GREENER UTILITIES BY IMPROVING DATA-QUALITY

Author: J.C. Takman
Student number: 5630312
E-mail: j.c.takman@students.uu.nl
Study: Information sciences

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First supervisor: J. Gulden
Second supervisor: N.A. Brand

Abstract

Determining the value of a data-standardization is a complex job for a company. It is hard to capture that value in money. In this paper, the value is assessed in a different way, not by looking at its monetary or exchange value, but by using the concept of use value. A framework has been created that enables a company to get an insight in how a data-standardization would influence its use values, by first identifying how the company creates value, then looking at how data is used and finally look at how the chosen standard influences these company's values through its data usage. This research has been done in the context of the utility market but can be useful in other markets too.

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1. Introduction

1.1 The utility market

Our current modern society would not be able to exist without utilities or power, mainly supplied by electricity and gas. Almost everything we do in our life is influenced by utilities. Internet, cooking, traffic regulation, to name some things, none of them would have been possible without our utility net. In the Netherlands, management of these nets have been privatized. This means that there are public companies responsible for its management. As mentioned, electricity and gas are the main sources of these utilities. The electricity net is divided into the high, medium, and low-voltage nets. High voltage is used to transport electricity over longer distances and in the Netherlands, the high voltage net is managed by a company named Tennet. Although it is a public company, its shares are 100% owned by the Dutch state. The national gas net is managed by Nederlandse Gasunie. Another word for the net is the grid.

The medium and low voltage net and the regional gas nets are managed regionally by other companies. The largest net manager is Liander, who is responsible for the management of the net in Gelderland, Noord-Holland, Friesland, Flevoland, and parts of Zuid-Holland. Liander is part of Alliander. Enexis manages the net in Groningen, Noord-Brabant, Limburg, and parts Overijssel and Drenthe. Stedin is responsible for the nets in Utrecht and the larger part of Zuid-Holland and the net in Zeeland is managed by Enduris. There are also a few small regions managed by small companies. It is decided by Dutch law that majorities of the shares of those companies should be in possession of the Dutch governments and that commercial parties may not be engaged.

The utility management market is not a regular, open market, as becomes clear from the previous part. Ownership of the different parts of the net is fixed and there are no commercial interests. This basically means that the net managers are monopolists, there is no competition. They are however, under strict supervision of the Authority for Consumers and Market (ACM), an independent supervising body, which is part of the Dutch ministry of the economy. And since their shareholders are Dutch governmental bodies such as provinces and municipalities, they must act in their favor. Because of these special conditions, many existing studies and literature about economics are not fully applicable to companies active in the Dutch utility market.

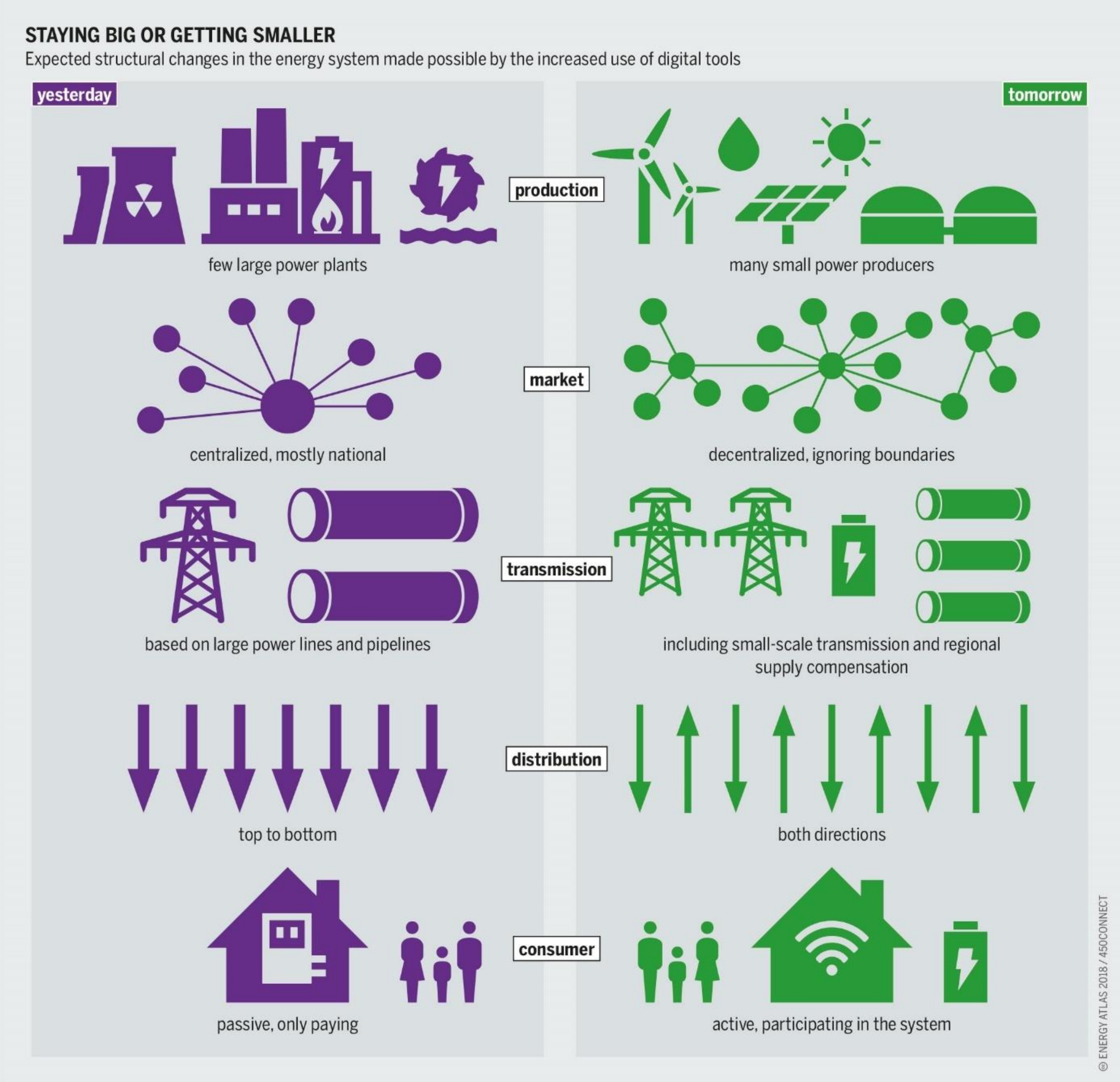
Based on the international Paris agreement from 2015 and the Dutch climate agreement from 2019 a large energy transition is currently going on. Net managers and companies in the utility market play a major role in this transition. In 2030, 70% of the Dutch electricity should be generated by green sources, such as windmills and solar panels. These sources of energy, however, can cause high peaks of electricity generation, but also deep drops. The same goes for the consumption. As a result, the net needs to be flexible. There needs to be reserve capacity of energy, but also reserve storage capacity. To manage this, the net needs to become smart and based on historical and real-time data the capacity should be adapted to the supply and demand.

1.2 Towards a smart grid

The current energy transition requires a different kind of grid, which is another word for net. The grid used to be a centralized, one-direction sort of net, where the supplier delivered power from a few large power plants to passive consumers. But to become green, the grid had to be changed and the smart grid came into existence. The changes from the old-style grid to the smart grid are shown in Figure 1. In the smart grid, power also comes from multiple smaller sources, such as wind farms and solar parks, on a regional scale, besides large-scale producing sources. And consumers also can deliver power back to the net, with for example solar cells on their roof. This requires active management and analysis and to do that properly, large amounts of data are gathered, stored, and used on all different entities (such as smart meters in homes and stations in neighborhoods) of the grid. These data are used on different levels, such as the organizational or technical level. And the data are about different parts of the net called domains, like the generation or the distribution. And they are saying something about different scales of the domains, called zones. To make these processes of data exchange between entities more insightful and easier to understand, a council that is set up by order of the European Union created a model, the Smart Grid Architecture Model (SGAM). This model is explained and discussed further in this report.

Figure 1

The change in the grid



Note. Image from Heinrich Boll foundation (2018). *Energy Atlas* (joint report). Bartz/Stockmar, CC BY 4.0. Retrieved Januari 8, 2021 from https://www.boell.de/sites/default/files/energyatlas2018_facts-and-figures-renewables-europe.pdf

1.3 Alliander

This before active analysis and management is a job of the utility net manger and for this research, focus will lay on Alliander, the parent company of the net manger Liander. Looking at Figure 1, they can be placed on the distribution part of the net and partly at the consumer, since they are responsible only for the connection and meter of the customer. More details about Alliander can be found in section 2.2.

Alliander considers itself as a key player in the energy transition. Their grid needs to be able to facilitate this transition. As said, the smart grid needs to deal with fluctuations in supply and demand, since green energy cannot always be generated and demand also fluctuate, depending on the time, weather, and season. One way to deal with these fluctuations is to expand the capacity of the net, to store power temporarily when there is a peak in supply and use this stored power when there is a peak in demand. However, this requires major investments in development and expansion of the net, for which there is not enough workforce and manpower available. Yet, the grid must become capable of facilitating the energy transition. To establish that, Alliander came up with the idea of data driven net management: based on data, sources of power can be temporarily shut down or turned on and consumers can be asked to for example stop charging their car at peak moments of demand. Investment and development of the net will also be decided on based on the data. Ultimately, every management task should be done based on data. But to be able to fully rely on data, the quality of the data needs to be good. Otherwise, wrong decisions may be made, and the reliability of the net will decrease. Also, bad data quality has a negative effect on interoperability, a key driver for the smart grid (CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012; Haug et al., 2011). Currently, the data quality at Alliander is not good enough. Data is splintered, ownership and responsibility are unclear, semantics are hard to understand and there are other problems.

1.4 Problem statement

Improving the data-quality can be done by implementing a standard, but this can be a complicated task. Alliander is a decentralized company, working partly agile. There are many teams and other entities involved with the data, so this would be a major investment. The value of such an investment is not clear, but at the long term this can be valuable, but how valuable, is hard to determine. This research will look at how the value of such a standardization can be determined, leading to the following research question:

“How to determine the value of a data-standardization in a decentralized business?”

In order to answer this question appropriately, some fundamental research needs to be done first. This leads to the following sub-questions:

“What role does data play in the utility market?”

“How is Alliander organized?”

“What is standardization?”

“What is value?

How is value created?”

“What are already existing frameworks to determine the value of a data-standardization?”

2. Fundamentals

2.1 GWAC & SGAM

To make the processes of data exchange between entities in the utility grid more insightful and easier to understand, a council that is set up by order of the European Union created a framework, the Smart Grid Architecture Model (SGAM). This framework combines the GWAC-stack, a model designed by the

GridWise Architecture Council (GWAC) shown in **Error! Reference source not found.**, with the smart grid plane, shown in **Error! Reference source not found.**. First the GWAC-stack will be discussed, second the smart grid pane and finally they will be merged into the SGAM.

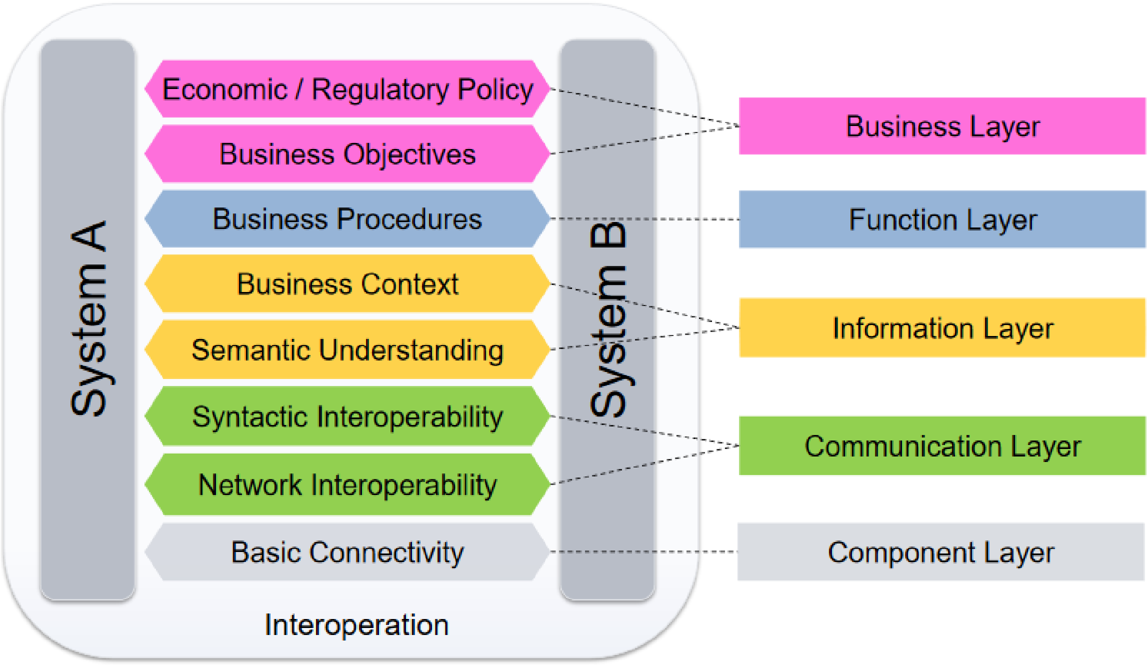
2.1.1 GWAC-stack

According to the CEN-CENELEC-ETSI Smart Grid Coordination Group, (2012) interoperability is the main enabler for the smart grid. Interoperability is the ability of different systems to exchange data and use each other's data. To make this interoperability between systems on the different layers more insightful, the GWAC-stack has been created. Below these layers are explained.

- The business layer is about the business view on the information exchange. It can be used to look at the whole market and get an insight in policies, regulations, business models and portfolios. Business processes can also be described in this layer. It can support management in decision-making.
- The function layer describes the functions and services of different business procedures, independent from actors and physical implementations.
- The information layer describes the information that is exchanged with those functions and services. This layer also contains underlying canonical data models and information objects.
- The communication layer describes protocols, data models information objects and mechanisms necessary for the information exchange.
- The component layer is there to describe all components in the smart grid. These can be for example systems, stations, computers, and applications.

Figure 2

The layers of the GWAC



Note. From CEN-CENELEC-ETSI Smart Grid Coordination Group (2012). Smart Grid Reference Architecture.

2.1.2 The domains

The smart grid itself can be schematically shown in a plane. This plane is found in **Error! Reference source not found.**. It describes five domains and six zones. Domains describe whole energy conversion chain, and the zones describe the hierarchical levels of the power system management.

- The generation domain is about the bulk generation of power. Sources of this power vary, examples are natural gas, nuclear power, and burning of biomass. These generators are operated by different companies.
- The transmission domain is about the long-distance transport of the energy. In the Netherlands, Tennet is responsible for the transport of the electricity and Gasunie for the transport of gas.
- The distribution domain is about the local grid that enables distribution to consumers is meant. This is the responsibility of the earlier mentioned net managers, like Liander.
- The DER domain, which stands for Distributed Electric Resources, are smaller and local scale sources of power, like small windmill parks or solar cell parks, which are directly connected to the local grid.
- The customer premises are the connections to end users. This can be homes, but also larger scale connections, like airports, company buildings or harbors. The premises not only consume energy but can also deliver energy back to the grid. This requires smart meters to accurately measure and manage consumption and production.

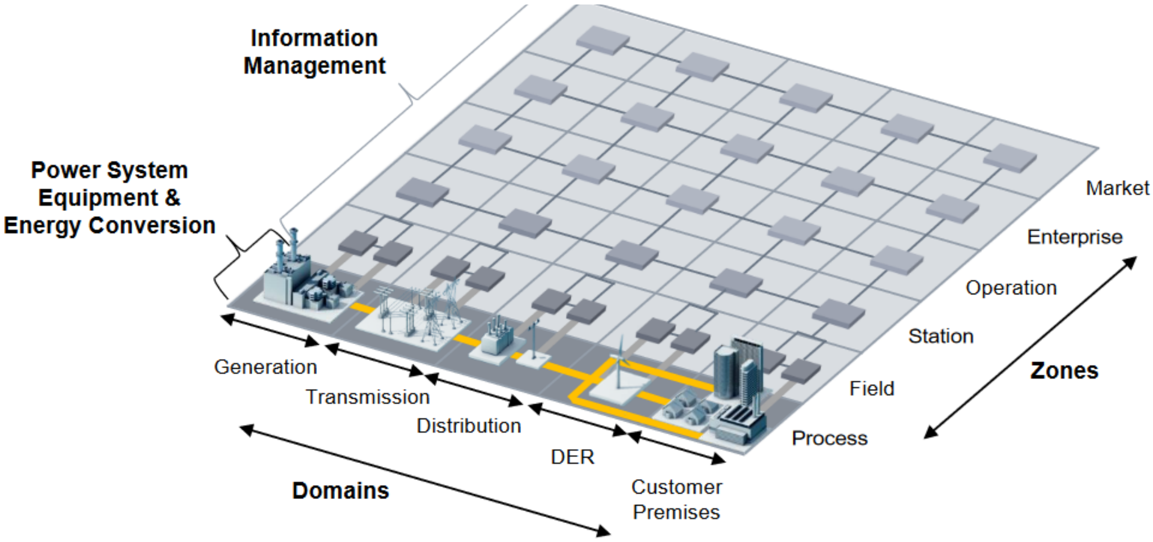
2.1.3 Zones

As visible in figure 3, multiple zones can be distinguished in the grid. These are the different zones on which by hierarchical level data are gathered. These zones will be explained briefly below.

- Process zone: The lowest zone in the hierarchical order and is about information on the physical process of the domain, like cables, transformers, and sensors.
- Field zone: This zone is about protection, control, and monitoring of the physical processes and consists of multiple instances out of the process zone.
- Station zone: In this zone the different fields are aggregated. This is where all the information from the process zone and the field zone come together and is used to monitor these processes.
- Operations zone: The management system of the whole domain. This can be considered as the core business of Alliander, supported by information from the lower domains.
- Enterprise zone: In this zone, data are about the commercial and organizational processes.
- Market zone: This final zone describes market processes and interactions between different enterprises in the market.

Figure 3

The smart grid plane



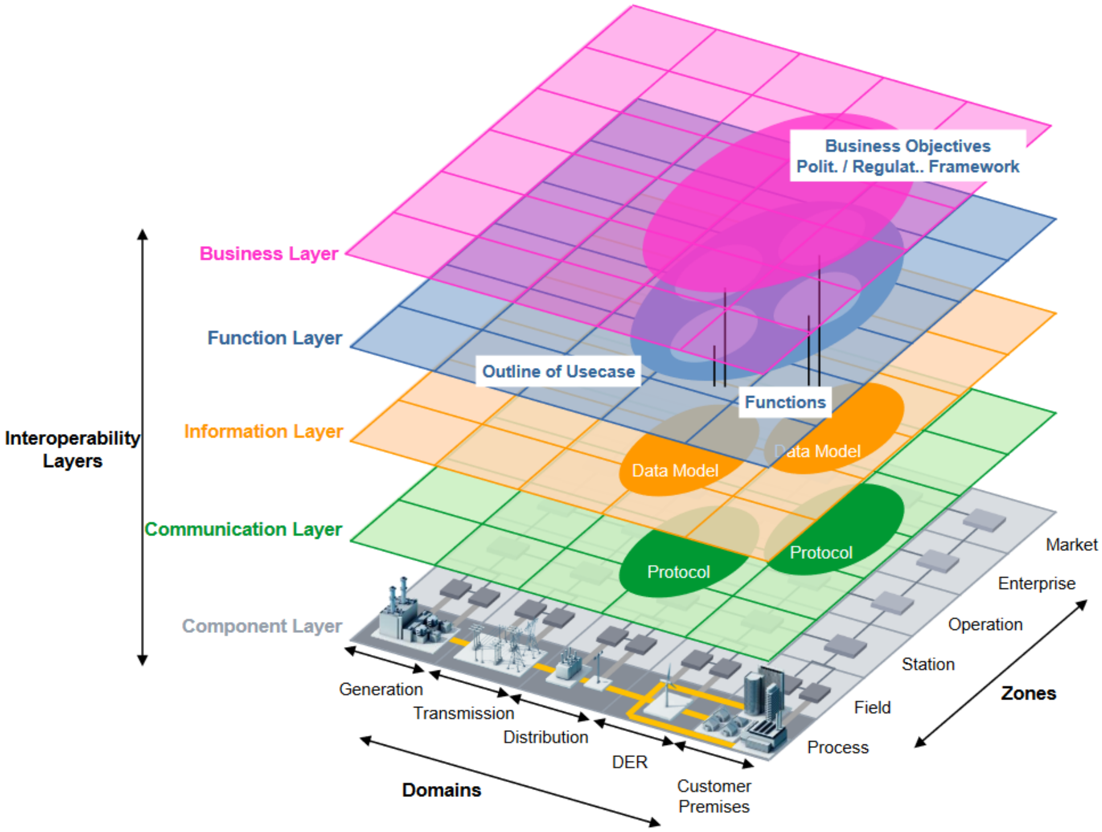
Note. From CEN-CENELEC-ETSI Smart Grid Coordination Group (2012). Smart Grid Reference Architecture.

Finally, the five layers from the GWAC-stack, together with the smart grid pane, form the SGAM-framework (Smart Grid Architecture Model), shown in **Error! Reference source not found.**. With this framework, the smart grid architecture can be described and studied, and problems can be modeled. The data quality problem of Alliander for example can be placed in this model. Alliander is active mainly in the distribution and customer premises part and data are coming from the process zone, field zone, station zone, operation zone, and enterprise zone. From the process zone this can be information about where the cables are located or how long they are laying there. From the field zone this can be information about how much power there currently is going through a set of cables. The station zone can for example say something about the power demand from a whole neighborhood and the operation zone can for example decide that one station needs to transfer power to another station because of a difference in supply and demand. The enterprise zone can be about sending engineers to where a problem is.

To conclude, the data quality problems are spread over 2 interoperability layers of the plane, which are information layer and the communication layer. More specifically, the problems are on the semantic understanding part of the information layer and both components of the communication layer.

Figure 4

The SGAM framework



Note. From CEN-CENELEC-ETSI Smart Grid Coordination Group (2012). Smart Grid Reference Architecture.

2.2 Alliander

Alliander N.V. is a Dutch utility company responsible for managing, developing, and innovating the electricity and gas grid in 5 provinces (Gelderland, Noord-Holland, Friesland, Flevoland, and parts of Zuid-Holland) of the Netherlands. More than 5.8 million customers are connected to their grid, which is made possible by more than 7.000 employees. The firm, with its head office located in Arnhem, consists of multiple business units:

- **Liander**, the largest unit, is responsible for the operation and management of the network. Other, separate business units are:
- **Qirion**, a knowledge center for complex energy issues
- **Firan**, this unit develops, builds, and manages alternative energy infrastructures
- **Kenter**, a supplier of innovations for energy metering and management
- **Alliander Telecom and Utility Connect**, a supplier of reliable telecommunication systems that are used around critical infrastructures for control and protection
- **Entrnce**, an independent B2B platform for trading between generators and users of electricity
- **Alliander AG**, that is only active in some parts of Germany and manages some infrastructures

Liander is separated from the other business units, because they are legally not allowed to be involved in the energy supply market and those business units are often outflows of large projects within Liander, large enough to be their own separate business unit. When a unit becomes a profitable, solid firm, it can be easily sold. An example of this is Allego, an electronic vehicle charging station provider, that was sold to a French investment company.

Its shares are all owned by Dutch provinces and municipalities. The largest owner, the province of Gelderland, owns 44,68% of the shares. Other large owners are the provinces of Friesland and Noord-Holland and the municipality Amsterdam. The rest is owned by more than 70 other municipalities throughout the Netherlands.

2.2.1 Mission & Vision

Alliander has stated the following mission: "*We stand for an energy supply where everyone has access to reliable, affordable and renewable energy on equal terms. This is a mission we work towards every day. It is our job to make sure the lights are on, homes are heated, and businesses can keep operating – not just today, but in a sustainable tomorrow too*".(Alliander, 2020)

They want to make a difference by focusing on reliability, affordability, and accessibility. Reliability is important because 5.8 million customers rely 24/7 on their network and electricity plays a key role in their safety. The goal is to minimalize power outages, which over 2019 was 21,9 minutes on average. This makes their network one of the most reliable networks in the world. This is made possible by advanced digital analysis tools.

Affordability is also important for their customers, so Alliander is trying to work as effective and efficient as possible. This also improves the accessibility. By keeping the costs low, energy suppliers can also reduce their prices and thus customers can freely choose their energy supplier. This keeps the net accessible to everyone, independent of their financial situation.

2.2.2 Organizational structure

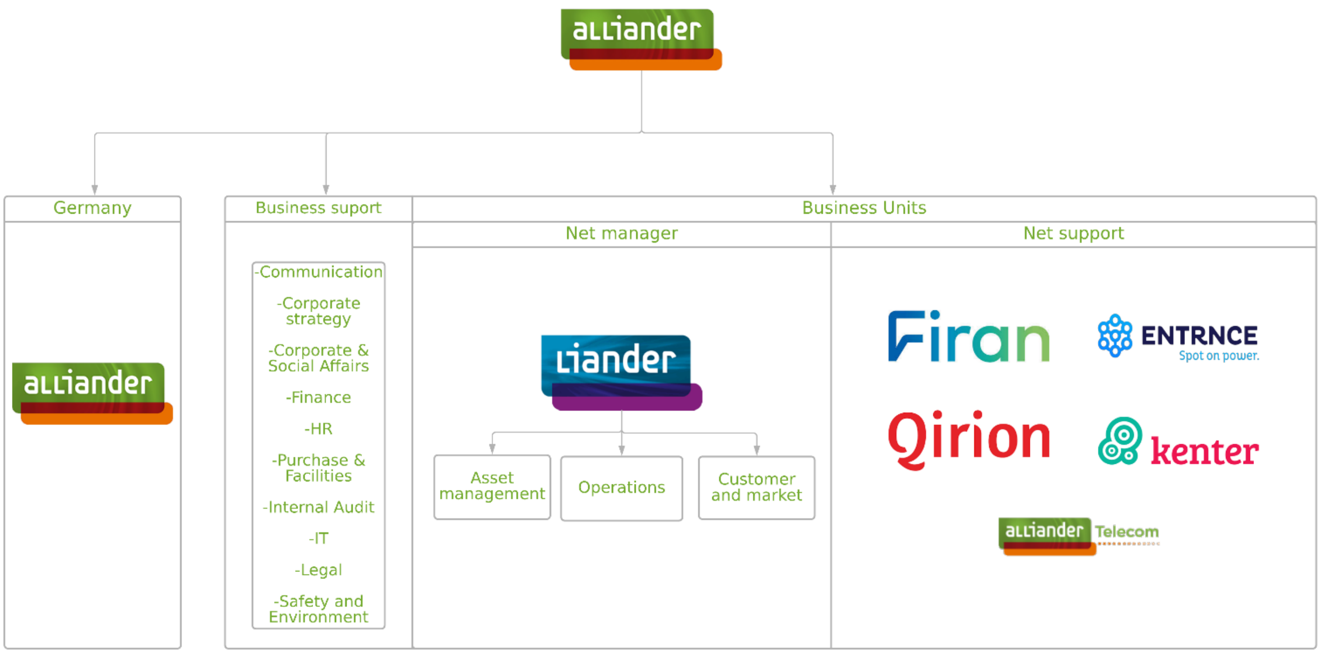
In figure 5, the organizational structure of Alliander and its business units, as stated earlier in the introduction, is shown.

Liander is the main business unit, as that is the net managing business unit. Liander consists of 3 parts: Asset management, operations, and customer and market. Asset management owns the net and manages it. Their activities are divided in seven main tasks:

- Set up asset strategy and planning
- Manage investments
- Set up policy and standardization
- Plan operations
- Manage net analysis and information
- Continuously improve and facilitate
- Innovate

Figure 5

Organizational model of Alliander



Note. Based on Alliander (2020) *Alliander annual report 2019.*

Operations is responsible for the construction of new parts of the net and does the maintenance of the net, while the department of customer and market is concerned with customer contact and market analysis. Since Liander only is responsible for the management of the net and may not supply energy, there is no direct contact with regular households. Payments to Alliander are included within the contract they have with their energy supplier. Their only contact with Alliander is in the case of problems.

Alliander does have some business customers. When a business needs a large, separate supply of energy, they encounter Customer and market, who make an offer, and then Operations builds the desired infrastructure. Asset management then digitally captures the net.

Besides the 3 mentioned business parts, which are covered by Liander, and the separate business units, Alliander also has supporting parts that other firms also have, which are:

- Communication
- Corporate strategy
- Corporate & Social Affairs
- Finance
- HR
- Purchase & Facilities
- Internal Audit
- IT
- Legal
- Safety and Environment

Under asset management there is a department “Data and analytics”. This department has the goal to create value out of the relevant asset data. Employees of this department are experts in the domain net data. The department is responsible for managing the asset data and guaranteeing the quality of the data. Another task is to use the data for predicting usage and load of the net, based on historical data and developments.

The IT department is completely agile. This means that the IT department is further divided into chapters. Those chapters are groups of specialized employees in multiple domains, for instance data & analytics and software development. Out of these groups, product teams are formed, which are responsible for a single product (application). Those products are requested by Liander and its three parts (Asset management, customer and market, and operations). Responsible for such a product team is a product owner.

2.2.3 Stakeholders

Because the electrical and gas grid plays such a major role in society, Alliander has many stakeholders, which will be briefly discussed.

There are three key stakeholders. Customers are one of the three key stakeholders. Two types of customers can be distinguished: Consumers and business customers. Consumers are the regular households that rely on the power supplied over Alliander its network. They have multiple interests in Alliander, for instance a reliable power supply, security of their data, affordable energy, and renewable and sustainable energy. They can interact in various ways with the company, for example on their website or through associations. The other group of customers are business customers, who have the same interests and mainly interact with Alliander through associations.

Employees are another stakeholder group. They are interested in e.g., a safe working environment, workplace well-being and education. Through dialogue, surveys, and associations they can interact.

The final key stakeholder group are the shareholders and investors, which are mainly Dutch provinces and municipalities. Their interests are basically all the interests that other stakeholders have. Their interaction goes by meetings, visits, surveys, and newsletters.

Besides the three key stakeholders, there are also other stakeholders. The European Union and the Dutch national government, together with local governments form the governmental stakeholders. Together with Dutch politicians, the political stakeholders, they are interested in the promotion of renewable energy, innovation, a future-proof network, and affordable energy. They interact by consultation, collaborate projects and updates.

Industry regulators, who are interested in reliability, safety and data security are also stakeholders, who keep control of the market and its companies.

The energy sector, consisting of for example energy suppliers and other net managers, have many interests i.e. reliability, safety, and innovation. Since Alliander is not performing in an open market, other net managers are not necessarily competitors, but more like partners. They can share knowledge and information with each other. They also share knowledge with another stakeholder group, which are the knowledge institutions, consisting of universities.

Suppliers exist of contractors and manufacturers, who are mostly interested in corporate responsibility.

Other stakeholders are the media, social sector organizations and partnering companies, with each different interests.

2.2.4 Current situation regarding data

There are multiple parts of Alliander concerned with data and analytics, as mentioned earlier. There are teams that are dedicated to the governance of the data, teams that are concerned with improving the data, teams that use the data for predictions and there are many other teams that have to do with data. Some parts of the database are 20 or more years old, while other parts are relatively new. Most of the data are saying something about the net, but there are also financial data and HR data.

The data of Alliander are spread over many databases and divided into many different classes with all the attributes. Rules for naming the attributes are captured in Allianders' Enterprise Semantic Model (ESM). This ESM captures the semantics of the information necessary for Alliander, for example the information required for managing the net. This can be information about for example power cables or power stations. Names of these attributes are often vague and confusing, and each attribute needs an explanation when people have to work with it. The names of the attributes cannot be changed however, since they are fixed in the Common Information Model (CIM). The CIM is a standard from the International Electrotechnical Commission (IEC) and is used to standardize data exchange between applications in the utilities sector (Electric Power Research Institute, 2015). IEC's CIM standard is used for naming information about the net, but for HR and financial information, there are other standards. This CIM can be placed in the communication layer of the GWAC-stack, on the syntactic interoperability category. Together, these standards are captured in Allianders' ESM. To increase the interoperability between separate systems, Application Programming Interfaces (API's) are used. However, naming and terminology in these interfaces are often still specific to the application supplier and Alliander, resulting in different disadvantages. These disadvantages are: Dependance on the owners of the specific knowledge, new projects cost more time because everyone needs time to understand the interfaces, high maintenance costs due to complexity, semantic inconsistences leading to misinterpretation and non-market conform standards.

2.3 Standardization

2.3.1 History of standardization

The use of standards can be seen as something that distinguishes us, the homo sapiens or humans, from other animals. That is, because probably the most well-known and oldest standard is human language. Language, according to the Oxford English Dictionary (2014) is "*The system of spoken or written communication used by a particular country, people, community, etc., typically consisting of words used within a regular grammatical and syntactic structure*". Language enables us to express what is in our head to someone else. By using language, early humans to share information with each other, discuss it, and create a plan with it. Although we were not as strong as our last real competitor, the Homo Neanderthalis, we were smarter and had more advanced language capabilities, which made that we survived and the neandertals went extinct (Harari, 2015). Animals can communicate too, for example antelopes can make a sound to notify each other about an approaching group of lions and thus flee. But humans can communicate the exact location, the size of the group and conduct a tactic to kill the lions. And because of the existence of human language, humans can maintain social relations with other humans (Aiello & Dunbar, 1993).

Standards are found everywhere, from daily life to science. The most widely known is our metric system, the International System of Units (SI), which for example describes standards for mass, time, and length (Bureau International des Poids et Mesures, 2019, pp. 125-126). Because the SI-system is adopted worldwide it enables people all around the world to effectively communicate about all the units in the system, because one meter or one kilogram is measured the same everywhere. Difficulties when not making use of a standardized unit quickly arise, because when you tell a European citizen that he/she is 5.9 foot (from the imperial system, used in the USA), he will not understand that he/she is 180 cm. The meter origins from France, where during the ruling of the French monarchy around 250.000 different measures of length and weight existed, since every town and province used its own. (Russell, 2005). During the revolution, when power over those provinces was centralized, it was decided that standards such as the meter, would be helpful to establish liberty and equality, which were two of the main motives for the revolution (Russell, 2005).

France was not the only country that started introducing standards. The British empire, where the telegraph just had been discovered, started to set up telegraph networks across the country which worked properly. But after that, they wanted to expand their network to their overseas territories, which required cables running over the bottom of the Atlantic Ocean. Over such distances, resistance of the transmitting material became important. However, there was no standard yet in how to accurately measure this resistance and so the Ohm was introduced, the standard of electrical resistance, accurately describing all the variables that could influence the resistance (Hunt, 1994).

These kinds of standards started to emerge in many countries and as a result, in the German Empire the "Physikalisch-Technische Reichsanstalt" (German Imperial Institute of Physics and Technology)" was founded in 1887, with the goal to coordinate innovation in different industries, perform research and set standards (Alter, 1993). This enabled to the German industry to grow fast and because of the success other empires and countries decided to do the same, with the USA founding the American National Standards Institute (ANSI) and in the Netherlands the "Nederlands Normalisatie-Instituut" (NNI) and the "Nederlands Elektrotechnisch Comité" (NEC) were founded, which currently form the Nederlandse Norm (NEN) (Nederlandse Norm, n.d.).

During the 20th century, the focus shifted from national standards to international standards and resulted in the foundation of the International Organization for Standardization (ISO) (Brunsson et al., 2012). The ISO provides standards in all kinds of areas (Quality, environmental, Health and safety, and many more) to every kind of organization (manufacturers, sellers, and governments for example). Closely related to the ISO is the International Electrotechnical Commission (IEC). The IEC is the governing body for electrical and electronic related standards, like power outlet plugs.

2.3.2 Standards in businesses

Businesses also have a long history of using standards. In the 18th century for example, arms manufacturers started making interchangeable parts, which made production and maintenance cheaper and easier (Russell, 2005). Standards were also formed and used during the development of the American Railroad System (Taylor et al., 1956). It made sure that trains, produced by different manufacturers, could run on tracks that were made by again another company. Because of the success, other industry groups also started to use and develop standards, such as the automobile and bicycle industry (Russell, 2005).

Standards are also used in information systems, with for example Hypertext Markup Language (HTML) being the standard language to design webpages(Cowley, 2007, pp. 108-110). Because of this standard, every web-browser can read the structure of every webpage that is written in this language, and in combination with another standard like CSS every web browser shows the pages the same way. These standards are developed and maintained by a consortium called W3C (Cowley, 2007, p. 107). Such open standards, "*standards that can have any committed expert involved in the design, that have been widely reviewed as acceptable, that are available for free on the Web, and that are royalty-free (no need to pay) for developers and users*" form the foundation of the current internet, according to Berners-Lee (2010), one of the founders of the web and internet.

An article from Meeks & Swann (2009) discusses the effects of standards on economics. According to that article, they contribute with 6 mechanisms to economic growth and efficiency. Those mechanisms are:

- Division of Labor: Already in 1776 it was noted by that it was more efficient to have a worker who is specialized in one specific part of a process than to have one who does all the parts of the process (Smith, 2010). This requires some standardization to each process, so that the person responsible for the next part of the process gets what is needed.
- Transaction costs and international trade: Standards reduce transaction costs, as confirmed by many studies (Akkermans & Van der Horst, 2002; Den Butter et al., 2007; Hudson & Jones, 2003; Nadvi & Waeltring, 2004). Examples are financial reporting standards, packaging standards and barcode standard. With such standards, costs that have to be made to establish a (international) trade, are reduced and global markets are made possible. (Den Butter et al., 2007; Nadvi & Waeltring, 2004)
- Reducing barriers to entry: Standards roughly define how something should be done. As Meeks and Swan (2009) describe, when there are no standards, companies that have been in the industry for a long time, precisely know how to do or make something, making it hard for new companies to enter. However, when there are standards that can be used, new companies do not have to find out everything by themselves, they can instead use the standards and thus save a lot of time and money.
- Co-operation to exploit network effects: This one is best explained by Metcalfe's law: The value of a network increases with the square of the number of users, while the costs are only linear (Hendler & Golbeck, 2008). So, the bigger the network, the higher the value. Because, when you have only one person with a phone, he cannot call anyone and thus the 'network' is useless. Open standards are essential for these networks, as Tim Berners-Lee (2010), says. Without these, the internet as we know it could not exist and companies and governments trying to commercialize or control it, endanger its idea (Berners-Lee, 2010).

- Innovation: Standards on one hand can benefit innovation, but also limit it. Standards benefit the earlier mentioned division of labor, because the division can help generate innovation activity (Meeks & Swann, 2009). Second, as mentioned earlier it enables new competitors in markets, thriving others to innovate, and finally, a large, open network enables companies to come up with functional add-ons, compatible with the large existing networks (Meeks & Swann, 2009). But innovation can also be limited by standardization (Shin et al., 2015). Companies can choose not to develop a new product or technology, because it will be hard to bring it on the market if it does not comply to the standards. Creativity is also impeded by standards, because they can force people to think in fixed ways (Kondo, 2000).
- Trust between sellers and buyers: As Akerlof (1978) stated, information asymmetry leads to distrust between sellers and buyers. Standards, however, can guarantee a buyer that a product from a seller complies to certain standards and thus the buyer exactly know what he gets (Boom, 1995).

2.3.3 Towards a definition

There is no standardized definition of a standard, ironically enough. But in this part different definitions and types of standards will be discussed. Here, definitions for standards and standardization are used interchangeably, as standardization can be seen as the process of developing and/or implementing a standard.

The ISO maintains the following definition: "*a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*"(International Organization for Standards, 2020). In this definition, it is clearly stated that a standard needs to be approved by a recognized body. A standard however, can also be used or formulated within an organization or within 2 or more organizations. In such a case, there is no recognized body involved. A definition by Xie et al. (2016), leaves out the governing body and states it as follows: "*Standardization is the process of developing and implementing specifications based on the consensus of the views of firms, users, interest groups and governments*". Another, totally different definition of a standard is given by the Dublin Core, that defines it as "*A reference point against which other things can be evaluated or compared"* (Dublin Core Metadata Initiative, 2020). The Dublin Core is an organization that supports the innovation in metadata design. They have set 15 core elements or properties for describing resources. Those elements are standardized in an ISO standard: ISO15836.

Brunsson et al. (2012) state a definition of a standard based on three characteristics. The first one is that a standard is a specific type or rule, which is also supported by Blind, (2004, p. 4). The second characteristic is that a standard should be voluntary and not obliged. However, powerful organizations such as large companies, can demand from other companies that they comply to certain standards, in order to do business with them (Guler et al., 2002). Or not adopting a certain standard can lead to being unable to enter a market, because the product does not function without that standard. Furthermore, an organization adopting a standard can demand from its own employees/teams that they comply with the standard. The final characteristic is that standards are meant for common use, so it basically is an advice on how to do something (Rasche, 2010). Together these characteristics lead to the following definition by Brunsson et al. (2012): "*a rule for common and voluntary use, decided by one or several people or organizations.*".

Besides different definitions, standards can also be classified in different types. Brunsson & Jacobsson, (2000, p. 4) distinguish 3 types of standards; standards about how to do something, standards about being something and standards about having something. A standard on how to do something describes a process, for example the process of making something or the process how to clean a room. A standard about being something describes what something needs to have in order to be that thing, so a meter or a football for example. The final type, a standard about having something, describes what an organization or a person needs to be what they want to be. A governmental organization needs to have an HR department for example and a person that wants to qualify for a job needs to have certain qualifications for that job.

Another distinguishment between standards is the distinguishment between de jure and de facto standards (Brunsson et al., 2012; Shin et al., 2015; Techatassanasoontorn & Suo, 2011). De jure standards are standards that are standards that get chosen by a governing body as a standard. An example is the European Union choosing to use the GSM network standard telecommunications (Techatassanasoontorn & Suo, 2011). De facto standards on the other hand, are standards that are set by the use of the public, with the QWERTY-keyboard layout as a well-known example (Shin et al., 2015). In most western countries this is the stand keyboard layout, but some countries use AZERTY.

Weitzel, (2004) divides standards in two categories; technical and non-technical. Technical standards are technologies, used in IT systems. They have one main goal, which is to ensure compatibility and interoperability, between 2 or more components in an IT-system (Ide & Pustejovsky, 2010; Weitzel, 2004). Compatibility is the property of components to work together (Weitzel, 2004). Interoperability is “a measure of the degree to which diverse systems, organizations, and/or individuals are able to work together to achieve a common goal” (Ide & Pustejovsky, 2010). Non-technical standards are simply said all other standards.

2.3.4 Defining a definition of standardization

The definition of standardization that will be used in this research is a combination of the definitions mentioned earlier and is as follows:

Standardization is the process of creating and implementing specifications based on the consensus of the views of the stakeholders, decided by one or several people or organizations, with the goal to enhance compatibility and interoperability.

This is a combination of the definitions given by Xie et al., (2016) , Brunsson et al., (2012), and Weitzel, (2004). This combination is chosen because Xie et al. (2016) clearly describes what should be in a standard. But in the context of this research, there is an organization (Alliander), that decides what standard is used, so that is why the last part of the definition Brunsson et al., (2012) is used. Also, for this research it is clear that it is a technical standard, and the goal is to increase the compatibility and interoperability of the data (Weitzel, 2004).

2.3.5 FAIR

An example of a data-standardization is the FAIR-standard. Fair contains specifications where data should comply to. The FAIR data principles origin from the scientific world and its goals are to improve the **F**indability, **A**ccessibility, **I**nteroperability and **R**euse of digital assets (Wilkinson et al., 2016). To become ‘Fair’, these principles should apply to the data itself, metadata, and the infrastructure. In Table 1 the criteria of the principles are shown.

Table 1

The FAIR guiding principles

To be **Findable**: F1. (meta)data are assigned a globally unique and persistent identifier F2. data are described with rich metadata (defined by R1 below) F3. metadata clearly and explicitly include the identifier of the data it describes F4. (meta)data are registered or indexed in a searchable resource
To be **Accessible**: A1. (meta)data are retrievable by their identifier using a standardized communications protocol A1.1 the protocol is open, free, and universally implementable A1.2 the protocol allows for an authentication and authorization procedure, where necessary A2. metadata are accessible, even when the data are no longer available
To be **Interoperable**: I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation. I2. (meta)data use vocabularies that follow FAIR principles I3. (meta)data include qualified references to other (meta)data
To be **Reusable**: R1. meta(data) are richly described with a plurality of accurate and relevant attributes R1.1. (meta)data are released with a clear and accessible data usage license R1.2. (meta)data are associated with detailed provenance R1.3. (meta)data meet domain-relevant community standards

Note. Adapted from Wilkinson, M. D., et al (2016). The FAIR guiding principles for scientific data management and stewardship. *Scientific Data*, 3(1)

2.4 Value

The concept value has different perspectives from where it can be seen. In this part an introduction to the concept of value will be given and the different perspectives and theories will be assessed. In contrast to the previous chapter about standardization, there is a clear definition, but what is more complicated is where value actually comes from. There are many theories about that subject, which will be discussed.

With a basic definition of value “the importance or worth of something to someone” (*VALUE | meaning in the cambridge english dictionary.* n.d.), it can be concluded that the concept is as old as the first humans started to possess things. The economic, perspective probably emerged when the first humans or groups of humans started to trade. Although money did not exist until probably 3000 years ago, barter did (Beattie, 2015). One of the first signs of trade is found in 30.000-year-old settlements Mid-Europe, where shells were found that origin from the Mediterranean and Atlantic coasts (Harari, 2015).

The first views on value origin from the fourth century B.C. and were written down by the Greek philosopher Aristotle (Fleetwood, 1997). He was the first to distinguish to types of value: Use value and exchange value (Vargo et al., 2008). As a philosopher, he was trying to explain differences between things and stated that things have qualities and quantities. Qualities are of use value, while quantity are of exchange value (Vargo et al., 2008). Qualities of a thing are subjective experiences related to that thing. Looking at a home for example, which can be big or small, with a garden or without or light or dark. Every person differs in what qualities are preferred and it can be explained clearly. Exchange value, however, is something Aristotle could not explain. He considered exchange value as the "quantity of a substance that could be the commensurable value of all things". He was sure it existed but did not know what it was. Two completely different things can be bartered, but then you cannot tell what the commensurable dimension (exchange value) is. He tried to measure exchange value with money and need, but both did not work. Money did not, because money could not be a measure of a substance that was not commensurable. Need held the process of exchange together but could not be measured. He also tried to measure need with money but did conclude that although need was the thing that coupled the exchange together, it was not of the same value as the exchanged subject.

Before modern economics existed, it was assumed that value was different from price; people paid for something because they saw it had value for another reason (Graeber, 2005). Value was thus defined by the use value definition of Aristotle. In that time, value was purely created satisfying people's needs (Dixon, 1990). This vision is illustrated best by the following quote dating from 1776 from Smith, (2010), describing the paradox of value:

"*The word value, it is to be observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one maybe called 'value in use'; the other, 'value in exchange.' The things which have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it."*

What creates this paradox is the fact that labor is not accounted for in this quote, which forms the basis for one of the theories of value: the labor theory of value (Graeber, 2005). More on these theories can be found later in this paper.

The modern view of value comes from the neoclassical economics, which emerged around 1870. It was the successor of the classical economic period (Bowman & Ambrosini, 2000; Graeber, 2005; Windsor, 2017). During the classical period, value was seen as a subjective measure for desire, it increased based on how much the buyer wanted to pay for it and thus was similar to the use value. (Graeber, 2005). Prices were determined by the amount of labor necessary for the product. It became indistinguishable of the price of an object.

In the neoclassical period prices were formed based on demand by customers. Value was seen as the amount for how much it could be sold on the market (Graeber, 2005). This value was thus the exchange value definition. During this period modern economic sciences emerged. The first, real economic studies were done and as a result, this perspective on value became the dominant view in further and current studies (Graeber, 2005; Vargo et al., 2008).

A more modern definition of exchange value and use value is given by Bowman & Ambrosini, (2011) and Lepak et al., (2007), who define exchange value as "*the monetary amount realized at a certain point in time, when the exchange of the new task, good, or service product takes place, or the amount paid by the user for the use value*" and use value as "*specific quality of a new job, task, product, or service as perceived by users, in relation to their needs*".

2.5 Value creation theories

Value creation is the theory of how the exchange value of a product or service is created (Windsor, 2017). In this chapter, some early or widely used theories are discussed.

The labor theory of value, one of the first value theories, states that the value of goods is derived from the amount of labor required to produce the goods (Bowman & Ambrosini, 2000; Graeber, 2005). Relative prices are expected to get to some sort of "natural price", based on the relative amount of work necessary (Graeber, 2005). This theory is an answer of Smith, (2010) to his earlier mentioned paradox, which did not take labor into consideration. One of the problems of the labor theory are that value not only comes from labor, but from many other resources and thus resulted in fluctuating prices and no "natural price" (Keen, 1993). Another problem is that labor can also destroy value and thus more labor does not necessarily mean that the value increases (Bowman & Ambrosini, 2000; Keen, 1993). This labor theory has been, as earlier mentioned, the basis for our current economic studies. It laid the focus on the good produced and basically sketched that what a firm does is using some resources, embed some value to it in the production process and finally sell it, for the market price (Vargo et al., 2008). To increase the margin, standardization and economies of scale are necessary. As Vargo et al. (2008) states it, this is the Goods-Dominant logic.

The resource based theory of the firm, that considers a firm as a bundle of resources that are valuable, rare, (partly) inimitable and (partly) in substitutable, is a theory that also describes what value is and how it is created by firms (Bowman & Ambrosini, 2000). It argues that a firm's advantage is derived from its resources and that use value for its customers is created by the labor done by the firm its employees (Wright et al., 1994). However, this labor can also destroy the value. By selling its created use value, exchange value is realized and adds up to the firm its profit, on which the firms total value gets based (Bowman & Ambrosini, 2000).

Another theory, the agency theory, argues that firms operate in a pure market economy and that the only value that is important, is the exchange value created for its owners (shareholders) (McWilliams & Siegel, 2001; Windsor, 2017). Use value (or stakeholder value as it is called in the study), in this theory, only serves as an instrument to increase (or decrease) shareholder value. Value might even be destroyed, as when that is considered necessary to increase the exchange value of its shares (Windsor, 2017).

Yet another theory is the stakeholder theory that, in contrary to the agency theory, that states that a firm not only operate in a market economy, but also in a non-market economy (Windsor, 2017). Value needs to be created for many stakeholders, and not only the shareholder, but society also needs to benefit from the value created by a firm (Schwartz & Carroll, 2008).

A step further and a totally different perspective to the agency theory and the goods-dominant logic is the service-dominant logic, which is based on the use value definition of value. In this logic, value comes from the beneficial application of resources, that sometimes are transmitted through exchange of resources or produced goods (Vargo & Lusch, 2004). This view results in that value is created by co-creation and thus not only by the firm, but by all stakeholders, such as customers, employees, and governments (Vargo et al., 2008). The job of the firm in this perspective is to use its resources and assets to co-create the value that they proposed. The value that a firm proposes, is based on their competences and capabilities, or their skills and knowledge. Table 2 gives a clear overview of the differences and aspects of the two different logics. A flaw of the co-creation theory and use-value in general is that it is hard to quantify, whereas exchange value can easily be quantified in monetary units.

Table 2

G-D logic vs. S-D logic on value creation

	Goods-Dominant logic	**Service-Dominant logic**
Value Driver	Exchange value	Use value
Creator of value	Firm, often with input from firms in a supply chain	Firm, network partners, and customers
Process of value creation	Firms embed value in "goods" or "services", value is 'added' by enhancing or increasing attributes	Firms propose value through market offerings, customers continue value-creation process through use
Purpose of value	Increase wealth for the firm	Increase adaptability, survivability, and system wellbeing through service (applied knowledge and skills) of others
Measurement of value	The amount of nominal value, price received in exchange	The adaptability and survivability of the beneficiary system
Resources used	Primarily operand resources	Primarily operant resources, sometimes transferred by embedding them in operand resources-goods
Role of the firm	Produce and distribute value	Propose and co-create value, provide service
Role of goods	Units of output, operand resources that are embedded with value	Vehicle for operant resources, enables access to benefits of firm competences
Role of customers	To 'use up' or 'destroy' value created by the firm	Co-create value through the integration of firm-provided resources with other private and public resources

Note. From Vargo, S. L., & Lusch, R. F. (2004). *Evolving to a new dominant logic for marketing*

2.5.1 Choosing a view and theory of value

For value, the use value view is chosen. This is because the value of data depends on how it is used and many potential uses of data are often yet unknown yet (Tayi & Ballou, 1998). The theory of value creation that will be used is the co-creation theory of Vargo & Lusch, (2004). The effects of a standardization will probably be too complex to try to express it in a single exchange value. Use values are easy to identify and can be split into smaller use values and therefor the concept of use value and the co-creation theory will be used.

2.6 Existing research on valuing data

Below in section 2.6.1 and 2.6.2, research into already existing ways of valuing data can be found. This parts focus on the costs of bad data quality and benefits of good data quality.

2.6.1 Costs of bad data quality

A study done by Haug et al. (2011) focused on the costs of bad data quality. They found that bad data quality can impact the efficiency of a company in a negative way, while good data quality can greatly contribute to a company's success.

Loshin, (2011) identifies four areas on which bad data quality can have an impact. Those are financial, confidence and satisfaction, productivity and risk and compliance. Financial impacts can be reduced profits, missed opportunities, fines, and delays. Confidence and social impacts are about trust from customers, employees, and other stakeholders. Productivity is impacted by higher workload, longer process times and lower quality and Risk and compliance is about higher investment risks, compliance to regulations and fraud.

Eppler & Helfert, (2004) made an overview of costs that can occur in relation to bad data quality. They classify two types of costs: Costs caused by low data quality and costs of improving or assuring data quality. The first classification can be further divided into direct and indirect costs and the second into prevention costs, detection costs, and repair costs. The costs are shown below:

- Costs caused by low data quality
    - Direct
        - Verification costs
        - Re-entry costs
        - Compensation costs
    - Indirect
        - Costs based on lower reputation
        - Costs based on wrong decisions or actions
        - Sunk investment costs

- Costs of improving or assuring data quality
    - Prevention costs
        - Training costs
        - Monitoring costs
        - Standard development and deployment costs
    - Detection costs
        - Analysis costs
        - Reporting costs
    - Repair costs
        - Repair planning costs
        - Repair implementation costs

2.6.2 Value of good data-quality

As mentioned earlier data value is hard to quantify. However, studies have tried to quantify the value of data assets. For example, a study from Belissent, (2020), which looked at how companies make revenue out of data. Companies can for example sell their data to other parties or create an API so external parties can, against a payment, use their data for their own applications. Finally, Douglas mentions 11 ways of how data can be monetized (2018, p.53):

1. Increasing customer acquisition/retention
2. Creating a supplemental revenue stream
3. Introducing a new line of business
4. Entering new markets
5. Enabling competitive differentiation
6. Bartering for goods and services
7. Bartering for favorable terms and conditions, and improved relationships
8. Defraying the costs of information management and analytics
9. Reducing maintenance costs, cost overruns, and delays
10. Identifying and reducing fraud and risk
11. Improving citizen well-being

3. Elaboration

3.1 Research design

3.1.1 Literature study

Deeper research into the Dutch utility market and Alliander has been done, as well as literature research into what standards are, what value is and how it is created, and already existing methods to value data and standardization. This can be found in section 2. This has been done to get a better view on what ways there already are and how what they take into consideration. It can be concluded that there has not yet been done much research into this specific problem, so what is found are some articles about how bad-data quality affect value and what benefits good-data quality can have. But this is too limited to be able to value a data-standardization.

3.1.2 Interviews

Interviews with employees of Alliander have been done to see what their view on the data-quality is, where they think the value of data standardization lays and what problems they think will arise when a standard is being implemented. These employees were mostly product owners, who are responsible for a certain application, and business analysts, who use data to discover potential beneficial future uses. These interviews were semi-structured, with some prepared questions to steer them into the direction where they would explain more about their problems regarding data and their ideas about where the value can be found. These interviews have only been used to get an overview of the problems regarding data-quality and have contributed only a minor part to this paper. Therefore, there is no separate part where the findings of these interviews are presented. When taken in consideration for a certain, it will be mentioned there.

3.1.3 Framework

To express the value of a data-standardization, in the following part a framework will be created. This framework will be built upon the results of the research into standardization, value, and existing methods. Also, the results of the interviews are taken into consideration. This framework can be used by the management to get a view on a certain standardization benefits the value of the company. To show how the framework works, it has been applied to Alliander. As a standardization, the FAIR standard introduced in section 2.3.5 has been used.

3.2 Creating the framework

From the literature study it has become clear that value is also created by what you do as a company for your stakeholders and that value not only is created by money or exchange value. Value also comes from how a company's stakeholders use their products or services. Therefore, a company should be aware of the values it creates. The same goes for the data. The value of data is not determined by for how much it can be exchanged, but for how it is used. These findings are also confirmed by the interviews with employees. They also say that the value of data and data-standardization lies in how it can be used on the long term. Research into existing methods to value data and a data-standardization has also proven to come short. Therefore, a new framework will be developed in this section.

The first two steps are dependent on the organization and differ for each organization. This leads to the first two steps of the framework:

1. How does the company create value?

In the first step, the company states the values it creates. These values are not only about their core business but consider their role in society and the different values they create for all their stakeholders.

2. What uses are there for the data?

The second step is identifying the different ways data is used by the company and in which processes data play a role. This should result in a list of ways data is used.

Then, it should be defined what standardization is going to take place. For a standardization, the definition mentioned in the methods is used. It is thus about implementing a set specifications. The standard can be chosen by the body responsible for the data. They can choose to develop their own standard or use an already existing standard. This leads to the next step in the framework:

3. What standardization is going to take place?

The three concepts necessary to determine the value have now been determined. In order to be able to express the value of the data-standardization, it needs to be clear how these three things are related to each other. Therefore, the contribution of the uses of data to the values need to be determined and the effects of the standardization on the uses of data need to be determined. These are the next two steps of the framework:

4. How do these uses contribute to the values of the company?

In this fourth step the found uses of data need to be linked to the value. One use can contribute to zero, one or multiple values.

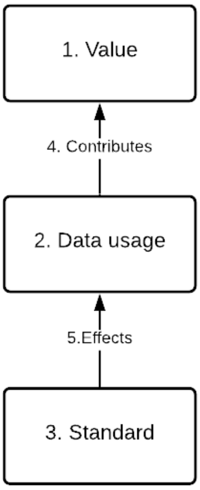
5. How does the standardization effect these uses?

In the fifth step, the effect of the selected standardization on the data uses will be shown. The standardization can influence zero, one or multiple uses.

After the first five steps, all the information necessary to express the value of a data-standardization is known. This information can now be modeled, to get an overview of the standardization effects on the value. An overview of this model is shown in figure 6.

Figure 6

The framework in a model



3.3 Applying the framework

3.3.1 Values important to Alliander

The core of Alliander is illustrated by their mission, which is to own a reliable, affordable, and accessible energy net, not only for today but also for a sustainable tomorrow. This mission is supported by its value creation model, found in the annual report. This model is shown in figure 7. It shows similarities to the value co-creation theory of Vargo et al. (2008), as Alliander focusses on the value they create for their stakeholders and involves them in their creation process. Four of those values are use-values, while "A creditworthy company with solid returns" being based on exchange value.

The first value, high reliability of supply at low costs, is also a major part of the mission of Alliander. The mission of Alliander is to keep energy accessible and reliable at an affordable way. Keeping it reliable requires excellent management of the net. An extra challenge is the increasing pressure on the net. While the demand for capacity, caused by for example new solar farms and data centers, keeps on rising, the growth of the capacity cannot match that pace. This requires even more improved management. To improve the net management, various operating processes are improved, innovations to the net are made and the effectiveness of the company is increased, resulting in organizational changes.

"A creditworthy company with solid returns", is their second value. This value is about keeping their financials healthy and proving that money, mostly received from the government and customers gets well spend, on useful investments for example.

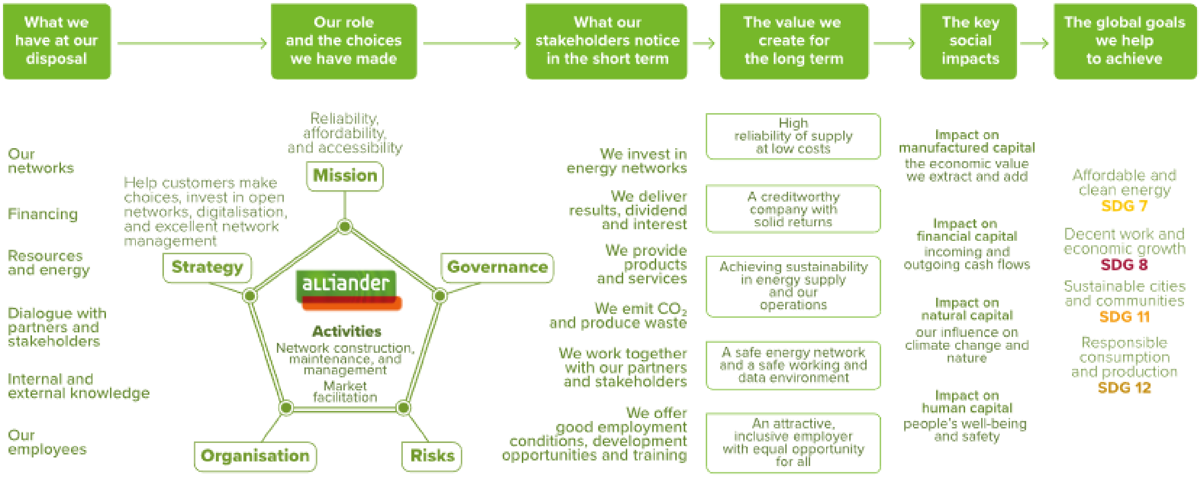
The third value, "Achieving sustainability in energy supply and our operations" is driven by the energy transition and is, as the title suggests, focused on sustainability. Not only in the energy supply, but also their own operations, focused on the internal processes.

Then there is the value "A safe energy network and a safe working and data environment", focused on safety. This safety not only regards the safety of their network itself, but also the working environment for employees and the data environment.

The last value is “An attractive, inclusive employer with equal opportunity for all” which is focused on making their workforce more diversified, but also about being an attractive employer.

Figure 7

Value creation model of Alliander



Note. from Alliander (2020) *Alliander annual report 2019.*

3.3.2 Uses of data

Data is used in different ways by Alliander:

- Business operations

Business operations is about the managing the state of the net, from maintenance to problem solving. Examples of data that support this are data from stations, where disruptions can be noticed from and data about the field assets, like cables, that say something about the age of these cables, with which other assets they are connected and their exact location. This data is then used to create other data, for example an error notification to engineers, so they can fix the problem. Maintenance planning can also be made more efficient with data, by looking at scheduled maintenances that can be done in once.

- Support investment decision making

Data about field assets and data about consumption and supply is also used to generate estimates about the state of the net in the future. Based on these estimates decisions about different investments can be made, for example if extra engineers need to be hired or if capacity of the net needs to be expanded. Or when placing new medium-voltage compartments, their most efficient locations can be calculated using data to achieve the highest effectiveness.

- Congestion management

Congestion management is there to match supply and demand. This needs to be real time data about where consumption is high or where supply is high. Data that is used for this can for example be coming from stations in neighborhoods. It can be seen as the traffic management of the net.

An example of this is that charging stations for electric cars might be temporarily turned off when there is a large peak in the demand of electricity and turned on when demand is low, and supply is high.

- Safety & trust

Data is also used to guarantee safety for employees and consumers. When for example an engineer is going to work on a cable, it needs to be guaranteed that there is no power on that cable. Another safety application, which is for consumers, is about detecting fraud, which is often committed by unsafe usage of cables and connections. This can be traced by using local station and cable data. Trust also is created by data. If it proofs to be accurate and complete, management may choose to rely more on data.

- Environmental management

Environmental management is about sharing data with other stakeholders, like municipalities and energy contract suppliers. Alliander owns a lot of data, that other stakeholders may want to use too. Municipalities can use this to for example decide whether there is capacity on the net to build new houses.

3.3.3 Relation of uses to the values

Below the relation of the different uses of data and the values of Alliander are explained. Some of them benefits are also applicable to other values because some values are overlapping, like the low costs and the creditworthy company. And a safe environment also benefits employees.

- Business operations
  - High reliability and supply at low costs: Because high reliability is depending on the state of the net and good management reduces the number of outages. In the case of outages, these can be noted as quick as possible and the time of an outage can be reduced. Outages also cost money, about 1 euro per minute per customer. With 5.8 million customers, every second the outage is reduced with saves almost €100.000. Efficient planning of maintenance helps reducing expenses and make that they can keep the price low.
  - A creditworthy company with solid returns: The above-mentioned reasons about outages and efficient planning of maintenance also contributes to this value since this is about keeping the balance between expenses and income.
  - Achieving sustainability in our supply and our operations: Business operations contributes to this value by not unnecessarily replacing assets in the field, because their state can be managed thoroughly.
  - A safe energy network and a safe working and data environment: This value is benefited because it keeps the network safe and unsafe situations regarding installations can be prevented, resulting in safety for customers and employees.
  - An attractive, inclusive employer with equal opportunity for all: By maintaining an excellent functioning and safe net, employees will be happy to work for Alliander.

- Support investment decision making
  - High reliability and supply at low costs: By making the right investments, based on predictions supported by data, the quality of the net can be guaranteed for the future and bad investments are reduced, resulting in lower costs.
  - A creditworthy company with solid returns: Returns on investments can be maximized by making the right investment decisions based on data.
  - Achieving sustainability in our supply and our operations: By making the right investment decisions the network can be made ready for new green solutions and green sources of energy.

- Congestion management
  - High reliability and supply at low costs: By actively managing the supply and demand, it can be made sure that energy is available all the time and that as less energy is wasted. It helps lowering the pressure on the net.
  - Achieving sustainability in our supply and our operations: Congestion management makes it possible that during peak hours of demand, fossil sources of energy do not need to be used and that shortages can be filled up with green energy from other places, where demand is lower, or supply is higher.

- Safety & trust
  - High reliability and supply at low costs: By higher trust in data, established by proven correctness, data may be used in more processes, making them more efficient. An example of this is finding connections that are not being paid for. They used to identify these by using the postal code and house number and then send a notification of this to that address of the connection, but there are many cases where the resident of a house is not the owner. These notifications were often ignored. But by using an id specific for identifying buildings, owners can be contacted directly. This saved the company €7 million in 2019. This may reduce the costs.
  - A creditworthy company with solid returns: The example above also benefits this value. Again, higher trust in data may make processes more efficient.
  - A safe energy network and a safe working and data environment: Data is used to keep the net safe, as already discussed under business and operations. But data used for safety can also be used to trace down fraud, because fraud is often committed in unsafe circumstances
  - An attractive, inclusive employer with equal opportunity for all: Data used for safety and creating trust in data also benefits the employers, so they can trust on data provided by them guaranteeing they work in a safe working environment.

- Environmental management
  - A creditworthy company with solid returns: Making data easily accessible for other parties can lead to a save in costs, because it is not necessary anymore to supply data per request. Instead, interested parties can easily access the data they want and are authorized to access.
  - A safe energy network and a safe working and data environment: By sharing the data with other stakeholders, they can together make sure the circumstances around stay safe

3.3.4 Effects of the intended standardization

For this case, the principles of FAIR will be applied to the data usage Alliander, as described in the methods section.

- Business operations
  - Business operations makes use of data from many different sources and contains a complex chain of applications. Therefore, introducing the principles of FAIR will make it easier to find information necessary. This is important to for example exactly locate a cable that needs maintenance. Because it is a complex chain of applications, interoperability is also important. And there are also many data created in this part, so it is important that it is reusable.
- Support investment decision making
  - In this usage of data, future predictions of the net are made and based on those predictions, decisions are made. So, it is important that the data they use, really is the data they think they use. That is why findability will improve this. Another way findability is important for this use is that the data necessary for these predictions is coming from many different sources of data. Because parts of the predictions are also based on real-time data, which needs to be easily and quickly accessible. And It is also important that the data is interoperable, so they can directly use the data delivered by other applications. The data that they produce, also needs to be reused by other applications

- Congestion management
  - For congestion management it is important that the data is accurate, which can be improved with the findability aspect of FAIR. Data is also coming from multiple sources, so interoperability will also benefit this use.

- Safety & trust
  - The findability aspect of FAIR benefits the use for safety and trust by making fraud and errors in the net easier to track down. This fraud requires detailed, accurate, and specific data, which can be benefited by improving the findability. The same goes for tracking down errors threatening the safety of the net. Safety is also about how safe the data is being kept at Alliander, so here is where accessibility can benefit the safety, by making sure that data is only accessible for the people authorized too. Trust in the data is established by proven usability of the data and as less errors as possible. This proven usability is influenced by all other data usage, so if FAIR benefits the other uses, the trust is also benefited.
- Environmental management
  - Findability benefits this use because external parties that want to access data often do not know much about the data. This access would be facilitated better if there was proper documentation and attribute names are chosen so they best describe what they are. Accessibility is also key in this use, because when sharing data with external parties, sensitive data may not be shared, and the external parties may only access the data that they are allowed to. Because this is about data that is shared with external

parties, which often use their own system and applications, interoperability is another import aspect that will be benefited by FAIR. Finally, reusability also requires that the data meets domain relevant standards, so this will make that the data that is shared can also be used by external parties. An example of such a standard is the before mentioned CIM.

3.3.5 An overview of the effects

In the following figures 8 till 12, the finding from the above steps of the framework have been modelled, so an overview of the effects of the standard on the uses of data and its benefits for the values is shown. For each usage of data, a new model is made, to reduce complexity and ease the overview. It is chosen to model the standard by its four different aspects, to also ease the overview. These models will be used to give advice to Alliander in the advice section in the conclusion.

Figure 8

The impact on the values through the use "Business operations"

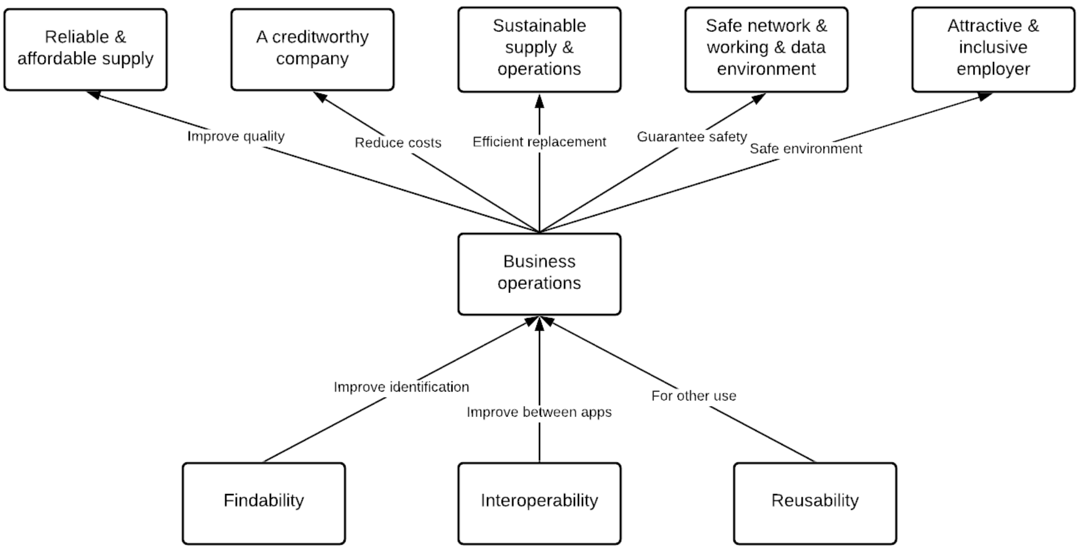


Figure 9

The impact on the values through the use "Investment decision making"

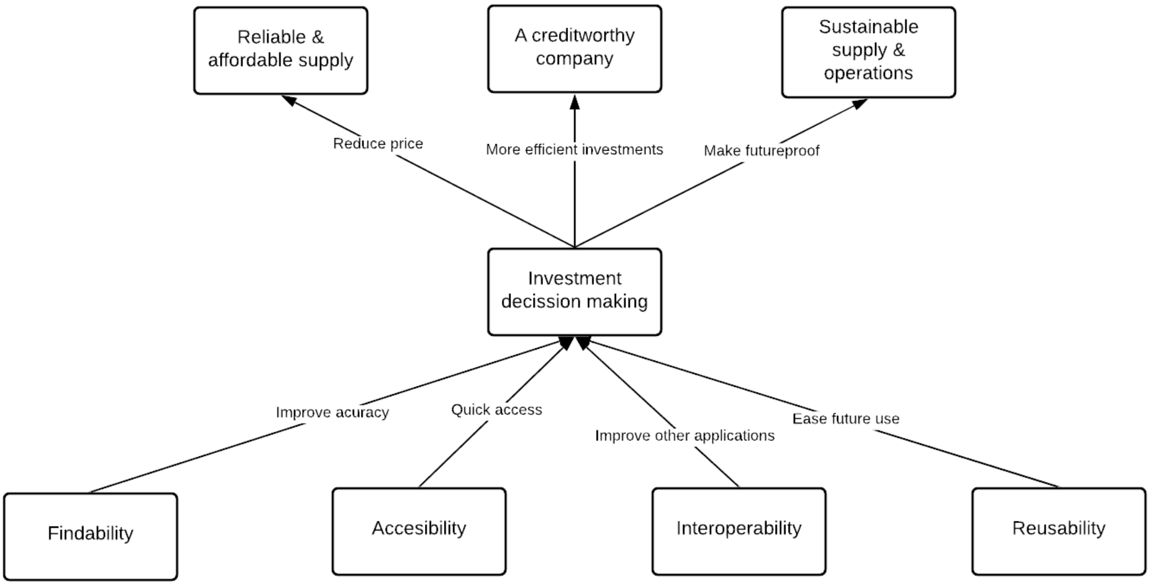


Figure 10

The impact on the values through the use "Safety & Trust"

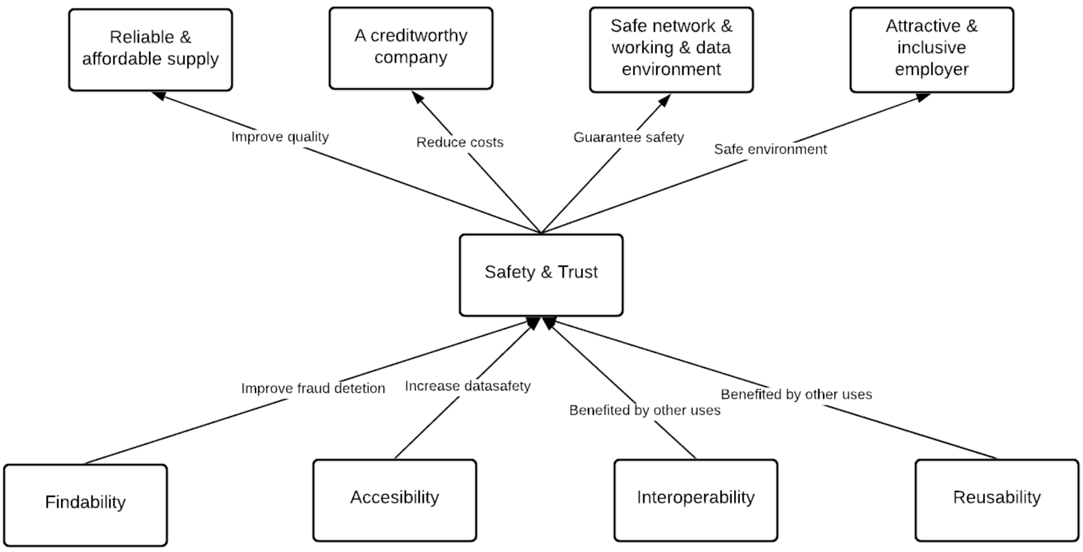


Figure 12

The impact on the values through the use "Congestion management"

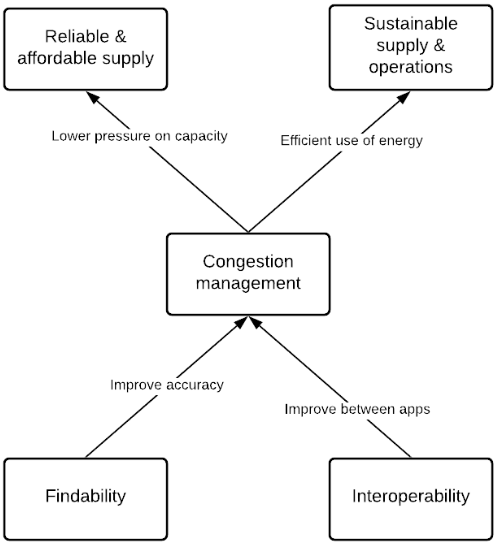
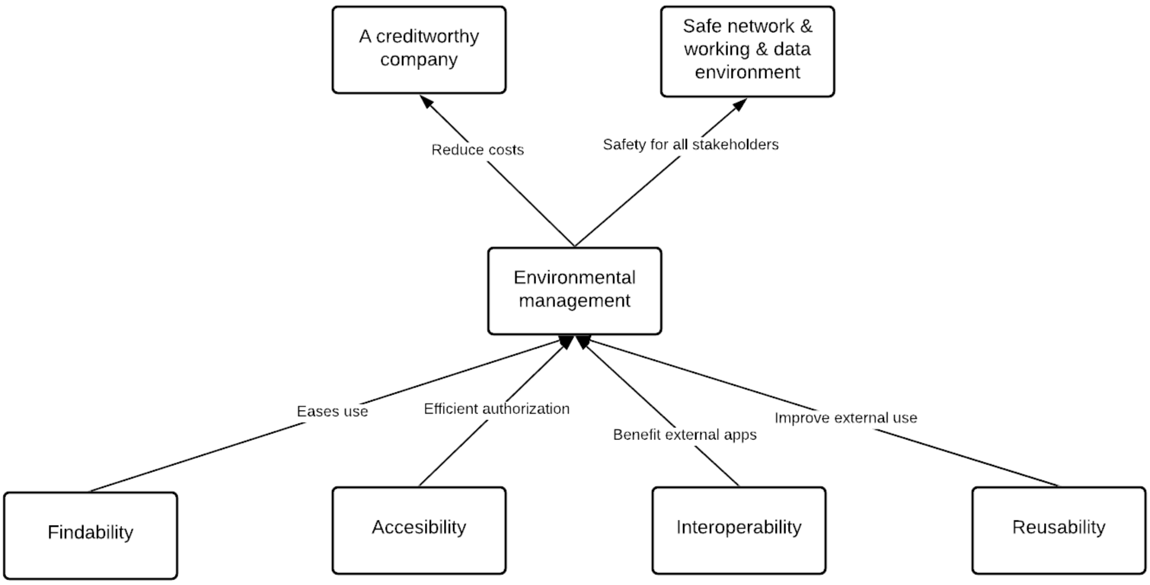


Figure 11

The impact on the values through the use "Environmental management"



4. Conclusion

4.1 General conclusion

It has become clear that valuing a data-standardization is a complex process. This is because the value of data itself is already hard to express, due to the fact that most of its value lays in its use. But by using a framework that looks at how data is used throughout a company and connecting the uses to the values the company creates, it is possible to get an overview of the value of data for a specific company. And by connecting how a selected standardization influences the uses of data, ultimately the effects of a standardization on the value of the company can be seen. So, the main research question can be answered by using a framework that is based on the use value concept.

Before getting to this answer, first some deeper research into data usage in the utility market has been done. This can be modeled using the Smart Grid Architecture model. After that, a closer a look at Alliander as a company has been taken to get a better insight in the data-quality problem.

To be able to answer the research question, first it needed to be defined what a standardization is. It was defined as "the process of creating and implementing specifications based on the consensus of the views of the stakeholders, decided by one or several people or organizations, with the goal to enhance compatibility and interoperability."

The concept of value had also to be understood. To do this, first a historical view on the concept has been done and it was concluded that there are two types of value, exchange value and use value. While exchange value is where economic studies are mostly based on, use value is a suitable way to look at value that is hard to express in exchange value. Therefore, use value was chosen as the view to express the value of a data-standardization and the co-creation theory, which is based on the use value concept, as the way to express how a company creates value.

It can also be concluded that existing literature and methods into valuing in data comes short to deliver a framework for expressing this value and therefore there has been chosen to create a new framework.

This newly created framework is made with the special conditions of the utility market in consideration, so this the framework can also be suited for other special markets like the railroad market, postal services market, or the water market. Further research for other markets however needs to be performed first.

4.2 Advice to Alliander

Based on the findings by the framework which are shown in models in section 3.3.5, it can be concluded that implementing FAIR will improve their values by multiple ways. And despite that the framework does not focus on improving on problems regarding data usage, it is clear that some will be improved on. The splintered data for example, is an often-mentioned problem, will be improved on by the findability aspect of FAIR. Therefore, the recommendation for Alliander is to further investigate on FAIR, for example on the costs. It could also be useful to more quantify the benefits. But what should be kept in mind is that this will not directly result in more exchange value (money). At first, it will require an investment, but it will make their data better robust for the future. Also, the values that Alliander creates are focused on the long term, so focus should also lay on the long-term benefits of the standardization, instead of short-term value like money. Furthermore, one often-mentioned problem, regarding data-ownership and responsibility is not at all influenced by FAIR and therefore the specification might be expanded with a principle regarding that topic or another standard regarding hat topic might be chosen to implement.

4.3 Limitations

This research was an exploratory research into expressing the value of a data-standardization. It created a framework that enables a company to couple the effects of a data-standardization to the value it creates. However, research into the concept of use-value is relatively new and therefore not many sources are available. Therefore, the fundament of the framework is based on only a few previous studies into the concept of use value. Also, research into quantifying use-values has not yet been done and therefore the results of this research are rather qualitative. This is also an opportunity for further research.

Also, the problems regarding data usage are not taken into account with this framework. This would make the framework much more complicated and would not help getting a quick, insightful overview of the value of data-standardization, because the problems directly affect the values, but also indirectly affect them through the usage of data. Although it is clear that certain problems, like bad documentation and low findability are affected with a standardization, this is not explicitly visible in the framework.

Another limitation is that no member of the management of Alliander has been interviewed. This would have given another perspective on how they perceive the value data. But this could partly be covered by thorough reading of the annual report, which was able to show in some ways how Alliander perceives data.

The framework is also applied only once, only on Alliander and not on other organizations active in different markets. As said, the utility market is a special market, without competitions and financial performance is less important.

The current situation due to Covid-19 also made that this research had to executed at home, which resulted in less productivity and made it harder to really dive into the problem, because it was not possible to really become a part of Alliander.

4.3 Further research

As said, this research was of a qualitative nature, so further research can be done in quantitative ways to express use value. Some measures for qualitative research can be time, customer and employee satisfaction scores or money.

Further research could also try to take the actual problems regarding data-quality into consideration. This has currently not been done, as explained in the limitations. Therefore, it would be a good idea to research whether problems can also be taken into consideration.

Furthermore, more research can be done in how applicable the framework is in other contexts. This framework has been created with the utility market in consideration, but this is, as said, a special market without competition and creating profits is not the main focus.

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