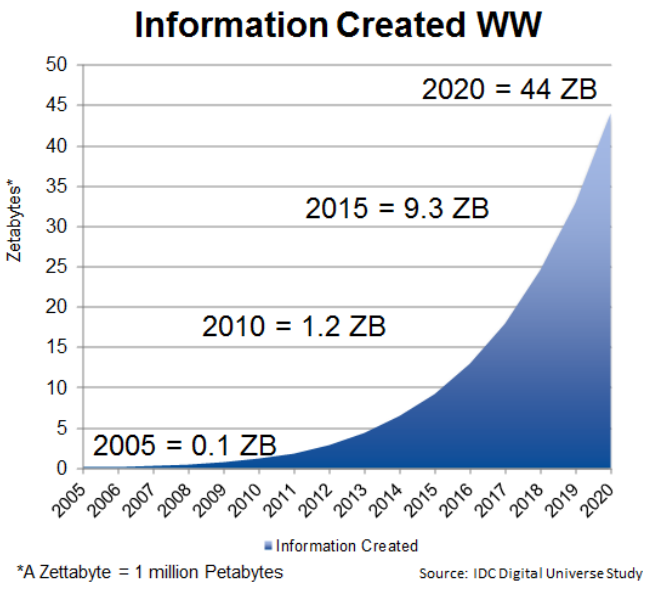
[44] https://medium.com/@sbmeunier/when-do-you-need-blockchain-decision-models-a5c40e7c9ba1
[45] https://ethereum.org/
[46] https://www.hyperledger.org/
[47] https://www.tennet.eu/news/detail/tennet-unlocks-distributed-flexibility-via-blockchain/
[48] http://btl.co/
[49] https://www.reuters.com/article/us-bp-eni-blockchain/bp-eni-deepen-blockchain-trading-in-european-gas-idUSKBN18W1N2
[50] https://www.openchain.org/
[51] https://jouliette.net/
[52] https://www.corda.net/
[53] http://iota.org/

questions raised by the community of European utilities, who are members of the EURELECTRIC Blockchain platform, and aims to engage technology developers who could provide answers and solutions.

The question of costs is often raised, with further questions on cost-benefit analysis, business case, and value creation. While such questions are important and will need to be answered as the technology matures beyond pilots and commercial break-even, it is also important to keep in mind the broad picture of technology mega-trends, externalised costs of current centralised solutions, and the early indications of blockchain competitive advantage as communicated by industry representatives.

Exhibit 6: *Information created worldwide. Figure courtesy of IDC.*

Technology mega-trends lead to a steady increase in available IT resources. One example is computer storage, which is being tracked by the International Data Corporation (IDC). As Exhibit 6 indicates, the amount of *Information Created* follows an almost exponential trend between 2005 and 2020. While substantial share of the information consists of *Transient Data,* IDC[54] research shows that the amount of *Installed Bytes* and *Used Bytes* grows as well. Furthermore, IDC expects 50% utilisation rate across all storage mediums by 2020. *For the purpose of this report, we can assume that there will be a decentralised, growing amount of free storage available.*



Current centralised solutions may externalise costs, which ultimately impairs the quality of customer experience. Examples include the cancellation of service to customers, as illustrated by the outage of British Airlines IT systems in May 2017 which affected 75,000 passengers in more than 670 flights over three days and caused estimated costs of €100 million[55]. Breaches of personal data are also an issue, with the recent example of the US company Equifax which saw 145 million customer records compromised, including sensitive information about 700,000 customers from the UK[56].

Regarding early indications of benefits of blockchain in the energy industry, a recent article in Financial Times[57] quotes David Eyton, head of technology for BP, saying "There are uses for blockchain that could give us a competitive advantage. Blockchain can be much more efficient in terms of speed and verification of transactions." BP participates in the BTL blockchain trading pilot with Eni and Wien Energie.

[54] IDC, "Data Consumption is Driving our Digital Universe"
[55] https://www.bloomberg.com/news/articles/2017-06-06/british-airways-points-to-human-error-for-may-flight-outage
[56] https://www.reuters.com/article/us-equifax-cyber/equifax-says-15-2-million-uk-records-exposed-in-cyber-breach-idUSKBN1CF2JU
[57] "BP experiments with blockchain for oil and gas trading", Financial Times, Oct 3, 2017

Blockchain offers new solutions to the operational issues, building on technology trends and with early indications of possible success. Business analyses should take into account the new ways of operation and include in the comparison also the currently externalised costs. This issue deserves further attention with a long-term perspective which would reflect the possible transformational nature of the technology and hence its ability to unlock pools of value which are unforeseeable at this stage.

Hardware infrastructure for blockchain deployment is another topic raised by EURELECTRIC blockchain platform members. This issue has two elements, covering hardware for cryptocurrency mining[58] and for the operation of blockchain wallets and nodes. The topic of hardware for mining is beyond the scope of this report, since mining is a relatively straightforward, commercial, and speculative area beyond use cases specific for the energy sector. Furthermore, mining is not necessary in all blockchain implementations, for example in case of permissioned/consortium blockchain using Proof-of-Stake or Proof-of-Authority.

Hardware for operation of blockchain wallets requires a high standard of cybersecurity. An example of such new development is the Grid+ hardware agent and system, which aims to maintain a high degree of security due to hardware-level security features, i.e. cryptographic chips. Grid+ estimates[59] that the manufacturing cost of its Smart Agent will be close to $50.

The operation of blockchain nodes (without mining) does not require specialised hardware, and users indicate that various blockchain nodes can be run on commodity hardware, such as off-the-shelf servers or even the Raspberry Pi family of micro-computers, priced at around $35. Ponton, developer of the Enerchain blockchain-based trading platform, estimated the cost of operating one node at €10-20/month; a permissioned blockchain can be expected to operate with 4-20 nodes, which would imply annual hosting cost as low as €1,000-€4,000.

Oracles as decentralised interfaces between the physical and digital world: an energy blockchain solution could be seen as a digital twin on top of the physical grid, replicating the physical power network in the digital world. The oracle is an interface between the physical and digital world. As long as data sent to the blockchain cannot be removed or changed, there is a need to have a system which allows only certified information to be sent to the blockchain. Such physical-digital interface could be implemented as a piece of hardware. To prevent tampering, hardware malfunction, and other anomalous and harmful situations, resilient solutions should and will be adopted. These could include the concept of "hardware wallet", methods of managing private cryptographic keys, multi-signature solutions, and additional instances of innovation.

Use cases in the energy sector mostly revolve around metered information, usually involving power injection into the grid or consumption from the grid. The development of "oracle hardware wallets" is important in order to scale concrete use cases while preserving the integrity of the blockchain.

Other industries are testing also more abstract types of oracles, e.g. the insurance company AXA released a blockchain-based flight delay insurance called Fizzy[60], which uses an oracle providing external information about flight delays. Thomson Reuters released smart oracle[61] as an experimental source of external data for use cases in financial services.

[58] Future mining might require intensive computation or use more energy-efficient algorithms.
[59] https://gridplus.io/
[60] https://www.linkedin.com/pulse/fizzy-innovation-axa-launched-laurent-benichou
[61] https://www.thomsonreuters.com/en/press-releases/2017/june/thomson-reuters-releases-blockone-iq-into-blockchain-developer-community.html

The creative combination of various types of blockchain oracles could give rise to fundamental innovation of the magnitude similar to smartphones, which blended sensory information from geolocation, accelerometers, cameras, microphones, touchscreens, and wireless communication to change the way multiple industries serve their customers. “Oracle hardware wallets” could be a fundamental contribution of the energy sector to this multi-sectoral innovation.

There are also other identified issues related to the evolution of blockchain, such as the current limits on the transaction volume in some platforms and issues surrounding privacy designs. Some platform members are also interested in potential middleware solutions, such as Gem[62]*.*

[62] https://gem.co/

Blockchain: a regulatory perspective

Blockchain technologies and associated cryptocurrencies have already captured the interest of many policymakers and commercial adopters. Governments and supranational bodies are exploring the topic from multiple angles. For example, the **European Commission** has concluded a tender an the end of September on setting up a European Blockchain Observatory[63], the **European Parliament** published an in-depth analysis *How blockchain technology could change our lives*[64], the **World Economic Forum** published a white paper *Realizing the Potential of Blockchain: A Multistakeholder Approach to the Stewardship of Blockchain and Cryptocurrencies*[65], and the **UK Government Chief Scientific Adviser** explored *Distributed Ledger Technology: beyond block chain*[66].

Exploring the more specific government use cases indirectly related to the energy sector, McKinsey reports about *Using blockchain to improve data management in the public sector*[67], with specific examples of **Estonia** protecting critical data, **Sweden** piloting a blockchain solution to streamline real-estate transactions, and the **US State of Delaware** being in the early stages of creating company incorporation services based on blockchain records and smart contracts, rather than paper-based exchanges.

The European Central Bank and the **Bank of Japan** reached a conclusion that the technology has significant potential, as Reuters reports[68], "giving reasons to be optimistic", but said that issues including latency remained and that further development and testing were needed. "Given the relative immaturity of the technology, distributed ledger technology is not a solution for large-scale applications like BOJ-NET and TARGET2 at this stage of development," the ECB and BOJ said, adding that "this joint effort has produced a thorough set of results that provide reasons to be optimistic with respect to the capabilities of DLT *[distributed ledger technologies]* within payment systems."

Reuters further reports that **banks and other large financial institutions** have been ramping up efforts to develop blockchain-based technology to run some of their most burdensome back-office processes, such as the clearing and settlement of securities.

Managing Director of the **International Monetary Fund**, Christine Lagarde, said: "*So in many ways, virtual currencies might just give existing currencies and monetary policy a run for their money. The best response by central bankers is to continue running effective monetary policy, while being open to fresh ideas and new demands, as economies evolve.*"[69] Judging from the pilots explored in this report, energy regulators may soon face a similar challenge.

General consideration of the digital industry

European policymakers are already discussing the future of Europe's digital economy, with the European Commission exploring topics such as *Fair Taxation of the Digital Economy*[70]. These discussions focus primarily on mature, centralised digital platforms which are operated mainly by

[63] https://ec.europa.eu/digital-single-market/en/news/eu-blockchain-observatory-and-forum
[64] http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf
[65] http://www3.weforum.org/docs/WEF_Realizing_Potential_Blockchain.pdf
[66] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf
[67] https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/using-blockchain-to-improve-data-management-in-the-public-sector
[68] https://www.reuters.com/article/us-blockchain-ecb/blockchain-immature-for-big-central-banks-ecb-and-boj-say-idUSKCN1BH2DH
[69] https://www.imf.org/en/News/Articles/2017/09/28/sp092917-central-banking-and-fintech-a-brave-new-world
[70] https://ec.europa.eu/taxation_customs/business/company-tax/fair-taxation-digital-economy_en

major American companies like Google, Apple, Facebook, Amazon. Due to its decentralised nature, blockchain technology can provide an opportunity to counterbalance the economic weight of established digital giants by new, more inclusive means of organising the digital economy that would eventually span beyond financial services. European policymakers enable investments into innovative developments with high added value by examining and adapting regulatory and legal frameworks, as well as with funding and financing instruments in a way which allows the entry of innovative solutions aligned with the obligations and responsibilities of current market participants. Regulators across the world are already exploring the potential, enabling experimentation, or limiting certain blockchain use cases which require further evaluation and regulation. The broad range of actors and activities includes:

- **The European Court of Justice**, which ruled that cryptocurrencies are exempt from VAT[71], as explained also by Norton Rose Fulbright[72];
- **The Bitlicense in New York**[73], which sets rules for the operation of a business using virtual currencies;
- **Dutch Blockchain Coalition**[74], a joint venture between industry, government, and knowledge institutions, which tries to stimulate the large-scale deployment of blockchain technology in The Netherlands.

While all similar actions by regulators refer mainly to blockchain use cases in the financial services sector, it is important to anticipate a similar level of activity from energy regulators once the use cases of blockchain in the energy sector reach a similar level of technological maturity and public awareness, in the same way cryptocurrencies did. This is why it is crucial for the energy sector to evaluate the potential disruption factor of blockchain and work with the responsible institutions today to develop the rules by which this transformation could take place without fundamentally incapacitating our energy system and the reliability of the services it offers.

Potential clashes and overlaps of competencies between different regulatory authorities will also have to be anticipated and resolved especially in light of trends of industrial sectors convergence. The disruption that blockchain and rapid digitalisation of the energy sector could bring about could expose the vulnerabilities of energy systems, and although the majority of customers would not notice the disappearance of bitcoin, they would certainly be alarmed by an interruption of their electricity system.

Opportunities to promote digital innovation and competitiveness in Europe

Policymakers and regulators in the EU and its Member States could help in piloting and adoption of digital services benefiting customers and markets in several areas, including financial regulation, tax authorities, and the energy sector.

Financial policy makers and regulators could foster innovation by providing "regulatory sandboxes" similar to the ones being implemented for FinTech start-ups in UK, Switzerland, Hong Kong, Australia, Thailand, Singapore[75] and proposed in Austria[76]. Such initiatives could help the European economy remain competitive in an environment with governmental support for FinTech innovation.

[71] http://curia.europa.eu/juris/document/document.jsf?text=&docid=170305
[72] http://www.nortonrosefulbright.com/knowledge/publications/133585/bitcoins-ecj-rules-that-buying-and-selling-bitcoin-is-exempt-from-vat
[73] http://www.dfs.ny.gov/legal/regulations/bitlicense_reg_framework.htm
[74] https://www.dutchdigitaldelta.nl/en/blockchain
[75] https://www.bbva.com/en/first-cohort-first-fintech-regulatory-sandbox/
[76] http://www.svlaw.at/en/austria-land-of-mountains-land-of-blockchain

Tax authorities could consider streamlining tax rules to benefit from digital innovation, including transactions based on blockchain technologies, as such technologies mature. Electro-mobility across borders could benefit from streamlined taxation rules which could be automated to benefit customers and service providers, who could design more attractive services. Furthermore, tax authorities could enable a direct and secure tax payment for the taxable persons or business units collecting VAT and other duties seamlessly upon every charging. This would drastically decrease the authorities' administrative costs and create transparency on the exchanged information.

Energy sector policymakers and regulators could consider regulatory tools to explore Peer-to-Peer Electricity Trading in those jurisdictions where such activities are obstructed by the complexity of established procedures, e.g. Tenant Supply / Mieterstrom in Germany and Austria, or the trading within a postal code in the Netherlands. Regulatory and legislative changes should not create disadvantages for incumbents and should foresee responsibilities and obligations for new entrants similar to those against which incumbent energy market participants are held accountable.

Electro-mobility customers could also benefit from simplified rules on charger licensing and access, Peer-to-Peer sharing, and similar concepts. But first and foremost, identifying the regulatory and legislative gaps and barriers at EU and national level requires a similar "sandbox" approach in piloting blockchain solutions for various use cases in the energy sector. For example, developing and perfecting a system solution, which would unlock a platform versus pipeline approach to new energy services and products as proposed earlier, while testing and establishing the real value added of blockchain, would require a regulation-free zone or sandbox.

More dialogue will be needed among all actors across Europe in the energy sector and adjacent industries. We could draw inspiration from Christine Lagarde, Managing Director of the International Monetary Fund, who said at a recent Bank of England event[77]:

> *"[T]o make things smoother - at least a bit - we need dialogue. Between experienced regulators and those regulators that are just beginning to tackle fintech. Between policymakers, investors, and financial services firms. And between countries.*
>
> *Reaching across borders will be critical as the focus of regulation widens - from national entities to borderless activities, from your local bank branch to quantum-encrypted global transactions."*

Future work

Blockchain technology forms a complex, rapidly evolving environment, which creates novel challenges for existing regulatory and legal frameworks. As the sector evolves to improve everyday services to customers, the following topics will need to be addressed:

- **Customer protection rules**, data privacy and ownership, including GDPR[78];
- **Regulatory compliance costs**, which were raised by some platform members, seem to be a concern as energy trade volumes increase with the development of flexible intra-day and intra-hour markets and the regulatory compliance costs (for instance REMIT[79]) incurred by the required data management have a stifling effect on market development and lead to high barriers to entry for smaller market participants;

[77] http://www.imf.org/en/News/Articles/2017/09/28/sp092917-central-banking-and-fintech-a-brave-new-world
[78] http://ec.europa.eu/justice/data-protection/reform/index_en.htm
[79] Regulation No 1227/2011 on wholesale energy market integrity and transparency

- **Legal status of "smart contracts"**, which despite their name are not complete, legal contracts, but pieces of computer code deployed on the decentralised blockchain network. Public blockchain networks have no centralised counterparty that would bear responsibility for such code, which might lead to the ineffectiveness of certain existing laws, rules, and regulation, which in turn opens a discussion about AML (anti money laundering) and KYC (know your customer) rules;
- **Taxation** of crypto-currencies and tokens.

Some customers in the energy sector will be interested in actively testing the novel, decentralised transaction concepts developed in the financial services sector and other industries. Many other customers will have the same expectations about their energy services as today: being sure that the lights stay on, that energy is being used rationally and sustainably, and that their monthly bills are affordable. The EURELECTRIC Blockchain platform is prepared to engage with policymakers and regulators to ensure that early adopters can become customers of innovative services developed in "regulatory sandboxes" and that legacy rules are reconsidered where needed.

Cooperation and demonstration perspective

Members of EURELECTRIC's Blockchain platform are committed to helping and promoting the integration of smart EV charging and other decentralised technologies, leveraging innovative blockchain technologies. This could be achieved by building on existing experience of early movers in the European energy sector, by cooperation with national blockchain associations, and drawing on experience. The result could foster compatibility across multiple services and scales, thus fulfilling the needs of customers and communities.

Existing open partnerships exploring blockchain in the energy sector

European utilities are already cooperating to explore, implement, and benefit from blockchain solutions in electro-mobility and other energy-related activities. The following initiatives were identified as open to partners from the energy sector and neighbouring industries:

- **Oslo2Rome**[80], the decentral network connecting public and private e-charging infrastructure across Europe to enable direct, cross-country EV charging as the basis for future mobility; in the context of this initative electro-mobilists will be travelling in November 2017 around Europe with the so-called "e-mobility wallet" in order to test a cross-border charging network based on blockchain technology, aided by the combined efforts of six strong European partners;
- **PONTON Enerchain**[81], a blockchain-based marketplace which allows trading partners to conduct deals directly with each other in seconds, without a need for a central intermediary; in June 2017[82] the first live trade between Iberdrola and TOTAL was undertaken in Prague at a public demonstration at the ETCSEE (Energy Trading Central and South Eastern Europe) conference, and later in October 2017 the first real trades with the deployed infrastructure were undertaken at a public demonstration[83] between Wien Energie and Neas, and between ENEL and E.ON; 33 utility partners were involved in Enerchain at the time of writing of this report;
- **Energy Web Foundation**[84], a global non-profit organisation focused on accelerating blockchain technology across the energy sector. The Energy Web Foundation was co-created by the Rocky Mountain Institute and Grid Singularity; in October 2017 the EWF launched a test network based on the Proof-of-Authority consensus, with validator nodes operated by EWF utility affiliates Singapore Power Group, Elia, Engie, Shell, and by other partners[85].

Each initiative explores the novel opportunities from a different angle, but all three aim to develop and demonstrate real use cases and tools which would support them, building and sharing the practical experience.

National blockchain associations and consortia

Innovators in several EU Member States are exploring the possibilities enabled by blockchain technologies, often through use cases spanning across multiple industries. Examples of such consortia include:

[80] http://www.oslo2rome.com/
[81] https://enerchain.ponton.de/
[82] http://www.energytradingcsee.com/uploads/Pages/site221_54236_en_file1.pdf
[83] https://enerchain.ponton.de/index.php/32-enerchain-project-enters-proof-of-concept-phase
[84] http://energyweb.org/
[85] http://energyweb.org/wp-content/uploads/2017/10/EWF_Test_Network_Launch_PR_Oct_3_2017.pdf

- **Data Market Austria**, a research-driven project creating a data-services ecosystem in Austria by advancing technology foundations for secure data markets and cloud interoperability, and creating an environment encouraging data-centered innovation[86];
- **Industrial Data Space**, a project for industrial data markets in Germany, initiated by Fraunhofer[87];
- **Dutch Blockchain Coalition**, a joint venture between industry, government and knowledge institutions[88];
- **Alastria in Spain**, a blockchain consortium established by the main Spanish banking, energy and telecommunications companies, among other sectors, engaging also with the public administration and regulators[89];

Power utilities are in some cases already members of such consortia. Closer interaction between the European electricity industry and the national associations could help the development of cross-industry solutions benefitting the customers and citizens across Europe.

Future Work

Discussions among members of the EURELECTRIC Blockchain platform highlighted several issues, which could be addressed in the future. This section outlines initial thinking in this area.

Definition of a scope for cooperation between competitors: Many ground-breaking internet initiatives like the *World Wide Web Consortium*[90], the *Linux Foundation*[91], or the *Open Compute Project*[92] are based on intense collaboration and co-creation between otherwise competing digital corporations, who have agreed to work together on a specific common technological topic. Through organisations with independent governance, such consortia have delivered on great challenges and appear to provide a model that can be followed by the energy industry on blockchain innovation, and in more general terms, on digital transformation.

Role of transmission and distribution grid operators: Through the discussions among the members of the EURELECTRIC blockchain platform, an idea surfaced of an EU-wide system of trusted blockchain nodes and oracles[93], operated by distribution grid and transmission grid operators, to foster efficient and trusted transactions in the industry. This concept deserves further discussion, to assess, for example, how it could benefit from and contribute to more diversity. It is also already obvious that multiple operators are active in exploring the novel opportunities, with examples of the TSOs TenneT and Elia, and the DSOs Alliander, Enexis, and others.

Governance and costs of developing and running shared blockchain solutions: this issue will need to be addressed at the latest as the blockchain solutions mature beyond early stage development and enter production phase.

Interoperability and open standards: given the relatively large number of blockchain technologies, interoperability will be a key concern for utilities. Active approach to solving this issue would benefit customers and all other stakeholders by ensuring interoperability in the

[86] https://datamarket.at/en/
[87] http://www.industrialdataspace.org/
[88] https://www.dutchdigitaldelta.nl/en/blockchain
[89] https://www.bbva.com/en/large-spanish-companies-form-alastria-consortium-develop-blockchain-ecosystem-spain/
[90] https://www.w3.org/
[91] The Linux Foundation secures key open source projects, with members such as IBM, Oracle, Microsoft, Samsung, Huawei, and Intel
[92] The Open Compute Project improves standards in IT infrastructure, its members include Facebook, Google, Microsoft, IBM, Intel, and Goldman Sachs. http://www.opencompute.org/
[93] Grid Oracles could for instance provide smart meter data, grid congestion information, prices, etc.

future but also speed of deployment of digital solutions that have proved their cost-efficiency even today, if they fulfil also other long-term expectations for best customer experience, secure operation, and sustainability. Co-developing a global solution might be another, albeit more ambitious, way forward.

The European Commission and EU Member States could foster innovation and demonstration of improved customer experience in e-mobility and other services in the energy and mobility sector. Specifically, programmes such as Horizon2020[94], the EU framework programme for research and innovation, could help to develop cross-border solutions improving lives of citizens in Europe.

[94] https://ec.europa.eu/programmes/horizon2020/

Conclusion

The European economy and society are at the beginning of a long but promising journey towards the electrification and digitalisation of the transport and energy sectors. This will improve the modern daily customer services in the energy, mobility, financial services, and other industries.

Although there are already operational services in the energy sector based on blockchain, such as Share&Charge, Ponton Enerchain, or BTL Interbit, it should be explicitly noted that blockchain-based solutions are still in the early-stage experimental phase, typically with 2-5 years to reach expected maturity.

Several of the high-profile blockchain initiatives in the energy sector at the time of publication of this report expect their development phase to take at least 2 years: PowerLedger outlined on their webpage[95] a development and testing roadmap until Q3 2019, Grid+ has similar plans[96] until Q4 2019 and Q1 2020, and OMOS in their concept paper plans to "Go-Live" with continuous refinement as of mid-2019.

The situation in other industries is similar, McKinsey in their *Blockchain Technology in the Insurance Sector*[97] in January 2017 estimated that "based on the current rate of evolution, we believe blockchain solutions could reach their full potential in the next 5 years".

This interim report by the EURELECTRIC blockchain platform explored the perspectives of customers and users of electric vehicles and the underlying situation of energy and mobility industries, to outline the unfulfilled needs and possibilities of improving the customer experience and cross-industry integration, augmented by blockchain solutions. With the perspective on one of the mega trends towards digitalisation - the blockchain technology - we outlined basic concepts, tentative criteria for identification of meaningful use cases, solutions which are already being tested in the energy sector, and an initial set of issues which need to be addressed.

The regulatory and legal perspective indicates that the technology is already being explored by key stakeholders, including policymakers and regulators in various jurisdictions, and that there are opportunities to promote digital innovation as a tool of fostering the competitiveness of the European economy. Finally, both electro-mobility and blockchain technology share a common theme, which is the benefit of cooperation. Demonstration projects could help in building common understanding and development of seamless experience for customers.

The EURELECTRIC blockchain platform will continue to explore and discuss this and other use cases, such as trading and flexibility. We invite the European Commission and other stakeholders to join us in exploring the ways of developing novel and improved energy services for customers and citizens of Europe.

[95] https://powerledger.io/
[96] https://gridplus.io/
[97] https://www.treasury.gov/initiatives/fio/Documents/McKinsey_FACI_Blockchain_in_Insurance.pdf

EURELECTRIC pursues in all its activities the application of the following sustainable development values:

Economic Development

- Growth, added-value, efficiency

Environmental Leadership

- Commitment, innovation, pro-activeness

Social Responsibility

- Transparency, ethics, accountability

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