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German Energy Agency

dena MULTI-STAKEHOLDER STUDY

Blockchain in the integrated energy transition

Study findings (dena)

Legal information

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Content

Foreword

One thing is for sure: with blockchain technology, a new form of digital information exchange is developing, and with it an innovative method of data storage and representing transactions. Many are speaking of a digital revolution, of a global phenomenon that will change how humans live and interact — as per the steam engine, electricity, automobiles, and the internet.

Despite all justified optimism regarding the future of blockchain — it needs to be viewed in a wider context of digitisation, however there are also other technologies which have successfully established themselves on the market for particular applications.

That is why it is all the more important to understand exactly what the advantages of the blockchain are, and above all how they can be utilised for the transformation of the energy system. For this, we need to examine the properties of the technology in-depth and compare them to their real-world applicability and environment both now, and in the future. This allows us to make a valid assessment.

It is with this approach, the current multi-stakeholder study follows. On one hand, it is a deep dive into the integrated energy transition with its multiple assets and stakeholders, whilst on the other hand, a reality check for blockchain in clearly defined application scenarios.

This study, which has set itself the goal of delving deep into the current and upcoming use cases of the blockchain — and the associated business opportunities — can only succeed if it consolidates existing cumulative know-how. This is exactly what it has achieved. Hence, we are above all indebted to our study partners who, with their commitment, expertise, and experience, have intensively supported every step of the development process of the study from the very beginning. Their valuable contributions during discussions over numerous sessions and in individual exchanges have enabled the greatest possible real-world relevance and kept the study grounded.

We would also like to express our special thanks to our scientific consultants and in particular our two experts, Prof. Dr. Jens Strüker and Dr. Ludwig Einhellig. Without their expertise, the well-founded technical, economic, and regulatory assessment of the application scenarios for the blockchain would not have been possible.

For us, the Deutsche Energie-Agentur (dena) — the German Energy Agency, this study makes one thing clear: the integrated energy transition is an accelerator of innovation which can help young technologies to achieve a breakthrough. At the same time, the innovation dynamic is not that of a sure-fire success — it becomes sustainable only when the foundations have been laid. This also involves removing regulatory restrictions and creating a positive climate for novel ideas.

Our aim is to contribute to stimulating societal discourse in order to increase the urgently needed innovation potential required for the energy transition. Blockchain is a good example of this. This is because the integrated energy transition involves a complex interplay of assets and markets, of new and old stakeholders, and of proven technologies and innovations. If we want to successfully link these areas, blockchain can and will make an important contribution as a secure and decentralised technology. We are convinced of this.

If this study provides some inspiration for the integrated energy transition, then that is an achievement in its own right. However, the question of whether it will become a true accelerator of innovation is something that you, the reader, will ultimately get to decide.

Sincerely yours,

Andreas Kuhlmann

Andreas Kuhlmann
Chief Executive of the Deutsche Energie-Agentur (dena) —
the German Energy Agency

Executive summary

The dena multi-stakeholder study "Blockchain in the integrated energy transition"

"Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels"[1] — from time to time, we should make ourselves aware of this finding and the well-known symptoms of progressive climate change[2] and its global consequences[3] in order to remind ourselves of the most important motivation for the energy transition. The energy transition is not an end in itself. Instead, solving the challenges associated with it is also an ecological, economic and social necessity, with the urgent goal of taking action.

The challenges, but also the opportunities, are manifold: an increasingly decentralised power generation structure; a comprehensive integration of the sectors (electricity, heat, gas, transport); the expansion of both electromobility and alternative energy sources, also called synthetic fuels; the necessary expansion and restructuring of the power grid and the intelligent use of existing grids; the use of existing flexibility potentials; a new way of handling digital information exchange; a reordering of customer relationships, and much more.

But without decentralisation and digitisation, the transformation of the energy systems would not be conceivable: the sheer quantity of production and consumption units and their intelligent comparison, as well as the increasing number of prosumers, who act and interact in a self-determined fashion in the energy system, make it clear that the use of digital technologies is a necessity. At the same time, the digital energy transition also gives rise to new challenges such as the secure and protected collection, storage, disclosure and processing of (energy) data — which is particularly important for society's acceptance of the energy transition — as well as the issue of social justice.

This is the context blockchain technology needs to be viewed in. As an information system of a decentralised nature, it is a technological manifestation of digitisation, an information protocol and decentrally organised data register which its characterised by its specific properties of security, immutability, transparency, robustness and multi-stakeholder participation.

So what can the blockchain contribute to the energy transition? And where exactly can this technology be utilised? Together with 16 partner companies from the energy sector and with the involvement of two scientific experts, four scientific advisors and four advisors from the blockchain scene, dena systematically explores these issues with the present study. The study focuses on 11 selected use cases from the five overarching areas of application asset management, data management, market communications (electricity), trade (electricity) and financing & tokenisation, thereby highlighting the various aspects of the application of the technology in the energy system of tomorrow. All use cases will be analysed and evaluated with regard to their technological maturity, the competitive situation with other technologies, the micro-economic (business economic) as well as macro-economic (economic) benefits, the strategic added value and the regulatory environment. The findings of these case-specific analyses (cf. also chapter 3) support companies and policymakers with the categorisation and the decisions regarding the use of blockchain technology in the integrated energy transition. At the same time, the findings provide the developmental stage of this still very young technology with a range of corresponding starting points for further investigations. Particular attention should be focused here on systemic efficiency gains which result from synergies due to the simultaneous testing and implementation of individual use cases.

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[1] IPCC (2018).

[2] E.g. the rise in sea level, clusters of extreme weather events, reduction in biodiversity etc.

[3] E.g. hunger, water shortage, forced migration, intra-state and domestic crises, weakened economies etc.

The use and further development of blockchain technology offers exciting approaches for the energy industry and can contribute to the successful transformation of the energy system as an important driver for the development of new digital business models. For stakeholders in the energy industry, this opens up the opportunity to skip individual technological developmental stages and to position themselves as an innovative model for other industries.

Blockchain technology makes digitisation more tangible and opens up space for economic added value in the handling of digital information. At the same time, it is a digital enabling technology which is highly likely to have a significant influence on the digital information flows of tomorrow. In the scene, the term “Web 3.0” has been used for some time now. In Web 3.0, information can be assigned a value and be transmitted and utilised in a traceable, authentic, automated and self-executing manner. Blockchain technology can serve as the backbone of such an internet of value. It also provides the basis of discussion for game theory incentive systems in order to answer the directly related questions of a sustainable, traceable and (partially) automated distribution of value.

The earlier the regulatory and technical prerequisites for the use of the blockchain in the energy sector are identified and fulfilled, the more consistently these added values can be tested and boosted.

However, it should be noted that the blockchain is not necessarily the “missing key” of the energy sector which promises to be the solution to all of the energy transition’s challenges. Such an attribution exceeds the expectations of the technology and threatens to slow down its proliferation in the specific areas of application of the energy industry where the use of this technology is indeed expedient and offers added value. Instead, the blockchain should, suffice it to say as an introduction, be tested, implemented, and further developed in a pragmatic fashion in the areas where its core properties can realise their potential. After the hype surrounding cryptocurrencies has died down, the transition to a serious test phase needs to take place. The regularly appearing reports on new cooperative agreements between energy providers, grid operators, energy traders, device manufacturers and technology suppliers with start-ups from the blockchain scene clearly show that a promising dynamic is already developing.

Recommended courses of action

Listed in the following are the most important recommended courses of action for policymakers, the energy industry, and the blockchain scene:

Take into consideration the study findings in the blockchain strategy by the Federal Government

The potential of blockchain technology was also documented at a political level via inclusion in various parts of the coalition agreement. For example, in the Federal Government's "Shaping digitisation" implementation strategy, a comprehensive blockchain strategy has been announced for summer 2019. The goal is to define suitable regulatory frameworks for the technology and crypto assets in order to boost potential and avoid misuse.[4] For a discussion of further steps for applications in the energy sector, the partner network of the study proposal and the findings of the study provide a great deal of expertise which should be comprehensively integrated into the planning of the subsequent steps.

Set up working group with translation function for political decision-makers

The blockchain is developing rapidly and stands for a new form of digital data services which will successively gain significance over the coming decades. Worldwide, people are working on improving the technology and changes are a daily affair. Special designs, for example with an eye on the cryptological procedures for ensuring the secure and decentralised handling of data, game theory structures for sustainable development for the decentralised operation of the blockchain, or also questions regarding the interoperability of various blockchains are highly complicated and require a translation function for political decision-makers. With the goal of translating the developments for policymakers, a working group should be constituted which compiles regular reports with a view to possible applications in the energy industry and provides information regarding the current progress of blockchain technology.

Strengthen dialogue regarding hardware- and software-based data security and data protection

The technical abilities of blockchain technology could, on the software side, contribute to promoting reliable and protected data handling. Accordingly, it should be examined to what extent the technology and the secure structuring of digital measurement infrastructure (hardware) are compatible with each other for the purposes of realising an end-to-end information chain. Feasibility studies and discussion dialogues on these topics between the experts of the respective domains are to be supported politically in order to consolidate parallel developments and boost added value. With an eye on the energy industry, this applies primarily to the reconcilability of the technology with the developments associated with the smart meter rollout. Similarly, the developments of the technology should be followed closely with a focus on the discussions regarding data protection. In addition to a legal clarification regarding which data is still to be considered as personal information[5], the further technological developments in the field of pseudonymisation and anonymisation are to be examined and assessed regularly (focus on data sovereignty).

Establish a register for smart contracts for the energy industry

As digitisation progresses, the importance of smart contracts is increasing for the energy industry as well. However, the translation of contractual relationships into digital language is not the sole domain of blockchain technology. A register which lists contractual relationships within the energy industry and hence simultaneously serves as a starting point for a system is a first step for conducting a discussion on which relationships can be converted into an automated, self-executing contract. The creation of such a platform should be performed by an independent institution, be freely accessible, and the entries should be permanently viewed, rated, discussed and commented.

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[4] The Federal Government (2018).

[5] German Bundestag (2018).

Research the significance of the technology for the acceptance of the energy transition
With blockchain technology, a decentralised form of digital services with the ability to transmit value in the digital domain is gaining in importance. In this case, the decentrally organised, technical and mathematical trust function replaces central trust and control entities, thereby generally supporting the idea of participation, a key success criterion of the energy transition. The overarching importance of decentralised trust and control instruments for the acceptance of the energy transition should therefore be examined in a study proposal or a market test in order to address possible economic effects of the technology as well.

Establish a "blockchain lab" for pilot projects
The core findings of this study also include the fact that the next step will increasingly lead towards the actual implementation of blockchain technology. Policymakers should, in cooperative agreement with stakeholders from the energy industry, promote a broad-based trial of the still young technology for applications in the energy sector in order to test its potential under real-world conditions. For this purpose, the findings of this study are to serve as a starting point, based on which a number of selected and particularly promising use cases are implemented in a blockchain lab, and in particular also allowing the systemic efficiency gains resulting from a combination of different use cases to be researched. Such a pilot laboratory could also be used in parallel for additional digital core topics such as artificial intelligence for the energy industry.

Checklist for blockchain in the integrated energy transition

The following checklist aims to show users of blockchain technology in the energy sector which steps need to be taken in order to utilise the technology to create added value as well as to test the potential of the use cases operatively. The individual points should not be viewed as a linear sequence, as the carrying out of pilot projects always has a recursive and explorative character.

✓ **Validate the added value and unique selling point of a particular use of the blockchain**

Many applications today require multiple exchanges of information. In an increasingly globally networked world, in which in some cases unknown identities and/or automated entities communicate with each other, an information protocol such as blockchain technology with its core properties of security, immutability, transparency, robustness and multi-stakeholder participation is gaining in importance.

To this end, it must first be examined in various variants and with the use of business development tools whether the requirements of the special use case correspond to the core properties of blockchain technology and whether this constitutes a specific added value and/or allows a business model to be built on it. If this is not the case, alternative technologies should be taken into consideration.

✓ **Define pilot projects and form interest-based communities**

Pilot projects for the application of blockchain technology in the energy sector are particularly promising when strategic partnerships from the three sectors of politics, economy (technology companies, companies from the energy industry, as well as industry) and science are formed. After a plausible inspection of alternative technologies concludes that blockchain technology is the optimal solution for the desired use case, the next step is to build consortia with the same shared ideas and similar interests and to define the framework for the pilot project (use case, targets, duration, financing, assignment of roles, participation etc.). Because blockchain technology usually operates across value creation stages, open approaches during the constitution of the consortia are recommended. For use cases whose operation is dependent on only a few stakeholders with main responsibility (e.g. “Congestion management in electricity distribution grids (e-mobility)” (use case 1), whereby the main duty lies with the distribution system operator), the formation of a consortium should be easier than for use cases where a large number of stakeholders from various value creation stages of the energy industry need to be integrated (e.g. “Trade and allocation of grid capacities (electricity)” (use case 9) or “Termination and switching suppliers (electricity)” (use case 6)).

✓ **Working out detailed planning and clarifying technical requirements**

Furthermore, the technological requirements of the planned application are to be clarified in detail in order to be able to perform a cost estimate for the proposal. In this case, a holistic procedure should be used to map the entire information chain “end-to-end”. This includes all hardware and software components such as crypto chips, oracle services, database systems etc. in order to ensure secure data transfer between the physical and the virtual world. Furthermore, blockchain-specific technical requirements such as the required transaction speed, the security level, the selection of the node procedure etc. are to be described in detail for the selected use case. Particularly use cases with a mandatory hardware component (such as the use case “Registration of installations in the core market data register (MaStR)” (use case 3), in which crypto chips are used), could pose technical challenges for the user. In the use cases “Energy services for buildings & industrial processes (maintenance)” (use case 2), “P2P trading between customers of an electricity supplier” (use case 8) and “Landlord-to-tenant electricity supply” (use case 10), on the other hand, the technological maturity as well as the number of suitable blockchain solutions are extremely high, which means that a great number of the technical requirements for pilot projects are fulfilled for these use cases.

✓ **Define the governance, consensus mechanism and incentive system**

Important aspects which should be defined by the consortium early on involve the governance structure, the consensus mechanism, as well as the incentive system of the selected blockchain solution. Particularly with regard to energy consumption and the associated sustainable acceptance of the use case, the selection of an appropriate incentive system and consensus mechanism (proof of work, proof of stake, proof of authority) is decisive. Governance structures should be determined early on and as detailed as possible in consensus with all involved parties of a consortium, as they are indispensable for the smooth operation of the blockchain application, and retroactive adaptations may be problematic depending on the nature of the selected blockchain. Particularly for use cases with a large number of stakeholders from various value creation stages of the energy industry and differing realms of interest, it is important to define the governance structures early on. The identification of a suitable incentive system mainly affects use cases with a strong market element as well as the integration of the end users via token systems, as described in the use cases "Congestion management in electricity distribution grids (e-mobility)" (use case 1) and "Shared investments in the case of external landlord-to-tenant electricity supply" (use case 11).

- ✓ **Review regulatory environment and take it into account**
In order to not endanger the rollout and scaling of the use case, the regulatory environment of the selected use case should be carefully reviewed. Blockchain applications for the energy industry are affected by multiple regulatory aspects at the same time: data protection laws, data security laws, as well as energy laws. Similarly, in many applications involving token solutions, financial laws also play an important role. On all levels, preventive action should be taken in these cases, as many aspects need to be compared with current provisions and dictate to a great extent the implementation of the use case. Of the use cases examined, the two cases of the application group data management ("Registration of installations in the core market data register (MaStR)" (use case 3) and "Certificates of origin" (use case 4)) pose the greatest regulatory challenges for users, as they are affected by various statutory regulations and national standards would need to be significantly modified in order to commission these use cases with the aid of blockchain technology. The use case "Energy services for buildings & industrial processes (maintenance)" (use case 2), on the other hand, is mostly unproblematic from a regulatory standpoint.

- ✓ **Perform execution planning and secure resources**
This step includes all tasks which are necessary for the actual implementation of the planned blockchain application. Based on the previously clarified technical requirements as well as the economic and regulatory review, a detailed listing of the planned implementation steps and the required technology is generated in order to successfully carry out the project. The timely budgeting and securing of personnel with the ability to implement the project on the blockchain front and the provision of programming capacity for the establishment of smart contracts are also of great importance.

Generally, it can be said that sweeping statements on the meaningfulness of blockchain technology in the energy sector are not constructive. The use cases selected in this study establish model use cases, based on which their potential users are shown the technical, economic and regulatory aspects of blockchain technology in greater detail and are offered the option of compiling the suitable use case (or a variant of the same) and/or a combination of different use cases to suit their own needs.

Technical findings

The following figure shows the largely positive technical assessment of the 11 use cases. The appraisal of the suitability of the blockchain technology based on a wide range of criteria (unique selling point, technological maturity, number of suitable solutions, status of trials, switching costs and fulfilment of responsibility requirements) also makes it clear that the technical requirements of the respective use cases are fulfilled by the blockchain to what are sometimes highly varying degrees. A detailed examination of each individual use case is therefore of overarching importance (cf. also chapter 3 and the technical report in Part B).

The star rating shown per use case describes the degree of fulfilment of technical requirements on a scale of 1 (very low) to 5 (very high). It is based on the weighted rating of the six criteria at the centre of the figure.

Scalable blockchains suitable for the masses in the works
Widespread implementation of blockchain technology is currently hindered by the fact that the use of the technology is still comparatively complex and that there is rarely good documentation available. Correspondingly, blockchain technology today continues to have the predominant status of an “expert technology” at an early developmental stage. Mature and standardised products which can be used directly by users are practically non-existent. Developers and staff members with an affinity for programming, however, find it exceedingly easy, quick, and straightforward to get started with blockchain technology. In the case of public and/or open source blockchains, this is also facilitated by the fact that no licensing costs need to be paid.

The technology is currently in the development stage on its way towards technical maturity. Interfaces to other information systems are getting significantly better and initial tendencies towards standardisation can also be observed: one example of this is the collaboration between the Enterprise Ethereum Alliance and Hyperledger, which promises a significant boost for blockchain applications in the corporate world. “Blockchain as a service” offerings from established companies such as Amazon, IBM and SAP also promote the further development of the technology as well as its adaptation in the energy industry. The Energy Web Foundation and its technology partners Parity Technologies and Slock.it are also working on a solution for the energy industry that is suitable for the masses. All in all, there is a great deal of activity across sectors.

Hardware basis necessary for comprehensive blockchain implementation

The use cases examined in this study show that to date, it is only in a few cases that applications have been stalled by technological maturity and the associated requirements for speed, scalability etc. Instead, what plays a decisive role is that the necessary hardware for the large-scale collection of data is in many cases not yet available and/or not configured so that the data is directly transmitted to the blockchain such that the overall added value of the technology implementation is realised. For the majority of use cases examined, digital electricity meters and the associated databases are a significant prerequisite for implementation. The delayed smart meter rollout in Germany has therefore also proven to be an obstacle for the short-term proliferation of the technology.

Stronger focus on background services in the future

Many “connecting pieces” between blockchains and traditional information systems are still missing today. Database applications such as oracle services are a prime example, as e.g. the triggering of a smart contract via a load profile measurement also requires the secure origin, transmission and immutability of the measured value. Many of these missing services (business-to-business (B2B) as well as business-to-consumer (B2C)) promise high procedural added value as compared to typical end user applications, which on the contrary require less domain knowledge and hence appear to be easier to implement at first glance. Furthermore, a number of technical problems and regulatory challenges also do not apply for background services.

A wide variety of offerings — rapid technological developments expected

The core elements of the blockchain technology itself are subject to continued development at a remarkable speed. This applies in particular to consensus mechanisms, governance structures, transaction processing times and the interaction with other information systems and the physical world, e.g. oracle services. However, technological adaptations to regulatory requirements such as the EU GDPR or territorial laws in the EU are also progressing at breakneck pace.

If the requirements of the use case exceed those set out for the originally selected technology partner and their blockchain solution and/or if additional use cases need to be developed, switching to a different blockchain may be advantageous. The parallel emergence of numerous blockchains may facilitate the switch, thereby reducing switching costs. Generally, it applies that the switching costs for open source blockchains are comparatively low, especially since the core technology is continually evolving. What is critical in this context and/or currently still unresolved are challenges related to the migration of datasets when switching blockchains. The development of standards could be helpful in this case, where attention should also be paid to ensuring that necessary innovations are not inhibited or even prevented. The character of the blockchain as an enabling technology is becoming increasingly apparent. A private cryptonetwork and/or one with restricted access and a fixed, small number of applications is unable to afford these network effects per se.

Cryptonetworks are diversifying

Current pilot and demonstration projects in the energy industry mostly use either the public smart contract platform Ethereum or the Hyperledger Fabric Framework. The main advantages of Ethereum lie in the fact that it is a large ecosystem which is stable, open and open source. However, this also results in disadvantages in the form of a relatively low transaction speed and sparse, incomplete documentation. The Hyperledger Fabric Framework offers the advantage of making it easier for companies to get started with good documentation, for one. The Energy Web Foundation is promising a possible “third” way for the energy industry: its blockchain is not generally access-restricted, and at the same time it solves the typical governance problem for open blockchains in that validation takes place via what are called “authority nodes” according to rules set by the foundation, and which are therefore verifiable. In this manner, experiences of a technical and regulatory nature from suppliers all over the world flow into the network, while generic “apps” such as those for certificates of origin are freely available.

Technical development is currently supplying an entire range of “new” and additional smart contract platforms which promise to overcome the existing disadvantages of Ethereum. The number of transactions per second is to be increased, scalability made possible, costs and energy consumption reduced, and data protection ensured (cf. also chapter 2).

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[6] A distinction is to be made here between the German iMSys and general AMI systems as well as alternative meters and gateway solutions.

[7] An oracle in the context of blockchain technology and the use of smart contracts is an agent that finds and verifies incidents in the real world and transmits them securely to the blockchain, which are then used by smart contracts (data integrity).

Economic findings

The economic benefits of the blockchain (micro-economic/business economic and macro-economic/economic) are very different depending on the use case. As shown in the following figure, the use of blockchains does indeed offer economic potential in a number of cases, while a relatively small amount of economic benefit is attested for other use cases. In this case, reading the detailed analyses in chapter 3 and in particular in the economic report in Part B would be a worthwhile choice.

The star rating shown per use case describes the degree of economic benefit on a scale of 1 (very low) to 5 (very high). It is based on the weighted rating of the three micro- and macroeconomic criteria at the centre of the figure.

A good time to get on board for companies

For companies in the energy industry collecting initial experience with blockchain technology or who would like to initiate pilot projects, the current point in time is a favourable one. Because no licensing fees need to be paid for the use of open blockchains, the costs of a trial today are comparatively low when considering the personnel costs to be invested. Transaction costs to be budgeted for the validation of information on the blockchain, on the other hand, are not insignificant for public blockchains and transaction-intensive use cases. In this case, test networks which are sufficient for testing the application are a good idea.

The initial situation for available collaborative partners from the blockchain scene is currently also considered to be favourable. Because the competition for suitable specialists from the IT sector has already become a critical factor for successful company development in most industries, the energy industry currently has a rather favourable starting point which holds a particular attractiveness for the scene and counts a number of start-ups in Europe among its own.

Efficiency and effectiveness increasing, added-value approaches on the rise

Blockchain technology has the potential to reduce running costs in companies as via automation effects and process optimisations, as well as transaction costs, i.e. the costs of using the market, via network effects (among others). Since cryptonetworks are genuine networking technologies, there are currently indications of greater utilisation of the market. However, it is not just services which users previously created themselves that are procured via the market. Instead, it is the emerging peer-to-peer marketplaces that are particularly ready to compete with existing platform strategies of large internet companies and combine public goods and/or network effects in a modified form within the framework of company strategies. As such, certificates of origin via blockchains become more valuable the more participants a cryptonetwork has. At the same time, however, no central platform operator is necessary to offer the service “guarantee of origin” more or less as a monopoly.

The energy industry of today exhibits additional automation potential as well as space for trust-building solutions in many areas. In cases where such potential has not yet been leveraged, this leads to friction and unnecessary costs, as the example of switching suppliers makes clear — with 900 distribution system operators communicating with potentially almost 1,000 electricity suppliers, whereby almost every stakeholder uses a different system. Adaptations made necessary by law lead to high costs as well as generally to labour-intensive rework in the case of erroneous switching processes. By saving the data in a decentralised information system, the trust-related costs can be significantly reduced, whereby alternative technologies may also be used for this purpose.

But the “promise of automation and trust” is only a first step in this case. Above all, significant added value arises from the majority of the use cases via the interaction and/or the realisation of additional blockchain use cases.

Rise in strategic benefits

The use of blockchain technology also offers strategic advantages for companies. Blockchain technology frequently plays the role of an enabler, in that it directly increases the benefits of smart metering and other IT innovations for companies. When a company experiments with blockchain technology, various future-oriented aspects are addressed in parallel. As such, the learning and trying out of blockchain technology conveys approaches and builds expertise which open up entirely different levels of the business world than are currently used in the digital space. In addition to significant process optimisations achieved over the medium term which promise micro-economic financial net effects, basic security technology principles are also developed, understood and implemented, which occupy a position that deserves to be highlighted, particularly in the energy industry. The handling of data flows, regardless of whether in a business-to-business context or in a business-to-consumer context, is entirely re-evaluated via the documentation-enabled character of the technology, in addition unleashing massive value creation in information management.

Instead of focusing solely on reducing costs, the emphasis from the very beginning should also be on the ability of the technology to increase the quality of information, as the example of certificates of origin illustrates.

The value of state and control information will also increase greatly over the coming years for the energy industry and play a significant role for successful business models. Whether blockchain technology will be the only information protocol which expediently, cost-effectively, and securely functions as a verification register is unlikely, but it is likely that the blockchain will play a significant role and the principle itself will have a strong influence.

Falling market entry barriers

For the energy transition and the integration towards a high-frequency real-time energy industry, it is becoming increasingly apparent how the blockchain enabling technology and its characteristics interact with other technologies and IT innovations and how they depend on each other. A large number of synergy effects exist here.

Generally, it can be said that the reduction of transaction costs, which were recorded in all use cases examined, will significantly facilitate market entry for small RES producers as well as consumers on the whole. On the one hand, this means that an increase in the percentage of renewable energy in the energy mix can be expected. The increase in the number of market participants will also result in greater trading activity, as the market will become divided into smaller sections and act with a higher frequency. An increase in the overall efficiency of the system can be expected from this. In turn, both can also lead to a reduction in emissions.

In addition to low economic market entry barriers and increased competitive intensity, the use of blockchain technology can also result in decisive new degrees of freedom for the design of the market. Drawing on the use case of the core market data register as an example, this would mean that the responsibility for the feed-in and discharging of EEG facilities into the distribution grid can be mapped via the utilisation. By linking it with blockchain technology, such a register could document the existence of an installation via the use of a crypto chip and register it in an automated process. A spontaneous switch between market segments, e.g. from owner consumption to the spot market, which can currently take several weeks, would also be possible. As a result, balancing groups could also be made smaller, trading windows made significantly shorter, and the utilisation of the grid could be planned using real-time data. All these steps would lead to a higher economic efficiency as well as a higher efficiency of the overall system.

For public goods such as electricity or gas grids, blockchain technology could help to create new forms of financing. Infrastructure development could be financed via tokenisation in the future and subsequently be allocated directly via usage by directly offsetting usage and production via work tokens.

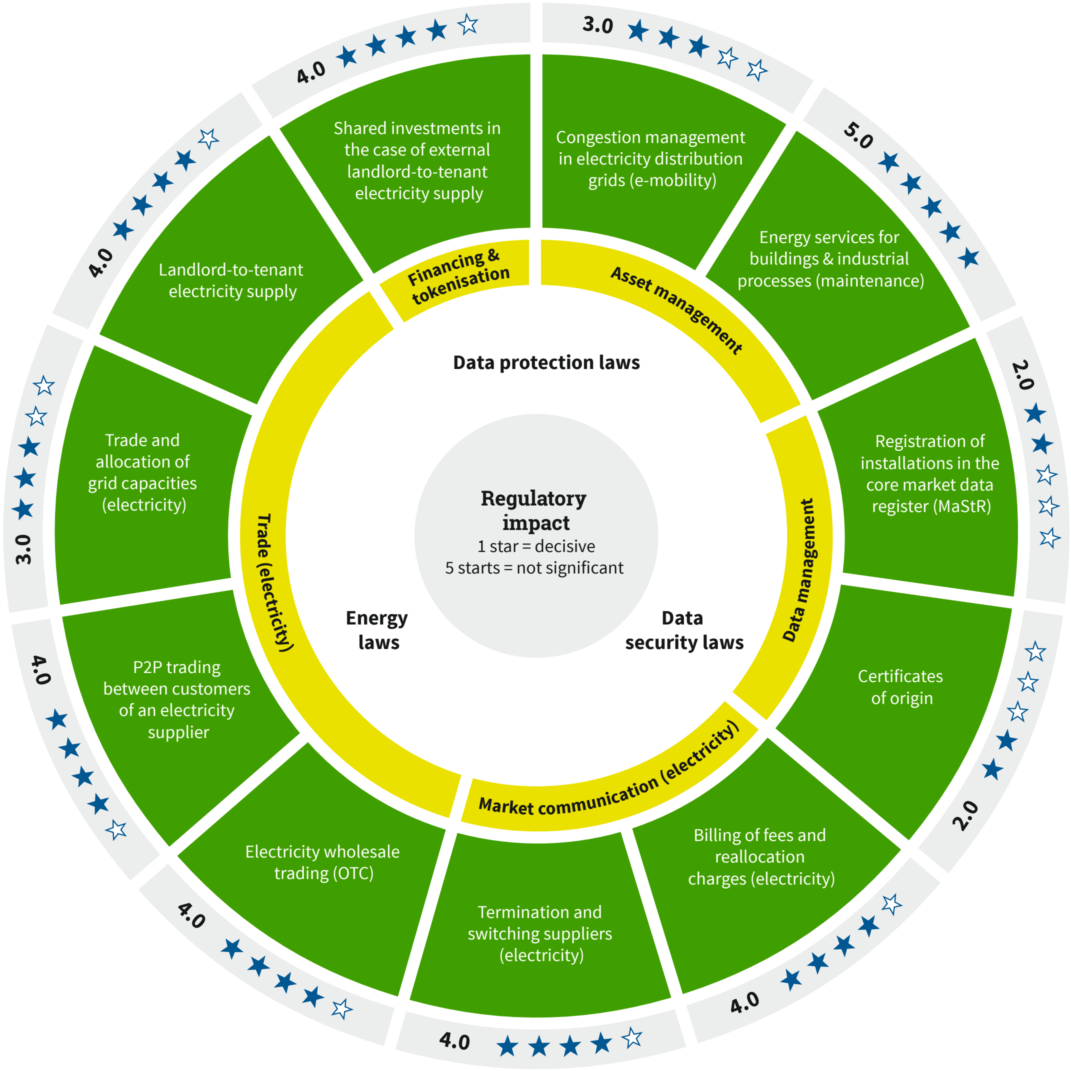
High documentary accuracy and increasing participation in the energy transition

The status quo of the energy policy pay-as-you-go systems is being discussed: today's grid fees and electricity consumption prices only insufficiently reflect bottlenecks in grids or the scarcity on the wholesale market. Via an exact documentation of the location- and time-specific production and consumption information with the aid of blockchain technology, these systems could be designed more effectively. It is then the task of policymakers to decide which distribution instruments can be implemented. These redistribution instruments could also be realised with the aid of tokenisation.

Lower market entry barriers also have a positive effect on the participation of residents with regard to the energy transition. As such, the “trust layer” of blockchain technology could e.g. significantly increase the acceptance of the energy transition for guarantees of origin by allowing for the simple and secure verification of how high the gross value creation of the electricity generated in RES installations on site is — i.e. how much value created in EUR does not leave the local community, but remains within it. The general possibility for increasing data sovereignty also functions in much the same way.

Regulatory findings

The regulatory evaluation, in particular based on the detailed analysis of data security, data protection and energy laws, also yielded highly differing results depending on the use case. On the one hand, this is due to the fact that different legal fields and regulations are affected. On the other hand, the regulations — whether positive or negative — have varying degrees of influence on the respective use cases (for details, cf. also chapter 3 and the regulatory report in Part B).



The star rating shown per use case describes the regulatory influence on a scale of 1 (decisive) to 5 (not significant). A decisive influence, however, is not to be equated directly with a negative regulatory environment. The star rating is based on an analysis of the three legal fields indicated in the centre of the figure.

Regulatory case-specific assessment required

In order to be able to use the technology as a driver of innovation in Germany and Europe, it is more legal certainty and clarity that the affected companies require more than anything. As blockchain technology is only in its infancy in the energy industry, the application of the current regulatory framework leads to numerous issues with regard to interpretation. Generally, it can be said that the use of blockchain technology is certainly also possible in the energy sector, as long as it operates according to the rules of energy laws. Furthermore, the legal assessment of the use of blockchain technology requires a case-by-case evaluation.

Further development of data protection principles with regard to decentralisation and the digital internal market

In the interpretation of compliance with data protection regulations, a distinction must generally be made between public and private blockchains. In the case of a private (permissioned) blockchain, users are usually known, as they were previously identified during registration. Accordingly, the Telemedia Act (TMG), Federal Data Protection Act (BDSG) and/or the General Data Protection Regulation (GDPR) apply to the full extent.

Blockchain technology and the right to be forgotten are antagonists. If the right to deletion is taken seriously in its current form, the use of blockchain technology in a wide range of areas is only conceivable in a manner that violates its basic principles: designs that make it possible to delete data at a later point in time severely limit the particular trustworthiness and completeness of the transactions processed via the blockchain. Although it is possible to implement an existing deletion obligation for completed transactions in a manner that preserves functionality per se (called pruning), the data subject has a very small chance of actually enforcing their rights effectively. This applies in particular to non-restricted blockchains with decentralised responsibility.

The fulcrum of potential blockchain-based data collection in the energy industry in the future will be the smart meter gateway, as it allows for a secure representation and/or verification of assets to take place. For companies in the energy industry, the implementation of the blockchain also involves the establishment of effective data protection management and an evaluation of existing data processing procedures. Furthermore, the development of internal company guidelines and concepts which define the handling of data according to the General Data Protection Regulation (GDPR) across the company and serve as evidence of compliance with requirements is recommended.

In order to not endanger the innovation potential of blockchain technology on the whole, lawmakers will need to reduce the right of deletion for complex and decentrally organised IT architectures in favour of a right to sufficient protective measures, in particular pseudonymisation. Yet, blockchain technology generally aims to strengthen consumers' sovereignty over their own data. To date, the data protection principles do not correspond to the idea of decentralised data management.

In the case of non-personal data, the European Union is already taking one step further towards a digital internal market. However, the legal framework does not fully live up to the significance of decentralised data management.

Range of application for smart contracts is determined by the circumstances

The use of a platform purely for data storage does not constitute a contract with other users of equal ranking at a horizontal level. These findings apply to all possible basic blockchain models. Smart contracts can be used for applications in the energy industry where classic contracts are too slow and too expensive. In cases where formal requirements cannot be represented in the blockchain, a corresponding smart contract would be null and void in accordance with Section 125 of the Civil Code (BGB). However, this does not hinder the option of using smart contracts in the energy industry, as classic contracts which need to fulfil formal requirements can be mirrored in the blockchain via smart contracts.

Decentralised and blockchain-based electricity trading is highly dependent on metering infrastructure

A completely decentralised application of trade models based on blockchain still appears unfeasible in light of the existing legal framework. For this purpose, it must be possible for the blockchain network customer to balance accounts and perform invoicing based on meter counter readings in accordance with Section 12(4) of the Electricity Network Access Ordinance (StromNZV), as is already provided for in the case of “variable tariffs”. For this, the determination of the feed-in and consumption behaviour with intelligent measurement systems according to the Metering Point Operation Law (MsbG) is a prerequisite. To this extent, a smart meter rollout and an application of the blockchain are mutually dependent.

Financial regulation as an additional necessary field of development

Although blockchains are significantly more established in the financial sector than in the energy sector, there is still a great deal of uncertainty in this area regarding the legal and regulatory categorisation. This is already shown by the fact that it is still uncertain whether cryptocurrencies or share tokens are to be considered as financial instruments at all under trade law.

- **Cryptocurrencies as means of payment or currency units**
  A categorisation of cryptocurrencies as means of payment or currency units is currently not under consideration. Blockchain-based means of payment are also not “money”, as they are neither objective cash nor claim-based deposit money, and also not considered e-money as defined in Section 2(2) of the Electronic Money Directive (E-Geld-Richtlinie). The relevant regulatory provisions therefore do not apply. It also does not (yet) qualify to be categorised as a(nother) financial instrument. However, centrally administered virtual currencies may be viewed differently (in some cases, they may be considered “intangible assets”).
- **Tokens as securities**
  It can be assumed that digitisation will soon also extend to the issuing of securities and the property of securitisation will decline in importance, and/or that securitisation will no longer require a paper copy in the future. Lawmakers need to take action here too. This regulatory regime that has yet to be created will then also apply equally to digitised securities as well as tokenised rights and claims.
- **Laws governing payment transactions**
  The legal framework for the payment transactions of today is completely tailored to the legal relationships between the classic agents (sender, recipient and intermediaries, e.g. banks). In order to enable transactions to be processed via blockchain technology, a fundamental review of the basics of the payment transaction system by lawmakers is therefore necessary.
- **Money laundering**
  In light of the European Banking Federation’s recommendation in 2014 to audit trade platforms according to the EU money laundering directive, the relevant regulations will also need to be taken into consideration for corresponding blockchain applications in the energy sector.

1

Blockchain in the integrated energy transition

> *Today the world's leading scientific experts collectively reinforced what Mother Nature has made clear — that we need to undergo an urgent and rapid transformation to a global clean energy economy. The Paris Agreement was monumental, but we must now go further, ratchet up commitments and develop solutions that meet the scale of the climate crisis.*
>
> Al Gore on the IPCC Special Report on Global Warming

Worldwide climate targets

This quote comes from the autumn of 2018 as a reaction to the previously published special report of the Intergovernmental Panel on Climate Change (IPCC), which summarises recommendations from all leading scientists in the field of climatology around the world.[8] The special report was adopted by 195 member states and came to the conclusion that a rapid cross-sectoral restructuring of the world economy is necessary in order to achieve the 1.5 degree goal, whilst also demonstrating that it is both technically and economically feasible. The costs of the restructuring are estimated at 2.1 trillion euros worldwide up to the year 2035.[9] This is an enormous challenge which needs to be approached directly and consistently across its entire breadth, particularly in the energy industry.

The energy transition is not an end in itself

The energy transition in Germany as well as worldwide is therefore a necessity, driven primarily by the need to halt climate change and simultaneously search for solutions without any nuclear energy production, and hence eliminate the associated risks for mankind. These two objectives are accompanied by what are primarily social and economic motivators: 1. To drive

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[8] German Coordination Office of the IPCC (2018).

[9] Die Zeit (2018).

progress, 2. Generate growth, and 3. Ensuring security of energy supply and social justice for future generations as well. These different dimensions are weighted differently by various stakeholders and countries, such that there is generally less disagreement regarding the actual objective of climate preservation than regarding the available instruments, time frames, and paths.[10]

Germany's energy transition, which was launched in 2000 with the Renewable Energy Sources Act (EEG), has for many years now also included the shutting down of nuclear power plants and a decarbonisation strategy. While the withdrawal from nuclear power by the year 2022, which was initiated in 2011, is already a done deal, there was recently intensive wrangling in the Coal Commission for the withdrawal from coal-based power. In addition, the energy transition also has a number of major issues to grapple with: the expansion and restructuring of the power grid, the integration of individual sectors, the transport transition, as well as the increased use of alternative energy sources, referred to as synthetic fuels or power fuels. All of the issues previously mentioned illustrate the complexity of the necessary transformation of the energy system.

Digitisation is helping the energy industry to change

In the battle against climate change, digitisation is seen as a global beacon of hope in the 21st century, and one that offers new technical possibilities for dealing with climate change. Overall, the energy sector is developing from what is primarily a strongly commodity-based business into a client and service-oriented, broad-footed industry. Data is ubiquitous and hence plays an increasingly significant role in this context as well. Whether it is in future models for a better utilisation of existing grids, for plant control and remote maintenance in the production and consumption sector, for the development of e-mobility and the associated charging concepts, in energy trading, or in the service sector for end consumers — without the digital exchange of information, the transformation of the energy system would come to a halt and hence be all but unimaginable.

Because information and its practical application form the basis of all economic development and scientific progress, the — in some cases disruptive — upheaval in certain industries over the past 10 to 20 years can be explained and to a great extent traced back to digitisation. In the past, the energy industry appears to have been shielded for the most part from a similarly radical upheaval for various reasons. However, major changes can now also be felt in this industry as well. Sectors are growing closer due to digitisation, business models are being developed in the value added chain, and stakeholders from outside the sector are showing increasing interest in the energy industry.

For the successful transformation of the global energy system, the great complexity of this changing system will initially result in a wide range of opportunities. Individual companies active in the energy sector can emerge as winners if they consistently and boldly take on the challenges that will emerge as a result.

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[10] Stern, N. (2007).

Increasing requirements for digitisation

Data plays an immensely important role in the digital energy sector, but at the same time poses new challenges. In order to ensure the security of the digitally supported energy supply of tomorrow in the future, data protection and data security requirements must be fulfilled, ranging from the collection of the data, its use and storage, to its disclosure and processing.

While globally active internet conglomerates have shown strong growth over the past 10 to 15 years — among other things because the handling of personal data has been relatively unregulated at the international level — a new legal framework has now emerged in this context. The General Data Protection Regulation (GDPR), which entered into force on 25th May 2018, and applies to the entire EU, as well as the discussions regarding digital taxes could already be an indication that the flow of data between commercially active stakeholders will be more traceable in the future, and that value creation based on unclarified data use will become more difficult.

It appears that digitisation is also moving on from its initial phase. New terms such as the platform economy, data sovereignty, digital twin, blockchain, and artificial intelligence are receiving extensive news coverage. Search engines, online shops, and big data on the other hand, are mentioned with decreasing frequency.

With the changes described above, the requirements placed on the quality of data exchange are increasing significantly. Data quantities and transfer speeds pose great challenges for infrastructure operators. Particularly in light of Germany's deficiencies in international comparisons where fast internet coverage is concerned, it is not only the digital scene which sees grave consequences for the overall economy.[11] In addition, the increasing interlinkage between all sectors of the energy industry has resulted in demands for a higher security level associated with the data transfer. In order to operate the integrated energy supply system at the same consistently high level in the future, new concepts for ensuring data and IT security for the energy industry will be of vital importance. This is where the fledgling blockchain technology comes in.

The energy industry as a testing zone for blockchain technology

Information systems of a decentralised nature, distributed ledger technologies (DLT) in general, or specifically blockchain technology, could play an important role in all industry sectors in the future. The reason for this is simple: in order to provide a backbone for the documentation of data with intrinsic value in an increasingly decentralised energy sector, technologies are required which will be able to support this technically. Therefore, in addition to existing centralised systems, alternatives which appear more suitable for the intended decentralised purpose in a particular use case are becoming increasingly important. These technologies are at the beginning of their development. After the initial hype surrounding the use of the blockchain, a certain amount of disillusionment has now set in. On the one hand, this is due to the fact that the blockchain has been frequently reduced to the cryptocurrency Bitcoin. After a dizzying rise in the price of this cryptocurrency at the beginning of 2018, it has now fallen sharply. The energy consumption of individual blockchains, which in some cases can be extremely high, also raises the issue of the plausibility for the entire technology — particularly in the energy industry (whether this is justified depends to a great deal on what the consensus may be). Furthermore, there is a certain impatience spreading across sectors which is demanding prototype testing before solutions are set loose in the real-world economy.

Because it is currently undergoing a transition, the energy industry is providing an impression of being an ideal test field for experimentation. This makes the significance of the secure handling of information appear especially relevant, particularly in light of the importance of security of supply in the energy system. The fact that the energy industry has evolved at a slightly slower pace than other industries to date and that blockchain technology is still in its initial stages could lead to a kindred partnership forming, in which implementations are tested together step by step in highly controlled environments while fulfilling extremely high demands with regard to reliability.

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[11] Der Tagesspiegel (2018).

The present study provides a case-related assessment of the blockchain in the integrated energy transition

In order to evaluate the actual development and the probable diffusion paths of blockchain technology in the energy industry, a case-related examination is absolutely necessary. An assessment of the applications must take place based on the current level of maturity of blockchain technology, the competitive situation, the prospects it offers for business and the whole economy, and the regulatory environment. The present study pursues precisely this objective. For this purpose, 11 use cases were analysed according to the principle described below. The detailed assessment findings of all use cases are summarised in chapter 3.

Blockchain in the integrated energy transition

- Examination of 11 use cases along the value creation network of the energy industry
- Standardised rating of the opportunities and risks of the use cases
- Compilation of and agreement on recommended courses of action

Technical

- Unique position
- Technological maturity
- Switching costs
- etc.

Economic

- Microeconomic financial benefits
- Microeconomic strategic benefits
- Welfare effects

Regulatory

- Influence of existing regulatory framework on the implementability of blockchain applications

2

Blockchain technology: status quo and development prospects

Ten years after the publication of the Bitcoin white paper[12], the original protocol of the Bitcoin blockchain has developed into numerous variants, new concepts, and countless applications in various industry sectors. The blockchain field is attracting an increasing number of software developers and experts specialising in distributed systems, cryptography, game theory, programming languages, economics, as well as many other disciplines. This rapidly growing number has in turn led to more new protocols and applications on a global scale, such that there now exists a highly differentiated developmental landscape which interacts in a wide variety of ways.[13] Hence, industries such as the energy sector, which would like to examine the added value of blockchain applications, are initially faced with the challenge of determining the blockchain technologies that are available today, and the functions they offer.

With the heterogeneous phenomenon of the blockchain and the rapid ongoing development of the core technologies in mind, a few basic terms will be explained in the first step. In this section, distributed ledger technologies, blockchains, and cryptonetworks will first be differentiated, and the significance of tokens, coins, and smart contracts as well their functioning modes will be explained. This will be followed by a short presentation of the development prospects of blockchain technology in the form of a store of value, smart contract platforms, and marketplaces for the decentralised exchange of value and services.

Finally, in the technical report in Part B, various properties of different blockchain technologies will be compared and their technological maturity determined. For a general introduction on how blockchains work, please refer to the relevant and now comprehensive body of literature.[14]

Basics and organisational principles

Distributed ledger technologies, blockchains, and cryptonetworks

The development of blockchain technology is proceeding at a breakneck pace, and the associated terms and definitions are still evolving. This is comparable to the situation in the 90s, when there were long and intensive disputes regarding the correct way to refer to the phenomenon called the internet. For one, there was a lack of agreement regarding whether the internet actually existed, or if one should instead have spoken of “internets”.[15] The following definitions and delineations are the product of a comparable transitional phase and hence only reflect an understanding of the terms which prevail at the current point in time.

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[12] Nakamoto, S. (2009).

[13] The market capitalisation of cryptonetworks in 2018 has fallen greatly as compared to 2017. At the same time, the activity, measured in participants and transactions, developers, ecosystems etc. has continued to grow markedly. Cf. Lubin, J. (2018) for an overview by the Ethereum co-founder and ConsenSys founder.

[14] Recommended introductions include e.g. BDEW (2017) and BDEW (2018). Another easy-to-understand introduction which subsequently delves into the details is from Merz, M. (2019). In particular, explanations of the technological concepts can be found on the BlockchainHub website, cf. also BlockchainHub (2018).

[15] Overall, intranets, on which the TCP/IP network protocols were used for non-public company networks, were in widespread use for a considerable period of time.

This chapter was authored by Prof. Dr. Jens Strüker.

Distributed ledger technologies (DLT) allow networked computers to find a consensus regarding the sequence of transactions performed, to save this state, and to continually update it.[16] In this manner, the transaction databases allow for data to be administered without a central platform. Individual computers of the network (called nodes) save, share, and synchronise the transactions based on their own latest copies of the database.

A **blockchain** is the most prominent variant of a distributed ledger technology. In this case, a continuously expandable list of datasets (blocks) are linked to each other via cryptographic procedures. Because not all distributed ledger technologies are based on the linking of blocks as an ordering principle, it is correct to say that every blockchain is a distributed ledger technology, but not every distributed ledger technology is a blockchain.[17]

Over the past few years, companies have tested blockchain solutions, during which they have restricted participation (by restricting read and write permissions) and assigned members of a consortium or a legal unit of the same company the role of the validator of transactions. In order to differentiate them from publicly accessible blockchains, these company blockchains are therefore frequently called DLTs. However, there exists no clear definitional distinction between blockchains and DLTs to date.

Cryptonetworks can be defined as a unit composed of a distributed ledger technology and an incentive structure which is specified in the DLT protocol (i.e. the software). The intrinsic purpose of cryptonetworks is the collaborative provision of digital services. Tokens (digitally guaranteed rights) constitute the incentive structure defined in the protocol, and are therefore vital for the operation of cryptonetworks. Correspondingly, the Bitcoin cryptonetwork consists of (a) a specific blockchain and (b) an incentive structure defined in the protocol for achieving consensus.[18] The service provided is the store of value and/or the transfer of money and/or Bitcoins. A number of distributed ledger technologies currently in use within and between companies do without incentive structures and/or the use of tokens.

The Bitcoin protocol can be viewed as a coordination instrument which precisely controls the behaviour of a large number of users without utilising a central hierarchy.[19] In a hierarchical solution as is commonly encountered in a company, on the other hand, Bitcoin would instead need to organise the validation of the transactions centrally via mining processes.[20] It is at least questionable whether such coordination processes including rewards would be able to take place as smoothly and efficiently as they would with the decentralised Bitcoin protocol. For years, this has provided sufficient incentives for many stakeholders worldwide in order to achieve exactly the desired behaviour and result. One other example is the coordination of capital via cryptonetworks (called Initial Coin Offerings — ICOs). These ICOs have been described as the most rapid and efficient form of capital coordination to date since the invention of money: In 2017, the address of a cryptocurrency (account) was published on various websites, and within seconds hundreds of millions of dollars had been raised.[21]

The terms distributed ledger technology, blockchain, and cryptonetwork cannot currently be distinguished from each other without contradiction, as previously explained. Furthermore, the use of the term distributed ledger technology (DLT) is not very convenient, such that expert articles, newspapers, blogs, and white papers frequently utilise blockchain and DLT synonymously.

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[16] BaFin (2016).

[17] An example of the aforementioned DLT is IOTA with the concept of a Tangle as an alternative consensus mechanism (Directed Acyclic Graphs — DAGs). Other variants of DLTs include Hashgraph or Holochain, which utilise gossip protocols.

[18] In the case of the cryptonetwork Bitcoin, system-compliant positive behaviour is rewarded via the assignment of units of the currency Bitcoin to network participants who solve the cryptographic puzzle (mining).

[19] Cf. Olaf Carlson-Wee, founder and CEO of Polychain Capital, in a16z-Podcast (2017).

[20] In the case of blockchains such as Bitcoin or Ethereum, mining refers to the creation of blocks via the solving of complex cryptographic tasks. Cf. the detailed explanation in e.g. BDEW (2017).

[21] Cf. Olaf Carlson-Wee, founder and CEO of Polychain Capital, in a16z-Podcast (2017).

Smart contracts
Smart contracts supplement the storage layer of blockchains such as Bitcoin with a functional transaction layer which triggers autonomous actions such as payments, data transfers, or the storage and/or documenting of a procedure/result. Because they take place within a blockchain, the same stringent properties apply to them with regard to immutability and stability.

The Bitcoin blockchain utilises its validation function not just for each individual transaction, but also for multi-stage transactions such as multisignature (multisig):[22] Multiple participants make deposits to an account and only when the sum exceeds a defined limit value does the transfer of the total amount to the specified recipient address take place. Subsequent evolutions of the Bitcoin blockchain such as the cryptonetwork Ethereum, on the other hand, do not limit themselves to the validation of individual data elements.[23] They utilise if-then relationships which are written in the code and which are executed and monitored in the blockchain: these are called **smart contracts**.[24] Their automated execution aims to reduce transaction costs and ensure a higher contractual security, as subsequent actions which deviate from what was agreed upon are rendered impossible or highly difficult.[25]

In this case, the application logic is encapsulated such that it can be executed on a blockchain.[26] Accordingly, the running of programs is on the one hand verifiable and the execution of the program code cannot be prevented via conventional attacks: although the code logic for smart contracts is available centrally, it is stored decentralised in copies. Hence, smart contracts cannot be removed from the majority of all blockchain nodes. This is the primary subsequent content-based modification to the original use of the term smart contract in the context of network transactions.[27] One example scenario is the automated transfer of ownership and the payment of goods between a supplier and a buyer. As soon as the software installed on both computers sends the signal that the digital payment has been made via cryptocurrency and/or a digitally guaranteed promise of payment has been made, the proof of ownership is simultaneously transferred. Another example of these forms of programmable money is making payment for a rental car using a token which is also used to activate the engine.

A number of smart contract platforms such as Ethereum charge a fee for the execution of code, which in the case of Ethereum is called gas. Once the smart contract has been executed, the gas is transferred to the miner and deducted from the account which initiated the procedure. Gas is a sub-unit of an Ether (ETH) and equal to a nanoether. It is defined as one billionth of an Ether (i.e. when 1 ETH = EUR 1,000, 1 gas = 0.0001 cents). The pricing of the service "Execution of a smart contract" not only provides incentives for miners, but in particular is also an effective form of protection against spam attacks. In much the same way, a negligible price for the sending of e-mails would likely immediately end the phenomenon of mass e-mails.

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[22] Wiki Bitcoin (2017).
[23] Merz, M. (2019).
[24] Other smart contract platforms avoid the term smart contract and speak instead of e.g. a "chaincode" (cf. Hyperledger Fabric).
[25] Cf. detailed explanation in BDEW (2017).
[26] For clear, detailed examples, please refer to chapter 3 of Merz, M. (2019).
[27] Nick Szabo, N. (1996).

Coins and tokens

Up until now, the terms token and coin have not been used in a standardised fashion.[28] At times, tokens and coins are used as synonyms and called cryptocurrencies. On the other hand, there are also those who make an explicit distinction between the terms. In this case, **coins** (also called altcoins) are defined as digital money which constitutes a store of value. Coins are therefore exchangeable, divisible, can be held, and constitute a limited good (limited supply).[29] Apart from their function as money, coins initially play no other role. Hence, they are always connected to a public blockchain; i.e. anyone can participate in the network, and there are no admission restrictions. Bitcoin is the most prominent example of coins.

In contrast to coins, **tokens** generally operate on a blockchain which offers smart contracts and/or decentralised applications. They can be defined as a specific digitally guaranteed right which may represent asset values, securities, an ownership or profit claim, but also voting rights and admission tickets.[30] Tokens may also exhibit payment functions, but their ability to be exchanged, as is the case with digital money, is not the main focus. This is comparable to a concert ticket, which cannot be used for payment in a restaurant. Furthermore, a coin can be used to acquire a token, but not the other way around.

Tokens are currently more numerous than coins, as they are significantly easier to generate. For one, not a single line of new code needs to be written or adapted for the generation of a token. It is sufficient to use a standard template from platforms such as Ethereum. In this case, a token is generated in just a few steps. Furthermore, the standard templates also allow for a certain degree of interoperability, such that various tokens can be stored in a (digital) wallet.

What is called a **usage token** (also called a “utility” token) first needs to be procured, which is required in order to utilise a digital service.[31] Bitcoin is the most well-known usage token. Its ownership is necessary in order to store and transfer money. The service used is the Bitcoin network.[32] In this case, the value of the token is inextricably linked in the long term to the utility which the digital service creates as demand grows, as well as its scarcity as a resource. Against this there is purely speculative demand, where people simply bet on being able to sell a token at a higher price at a later point in time.

Ownership of a **work token**, on the other hand, grants the ability to perform a certain form of work, i.e. a service for a decentralised organisation such as a cryptonetwork. This work is then rewarded. One example of this form of reward is the consensus mechanism proof of stake.[33] Proof of stake eliminates the artificial computing cost for the generation of the hash value for the validation of a block. For Bitcoin, this solving of the puzzle (mining) is a necessary component of the validation of transactions (cf. proof of work[34]). Instead, proof of stake allows a number of computers to be randomly chosen from all participating computers for the validation of the block and/or the transactions they contain. These computers then generate only a hash value, for which they receive a monetary reward. The probability of being chosen increases with growing ownership of the currency immanent to the blockchain.

The trustworthiness of the validated node is ensured via the deposition of a stake (monetary pledge). The cryptonetwork Ethereum will switch from the consensus mechanism proof of work to proof of stake.[35] Users will then need to own Ether in order to execute smart contracts. At the same time, the ownership of Ether will make it possible to earn the fees for the transaction validation. Ether will then be both a usage as well as a work token. Other examples of work tokens are the reputation token in the cryptonetwork Augur[36] or the governance token in Zero X (0x)[37]. In the latter case, the work is the governance itself.

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[28] Cf. also the classification by Euler, T. (2018).

[29] For a delineation of the differences, cf. e.g. Bonpay (2018).

[30] World Bank Group (2017).

[31] Tokens can also represent non-digital asset values such as real estate. However, their digital representation is technically identical with that of other digitally guaranteed rights (tokens).

[32] Cf. Nick Tomaino, founder and General Partner of 1confirmation, in a16z-Podcast (2018).

[33] Cf. explanation of proof of stake in the glossary in BDEW (2017).

[34] In this case, all computers participating in the network compete in a trial and error procedure to solve an algorithmic puzzle, whereby the winner generates the hash value and hence the next block, for which he receives a reward in the underlying digital currency.

[35] Poon, J.; Buterin, V. (2017).

[36] Augur (2019).

[37] 0xproject (2019).

From stores of value to smart contract platforms and marketplaces for the decentralised exchange of value and services

The purpose of cryptonetworks is to provide digital services. Correspondingly, in the following, cryptonetworks will be divided up in a simplified fashion into the three categories store of value, smart contract platforms, and marketplaces for the decentralised exchange of value and services. The overarching goal is not so much a detailed representation of their complex diversity, as a working out of the relevant development tendencies for users in the energy industry.

The difference between company cryptonetworks with restricted access (private, permissioned) and cryptonetworks with no access restrictions (public, permissionless), over which a passionate discussion is still ongoing[38], shall not be considered at this point for the categorisation. Generally, it applies that from a corporate perspective in 2019, private cryptonetworks can offer significant advantages over public cryptonetworks, above all through their higher scalability, the guaranteeing of data protection, and their lower energy consumption. In Part B, the distinctions and different properties will be explained in detail. However, for the categorisation of cryptonetworks, the digital services offered must be the focus. If blockchain technologies are used primarily for the optimisation of existing internal and external company processes, companies run the risk of losing sight of the **network effects** of cryptonetworks as the basis for what is possibly a new class of applications.[39] The network effects are seen as being so significant because they are exactly what made computer networks so powerful already back during the internet-intranet development in the 90s.

Public cryptonetworks can be accessed by anyone and hence promise higher numbers of users by definition; i.e. a higher number of transactions and hence more powerful network effects. Furthermore, if public cryptonetworks are also available as open source software which can be freely copied and modified, the number of developers is potentially also significantly greater than is the case with company networks. In entirely closed networks, the network effects are negligible. Hence, if public cryptonetworks were to become scalable and able to ensure data protection in compliance with the GDPR, private cryptonetworks will very likely become unattractive for companies in the near future, as was the case for intranets.

In the meantime, interoperable company cryptonetworks, i.e. those that are able to interact with public cryptonetworks (called hybrid company networks) might increase network effects in a targeted fashion. One such active endeavour to be mentioned here is the Energy Web Chain of the Energy Web Foundation, which combines the advantages of both worlds (at the current time). The foundation combines public access in the form of an open source approach as well as Ethereum compatibility from the public blockchain world with authority nodes (proof of authority) and clear responsibility for compliance with the regulatory framework (governance) from the private blockchain world.[40]

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[38] For the keywords DLT versus blockchain, compare the corresponding articles on medium.com and the debates on twitter.com.

[39] a16zcrypto (2019).

[40] EWF (2018).

Stores of value
For the very first time, the cryptonetwork Bitcoin showcased the possibility of a secure database distributed across thousands of computers and which manages without a central controlling authority that verifies data authenticity. At the same time, an incentive structure is implemented in the protocol, according to which the work for managing the distributed database (mining) is rewarded with smaller, increasingly scarce Bitcoin payments. The technical novelty over existing database systems is, on the one hand, that agreement regarding the state of the distributed network can be achieved without the role of a responsible party. Secondly, it demonstrates a method by which participants can be compensated for helping to make the service and/or the entire network more valuable by providing a service (mining), without utilising classic salary payments or shares in a company. Both these features have set the conditions for Bitcoin's ability to be a functioning and scaling crypto store of value as well as a medium of exchange and payment. Specifically, the multiple use of tokens (called double-spending) is effectively prevented while at the same time ensuring the upscaling of the decentralised service. Over the past few years, numerous other cryptocurrencies have also emerged.[41]

Cryptocurrencies are seen as being of great importance for the continued development of the internet economy, because there exists no native or built-in internet currency to date. Furthermore, the business models of large internet platforms such as Google, Facebook, Twitter or Snapchat are almost completely financed through advertising.[42] For example, the ad revenue of the largest media company worldwide, Google Alphabet, accounted for 87% of its total revenue of 90 billion US dollars in 2016.[43] At Facebook, this figure was even higher at 95% in 2015.[44] Other successful models such as Spotify or Netflix are subscription-based.[45] Transaction-based business models, on the other hand — above all micro-transactions in this case — promise enormous economic potential that remains hitherto untapped.[46] The video games industry is an exception here and recorded a micropayment volume of 50 billion US dollars in 2017.[47] However, for music, creative writing, and the making of videos, there exist no widespread solutions to date, and hence only marginal revenues have been raised. Compared to platform operators, the copyright holders of works participate only to a small extent in value creation.

The integration of a growing number and smaller market players into the energy markets and the collection of payments at public and private e-charging stations constitute great economic potential for cryptocurrencies. Microtransactions in the energy industry often cannot be processed economically with today's information systems.[48] The new version of the Renewable Energy Directive dated November 2018 stipulates that prosumers are not to fall under the definition of a supplier in European or national contexts up to a certain delivery quantity. This will likely result in energy collectives with highly frequent billing cycles for very small deliveries and consumption quantities.

> *"Ignoring cryptocurrencies is like ignoring the Internet in 1993."*
>
> **Benedict Evans, venture capitalist and general partner of Andreessen Horowitz (A16Z)**

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[41] Cf. the overview under Coinmarketcap (2019).

[42] Evans, B. (2018).

[43] United States Securities and Exchange Commission (2016).

[44] Webb, R. (2017).

[45] Among the largest Chinese internet companies such as Tencent, advertising makes up a significantly smaller portion of revenue as compared to US companies.

[46] Cf. Chris Dixon, General Partner of Andreessen Horowitz, in a16z-Podcast (2018). According to Benedict Evans, the advertising revenue of US internet companies accounts for 3 % of GDP, cf. Evans, B. (2018).

[47] Cf. Chris Dixon, General Partner of Andreessen Horowitz, in a16z-Podcast (2018).

[48] One example for high transaction costs as compared to the value of the transaction are the ongoing trade transactions that need to be conducted and invoiced in the cases where landlords supply tenants with sub-metered electricity. Blockchain technology is considered highly suitable for the handling of microtransactions, cf. FfE (2018).

Smart contract platforms
The major conceptional development of the Bitcoin blockchain has been the introduction of smart contract platforms such as Ethereum.[49] In terms of market capitalisation and the number of software developers working with it, the public and freely accessible blockchain Ethereum is by far the most important cryptonetwork upon which smart contracts can be executed.[50] Ethereum smart contracts are small programs which are uploaded to the blockchain. The program code is additional content belonging to the transaction, and the actual execution takes place via the Ethereum Virtual Machine.[51] For an Ethereum application, the logic is integrated into a graphical website interface via which users can interact.[52] This combination of front end and smart contract is called a distributed application (dApp).

The blockchain properties such as immutability, availability, and the lack of need for trust with the smart contract are therefore hidden behind an interface familiar to users.[53] Using these modules, software components such as application-specific currencies[54], digital rights of disposal[55], open financial instruments[56] or software-based organisations[57] can be constructed.[58] Over the past years, these components have in turn been used to further develop new infrastructures and applications such as decentralised data storage facilities or blockchain-based identity authentication.[59] Overall, there exist numerous smart contract platforms today which in certain cases differ markedly from the Ethereum network in terms of their consensus mechanisms, governance approaches, and a range of additional criteria.

Public smart contract platforms also create a different starting point for software developers and entrepreneurs: if applications are developed for a cryptonetwork, there is no fear of any subsequent change to the rules of the game. Developers for centralised internet platforms such as Google, Apple, Facebook, or Amazon, on the other hand, are entirely dependent on the decisions of these companies.[60] A public blockchain is — depending on the consensus mechanism chosen — not per se free of tendencies towards market concentration (cf. Part B). Hence, even in cryptonetworks, situations may still occur in which the validation of transactions lies in the hands of the few. In these cases, the rules of the game on the cryptonetwork may be changed. However, while the monopolisation of markets on the aforementioned internet platforms is based on the extraction of customer data as part of what is called a two-sided market[61], there exist no comparable switching costs for users of cryptonetworks. The users do not cede their data rights to a platform operator, which means that they can always retain control over their data. Users of cryptonetworks therefore always have an exit option by selling their tokens or (as a means of last resort) performing a fork of the protocol. In such a fork, participants of the blockchain split off in order to use a blockchain of their own design parallel to the existing implementation.[62]

Furthermore, it is a basic principle of public cryptonetworks without access restrictions that users of a platform control the blockchain jointly via token ownership.[63] Specifically, the crypto protocol incentivises network users to work together on the joint goals of network growth and increasing the value of the token.

Almost all use cases from the energy industry use a smart contract platform (cf. chapter 3). The processes in this case encompass use cases ranging from programmable money and ancillary services for the electricity grid to the organisation of energy quantities and values in energy collectives.

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[49] For an overview, cf. e.g. GitHub (2019a).
[50] Coinmarketcap (2019).
[51] Merz, M. (2019).
[52] Merz, M. (2019).
[53] Merz, M. (2019).
[54] Wikipedia (2019).
[55] GitHub (2019b).
[56] GitHub (2019c).
[57] GitHub (2019d).
[58] a16zcrypto (2019).
[59] a16zcrypto (2019).
[60] Dixon, C. (2018).
[61] Huberman, G.; Leshno, J.; Moallemi, C. (2017).
[62] A prominent example is the splitting up of Ethereum (ETH) and Ethereum Classic (ETC) after a hard fork due to the DAO hack in 2016. Cf. Falkon, S. (2017) and Biederbeck, M. (2016).
[63] Mercatus Center (2018).

Marketplaces for the decentralised exchange of value and services

We are currently experiencing a trend towards novel, decentralised (peer-to-peer) marketplaces without intermediaries in the development of cryptonetworks.[64] This also applies to crypto exchange networks such as Coinbase. To date, users of such networks have had to trust at least one crypto exchange network with their monetary assets in order to buy and sell currency. This resulted in the downside of centralised security architectures in the form of a single point of failure, i.e. a high risk of hacker attacks. A decentralised marketplace, on the other hand, theoretically enables the trust-free exchange of digitalised content of all types. The only prerequisite for secure trade in this case is control over the private keys.

The cryptonetwork *Filecoin*[65] is an example of a peer-to-peer system with unlimited decentralisation, in which tokens are used to broker data storage between vendors and consumers. Technically, it should be possible to trade freely available storage on computers of all types. Filecoin uses Ethereum and the IPFS protocol[66]. Filecoins can be earned by working on improvements to the software as well as by providing hardware storage space.

Storage space as well as data transfer bandwidth and CPU/GPU cycles are traditionally marketed via merchants. Hence, apart from Filecoins for storage space, WiFi coins or Compute coins are conceivable. Similarly, many of the major Web 2.0 companies such as Twitter, Tumblr, Ebay or Uber could face serious competition from decentralised marketplaces.[67] Promising concepts for marketplaces for the decentralised exchange of value and services are the IOTA Data Marketplace[68], DataBrokerDAO[69], and the OCEAN BigChainDB protocol.[70] Cryptonetworks are also promising for the implementation of prognosis markets such as Augur, as they make it possible to overcome the existing impediments of global security and the enforcing of ownership rights, the immediate and complete processing of micropayments, as well as the setting of incentives and participation.[71]

Marketplaces for the decentralised exchange of value and services promise to fill a significant gap in the transformation of the energy system. In an energy system with an increasing number of stakeholders and devices as well as small-scale energy consumption and deliveries, the flexible, secure, and economic exchange of data is an indispensable prerequisite for its ability to function.

The following diagram provides an overview of the three categories of cryptonetworks with corresponding examples.

Cryptonetworks as stores of value	**Smart contract platforms**	**Decentralised exchange of value and services**
Bitcoin	Cardano	0x
Bitcoin Cash	DFINITY	Attention Token
Dash	Energy Web Foundation	Civic
Decred	EOS	Filecoin
Monero	Ethereum	The Raiden Network
Zcash	Kadena	…
…	NEO	
	Nervos CKB	
	…	

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[64] Cf. Olaf Carlson-Wee, founder and CEO of Polychain Capital, in a16z-Podcast (2017).
[65] Filecoin (2019).
[66] IPFS (2019).
[67] a16z-Podcast (2017).
[68] Sønstebø, D. (2017).
[69] DataBroker DAO (2018).
[70] Oceanprotocol (2019).
[71] Augur (2019), cf. also Chris Dixon, General Partner of Andreessen Horowitz, in a16z-Podcast (2018).

→ 3

Assessment of blockchain applications in the energy industry

In the context of the present study, 11 selected blockchain applications (use cases) in the energy industry were examined and assessed with regard to their technical, economic and regulatory maturity and feasibility. The use cases are assigned to five application groups which, on the one hand, serve to improve classification and, on the other hand, illustrate the diversity of the considered blockchain applications across value networks. The following figure provides an overview of the use cases and their application groups.

The use cases referred to certainly do not cover every imaginable blockchain application in the energy industry. Likewise, the majority of the use cases under consideration are conceivable in a range of different variants. However, the use cases examined in the context of the present study represent, in our opinion, a very good and comprehensive selection of the many imaginable blockchain applications in the energy industry. The use cases examined in the present study and their process chains were defined and selected jointly and by mutual agreement in several working sessions by linking the expertise of the study partners and dena as well as with the expert support of the assessors.

In this chapter, the use cases are described in detail and thus also differentiated from conceivable alternative variants. Using the defined process chains, the parties involved as well as the individual process steps of the use case are presented transparently. Parties with write permission in the ledger are highlighted in shades of grey.

The process chains in turn provide the basis for the technical, economic and regulatory assessment of the individual use cases:

- The respective assessment results of the reports are summarised quantitatively according to a five-star system. The rating is higher or lower depending on the degree to which technical requirements are fulfilled, what the economic benefits are and how decisive the regulatory influence is on the use case[72].
- A short qualitative summary of the results of the technical, economic and regulatory analysis is then provided. Furthermore, the main results of the underlying assessment criteria are also presented graphically.

For a detailed explanation of the respective technical, economic and regulatory assessments and their methodology, please refer to the full report in Part B.

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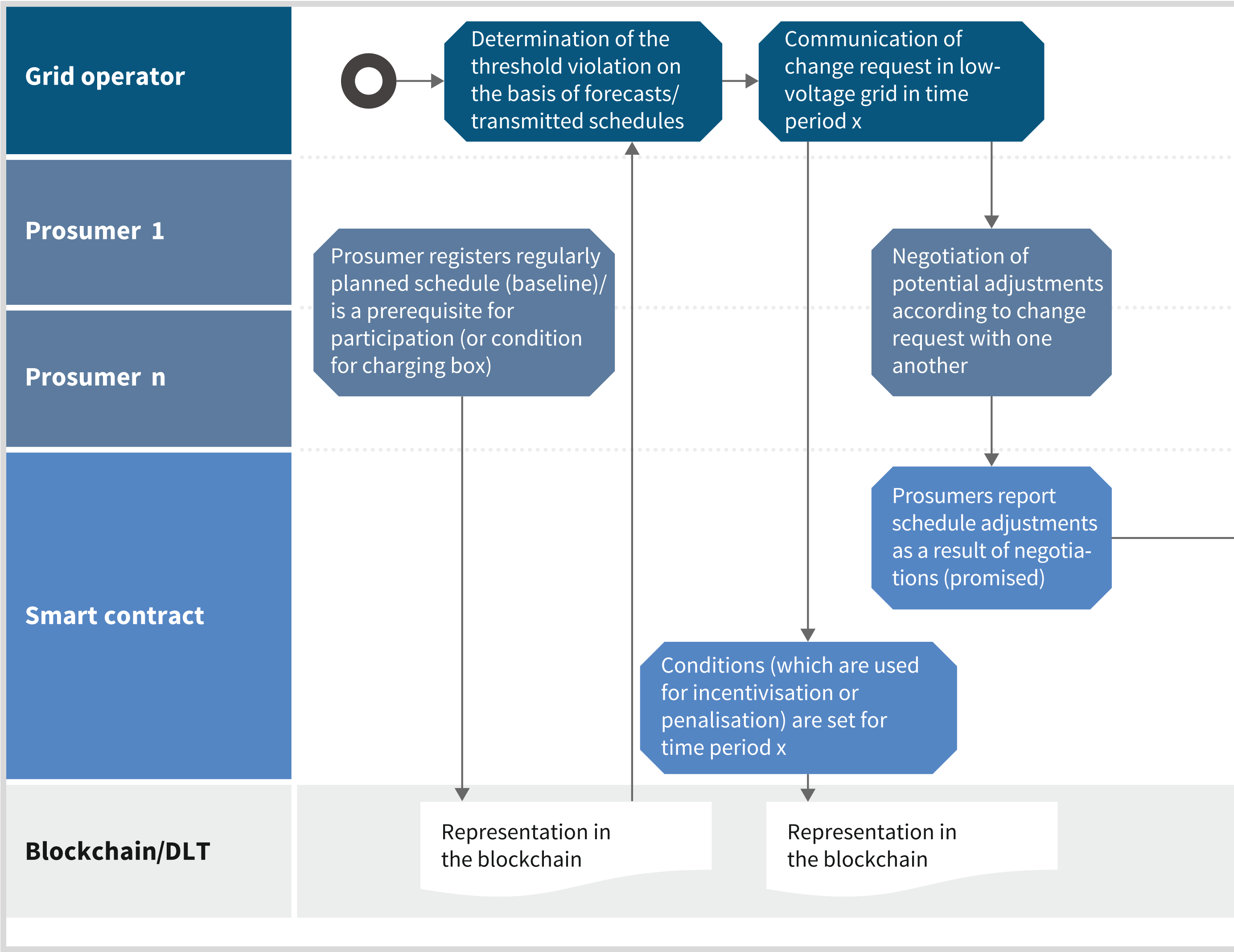
[72] A decisive influence receives a one-star rating. If the influence is not significant, it receives a five-star rating. The rating is not normative, i.e. a high rating is not necessarily positive or even conducive and, conversely, a low rating is not necessarily negative or even a hindrance to the use case.

[73] The individual quantitative evaluation results (technical, economic, regulatory) were deliberately not translated into an overall evaluation per use case. Otherwise — and especially against the background of the different geographical frameworks of the two expert opinions (technical-economic: international; regulatory: German-speaking area) — there would be the risk of an inadmissible simplification of a complex world of results.

Application group: Asset management

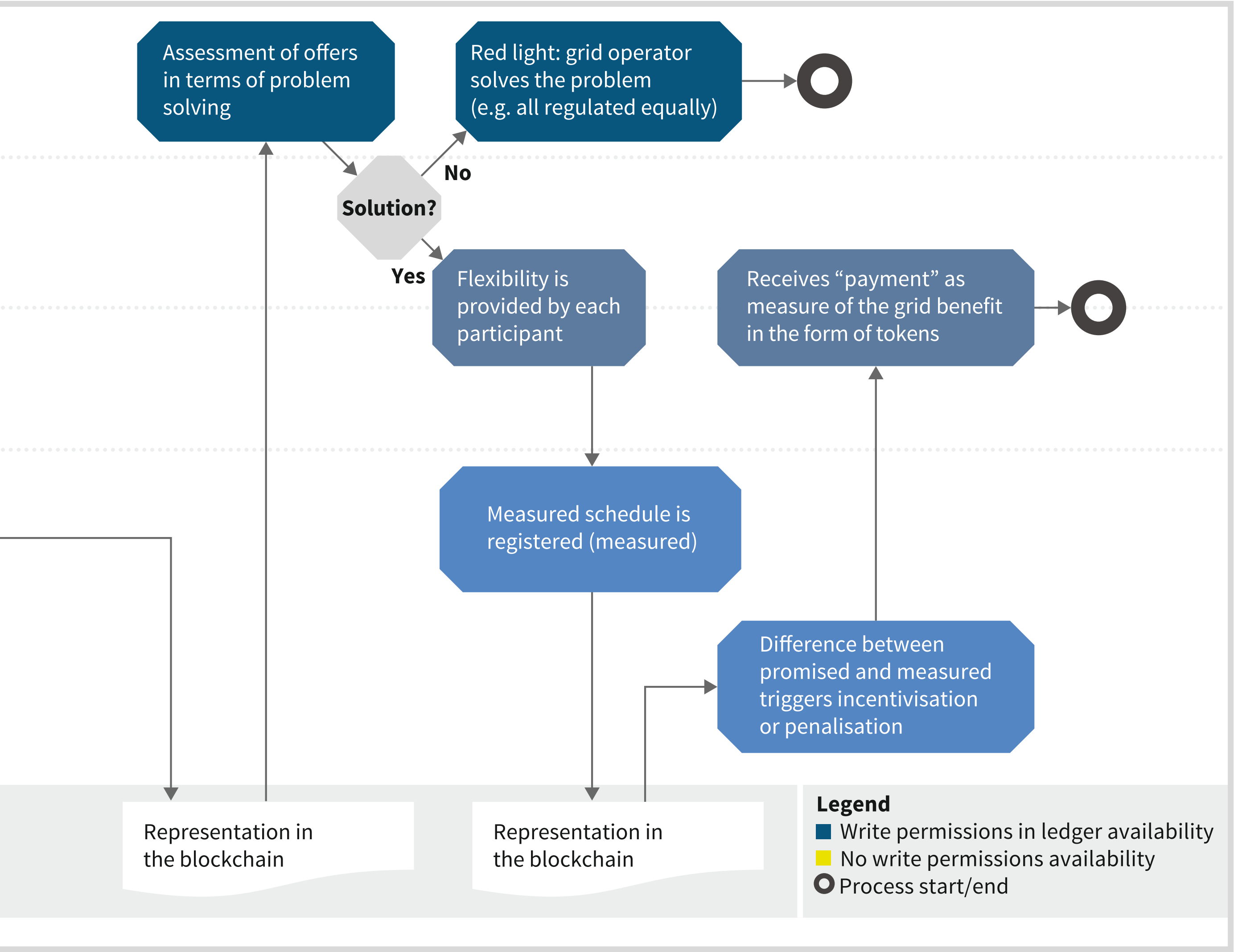
Use Case 1: Congestion management in electricity distribution grids (e-mobility)

Process chain



Process description

As electromobility and the connection of private charging boxes increase, local electrical grids are increasingly coming up against capacity limits. In particular, the simultaneity of charging procedures is becoming a challenge. Automated and digitally supported grid management by the distribution system operator is required. Blockchain-based congestion management at the distribution grid level supports the complex communication and cooperation of many stakeholders or assets with the aim of avoiding bottlenecks at the distribution grid level due to load shifting. Blockchain technology is used to store verifiably forecasted, adapted and actually measured load profiles (schedules). In addition to the execution and settlement of transactions, a token is used for offsetting. It stimulates behaviour beneficial to the grid in the form of flexibility and allows it to be quantified and billed at the same time. A corresponding digital infrastructure in the form of intelligent measuring systems (iMSys) is a prerequisite for this use case.



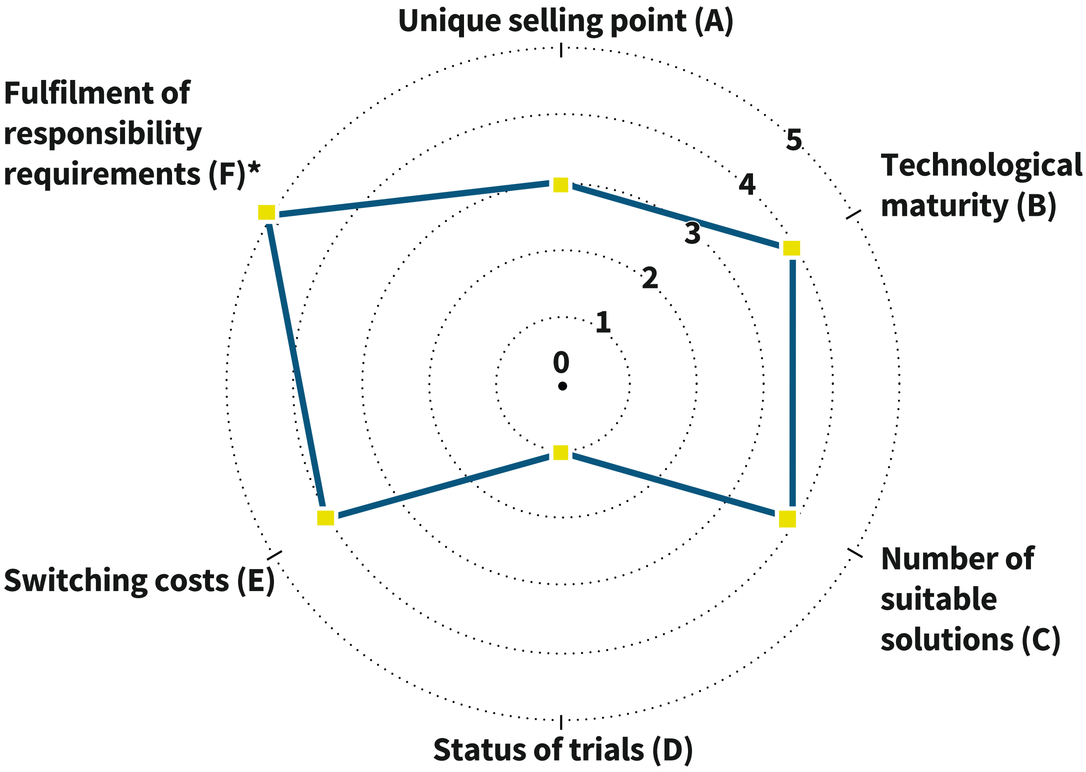
Assessment results

Degree of fulfilment of technical requirements

3.6 ★ ★ ★ ⯪ ☆

One star = very low
Five stars = very high

The electricity distribution grid is a critical infrastructure, which means that public blockchains are eliminated for this use case. Privately operated copies of public blockchains, private blockchains or public blockchains with responsible operators, on the other hand, are generally suitable. The requirement for the number of possible transactions per second is relatively low, since no real-time requirements apply due to the extensive lead time between tendering and execution. Today, scalability can be ensured by various available blockchain solutions. Reassessment is required in the event of the full inclusion of microdevices (production and load). Tokens in the form of a pure accounting unit are sufficient for the use case and can be realised by means of a number of blockchain solutions. Overall, the genuine advantages of a blockchain solution increase for the use case (a) with the number, heterogeneity and dynamism of the stakeholders, (b) with the frequency of the tender, and (c) with the interplay with other use cases (see Use Cases 3, 4, 5, 7, 8, 9 and 10).



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4 = low risk, 5 = no risk

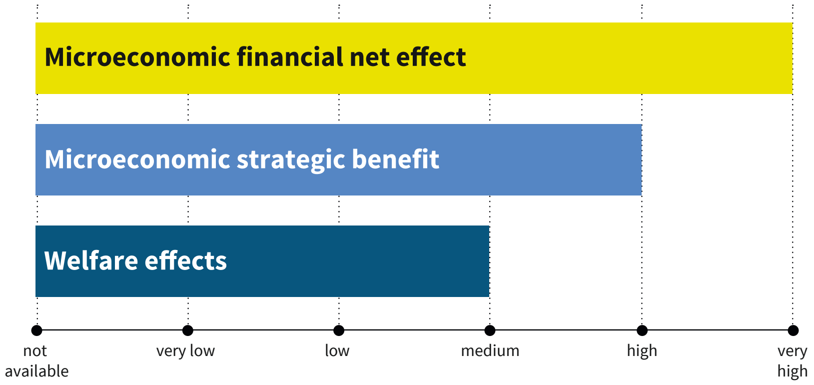
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

4.2 ★★★★☆

One star = very low
Five stars = very high

The blockchain-based coordination of demand management is a new tool to avoid grid congestion that reduces search, information and implementation costs. Using a private blockchain makes it possible to monitor the complex operations throughout the process in a cost-effective way. The automated storage of transactions also enables simple billing, which would not be practical manually. The remuneration option for household flexibility resources in the form of tokens corresponds to a local market that can reduce potentially necessary procurement volumes in downstream flexibility markets and thus increase overall market efficiency. Moreover, the involvement of households opens up the value of their activatable flexibility resources, thus reducing intrinsic market entry barriers for other uses of the resources. In addition, the use of battery storage in households as flexibility in congestion management promotes the integration of electromobility as an emission-reducing technology.

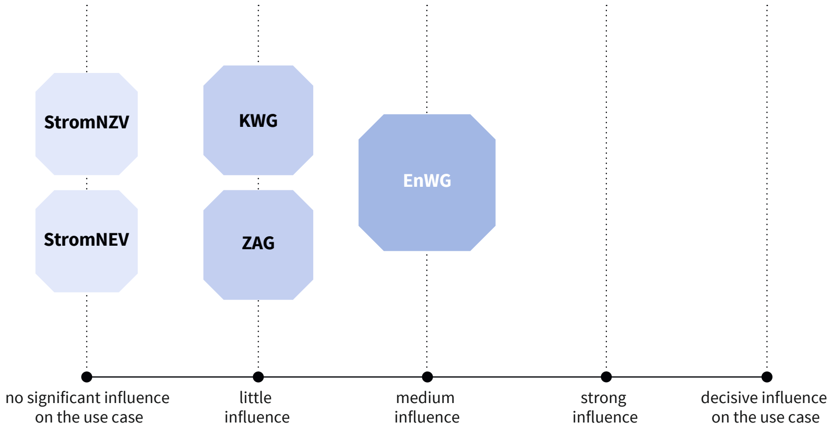


Regulatory impact

3.0 ★★★☆☆

One star = decisive
Five stars = not significant

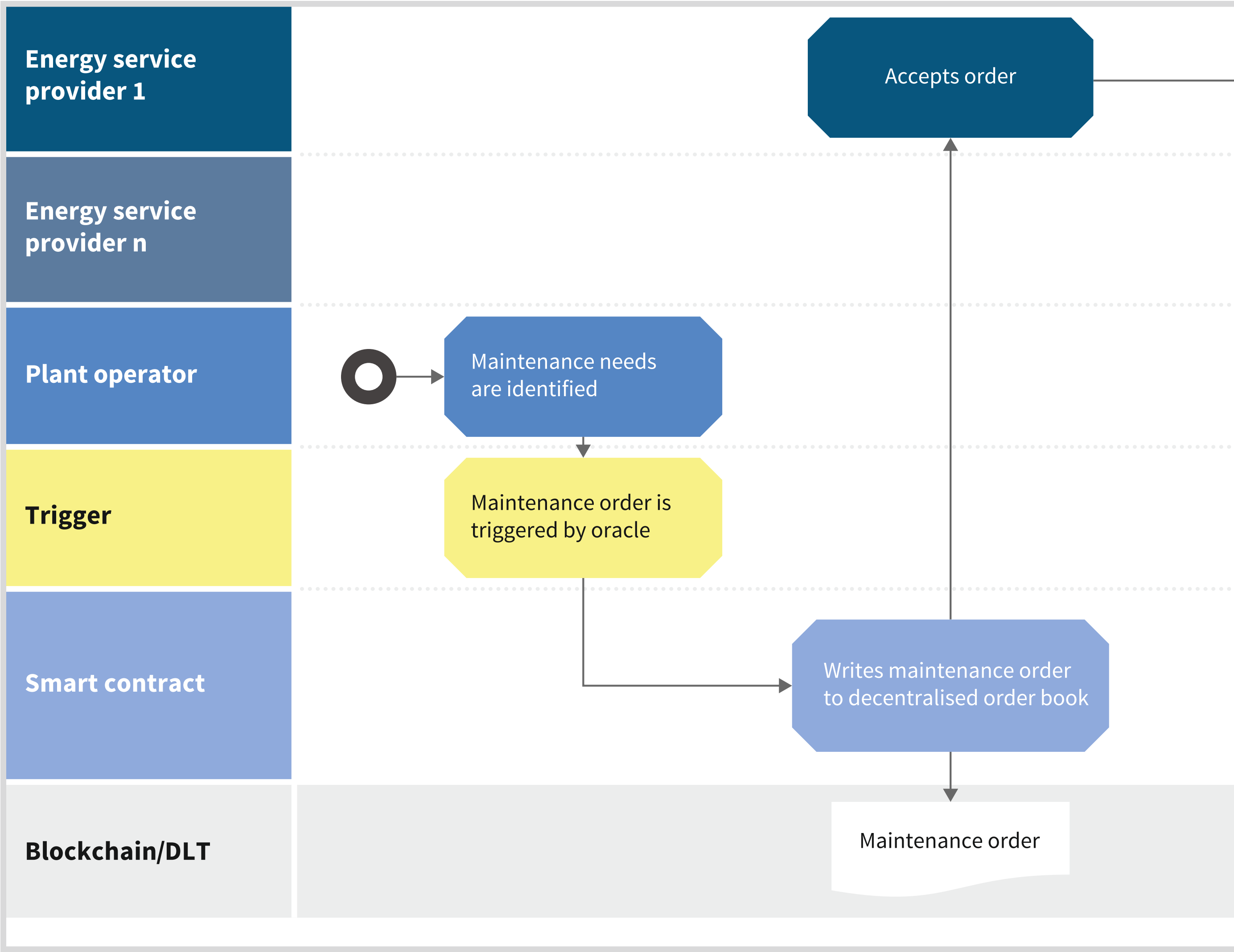
Firstly, there is nothing wrong with measuring to what extent a grid customer is beneficial to the distribution grid. If this parameter (here: “number of tokens”) is to be used to calculate or reduce grid fees via the process of congestion management described in regulation, energy law requirements (e.g. Section 13 et seq. of the German Energy Industry Act [EnWG]) must be observed and, if the tokens are converted directly into money, the financial supervisory regulations must also be observed (Sections 1 and 32 of the German Banking Act [KWG]). In the case of a transfer with the involvement of a third party (such as with a platform), as well as in the case of money remittance (Section 1 of the German Payment Services Supervision Act [ZAG]), a permit is to be considered for the provision of payment services (Section 10 of the ZAG). Although the given framework of the EnWG does not pose a hindrance, it is rather complex and further regulations must be observed when paying with tokens; the use case is therefore rated “medium”.



Application group: Asset management

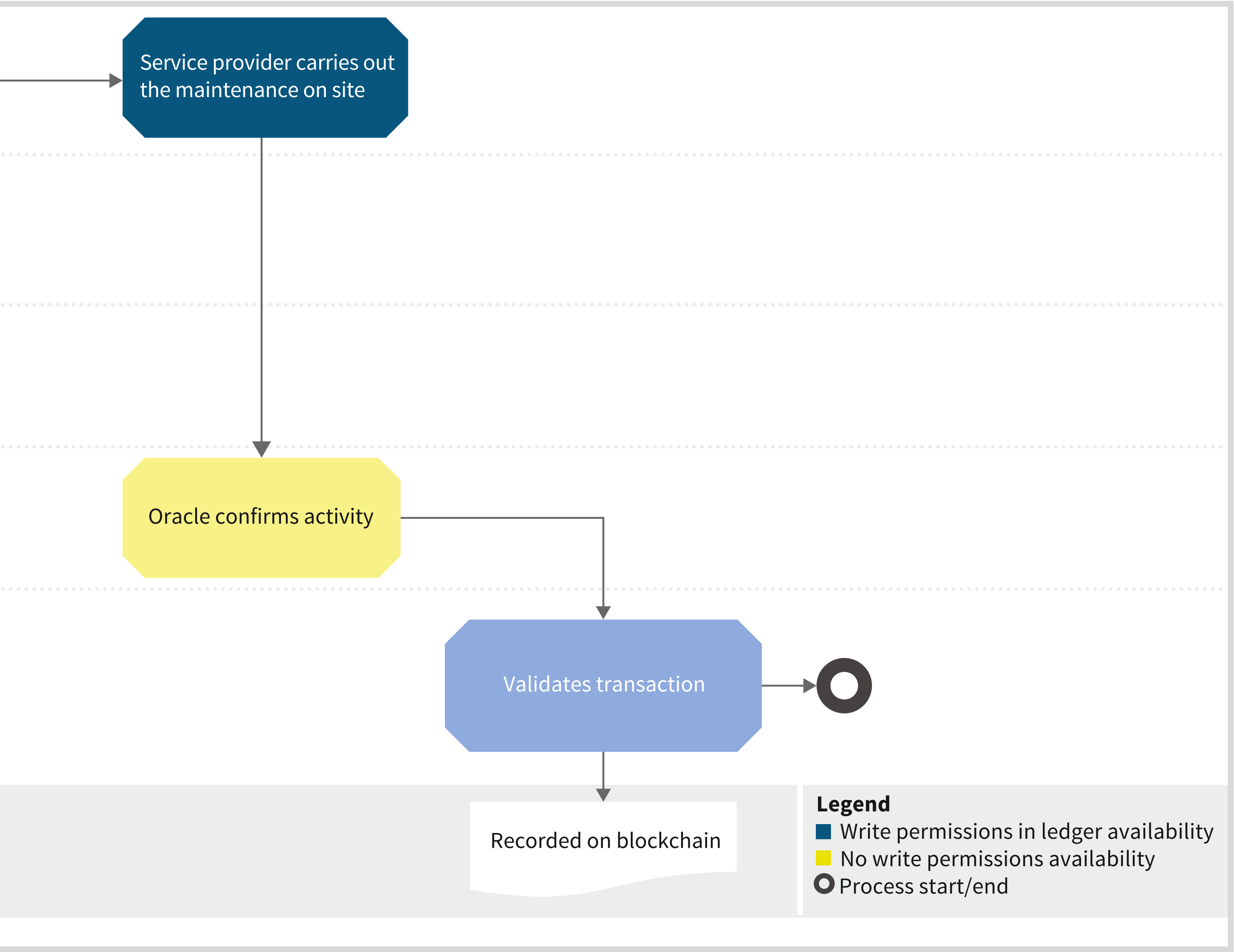
Use Case 2: Energy services for buildings and industrial processes (maintenance)

Process chain



Process description

Various devices and systems in buildings require regular servicing and maintenance. In addition to the central control system, this also affects heating, ventilation and air conditioning installation components such as boilers, cooling compressors, pumps and fans. The requirements regarding the frequency of maintenance and repair of equipment are correspondingly heterogeneous. In the use case, the servicing and maintenance activities of the service providers are stored in a blockchain, thus enabling traceability and accountability as well as direct linking between services and payments via smart contracts.



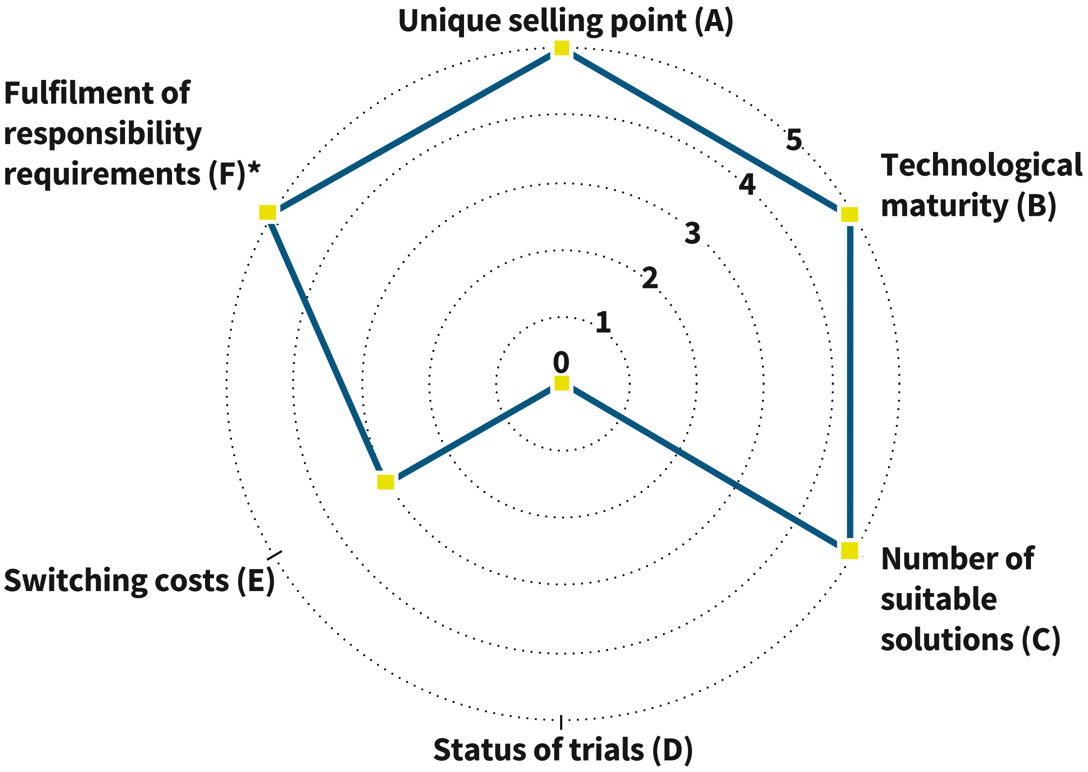
Assessment results

Degree of fulfilment of technical requirements

4.3 ★ ★ ★ ★ ☆

One star = very low
Five stars = very high

In the use case, the blockchain forms a standardised, innovative interface through which maintenance activities can be tracked and exchanged automatically between interaction partners in a verifiable and secure manner. The required trust between interaction partners is correspondingly low, which can only be achieved with significantly more effort if alternative technologies such as certified systems are used. Furthermore, service traceability and accountability can be directly linked to performance and payment via the blockchain. The possibility of technical switching costs emerging (through the complication of data migration), as well as meeting the accountability requirements to execute transactions and operate the blockchain, depends on the type of blockchain chosen: If a private blockchain is chosen, the risk is high. On the other hand, choosing a public blockchain poses no risk.



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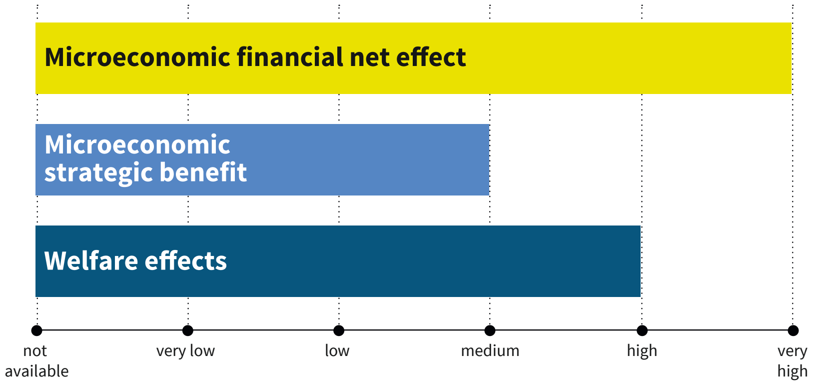
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

4.3 ★★★★☆

One star = very low
Five stars = very high

The predictable financial savings effect (working time) for the automation of servicing and maintenance processes is high. Modern HVAC systems often already offer the option of using smart interfaces with manual verification routines. In this context, however, it is important to ensure the data collection (data integrity) is secure so the tamper-proof handling of data in the blockchain is not endangered. Entrepreneurial strategic value results from data-based business models, which are made possible by verifiable machine running times that can be divided at a low cost. The data stored on the blockchain can also be used to process warranty services, i.e. in the event of deviations from defined leeway, repayments are automatically triggered via smart contracts. Device usage data may be used and released at the discretion of the user for individual servicing or maintenance processes. The users retain full control over the use of the data, which strengthens the sovereignty over the user-related data of each citizen.

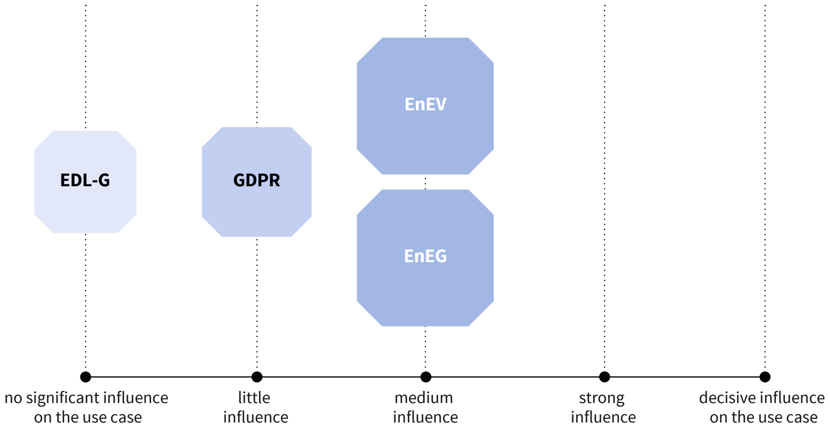


Regulatory impact

5.0 ★★★★★

One star = decisive
Five stars = not significant

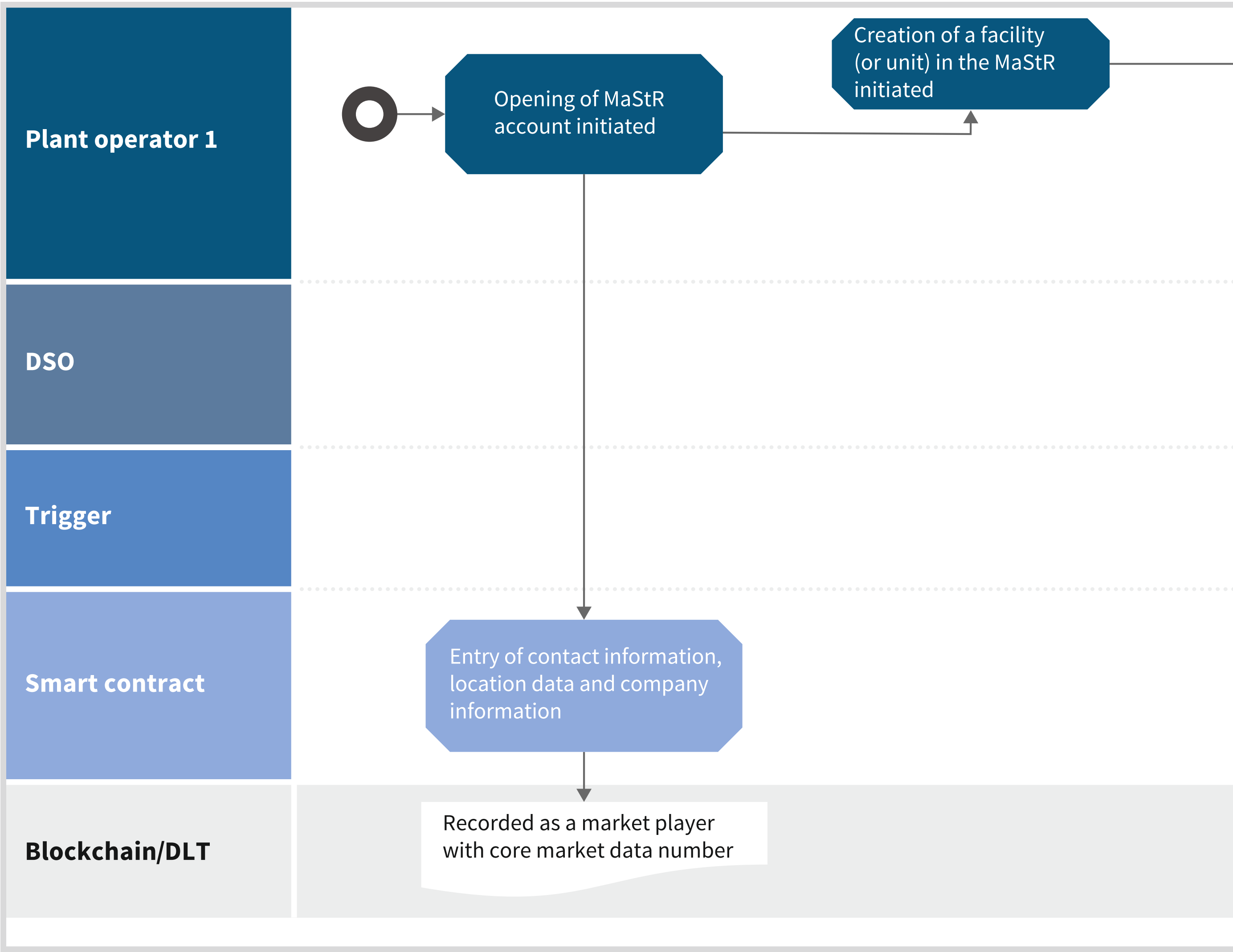
Requirements for servicing and maintenance processes are regulated by the German Energy Savings Act (EnEG, Section 3) and the German Energy Saving Ordinance (EnEV, Section 11). Components with a significant impact on the efficiency of the installations must, therefore, be regularly serviced and maintained by the operator. This requires specialist expertise (= necessary knowledge). With regard to the application of blockchain technology, it should be noted, particularly in the context of private-sector maintenance processes, that the blockchain does not allow the subsequent alteration or deletion of transactions for security reasons. Therefore, smart contracts should always be designed in such a manner that they are less prone to disputes, for instance. If personal data, such as those of a service technician, are included — as in each use case — the provisions of the GDPR (e.g. especially Article 17) must be observed. Essentially, the market for energy services is not subject to much regulation and the services are encouraged by law (German Energy Services Act [EDL-G]).



Application group: Data management

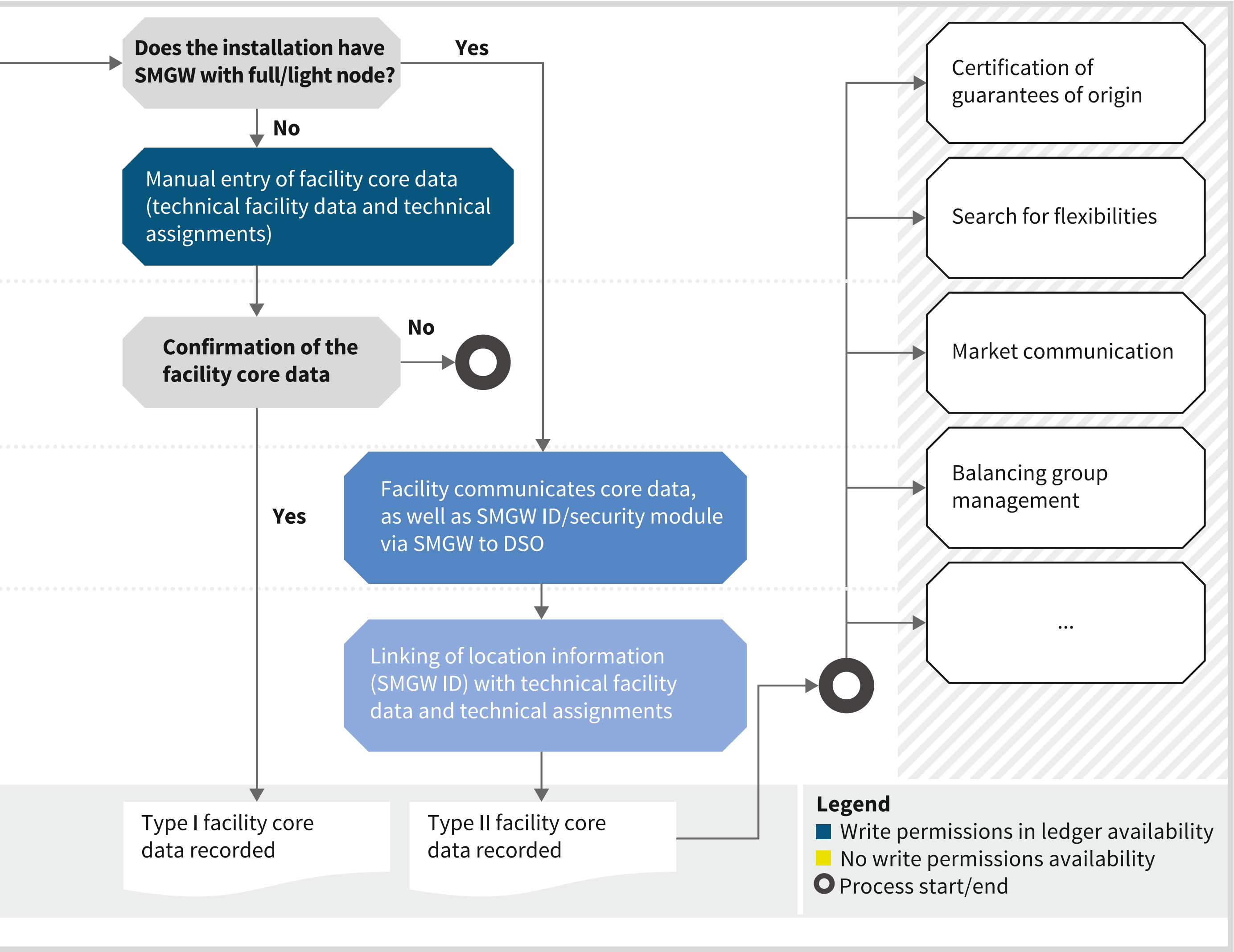
Use Case 3: Registration of installations in the core market data register (MaStR)

Process chain



Process description

According to the German ordinance on the central electronic directory of energy industry data, known as the Core Energy Market Data Register Ordinance (MaStRV), each electricity generation system (e.g. also small installations on a balcony), gas generation system and electricity storage system must be registered, whether it is connected to an electricity or gas grid directly or indirectly. This also applies to electricity consumption systems that are connected to a high or ultra-high voltage grid. The illustrated use of a blockchain for the digital administration of such a register instead of a conventional database promises semi-automated registration, management and selective provision of core market data. In particular, the connection of a smart meter gateway (SMGW) via the built-in crypto chip to the register of installations promises the secure authentication of installations that can be verified electronically at any time. For distribution system operators, some of the audit tasks assigned to them in accordance with the MaStRV are simplified. The SMGW becomes a participating computer in a blockchain network (node).



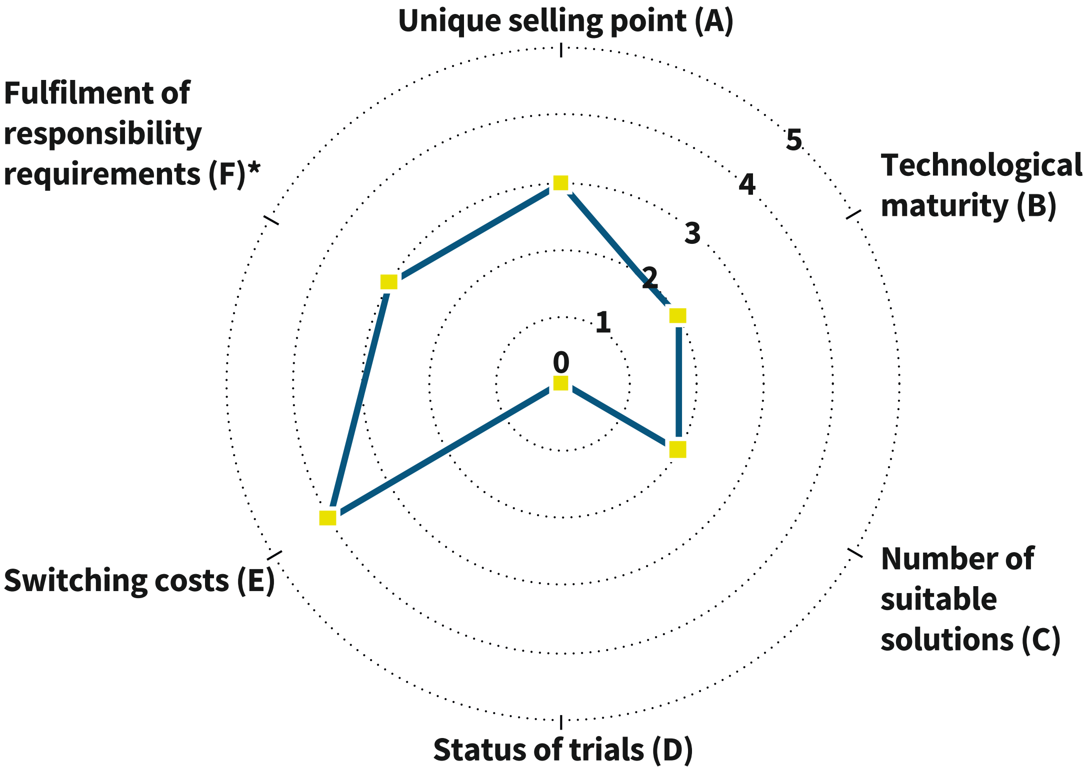
Assessment results

Degree of fulfilment of technical requirements

2.3 ★★⯪☆☆

One star = very low
Five stars = very high

The (partial) automation of registration is technically possible with other technologies. The special technological added value of blockchain technology lies in linking a device identification with a sovereign register of energy industry installations to a highly flexible, secure base trust layer for numerous existing and new energy industry services. Implementation experience in the energy industry is currently not available worldwide. In other industries, however, the principle of a trust anchor or the use of crypto chips is common. The German core market data register is already operational and the roll-out of smart meter gateways will start in 2019. Overall, the concrete requirements of this complex overall system consisting of a register of installations, the smart meter gateway and a cryptonetwork are still largely uncertain.



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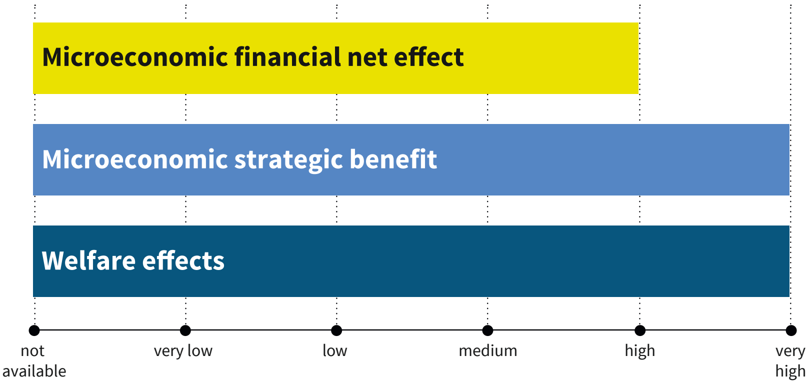
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

4.5 ★ ★ ★ ★ ⯪

One star = very low
Five stars = very high

For the (partially) automated registration process, blockchain technology is just one of the available options. The decisive financial added value lies in the macroeconomic effect: The secure authentication of systems, which can be verified electronically at any time, eliminates a major obstacle to the consistent automation of existing processes such as market communication, switching between market segments (self-generation/consumption, balancing energy and spot markets) and balancing group management, and the emergence of new digital value-added services such as system-oriented guarantees of origin (green, local electricity) can be actively promoted. Overall, the potential impact on market entry barriers and market efficiency is highly positive.

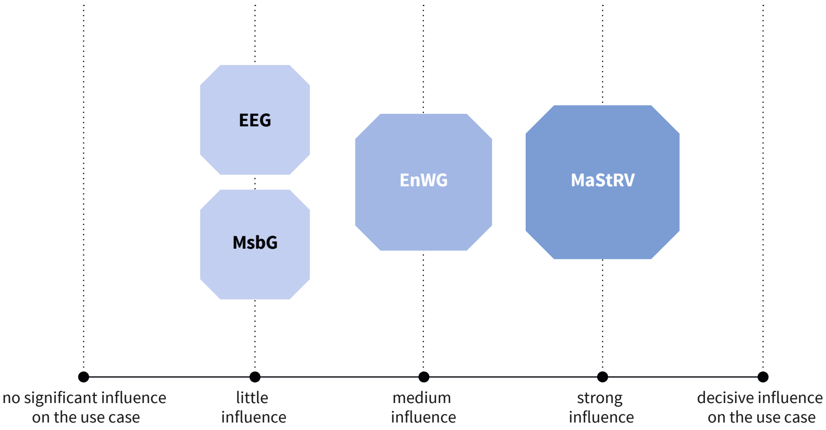


Regulatory impact

2.0 ★ ★ ☆ ☆ ☆

One star = decisive
Five stars = not significant

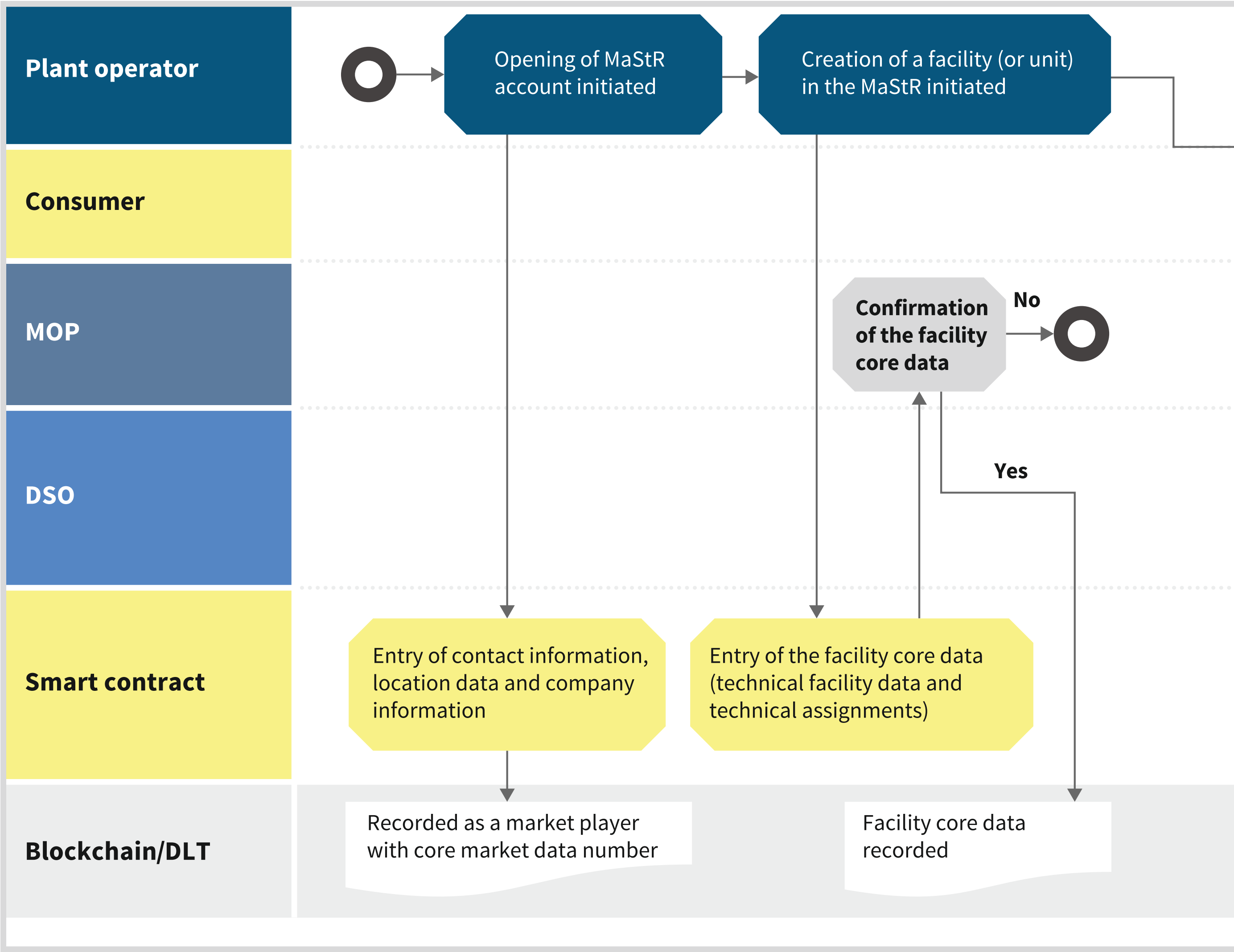
The Federal Network Agency (BNetzA) establishes and operates (Section 111e of the German Energy Industry Act [EnWG], Section 6 of the German Renewable Energy Sources Act [EEG]) an "electronic directory with energy industry data" as a core market data register (MaStR). The automated transmission of core market data via a smart meter gateway is fundamentally possible in compliance with the provisions of the German Metering Point Operation Law (MsbG). The use and processing of (also personal) data for the purpose of maintaining the register is allowed, but the regulations explicitly require a deletion of data (Section 9 of the MaStRV, Section 63 of the MsbG). The market player may even transmit data and other information to the MaStR in writing/physically; forms which the BNetzA provides on request (Section 8 of the MaStRV) are used for this purpose. If a blockchain is to be used as the technology substructure of a core market data register, various statutory regulations would have to be observed and national standards would have to be significantly modified.



Application group: Data management

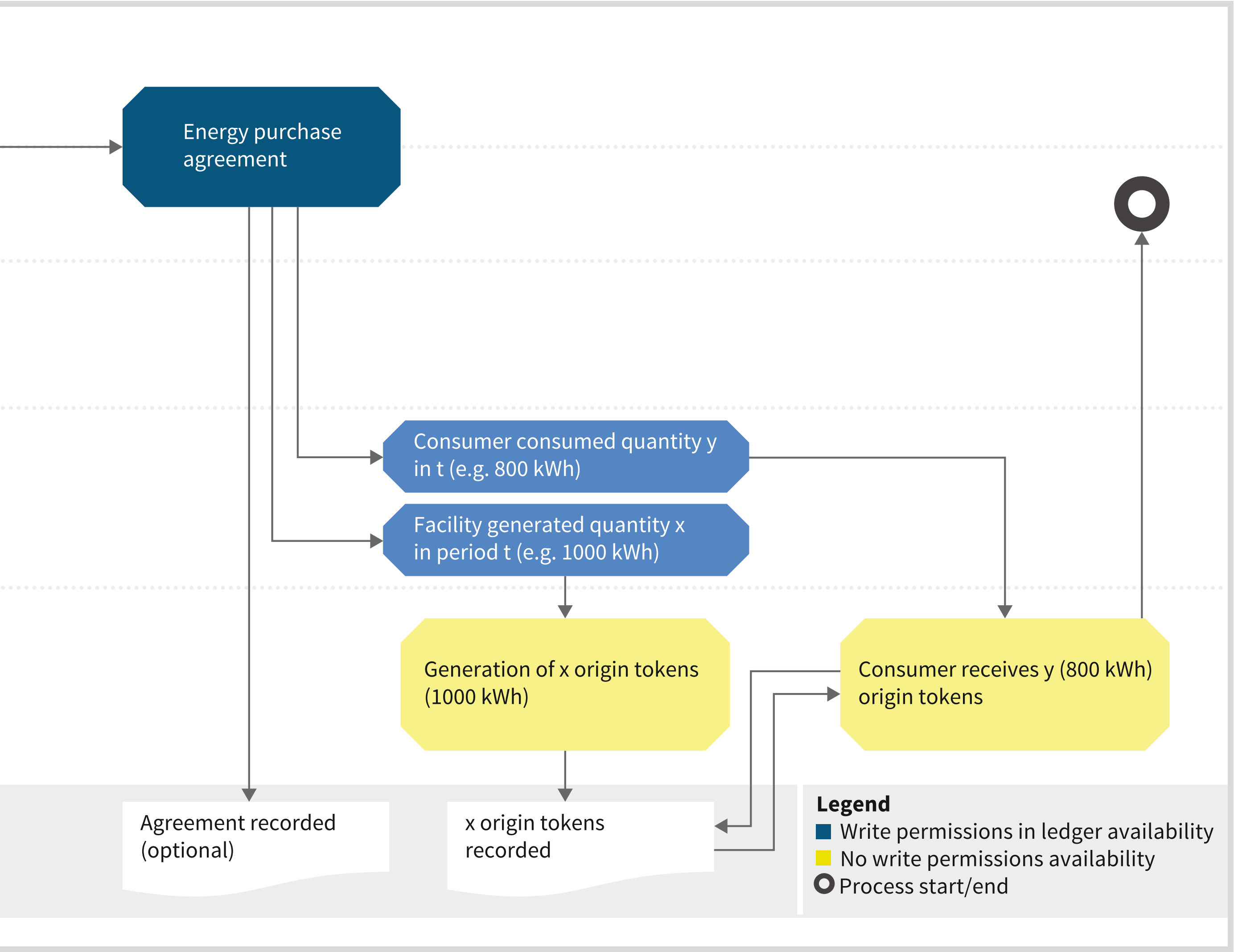
Use Case 4: Certificates of origin

Process chain



Process description

For electricity and gas customers today, the actual origin of the energy is untraceable and imprecise certificates established after the fact provide the only evidence. The use of blockchain technology for verifying the output, trading, tracking and collection of electricity or gas now enables end-to-end certification, and thus “installation-specific” evidence, for the first time. The use case is linked directly to the verifiable, blockchain-based authentication using a core market data register, but it can also be imagined independently. After an installation is registered, an energy purchase is agreed with a consumer. After recording the concluded transaction on a blockchain, the quantities generated and consumed are transferred from the responsible metering station operators in a smart contract. In this way, origin tokens are generated for the units generated by the registered installation and then transmitted to the consumer.



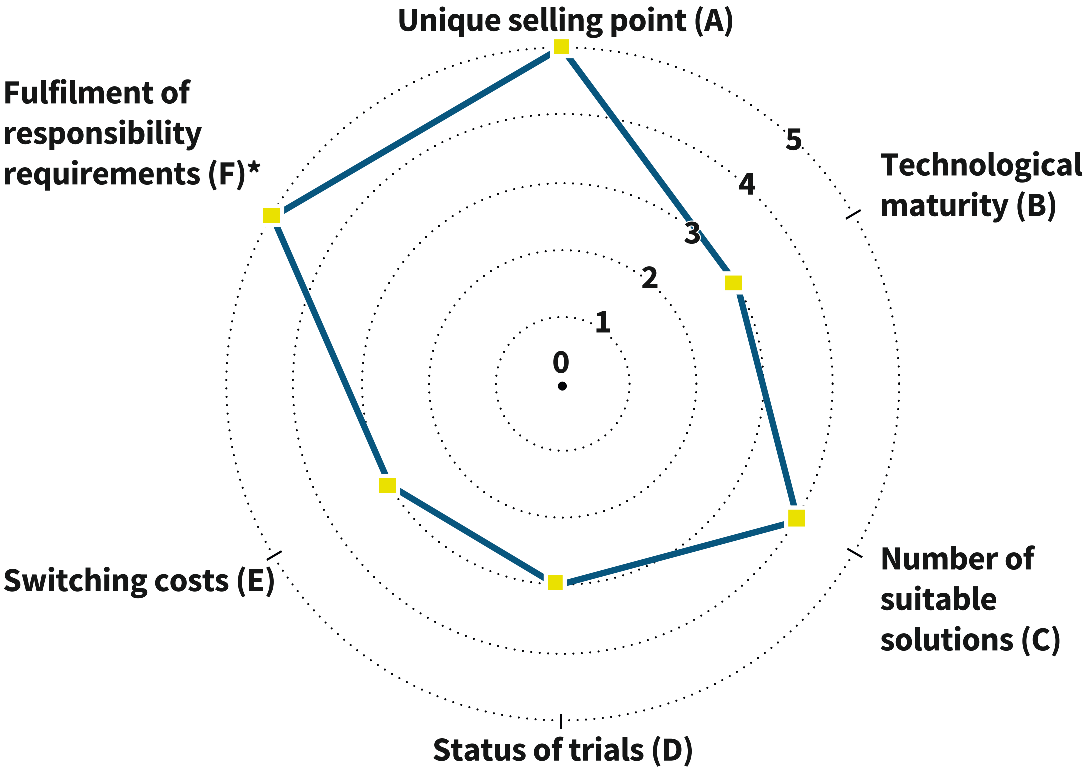
Assessment results

Degree of fulfilment of technical requirements

3.8 ★★★★☆

One star = very low
Five stars = very high

Unlike other blockchain-based certificates of origin for electricity and gas, the technically verifiable registration in a register of installations makes the individual energy-generating or consuming installation the starting point of the verification chain in this use case. The high integration of this use case with the blockchain-based register of installations (see Use Case 3) means that the availability of alternative technologies is very low. While a number of different blockchain technologies are suitable for the use case, the technological maturity of the corresponding cryptonetworks still needs to be verified in terms of scalability and long-term mass suitability. This includes encrypted smart contracts.



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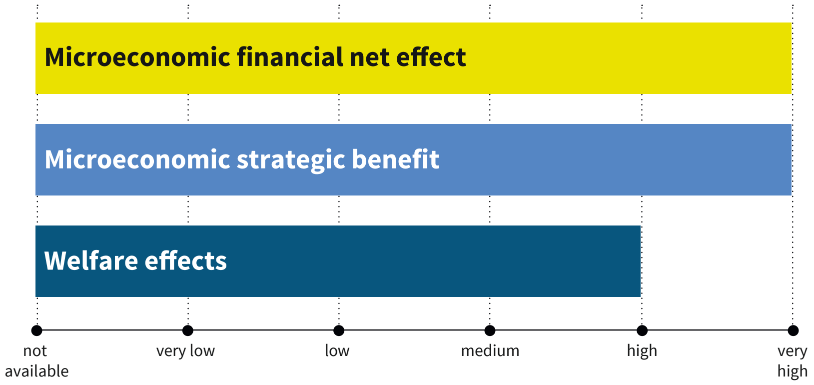
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

4.7 ★ ★ ★ ★ ★

One star = very low
Five stars = very high

In the use case, the use of blockchain technology significantly reduces the costs of creating certificates of origin. At the same time, strategic added value results from new processes and business models based on the digital acquisition of information. The basis for this is easily divisible, immutable data on the location, time, installation, type, etc. This use case presents a great opportunity for energy providers to learn. The economic value lies in particular in the differentiability of products and thus in the possible increase in competitive intensity. However, the scalability of the use case significantly depends on the availability of a digital metering infrastructure which, according to current plans, will not be available in Germany until 2032.

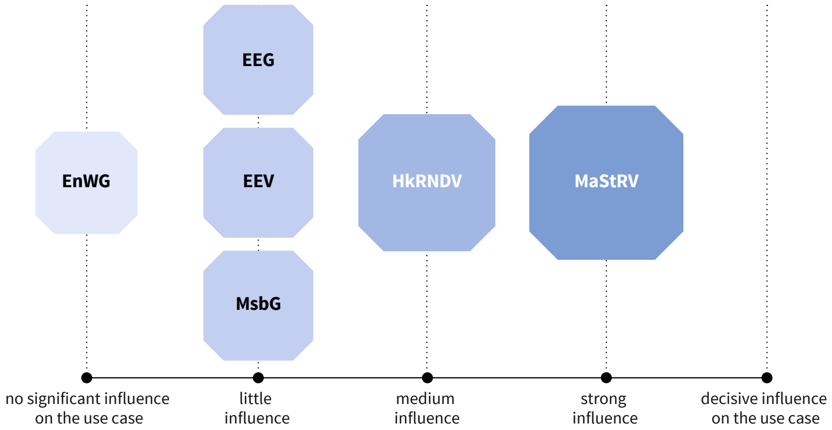


Regulatory impact

2.0 ★ ★ ☆ ☆ ☆

One star = decisive
Five stars = not significant

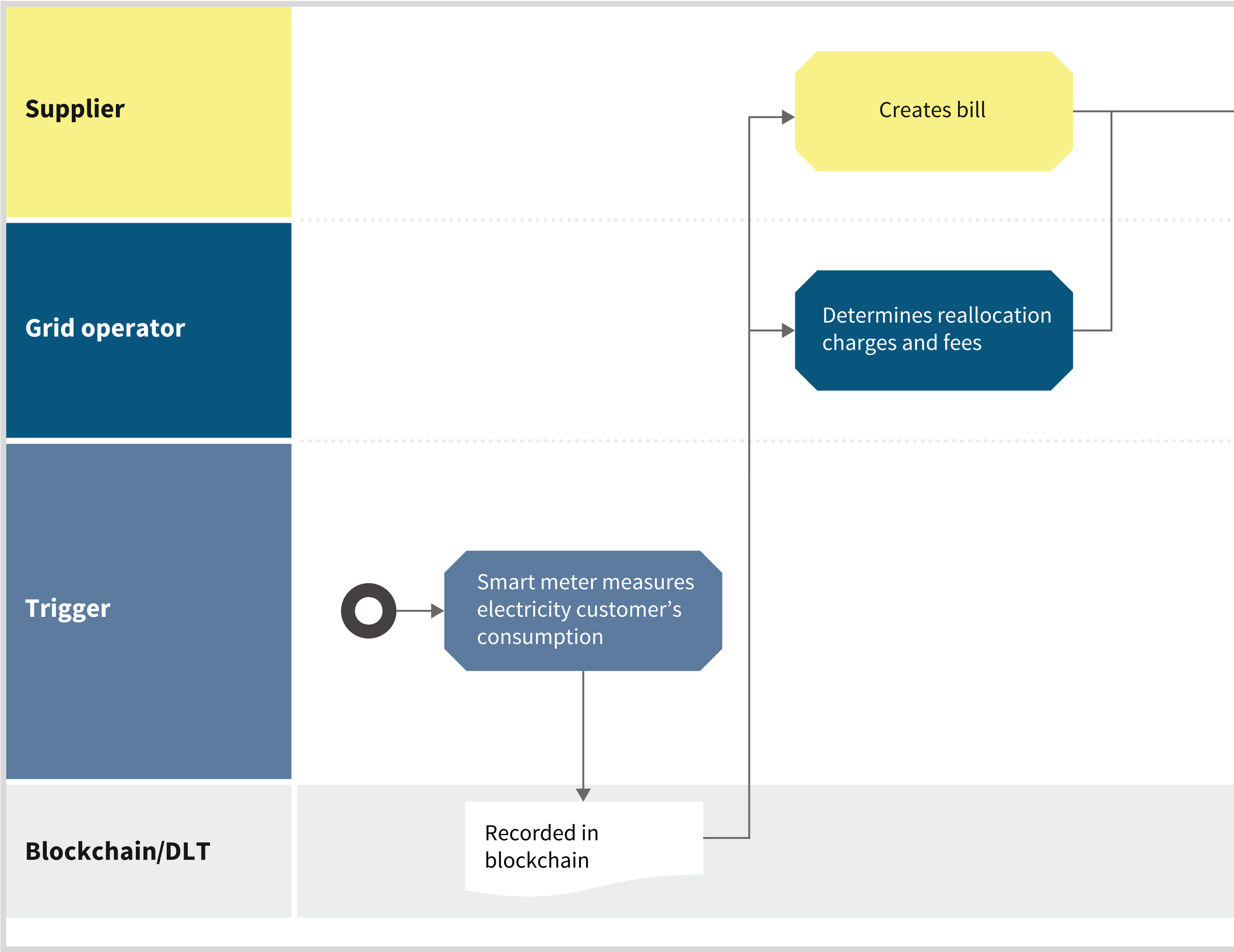
HkRNDV 2018 regulates the requirements for certificates of origin in Germany. In the process it describes, a differentiation must be made between the mandatory electricity labelling of the energy provider for the end customer (Section 42 of the German Energy Industry Act [EnWG]), a direct certificate of origin for electricity from renewable energy sources (RES) or another certificate of origin (Section 3 of the EnWG). A supplier may only label electricity as RES and present it as such on the electricity bill if it has also validated certificates of origin in the register of certificates of origin for the delivered quantity of RES electricity. This register is operated by the Federal Environment Agency (Section 7 of the German Renewable Energy Sources Act [EEV]) and the process follows the provisions of the HkRNDV. If a blockchain is to be used as a database for certificates of origin (in this case, also for the core market data register), a wide variety of statutory regulations would have to be observed and national standards would have to be significantly modified.



Application group: Market communication (electricity)

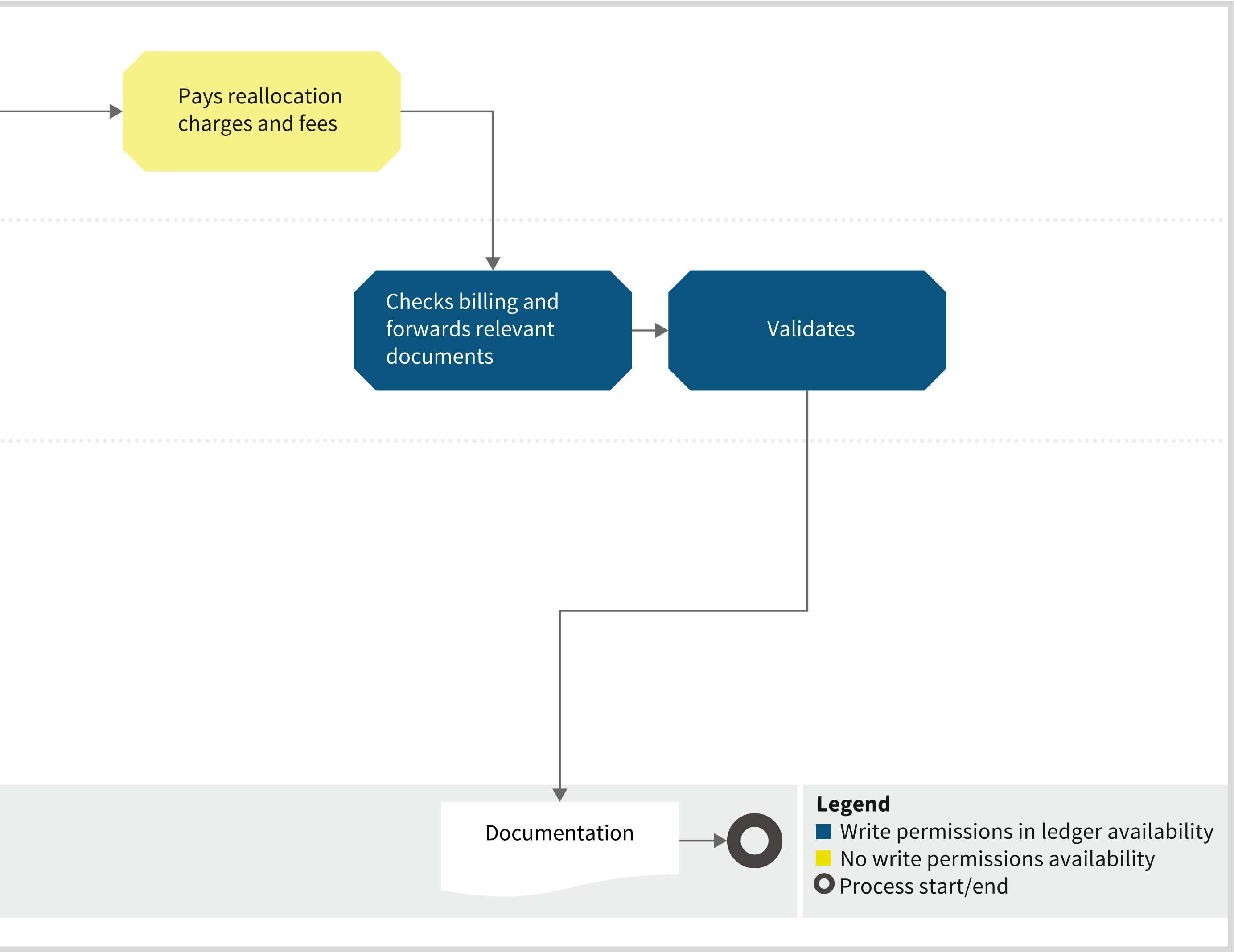
Use Case 5: Billing of fees and reallocation charges (electricity)

Process chain



Process description

Processes in the energy industry, such as the billing of fees and reallocation charges, require data exchange between various market players. In this use case, a customer's consumption data is written to the blockchain via an intelligent metering system (smart meter gateway). An appropriate infrastructure is required in the use case. The supplier then draws up the invoice while the distribution system operator or the transmission system operator determines the amount of the reallocation charges and fees. After they are verified and transferred, the validated values are also written to the blockchain.



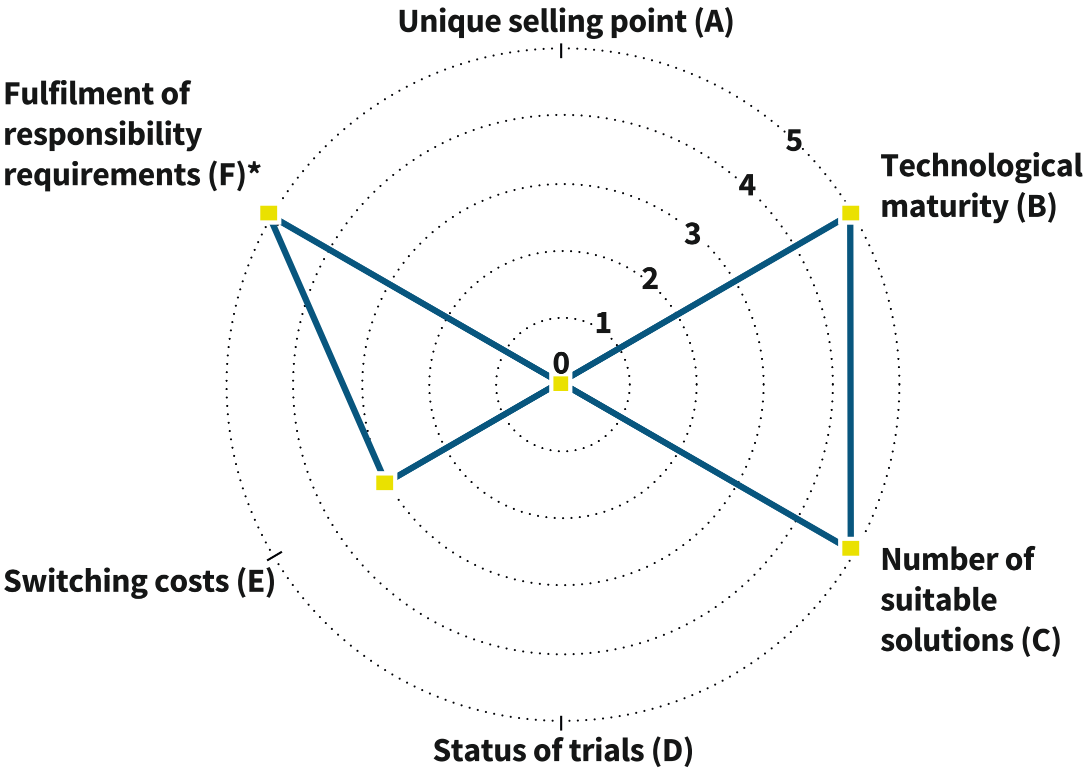
Assessment results

Degree of fulfilment of technical requirements

3.3 ★★★⯪☆

One star = very low
Five stars = very high

Overall, a whole range of currently available cryptonetworks meet the technical requirements of the use case. The degree to which blockchain technology can be substituted by technological alternatives in the use case decreases with an increasing number of suppliers, balancing group managers and distribution system operators, as well as the further integration of smaller generating units and loads as active market participants.



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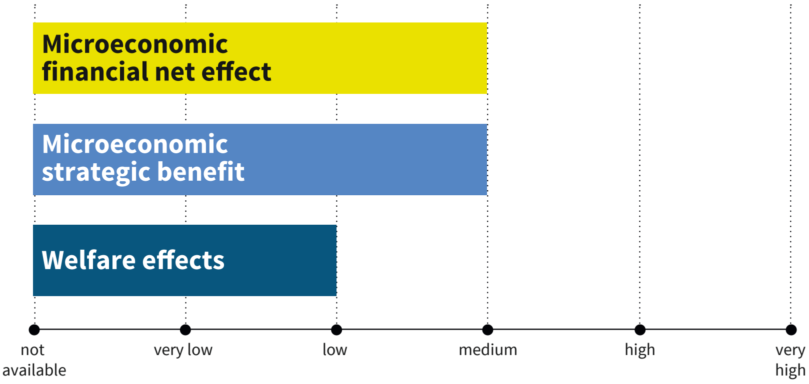
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

2.7 ★★⯪☆☆

One star = very low
Five stars = very high

The use of a blockchain to automate today's billing processes for fees and reallocation charges promises certain cost savings in comparison to the status quo. However, there are alternatives that may cost less to implement and operate. Once dynamic and differentiated grid fees are collected, blockchain technologies can provide their genuine benefits. Blockchains are also financially attractive for billing e-mobility (roaming) charging procedures.

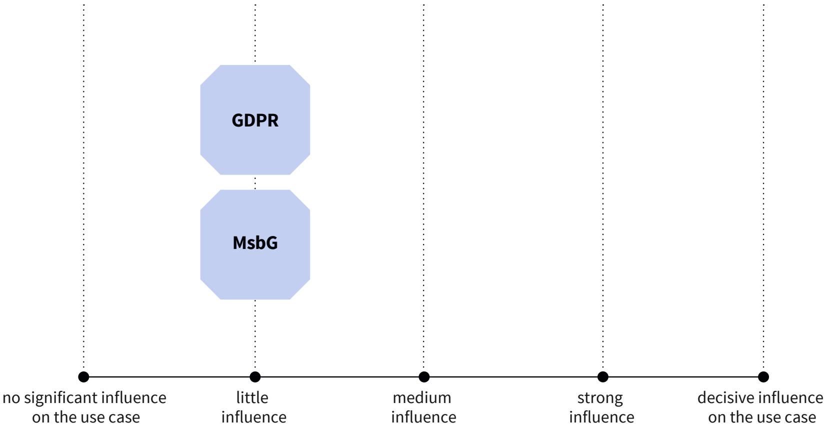


Regulatory impact

4.0 ★★★★☆

One star = decisive
Five stars = not significant

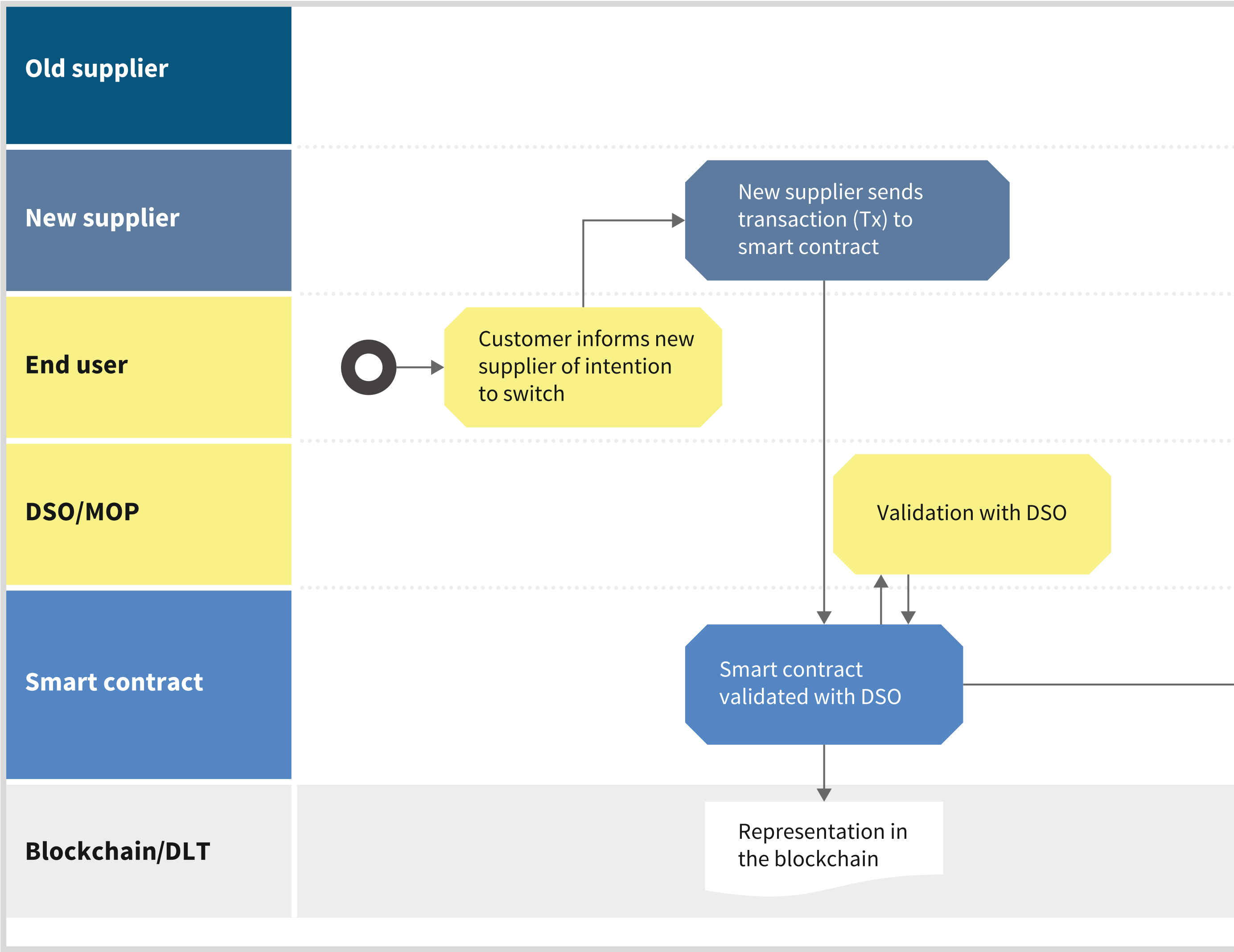
Although a modern metering system (mMe), which becomes an intelligent metering system (iMSys, referred to as "smart meter" at this point in the process) via a smart meter gateway (SMGW), measures an end consumer's consumption of electricity, for each data transfer, the area of application of the German Metering Point Operation Act (MsbG) is immediately broadened. The MsbG regulates, in particular, the handling of consumption data. In the process it entails, the electricity consumption data is stored directly on a blockchain. The MsbG (Section 19) only allows technical systems and components for which the data processing, for instance, meets the requirements of the MsbG (Sections 21 and 22) for the processes. For the purposes of billing in the use case, both the DSO and the supplier are entitled to handle the data (Section 50 of the MsbG) in order to process the required data. The market processes (e.g. interim model, target model or MaBiS) must also be observed accordingly.



Application group: Market communication (electricity)

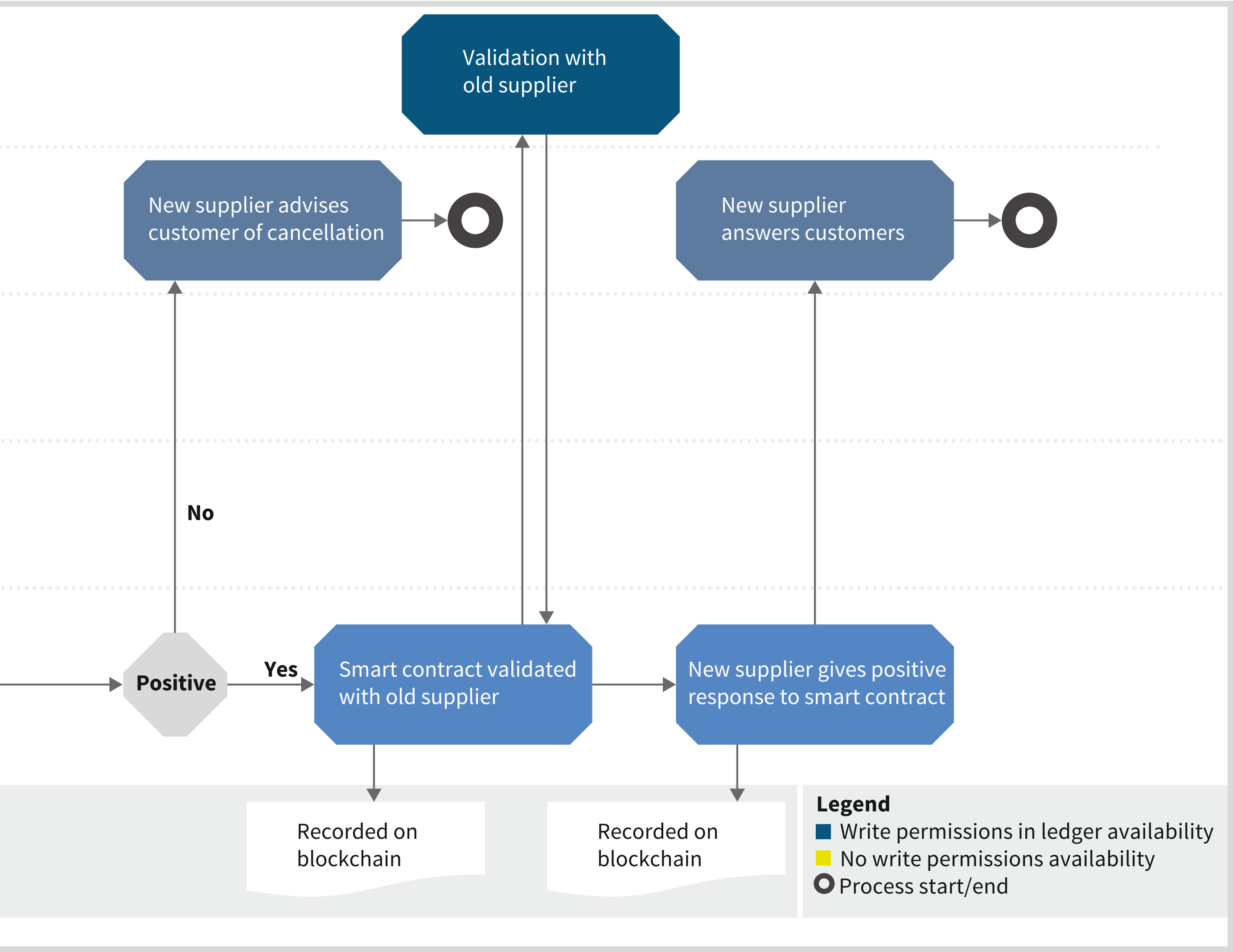
Use Case 6: Termination and switching suppliers (electricity)

Process chain



Process description

A change of electricity supplier in a liberalised energy market requires an intensive exchange of information between market players. Market players' various systems and manual process steps have hitherto prevented further process automation. The switch to a blockchain-based interaction between market participants allows the process to be streamlined and reduces technology and media disruptions. In the use case, communication takes place specifically via smart contracts and the validation of the data is standardised. Registration by the supplier, deregistration by the supplier and deregistration by the grid operator due to decommissioning and deregistration requests are taken into account.



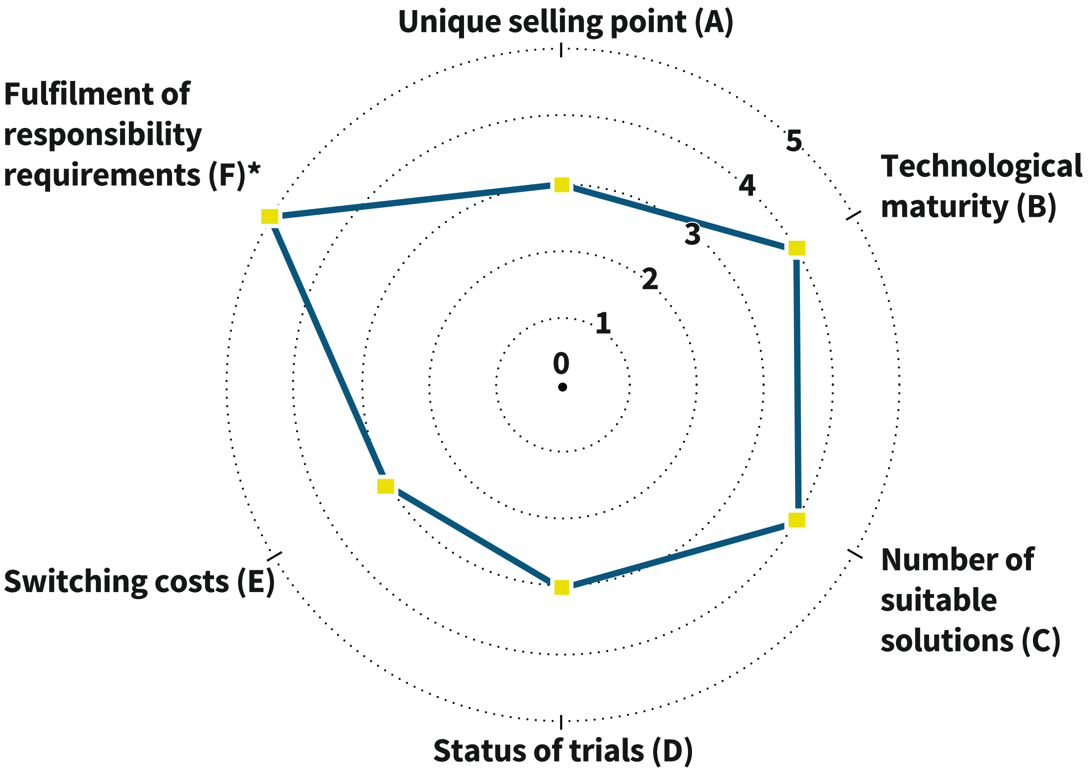
Assessment results

Degree of fulfilment of technical requirements

3.7 ★ ★ ★ ⯪ ☆

One star = very low
Five stars = very high

The use of blockchain technology for switching suppliers is only conditionally advisable in the case of an unchanged, stable number of grid operators, electricity suppliers and electricity consumers willing to switch. Current database technologies permit the cost-effective automation of the process to switch suppliers. However, if the number of market participants and interactions increases, or changes, then blockchains can utilise their unique technical selling point with regard to the immutability of entries, their secure exchange in a less reliable context and the increased quality of information.



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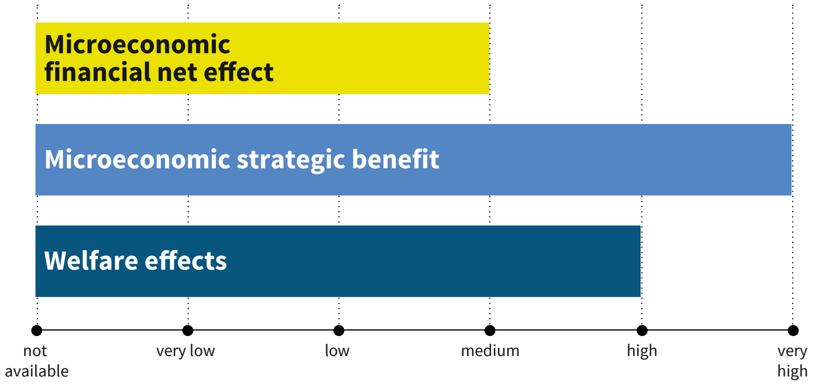
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

3.7 ★ ★ ★ ⯪ ☆

One star = very low
Five stars = very high

If the data required for market communication is stored on a blockchain, a standardised view of the data is generated for all authorised market players. On this basis, an automated switching process using smart contracts (automation) then leads to a number of economic effects for distribution system operators and electricity suppliers if there is a high number of market participants with corresponding interactions: Process cycle times are shortened, the process stability increases, the susceptibility to errors decreases and less post-processing is necessary. Regular labour-intensive format changes in market communication are implemented by energy providers in Germany every year. These changes can also be carried out uniformly and fully automatically using blockchain technology in the use case.

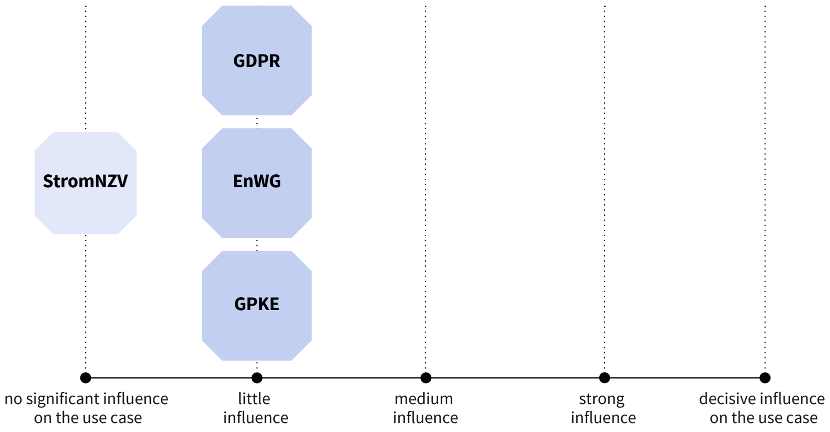


Regulatory impact

4.0 ★ ★ ★ ★ ☆

One star = decisive
Five stars = not significant

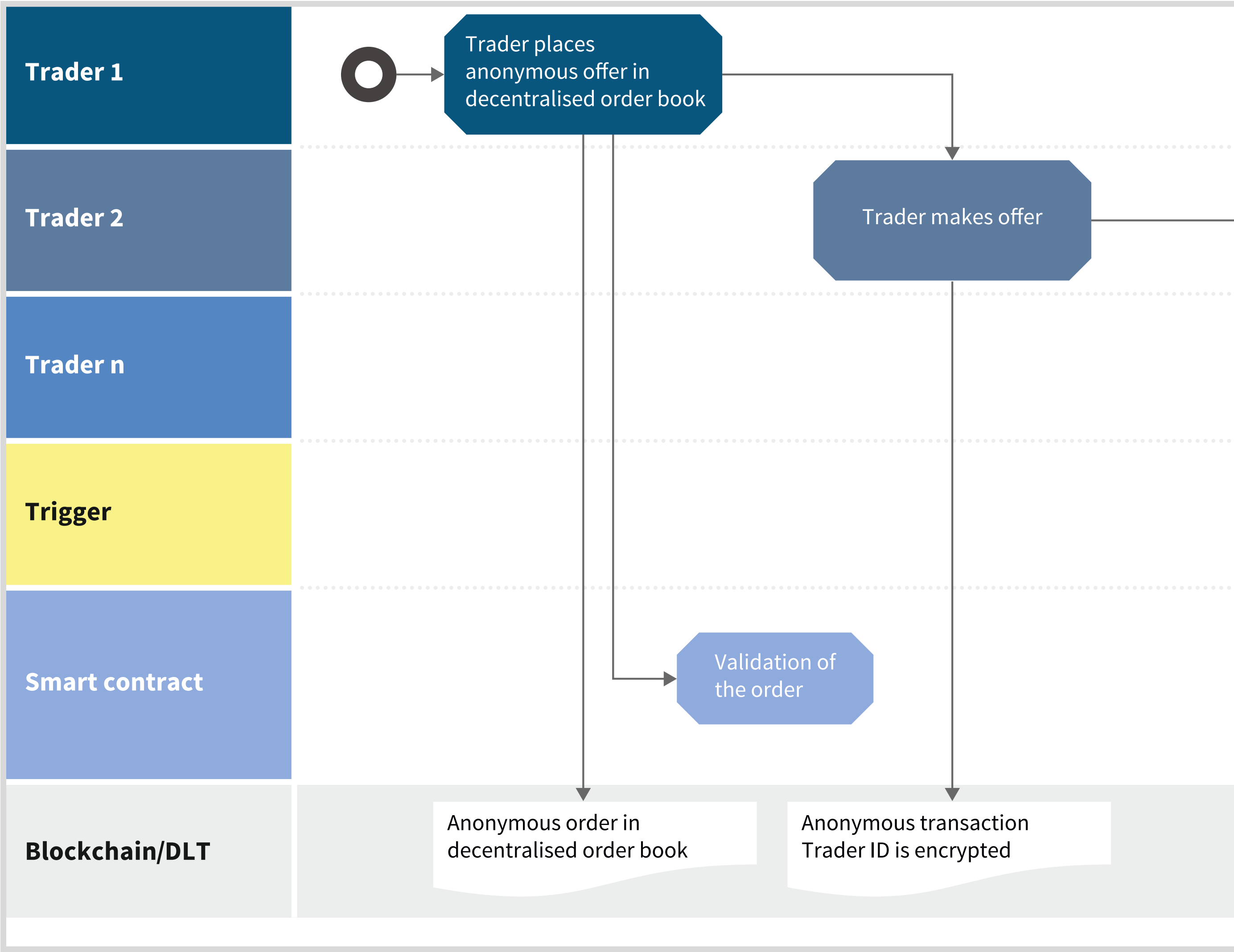
The legal basis of switching electricity suppliers, invoice processing and the actual contract is mainly anchored in the German Energy Industry Act (EnWG) (Sections 20a, 40 and 41). The processes to switch electricity suppliers are defined in detail by the Federal Network Agency (BNetzA). The GPKE determination is defined by the German Association of Energy and Water Industries (BDEW) in current process standards that are usual in the industry and formally provides for the EDIFACT data format. The use case described here is intended to substitute the “termination” process, which is reflected in the BDEW’s “basic processes”. Among other things, it should be noted that immediate confirmation of the new supplier and the date on which a delivery is possible is also required. According to the current legal situation, the process must be completed quickly and be free of charge for the end user (Section 20a of the German Energy Industry Act [EnWG]). From a regulatory point of view, however, there is no obstacle to implementation with a blockchain in compliance with the guidelines or slight adjustments to the regulations.



Application group: Trade (electricity)

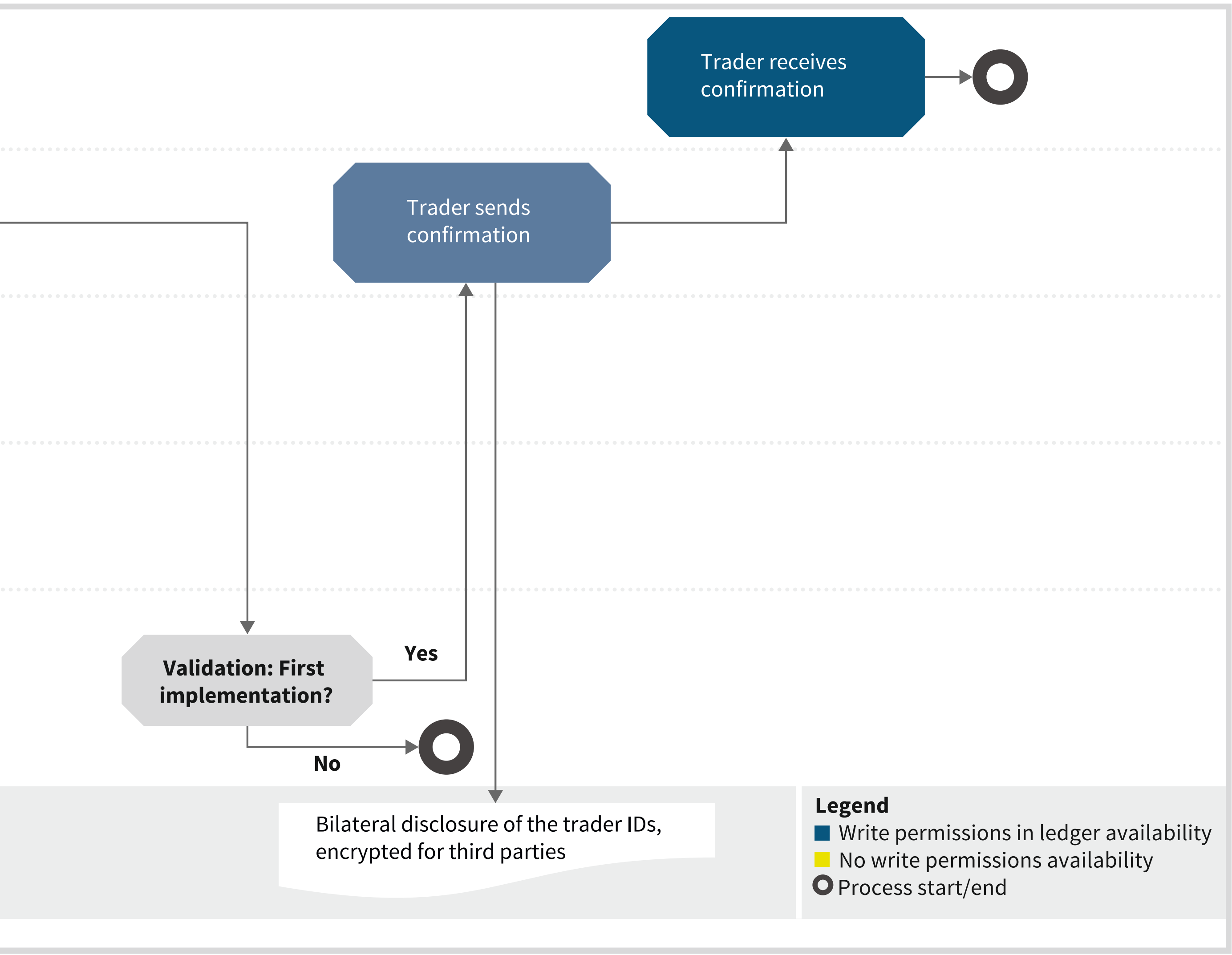
Use Case 7: Electricity wholesale trading (OTC)

Process chain



Process description

In this process chain for electricity wholesale trading (OTC), a trader anonymously submits a bid in a decentralised, blockchain-based order book. It is therefore not possible to track the trader's bid. Only after the execution of the bid, which is also anonymous, is the trade between the two traders mutually disclosed, but no third parties can view the data. The fulfilment of the transaction (i.e. the supply, booking and consumption of the "electricity" good) is not handled via the blockchain in this use case.



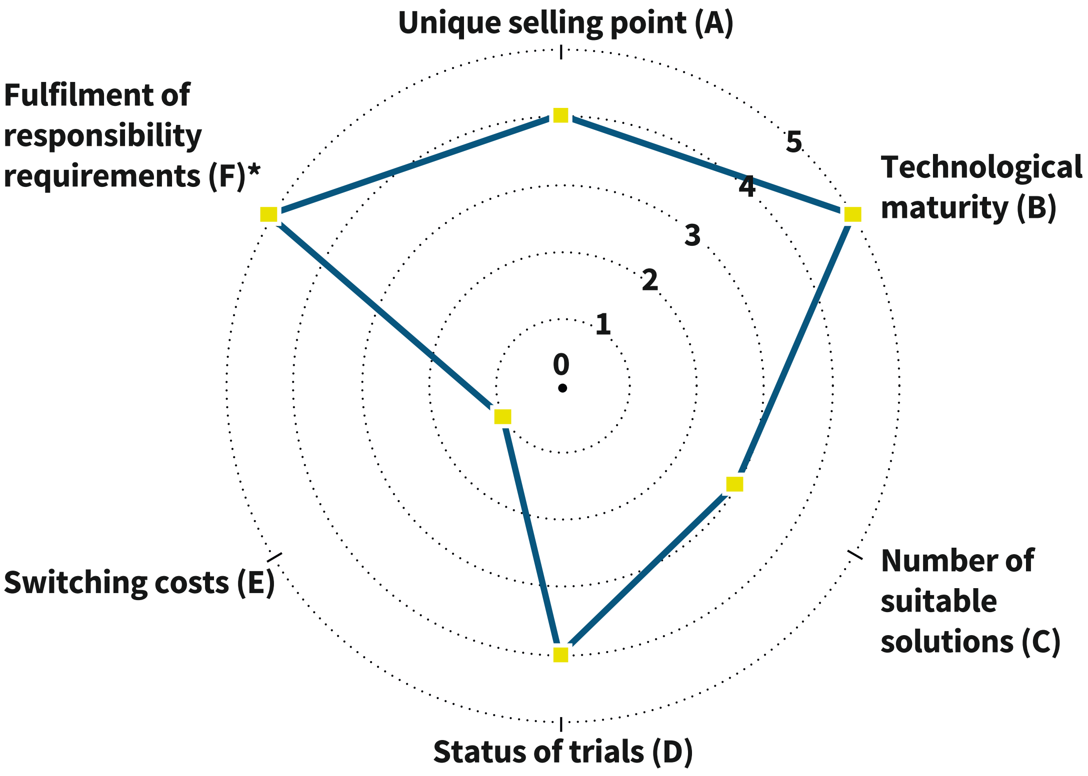
Assessment results

Degree of fulfilment of technical requirements

3.9 ★★★★☆

One star = very low
Five stars = very high

Electricity wholesale trading (OTC) is already easy to implement with today's blockchain technologies in comparison to other applications. Transaction speed requirements can be met by private blockchains. A unique technical selling point of blockchains in the use case is the combination of immutability of entries, their secure exchange in a less reliable context and the increased quality of information. Overall, there is a high degree of consistency between blockchain characteristics and use case requirements, and the status of the technical trials has almost reached market maturity. Operating a blockchain as a consortium is highly suitable in the use case, as this ensures conformity with respect to the regulatory framework. However, technically there is a close link to the blockchain solution or to a third-party operator, since the change to other solutions would require high additional programming effort.



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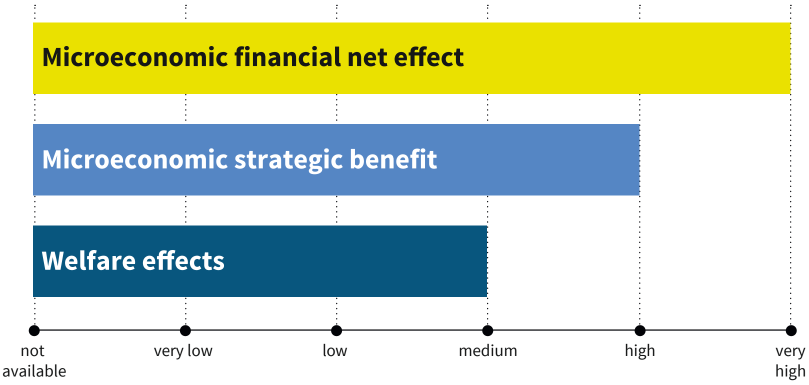
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

4.2 ★★★★☆

One star = very low
Five stars = very high

So far, electricity wholesale trading has been reserved primarily for large-scale power plants. After the end of the funding period for renewable energy sources, OTC trading will in principle be attractive to them for ensuring the purchase of electricity for the long term. Using a blockchain solution may result in up to 90% cost savings in comparison to the status quo, thus drastically lowering the market entry barrier for small producers. The resulting macroeconomic effect is an increase in competitive intensity. A reduction of the cost of regulation promises a reduction of the overall cost of OTC trading. Strategically, this use case is relatively low-risk in terms of its investment costs and regulatory obstacles. It has a high learning potential and can be well tested. The potential to accelerate the automation of energy trading is also considered to be high.

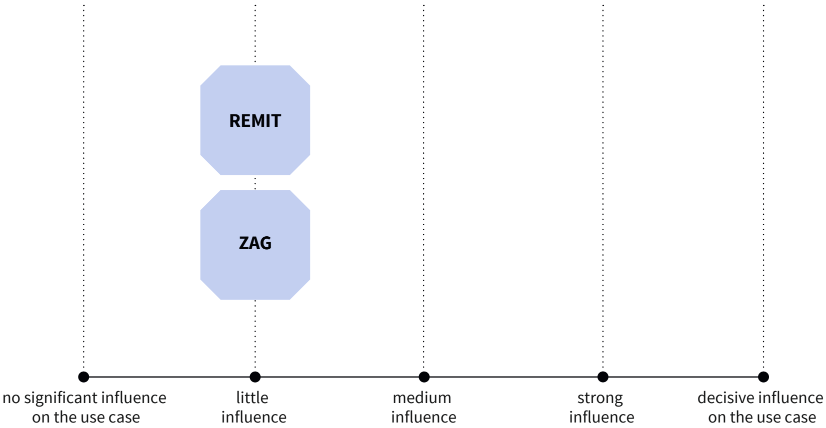


Regulatory impact

4.0 ★★★★☆

One star = decisive
Five stars = not significant

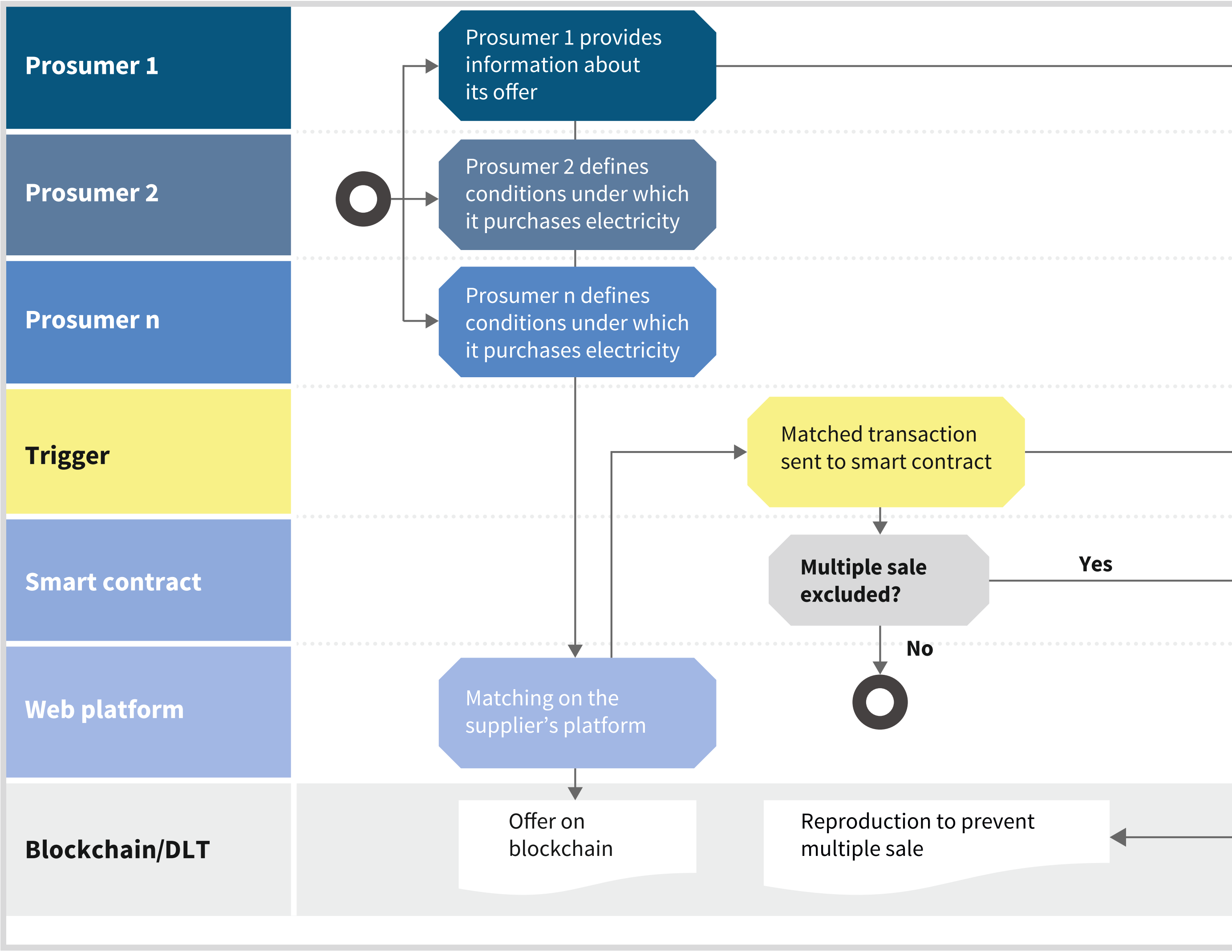
This process describes a decentralised trading platform on a blockchain basis which functions similar to a stock exchange. The aim of the REMIT Regulation is to curb market manipulation in wholesale markets through insider information. Article 1(2) of REMIT broadens the area of application if a wholesale energy product is traded. In the case of a transfer with the involvement of a third party as well as in the case of money remittance (Section 1 of the German Payment Services Supervision Act [ZAG]), a licence is required (Section 10 of the ZAG). If market participants have requested an exemption clause, the commercial transaction may be made prior to the publication of inside information. However, this information must still be published by the market participant in good time and effectively (obligation to publish). From a regulatory point of view, there is no extraordinary obstacle preventing this use case in its presented form.



Application group: Trade (electricity)

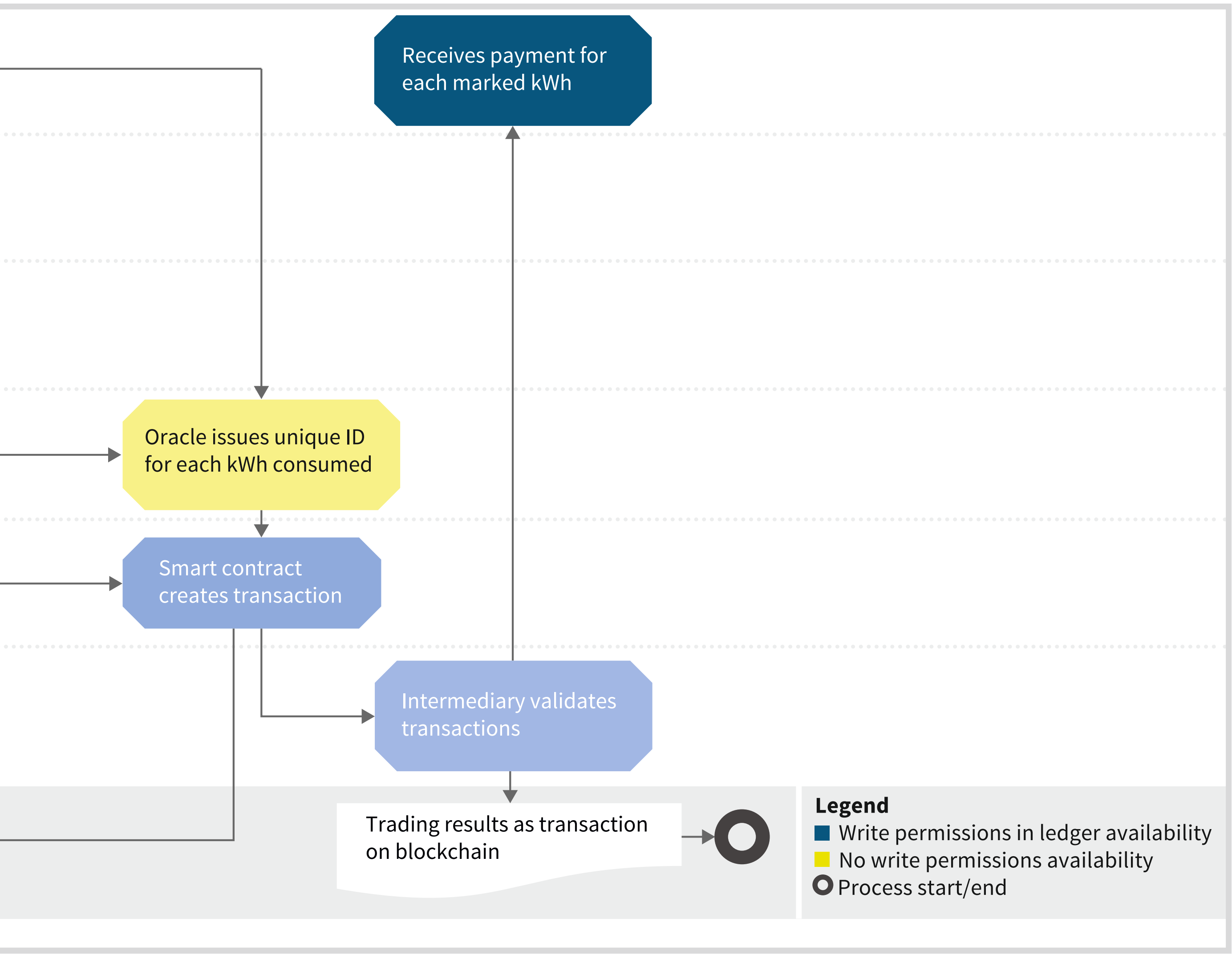
Use Case 8: P2P trading between customers of an electricity supplier

Process chain



Process description

In this use case, the electricity trade between customers of an electricity supplier is implemented via its own online trading platform. The electricity supplier remains responsible for balancing group management. However, local green electricity suppliers can adjust and sell their offer on the online trading platform, for instance. Local consumers can in turn choose the composition of their electricity consumption via the platform or switch suppliers. In this use case, the platform operator is necessarily the electricity supplier for all consumers. The trading platform can also be offered to its customers regardless of their place of residence. Within the framework of such a community approach, electricity suppliers with rooftop PV installations and/or home electricity storage systems can exchange electricity nationwide with consumers of the same electricity supplier via the trading platform.



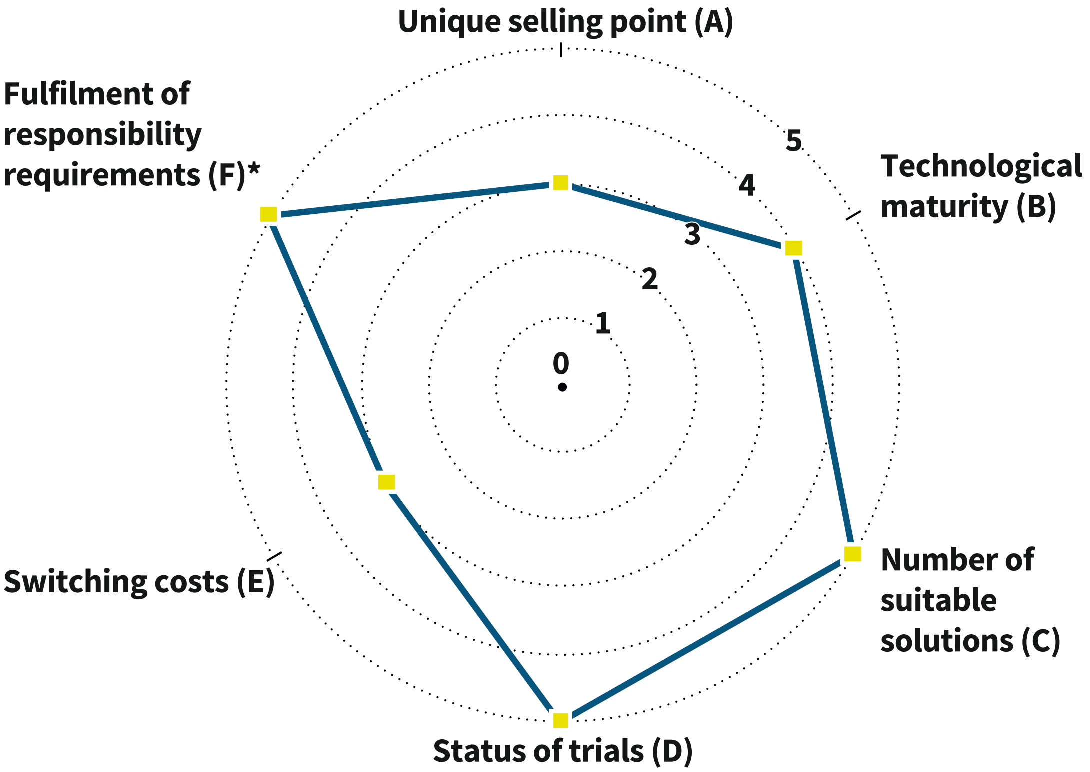
Assessment results

Degree of fulfilment of technical requirements

4.1 ★ ★ ★ ★ ☆

One star = very low
Five stars = very high

Blockchain technology is not necessarily required to market locally generated green electricity, for instance, to local customers. However, it is particularly secure, quick and cost-effective to provide evidence of compliance with the prohibition of multiple sale via the blockchain. Technical synergy effects arise for the operator of a blockchain-based platform, which allows its customers to trade among themselves, especially through the expansion of the blockchain-based use cases “guarantees of origin” (Use Case 4), “billing of fees and reallocation charges” (Use Case 5), “landlord-to-tenant electricity supply” (Use Case 10) or “registration of installations in the core market data register” (Use Case 3). In particular, the verifiable registration as well as the secure and rapid sharing of this information represents a technical added value for P2P electricity trading.



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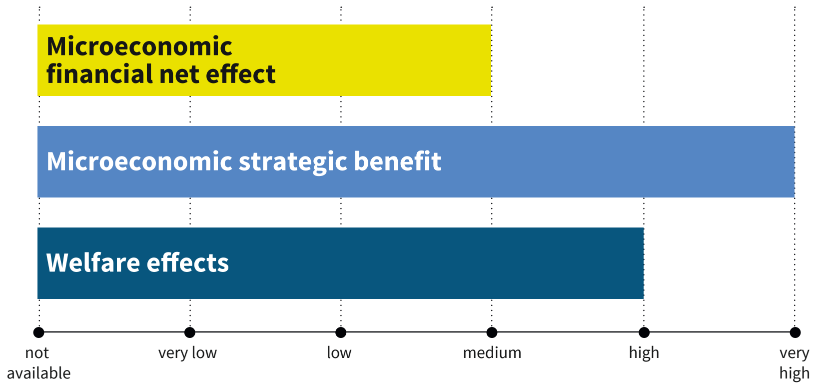
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

3.7 ★ ★ ★ ⯪ ☆

One star = very low
Five stars = very high

Variations of the use case depicted in the process chain are already being tested on the market by a number of companies internationally and in Germany. Positive revenue effects due to lower costs or increased sales can only be a model for the success of a few electricity suppliers. In the context of the expected market opening for small producers and loads, and with decreasing margins for electricity as a standard product, product differentiation seems to be a promising strategy for electricity suppliers. The option of product differentiation can be used as a means of developing and testing new products, thus attracting and retaining customers. Economically speaking, a positive effect for the energy transition can result in connection with the use case "guarantees of origin" (Use Case 4): The willingness to expand renewable energy sources may increase if it becomes apparent and verifiable how high the local gross added value is regarding local generation and consumption of electricity.

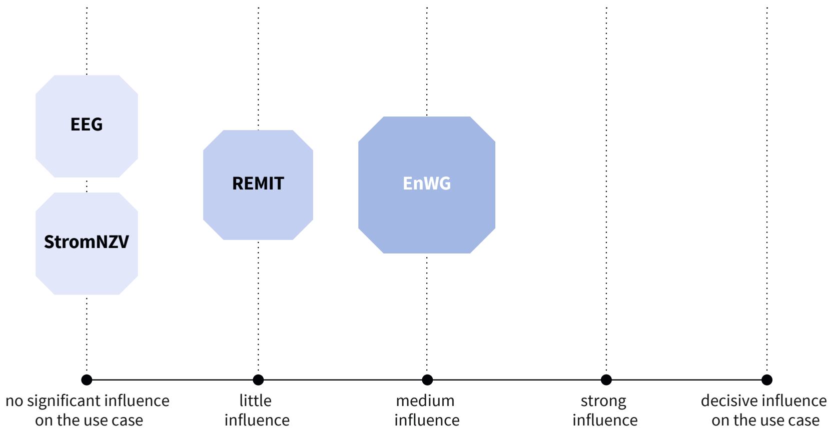


Regulatory impact

4.0 ★ ★ ★ ★ ☆

One star = decisive
Five stars = not significant

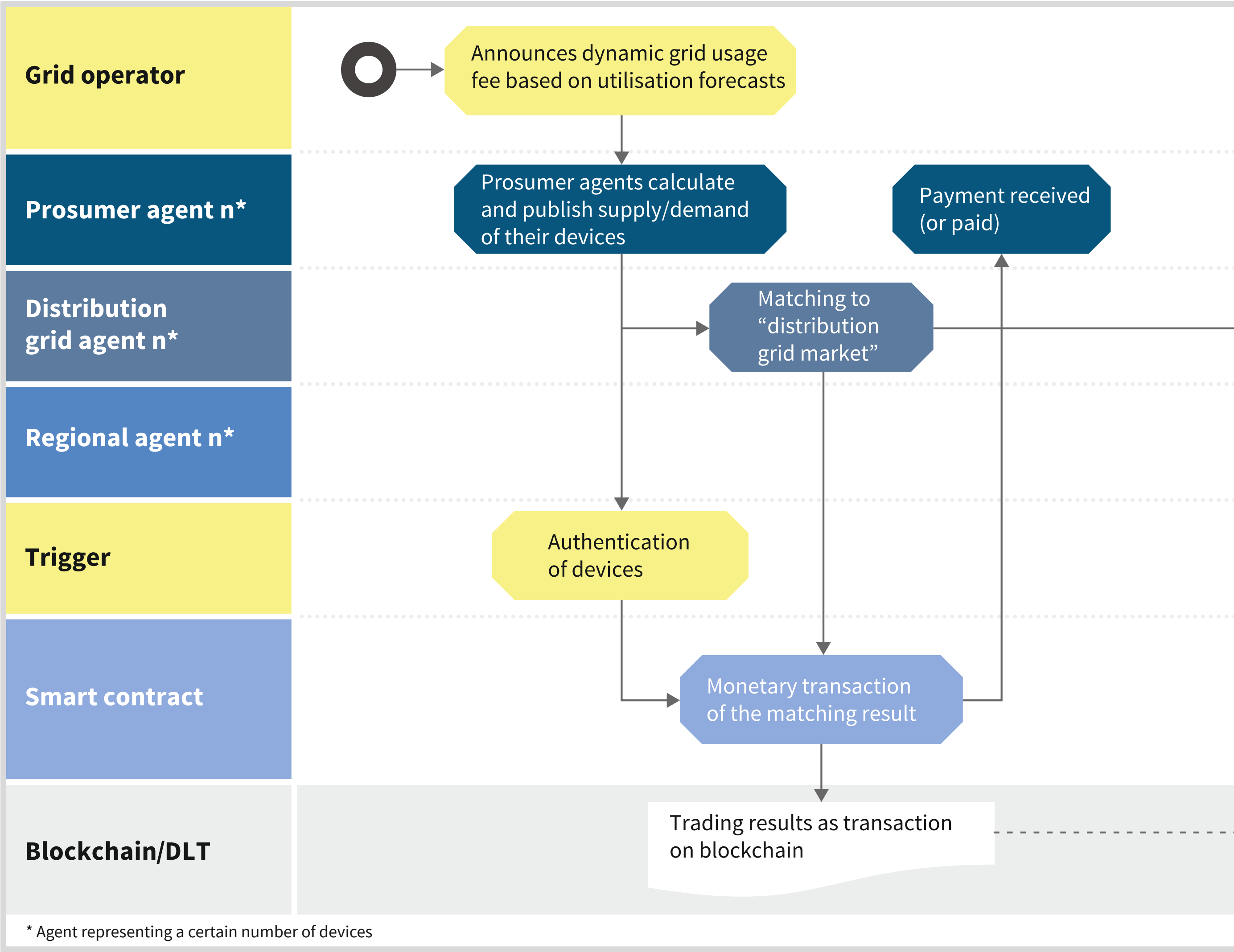
It makes little difference whether electricity is traded between two external market participants or between two customers of an electricity supplier. The prosumer can then be both supplier and energy supplier (Section 3 of the German Energy Industry Act [EnWG]). This would result in a reporting obligation in the (permanent) household customer supply to the regulatory authority, as well as a contractual retention of the data for documentation. The contractual arrangements of the user access must comply with the requirements of the EnWG (Section 23 et seq.). Existing minimum requirements for the contractual arrangement of energy supply contracts (Section 41 of the EnWG) must be taken into account. REMIT only applies in the case of wholesale energy products (> 600 GWh/a) (Article 2 of REMIT). Although extensive obligations arise from the EnWG, from a regulatory point of view there is rather less opposition to implementing the use case on a blockchain basis.



Application group: Trade (electricity)

Use Case 9: Trade and allocation of grid capacities (electricity)

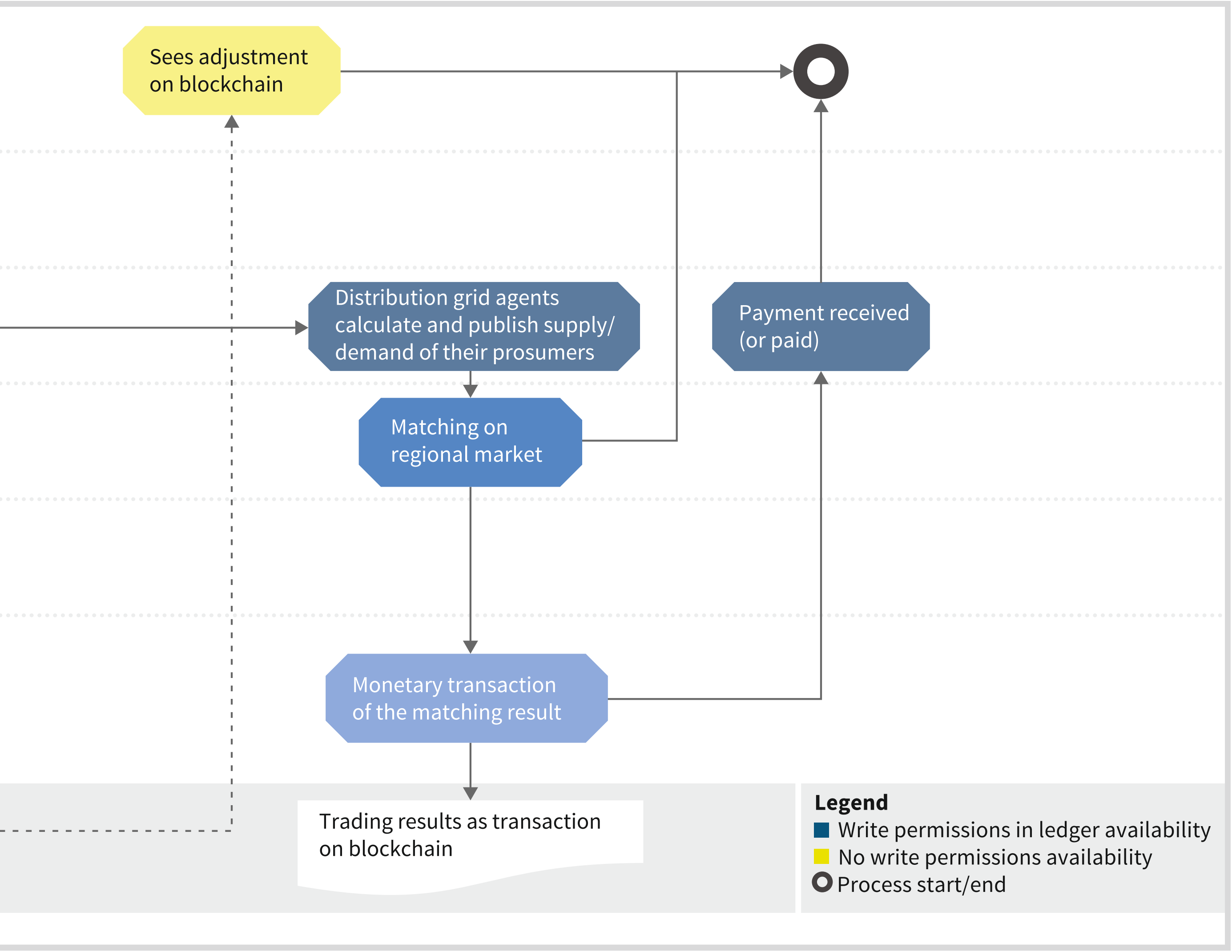
Process chain



* Agent representing a certain number of devices

Process description

In this forward-looking use case, the distribution system operator dynamically adjusts the grid usage fee on the basis of current utilisation forecasting. Local electricity consumers and producers are thus incentivised to behave in a manner that is beneficial to the grid. In contrast to the use case “congestion management in electricity distribution grids (e-mobility)” (Use Case 1), market trading, which takes place here on a local market within a distribution grid area, is not directly restricted, but the grid fee components of the end-user price are used as an indirect control mechanism. As part of the automated process, software agents of the distribution system operator and the prosumer interact with each other and the monetary transaction is undertaken via smart contracts. The trading results are recorded as transactions on the blockchain.



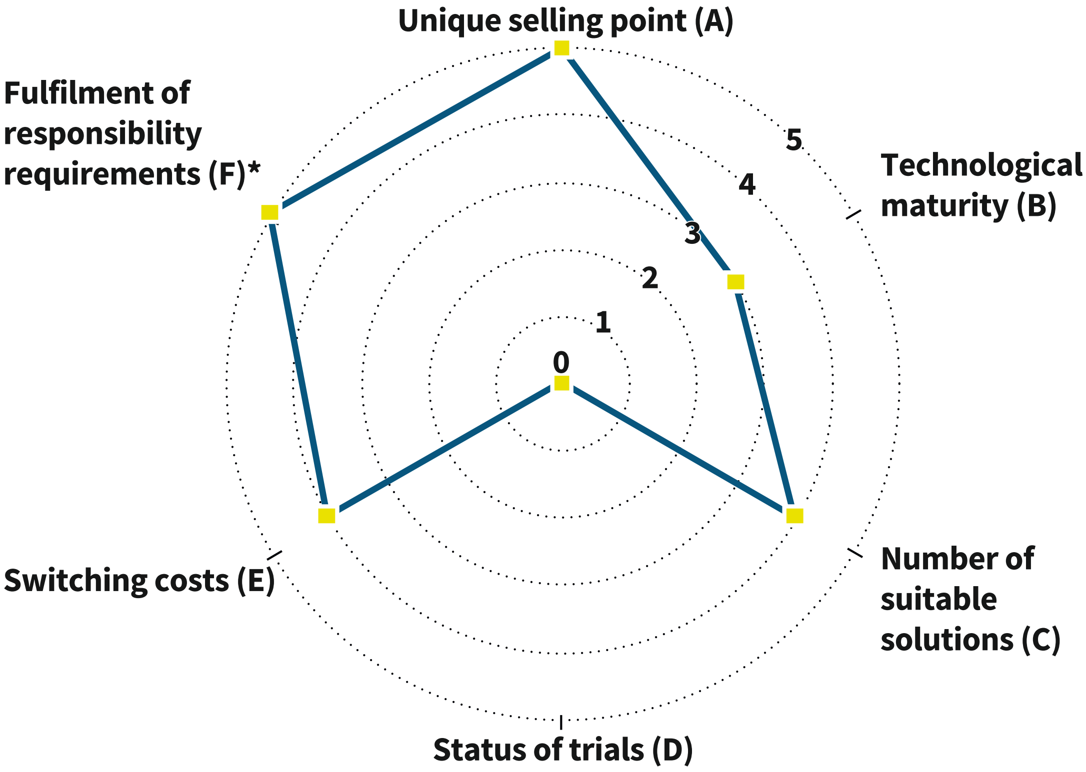
Assessment results

Degree of fulfilment of technical requirements

3.6 ★ ★ ★ ⯪ ☆

One star = very low
Five stars = very high

As part of the described process, software agents of the distribution system operator and the prosumer interact with each other and the monetary transaction is carried out via smart contracts. It therefore places high demands on the robustness, security and scalability of the information system, which are met by blockchain solutions, above all through auditable and unfalsifiable trading using smart contracts. In comparison to the use case “congestion management in electricity distribution grids (e-mobility)” (Use Case 1), slightly higher technical requirements apply with respect to scalability due to the shorter lead times, in particular due to the dynamic adjustment of the grid usage fee on the basis of current utilisation forecasts. Regarding the operation and suitability of blockchains, the requirements that apply are similar to the ones in Use Case 1. While the maturity and number of suitable solutions are promising, there is still very little experience with implementing the use case.



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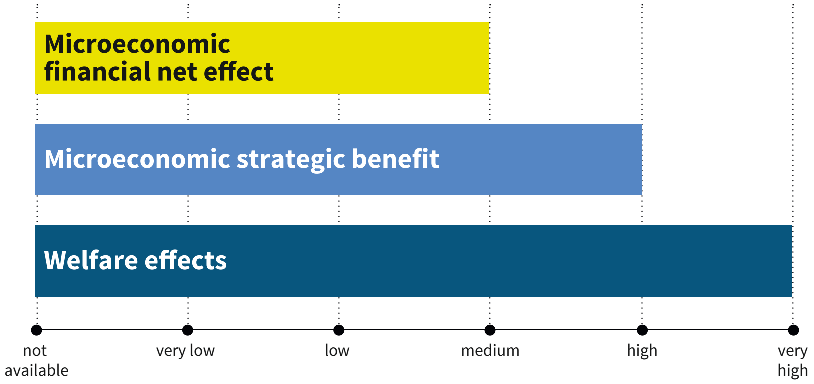
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

3.8 ★★★★☆

One star = very low
Five stars = very high

In the use case, a distribution system operator potentially receives an economically efficient instrument to prevent grid congestion. Strategically, its system function as an important local player is safeguarded and expanded. Welfare effects result from increased market efficiency, less expansion of the power grid in the long term, as well as important investment signals for the location of renewable energy systems. Interaction with the congestion management in Use Case 1 promises to further increase the effectiveness of this use case.

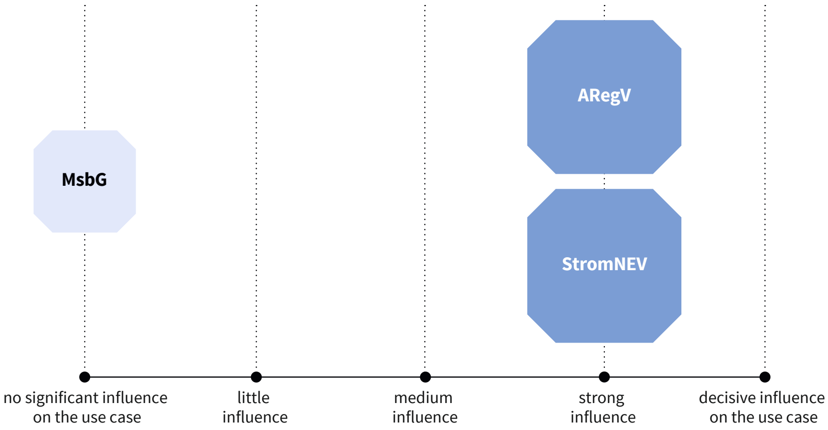


Regulatory impact

3.0 ★★★☆☆

One star = decisive
Five stars = not significant

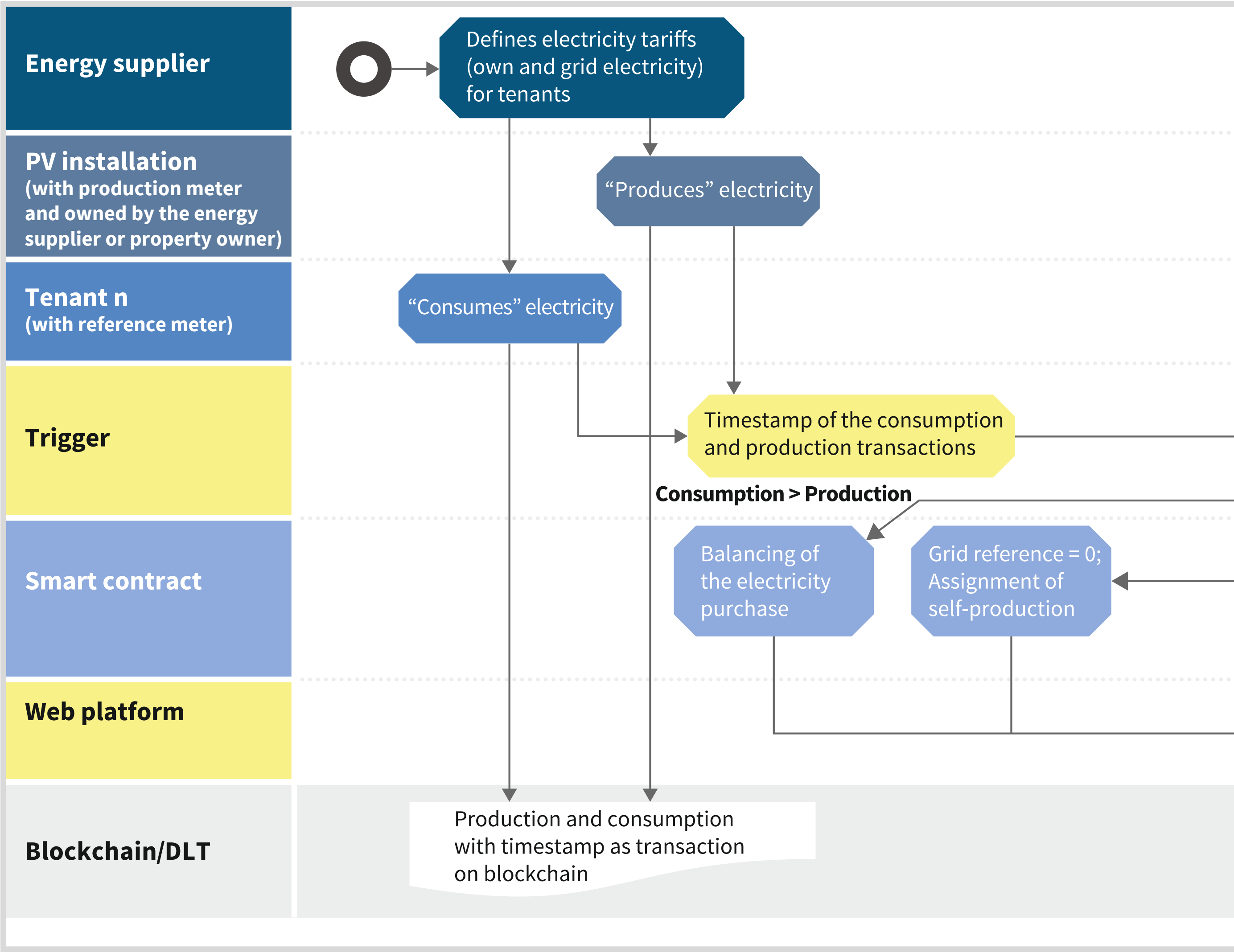
The process describes a fully automated interaction between the grid operator and the prosumer for a "distribution grid market" on the basis of blockchain. The first question that arises here is whether a dynamic grid usage fee based on utilisation forecasts is covered by the existing regulatory framework. The Federal Network Agency (BNetzA) generally determines the fee for grid access as a transaction-independent point model (Section 15 of the Electricity Network Charges Ordinance [StromNEV]) with corresponding upper limits (Section 32 of the Incentive Regulation Ordinance [ARegV]) and has rejected variable grid fees thus far. From a regulatory point of view, the described process also poses an important question as to whether a regional distribution grid can be operationally represented in the existing system. As a basis for this, contract requirements may be transferred from the system of a TSO control area, for instance. The requirements for a monetary transaction via the DSO are similar to Use Case 1. The process requires a massive change in the regulatory framework and the corresponding political will.



Application group: Trade (electricity)

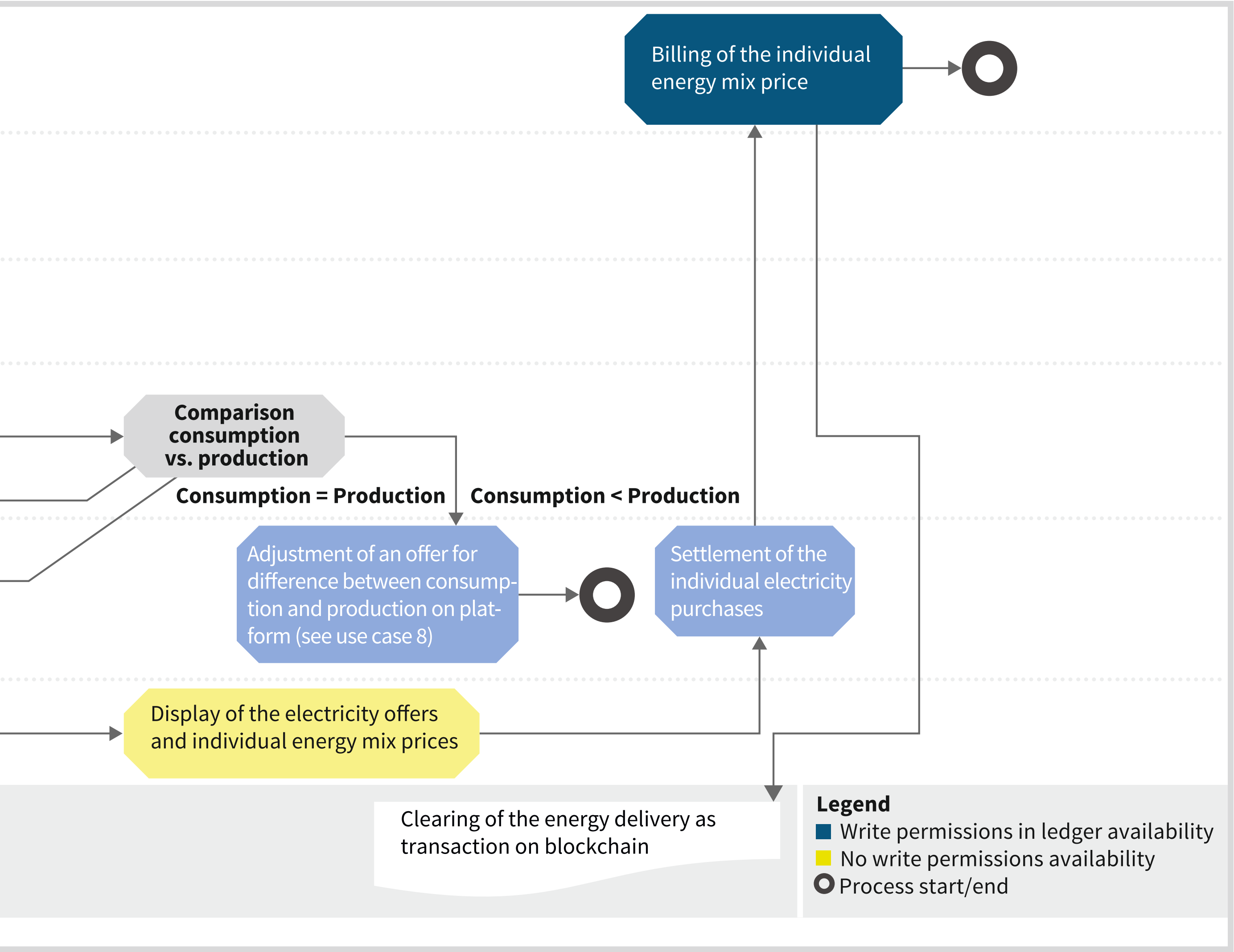
Use Case 10: Landlord-to-tenant electricity supply

Process chain



Process description

The aim of the blockchain-based interaction between the customer and owner of a landlord-to-tenant electricity supply property is to optimise local resources, i.e. the highest possible consumption of locally generated electricity. In the use case, the PV system is in the possession of the electricity supplier or the property owner, for instance. In addition to the electricity generation system, third-party tenants must also be considered in the metering concept, which complicates the billing between the involved parties (tenants, electricity suppliers, system owners, grid operators and metering station operators). From a technical-conceptual point of view, it is easy to extend this scenario to internal and external transactions between electricity storage facilities, electric car charging stations or balcony PV installations.



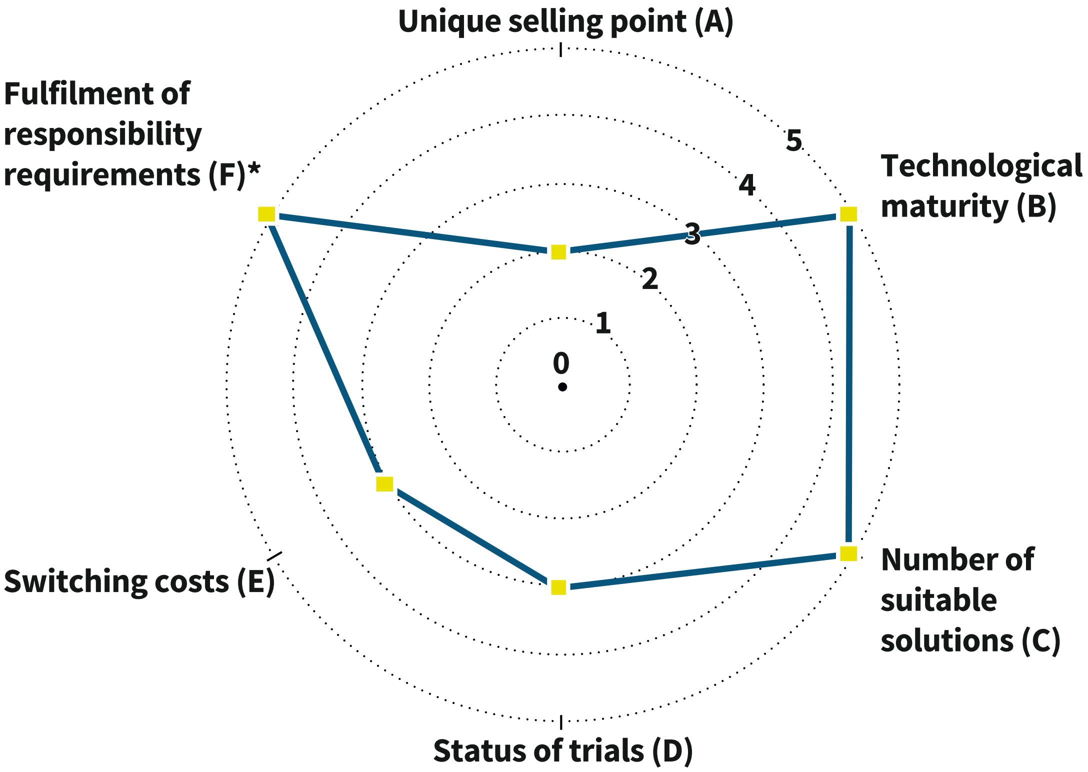
Assessment results

Degree of fulfilment of technical requirements

4.0 ★ ★ ★ ★ ☆

One star = very low
Five stars = very high

As an alternative to a high-cost adaptation of the billing system, specific software solutions for landlord-to-tenant electricity supply can also be used. One of the criteria that sets blockchain technology apart is that it offers the secure and transparent breakdown of the consumed and generated quantities of electricity as well as their exchange and re-use. This is the interface for the simple extension of the use case and for the creation of a natural interface to the use cases “core energy market data register” (Use Case 3), “guarantees of origin” (Use Case 4), “P2P trading between customers of an electricity supplier” (Use Case 8) and “shared investments in the case of external landlord-to-tenant electricity supply” (Use Case 11). An internal trading platform can also serve as the basis for trading between properties in a district.



A – D, F:
0 = not available, 1 = very low,
2 = low, 3 = medium, 4 = high,
5 = very high

E:
0 = very high risk, 1 = high risk,
2 = increased risk, 3 = medium risk,
4 = low risk, 5 = no risk

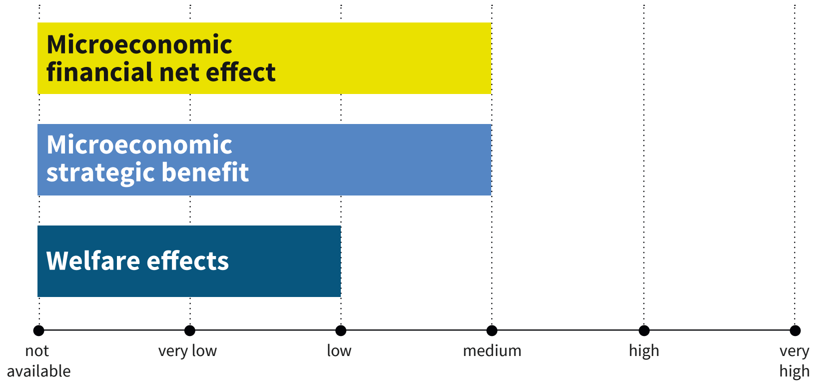
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

2.7 ★ ★ ⯪ ☆ ☆

One star = very low
Five stars = very high

Blockchain-based landlord-to-tenant electricity supply solutions are now technologically mature and economically viable. However, their advantages over alternative software solutions are particularly relevant in connection with residual electricity purchases: Through the use of blockchain-based trading platforms (see Use Case 8) and the purchase of external energy capacity in the form of shares in an EEG facility outside the property (see Use Case 11), the residual electricity purchase can be organised and billed flexibly. Residual electricity insurance products can also be created on the basis of a standardised view of the data. Overall, the use of blockchain promises to improve the cost-effectiveness of landlord-to-tenant electricity supply models, which have been based on public incentives thus far. Economically speaking, the efficient organisation of residual electricity purchases from renewable energy sources may have a positive effect on the efficiency of the energy market. For example, lower balancing group deviations may be expected in the future under certain circumstances. The need for extraction or feeding-in from transmission grids will decrease, and this may also result in increased local added value.

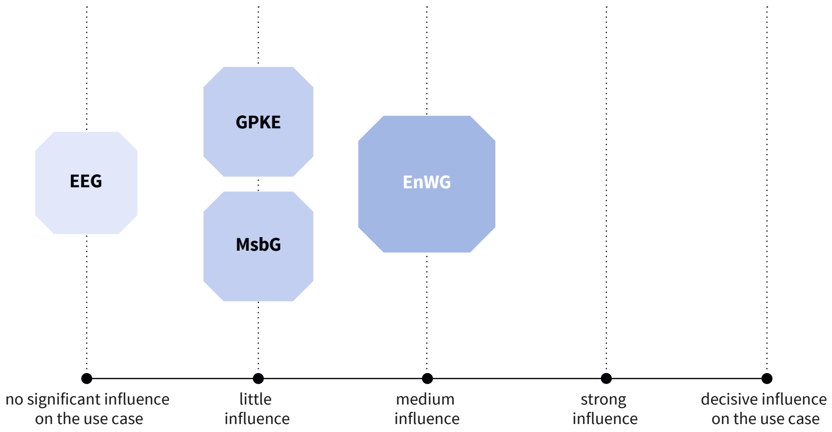


Regulatory impact

4.0 ★ ★ ★ ★ ☆

One star = decisive
Five stars = not significant

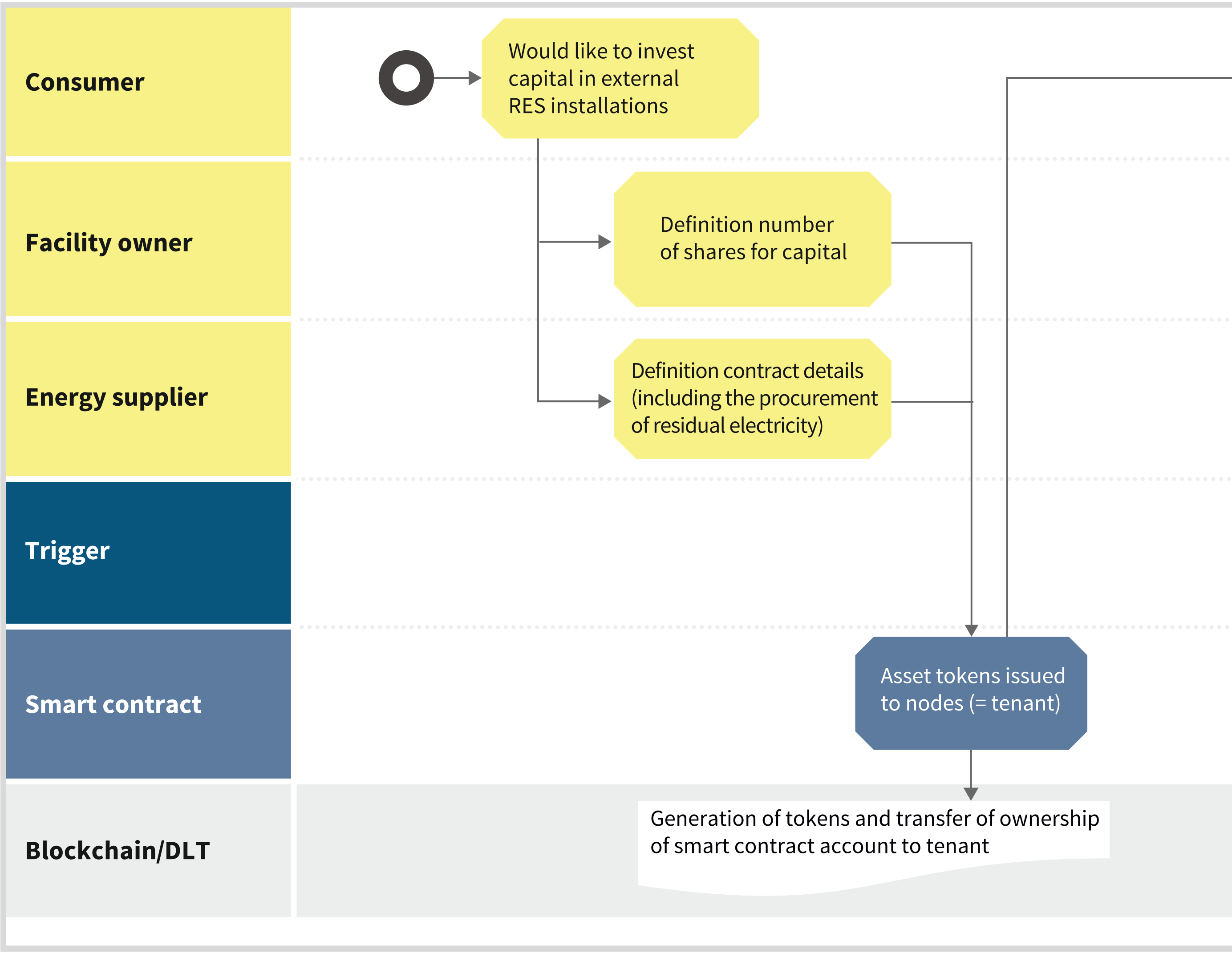
Unlike regular electricity purchases from the grid, certain cost components such as grid fees, grid-side reallocation charges, electricity tax and concession fees do not apply in the landlord-to-tenant electricity supply model. Furthermore, there is funding for every kilowatt-hour of landlord-to-tenant electricity (landlord-to-tenant electricity allowance). Within the customer system, however, there must be a suitable metering concept which enables the grid operator to allocate all the meters within the customer system to the supplied grid users and to automate the business processes for supplying customers with electricity (GPKE) (e.g. as per Sections 22, 26 and 60 of the German Metering Point Operation Act [MsbG]). Regardless of the technology used, the supply of landlord-to-tenant electricity is subject to a number of other legal obligations as per the German Energy Industry Act (EnWG) (e.g. Sections 5 and 40). For power supply companies and electricity suppliers, this in turn results in requirements for the contracts and invoices, as well as the advertising material for the end users. Despite bureaucratic obstacles, this use case has not been excluded from a regulatory point of view.



Application group: Financing and tokenisation

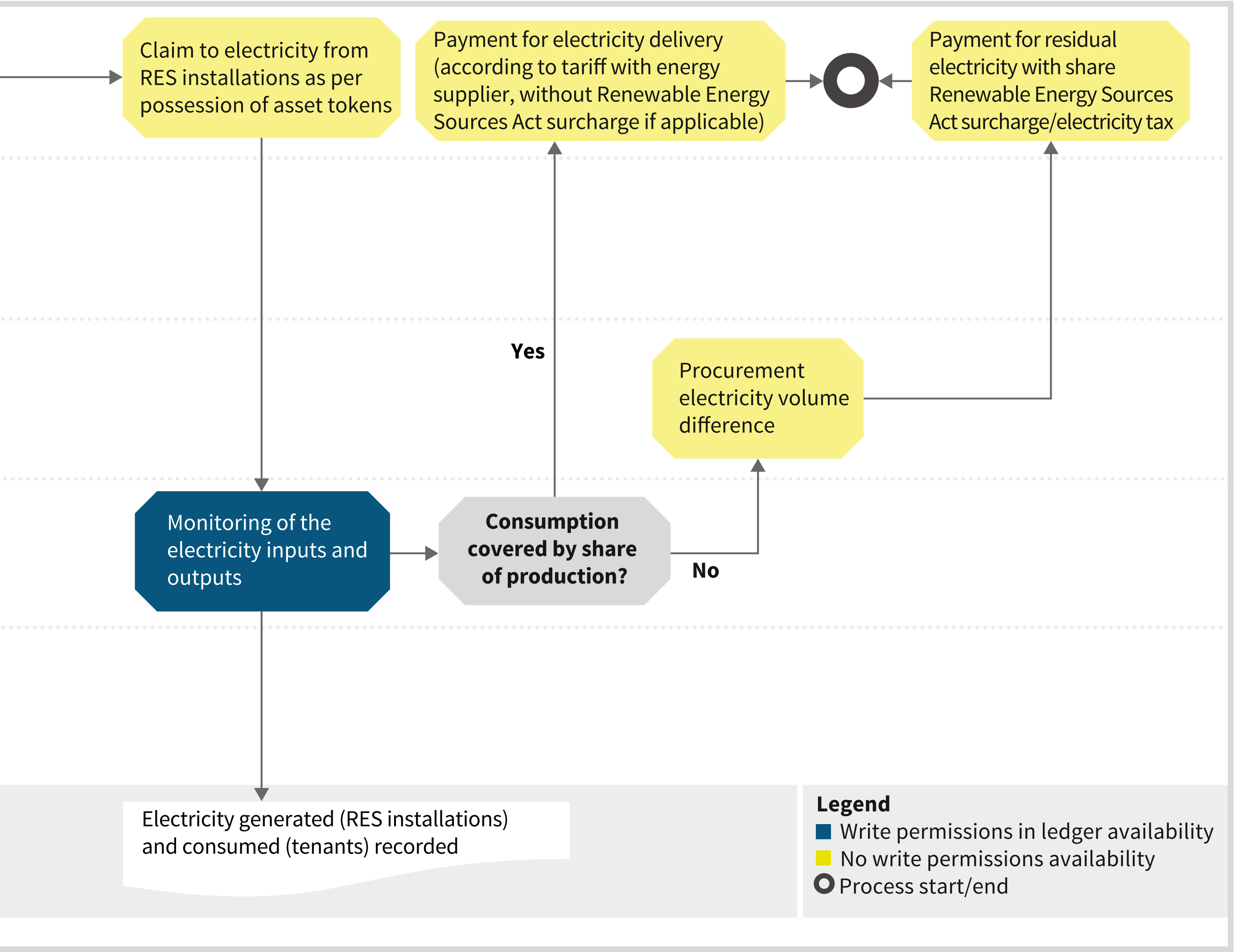
Use Case 11: Shared investments in the case of external landlord-to-tenant electricity supply

Process chain



Process description

The (partial) coverage of the residual electricity purchase by purchasing external energy capacity is an extension of the blockchain use case “landlord-to-tenant electricity supply” (Use Case 10). Consumers acquire shares in an EEG facility outside the property or district and receive asset tokens in return. These tokens certify a corresponding claim to the electricity generated in this facility. For the simultaneity of production and purchase, digital electricity meters and suitable metering concepts are just as necessary as a corresponding software solution for documentation and implementation. If the quantity purchased and produced are identical, then, unlike in the event of shortfall, there is no purchase of residual electricity at the times in question.



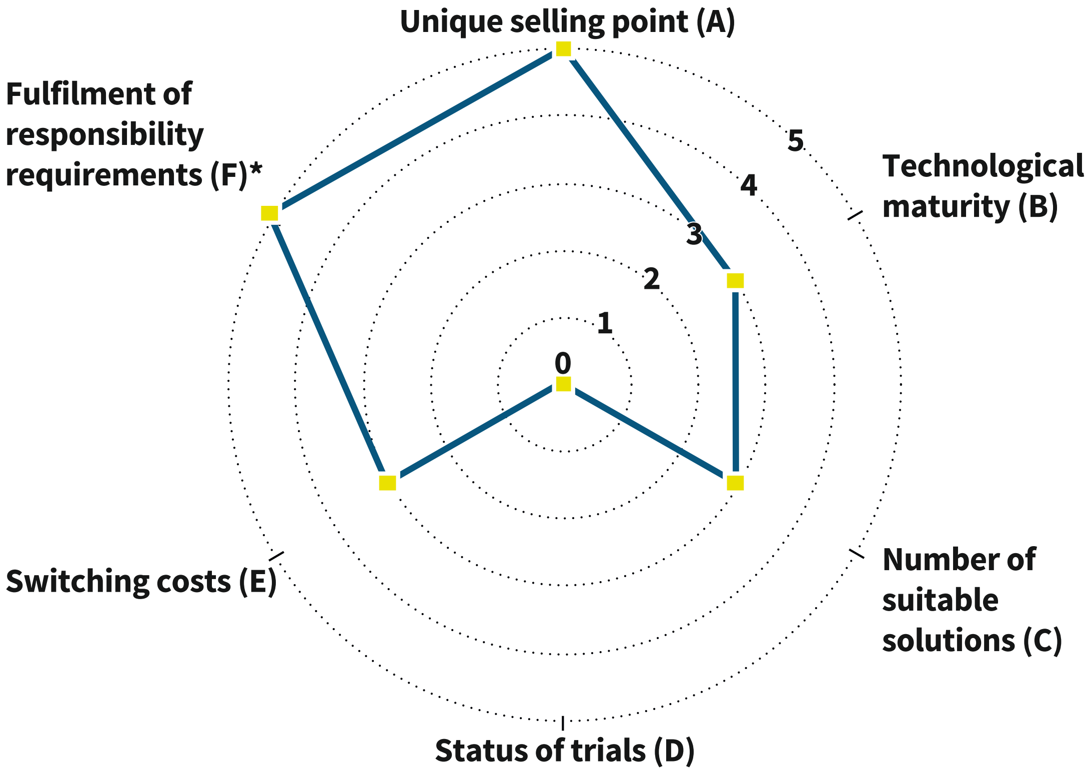
Assessment results

Degree of fulfilment of technical requirements

3.3 ★★★⯪☆

One star = very low
Five stars = very high

Blockchains make it technically possible to reduce the expenses related to the small-scale purchase of energy capacities and their organisation. Their specific properties in terms of robustness, security and transparency come to the fore here. There appears to be no specific technical requirements, such as a particularly high number of transactions per second, for the implementation of the use case. Once again, the selection of blockchain technologies is somewhat limited by the need to store personal data in accordance with the GDPR. Evidence of the long-term mass suitability must be provided by suitable blockchains, as in other use cases.



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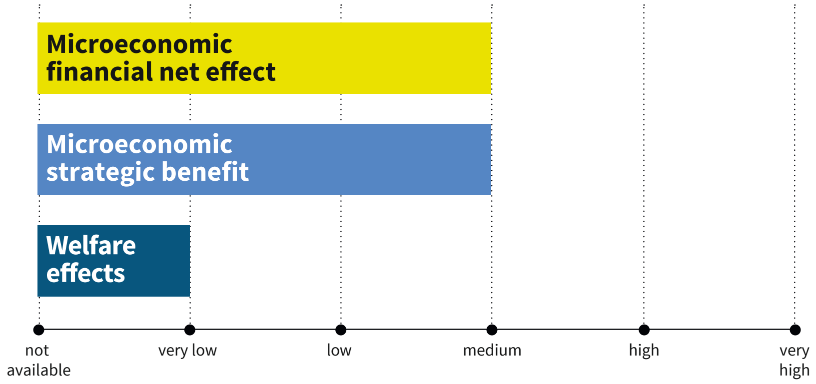
* Requirements regarding responsibility to execute transactions & operate the blockchain

Economic benefits

2.4 ★★⯪☆☆

One star = very low
Five stars = very high

The use case shows how high initiation costs for covering residual electricity purchases can be reduced by purchasing external energy capacity. Furthermore, the use of blockchain technology can also reduce the processing costs, which result above all from the significantly reduced expenses related to confirming the transfer of ownership from the current to the future owner of the share of the facility. For providers of corresponding landlord-to-tenant electricity supply models, however, there is a high risk regarding the generation of additional revenue: There have been very few documented market trials or pilots thus far. Economically speaking, the application promises increased market efficiency. The easier participation in renewable energy systems is not limited to landlord-to-tenant electricity supply models.

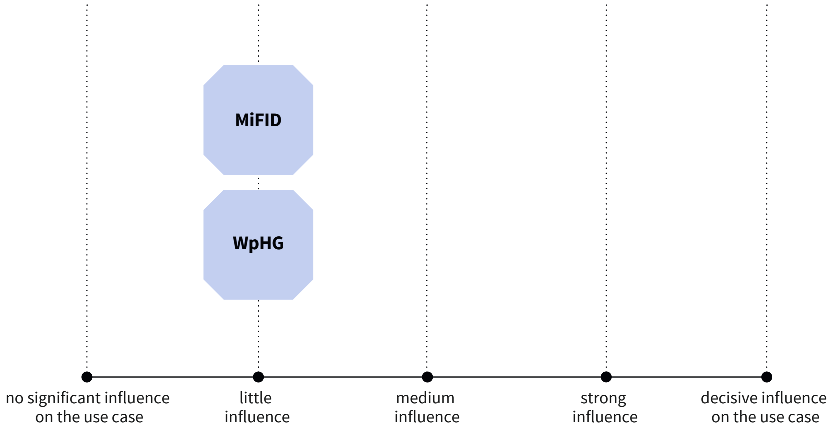


Regulatory impact

4.0 ★★★★☆

One star = decisive
Five stars = not significant

The object of investigation of the process presented here is the ownership right of several owners to split ownership of renewable energy facilities, represented by tokens. Depending on the legal position these tokens convey, they may be securities (these may also exist digitally), which is why the German Securities Trading Act (WpHG) may be relevant. According to BaFin (Federal Financial Supervisory Authority), it is sufficient to document transactions using the distributed ledger or blockchain technology such that the rights embodied in the tokens can be uniquely assigned to an address. The definition of the term "securities" has been transposed from the MiFID Directive into national law. On this basis, the criteria of transferability and tradability, among others, must be met at the same time. Overall, the assessment of the use case is very complex and needs to be analysed in each individual case, but implementation in compliance with the regulations is possible.



→ 4

Structure and group of partners

Project management

In May 2018, dena and 16 partners launched the existing study. This group of partners covers a wide range of business sectors both within and outside the energy industry. dena was responsible for the project management and hence the conceptualisation and implementation of the work programme, the involvement of expert assessors, as well as the communication of the study.

- Project management: Philipp Richard (Team Leader for Energy Systems and Digitisation)
- Leading collaborators: Lukas Vogel (Senior Expert for the International Energy Transition and Digitisation),
  Sara Mamel (Expert for Digitisation),
  Dr. Sebastian Fasbender (Expert for the Communication of Energy Systems and Energy Services)

Project structure

dena included renowned **scientific experts** when designing the study:

- Prof. Dr. Jens Strüker (Director of the Institute of Energy Economics, INEWI) led the technical and economic investigations.
- Dr. Ludwig Einhellig (Senior Manager and Head of Smart Grid at Deloitte) provided his expertise on the regulatory aspects.

Within the project, the study partners in the **project steering group**, which met three times over the course of the project, consulted and decided on the basic orientation of the study. The content of the study was decided primarily by the **working group**, which also met in three sessions. To provide contextual advice, external experts were invited both to the meetings of the project steering group as well as the working group.

Furthermore, a supporting **advisory board** was also appointed, the members of which served as points of contact for the group of partners and the scientific experts. They were also included during the commenting of the preliminary study findings. During the appointment, attention was paid on the one hand to establishing a link to current research via the selection of notable scientists, while also including important trendsetters of the blockchain scene in order to ensure a strong application focus.

Project phases

Commencing in May 2018, the investigation period lasted for nine months. The project phases were divided up into the definition of the investigation framework including a status quo analysis, definition of the study methodology, and the preselection of use cases (approx. 2 months). The subsequent analysis phase included, among other things, the coordination of the process chains which the use case analyses were based on, and the performance of a survey on the development status of the technology (approx. 3 months). In the third project phase, an in-depth analysis of the use cases as well as the compilation of the findings were conducted, including the formulation of recommended courses of action (approx. 3 months). This was followed by the communication of the study findings (approx. 1 month).

We thank our study partners:

alliander
BKW
cronos Unternehmensberatung GmbH
DKB Deutsche Kreditbank AG
EnBW
EWE netz
ista
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RNG Rheinische NETZGesellschaft
SIEMENS
Leipziger Stadtwerke
Verbund

We also thank the **members of the advisory board**:

- For the scientific aspects:
  - Prof. Dr. Stefan Grösser (Professor for Strategic Management and Organisation at the Bern University of Applied Sciences) for advice on IT-related aspects
  - Dr. Robert Kohrs (Head of Group Smart Grit ICT at Fraunhofer ISE) for advice on energy-related aspects
  - Prof. Dr. Andranik Tumasjan (Professor of Management and Digital Transformation at the Johannes Gutenberg University Mainz) for advice on economics-related aspects
  - Prof. Dr. Walter Blocher (Institute for Economic Law at the University of Kassel) for advice on legal aspects
- For the blockchain scene:
  - Ed Hesse (Energy Web Foundation) for the application group "Asset Management"
  - Kerstin Rock (LO3 Energy) for the application group "Data Management"
  - Raik Kulinna (SAP SE) for the application group "Market Communications (Electricity)"
  - Dr. Michael Merz (Ponton GmbH) for the application group "Trade (Electricity)"
  - Dominik Schiener (IOTA Foundation) for the application group "Financing & Tokenisation"

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