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1. Context and content of the report

5th generation heating and cooling networks are now showing up with the promise of new services. What are these new services and how can blockchain technology facilitate their implementation?

Heating and cooling accounts for 50% of the EU's total energy consumption but only 19.1% comes from renewable sources, and in 5 of the 7 North-West European countries, this share is less than 8.2%. The European D2Grids project aims to promote 5th generation heating networks by:

- A better definition of the technical concept
- A reduction in investment costs
- An innovative reflection on business models

5th generation heating networks are defined by the implementation of an **intelligent energy loop** in urban areas optimized and **driven by demand**, characterized by:

- A low-temperature network with decentralized low-carbon energy production,
- A closed thermal loop for heat recovery between cold and hot sources,
- The coupling of electrical and thermal networks by ensuring the electrical needs of auxiliaries through renewable production (PV) and storage,
- An upstream reflection on consumers and erasure mechanisms**.**
- A territorial vision that integrates heat recovery from industrial or large commercial actors.

The 5th generation heating and cooling network encourages the decarbonisation of the energy mix by making greater use of renewable energies. In addition, it introduces a break in terms of the services offered to stakeholders.

Based on a closed low-temperature loop, the possibilities of contributing to the network are widely extended and facilitated: low-temperature fatal heat from industries, heat recovery from the cold production of Data Centers or retail outlets, low-temperature geothermal energy, etc., so the number of stakeholders will be larger.

On the consumer side, this new generation of network could make it possible to change the game concerning the tariff model:

- By economically encouraging big consumers to smooth out their peaks in hot and cold consumption through flexibility mechanisms.
- By integrating the component of electricity market prices. The heating and cooling network consumes electricity for the operation of equipment (heat pumps) and auxiliary equipment (distribution pumps, etc.), this operation can be encouraged by electricity market price information.

To ensure and facilitate the settlement of this new business model opportunities the question of technology mean was raised. This report thus aims at presenting the blockchain as a technological solution to implement these new business models. It is organised in three chapters:

- Explanation of Blockchain technology
- Blockchain in the energy market
- Blockchain opportunities in 5GDHC

2. Blockchain

2.1. What is Blockchain?

Blockchain is a technology of transmission and storage of secure and transparent information working without any central entity.

It is a time-stamped series of immutable records of data (i.e transaction) that is managed by a cluster of computers not owned by any single entity. Each of these aggregates of data (i.e. block) are secured and bound to each other using cryptographic principles (i.e. chained to each other).

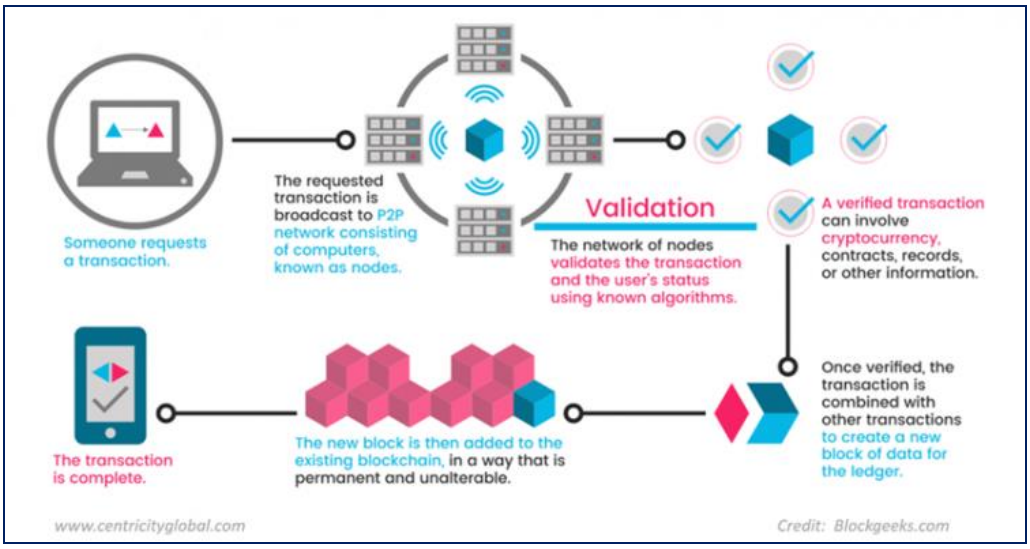


Figure 1: Recording of a transaction

Each transaction is encrypted and stored in a block, which can contain several separate transactions. A block includes a digital marking from the previous block which certifies its validity. This marking operation is carried out by voluntary users, who are commonly called “minors". They provide their time and the computing power of their computers to maintain the blockchain. This operation is commonly called "mining". Mining is economically incentivized as miners are rewarded in cryptocurrencies (e.g. bitcoins) for their work.

The security of the bitcoin network is maintained by software that adapts the difficulty of calculations to the computing power of active minors. The higher the computing power, the more complex the calculations and the more secure the blockchain.

Minors might also keep a copy of the entire blockchain (i.e. all the blocks and associated transactions). **However, you don’t have to be a minor (i.e. provide your computing power) to keep a copy of the entire blockchain, the name commonly given to these users are “nodes”**.

Some think that the blockchain will play a central role in our existence by replacing centralized trusted third parties such as banks, notaries, insurance companies...

Blockchain could appear as a game changer. But before talking about a game changer it is necessary to redefine the business model of the services targeted and the stakeholders in order to think how the blockchain can be a better solution for some use cases.

Blockchain is a new way to store, access and transfer information while preventing alterations.

As it is a decentralized technology, the rules of the game are clearly defined and a switch from a traditional system request a complete redesign of the previous process. Wherever an intermediary (e.g. a platform, a trusted third party, etc.) controls or certifies transactions between two or more stakeholders, the blockchain could be an alternative.

2.2. Blockchain vs. Conventional database

Before launching a new project, it is very important to validate if the blockchain technology fits to the different needs of the application otherwise it is advised to use a conventional database.

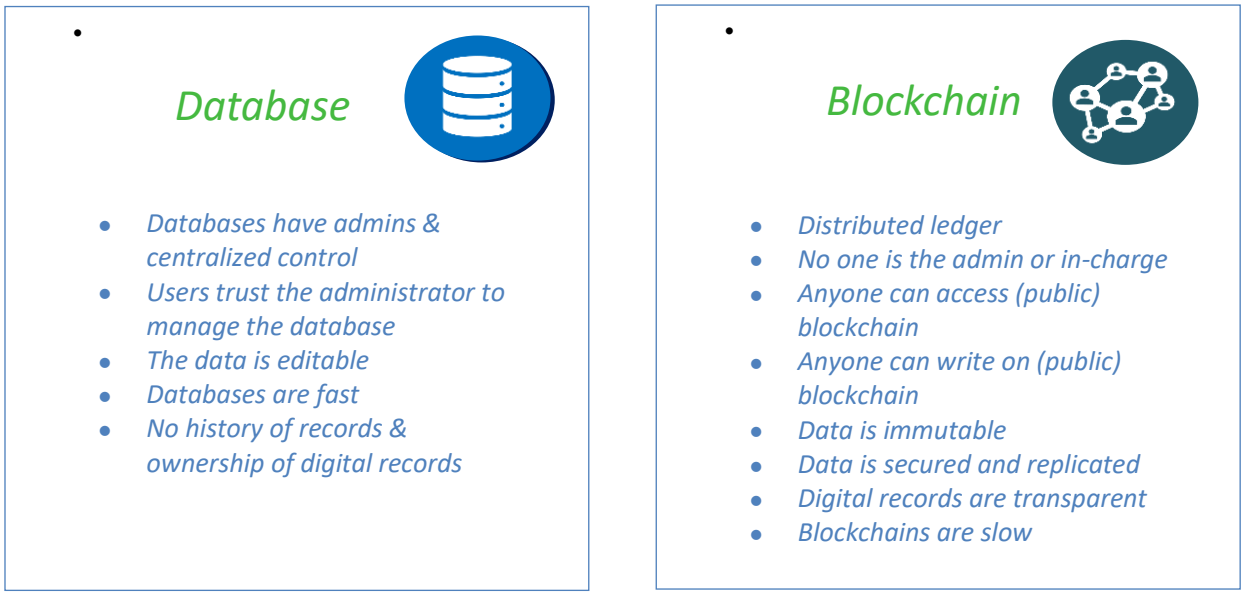


Figure 1: Blockchain vs Conventional Database

Once you understand the characteristics of each technology, it is necessary to identify if the flow of decisions answer to the needs of your application.

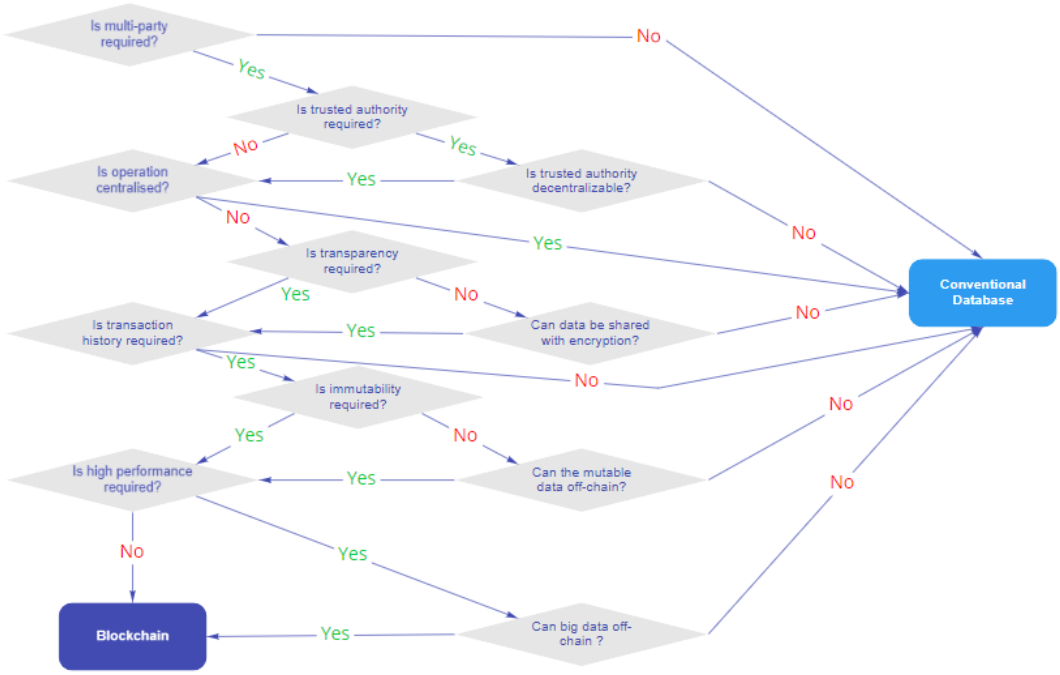


Figure 2: Why deploy a blockchain technology?

Multi-party: Blockchain is a technology for **databases with multiple writers**. In other words, there is a need to have more than one entity entitled to modify the database.

In most cases the writers will also run "nodes" which hold a copy of the database and relay transactions to other nodes in a peer-to-peer fashion. However, transactions might also be created by users who are not running a node themselves. If your application needs only one writer, you do not need to deploy a blockchain.

Trusted authority: Many stakeholders can connect to the platform even if they do not know each other or they do not trust each other.

Usually when stakeholders do not know each other, they also do not trust each other. By using a blockchain, the mistrust disappears with the common consensus defined and associated controls. In this case the blockchain act as a trusted authority, reinforced by the fact that the ledger is transparent allowing anyone to verify the integrity of transactions.

Operation centralized: The problem, as defined so far, is to enable a database with multiple non-trusted writers. And there is already a well-known solution to this problem: the trusted intermediary (e.g. a bank). Blockchains remove the need for trusted intermediaries by enabling databases to be modified directly by a consensus between multiple non-trusted writers. If you want only a trusted third party to validate the exchange of information, you must choose a conventional database.

Transparency: Is the information published on blockchain confidential? Are all stakeholders able to access the information or part of the information? There are different ways to manage the information: unencrypted data, encrypted data, or digital footprint (hash) linked to an off-chain data (i.e. a digital footprint is a piece of data contained in a blockchain transaction and that is strictly related to an off-chain data). To be compliant with GDPR (i.e. manage personal data) you could for example store operations not related to personal data on the blockchain and operations related to

personal data off-chain. Note that the integration in a transaction on the blockchain of a digital footprint linked to an off-chain data allows to verify, a posteriori, the integrity of the off-chain data (i.e. not corrupted/modified). **It means that we do not lose the integrity of the system as a whole if we have part of the data off-chain**. However, off-chain data must be carefully stored so they are not subject to loss or modification.

If none of these solutions is possible, blockchain is not compatible with the application project.

Immutability: It is not possible to delete information saved in the blockchain. The information can be modified but the historic remains. Every transaction is available.

High performance: Depending on the blockchain technology chosen, permissions granted (private or public blockchain) and the consensus mode (which is frequently linked to the permission). Note that the transaction throughput will be higher the more permissioned the blockchain will be. More and more people are working to improve the performance of different blockchain technology. It is possible to couple blockchain technology with off-chain data solution. But if the requirement of the application is to manage directly a large amount of data and to have a high level of performance, it is better to use a classic database already proven on this type of problem.

2.3. Public & Private Blockchain

Both are decentralized peer-to-peer networks, where each participant maintains a replica of a shared append-only ledger of digitally signed transactions.

Both maintain the replicas in sync through a protocol referred to as consensus.

Both provide guarantees on the immutability of the ledger, permissionless blockchain are by design harder to be modified because the more nodes there are the more difficult to alter the ledger becomes. In permissioned contexts, there are significantly less nodes therefore it is much easier to alter the ledger as nodes might collude to do so since they probably know each other.

2.3.1. Public blockchain network - permissionless

- completely open, anyone can join and participate in the network.
- The most popular and secure consensus in public blockchain is Proof-of-Work (PoW). A substantial amount of computational power is necessary to maintain the integrity of the distributed ledger. To achieve consensus, participants (i.e. miners which are also nodes) in the network must solve a complex, resource-intensive cryptographic problem (a proof of work) to ensure that they all have the same version of the distributed ledger.
- openness of public blockchain, which implies little to no privacy for transactions.

2.3.2. Private blockchain network - permissioned

- Requires an invitation to participate and must be validated by either the network starter or by a set of rules put in place by the network starter. These rules may change if a majority of participants in the network agree to change them (the rules define whether there is a need

for an absolute majority or a qualified majority to change the rules). These rules have legal value with the creation of a consortium (cf 1.4.2 - Risks, regulation) and their enforcement on-chain using smart contracts.

- Set up restrictions on who is allowed to participate in the network, and only in certain transactions.
- Once an entity has joined the network, it will play a role in maintaining the blockchain in a decentralized manner.

For an enterprise application, private blockchain are frequently considered more adapted. However, each use case being different, it is necessary to compare the advantages and disadvantages of each system before choosing.

2.4. Blockchain: Opportunities & Risks

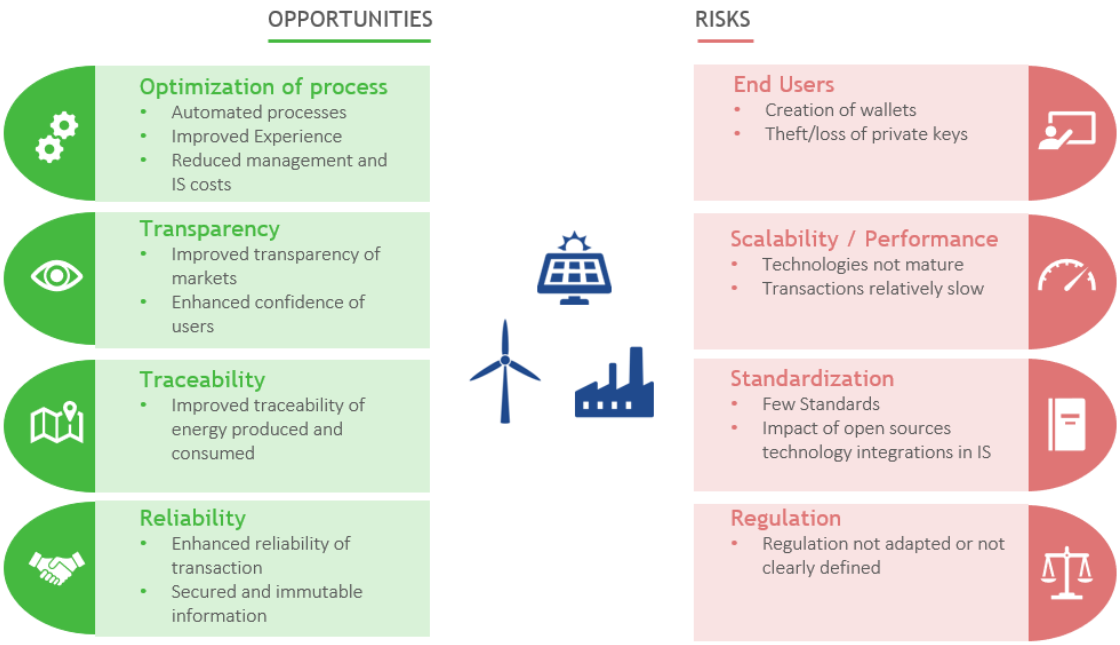


Figure 3: Opportunities vs risk of blockchain solutions

2.4.1. Opportunities

➔ *Optimization of process*

Blockchain technology helps improve the process of an application from the introduction of a stakeholder to the validation of a transaction.

The process is designed in order to avoid the intervention of a third party. Actions are more fluid (e.g. automation of tasks), and the experience is better for stakeholders (e.g. control over the data provided as they cannot be modified a posteriori by a third party)

This automation reduces the cost of operational management too. Blockchain is a protocol. With this protocol, using the ledger and smart contracts (defined in 1.5.), all the actors can interact together in a standardized way. They access the blockchain through an API or directly via a node, they can store data and execute operations. With a conventional infrastructure, each actor would have a different way of interacting with each other.

If we take the example of a supply chain, the end customers could access seamlessly every information of its products: raw material, transformation, delivery… The product information is enriched throughout its life cycle by the different stakeholders on the blockchain in order to inform the next contributor and trace the responsibility of each one.

➔ *Transparency*

With blockchain technology every information written on the blockchain is available and transparent. All partners are continuously and transparently informed of every transaction.

As the buyer can access every information of the product, his confidence in the product (and the vendor) is clearly enhanced.

The buyer knows everything about the product he buys: the origin, the distributor… He can check that the commitments sold are respected: the sweater he bought was made in Europe and was made of Scotland wool.

Note: if the information of the product is anonymized (i.e. using confidential transaction) or if the buyer has access indirectly to the blockchain (e.g. a mobile app) accessible information on the product may be restricted. These are design choices.

➔ *Traceability*

An opportunity that stems from transparency is traceability. Every transaction registered on the blockchain allows customers to track your product/service.

For example, a buyer could be confident that a product he buys is not fake and in the case of a work of art or a jewel he could also consult the previous vendors. In our case of energy, the buyer could verify the production origin of energy, if it is renewable energy and have access to the origin certificates.

➔ Integrity

The fact that transactions need to be validated before being stored on the blockchain really strengthens the integrity of the information. The initiator is not able to integrate any information in a block if the nodes have not validated it before.

Then when the transaction is validated, the information is replicated on every node of the blockchain. At this point, it is impossible to modify the information sent, the information becomes immutable.

It also strengthens the security of the solution, several actors need to validate the transaction and once the information is saved, it can be modified but all the changes will be tracked in blocks (since the blocks contain the transactions and they are chained together) and it will be possible to trace all the evolutions.

For example, if a buyer owns several shares of a company, nobody will be able to change his status of owner without his consent. If the buyer sells his assets, the ledger will be updated with a transaction between the previous and new owner.

2.4.2. Risks

➔ *End Users*

By end users we think of the users of the service delivered by the application, he will not host a node and participate in the validation process.

But if he is a participant (i.e. interaction with the blockchain via transactions) he will need a blockchain address, eventually a wallet with cryptocurrencies.

Blockchain can be a dark concept for this kind of users. Given that they do not understand the technology, they are not confident with the concept of creating a blockchain address, creating a wallet, buying cryptocurrencies…

And the tools to do that are not necessarily very user friendly, a large effort must be done in this direction in order to demystify the blockchain.

Blockchain use extensively cryptography, every user that interacts with the blockchain will be in possession of two keys: a private and public key. This is not necessarily easy to understand for every user.

- public key: the public key is mathematically linked to the address which is like a number linked to an account. You can give your address to everyone and they can transact with you on the blockchain through this means.
- private key: only known by the creator of the address, the private key is mathematically linked to the public key. It is used to sign the transaction.

In classic application, users are used to regenerate their password if they lose it and they feel covered if their password is lost. With blockchain, users must keep its private key and cannot change it (**note: it could create a new private key and transfer all his assets to the new address**). **Every person in possession of the private key can do a transaction on your behalf without your consent. Protecting your private key is mandatory.** If someone gets his private key stolen, he will lose everything relative to his blockchain address.

➔ *Scalability / Performance*

Although the first blockchain was created in 2008, applications in production compared to conventional systems are relatively rare.

Feedback is mainly based on Proof of Concept. Some blockchain technologies seem to be mature to go further but the performances are not tremendous yet. To fill this gap, it is possible to move off-chain several greedy actions (treatment of large amount of data, complex calculations…).

But like we said before, performance is one of the main subjects on which developers are working. With a growing number of transactions, scalability is also a main subject. A first solution was to increase the size of blocks, but it was not viable because only a few miners were able to treat them (i.e. increasing the size requires a better internet connection and to increase its storage capacity).

The Ethereum community - among many others - is addressing the issue, Ethereum developers are now exploring many ways to improve the scalability of the blockchain and deal with network congestion issues. The foundation has indeed opened a program offering grants to developers able to provide solutions to its problem of scalability.

➔ *Standardization*

There are many initiatives in various sectors: finance, supply chain, IOT, energy but each initiative is developed independently. There is a real lack of standards.

European actors intend to organize themselves and are involved in the standardization process.

The purpose of the voluntary standards under study is to: set a framework, describe good practices, develop a common language for all actors.

A disruptive technology is not viable if it is not interoperable! In the image of what exists in telecom, with the use of the same base to be able to make a call from any country in the world.

Another problem to solve is the integration of blockchain technology in the legacy systems of actors.

➔ *Regulation*

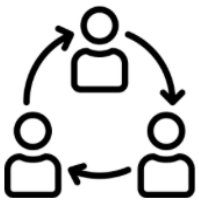
The technology must be compatible with the compliance policies of the actors and its infrastructure legacy, which is not always trivial depending on the areas of activity.

There are two main regulatory areas to focus on as these can have a major impact on the project:

- Regulations around the technology and tokens by government bodies.
- Regulations around personal data by government bodies. (e.g. GDPR compliance)

For the first point, we need to understand how new regulations might impact private and public blockchain and token systems as this sector come under increased scrutiny.

Actors can develop the project by creating a consortium:



Consortium
→ Relevance (Data sharing ? Common legal issues ? Responsibility towards third parties ?)
→ Organization of current and future relationships between members

Strategy
→ Define the consortium strategy
→ Structuring legally the consortium

Legal entity or contract ?
→ **Legal entity** : heavier, but allows the development of the project
→ **Contract** : light but rigid (e.g. in case of development)
→ Contract may become a legal entity

Consortium: By definition, a consortium is a group of entities that collaborate to achieve a common objective. Entities that participate in a consortium pool resources but are otherwise only responsible for the obligations that are set out in the consortium's agreement. Every entity that is under the consortium, therefore, remains independent with regard to their normal business operations and has no say over another member's operations that are not related to the consortium.

Strategy:

- Working with credible and experienced partners in key areas and allows new partners to join as needed.

- Continuous and tailored communication of the rationale and background of the project with key stakeholders (partners, authorities, etc.). - Performing a regular gap analysis to identify the need for additional expertise, resources and/or funding and pro-actively identify future partners or funding opportunities

Legal entity or contract: In order to remain flexible (add/remove members, change the strategy, etc.), the creation of a legal entity is better suited.

Agreement on Proof
→ Frame the legal value of on-chain data between members through an **Agreement on Proof**

Legal security of the project
→ Give, contractually, on-chain data a strong legal value between members of the consortium and in front of a judge

Advised : legal/technical risk audit
→ Document legal and technical compliance : in case of dispute, prove that the evidence is technically and legally sound

Agreement on Proof: blockchain evidence has, not yet, a legal value. In other words, it is up to the person who avails himself to bring the validity of this mode of proof (i.e. validity "a posteriori"). The Agreement on Proof makes it possible to foresee, between its members, that a blockchain evidence is valid "a priori".

Legal security of the project: framing probative value makes it possible to legally secure the project and avoid disputes on this basis.

Advised on legal and technical risk audit: document legal and technical compliance like an unofficial equivalent of an ISO standard

In the case there is a token system in place, some measures are to be considered. For example, in France a new regime (Loi Pacte) has been adopted for crypto-assets (tokens, crypto-currencies, etc.). A crypto-assets is legally defined as follows : "Any digital representation of a value that is not issued or guaranteed by a central bank or a public authority, that is not necessarily attached to a legal

tender and that does not have the legal status of a currency, but which is accepted by natural or legal persons as a means of exchange and which can be transferred, stored or exchanged electronically ".

Regulations are more than welcome as it legitimizes the use of blockchain and token systems by giving to companies and institutions clarity over their operations in this area.

It is important to note that the use of non-custodial solution (i.e. the user is in total control over his wallet containing his crypto-assets) or the use of a third party with appropriate accreditations is necessary to comply with French regulations regarding the operations below:

- the conservation service for third parties of crypto-assets or access to crypto-assets, for the purpose of holding, storing and transferring crypto-assets;
- the service of buying or selling crypto assets with fiat money (e.g. euro);
- the crypto-asset exchange service for other crypto-assets;
- the operation of a crypto-asset exchange platform;
- receipt and transmission of orders on crypto assets for third parties;
- crypto-assets portfolio management for third parties;

For the second point, we need to ensure the security of personal information, especially be GDPR compliant.

Personal data
→ The data is **pseudonymized** on the blockchain
→ They can be **anonymized** as needed

Irreversibility
→ keeping personal data under control (out of the blockchain)

Document compliance
→ on the legal and technical level
→ use of a new technology = study the relevance of a privacy impact study to ensure compliance of the project

Personal data: 'Pseudonymization' means the processing of personal data in such a way that it can no longer be attributed to a specific person without the use of additional information. Such additional information is kept separately and subject to technical and organizational measures to ensure that no personal data are attributed to an identified or identifiable person. Concretely, there are pseudonymization methods on both public and private blockchain. For example, you can use a digital footprint (hash) linked to an off-chain data in order to be GDPR compliant (cf 1.2 - Blockchain vs. Conventional database, figure 3, transparency).

It's important to note that there is mandatory application of GDPR for all pseudonymous data. However, from the moment there is no longer any connection with a person (e.g. anonymization) it is no more mandatory to apply GDPR.

Pseudonymous data become anonymous if their links to the "off-chain data" are broken. Namely, that the off-chain data has been deleted.

Document compliance: Article 35 of the GDPR (see below) provides for the conduct of a Privacy Impact Study where the processing of personal data is likely to create a high risk for the rights and freedoms of individuals concerned. Optional in principle, it is mandatory when the treatment is "likely to create a high risk for the rights and freedoms of the persons concerned". To assist managers, the Article 29 Data Protection Working Party has provided that it must be implemented when the treatment meets at least two of the nine criteria from its guidelines: evaluation / scoring (including profiling); automatic decision with legal effect or the like; systematic monitoring; collection of sensitive data or data of a highly personal nature; collection of personal data on a large scale; cross-referencing of data; vulnerable people (patients, elderly people, children, etc.); innovative use (use of new technology); exclusion of the benefit of a right / contract.

In summary: we must see if it is relevant to carry out a Privacy Impact Study, which is a kind of technical control to be sure that the system processing personal data is reliable in respect to GDPR, in view of the scope of the project, risks and legal provisions

GDPR, article 35 : “Where a type of processing in particular using new technologies, and taking into account the nature, scope, context and purposes of the processing, **is likely to result in a high risk** to the rights and freedoms of natural persons, the controller shall, prior to the processing, carry out an **assessment of the impact** of the envisaged processing operations on the protection of personal data. A single assessment may address a set of similar processing operations that present similar high risks.”

2.5. Smart Contracts

2.5.1. Definition

A smart contract is a digital contract which contains code that can be executed by any network member. The smart contract relies on blockchain technology to secure the terms.

Users can interact with smart contracts: they can call one or more functions. Functions will trigger execution of some operations in the smart contract.

Processes with smart contracts:

- **Automatic** – when a user calls a function in a smart contract, it will be triggered instantly
- **Fast** – it will happen within seconds
- **Direct** – "unstoppable code" as no trusted third party is involved
- **Cheap** – no fees are to be paid (depends on the hosting blockchain and the amount of computational work required to do the operation)
- **Transparent** – all the information will be registered on the blockchain

2.5.2. Use cases

Conditional payments are the first use case that come to mind when we speak about smart contracts.

For a sale for example, we can put mechanisms in place to be informed that the seller transmits the goods to his buyer (e.g. using smart contracts with external data source), that he perceives the financial counterpart, and that the buyer receives the goods.

Another example for travel insurance:

Finding that 60% of insured passengers against the delay of their flight never claimed their money, a team created during a hackathon in London in 2015 an automated insurance system based on smart contracts. This project is called Etherisc. A similar project was born sometime after pushed by Axa.

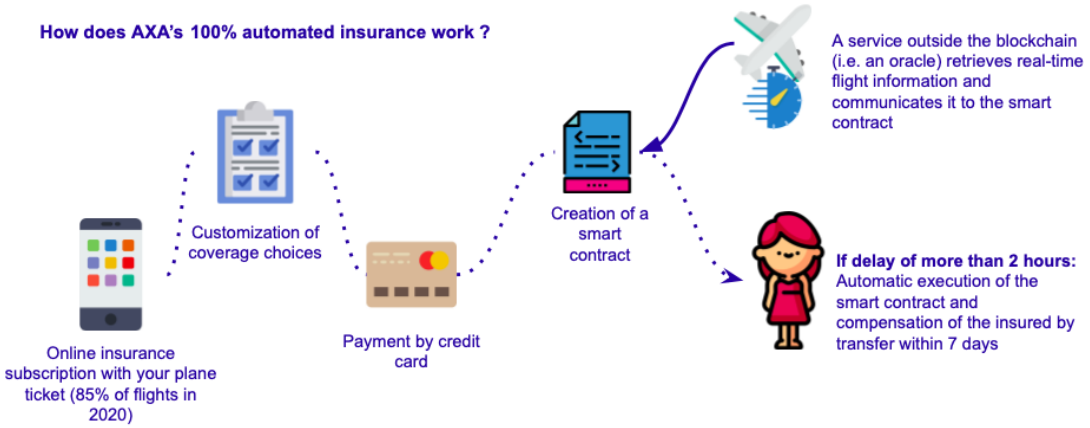


Figure 4: Axa reference

With this service, passengers are automatically compensated when their flight is late, without having to fill out any form, and therefore without the company having to manually process the requests. To trigger the payments, an oracle (i.e. oracles are services that send and verify real world occurrences and submit this information to smart contracts) is connected to a database containing flight delays, it will submit new delays to the insurance smart contract, triggering state changes on the blockchain (i.e. automatic refund in case of delay).

Smart contracts find application in the energy market too.

Figure 5: Smart contracts uses in the energy market

After these operations, sensors will verify that the amount of energy provided match the amount of energy sold.

2.6. Blockchain and Energy consumption

The energy consumption of the blockchain is often pointed out. But first of all, it is important to precise that several blockchain technologies exist and do not work the same way and especially do not have the same consensus to validate data.

The consensus algorithm that induces a problem of energy consumption is called "proof-of-work". The two most famous blockchains that use this algorithm are Bitcoin and Ethereum respectively number one and world number two in terms of capitalization.

With the popularity of Bitcoin, the value of bitcoin raised increasing the economic incentive to “mine” bitcoins (i.e. creation of bitcoins to reward the securitization of Bitcoin by miners). This phenomenon has led to an increase in the volume of electricity consumed. Given that with the Proof-of-Work (POW) consensus, a Bitcoin miner allocates computing power via his computer to perform complex calculations.

Bitcoin is not the only blockchain alternative, there are dozens of other blockchain technologies using other consensus algorithms to achieve consensus that consume less energy.

In the case of a private blockchain, participation in the consensus process is controlled and reserved for a restricted list of nodes authorized by the consortium administering the platform. **As such, there is no need to use Proof-of-Work to reach a consensus, and the consumption is similar to a conventional solution.**

3. Blockchain in energy

3.1. Blockchain maturity in the energy market

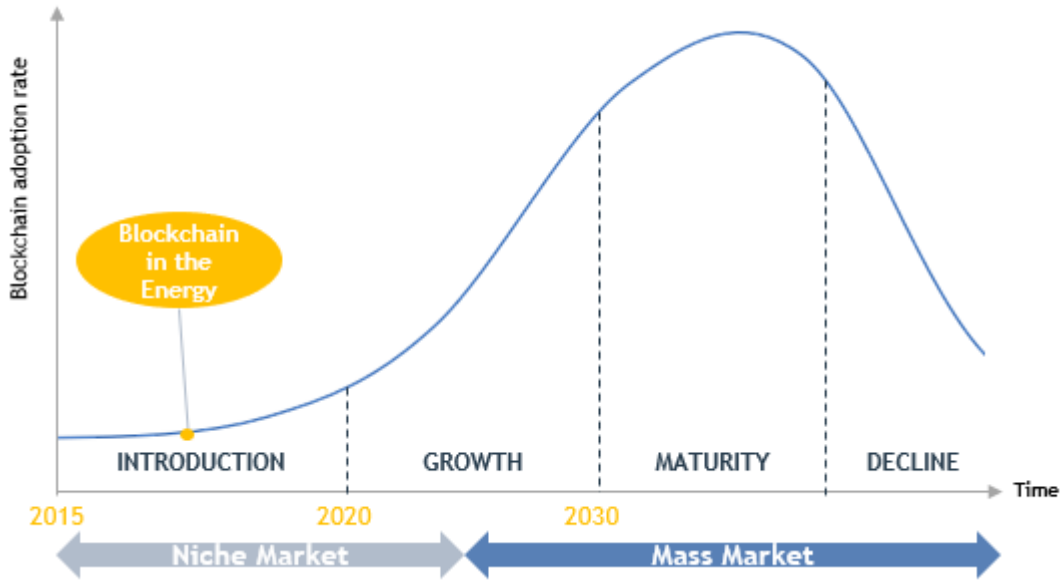


Figure 6: The blockchain in energy and the life cycle curve

Blockchain technology is still in a research and proof of concept phase.

This technology does not appear mature at the moment. There are numerous projects all around the globe but only a few are running and several brakes need to be clarified: technological, economic, regulatory, etc.

There is still some way to go before reaching growth market. But it also means that there are lots of opportunities, the new uber model of the energy is not yet defined.

The life cycle curve has 4 very clearly defined stages. At the end of the maturity stages, blockchain adoption rate will start to shrink and we will enter the decline stage. **This shrinkage is due to the market becoming saturated (i.e. all the companies and their customers in the energy market are already using blockchain technologies and there is no more space to fill)**.

3.2. Blockchain use case classification

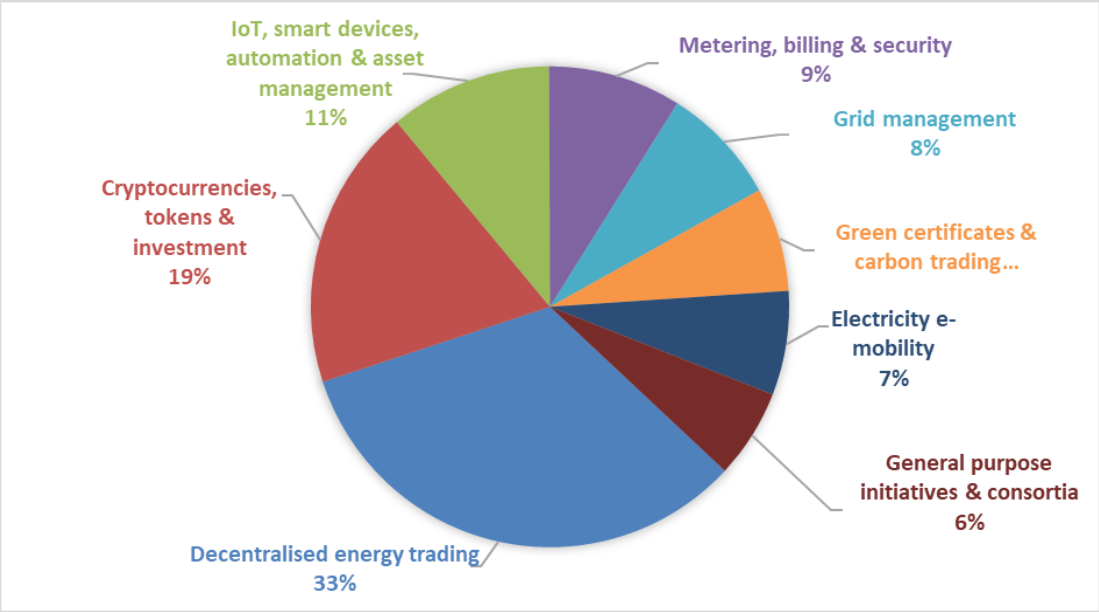


Figure 7: [Blockchain technology in the energy sector (140 initiatives)]

The majority of blockchain Energy projects are focusing on Electricity.

But it is very interesting to analyze what has been done on the energy market.

Like we said previously even if the stakeholders are not exactly the same on the production part, they have similar issues:

- How to optimize the production? Incentives to produce and consume?
- How to reduce the footprint of the production?
- How to offer new value-added services to consumers?
- How end users can intervene in the value chain?
- Is the business model on the energy market is evolving?
- What impacts of the decentralization of the energy market?

Today, each question concerns energy actors in general. The introduction of blockchain allow to treat subjects differently.

Blockchain does not modify physical exchange of energy but is an enabler for new added value services.

3.2.1. Decentralized Energy Trading

The blockchain platform connects sellers and energy buyers on different levels:

- Within the smart grid, between consumers and producers.
- Between the microgrid and the main network, small producers or consumers have direct access to traditional actors of data flows.

Several applications are being developed such as:

1. B2C Marketplace - small generators and end consumers,
2. C2C Marketplace - prosumers/consumers,
3. Marketplace connecting microgrid and main network
4. Wholesale energy trading,

We will focus on the first 2 applications.

B2C Marketplace - small generators and end consumers

Figure 8: Project segmentation of B2C platforms

Focus: Lition

Identity Record

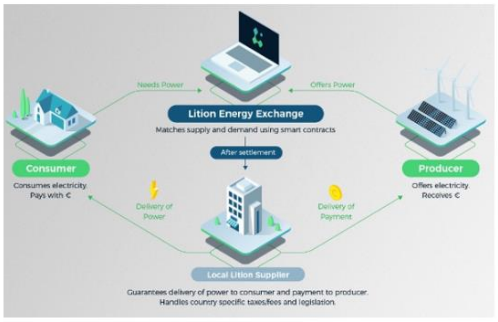
Location: Germany
Launch date: 2018
Stage of maturity: Running
Initiative: Private
Platform: Ethereum
Consensus: nd
Related Services: No
Hardware: No
Project leader: Lition

Description of the project leader

Start-up specialized in blockchain technology, created in 2018, Lition obtained the license of official energy supplier in Germany. Accessible to 41 million consumers in more than 11 cities across the country, the company supplies 700 households with renewable electricity.

Description of the platform and the project

The Lition platform connects consumers and producers of green energy directly. Consumers have the choice of the type of renewable electricity they want to buy (solar, wind, biomass). The start-up has partnered with the software company SAP to develop a new generation of blockchain platform, faster and better meeting the needs of its customers. It achieved a $ 2 million ICO in March 2019, after completing the testing / commercialization phase



Key Points - Innovations

- Direct contact between producers and consumers.
- Partnership with a renowned international player (SAP).
- Transparency: choice of the type of renewable energy and identification of the local producer.
- Very fast development of the platform (operational status less than a year after the launch of the project).
- Obtaining the status of energy supplier for a blockchain start-up.

Focus: Tal.Markt

Identity record

Location: Germany
Launch date: 2018
Stage of maturity: Running
Initiative: Private
Platform: Owner
Consensus: nd
Related services: Yes
Hardware: No
Project leader: WSW and Elblox

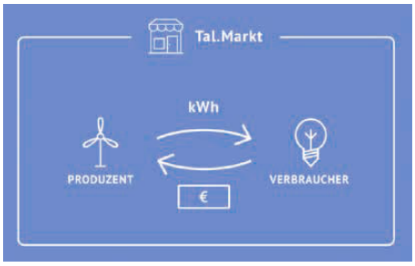
Description of the project leader

WSW (Wuppertal Stadtwerke Energy & Wasser) is the municipal energy supplier of the city of Wuppertal (Germany).

Elblox is the subsidiary of Axpo, a Swiss energy supplier. Created in 2017, it is developing a blockchain energy trading platform.

Description of the platform and the project

The WSW launched early 2018, in cooperation with the Swiss company Elblox the Tal.Markt platform, which establishes a local and regional market for renewable energy in Wuppertal. The aim is to link local renewable energy producers with citizens, including 5,000 wind turbines that will no longer be supported by grants after 2020. Tal.Markt used for these transactions a private blockchain which consumes less energy than public blockchain and which also allows the WSW to manage user access to the platform. Citizens can use the platform for free, while local producers pay WSW for the right to sell their energy on Tal.Markt. In addition, for the moment only local producers with installations of at least 30 KWp can access the platform. Thus, Tal.Markt's business model is that of an online marketplace.



Key Points - Innovations

- Putting producers in direct contact with consumers.
- Transparency: real-time monitoring of the volume of energy produced and identification of the local producer.
- In case of lack of renewable energy on Tal.Markt, WSW ensures security of supply.
- Allows investors to form a large enough group of citizens to encourage the construction of new wind turbines or solar installations.
- Collaboration energy supplier & Blockchain start-up.

Focus: Suncontract

Identity record

Location: Germany
Launch date: 2018
Stage of maturity: Running
Initiative: Private
Platform: Owner
Consensus: nd
Related services: Yes
Hardware: No
Project leader: WSW and Elblox

Description of the platform and the project

The SunContract blockchain platform connects consumers and green energy producers directly. The producer and the consumer decide on the offer and the price, a negotiation algorithm carries out the matching and the smart contracts allow the conclusion and automatic management of the transaction. To exchange electricity, participants must register and obtain SunContract (SNC) tokens. The platform has been operational in Slovenia since April 2018. The company intends to expand in Europe, the United States and Japan.
The start-up entered into a partnership with Microsoft in May 2018. This agreement is primarily intended to host and run the SunContract platform on the Microsoft blockchain infrastructure (Azure Blockchain Workbench) to optimize management, reduce costs , gain speed and agility, and expand the spectrum of use cases supported. The collaboration also opens up business opportunities for SunContract given Microsoft's global presence.

Description of the project leader

Founded in 2016, SunContract is a Slovenian company specializing in blockchain applied to energy. It directly connects consumers and energy producers.

SUNCONTRACT

Key Points - Innovations

- Direct contact between producers and consumers.
- Partnership with a major international player (Microsoft).
- Operational platform in Slovenia.
- Willingness to expand internationally.

C2C Marketplace - prosumers/consumers,

Figure 9: Project Segmentation of CtoC Marketplace

Focus: Power Ledger

Identity record

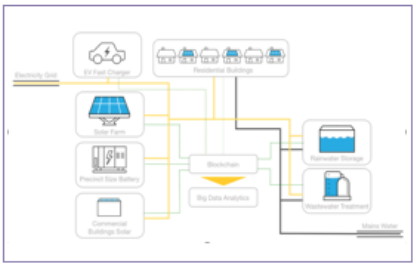
Location: Australia
Launch date: 2018
Stage of maturity: Pilot
Initiative: Public - Private
Project leader: Power Ledger, Curtin University, Murdoch University, Landcorp, Synergy, Western Power, energyOS, Cisco, Water Corporation...

Description of the platform and the project

The RENeW Nexus project aims to test blockchain and big data technologies to integrate distributed energy as well as the infrastructure of water supply systems. The experimental phase began at the end of 2018 and is scheduled to continue until June 2019 in the city of Fremantle (Australia). The project brings together many partners: universities, traditional actors of energy (Synergy, Western Power), IT actors (EnergyOS, Power Ledger), etc. Power Ledger's marketplace allows 40 households with solar panels to set their own buying and selling prices, to trade and sell self-generated energy directly. Data (consumption, price, etc.) are available at 30-minute intervals (compared to 30 to 60 days normally) to encourage residents to change their behavior.

Description of the project leader

An Australian start-up created in 2016, Power Ledger is now recognized as a major player in the blockchain in energy. It is involved in a wide variety of uses: local marketplace, electric mobility, network management, energy certificates, etc. The company achieved an ICO of $ 34 million at the end of 2017.



Key Points - Innovations

- Direct contact between producers and consumers.
- Pricing by participants.
- Daily charges are set by Western Power (DSO) and Synergy (energy company).
- Providing real-time information to participants.
- Large ecosystem of partners
- Financial support from the public authorities (government-municipality).

Focus: Brooklyn Microgrid

Identity record

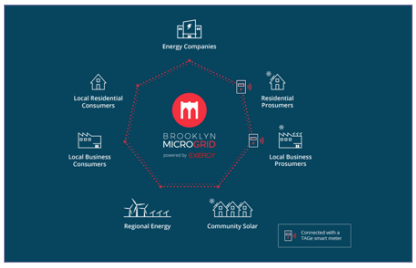
Location: Brooklyn (United States)
Launch date: 2016
Stage of maturity: Pilote
Initiative: Private
Platform: Owner
Consensus: nd
Related services: No
Hardware: Yes
Project leader: Transactive Grid

Description of the platform and the project

Inaugurated in 2016, the Brooklyn Microgrid is emblematic as one of the first pilot projects in peer-to-peer energy trading thanks to the blockchain. Five homes in the neighborhood can buy from five other homes with solar panels on the other side of the street. Transactive Grid has set up a blockchain platform that manages energy flows, from their entry to the exit of the network, while keeping the history of the energy produced and the transactions carried out. The project would involve today 300 housing units or small businesses as well as 50 production sites (almost all solar), representing an installed capacity of about 1.5 MW. LO3 Energy plans to launch its Exergy marketplace mid-2019, accessible through an application, which will allow residents to choose the energy they consume and buy it through a token system, which can then be exchanged locally.

Description of the project leader

Transactive Grid is a joint venture created in 2011 between ConsenSys, a blockchain start-up, and Lo3 Energy, a consulting firm that develops decentralized energy systems. It should be noted that the Centrica energy company as well as Siemens entered the capital of LO3 Energy in 2017.



Key Points - Innovations

- Direct contact between prosumers and consumers.
- Creation of a marketplace allowing the sale of local energy in exchange for tokens.
- Installation of an IOT device (TransActive Grid Element Generation) that measures consumption / production, shares data with other users and the local marketplace and controls other equipment in the home via a WiFi or Ethernet connection.

3.2.2. Cryptocurrencies, tokens & investments

Cryptocurrencies can serve different purpose:

- A method to 'tokenize' assets
- An instrument to attract investment and raise funding (also known as Initial Coin Offering or ICO)
- An Instrument to reward desired behaviors and facilitate green energy investments

A prosumer could keep the overproduction of his plant in the form of a cryptocurrency. The latter is then convertible into energy, whatever your position. It is then possible to recharge your electric car in a different place "from" the energy you produce.

Focus: Solarcoin

Identity record

Location: 73 countries
Launch date: 2014
Stage of maturity: Prototype
Initiative: Private (Hyperledger)
Platform: Cryptocurrency
Consensus: nd
Related services: no
Hardware: no
Project leader: Sunchain

Description of the platform and the project

SolarCoin is a reward for solar energy producers. The SolarCoin Foundation gives energy producers blockchain-based digital tokens at the rate of one SolarCoin (SLR) per Megawatt-Hour (MWh) of solar energy produced.

SolarCoin is based on two forms of proof. The first proof is the traditional proof of cryptographic work associated with digital currencies. The other proof of work is that of a third counterpart that proves the reading value of the meters of your solar installation. The SolarCoin program is articulated in a balanced way around these two pieces of work and is a way to reward and stimulate the production of solar energy.

SolarCoin is spendable and tradeable just like a cryptocurrency.

Description of the project leader

SolarCoin's vision is to incentivize a solar-powered planet. Rewards drive action. SolarCoin is global, decentralized, and independent of any government. The distribution part of the project is designed to last 40 years.

Produce One Megawatt Hour. Get One Free SolarCoin.

Key Points - Innovations

- Incentivizing a solar powered planet
- Address individuals or manufacturers, owners of their photovoltaic system or not (in the case of a third-party investor).

3.2.3. Iot & Smart Devices

In an IoT network, the blockchain can keep an immutable record of the history of smart devices.

This feature enables the autonomous functioning of smart devices without the need for centralized authority. As a result, the blockchain opens the door to a series of IoT scenarios that were remarkably difficult, or even impossible to implement without it.

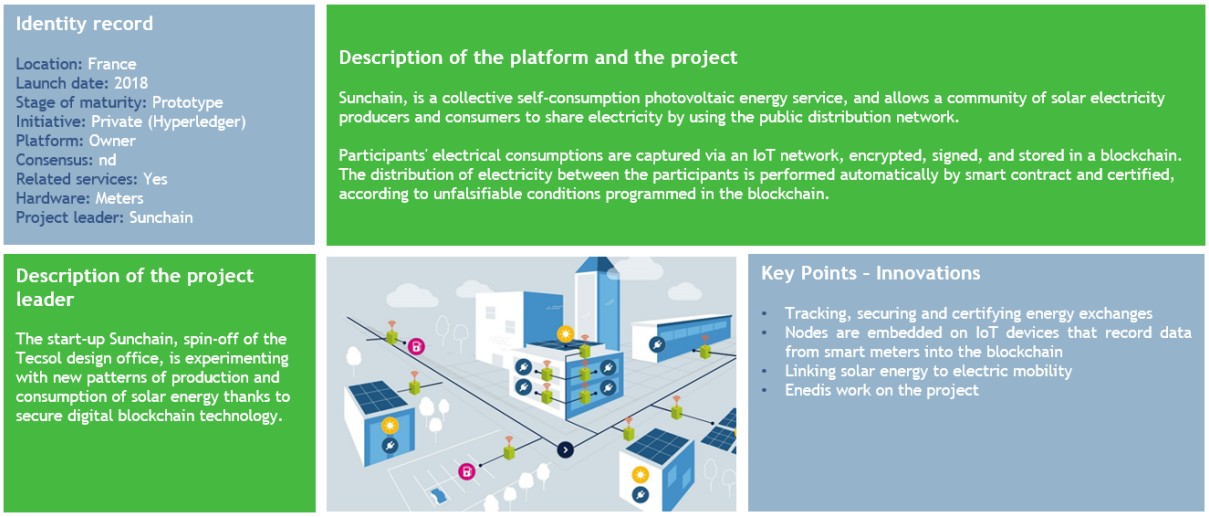
Concretely, there are several possibilities for the IOT to interact with the blockchain:

- Directly with the blockchain by being a node (need to be online all the time and have enough storage space to store all the blockchain)
- Sign a transaction and broadcast it to the nodes (need to be online only when you need to broadcast a transaction)

By leveraging the blockchain, industrial IoT solutions can enable secure, trustless messaging between devices in an IoT network. In this model, the blockchain will treat message exchanges between devices similar to financial transactions in a blockchain network.

To enable message exchanges, devices will leverage smart contracts which then model the agreement between the two parties.

Focus: Sunchain



3.2.4. Metering, billing & security

Blockchains provide the opportunity for automated billing in energy services for consumers and distributed generators, which comes with the potential of administrative cost reduction.

Traceability:

- Volume of energy produced
- Volume of energy consumed
- Origin of energy
- Cost of the energy
- Cost of infrastructure
- Bills

Focus CGI & Eneco

4. Blockchain & districts heating and cooling

4.1. Local loop Stakeholders

Heat and cold producers: they produce heat and cold for the local loop. They ensure that power is delivered to the consumer and a temperature setpoint. They can produce energy in different ways, but the objective is to reduce consumption of fossil fuel and to maximize the renewable energies in order to optimize their carbon footprint.

Electricity producers: There are 2 kinds of producers: the classic network and local producers of renewable energies.

Provider of storage solutions: In order to introduce flexibility, the operator of the micro loop must use energy storage solutions. It can allow the storage of the utility (heat / cold) or the storage of electricity to produce the utility later.

Professional consumers: They need heat and/or cold to feed their building(s) and the associated activities. Their objectives are to pay for this service and impact the environment as little as possible.

Residential consumers: They need energy for their home, they can have different objectives from one another. Some will want to consume locally and exclusively green other will prefer to pay as little as possible for the energy….

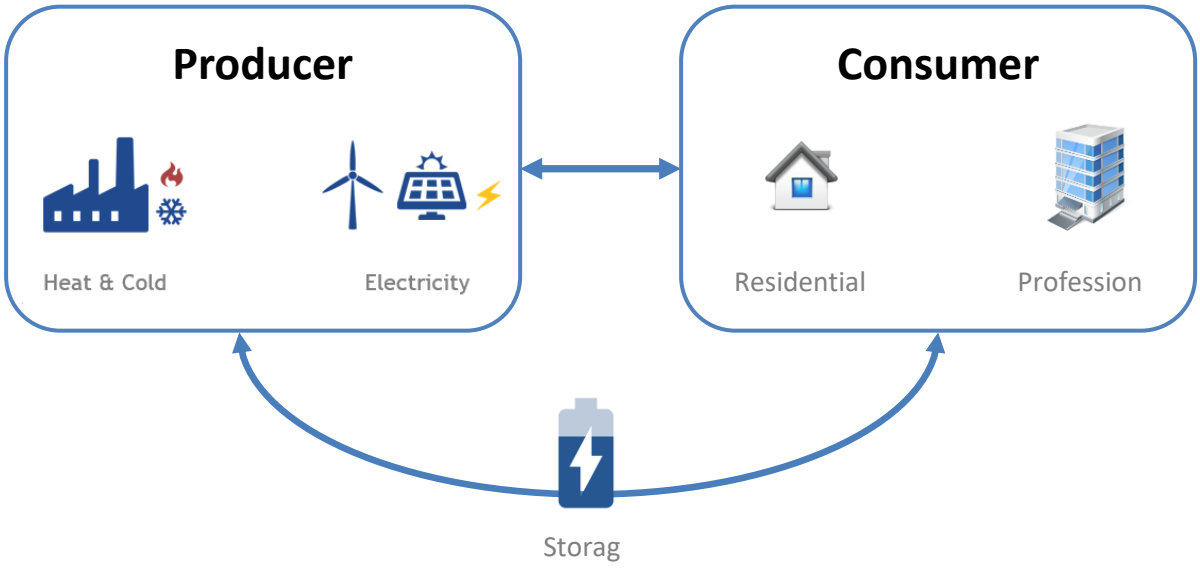


Figure 10: District heating and cooling stakeholders

In an ideal context, we could have 3 energy local loops in parallel:

- Electricity
- Cold
- Heat

The different stakeholders could intervene on each loop by producing, consuming or both. We could imagine that the industrial plant which produces cold or heat will promote the production during the pic of electricity production and vice versa.

The residential parties could also consume each energy and restitute what they produce.

Finally, even if we have 3 different loops, we could have common problematics, incentives and stakeholders. The flexibility could be managed with the combination of the 3 loops.

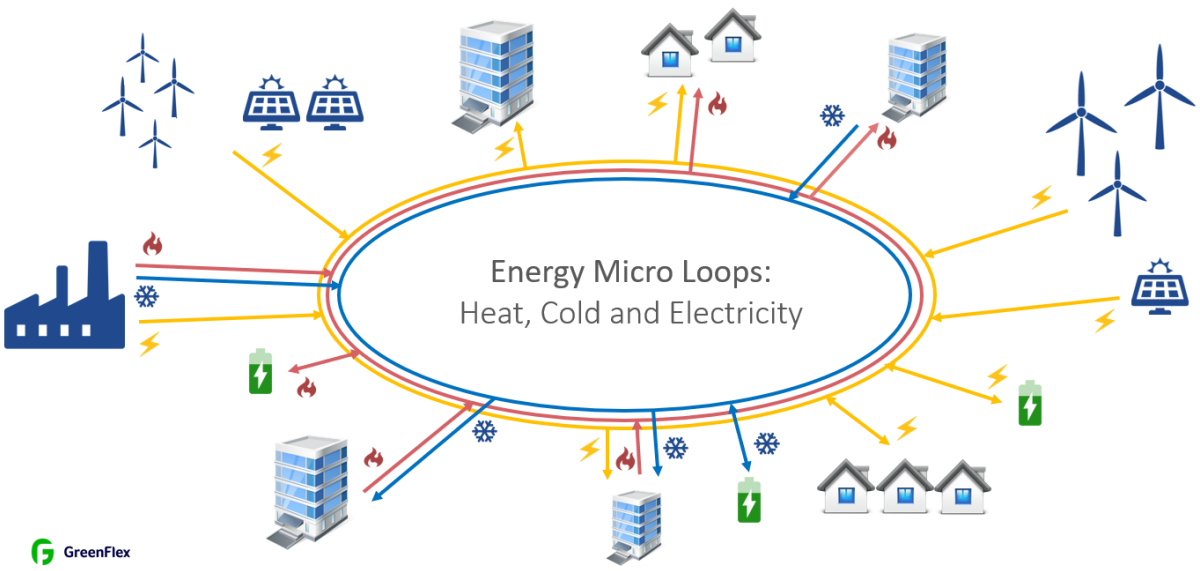


Figure 11: Energies (heat, cold, electricity) Flows

4.2. Regulation brake and lever

Districts heating and cooling are private networks governed by contracts between the various stakeholders. The contract defined the intervention perimeter of each participant and the rules of the game. The stakeholders can decide how they want the rules to be applied and which technology can be used in order to vehicle information.

4.3. Blockchain opportunities on heating and cooling districts

A conventional heating and cooling district infrastructure is operated by a central operator that equips its facility to collect all monitoring data, send commands and perform billing.

For this, a supervision solution is installed and is operated locally. In some cases, this solution is remote and is available in SaaS mode. These solutions are usually proprietary solutions for operators. It is quite rare that consumers have access to it: they are informed of their consumption when receiving invoices and have little or no verification solutions.

The 5th generation network has an innovative position; it aims to be decentralized which means that information must be shared with all stakeholders and the solution must also consider all the rules that have been defined upstream of the creation of the network.

Blockchain technology opens new perspectives and services for the management of 5th generation networks as it gives the ability to scale quickly across many actors. Incremental addition of consumers/prosumers/distributed suppliers/storage is more efficient with blockchain technology and would otherwise increase the burden of management substantially. Some use cases are detailed below.

4.3.1. Use Blockchain as a communication protocol for IOT devices

In the event of a breach, sensitive information could leak on a very large scale or IoT devices could be at risk of being hijacked by hackers. That's what happened in 2016 when the infamous Mirai botnet blocked access to many well-known sites, including Twitter, Airbnb and Netflix, harnessing the power of around 100,000 IoT devices to launch a DDoS (Distributed Denial of Service) attack.

Blockchain technology allows to secure the communication protocol, authenticate the equipment which sends information and automate actions and processes.

This decentralized approach would eliminate single points of failure, creating a more resilient ecosystem for devices to run on. The ledger is tamper-proof and cannot be manipulated by malicious actors (note: if there is no process in place to prevent hacked IoT devices to send information to the blockchain, malicious actors could flow the blockchain with false information). The blockchain technology allows a group of connected devices to communicate directly with each other without centralization of any kind. It secures interoperability of connected devices and allows to detect more effectively counterfeits.

The decentralized, autonomous, and trustless capabilities of the blockchain make it an ideal component to become a fundamental element of IoT solutions.

In an IoT network, the blockchain can keep an immutable record of the history of smart devices. This feature enables the autonomous functioning of smart devices without the need for centralized authority.

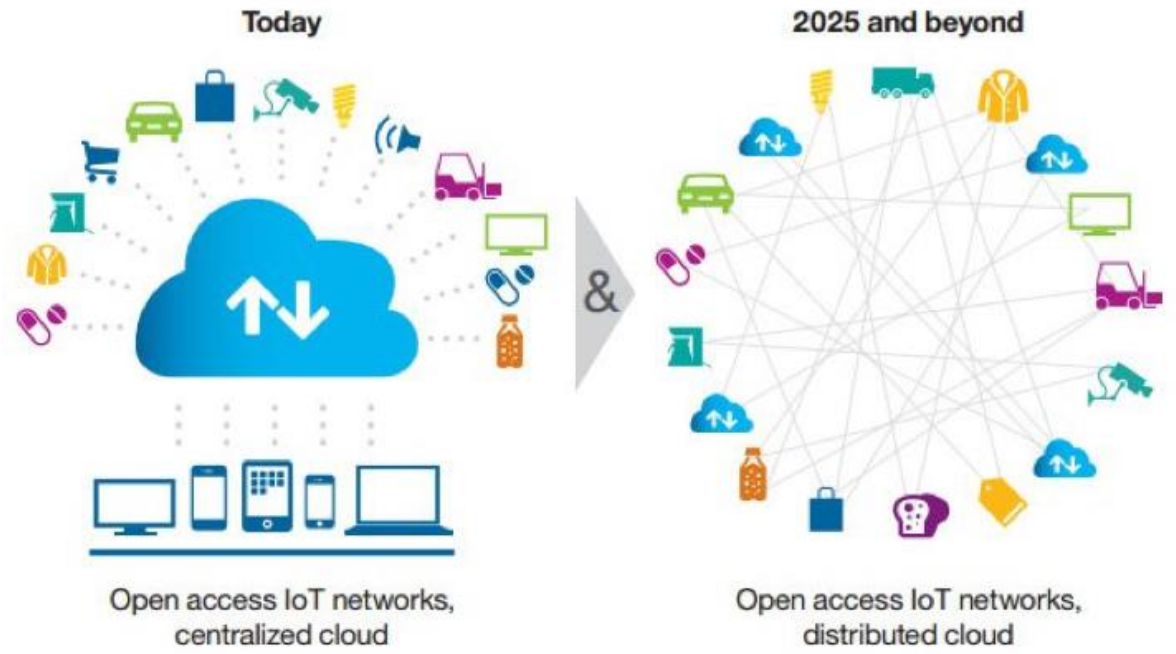


Figure 12: IOT Network representation with and without Blockchain

To enable message exchanges, devices will leverage smart contracts which then model the agreement between the two parties. Data received by smart contracts from sensors could trigger events that will be "listened" by other devices (for example if the outside temperature exceed a certain degree).

It could be coupled with an AI System.

#Secure #Authentication #Immutable #Distributed ledger

4.3.2. Ensure quality of the metering and maintenance tasks

The substations could send and receive information over the blockchain to and from the platform. All data would be replicated on different nodes.

If abnormal values would be recorded or the substation would stop sending information, it could trigger events by the smart contracts. Operating/maintenance technicians, district heating/cooling company and the customers are "listening" to the blockchain, awaiting triggered events. In case an event is triggered, listeners will take adequate measures according to their impact on them. The advantage with the solution is that all participants of the blockchain can work from the same secure and distributed record of data. This eliminates the risk of a single point of failure.

For example, through a blockchain platform could distribute information between all the stakeholders:

- The consumers could access to the detailed consumption information
- The producers could bill directly the consumers

- The operator could organize its maintenance operations in function of events and alarms declared
- Investors in the district could be ensured of the well-functioning and the return on investment

#Distributed ledger #Smart actions #Secure

4.3.3. Manage the billing

The blockchain solution can provide a dynamic control of the consumption. This facilitates the check of heat/cold temperature commitment in entry for the supplier and in return for the consumer. In function of all the information gathered, the blockchain application can automatically provide every information needed or edit the bills.

Information are not collected and processed by one central actor who is judge and party.

No challenge is possible: data is reliable and transparent.

#Secure #Transparency #Traceability

4.3.4. Enhance/Optimize Renewables Energies in the production mix of heat and cold

The aim is to embed Renewable production scenario in the smart contracts to maximize local consumption and to optimize the footprint of the heat and cold production. Note that the more complex the smart contract is, the higher the cost of development (as well as the risk of failure and bug).

The blockchain could help to deploy strategies of heat and cold production in function of several criteria:

- The actual weather and predictions
- The cost of energy
- The predictions of renewable energies production
- The supply and demand
- The storage capacity
- …..

Algorithm via smart contracts could drive the production of heat and cold in order to maximize the use of renewable energies. Blockchain could also be a way to certify the use of renewables energies to the end consumer.

#Smart actions #Traceability

4.3.5. Enhance the flexibility of the microgrid

In function of incentives and predefined scenario in smart contracts, the application could command the use and the load of storage (electricity, cold and heat) to optimize the cost of energy and make the microgrid completely flexible. This opportunity is close to the previous one, criteria are selected to define the scenario:

- Incentive of demand response
- Price of the electricity
- Storage availability
- Local energy available (if connected to a microgrid)
- Supply and demand

The blockchain platform allows consumers to access the information that confirms the benefices of implementing this kind of strategy. The information recorded on the blockchain justifies the win-win contract between the operator and the consumer.

#Smart actions #Traceability

4.3.6. Manage a common heat/cold production loop between district heating companies

Blockchain technology could allow the management of a micro loop opened to several district heating/cooling companies. The application will:

- Manage agreements and contract signing between participants
- Record which producer delivered heat/cold, at which time and at what volume
- Distribute the power delivered
- Share data (consumption, production, use of renewable energies …)
- Validate the commitments of each provider
- Distribute the revenue earned
- Integrate the infrastructure prices

As soon as the terms of the contract are defined between the actors, they will be modeled in smart contracts to automate tasks and reports.

In this use case, all the contributors could access data they need in order to verify the good management of a common heat/cold production loop.

#Distributed ledger #Traceability #Transparency #Decentralized

4.3.7. Create an open marketplace

Blockchain could connect each actor in the value chain:

- producers (district heating and cooling companies) and contributors (excess heat/cold supplier)
- Local heat storage facilities
- consumers (professional and residential)

Heat/cold consumers could be part of the system as electricity prosumers, they could for example produce heat or cold (with heat pump or air conditioning) during the pic of production of their photovoltaic plant if the price of heat/cold is more interesting than the price of electricity at the moment.

The blockchain will:

- Store and trace the information of every contributor,
- Reconcile producers and consumers,
- Give proof of the origin of the energy
- Manage the different profile and the rights in function of roles.

All the previous opportunities could be combined in this open marketplace:

- Authentication of communicating devices
- Control / Command of devices
- Trace of meters
- Transparency for all the contributors
- Flexibility
- Integration of renewables energies
- Mix several producers

To conclude this review of use cases we can state that the most obvious advantage of blockchain data structures are clarity over price paid and volumes as it will increase investor confidence both before investment (the right money will be paid to the right place for the right volume of energy) and also after investment (easy to track exactly how the projects make money, and where the bottlenecks are that can be optimized away).

#Distributed ledger #Traceability #Transparency #Decentralized #Secure #Smart actions #Authentication

N°	Opportunity	Business as usual	Problematic	Blockchain solution	Dependence	Complexity	Blokchain Added Value
a	Communication protocol for IOT services / Pour la communication en particulier je pense qu'il faut trouver la VA ailleurs, car les protocoles actuels sont fiables.	• Data fom communicating devices are centralized • IOT devices are linked to one solution / Platform	• IOT devices can be hacked • Devices are note interoperable • Devices does not communicate with each other	• Secure the communication protocol and interoperability of connected devices • Allow to detect more effectively counterfeits • Allow devices to communicate with each other			
b	Quality of metering and maintenance tasks	• Data is collected by the operator • Data is stored in a local solution or an excel file • Information stays at the operator level	• Data is managed by one entity, it can be modified, lost or erased • If abnormal information is stored, problem to control and transmit the information.	• Data verified • Immutable information • Automation of task in function of data collected • Historical data	a		
c	Manage the billing	• The operator consolidates data (meters, setpoints...) • The operator analyses data and interprets the commitment	• The operator is judge and jury • No one can compare, challenge the information of the billing with the data collected	• Integrity of on-chain data and transparent for every stakeholder (same record of data) • Commitments are automated by the use of smart contracts • Invoice can't be questionned by the consumer	a,b		
d	Optimize Renewables Energies	In a central solution, the operator manages directly the introduction of renewable energy in the mix of heat and cold production	In a decentralized system, it is complicated or impossible to manage the strategies of every contributor	• Strategies (production, consumption, storage in functions of criteria as price, source of energy ...) are implemented in smart contracts. Need to define what is on-chain and off-chain.	a		
e	Enhance Flexibility	• The operator decides to stop a substation • He sends an email to the client or call him • He stops the station remotely	• The client has no visibility on the operation performed (gain, duration, ...) • The operation is manual	• Transparency of every operation • Control of prices fairness • Control win-win operation for producer and consumer	a,c,d		
f	Multi producers loop	not applicable	Heating and cooling district are centralized	• Decentralization of the production • Management of different stakeholders (operator, producers, consumers, ...) and contributors (financing companies, Storage provider...)	a,c		
g	Open market place	not applicable		• Reconciliation of the offer and the demand • Tracing of trades • Justification of the energy origin	a,c,d,f		

Figure 13-Synthesis of Blockchain opportunities in 5GDHC

Heat and cold represent 40% of the energetic billing: Why not going further and Create an open marketplace melting Electricity, Cold and Heat?

4.4. Blockchain Concrete Use Case

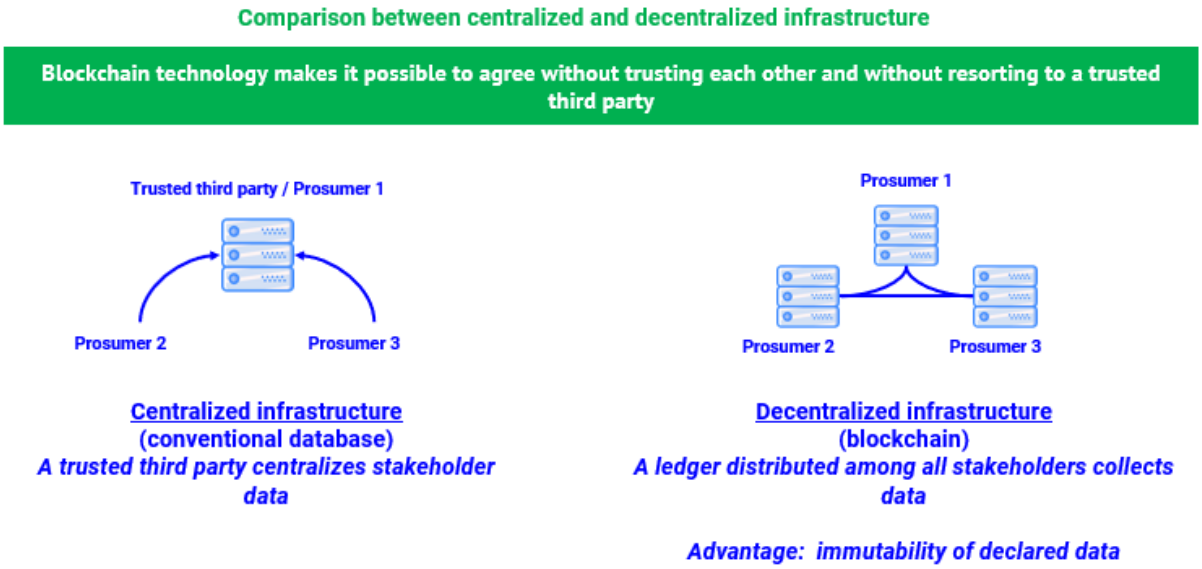


Figure 14: Comparison between centralized and decentralized infrastructure

Blockchain technology gives control to the prosumer on the declared data (i.e. a third party cannot unilaterally change the declared data), thus ensuring a better traceability of the responsibility.

As blockchain technology is still in its early stage, it is recommended to follow a step-by-step process. First, there is no need to go directly in the field: you can use a digital replica (i.e. a simulation) of the 5GDH project. In this manner, you will be able to simulate how stakeholders of the project will interact with each other (e.g. governance rules), how and what type of data needs to be collected, etc. This will ensure that you have the big picture, that you can control the cost of blockchain development. For example, you can add features as you go in order to not overcomplicate the project from the beginning: start with accounting, then billing and end with the peer-to-peer marketplace.

Once this first step is successfully completed, it is recommended to do an initial phase of rolling out conventional and blockchain solutions in parallel in the field. This step will ensure that the blockchain

solution behaves as desired and, in case of a problem or if you want to stop the experimentation at any time without real impact, the conventional solution is operational to keep the project running smoothly. This step continues until enough stakeholders are on-boarded for critical mass and the blockchain is running without downtimes.

Concerning costs of development, deployment and maintenance it depends if you use a public blockchain or a private blockchain.

Comparison of public and private blockchains from a company's point of view:

	Public Blockchain	Private Blockchain
Native crypto-asset	Yes does not work without it	Not necessarily
Network access	Open, public	Restricted
Read permissions	Public	Public or restricted
Efficiency	Low	High
Inalterability & ability to transfer value	Very high	Under condition
Infrastructure costs	None	High
Governance costs	None	High

Figure 15: comparison of public and private blockchains

In the case of a public blockchain you pay - with a native crypto-asset like bitcoin - each time you send data to the blockchain. In the case of a private blockchain, there is no transaction fees. However, each stakeholder will have to setup a server to run a node (i.e. store a copy of the ledger) and will have to participate actively in the governance process. (note: a node needs to stay online in order to participate in the consensus and avoid governance issues). A server can be on-premises or in the cloud (AWS, Microsoft Azure, Rockside, IBM Cloud, etc.). By experience (with AWS) the setup time is one day and the server rental is 50 € / month.

In the case of the 5GDHC project, private blockchain is the best solution as you can restrict network access, control costs of infrastructure and governance.

Blockchain is still an immature technology, deployment and development costs are high, this is due to several factors:

- Creation of a legal consortium (to give legal value to blockchain evidence between stakeholders)
- Need to acculturate the network stakeholders on the challenges of blockchain technology and frame process in order to standardize data reporting and set governance rules
- Interfacing with the stakeholder's information system
- Development of the architecture considering cost of blockchain developers
- Low visibility on the ROI (as there is very little existing project)

The duration of the framing meeting at the start and the cost of development are therefore greater than on a conventional solution.

However, once the infrastructure is in place, **it is easier to make change to the project as stakeholders find themselves around a common standard.** It also important to note that the cost is limited by the stakeholders (those who have a node – they have a copy of the ledger and they participate actively in the governance), the end users (i.e. consumers) there is no complexity or additional cost compared to a conventional solution (e.g. they will use a web platform or a mobile app without noticing what is going on under the hood).

The main question is how blockchain would be implemented as a data structure for energy transactions? As the 5GDHC project will use sensors to have metrics of the use of the network, these data will be stored on the blockchain.

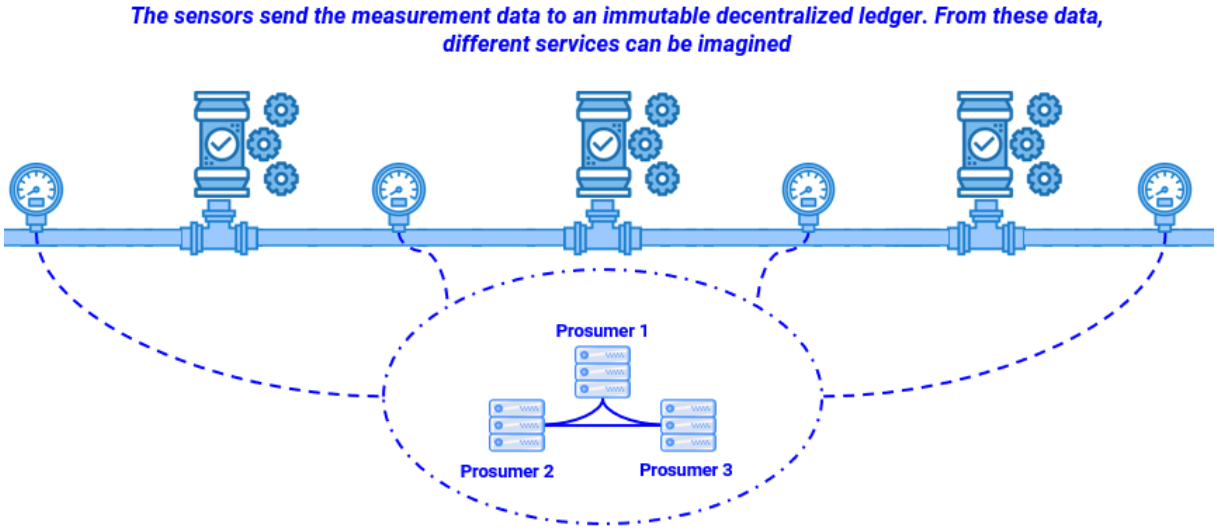


Figure 16: Blockchain technology: complementary element on 5GDHC

Blockchain technology is a way to make sure that once a data is on the blockchain, it becomes immutable. This clarity over volumes allows the creation of new services (see below).

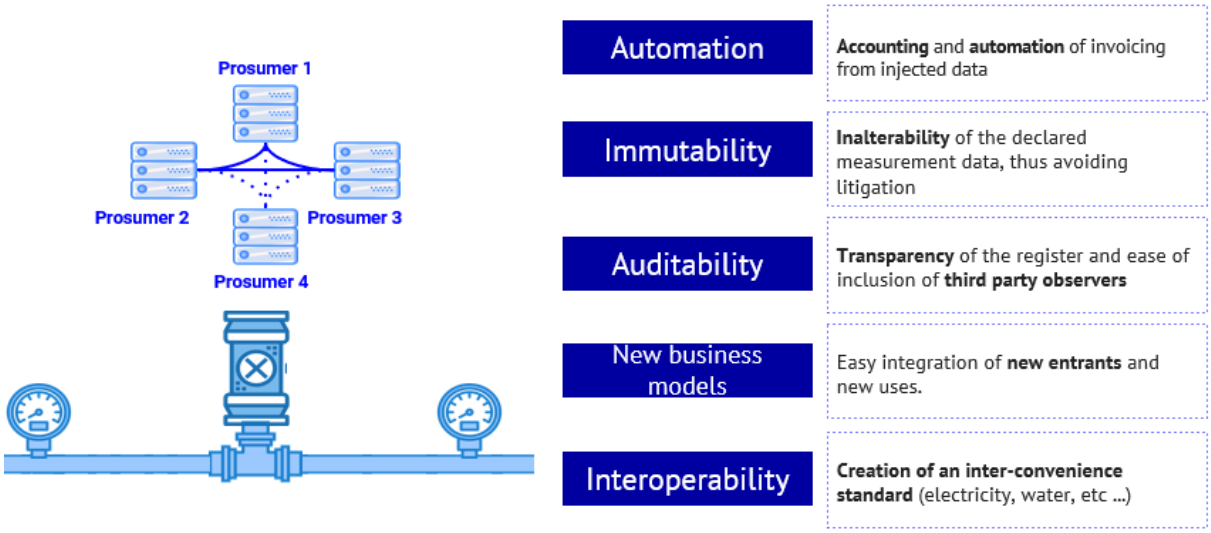


Figure 17: Easy Network Extension

The interest of these services is correlated to the number of stakeholders in the network (i.e. if there are a single generator and a single off taker the use of blockchain is of little interest). The advantage of blockchain technology over a conventional solution is the ability to ease integration of new entrants and new uses via the governance process. Indeed, each stakeholder can vote for the new state of the network (i.e. to accept or refuse a new block, a new member or a new governance rule) However, at the beginning, you will need to kick-off the network with few stakeholders (e.g. 3) to onboard and iterate quickly. Early on, it's ok not to have a 'critical mass' of supply and demand that makes blockchain a more effective solution than its conventional counterpart. It needs to be a goal in the long run.

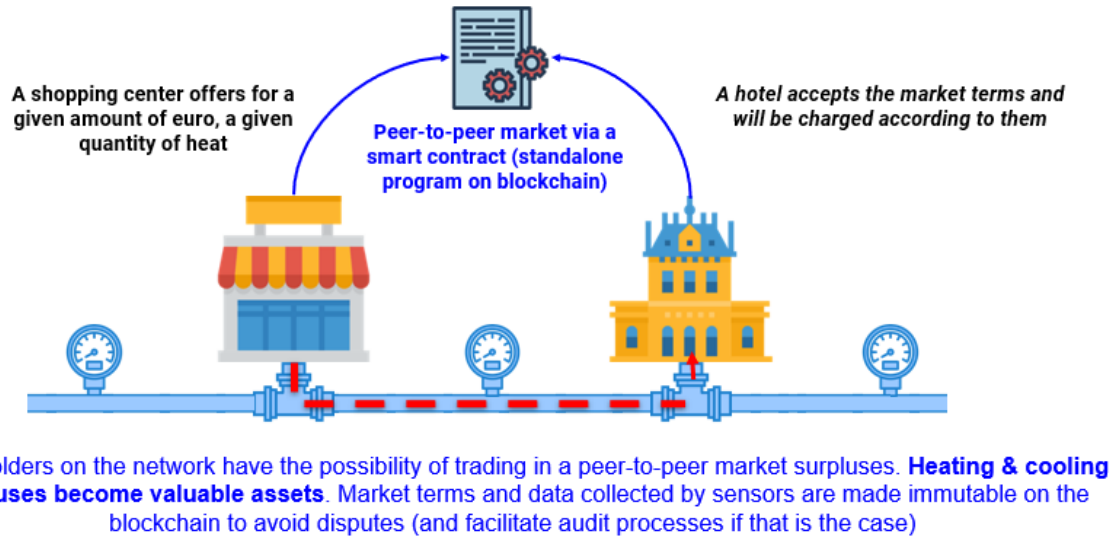


Figure 18: Macro schematization of blockchain integration in the D2Grids project

From a passive consumer's point of view, nothing changes compared to a connection to conventional database. Through a web platform or an app, the passive consumer can follow his consumption and have access to other blockchain data. Under the hood, the web platform or the app is connected, through an API, to one of the nodes. Nonetheless, if it's an active consumer (i.e. interact with the blockchain by performing operations), he will need a wallet for his identification on the network. Solutions exist to have a wallet in the classic form (i.e. login and password) to offer a frictionless experience but it will be at the cost of less decentralization.

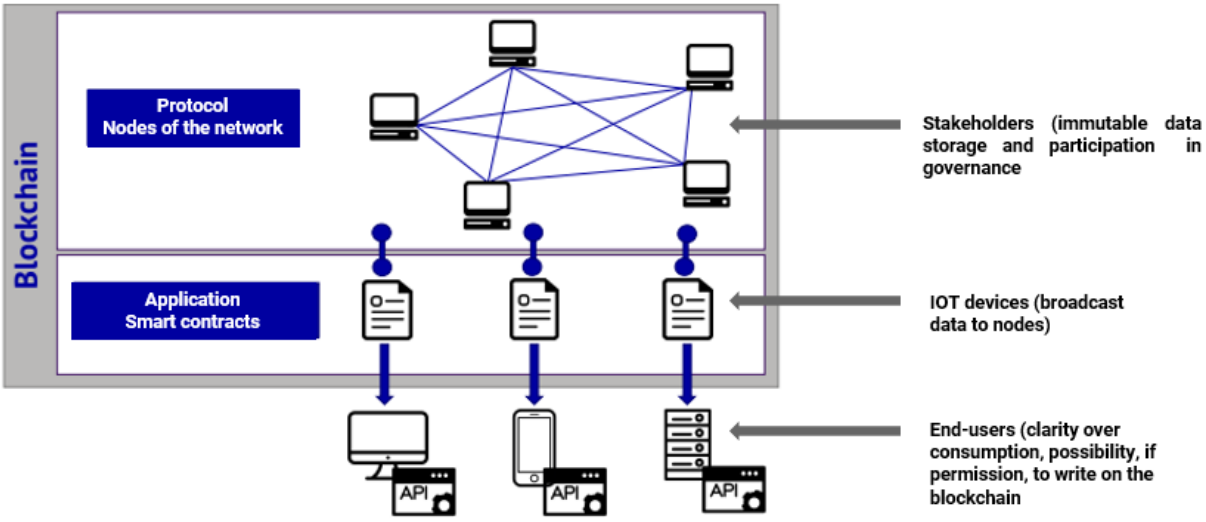


Figure 19: Summary diagram of the different roles and interactions with the blockchain

Stakeholders: They are the actor who operate the blockchain (in a private blockchain). They must be online at all time to participate in the government process and store the new blocks. They guarantee the security of the network and therefore the immutability of data.
IOT devices: As device that detects and responds to some type of input from the physical environment, they produce data that are sent to the blockchain. An IOT device does not need to be a node, it can broadcast data to nodes that will be put in a block.
End-users: They are consumers, external actors, auditors, etc. They can have permission to read or write on the blockchain through a mobile app, a web platform or an API. If they only read data that are on the blockchain, their experience will not be different than with a conventional solution. However, if the end-user must write on the blockchain, he will need a wallet for his identification on the network.

5. Conclusion

Blockchain has essential assets to facilitate the emergence of new services, which are strongly linked to decentralization and consumption optimization. It facilitates the implementation of these models through information tracking and automatic contract validation and triggering.

Intrinsically transparent and immutable, the Blockchain will make it possible to respond to the growing interest of consumers in knowing their consumption, the origin of the energy produced and the understanding of invoicing rules. The latter also helps to increase investor confidence.

The following step would be to go further on this subject selecting a use-case to implement on one of the 5GDHC pilot site.

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