Universiteit Leiden

ICT in Business and the Public Sector

What new forms of eco-systems can develop when markets shift to a combination of decentralized production, decentralized distribution, and a decentralized administration process?

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Date: 26/04/2019

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MASTER'S THESIS

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Acknowledgments

I would like to thank my family and girlfriend for always being there to support me during this research.

A special thanks to Koos Nuijten for his flexibility, extensive mentorship and for continuously challenging and pushing me to new extents during the entire duration of my research.

I would also like to thank my other supervisors Mohamed Atef for his guidance and feedback during the first half of my research until he sadly had to leave the project due to a private situation, and Tino de Rijk for his flexibility to become my substitute supervisor and his contribution and thorough review of this thesis.

Last but not least, a big thanks to the company CGI which made it possible for me to conduct my research there and to use their resources and information during this research. A special thanks to Mark Hartman for taking me in his team as a valued member within CGI and to Sjors Hijgenaars for his continuous and flexible guidance and feedback during my entire thesis duration.

Summary

In various fields the traditional hard division between consumers and producers seems to be shifting: technological developments enable (some) consumers to (sometimes) perform as producers. In the taxi industry, companies like Uber use the transportation vehicles of their drivers to drive their customers around. Airbnb uses the infrastructure of their platform users to rent out places to their customers. In the electricity market, prosumers generate, consume and supply their own electricity via their own generating infrastructure.

When consumers start performing as producers, market dynamics can be expected to change. In 2008 Airbnb changed the hotel industry by providing a platform where prosumers are able to rent out their own privately owned spaces to consumers, this industry change enabled Airbnb to rent out places without having to own any property themselves[1]. In 2009 Uber launched a similar industry changing service where their taxi drivers use their own vehicles to transport their customers around, instead of using company-owned vehicles[2]. In order to adapt, companies in such potentially disruptive changes need to understand the impact of consumer-producers (or prosumers) and the accompanying decentralization.

During this research, we will take a look into how markets change when there is a shift from centralized to decentralized systems. In order to scope down our research the following research question will be used for this research: "*What new forms of eco-systems can develop when markets shift to a combination of decentralized production, decentralized distribution, and a decentralized administration process?"*.

In order to understand dynamics between producers, consumers (and sometimes third parties) in markets, we first looked into market ecosystem archetypes. The archetypes were different for each ecosystem. There are archetypes where the only relation is between consumers and the providers. Other archetypes also have a third party that for example deliver to the provider, which on their turn delivers to the consumer. This, for example, could be Uber where the drivers provide the vehicle for transport and the company provides the taxi service to the consumer.

During our next step, we focused on exploring decentralization in the electricity sector via use case. By exploring existing documentation about decentralization in the electricity sector, we were able to first describe the current ecosystem as a reference. Then we designed and used a systematic decentralization grid to explore and describe potential near future decentralization scenarios.

Our analysis shows that the electricity sector is going through a fundamental change that is driven by decentralization. This affects the role, position, and desired product and services offered by the electricity companies (and the Distribution Service Operator(DSO): infrastructure). The electricity companies need to prepare for a role shift from a traditional electricity providing company, to a service based company. Instead of offering electricity as the main product, new service products could be providing administrative services, or providing leasable infrastructure for decentralized electricity production. The main change for the DSO would be to instead of providing nation-wide power grid infrastructure, providing small community-based power grids, where prosumers will be able to supply and consume their electricity from, and to other prosumers.

Our case study shows it is possible to develop a systematic grid to evaluate future scenarios for decentralizing (and thus possibly disruptive) markets. The approach we suggest for scenario forecasting entails (1) outlining of current market ecosystem archetypes, (2) listing all relevant parties in the ecosystem, (3) systematic evaluation of centralized – hybrid-decentralized positions for all ecosystem parties – rendering (4) all possible scenarios.

Contents

1
Background

There seems to be a change happening where consumers are turning into prosumers.[3] The traditional system usually exists as a producer that produces products and consumers whose sole role it is to use whatever is produced. However, new technologies seem to make it possible for consumers to not only use products and services but also to produce them themselves, turning them into 'prosumers'. This hybrid consumer-producer role may push centralized production systems towards decentralized production scenarios in which prosumers are facilitated to also sell the products they generate.

Decentralized production seems to be happening in various sectors such as share platforms[4], 3D printing[5], and the electricity market[3]. The decentralized production is different in every sector. However, this doesn't have to mean that it is limited to only a few sectors. Different sectors may have their own way in how their centralized production can shift to decentralized production and how companies can adjust and position themselves in this shift. Companies that act quick on these changes, may empower themselves towards a change leadership position.

Share Platforms offer a service, enabling prosumers to open their own resources to consumers, without the company having to own any products themselves. These companies feature as an administrative intermediate that takes care of the platform services and payments. Example of share platform companies are "Snappcar", that provides a platform where prosumers can open their own vehicle to consumers to use[6]; "AirBnB", that allows prosumers to open their own house as a location to sleep[7]; "ShareDnD", where amateur cooks offer their kitchen as a restaurant to consumers[8]; "Bsit", where independent babysitters offer their services to consumers[9].

The invention of 3D printing enables prosumers to design, print and share their own printed products as an alternative option next to buying these products at stores. 3D printing enables prosumers to make customized products based on their own needs and requirements. Probably, these personalized products can be a better fit for each individual than the standardized products available in stores[5]. Privately owned solar panels allow prosumers to generate their own electricity. Electricity they could also decide to sell to others. The small scale private investments in solar panels are showing a steep upward trend: In 2016 alone the investments in solar panels was more than the total of the five years preceding [12].

One of the reasons for this increase in prosumer investment the lead time for ROI break even is becoming shorter. Solar panels have started to add value to households and they generate free clean electricity. Solar panels can be bought individually, or with a group. Moreover, if there is no capital available to buy them, there is also the possibility to rent or lease [13]. It's estimated that in 2050, 7.2 million Dutch residents, around 40% of the total population, becomes a small electricity prosumer[14].

Given this context, it seems logical that in the electricity sector, the clear black and white positions of consumers and producers are shifting. Of course, this shift can have various drivers. Consumers may decide to invest in becoming a prosumer because it is attractive to them in a financial way, or because of environmental reasons, or because of society benefits.

The production decentralization is not happening in a vacuum. The introduction of decentralized administration processes may speed up the shift to decentralized production. Decentralized production enables prosumers to create their own products. However, the administration systems or organization behind the services such as for example share platforms, are still centralized. To benefit the full potential of decentralized production, the centralized administration process may also need to decentralize. Decentralization in administration could, for example, enable prosumers to make direct peer-to-peer transactions without having the involvement of third-party intermediates.

Companies like Airbnb and Uber use prosumers for decentralized production, but themselves they still remain functioning as centralized companies, using centralized billing processes that still puts the organizational dominance within the company instead of in the network. Since Airbnb and Uber use the resources, in this case, the houses and cars of the prosumers, they don’t own and use their own products. However, since the prosumers still use the company platform to contact consumers and consumers still use the platform to find the prosumers, the company will always remain an intermediate. The transactions are also made by the consumer to the company, and from the company to the prosumers[15]. This means that as long as this centralized administration system is in place, the company will always remain a central power in the process.

What would happen when the transactions also happen decentralized? Decentralized administration would take away the centralized authority between the prosumer and the consumer. Since payments would be made directly to one another in a peer-to-peer system, there wouldn’t be the need for a third party to process these transactions[16]. This can be compared with exchanging cash in a face to face transaction. The transactions would be done directly without having to wait for the processing time of the intermediate and also without having to pay any fees for using their services.

Decentralized administration can change the position of prosumers at a fundamental level and therefore accelerate and enhance the already existing shift from consumers to prosumers. Decentralized production already enables prosumers to generate their own products. However, centralized payments still limit the possibilities of this shift. Combining decentralized production with decentralized administration would not only enable prosumers to generate their own products but also to independently sell their products in a peer-to-peer system to other consumers or prosumers without any intermediates.

The combination of decentralized production and decentralized administration can have the potential to disruptively change the current ecosystem. The current ecosystem is built in a top-down system where producers sell products to consumers and the consumers pay the producers via a third party, a bank. Enabling prosumers to generate and sell their own products directly to other prosumers or consumers without the need of any third party, can have the potential for them, to start their own ecosystem where they manage their own supply and demand.

This research focuses on the following research question: "*What new forms of eco-systems can develop when markets shift to a combination of decentralized production, decentralized distribution, and a decentralized administration process?*".

Closely in line with the description given in Encyclopedia Britannica, the definition of ecosystems used in this research is "The interactions and interrelationships between all parties in a particular market or sector".

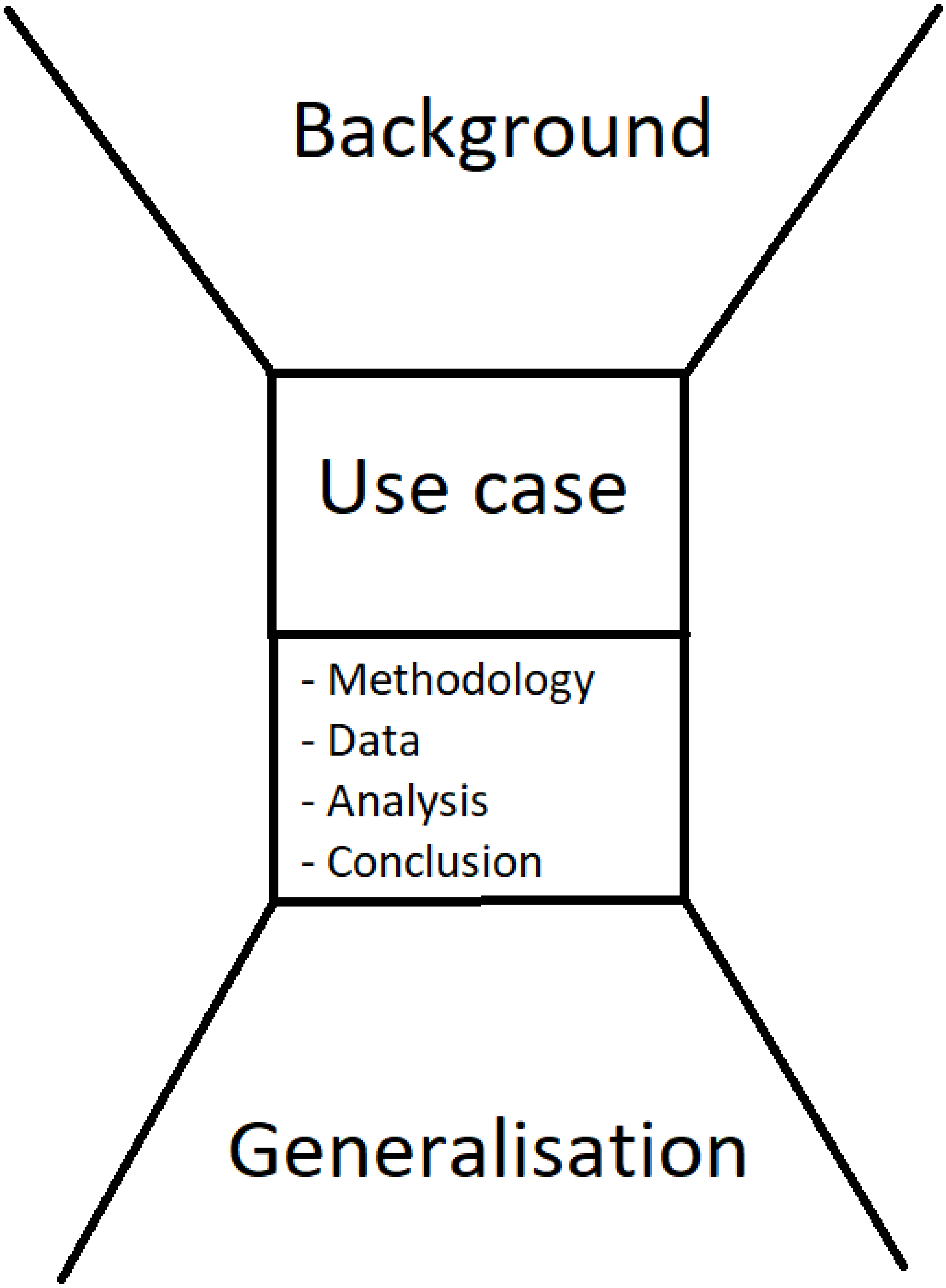


Figure 1: Thesis structure

2
Research

In order to determine what new forms of ecosystems can develop, we had to explore the current archetypes of ecosystems first. An archetype is a typical example of something, or the original model of something from which others are copied[20, 21]. By exploring the current archetypes, it gives us an understanding of what kind of interrelationships there are and how these ecosystems work. The explored archetypes will provide a baseline for our research on how these ecosystems could change when markets shift to a combination of decentralized production and decentralized administration.

It's impossible to explore every single archetype of every ecosystem during this research, therefore we will only focus on utility sectors. Within the utility, we will focus on the following sectors: transport, communication, recycling, water, gas, and electricity. Note that this is an extended but not complete list of utility sectors.

Transport sector
The transport sector is divided into three different archetypes, public transport, private transport and mobility as a Service[22]. Consumers have the possibility to pay fares to use the public transport products, but there is also the possibility to buy or rent their own transport product. Some of these archetypes have developed multiple ecosystems with different interrelationships. The following archetypes and ecosystems have been discovered during the exploration.

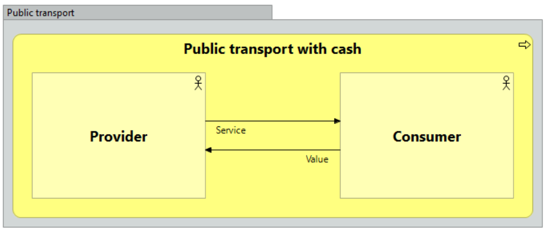


Figure 1: Public transport cash payments

Public transport is a form of transport which is available to the general public[23]. The public transport providers provide a service to transport the consumers to their destination, while the consumers pay the providers a fare to use this service[24]. Payments can be made directly with cash(Figure 1), or via a third party service such as a Chipcard(Figure 2). These third parties earn their money with consumers buying the Chipcard[25]. Examples of public transport are trains, trams, metros, buses, airplanes, and boats[26].

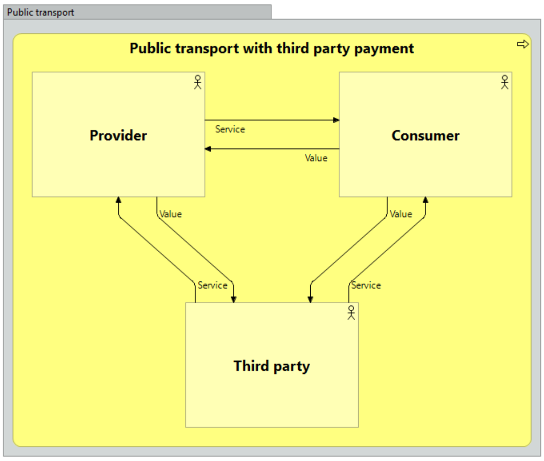


Figure 2: Public transport with third-party payment system

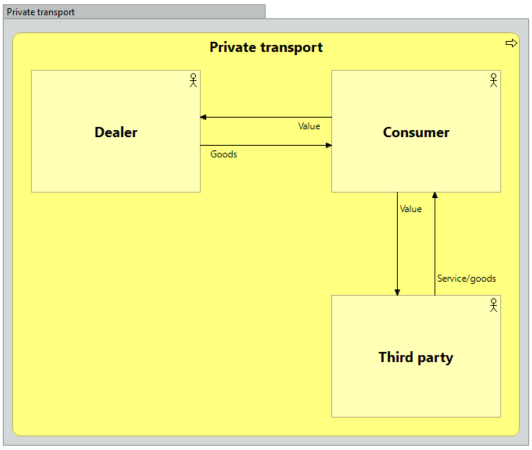


Figure 3: Private transportation

Private transport is a form of transport which is not available for use by the general public. Instead of using a third parties product for transportation, consumers can also buy their own transportation product. To receive the product, the consumer pays a one-time price to the product dealer[27]. However, extra third-party fee's may apply. These fees could be taxes (usage of the road, pollution, etc.) or operational costs (fuel, maintenance, insurance, etc.)[28](Figure 3). Examples of private transportation products are cars, bikes, boats, motorcycles, airplanes, and helicopters.

Mobility as a Service enables consumers to buy mobility services based on their needs instead of buying the means of transport[29]. Besides paying a party for transportation or buying a transport product yourself, there is also the possibility to rent a transport product. There are parties that provide their product for use to consumers but stay the owner of the product. The consumer pays a fee for the time they use the product, and once they are done with the product, the product returns to the owner. There are two kinds of providers, providers that own and rent their own product[30](Figure 4) and providers that don't own their own products, but rent products of third parties[4](Figure 5). Examples of providers that rent

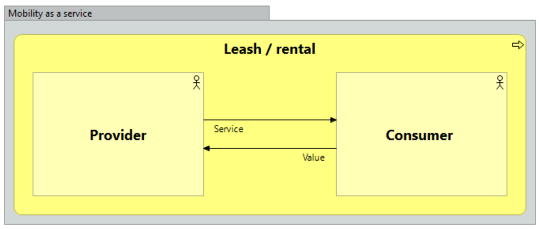
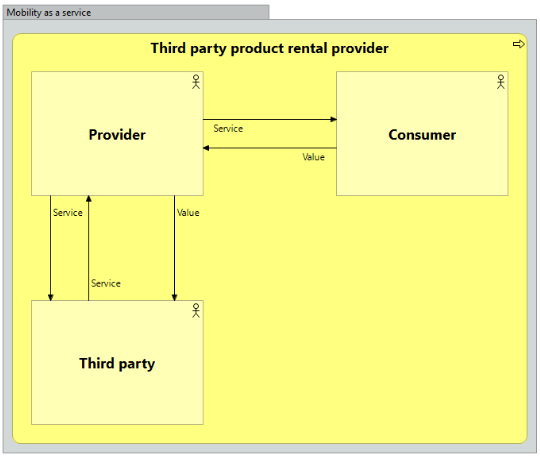


Figure 4: Mobility as a Service – Provider

their own products are “Sixt”[31] and “Hertz”[30] and an example of a provider that rents third-party products is “Snappcar”[32].



Communication sector

The communication sector only exists out of communication as a Service. Communication requires a large and complicated infrastructure, something that consumers don’t want, or are capable to deal with. In order to still be able to communicate with other individuals, consumers turn to communication as a Service. Communication as a Service is just one archetype, but there are many types of ecosystems in this archetype.

Communication as a Service enables a consumer to buy the communication service such as the internet, telephony, and media instead of buying the means to communicate. During our exploration, we divided the communication as a Service archetype into four different ecosystems. In the first ecosystem, there are providers that provide direct services to consumers without any third party involvement[33]. Consumers pay a periodic fee to use these services[34]. Examples of direct providers without third-party involvement are internet- and telephony providers(Figure 6).

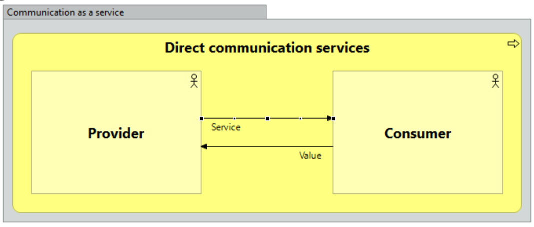


Figure 6: Communication as a Service – Direct communication services

In the second ecosystem, there are also providers that provide a service, without owning the service product themselves. The consumer still pays a fee to the provider for their services, but the provider pays on their turn a fee to the third party for using their product(Figure 7). An example of companies providing this services are “Telfort” that uses the network of “KPN”, “Tele2” that uses the network of “T-mobile”[33] and media channel like “Netflix”[35], “HBO”[36] or “Pathé thuis”[37] that rent content for their platform.

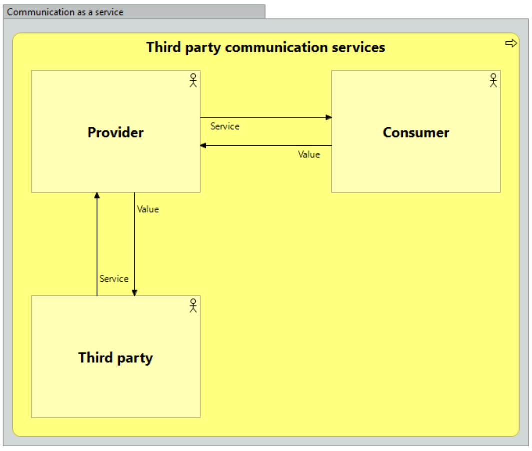


Figure 7: Communication as a Service – Third-party communication services

The third ecosystem exists out of providers that provide direct services to consumers but have third party content included. The providers provide a service to the third party to add their content to their customer services in exchange for a fee, this could be advertisements or commercials[38]. The provider then provides their services to the consumer which receives both their desired content as the paid third-party content. This paid content may lead to the consumer purchasing services or goods from the third party, enabling a new product and value exchange between the two parties. Depending on the type of services provided to the consumer, there may also be an optional value exchange from the consumer to the provider(Figure 8). Examples of free service with third party involvement are free newspapers[39] and radio channels[40]. Examples of paid services with third party involvement are public television[41], paid newspapers[42] and paid magazines[43].

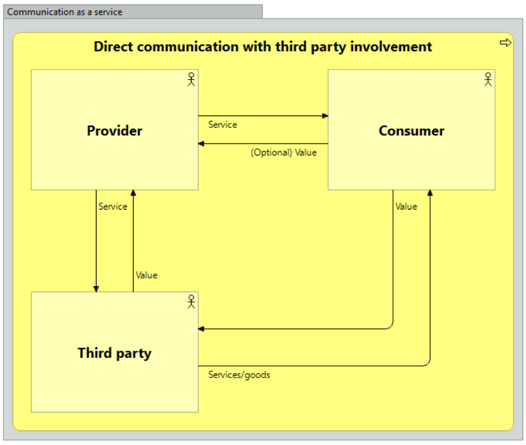


Figure 8: Communication as a Service - Direct communication with third-party involvement

The fourth ecosystem exists out of providers that provide a platform service to their customers. However, the content on these platforms is not produced by the providers, but by the platform prosumers in the form of a service. Just as with the third ecosystem, third parties are able to buy services from the provider to broadcast their paid content to the platform users(prosumers and consumers)[44]. Both the prosumer content and paid content are provided to the platform users. The paid content can then lead to the users purchasing goods or services from the third party. Based on the platform, there may be an optional value exchange from the provider to the prosumer for the content creation(Figure 9). An example of a prosumer paying social media platform is Youtube[45], where prosumers get paid based on the number of views they get on their content[46]. Examples of social media that doesn't pay prosumers are Facebook[47], Twitter[48] and Instagram[49].

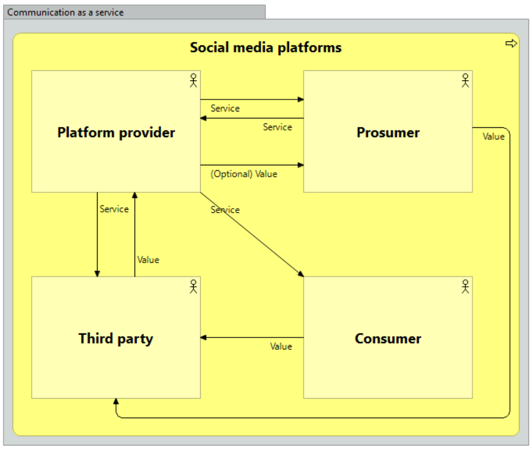


Figure 9: Communication as a Service - Social media platforms

Water sector

The water sector exists out of service based archetypes. There is the possibility to have water as a Service where water directly gets delivered to your location through for example pipelines[50], but there is also the possibility to buy your own water product at public locations such as supermarkets or other stores[51]. Both offer you the service to clean water without having to own or rent the means to produce clean water.

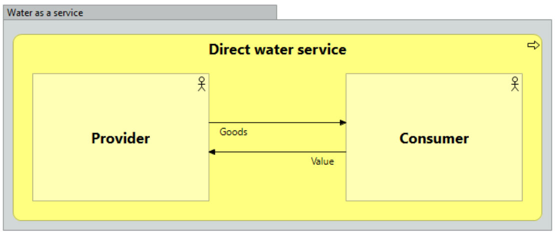


Figure 10: Water as a Service - Direct product service

Water as a Service provides clean water to consumers without having to buy the means to collect, purify or dispose of clean water. During our exploration of the water sector, we came across two ecosystems. The first ecosystem exists out of a provider that directly provides clean water to the consumer. The consumers pay for the amount of water they take from the water system to the provider(Figure 10). Examples of pipeline water providers are "Dunea"[52], "Vitens"[53] and "PWN"[54].

The second ecosystem exists out of providers that buy their water products from third parties such as water purification companies or wholesales[55] and re-sell their products for a higher price to consumers[51]. The third party will, therefore, deliver their goods to the provider and the provider pays the third party for these goods. The provider will then offer their products to consumers, and the consumers pay the provider for their product(Figure 11).

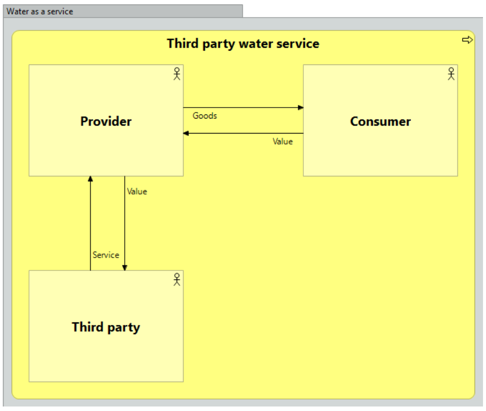


Figure 11: Water as a Service – Third-party product service

Recycling sector

The recycling ecosystem exists out of public recycling, private recycling, and recycling as a service. People can dispose of their products into public available bins or junkyards, sell their goods to other consumers/prosumers or have their goods get picked up by a junk collection service that disposes of the products for them.

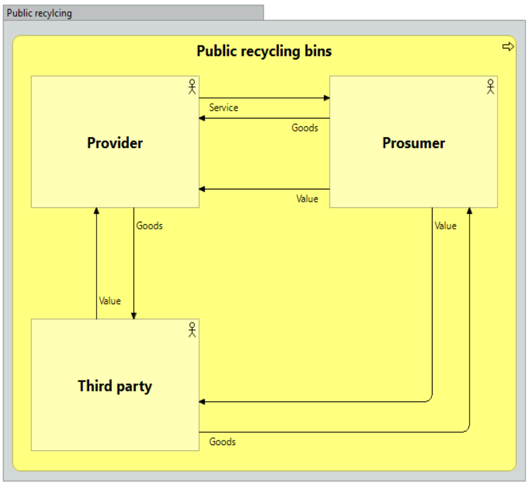


Figure 12: Public recycling

The public recycles system enables consumers to dispose of their waste into public waste bins, drop-off points, buyback points, and source separation bins.

A public recycling ecosystem is where providers provide consumers with publicly placed waste bins[59] or junkyard[60]. The consumer pays a fee (taxes) for the service[61]. The provider than either collects the waste themselves or hires a third party to do this. The provider then collects and sells the recycling goods to a third party recycling company. The third party than recycles the goods such as for example paper and glass or plastic bottles. These products will then be sold again to consumers and prosumers(Figure 12).

A second ecosystem is where providers provide a service where you can sell your goods to them. At the same time, both prosumers and consumer can buy these second-hand products from the provider in exchange for a fee(Figure 13). An example of a used product buying store is "Gamemania"[62].

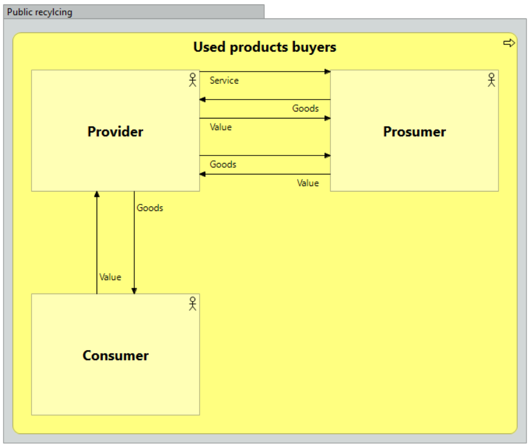


Figure 13: Public recycling - Used product buyers

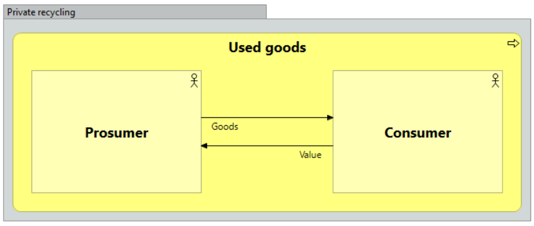


Figure 14: Recycling as a Service - Used goods

Private recycling enables prosumers to recycle their own products directly without third party involvement. The prosumers sell the goods directly to consumers and the consumer pays the prosumer the price of the goods(Figure 14). An example is when someone sells a used television to a neighbor. The prosumer gives the television to the neighbor and the neighbor pays the prosumer the television price.

Recycling as a Service enables consumers to buy the recycling service instead of having to move their waste to the designated public collection points. Just as with public recycling, there are two kinds of wastes. Waste that gets destroyed, and waste that gets recycled. In both cases, the provider offers a service to collect the waste at a certain location and time. In the case of regular waste, the provider collects the waste for free. The provider then transports the waste to a third party waste processing company in exchange for a fee(Figure 15).

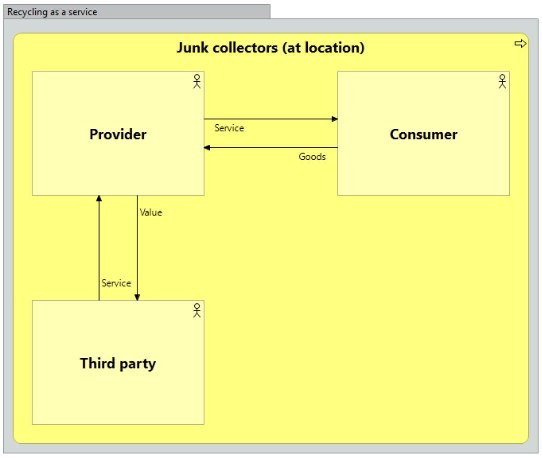


Figure 15: Recycling as a Service - waste

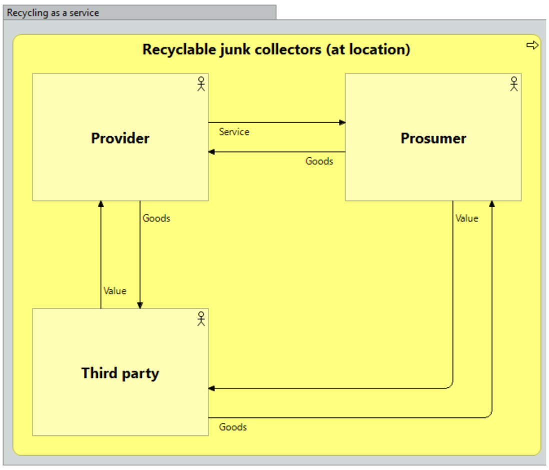


Figure 16: Recycling as a Service - Recyclable goods

In the case of recyclable goods, the consumer transfers the recyclable goods to the provider. The provider then sells the goods to a recycling company which on their turn sells the recycled goods such as paper, glass or bottles back to consumers or prosumers[63](Figure 16).

Gas sector

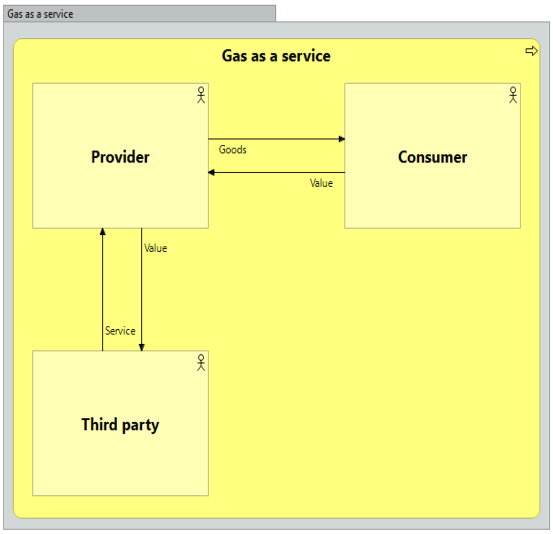


Figure 17: Gas as a Service - direct

The gas ecosystem exists only out of gas as a Service. Harvesting gas is a specialized process which is not available to the general public. Therefore, gas harvesting is done by specialized companies that provide the harvested gas to consumers, enabling gas as a Service[64].

Gas as a Service enables consumers to buy a service to consume gas instead of buying the means to produce gas. The gas as a Service archetype exploration showed us that there are two types of ecosystems in which gas gets provided. Gas can either be provided directly from the provider to the consumer through for example a pipeline system where the consumer pays the provider for the consumed gas[65], or the provider provides gas canister goods to consumers. The provider buys the gas from a third party and resells them for a higher price to consumers[66](Figure 17).

Electricity sector

The electricity ecosystem exists out of a private electricity system and electricity as a Service. Electricity used to be only generated by big centralized power plants, however, recent changes enabled prosumers to invest in infrastructure such as solar panels to generate their own electricity[67]. This enabled a new archetype "Private electricity" besides the already existing "Electricity as a Service".

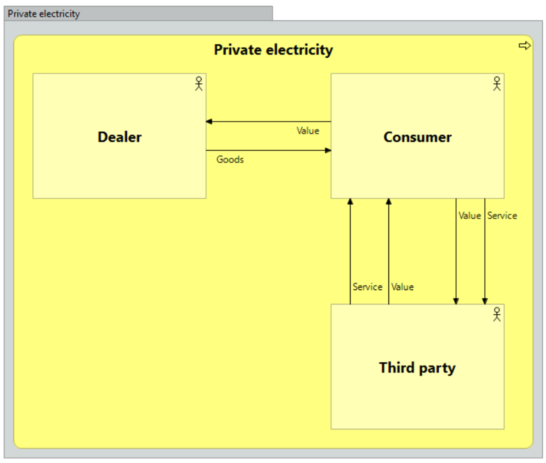


Figure 18: Private energy

The private electricity system enables prosumers to generate their own consumable electricity using their privately owned means. The prosumer buys solar panels from the dealer for a fixed price. The prosumer than starts to generate electricity which they can consume themselves. However, not every prosumer generates enough electricity to be independent of the traditional electricity supplier[68]. Therefore the electricity supplier still supplies electricity to the prosumer whenever they need more electricity than they generate. The consumer pays the electricity supplier for the electricity they consume from them. The consumer can however also generate more electricity than they can consume in real time. When this happens, the electricity gets supplied onto the third party electricity grid, the energy supplier pays the prosumer for the supplied electricity[69](Figure 18).

The electricity as a Service enables consumers to buy a service to consume electricity instead of buying the means to generate electricity. The providers buy electricity from a third party and resell this as a constant electricity service to the consumers[70]. The consumer pays the provider for the consumed electricity(Figure 19). Some examples of providers are “Essent”, “Eneco” and “Nuon”[71].

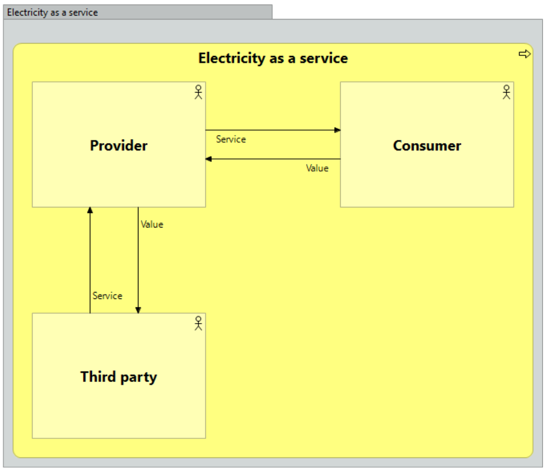


Figure 19: Electricity as a Service

Further project scoping: Deep Dive on the electricity sector

The amount of archetypes present in the chosen utility sectors is still too much to cover during this research, therefore I chose to scope down even further and to only use the electricity sector as a use case and to use blockchain for decentralized administration. The reason I chose the electricity sector over the other sectors is that there is already a change happening in the electricity sector. The shift from centralized production to decentralized production makes this sector a perfect sector for this research. Due to the knowledge and expertise in the electricity sector available at CGI, the company we are researching for, this sector is also a convenience case.

Each of the sub-sectors water, gas, and electricity in the electricity sector have their own business drivers depending on their archetype. A business driver is a resource, process or condition that is continued success and growth of a business. Changes in these drivers can have an impact on the business, and it’s no longer the question when the next change will take place, but who can signal this in time and anticipate this. Identifying and monitoring business drivers can enable businesses to anticipate these changes in time. The water, gas and electricity sectors all exist of the “as a service” archetype, however, the electricity sector also exists out of an extra private electricity archetype. The following drivers could be drivers in the electricity sector.

Water / Gas / Electricity as a service drivers	
Provider	**Consumer**
Demand[72]	Convenience
Financially attractive[73]	Financially attractive
Sustainable[74]	

Table 1: Water/Gas/Electricity as a service drivers

Private electricity system drivers	
Dealer	**Prosumer**
Demand[75]	Affordable[76]
Financially attractive	Financially attractive[77]
	Environmentally friendly[78]
	Independence of electricity supplier
	Sustainable[78]
	Participation in electricity supply

Table 2: Private electricity drivers

By taking a closer look at the drivers and exploring the factors that influence the drivers, it will provide us with a more detailed view of the existence of these archetypes. Each of the drivers depends on a set of factors, these factors influence the drivers. Changes in these factors will determine what kind of drivers drive the archetypes. If for example due to the scarcity of resources the production cost of electricity becomes more than the selling price, "Financially attractively" could no longer be a driver for this archetype. The following factors could be factors that influence drivers.

Water / Gas / Electricity as a service	
Provider drivers	**factors**
Demand[72]	Stable/increasing economy Increase in population / urbanization Increase in technology
Financially attractive[73]	Production costs Competitors
Sustainable[74]	Daily prosumer needs (water/gas/electricity) Complex electricity production/purification process
Consumers drivers	**factors**
Convenience	No means required
Financially attractive	Service costs less than self-production/purification

Table 3: As a service driver factors

Private electricity system	
Dealer drivers	**factors**
Demand[75]	Prosumer drivers
Financially attractive	Product production/buy-in price Competitors
Prosumer drivers	**factors**
Affordable[76]	Production costs
Financially attractive[77]	Electricity re-sale Electricity sell price
Environmentally friendly[78]	No pollution
Independence of electricity supplier	Decentralized production
Sustainable[78]	Energy source availability Mean lifespan
Participation in electricity supply	Decentralized production

Table 4: Private electricity driver factors

Due to already existing production change happening in the electricity sector, the electricity sector makes an ideal sector to also research the potential of decentralized automated value exchange. The two archetypes in the electricity sector show the already existing difference between centralized production (as a service) and decentralized production (private electricity system). The private electricity system pulls the electricity ecosystem closer to the prosumer, making them more independent of the electricity supplier. However, besides the decentralized production, there are still centralized processes required.

To push the boundaries of independence of electricity prosumers, we will explore the possibility of decentralized automated administration, with blockchain technology as an enabler. Centralized administration limits the possibility for prosumers to choose their own electricity customers and to also set their own electricity price. Decentralized automated administration can be the process where these limitations are broken and allow prosumers to sell their electricity to other prosumers or consumers and set their own prices.

3
Methodology

The approach used during the research is a case study as it focuses on a single unit for analysis, taking that single unit as exemplifying for a wider series of units. The reason for choosing a case study on the electricity sector instead of doing multiple case studies is because the electricity case study will be a representation of what changes to expect in other sectors as well.

3.1 Current situation

3.1.1 Document analysis

We chose for document analysis as a data collection method. The reason for choosing document analysis is because it's less time-consuming and therefore more efficient than other research methods. Many documents are also in the public domain, especially since the advent of the Internet and are openly available[79]. The inclusion of exact names, references, and details of events makes documents advantageous in the research process[80].

Documents used during, but not limited to, the document analysis are about the electricity sector and blockchain. The documents about the electricity sector describe the market structure[81]. By analyzing the documented organizational structure it gives us insight about the actors involved in the organization, the existing business processes and the roles in these processes. The blockchain documents will give us a basic understanding of blockchain and the technology behind it.

To be able to run a representative use case, the documents used require to meet certain criteria. The electricity sector and available technologies are constantly changing, therefore it's important to use up-to-date information in order to collect accurate information. To ensure that the research documents have the right qualifications in terms of knowledge, experience and accurate the following criteria have been developed:

Document criteria & requirements	
Criteria	**Requirements**
The document has to contain up-to-date information	Documents are not older than 10 years
The document has to come from a reliable publishing source	Source has to be either a credible University or Organization
The material has to be correct	The material has been peer-reviewed or is in line with other sources
The information has to be verifiable	The material has to provide additional references to the source of information

Table 5: Document requirements

Documents were accessed using credible publishing sources. The main documents used in this research were about the electricity sector, blockchain, and small prosumer processes. The documents were found using Google scholar, Researchgate and the Mendeley database. For blockchain, we also used many web pages, blogs, and forums of related content.

3.1.2 Expert validation

Expert validations are conducted as a data validation method, this enables the researcher to validate his initial understanding of certain subjects. Participants are able to share their experience and knowledge about certain subjects related to the research and validates the informational understanding of the researcher. This method verifies the information found during the document analysis with the practice.

Validation participants include data processing parties such as Energie Data Service Nederland (EDSN) and energy industry consultants. The sample size for validation was irrelevant as its goal was to collect rich amounts of information rather than being a representative of a large group[82]. To ensure that the validation participants have the right qualifications in terms of knowledge and experience the following criteria has been developed:

Expert validation participants	
Criteria	**Requirement**
Experience in the data processing service of the electricity supply process	At least five or more working years in data processing service.
Experienced in the electricity industry	At least five or more years of experience in the electricity industry (supply/distribution)

Table 6: selection criteria for validation participants

Data collection procedures

The researcher used his network to find participants for the research (convenience sampling). However, all participants were selected for their extensive experience in their working field and in the electricity sector.

3.2 Expected (near) future situation

Expert interviews

Expert interviews are conducted as another data collection method, this enables participants to share their experience and points of view towards certain subjects. Participants are able to share their experience, stories and give an in-depth answer that focuses on the participant's experience and opinion related to the research topic throughout an interview[83]. The structure of these interviews can range from highly structured to unstructured[84]. There are multiple factors that affect the degree of structure that is used in the research such as the purpose of the study and the availability of the participants[85].

This research will use semi-structured interviews with the participants. As we were able to obtain a basic understanding of the electricity sector and blockchain technology from the examined documents, we were able to interview in a semi-structured way. Semi-structured interviews give the researcher the ability to have a more flexible start of the interview with a brief introduction of the idea and goal of the research.

Non-probabilistic sampling will be used as a sampling technique as it relies more on the judgment of the researcher than the chance of selecting sufficient element. The chosen technique was chosen based on the assumption that the researcher needed to understand, discover and gain insights. To obtain this, the researcher had to select the participants who would be able to provide the required data and information from which most can be learned. Participants were selected according to the objective of the research and their ability to contribute to the research[86].

Data saturation is important to keep in consideration while discussing sample size in qualitative research. When the point is reached where new information doesn't bring any new information is called data saturation. Data saturation, in qualitative data collection, is when the researcher stops collecting data because new data does no longer bring new insights or reveals new properties[87]. The concept of data saturation might sound helpful at the conceptual level, but in the practical term, it gives little guidance for estimating the required sample size[82].

The research participants include mastodon and non-mastodon electricity suppliers, data processors such as Energie Data Service Nederland (EDSN), Blockchain experts and other sectors outside the utility industry. For the participants, the sample size is irrelevant because the goal was to collect rich amounts of information rather than being a representative of a large group[82]. To ensure that the research participants have the right qualifications in terms of knowledge and experience the following criteria has been developed:

Mastodont electricity supplier	
Criteria	**Requirement**
Experience in the electricity supply process	At least five years or more participation in the electricity industry
Blockchain technology understanding	Knowledge about the basic concepts of blockchain technology

Table 7: selection criteria for mastodont research participants

Non-Mastodont electricity supplier	
Criteria	**Requirement**
Non-bias to the current electricity industry	Less than five working years in the electricity industry
Blockchain technology understanding	Knowledge about the basic concepts of blockchain technology

Table 8: selection criteria for non-mastodon research participants

Electricty industry data processor	
Criteria	**Requirement**
Experience in the data processing service of the electricity supply process	At least five years or more experience in data processing service.
An understanding of the interaction between all the parties in the electricity industry	At least five years of experience in data processing between all electricity industry parties
Blockchain technology understanding	Knowledge about the basic concepts of blockchain technology

Table 9: selection criteria for electricity industry data processor research participants

Non-utility sector related party	
Criteria	**Requirement**
Not bias to the electricity industry or utility sectors	No experience in the electricity industry or other utility sectors
Blockchain technology understanding	Knowledge about the basic concepts of blockchain technology

Table 10: selection criteria for non-utility industry-related research participants

Data collection procedures

The researcher used his network to find these participants for the research. The participants were selected based on their experience in their working field and a basic understanding of blockchain technology.

Interview protocol

The participants were informed about the purpose of the research, the rights of the interviewer and that the collected data would only be used for this research purpose. The participants could withdraw themselves from the interview and the participation in this research at any time. The collected data was used for the purpose of this research only, and was saved on a secure database designed for this research only and was not shared with any other entity. See Appendix D: Interview protocol for the used interview questions.

4
Data and analysis

4.1 Current situation

4.1.1 Document analysis

During the document analyses on the current prosumer and electricity supplier processes, we came across three main distinctions, namely: Prosumer contracting, Prosumer consumption & production, and Prosumer consumption metering and billing[88][89]. Each process covers a specific stage in the entire electricity industry. The prosumer contracting process covers the administration part between the prosumer and the electricity supplier. The prosumer consumption & production process covers the production and consumption of electricity by prosumers. The prosumer consumption metering and billing process cover the consumption data collection of the electricity suppliers, the metering of the conventional and smart meter, and the consumption billing process.

To develop a comprehensive understanding and create a clear view of these processes, we created process models based on information gathered in the document analyses. These models are written out to create a comprehensive understanding of what each step is and does. However, since the available information at this stage is limited to only the document analysis, both the models and the description are incomplete.

1.0 Prosumer contracting

During the prosumer contracting process, the electricity supplier and the prosumer allegedly engage in a contract for the connection and transport of electricity. The prosumer contacts the new electricity supplier for a contract switch. The supplier drafts and sends a Connection and Transport Agreement (CTA) to the prosumer.

After the prosumer accepts the CTA, the new supplier initiates the “move-in” to become the current electricity supplier of the prosumer. They notify Energie Data Service Nederland (EDSN) which works for the Distribution Service Operator(DSO) about the connection switch. EDSN processes this notification and confirms it back to the new supplier. The new supplier then confirms the CTA back to the prosumer and the Prosumer electricity consumption & production process begins[88][89](See Figure 20: Pre-validation Prosumer Contracting(For a larger version of this model see Appendix B Figure 51: Pre-validation Prosumer Contracting LARGE)).

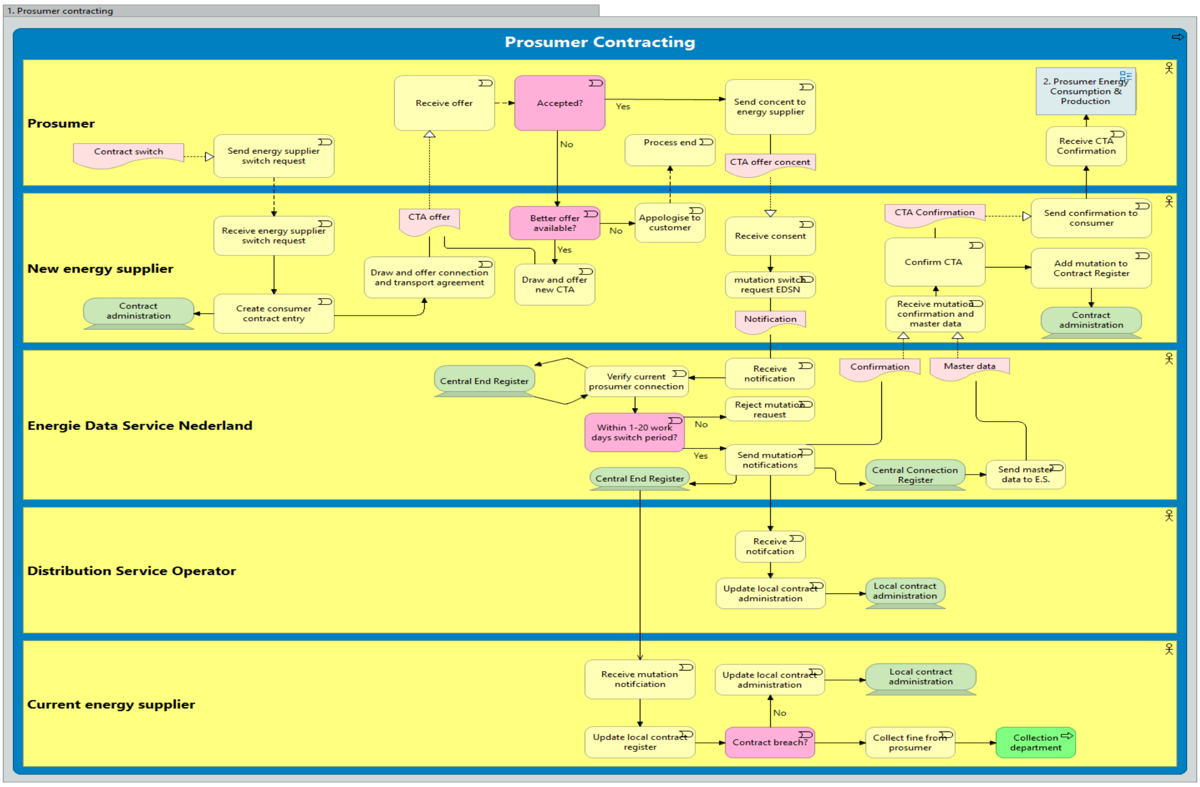


Figure 20: Pre-validation Prosumer Contracting

2.0 Electricity Supplier Switch

The new supplier sends a move-in notification to Energy Data Service Nederland(EDSN) which is part of the Distribution Service Operator(DSO). EDSN processes the request sent by the new supplier and checks the following, but not limited to, points: Is the notification complete and syntactically correct? Is the electricity connection known in the Central Connection Register? Is the notification date at least on the mutation date or at max 20 work days before the mutation date? And have there been no other effectuated supplier switches or move-ins received?

EDSN either accepts or rejects the move-in. When EDSN rejects the move-in they send a rejection notification to the new supplier. When EDSN accepts the move-in they send a GAIN (gained a connection) notification to the new supplier. EDSN also sends a LOSS (lost a connection) notification to the old supplier. The old supplier updates the mutation in their local administration and in the case of a contract breach, initiate their collection department.

EDSN effectuate the move-in notification on by the new supplier given mutation date. EDSN than sends the master data to the new supplier. The new supplier processes the master data and adds the mutation to their local administration. The new supplier also adds the definitive contract to the Contract End Register and the customer key to the Customer Key administration. The new supplier is now the active supplier for the connection and initiates the Prosumer Consumption & Production process[89](See Figure 21: Post-validation Supplier Switch(For a larger version of this model see Appending C Figure 55: Post-validation Supplier switch LARGE).

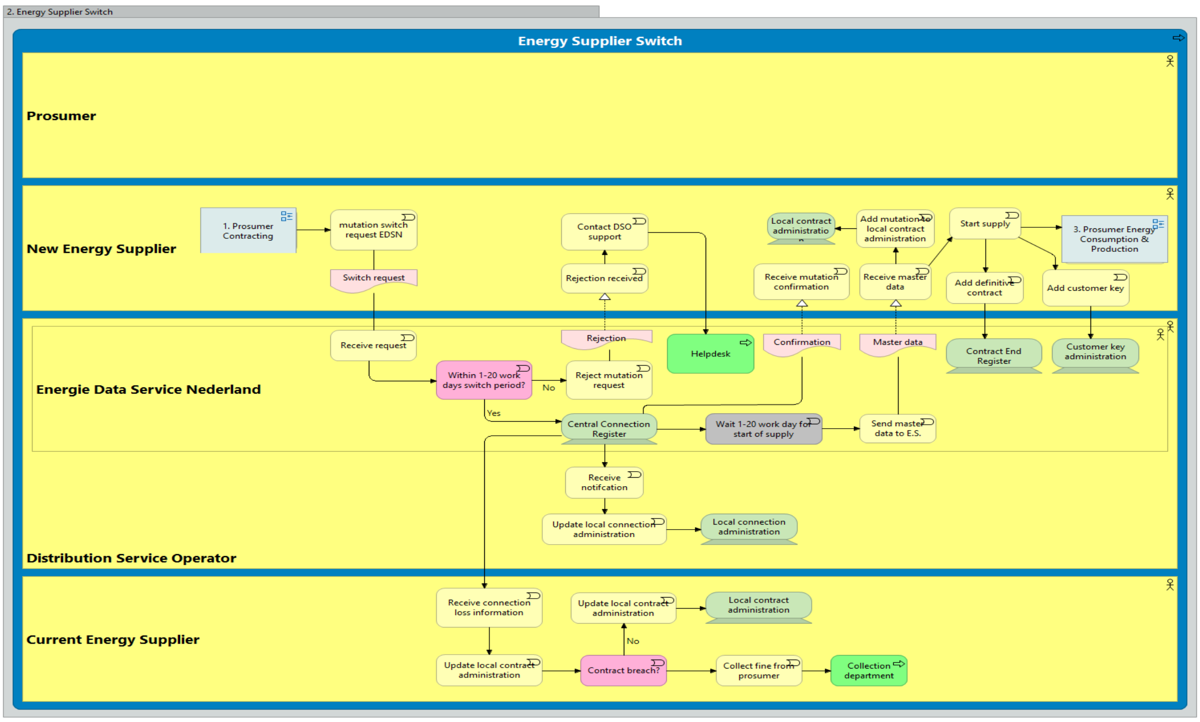


Figure 21: Post-validation Supplier Switch

3.0 Prosumer consumption & production

The prosumers generate their own electricity using private means such as solar panels. The generated electricity can be consumed directly by the prosumer. Using own generated electricity would result in a lower requirement of industrial electricity that is supplied by the electricity supplier.

The prosumers, however, can generate either more electricity than they consume or less. In case the prosumers generate more electricity than they consume, they supply their excess electricity back to the DSO. When the prosumer supplies electricity back, the conventional or smart meter will decrease the consumption data based on the amount supplied. When the prosumer generates less electricity than their consumption requires, the electricity supplier will supply the remaining required electricity to the prosumer. The supplied electricity from the supplier will increase the consumption data on the conventional or smart meter based on the amount of electricity consumed.

The increase and decrease of consumption data are periodically measured for billing. The supplier, however, does not always have direct access to all the consumption data. In order for the supplier to get the consumption data needed, they initiate the "Prosumer Consumption metering and Billing" process. Note that there was no exact documentation about the consumption and production process, and we developed this process based on logical thinking(see Figure 22: Pre-validation Prosumer consumption & production(For a larger version of this model see Appendix A Figure 52: Pre-validation Prosumer Consumption & Production LARGE)).

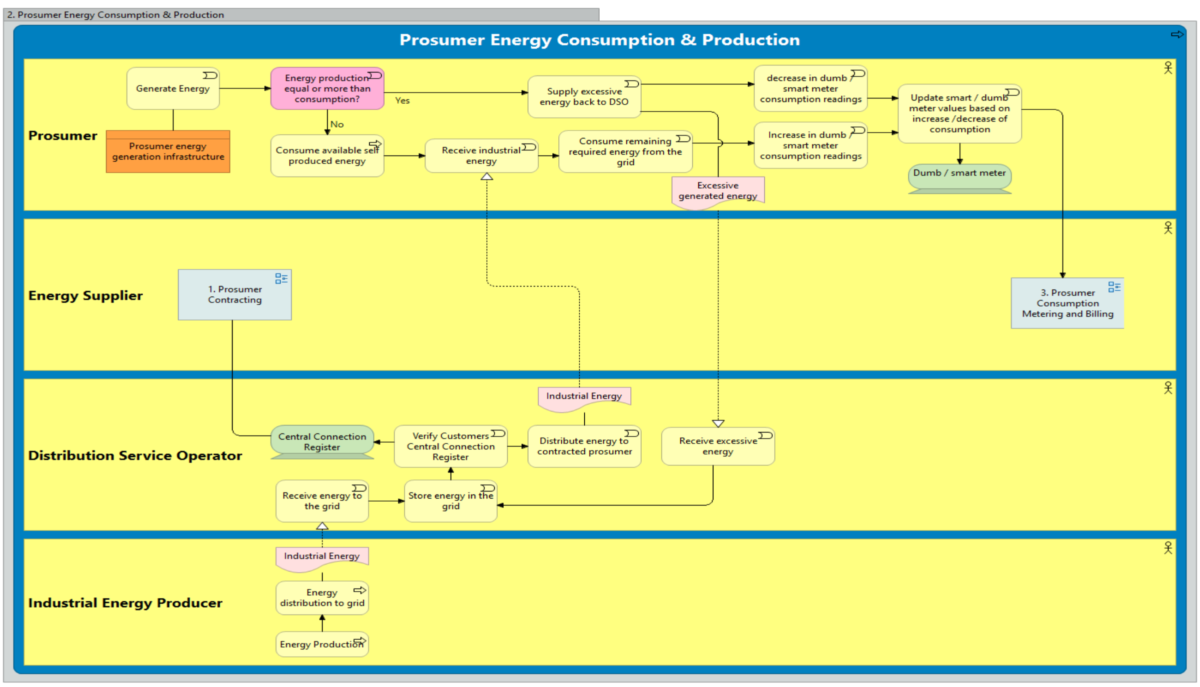


Figure 22: Pre-validation Prosumer consumption & production

4.0 Prosumer consumption metering and Billing

The Prosumer consumption metering and Billing process cover the collection of consumption data by electricity suppliers, measuring the conventional and smart meter, and consumption billing. The electricity supplier requests the prosumers consumption details from Energie Data Service Nederland (EDSN). EDSN checks this request to see if the supplier is actually the supplier of the connection. EDSN then forwards this request to the Distribution Service Operator who measures the meter readings. For the conventional meter, a representative will be sent to the prosumer to read the meter readings. For the smart meter, the DSO logs in into their P4 system and reads the meter readings remotely. The meter readings will be communicated back to the electricity supplier. The electricity supplier than calculates the prosumers consumption and bills accordingly[89](See Figure 23: Pre-validation Prosumer Consumption metering and Billing(For a larger version of this model see Appendix A Figure 53: Pre-validation Prosumer Consumption metering and Billing LARGE)).

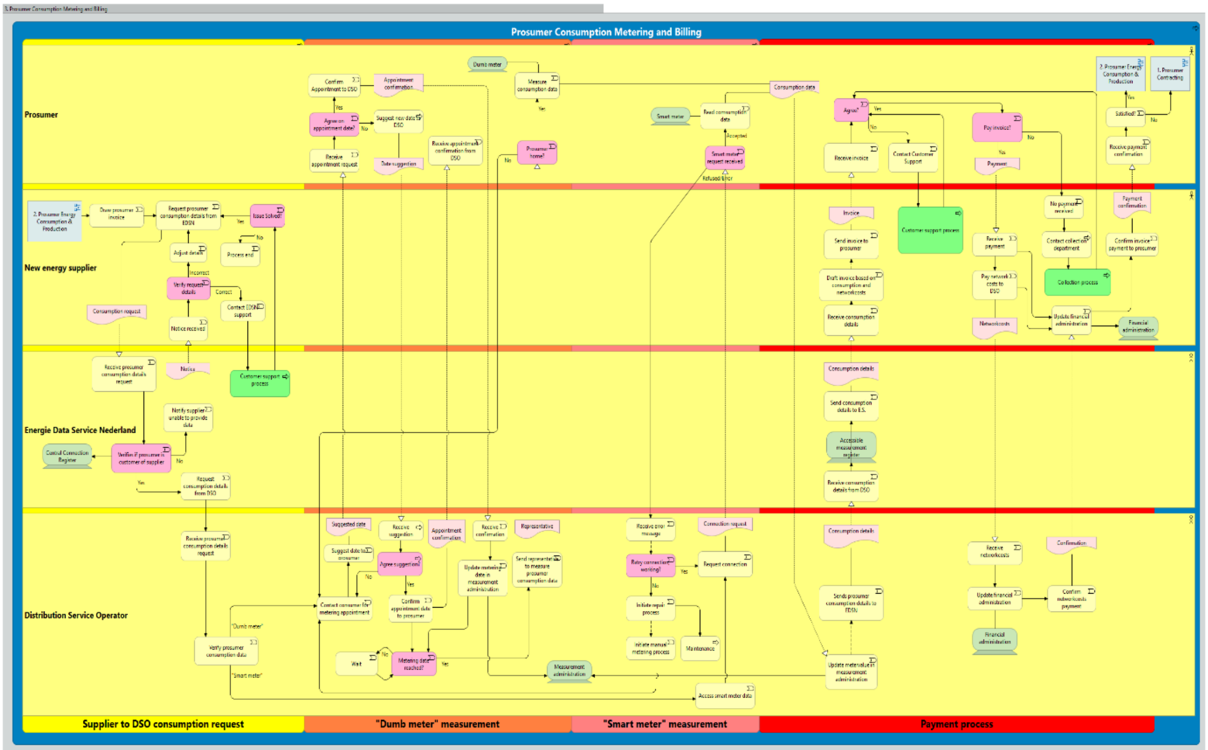


Figure 23: Pre-validation Prosumer Consumption metering and Billing

4.1.2 Expert validation

In order to validate our understanding, correctness, and completeness of the process, process model and description, we validated the Prosumer contracting process via an expert validation round. The feedback received during this validation round allowed us to create a clearer view of this process. By processing this feedback, we divided the processes into two separate processes. The first part of the process exists out of the Process contracting part and the second part about the Supplier switch part. The feedback allowed us to precisely describe which registers and steps are being used during the process and led us to the following models and descriptions.

1. Process contracting

During the contracting process, the prosumer allegedly contacts the new supplier about an electricity supply contract switch. The new electricity supplier receives the prosumers request and creates a new contract entry in their local contract administration. The new supplier then asks the prosumer for consent to look into the prosumer historical data in the Contract End Register(C-ER) and Contract Connection Register(CCR). The new supplier drafts and offers a Connection and Transport Agreement (CTA) to the prosumer based on the historical data.

The prosumers either accept or decline the offer. If the prosumers accept the offer they send their consent to the new supplier. The new supplier then notifies the prosumer about the 2 week consideration period. If the prosumer declines the offer, the new supplier will check if there is a better offer available and offer this to the prosumer if this is the case. If the new supplier doesn't have a better offer available they apologize to the prosumer and the contracting process ends. If the prosumer reconsiders on the offer during the considering period, the new supplier will also check if there is a better offer available and offer this to the prosumer if this is the case.

When the consideration period has passed without any notice from the prosumer, the new supplier sends the Connection and Transport Agreement (CTA) confirmation to the prosumer. The new supplier also adds a temporary contract to the Contract End Register(C-ER), after which they consult the Consumption Register, Contract End Register, and Central Connection Register data one more time. The new supplier will then add the contract mutation to their local administration and initiates the Energy Supplier Switch process[88][89](Figure 24: Post-validation Prosumer Contracting(For a larger version of the model see Appendix B Figure 54: Post-validation Prosumer contracting LARGE)).

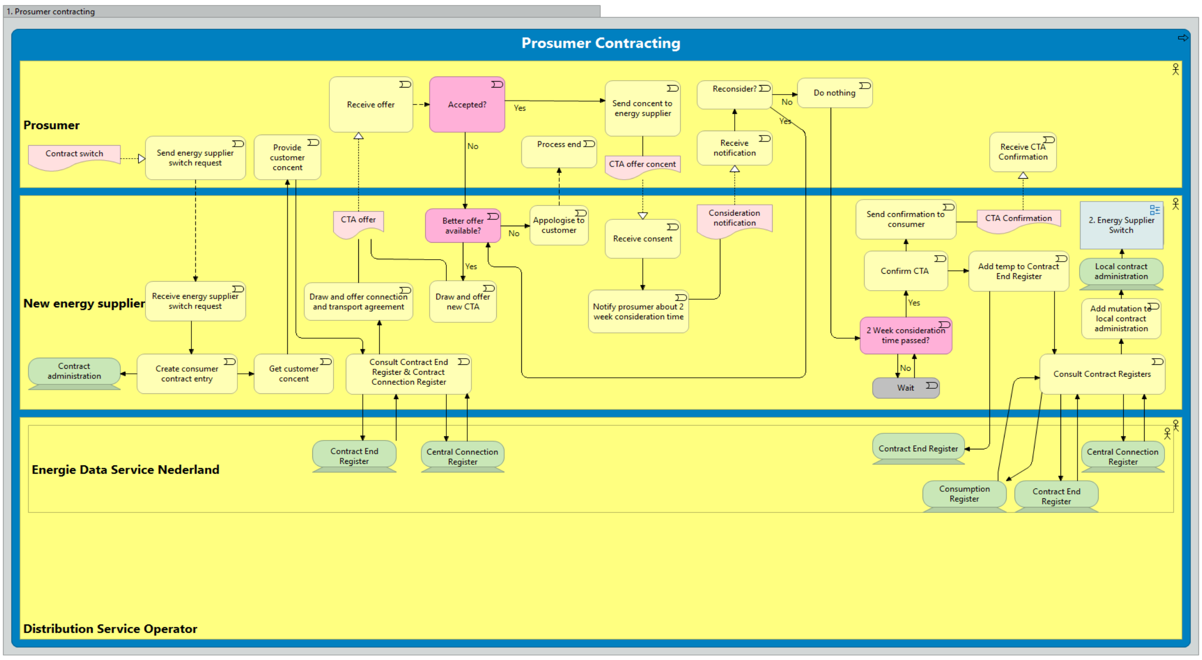


Figure 24: Post-validation Prosumer Contracting

2. Electricity Supplier Switch

The new supplier sends a move-in notification to Energy Data Service Nederland(EDSN) which is part of the Distribution Service Operator(DSO). EDSN processes the request sent by the new supplier and checks the following, but not limited to, points: Is the notification complete and syntactically correct? Is the electricity connection known in the Central Connection Register? Is the notification date at least on the mutation date or at max 20 work days before the mutation date? And have there been no other effectuated supplier switches or move-ins received?

EDSN either accepts or rejects the move-in. When EDSN rejects the move-in they send a rejection notification to the new supplier. When EDSN accepts the move-in they send a GAIN (gained a connection) notification to the new supplier. EDSN also sends a LOSS (lost a connection) notification to the old supplier. The old supplier updates the mutation in their local administration and in the case of a contract breach, initiate their collection department.

EDSN effectuate the move-in notification on by the new supplier given mutation date. EDSN than sends the master data to the new supplier. The new supplier processes the master data and adds the mutation to their local administration. The new supplier also adds the definitive contract to the Contract End Register and the customer key to the Customer Key administration. The new supplier is now the active supplier for the connection and initiates the Prosumer Consumption & Production process[89](See Figure 21: Post-validation Supplier Switch(For a larger version of this model see Appending B Figure 55: Post-validation Supplier switch LARGE).

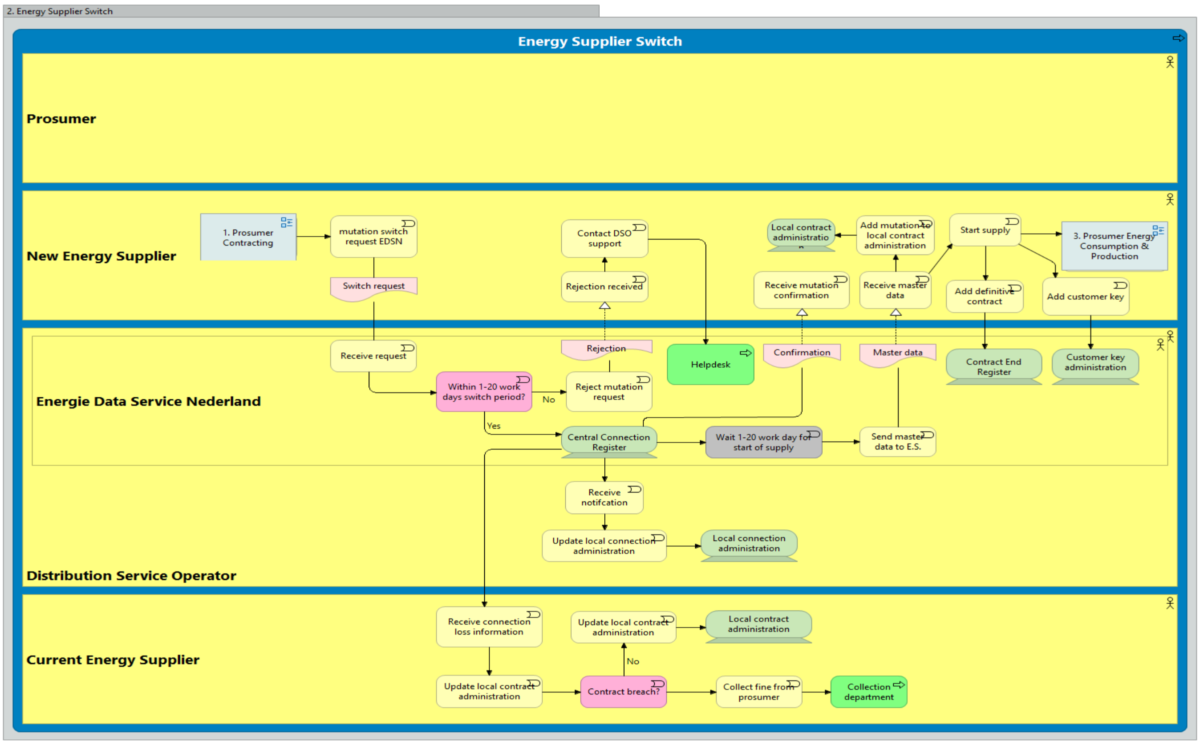


Figure 25: Post-validation Supplier Switch

3. Prosumer Consumption & Production

The prosumers generate their own electricity using private means such as solar panels. The generated electricity can be consumed directly by the prosumer. Using own generated electricity would result in a lower requirement of industrial electricity that is supplied by the electricity supplier.

The prosumers, however, can generate either more electricity than they consume or less. In case the prosumers generate more electricity than they consume, they supply their excess electricity back to the DSO. When the prosumer supplies electricity back, the conventional or smart meter will decrease the consumption data based on the amount supplied. When the prosumer generates less electricity than their consumption requires, the electricity supplier will supply the remaining required electricity to the prosumer. The supplied electricity from the supplier will increase the consumption data on the conventional or smart meter based on the amount of electricity consumed.

The increase and decrease of consumption data are periodically measured for billing. The supplier, however, does not always have direct access to all the consumption data. In order for the supplier to get the consumption data needed, they initiate the "Consumption data request" process(See Figure 26: Post-validation Prosumer consumption & production(For a larger version of the model see Appendix B Figure 56: Post-validation Prosumer consumption & production LARGE)).

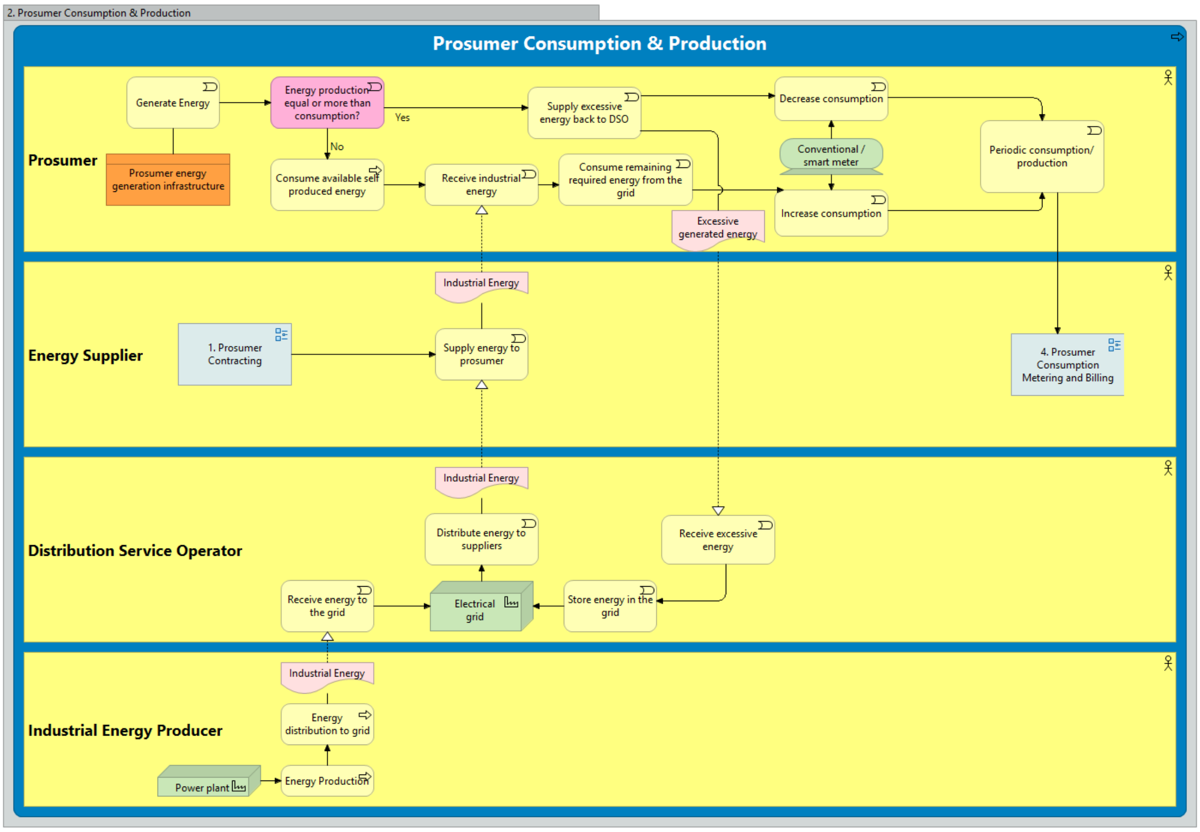


Figure 26: Post-validation Prosumer consumption & production

4.0 Consumption data request

In order for the supplier to draw a prosumer consumption invoice, it is required for them to have the consumption data. The Consumption data is measured from the electricity meter at the prosumer location. There are two types of meters, the conventional meter, and the smart meter.

The conventional meter can and will be measured by the supplier. The supplier could ask the prosumer to provide the meter data via email, or the supplier could send a representative that visually measures the consumption data. This process is during the “Conventional meter measurement” process.

The smart meter can be remotely measured by the portal owner, in this case, the DSO. The supplier does not have access to the P4 portal that is used to measure the smart meter remotely. In order for the supplier to access the smart meter consumption data, they have to contact EDSN and request them. EDSN verifies if the supplier is the active supplier of that connection. When the supplier turns out to be the active supplier of that connection, EDSN forwards the request to the DSO which on their turn initiate the “Smart meter measurement” process[89](See Figure 27: Post-validation Consumption data request(For a larger version of this mode see Appendix B Figure 57: Post-validation Consumption data request LARGE).

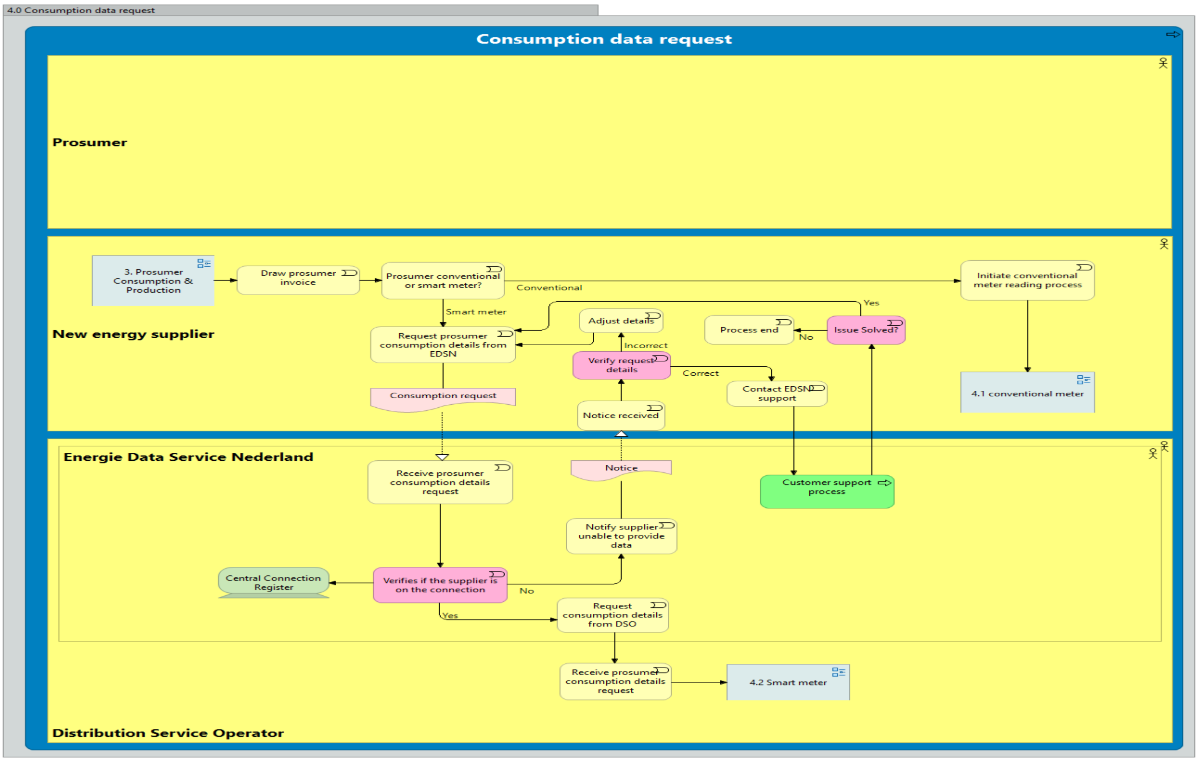


Figure 27: Post-validation Consumption data request

4.1 Conventional meter measurement

To measure the conventional meter data, the supplier sends out a meter data request via phone, letter or email. The prosumer receives the request and verifies the meter data and sends it back to the supplier.

The supplier receives the meter data from the prosumer and sends it to the DSO. The supplier adds the meter data in the Meet Data Distributie(MDD) system and sends it to the DSO. The DSO receives the data and updates the values in their local administration and also in the Consumption Register(TMR). The DSO than sends the consumption data back to the electricity supplier using the same MDD system.

The supplier receives the consumption data back from the DSO. The supplier adds the received consumption data to their local administration and initiates the “Billing” process(See Figure 28: Post-validation Conventional meter measurement[89](For a larger version of this model see Appendix B Figure 57: Post-validation Consumption data request LARGE)).

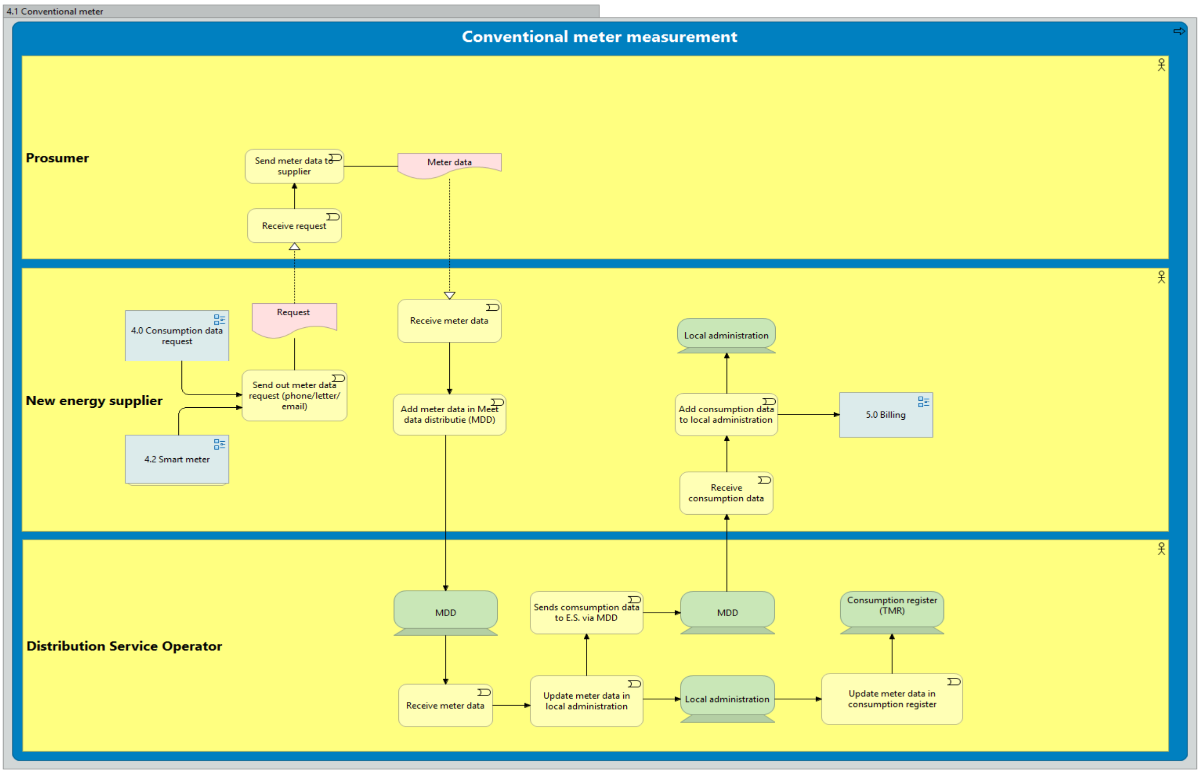


Figure 28: Post-validation Conventional meter measurement

4.2 Smart meter measurement

To remotely measure the smart meter the DSO uses the P4 portal to connect to the meter. The P4 portal requests a connection to the meter. If the connections fail and keep failing, the DSO initiates a repair process and notifies the supplier about this which on their turn initiates a manual measurement via the “Conventional meter measurement” process. If the connection succeeds, the P4 measures the consumption data and sends it back to the DSO.

The DSO sends the meter data to the supplier. After receiving the consumption data, the supplier adds the meter data to their local administration and also sends it to the DSO via the MDD system. The DSO receives and adds the meter data to their local administration and also in the Consumption Register(TMR). The DSO than sends the consumption data back to the supplier via the same MDD system, after which the supplier initiates the “Billing” process[89](See Figure 29: Post-validation Smart meter measurement(For a larger version of this model see Appendix B Figure 59: Post-validation Smart meter measurement LARGE)).

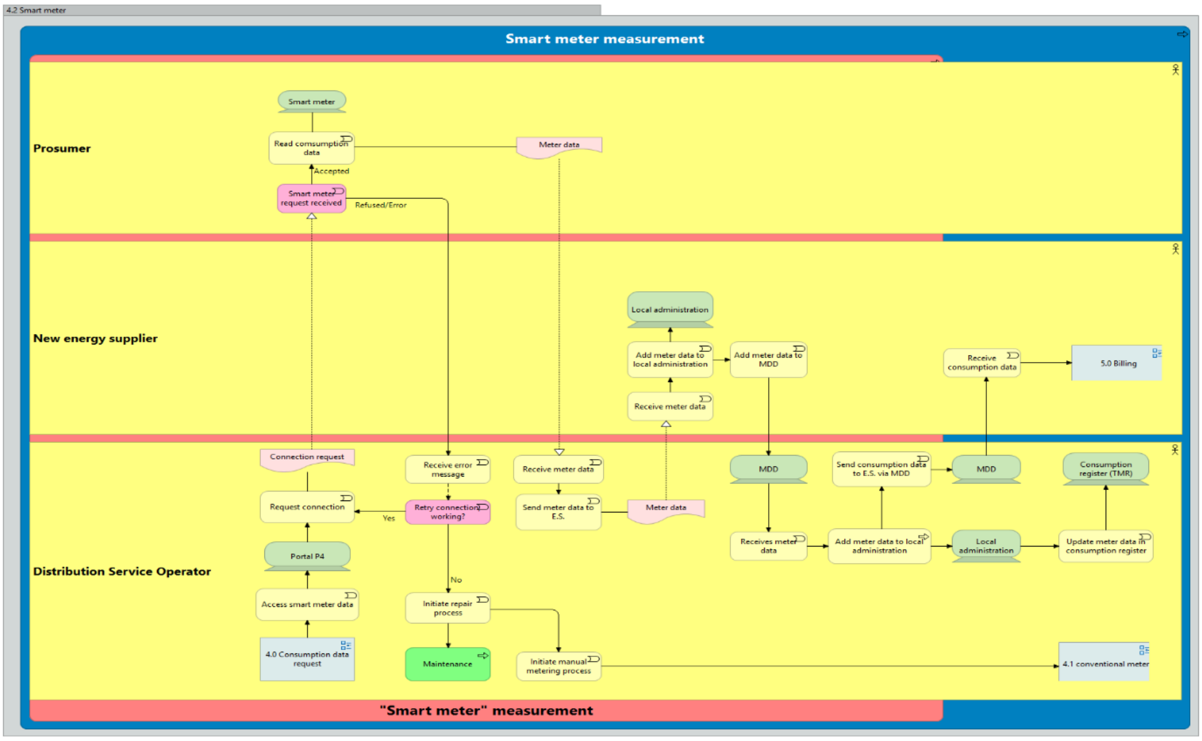


Figure 29: Post-validation Smart meter measurement

5.0 Prosumer Billing

Once the consumption data is gathered, the supplier drafts an invoice based on the consumption and network costs and sends this to the prosumer. The prosumer receives the invoice and has the option to pay, or not to pay. If the prosumer refuses to pay the invoice, they can contact the customer support department of the supplier. If the issue has been resolved the prosumer pays the invoice if the issue is not resolved and the prosumer keeps refusing to pay the invoice, the supplier contacts the collection department to initiate the collection process.

The prosumer pays the invoice to the supplier. The supplier receives the payment and updates this in their financial administration. After the payment has been processed, the supplier confirms the invoice payment to the prosumer.

The prosumer receives the payment confirmation. If the prosumer is satisfied with the contract and service provided by the supplier, the process cycle continues again from the "Prosumer Consumption & Production" process. If the prosumers are not satisfied, they could contact a new supplier to establish a new connection and transport agreement(CTA) during the "Prosumer contracting" process[89](See Figure 30: Post-validation Billing(For a larger version of this model see Appendix B Figure 60: Post-validation Billing LARGE)).

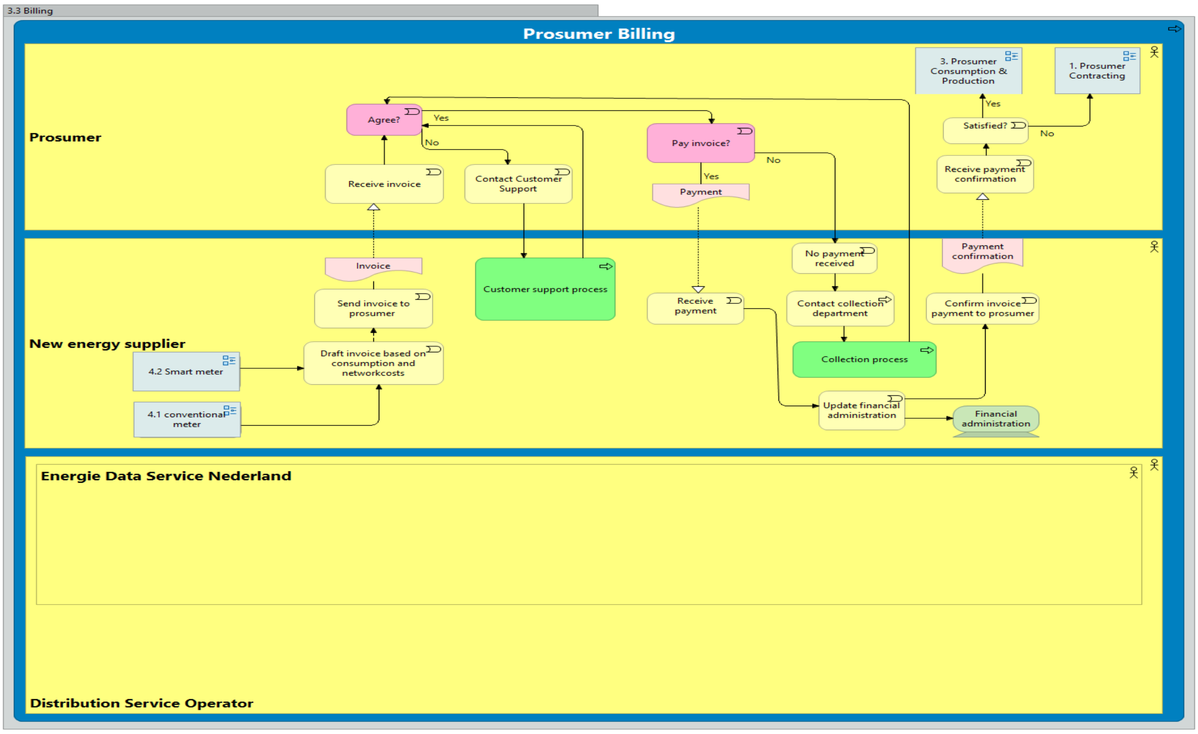


Figure 30: Post-validation Billing

4.2 Expected (near) future) situation

To explore the possible future business models of the electricity sector, we conducted several expert interviews with different parties present in the electricity sector. In order to gain a broad prospect of the view of future business models within the electricity sector, we interviewed both small and big electricity suppliers, in addition, we also interviewed the data processing company within the electricity sector.

Based on the information received during the expert interviews, we developed a decentralization matrix. The decentralization matrix will help us to make a distinction between the possible business scenarios. The matrix is developed with on one side decentralized production, decentralized administration and a combination of both, and the other side with aggregated grids, decentralized grid and a combination of both. The matrix looks as follows:

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Figure 31: Decentralization matrix

The information received during the expert interviews described several possible business scenarios. By processing the received information, we were able to divide the mentioned processes into different scenarios. Each of these scenarios exists out of different roles and processes. These scenarios are described separately below.

Scenario 1: Decentralized production aggregated grid

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

In scenario 1 there could be an aggregator who facilitates the community grid to the prosumers. The prosumers sign a contract with the aggregator to join the community grid. One of the prerequisites could be that the prosumers pay a periodical fee to the aggregator for using the grid, or that the aggregator receives a cut of all the electricity transactions made using the community grid. The processes in this scenario are as followed:

1.1 Aggregator – prosumer contracting

In this scenario, there is an aggregator who provides and manages the aggregator. In order for prosumers to join the community grid, they would have to contact and contract the aggregator. If the prosumer passes the criteria's such as geographic location and agrees on the contract details, they will be eligible to join. The aggregator then sends the contract confirmation to the prosumer and the "Scenario 1 – 2. Prosumer – Aggregator Consumption & Production" process starts(see Figure 32: Scenario 1 – 1. Aggregator - prosumer contracting(For a larger version of this model see Appendix C Figure 61: Scenario 1 -1. Aggregator - prosumer contracting LARGE)).

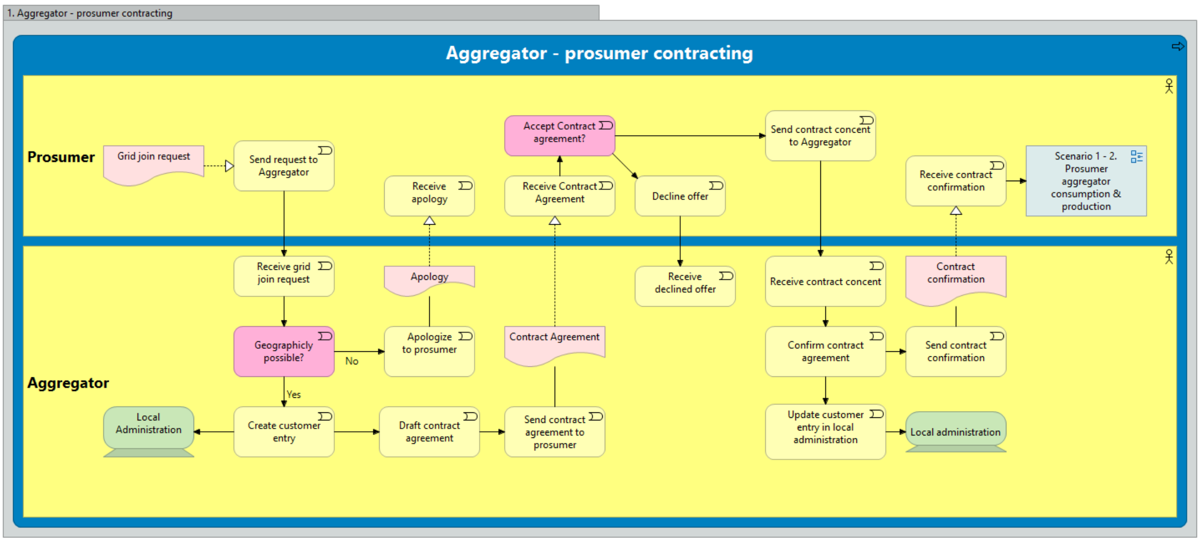
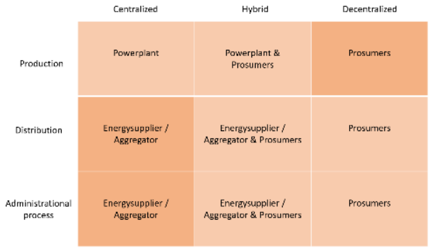


Figure 32: Scenario 1 – 1. Aggregator - prosumer contracting

1.2 Prosumer – aggregator consumption & production



	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

After joining the community grid, prosumers should be able to supply and receive electricity from the aggregator. The prosumers should be able to supply their excessive electricity onto the community grid, which the aggregator either directly supplies to consumers with electricity needs, or store it into the community grid battery. The smart meter will record the electricity supply and decrease the electricity consumption of the prosumer. At the same time, when prosumers consume more electricity than they produce they will be able to buy the required electricity from the community grid. The consumption will be recorded in a smart meter and used for future billing and the "Scenario 1 – 3. Prosumer – Aggregator Billing" processes begin (see Figure 33: Scenario 1 – 2. Prosumer aggregator consumption & production(For a larger version of this model see Appendix C Figure 62: Scenario 1 - 2. Prosumer - aggregator consumption & production LARGE)).

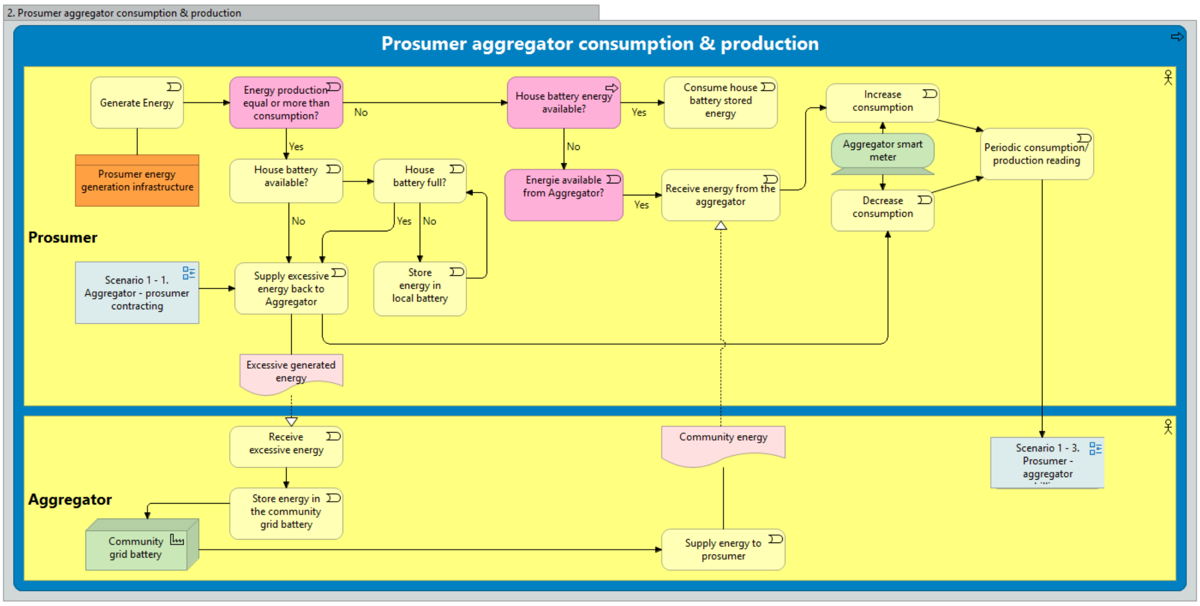
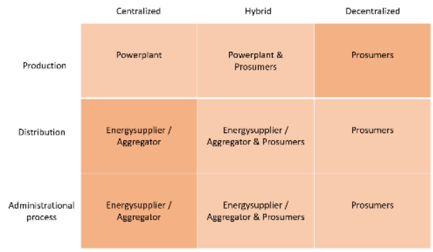


Figure 33: Scenario 1 – 2. Prosumer aggregator consumption & production

1.3 Prosumer – aggregator billing



Periodically the aggregator collects a fee from the grid users and drafts an invoice according to the contracts. Based on the type of contract between the aggregator and the prosumer, the aggregator drafts an invoice for a monthly "subscription" fee or the electricity consumption. In order to invoice the consumption, the aggregator connects to the smart meter and reads the consumption values. He then drafts and sends the invoice to the prosumer. If the prosumer consumed more than he produced, he will have to pay. If the prosumer produced more than he consumed, he will receive money back from the aggregator. After the prosumer paid the invoice or received the electricity supply cut, the process starts over again at the "Scenario 1 – 2. Prosumer Aggregator Consumption & Production" process(see Figure 34: Scenario 1 – 3. Prosumer - aggregator billings(For a larger version of this model see Appendix C Figure 63: Scenario 1 - 3. Prosumer - aggregator billing LARGE)).

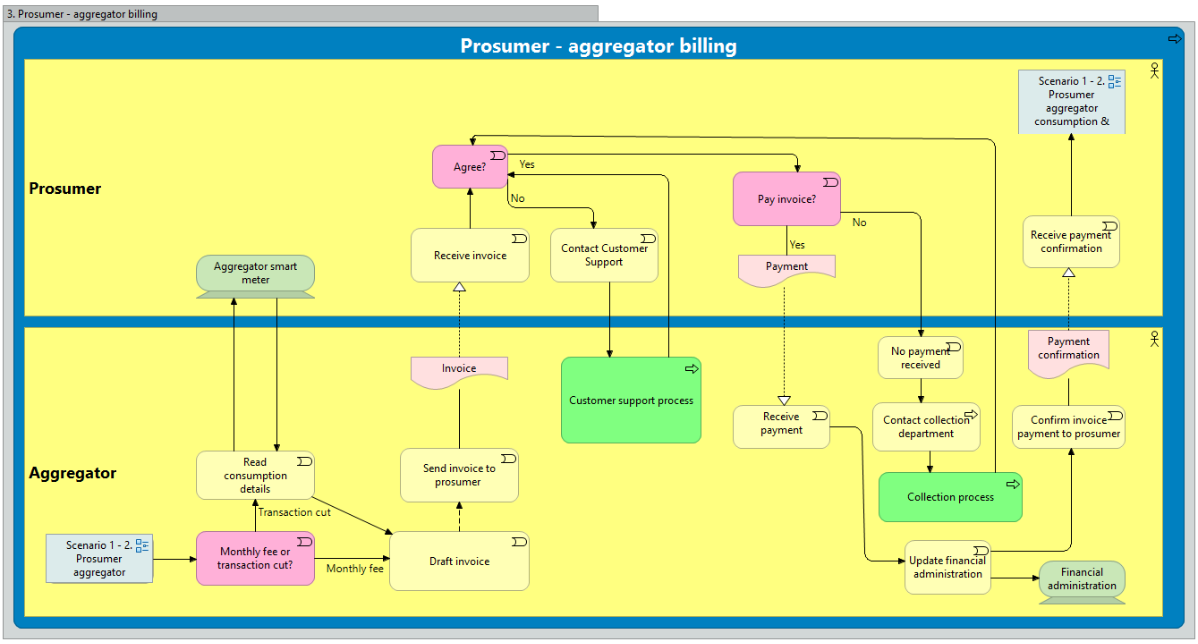


Figure 34: Scenario 1 – 3. Prosumer - aggregator billing

SWOT analysis for decentralized production on a centralized grid with centralized distribution and administration process

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

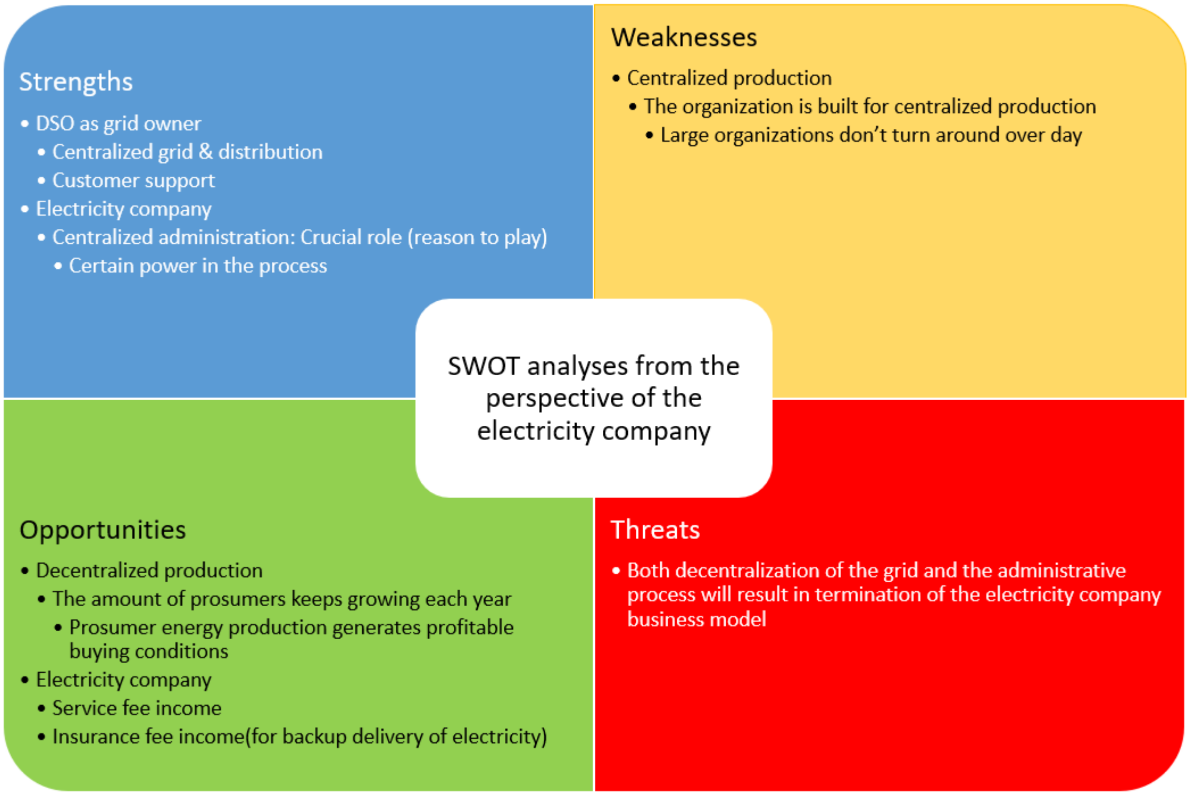


Figure 35: SWOT decentralized production on a centralized grid with centralized distribution and administration process

Scenario 2: Decentralized production and administrations aggregated grid

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

In scenario 2 there could be an aggregator who facilitates a blockchain based community grid to the prosumers. The prosumers sign a contract with the aggregator to join the community grid. One of the prerequisites could be that the prosumers pay a periodical fee to the aggregator for using the grid, or that the aggregator receives a cut of all the electricity transactions made using the community grid. The processes in this scenario are as followed:

2.1 Aggregator – prosumer contracting

In this scenario, there is an aggregator who provides and manages the blockchain based community grid. In order for prosumers to join the community grid, they would have to contact and contract the aggregator. If the prosumer passes the criteria's such as geographic location and agrees on the contract details, they will be eligible to join. The aggregator then sends the contract confirmation to the prosumer and the "Scenario 2 – 2. Blockchain-based prosumer – aggregator production" process starts(see Figure 36: Scenario 2 – 1. Aggregator - prosumer contracting(For a larger version of this model see Appendix C Figure 64: Scenario 2 - 1. Aggregator - prosumer contracting LARGE)).

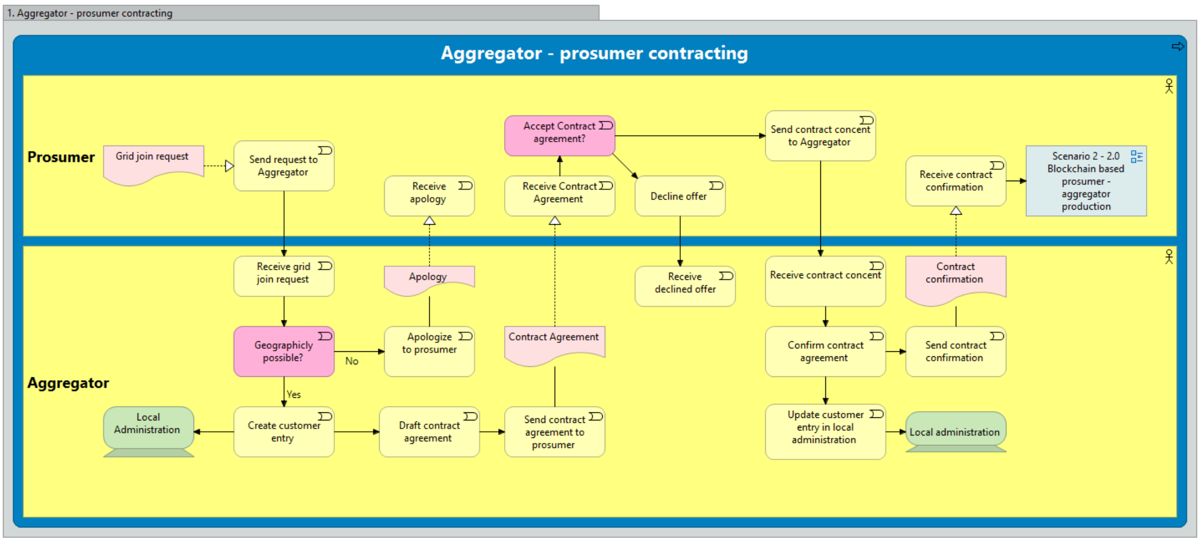


Figure 36: Scenario 2 – 1. Aggregator - prosumer contracting

2.2 Blockchain based prosumer – aggregator production

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

After joining the blockchain based community grid, prosumers should be able to supply electricity to the aggregator. The prosumers should be able to supply their excessive electricity onto the community grid, which the aggregator could either directly supply to consumers with electricity needs, or store it into the community grid battery. The smart meter will record the electricity supply of the prosumer. Based on the recorded electricity supplied, the smart meter could send a number of credits to the prosumer which counts as a digital currency. At the same time, when prosumers would consume more electricity than they produce, process "Scenario 2 - 2.1 Blockchain based prosumer – aggregator consumption" would start. After the production and consumption, a monthly "subscription" fee will be paid to the aggregator and this will be done during "Scenario 2 - 3. Prosumer aggregator billing"(see Figure 37: Scenario 2 – 2.0 Blockchain based prosumer - aggregator production(For a larger version of this model see Appendix C Figure 65: Scenario 2 - 2.0 Blockchain based prosumer - aggregator production LARGE)).

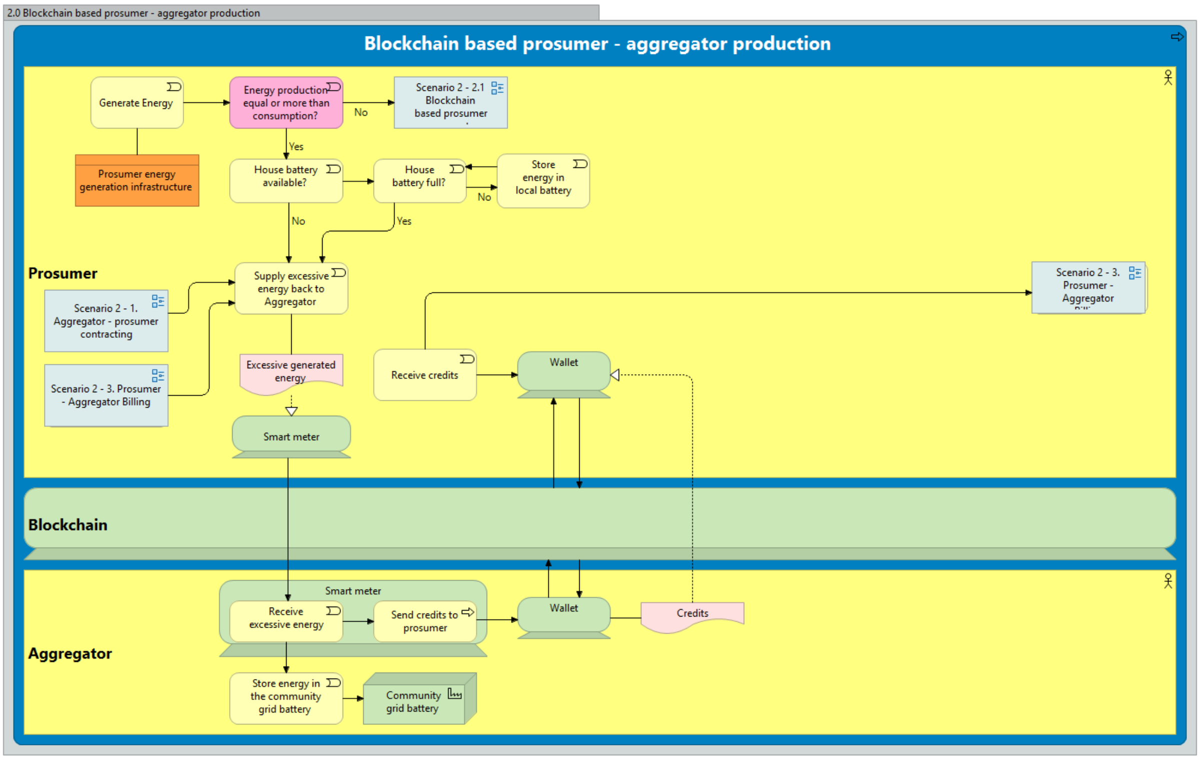


Figure 37: Scenario 2 – 2.0 Blockchain based prosumer - aggregator production

2.3 Blockchain based prosumer – aggregator consumption

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

If a prosumer would consume more electricity than they produce, they could be able to buy the required electricity from the aggregator. If the prosumer has a house battery, they could consume the stored electricity there first. When the prosumer has no house battery or the battery is depleted, they would be able to buy electricity from the aggregator. In order to buy electricity from the aggregator, the application managing the credits, in this case, blockchain, will check the prosumer's balance. If the balance is not enough, the request will be canceled. If the prosumer has enough balance, they will send the credits to the aggregator. Once the aggregator received the credits, they supply the electricity amount based on the payment, from the community grid to the prosumer. After the production and consumption, a monthly "subscription" fee will be paid to the aggregator and this will be done during "Scenario 2 - 3. Prosumer aggregator billing"(see Figure 38: Scenario 2 – 2.1 Blockchain based prosumer - aggregator consumption(For a larger version of this model see Appendix C Figure 66: Scenario 2 - 2.1 Blockchain based prosumer - aggregator consumption LARGE)).

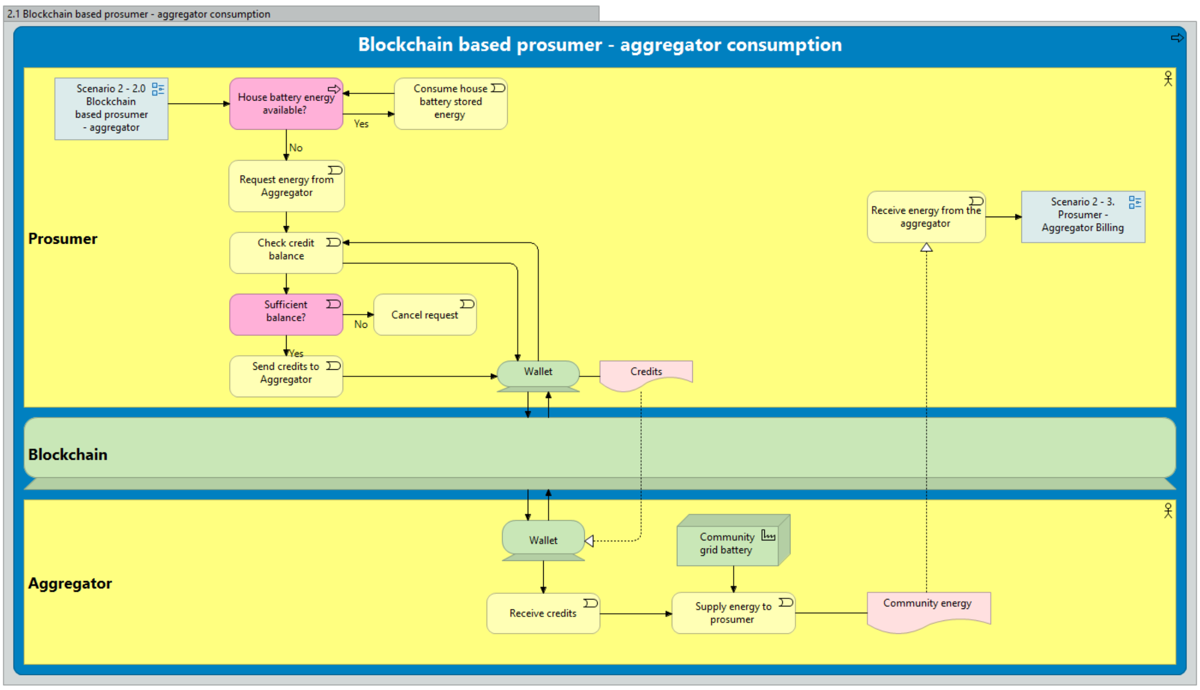


Figure 38: Scenario 2 – 2.1 Blockchain based prosumer - aggregator consumption

2.4 Prosumer – aggregator billing

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Periodically the aggregator collects a fee from the grid users and drafts an invoice according to the contracts. Based on the type of contract between the aggregator and the prosumer, the aggregator drafts an invoice for a monthly "subscription" fee, or a percentage cut of the transactions made. In order to invoice the transaction cut, the aggregator connects to the smart meter and reads the transactions made. He then drafts and sends the invoice to the prosumer. After the prosumer paid the invoice the process starts over again at the "Scenario 2 - 2.0 Blockchain based prosumer aggregator production" process(see Figure 39: Scenario 2 – 3. Prosumer - aggregator billing(For a larger version of this model see Appendix C Figure 67: Scenario 2 - 3. Prosumer - aggregator billing LARGE)).

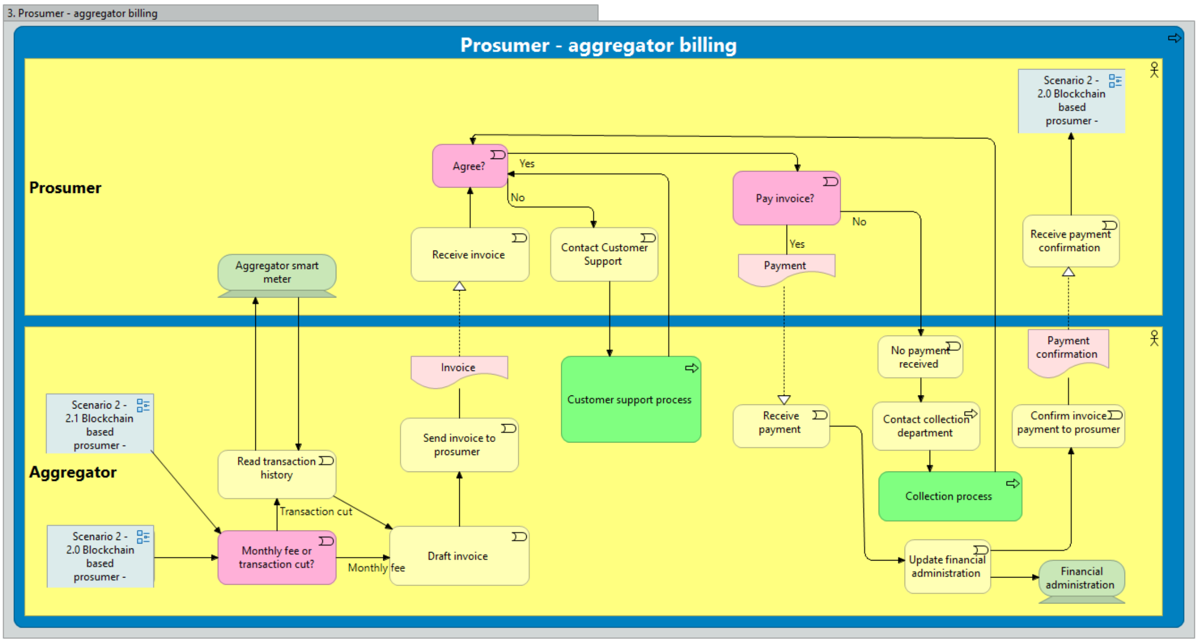


Figure 39: Scenario 2 – 3. Prosumer - aggregator billing

SWOT analysis for decentralized production and distribution on a centralized grid with a centralized administration process

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Figure 40: SWOT analysis for decentralized production and distribution on a centralized grid with a centralized administration process

Scenario 3: Decentralized production and administration decentralized grid

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Scenario 3 is a standalone process between different prosumers. In this scenario, prosumers are able to buy and sell their electricity directly from and to each other. The prosumers bought the community grid as a community and share shared ownership. There are no actors such as aggregator or other service provider included in this scenario.

3.1 Blockchain based prosumer to prosumer production

When prosumers generate more electricity than they consume, they would be able to sell it to other prosumers or consumers that are in need of electricity. Prosumers could have the ability to store a certain amount of electricity in a house battery. When the battery is full, they could sell the excess electricity to consumers or prosumers in electricity need, in this example we call them "prosumer 2". Prosumer 1 will send a credit request to Prosumer 2 for the required electricity. The application managing the credits, in this case, blockchain, will check Prosumer 2's balance. If the balance is not enough, the request will be canceled. If Prosumer 2 has enough balance, it will send the credits to Prosumer 1. Once Prosumer 1 received the credits, they will start supplying the electricity amount based on the credits received, to Prosumer 2 and the process starts over(see Figure 41: Scenario 3 – 1. Blockchain-based prosumer to prosumer production(For a larger version of this model see Appendix C Figure 68: Scenario 3 - 1. Blockchain based prosumer to prosumer production LARGE)).

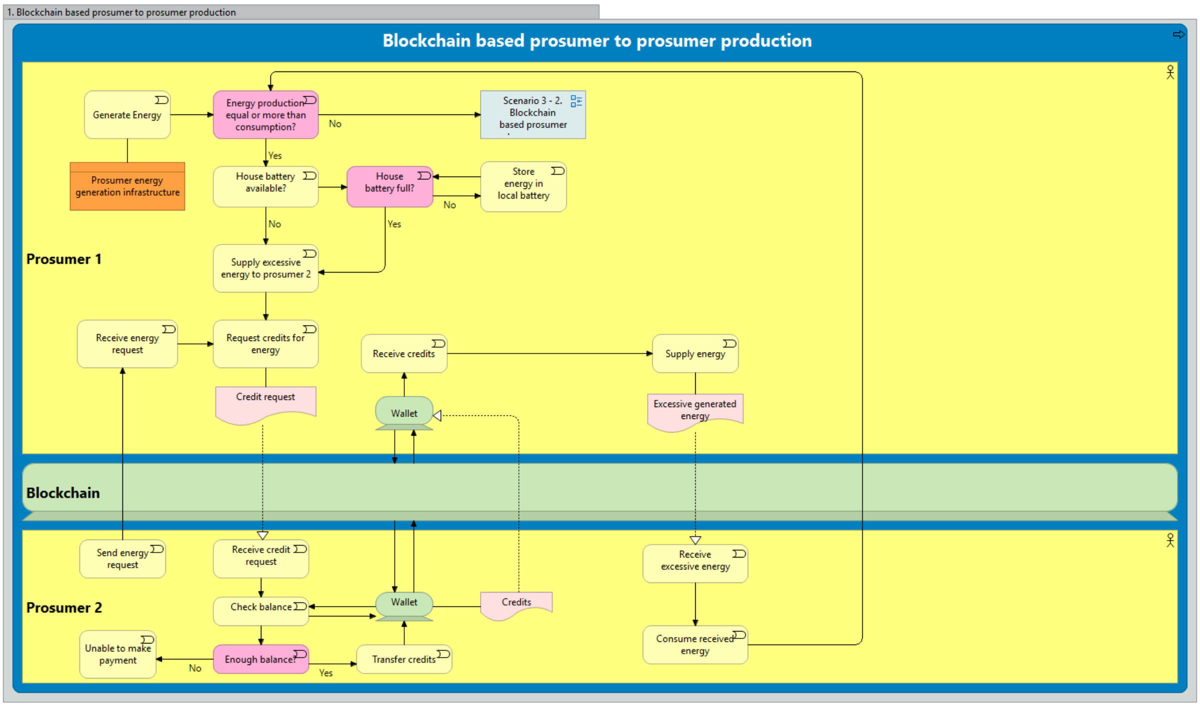


Figure 41: Scenario 3 – 1. Blockchain-based prosumer to prosumer production

3.2 Blockchain based prosumer to prosumer consumption

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

When prosumers generate less electricity than they consume, they could buy electricity directly from other prosumers If the prosumer has a house battery available, they could first consume the electricity stored in there. If they need more electricity than stored in the house battery, they could send an electricity request to a different prosumer, in this case, Prosumer 2. Prosumer 2 would receive the request and send a credit request based on the required amount of electricity. The application managing the credits, in this case, blockchain again, will check Prosumer 1 their balance. If the balance is not sufficient, the request will be canceled. If Prosumer 1 has enough balance, the blockchain will send the credits to Prosumer 2. Once Prosumer 2 received the credits, they will start supplying the electricity amount based on the number of credits received, to Prosumer 1 and the cycle will start over again with the "Scenario 3 - 1. Blockchain-based prosumer to prosumer production" process(see Figure 42: Scenario 3 – 2. Blockchain-based prosumer to prosumer consumption(For a larger version of this model see Appendix C Figure 69: Scenario 3 - 2. Blockchain based prosumer to prosumer consumption LARGE)).

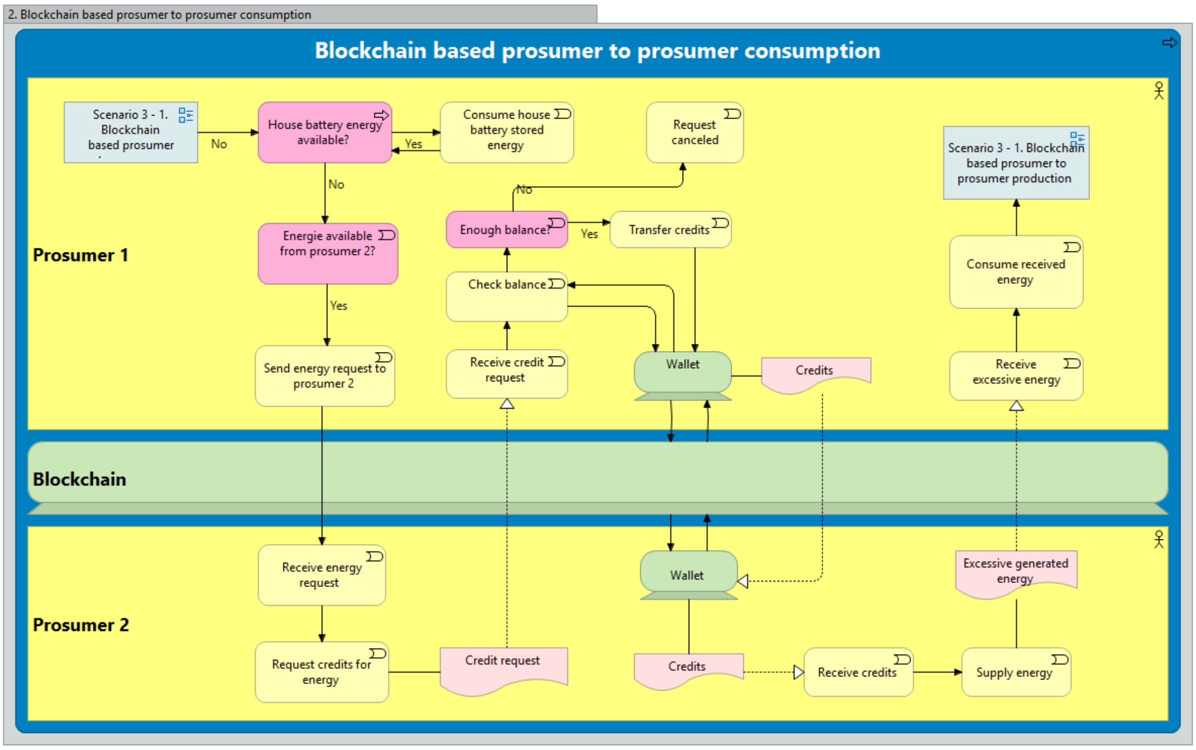
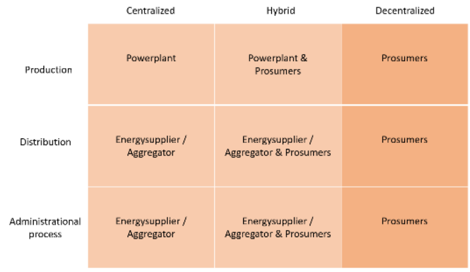


Figure 42: Scenario 3 – 2. Blockchain-based prosumer to prosumer consumption

SWOT analysis for a decentralized grid with decentralized production, distribution, and administration



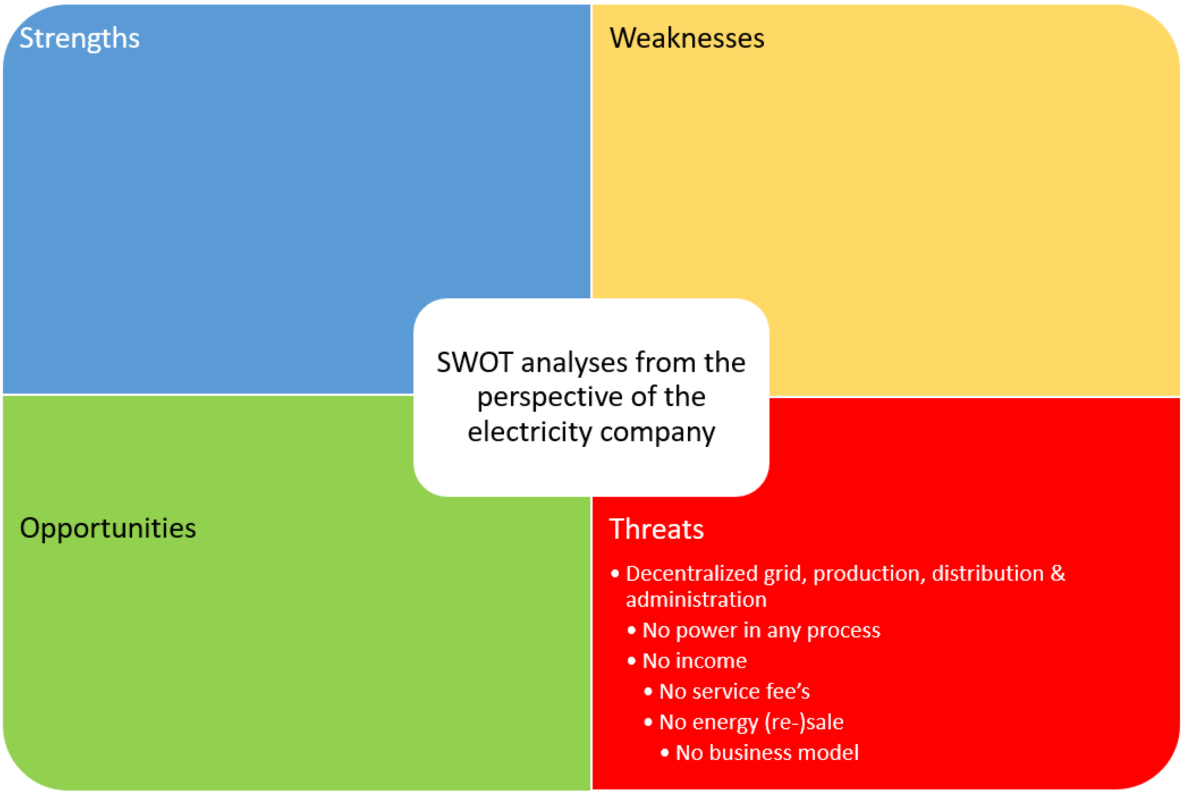
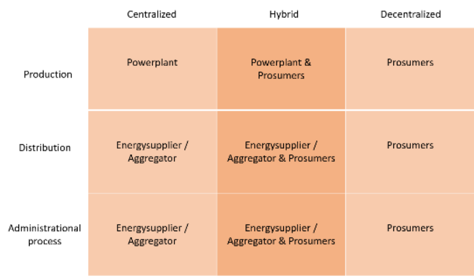


Figure 43: SWOT analysis for a decentralized grid with decentralized production, distribution, and administration

Scenario 4: Hybrid production and administration hybrid grid



	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Scenario 4 could be a blockchain based community grid with the combination of an aggregator and prosumers. The aggregator will provide and maintain the community grid, but in return, the prosumers will have to pay a monthly subscription fee or pay a cut of their transactions to the aggregator. However, unlike the previous scenarios where prosumers can either sell their electricity to an aggregator or prosumers, they have the possibility to choose either one during this process.

4.1 Aggregator – prosumer contracting

In this scenario, there is an aggregator who provides and manages the blockchain based community grid. In order for prosumers to join the community grid, they would have to contact and contract the aggregator. If the prosumer passes the criteria’s such as geographic location and agrees on the contract details, they will be eligible to join. The aggregator then sends the contract confirmation to the prosumer and the “Scenario 4 - Blockchain based prosumer – aggregator production” process starts(see Figure 44: Scenario 4 – 1. Aggregator - prosumer contracting(For a larger version of this model see Appendix C Figure 70: Scenario 4 - 1. Aggregator - prosumer contracting LARGE)).

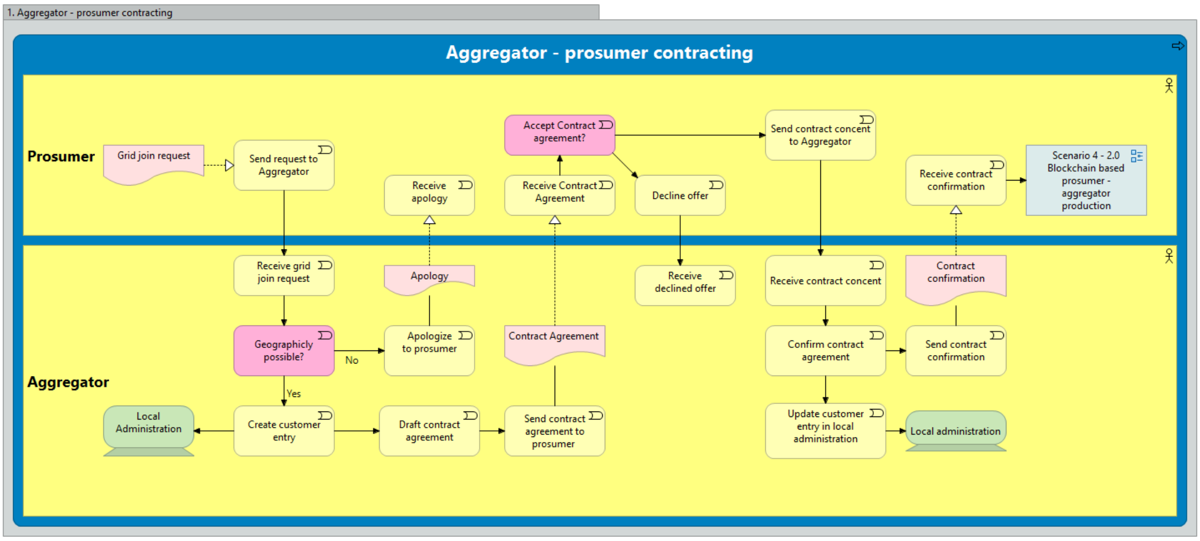


Figure 44: Scenario 4 – 1. Aggregator - prosumer contracting

4.2 Blockchain based prosumer – aggregator production

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

After joining the blockchain based community grid, prosumers should be able to supply electricity to the aggregator or other prosumers. If prosumers have a house battery, they could store their excess electricity into that battery first. If prosumers don't have a battery, or when the battery is full, there could be the option to sell the electricity to an aggregator or to other prosumers. When the prosumer wants to sell their electricity to another prosumer, process "Scenario 4 - 3.0 Blockchain based prosumer to prosumer production" begins.

When the prosumers supply their electricity to the aggregator, the smart meter could record the electricity supply of the prosumer. Based on the recorded electricity supplied, the smart meter could send a number of credits to the prosumer which counts as a digital currency. At the same time, when prosumers would consume more electricity than they produce, process "Scenario 4 - 2.1 Blockchain based prosumer – aggregator consumption" would start. After the production and consumption, a monthly "subscription" fee will be paid to the aggregator and this will be done during "Scenario 4 - 3. Prosumer aggregator billing"(see Figure 45: Scenario 4 – 2.0 Blockchain based prosumer - aggregator productions(For a larger version of this model see Appendix C Figure 71: Scenario 4 - 2.0 Blockchain based prosumer - aggregator production LARGE)).

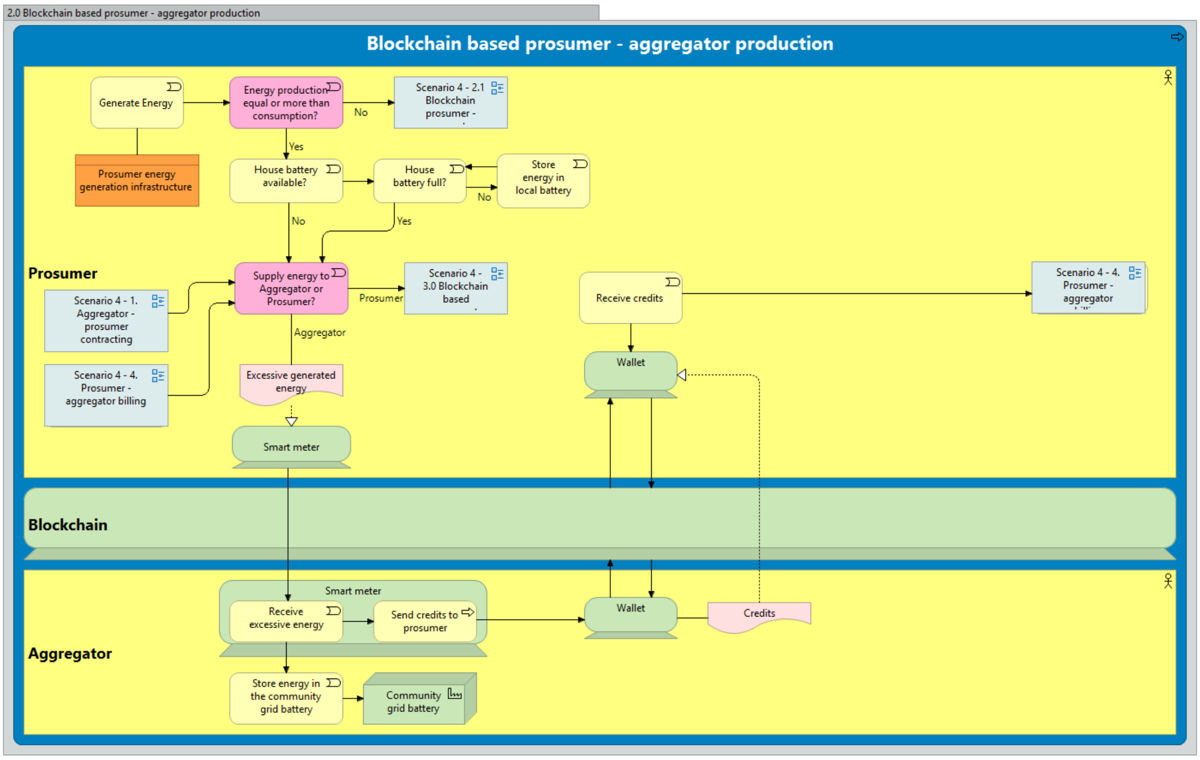


Figure 45: Scenario 4 – 2.0 Blockchain based prosumer - aggregator production

4.3 Blockchain based prosumer – aggregator consumption

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

If a prosumer would consume more electricity than they produce, they could be able to buy the required electricity from the aggregator or other prosumers. If the prosumer has a house battery, they could consume the stored electricity there first. When the prosumer has no house battery or the battery is depleted, they would be able to buy electricity from the aggregator or other prosumers. If the prosumer would choose to buy from another prosumer, process “Scenario 4 – 3.1 Blockchain based prosumer to prosumer consumption” begins.

When a prosumer chooses to buy from the aggregator, the application managing the credits, in this case, blockchain, will check the prosumer’s balance. If the balance is not enough, the request will be canceled. If the prosumer has enough balance, they will send the credits to the aggregator. Once the aggregator received the credits, they supply the electricity amount based on the payment, from the community grid to the prosumer. After the production and consumption, a monthly “subscription” fee will be paid to the aggregator and this will be done during “Scenario 4 - 4. Prosumer aggregator billing”(see Figure 46: Scenario 4 – 2.1 Blockchain prosumer - aggregator consumption(For a larger version of this model see Appendix C Figure 72: Scenario 4 -2.1 Blockchain based prosumer - aggregator consumption LARGE)).

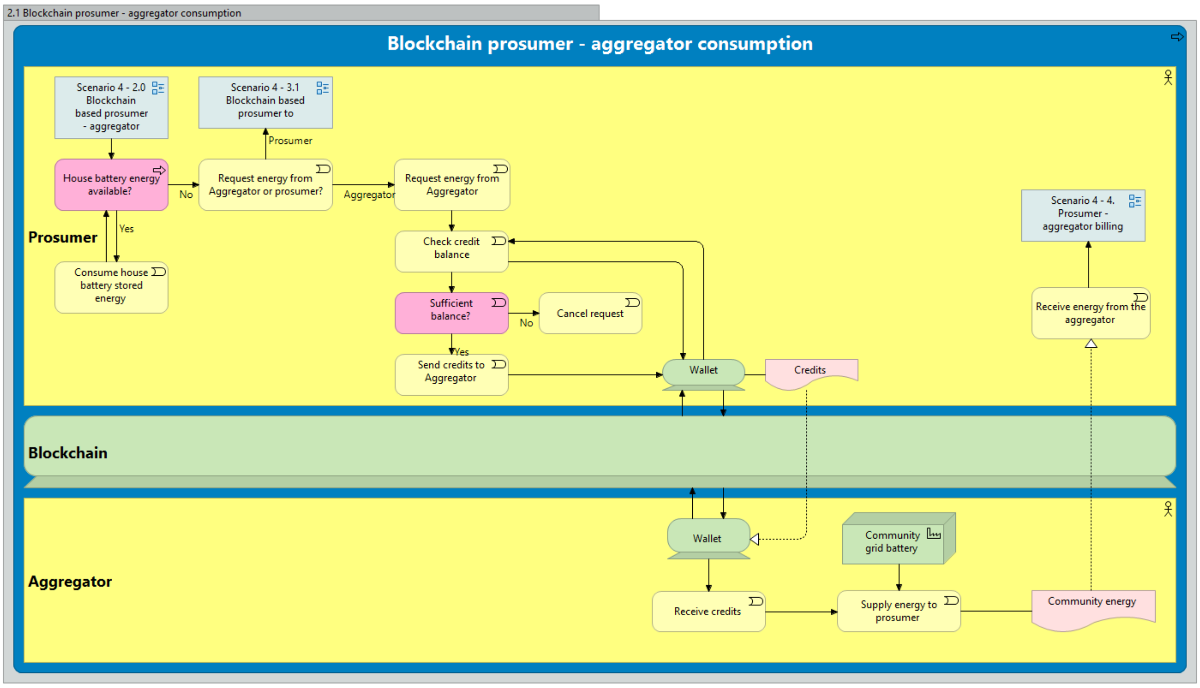


Figure 46: Scenario 4 – 2.1 Blockchain prosumer - aggregator consumption

4.4 Blockchain based prosumer to prosumer production

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

When prosumers generate more electricity than they consume, they would be able to sell it to other prosumers or consumers that are in need of electricity. Prosumers could have the ability to store a certain amount of electricity in a house battery. When the battery is full, they could sell the excess electricity to consumers or prosumers in electricity need, in this example we call them "prosumer 2". Prosumer 1 will send a credit request to Prosumer 2 for the required electricity. The application managing the credits, in this case, blockchain, will check Prosumer 2's balance. If the balance is not enough, the request will be canceled. If Prosumer 2 has enough balance, it will send the credits to Prosumer 1. Once Prosumer 1 received the credits, they will start supplying the electricity amount based on the credits received, to Prosumer 2. After the production the prosumer pays a monthly fee to the aggregator, this occurs during "Scenario 4 – 4. Prosumer – aggregator billing" process(see Figure 47: Scenario 4 – 3.0 Blockchain based prosumer to prosumer production(For a larger version of this model see Appendix C Figure 73: Scenario 4 - 3.0 Blockchain based prosumer to prosumer production LARGE)).

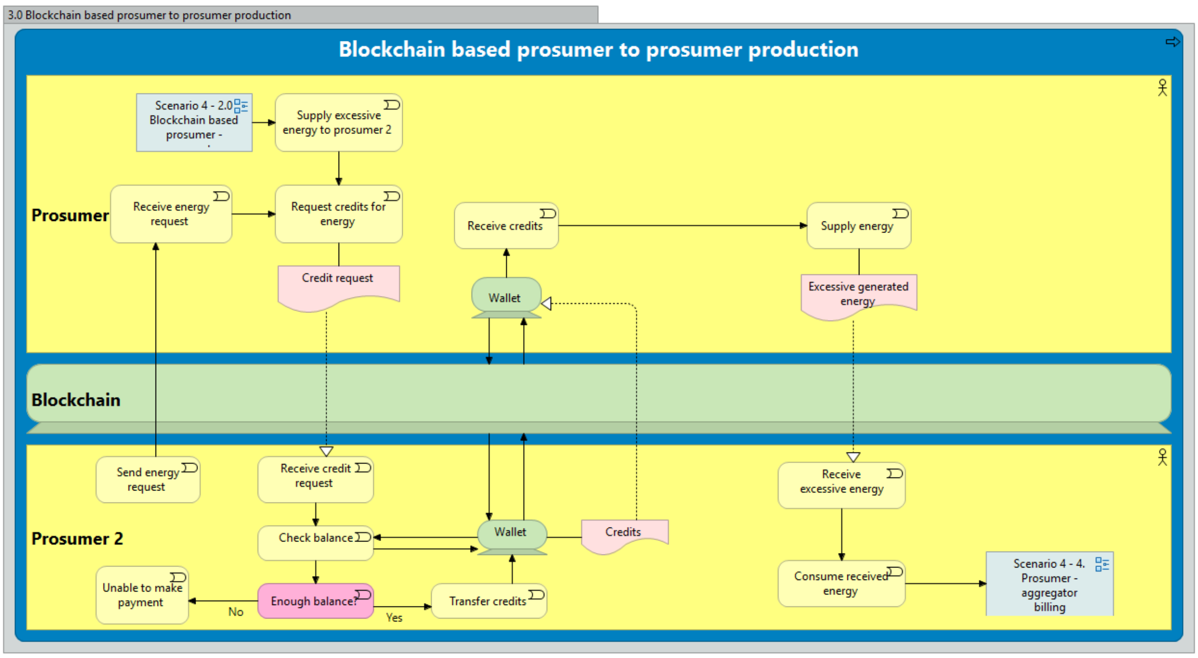


Figure 47: Scenario 4 – 3.0 Blockchain based prosumer to prosumer production

4.5 Blockchain based prosumer to prosumer consumption

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

When prosumers generate less electricity than they consume, they could buy electricity directly from other prosumers If the prosumer has a house battery available, they could first consume the electricity stored in there. If they need more electricity than stored in the house battery, they could send an electricity request to a different prosumer, in this case, Prosumer 2. Prosumer 2 would receive the request and send a credit request based on the required amount of electricity. The application managing the credits, in this case, blockchain again, will check Prosumer 1 their balance. If the balance is not sufficient, the request will be canceled. If Prosumer 1 has enough balance, the blockchain will send the credits to Prosumer 2. Once Prosumer 2 received the credits, they will start supplying the electricity amount based on the number of credits received, to Prosumer 1. After the consumption the prosumer pays a monthly fee to the aggregator, this occurs during “Scenario 4 – 4. Prosumer – aggregator billing” process(see Figure 48: Scenario 4 -3.1 Blockchain based prosumer to prosumer consumption(For a larger version of this model see Appendix C Figure 74: Scenario 4 - 3.1 Blockchain based prosumer to prosumer consumption LARGE)).

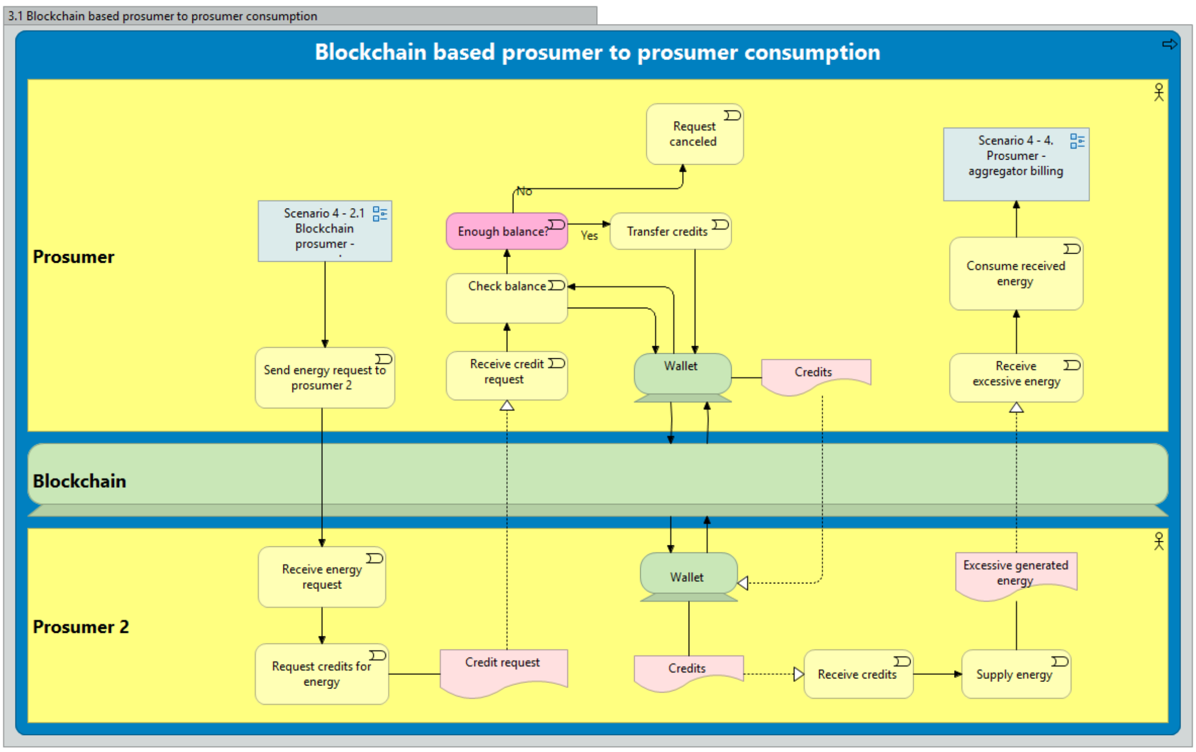


Figure 48: Scenario 4 -3.1 Blockchain based prosumer to prosumer consumption

4.6 Blockchain based prosumer – aggregator billing

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Periodically the aggregator collects a fee from the grid users and drafts an invoice according to the contracts. Based on the type of contract between the aggregator and the prosumer, the aggregator drafts an invoice for a monthly "subscription" fee, or a percentage cut of the transactions made. In order to invoice the transaction cut, the aggregator connects to the smart meter and reads the transactions made. He then drafts and sends the invoice to the prosumer. After the prosumer paid the invoice the process starts over again at the "Scenario 4 - 2.0 Blockchain based prosumer - aggregator production" process(see Figure 49: Scenario 4 - 4. Prosumer - aggregator billing(For a larger version of this model see Appendix C Figure 75: Scenario 4 -4. Prosumer - aggregator billing LARGE)).

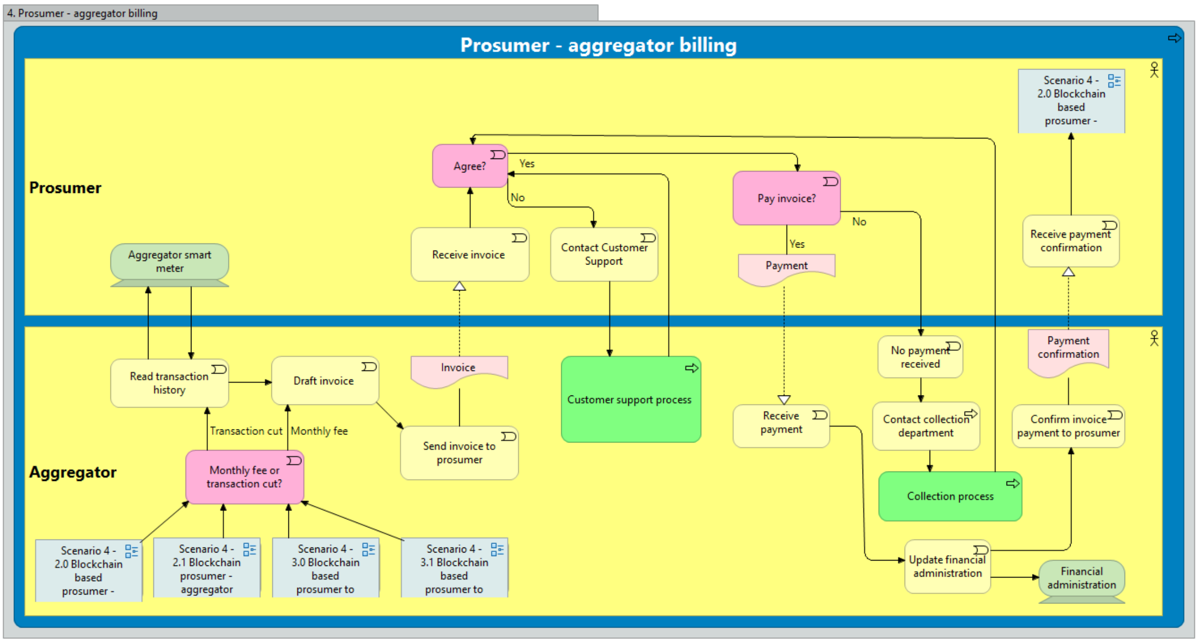


Figure 49: Scenario 4 - 4. Prosumer - aggregator billing

SWOT analysis for a centralized grid with hybrid production, distribution, and administration

	Centralized	Hybrid	Decentralized
Production	Powerplant	Powerplant & Prosumers	Prosumers
Distribution	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers
Administrational process	Energysupplier / Aggregator	Energysupplier / Aggregator & Prosumers	Prosumers

Figure 50: SWOT analysis for a centralized grid with hybrid production, distribution, and administration

5
Case conclusions and recommendations

Conclusion:

The sector of power production, distribution and administration is changing from a centralistic, centralized model to a more decentralized model. This change enables that consumers can also become producers. As a result of this change, distribution and administration can also move (partially) from a centralized system to a peer-to-peer system.

As the capabilities of prosumer electricity production grow (amongst others due to the government pressure of reducing the overall energy consumption by the Dutch population), both in capacity as well as variety (sun, wind, hydrogen), this development is unstoppable.

During this research, we have explored and examined the centralized, hybrid and decentralized models, as depicted in the summary-matrix in Figure 31: Decentralization matrix.

Based on our extensive research of the advantages and disadvantages of/ strengths and weaknesses in both the hybrid model as well as the fully decentral model, we arrived at the conclusion that the fully decentral model has too many drawbacks and that these drawbacks are impossible to work with.

However, at the same time, the current centralized model does no longer suffice the actual market context. Consumers are becoming prosumers and start to generate and consume their own electricity, and supply the excess electricity to third-party consumer-customers.

With the progress of consumers becoming prosumers, it follows logically that in line with decentral electricity production, the administration of electricity usage and production, and as an extent of that, the financial settlement, could also have the possibility of being fully or partially decentralized. However, our SWOT showed that the fully decentralized model had too many drawbacks, and therefore, companies should focus on a hybrid model for their business.

New emerging ICT technologies like Blockchain are able to facilitate the administrative process, as it allows for peer-to-peer communication of usage and production logging in a secure, transparent and non-repudiation kind of way. This enables all participants, both centralized as decentralized, to conduct a transparent production and consumption administration that could function for financial settlements.

However, for all this to work, the current, still monopolistic operating electricity providers need to facilitate these changes, both in their distribution as well as their administration infrastructure.

This will shift part of the negotiation power from the current electricity providers to a new "joint operation" in which they need to co-operate with a large number of small producer-customers that at the same time also are their consumer-customers, who can opt to either deliver the energy they produce to them (the central entity) OR to customers (electricity consumers) in their direct vicinity, in a peer-to-peer kind of way or a mix of this, depending on actual demand.

Recommendations:

Based on this research, our recommendations in this change are primarily geared towards the existing, large-scale, still largely centralistic operating electricity producers. The electricity producers that not only sell electricity to their customers but also generate this electricity themselves.

The unstoppable developments from centralized to decentralized systems bring both threats and opportunities with this change. It is important to understand these threats and opportunities in order to execute this change successfully.

The primary threat of electricity producers is that of losing production capacity, as the upcoming and increasing decentralized electricity production by prosumers will increase. The increased electricity production of prosumers will cause a decrease in demand for centralized produced electricity.

However, the current centralized producers, together with the distribution network providers (e.g. Tennet), still own the overall infrastructure in the public domain (i.e. outside the houses and offices). As such they are best situated to alter and extend this infrastructure in such a way that it becomes usable for dual ways of distribution: central-to-consumer, consumer to central and peer-to-peer within the local community.

There will always be an important role left for the central producers, as there will be a need for "peak-power" supply, and/or other step-in delivery of power, as the decentral constitution will typically be less reliable both in quality and quantity and redundancy.

There is a good new business opportunity for the current electricity producers to lease out decentralized electricity generating infrastructure to customers. This allows consumers to become prosumers without having to invest heavily in their own required infrastructure. These lease contracts will allow electricity producers to create prolonged customer lock-in.

There is also a good new business opportunity for the current producers in the form of offering new add-on administrative services. As they are hooked in any way into the new hybrid distribution network, they are in a unique position to monitor, log and administer both the centrally provided energy as well as the decentralized produced and consumed energy of all parties involved.

As an independent third party, the current producers are able to deliver an overall comprehensive overview of production and usage, split out into individual consumption/production location, on which the subsequent financial settlement can be based.

This system needs to also allow for various cost rates, based on the producer involved, which part of the distribution network is used, time of day, etc. Some of these rates will be determined centrally, and some others will be determined decentrally.

This hybrid system will of course also deliver more “shopping power” to the consumers and prosumers, as they have now multiple parties to choose from. The consumers and prosumers are able to choose any party based on the rates charged or offered.

If the central producers ignore these unstoppable developments, they will be side-lined. Ignoring these developments will allow competitors to step in. It might be possible that they receive Government support to do so. It might even turn into mandatory changes, dictated by new laws, linked to Government-issued license – like in the telecom market.

The changes in the administration system will likely be the easiest to implement. The current administration infrastructure already provides “smart meters” that offer remote readout and back-delivery capabilities. These “smart meters” could be used by the new administration service party.

However, it is important that both changes go hand-in-hand, as they both depend on each other and won’t be able to work separately.

6
Generalization

The shift from centralized to decentralize is now happening in the electricity market. Modern technology made it possible for prosumers to generate and consume their own decentralized electricity, while blockchain for example also made it possible for prosumers to make direct peer-to-peer transactions. This shift changes the business models of the current market as shown in the research above. However, this shift is not limited to just the electricity market and could just as well also happen in different markets.

The hotel market is a market where this shift is also happening. Corporations traditionally rented rooms of their own owned buildings in a centralized way. However, the company Airbnb changed this market by not owning their own buildings but having prosumers rent out their own rooms, houses or buildings and providing these to their platform customers. *"Airbnb and Uber are still centralized platforms, which get their value from each transaction made on their platform" – Head of Freedom Lab Future Studies thinktank*

Person transportation is another market where the shift from centralized to decentralized infrastructure is happening. Taxi companies use their own taxi's in which they transport people. However, in 2009 Uber entered the market and instead of owning their own transportation vehicles, they employed car owning drivers, and have them transport people using their own car. This way Uber didn't have to invest in any transportation resources but used their prosumers resources instead.

Even the media market sees a change from centralized to decentralized content. In the past when a media company wanted to display media to their customers, they had to make their own media for this. However, in 2007 Netflix entered the market with an online platform where they offer a big Scala of on-demand movies and series. Consumers are able to watch what they want, whenever they want. Much of their content is not generated by themselves but produced by third-party prosumers. By offering this service, Netflix competes with traditional television media providers such as Ziggo. *"The first mover advantage is so strong, that if you want to beat this entity, you'll have to come with something really unique and innovative." -Head researcher at Dasym Capital*

In the past, someone had to contact a centralized record company in order to try and get their song or album published. Spotify created a platform where prosumers can upload and sell their own music for a certain fee. This platform completely changed the music industry and allows artists to create and distribute their own content. *"Where artists traditionally have to pay up to 50% to the label company and distribute the remaining 50% over the other involved parties such as* *the writer, singer, musicians, etc. Spotify only charges 10-20% to publish the song on their platform and leaves the remaining money with the publisher." -Head researcher at Dasym Capital* This allows the artist to manage their own content and career, place-specific advertisements to their fan base without the use of a centralized party. The movements, models and settlement structures that we discussed in the electricity sector are therefore also reflected in many other social sectors.

7

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Appendix A: Pre-validated models

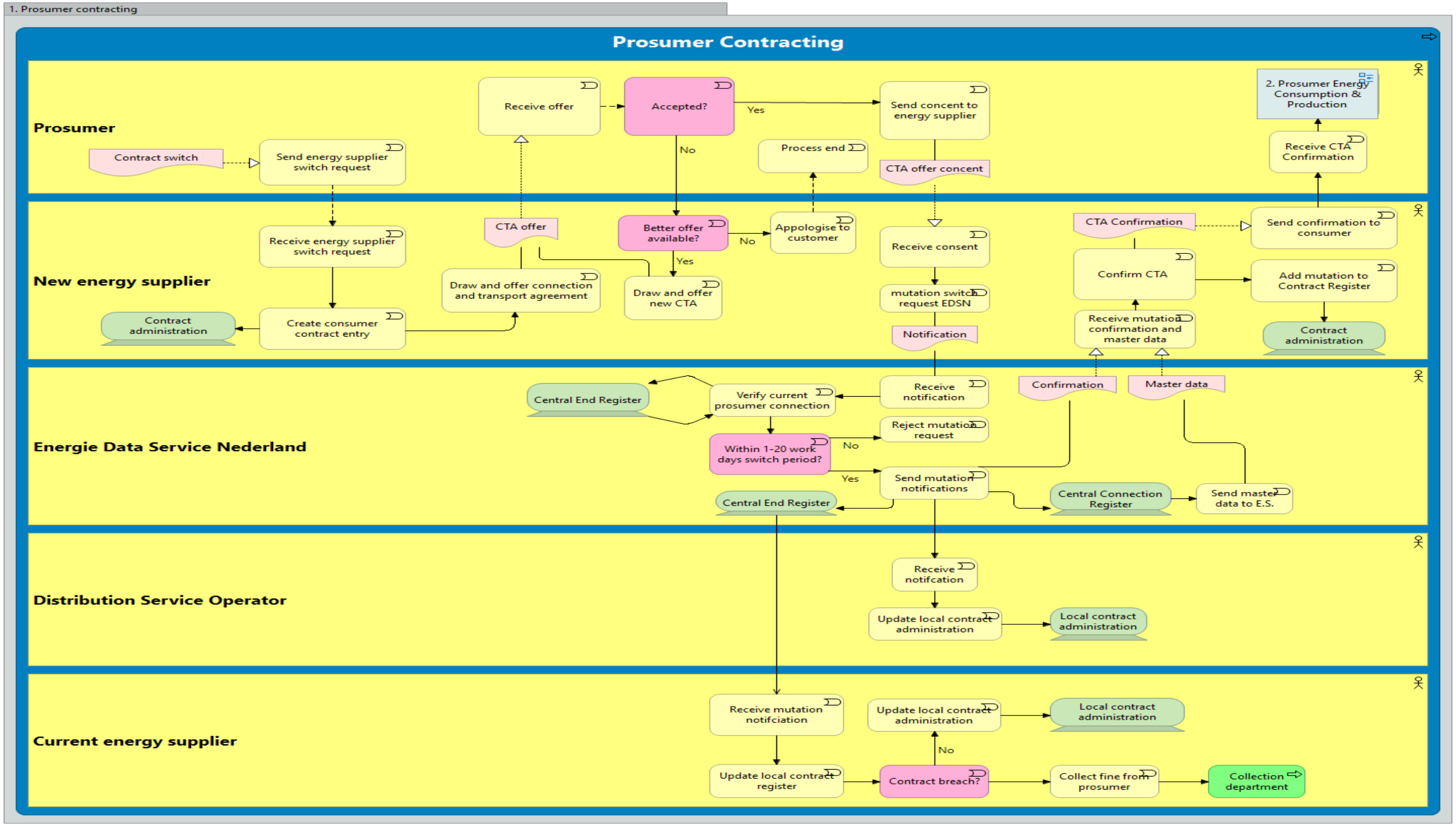

Figure 51: Pre-validation Prosumer Contracting LARGE

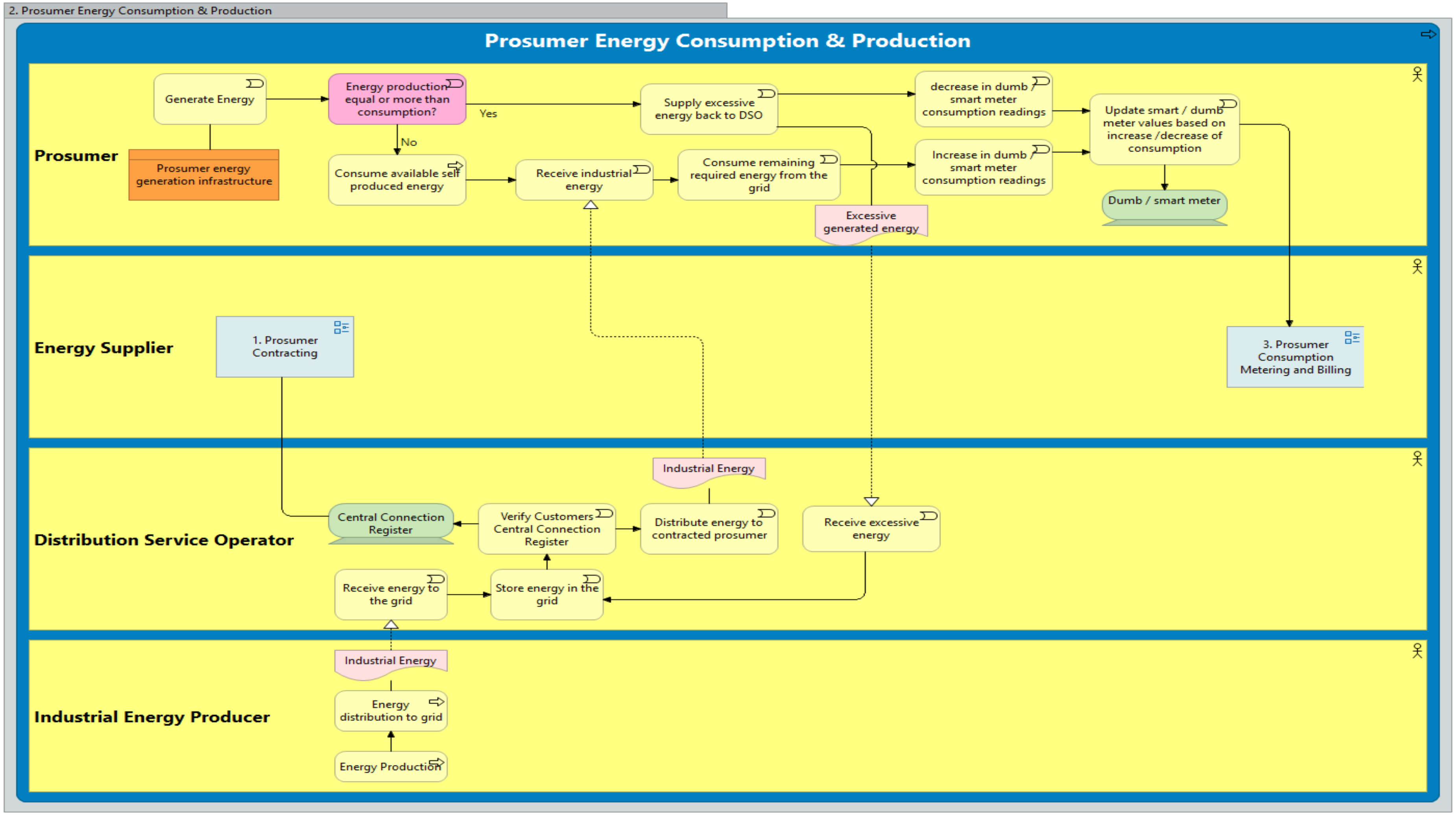

Figure 52: Pre-validation Prosumer Consumption & Production LARGE

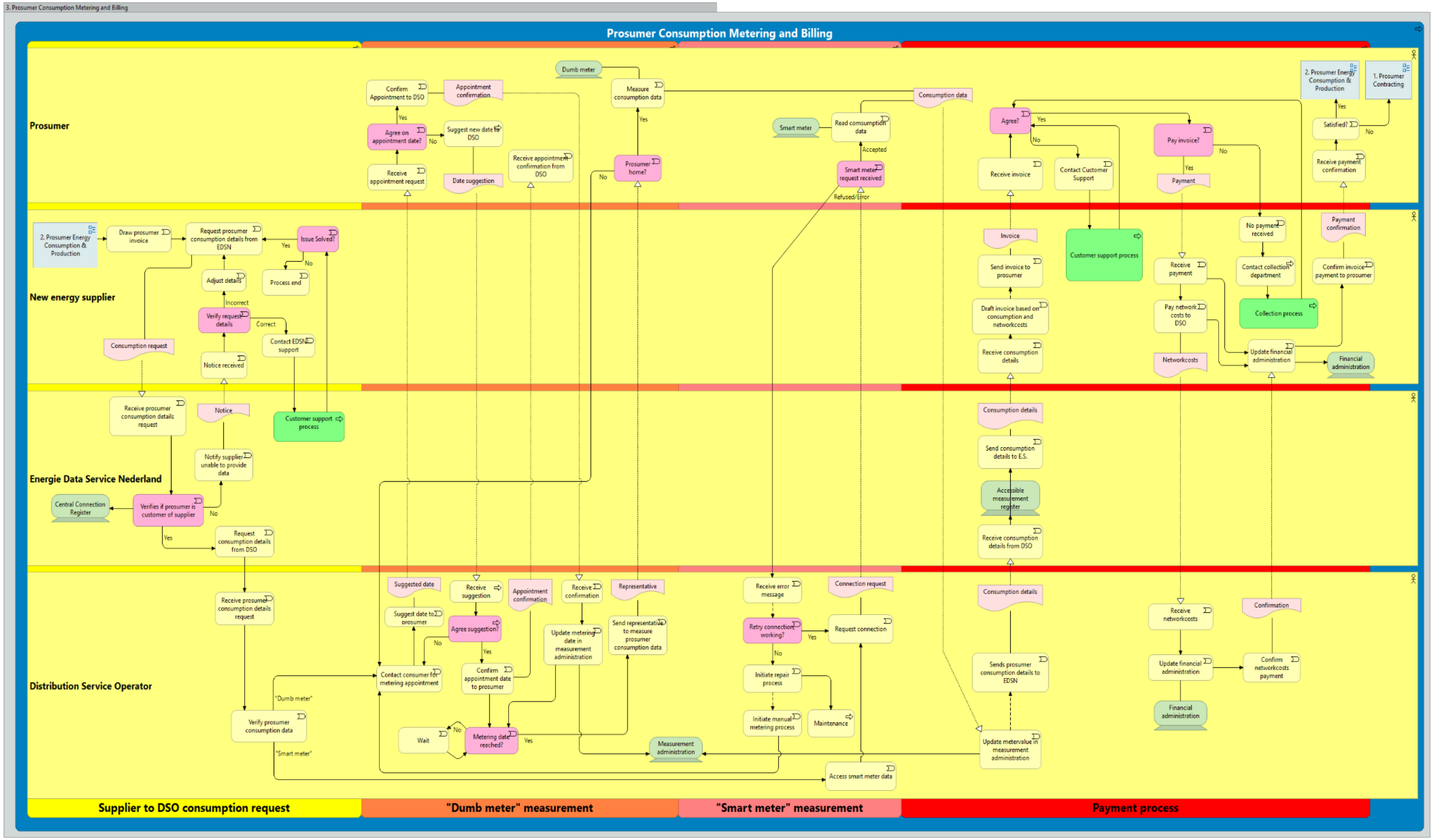

Figure 53: Pre-validation Prosumer Consumption metering and Billing LARGE

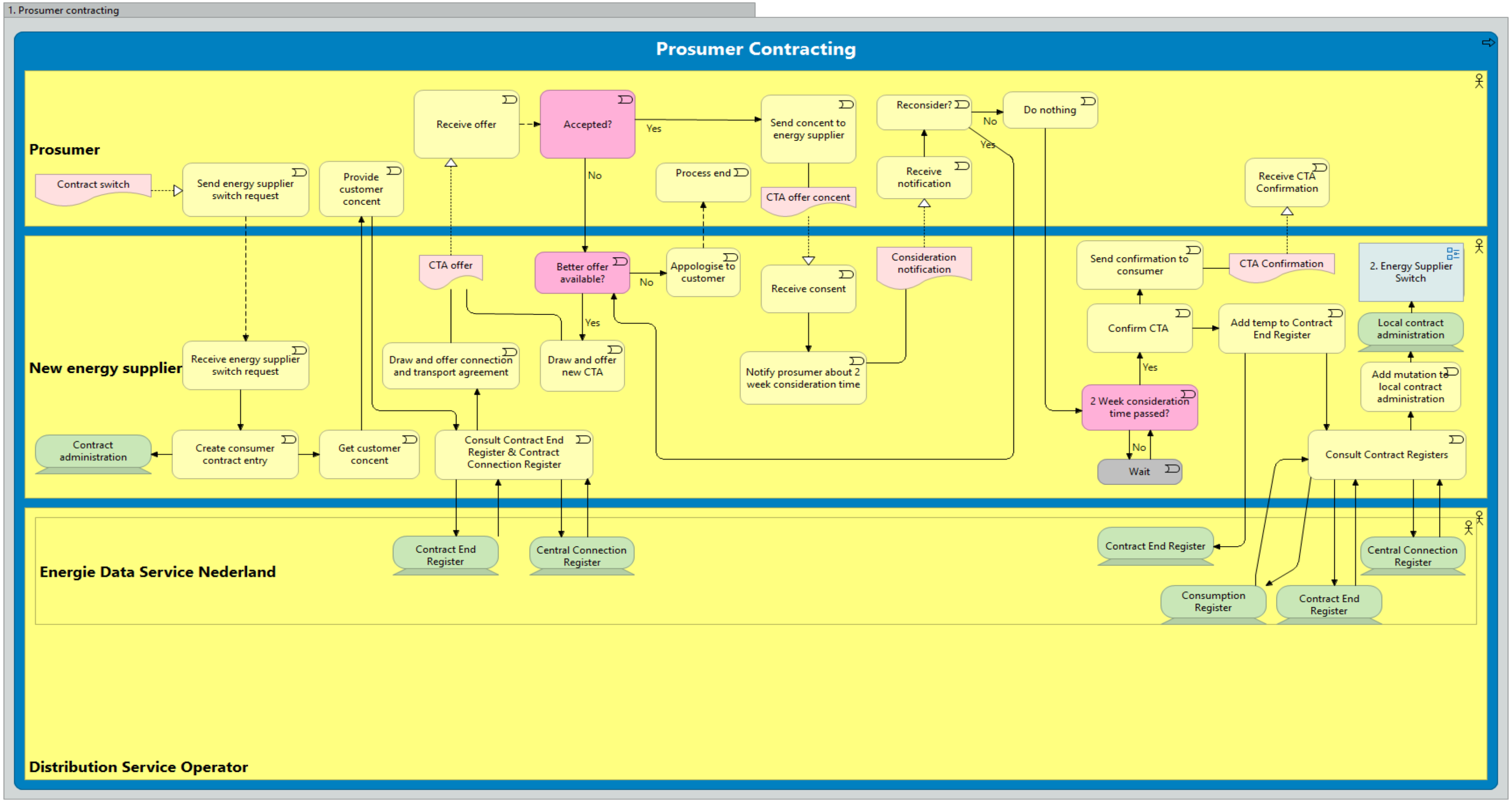

Figure 54: Post-validation Prosumer contracting LARGE

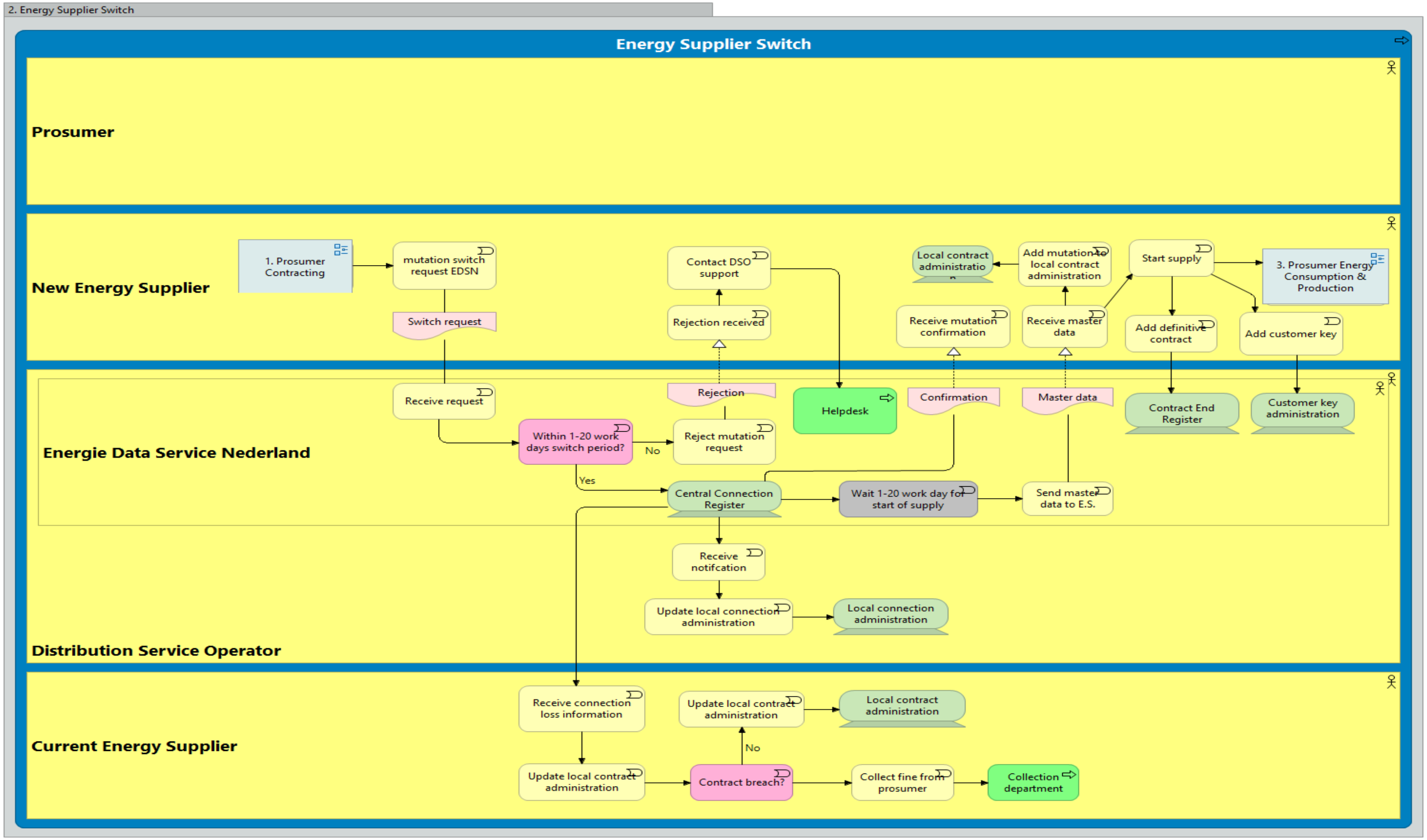

Figure 55: Post-validation Supplier switch LARGE

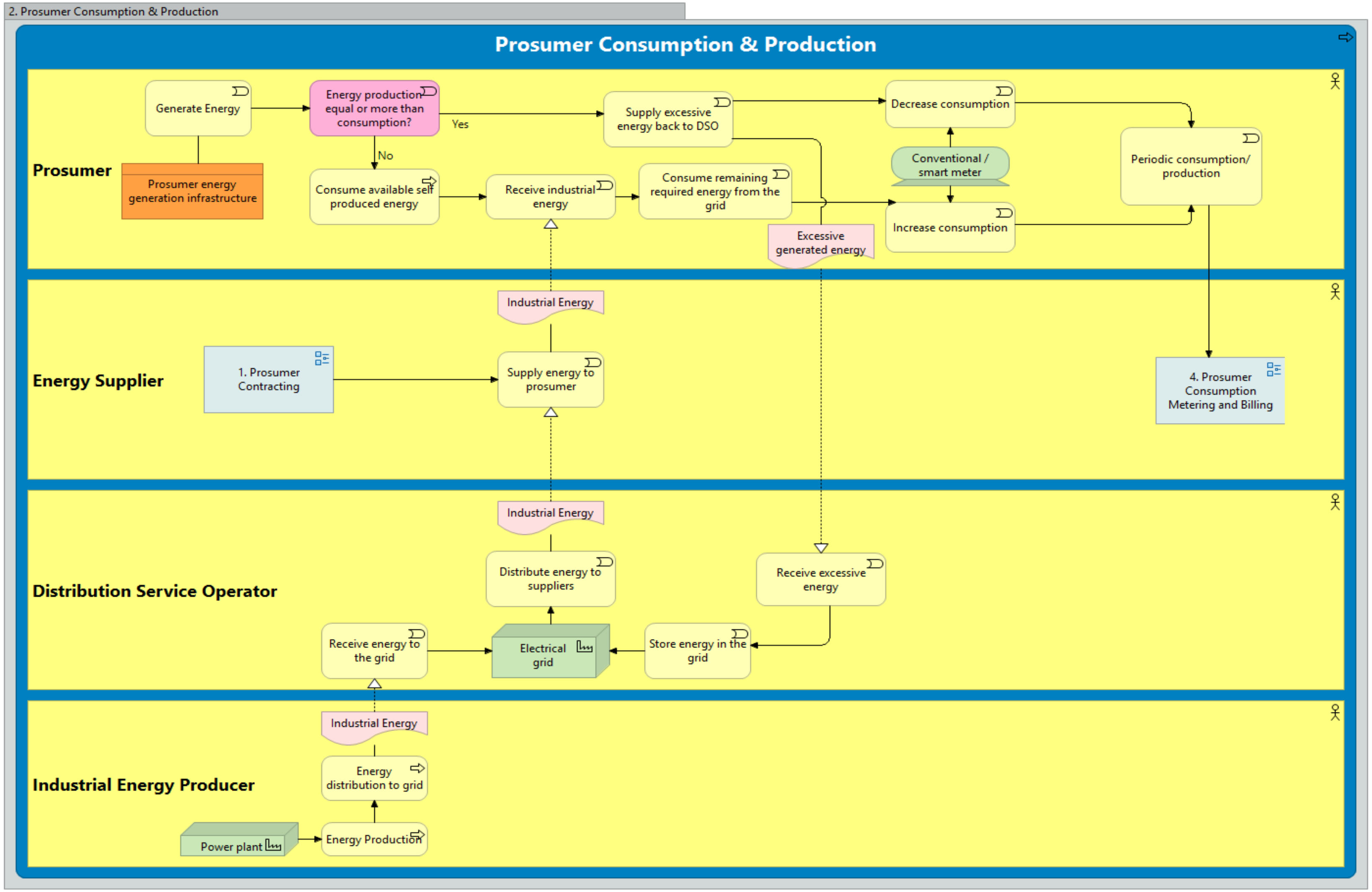

Figure 56: Post-validation Prosumer consumption & production LARGE

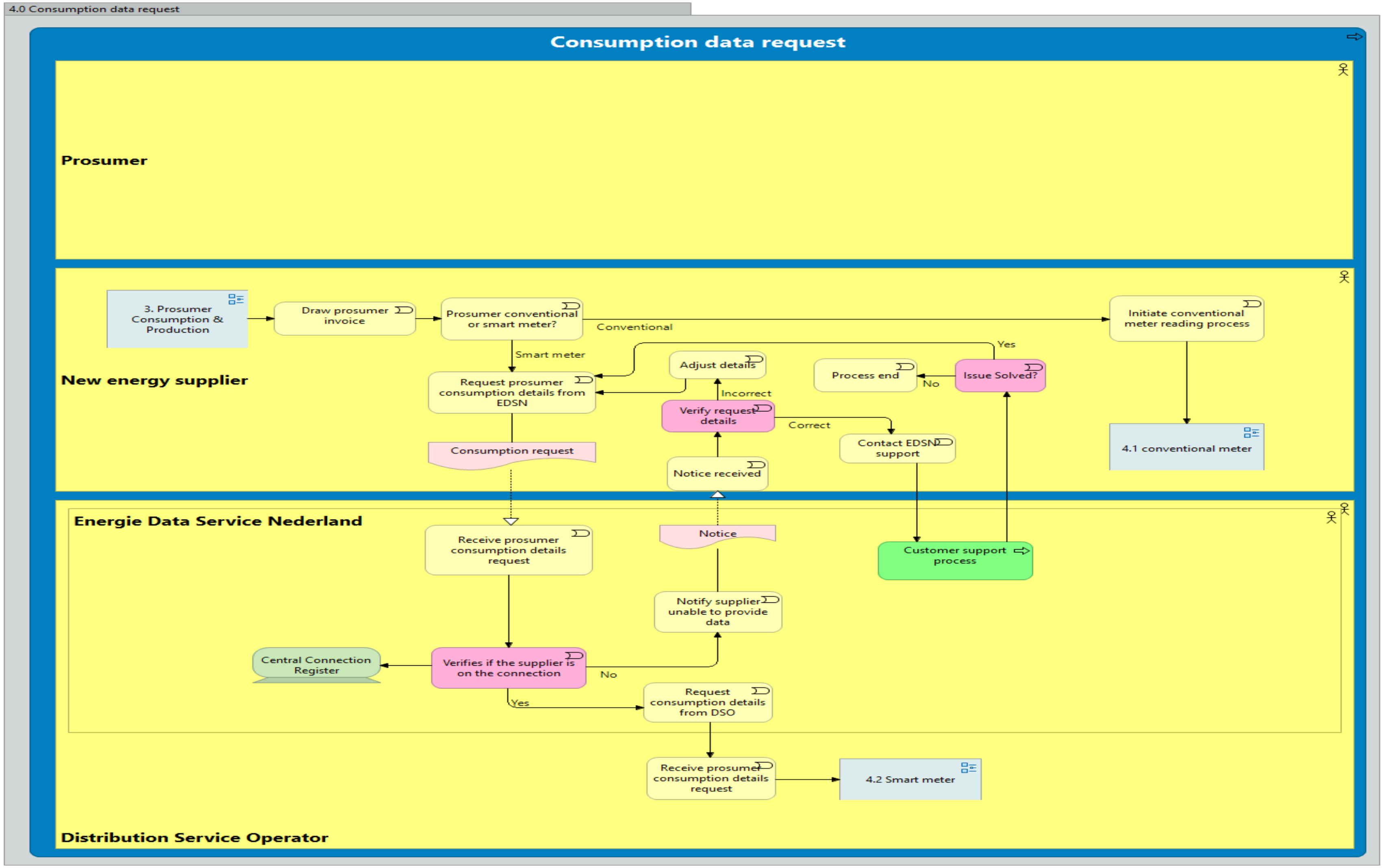

Figure 57: Post-validation Consumption data request LARGE

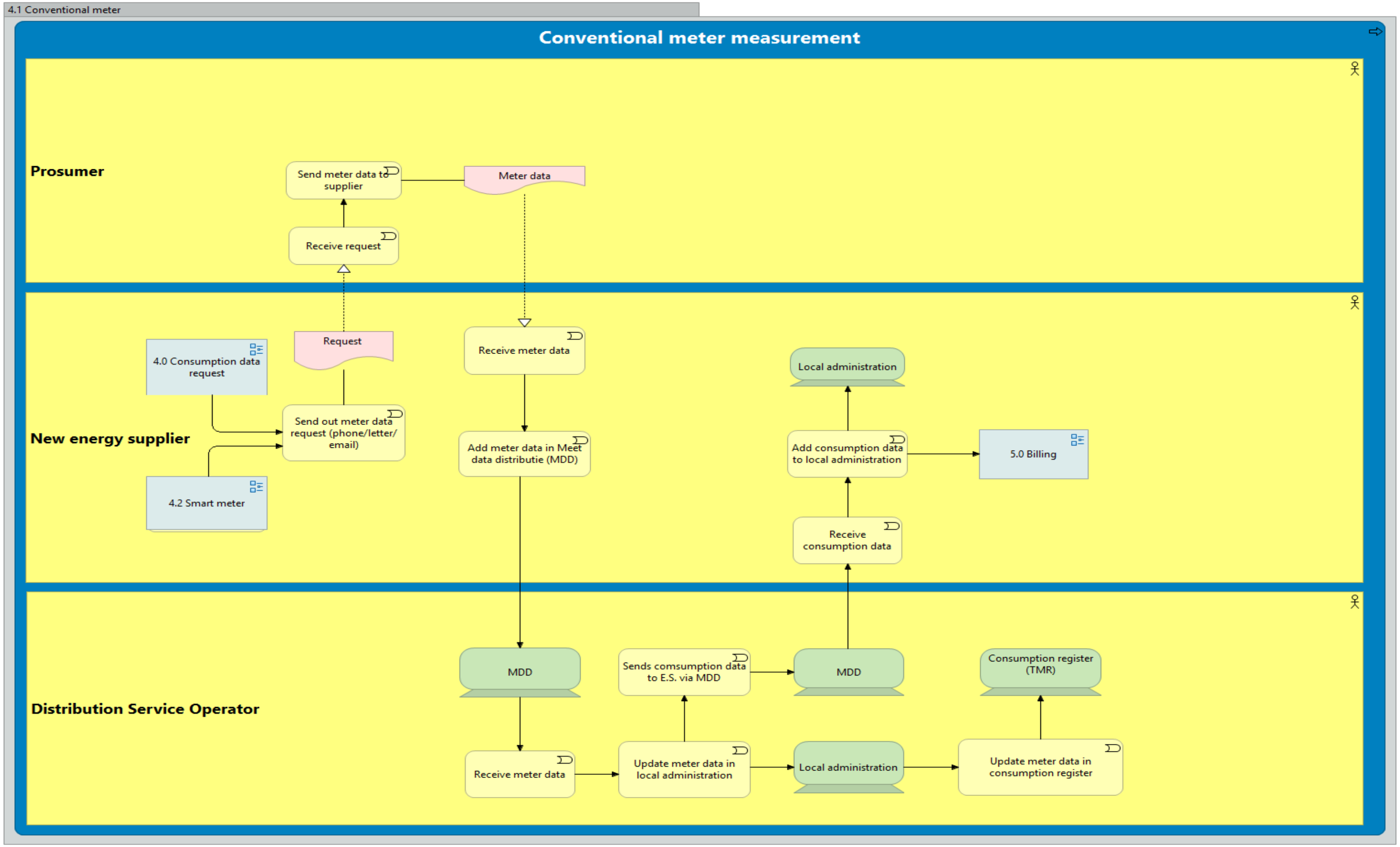

Figure 58: Post-validation Conventional meter measurement LARGE

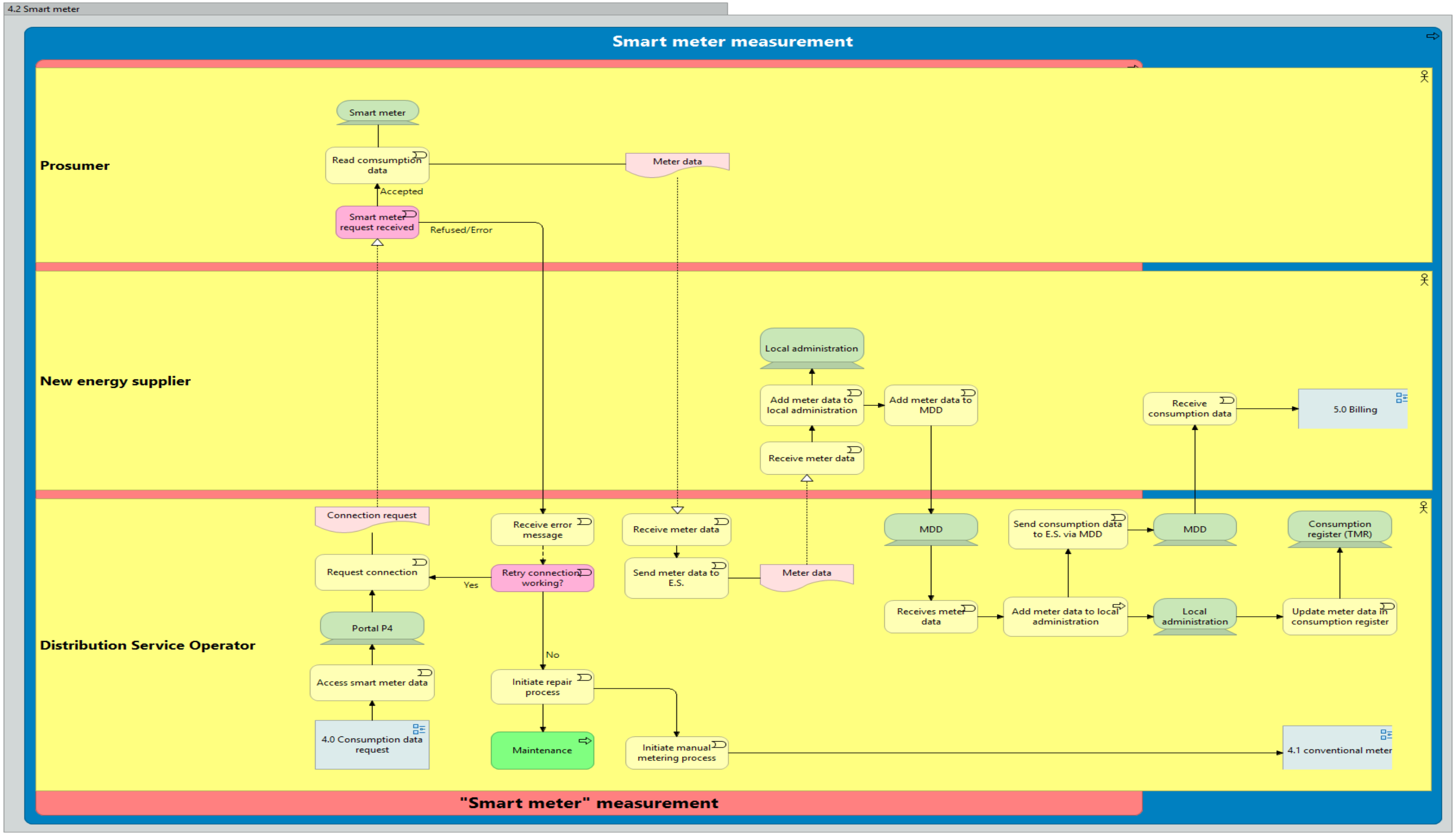

Figure 59: Post-validation Smart meter measurement LARGE

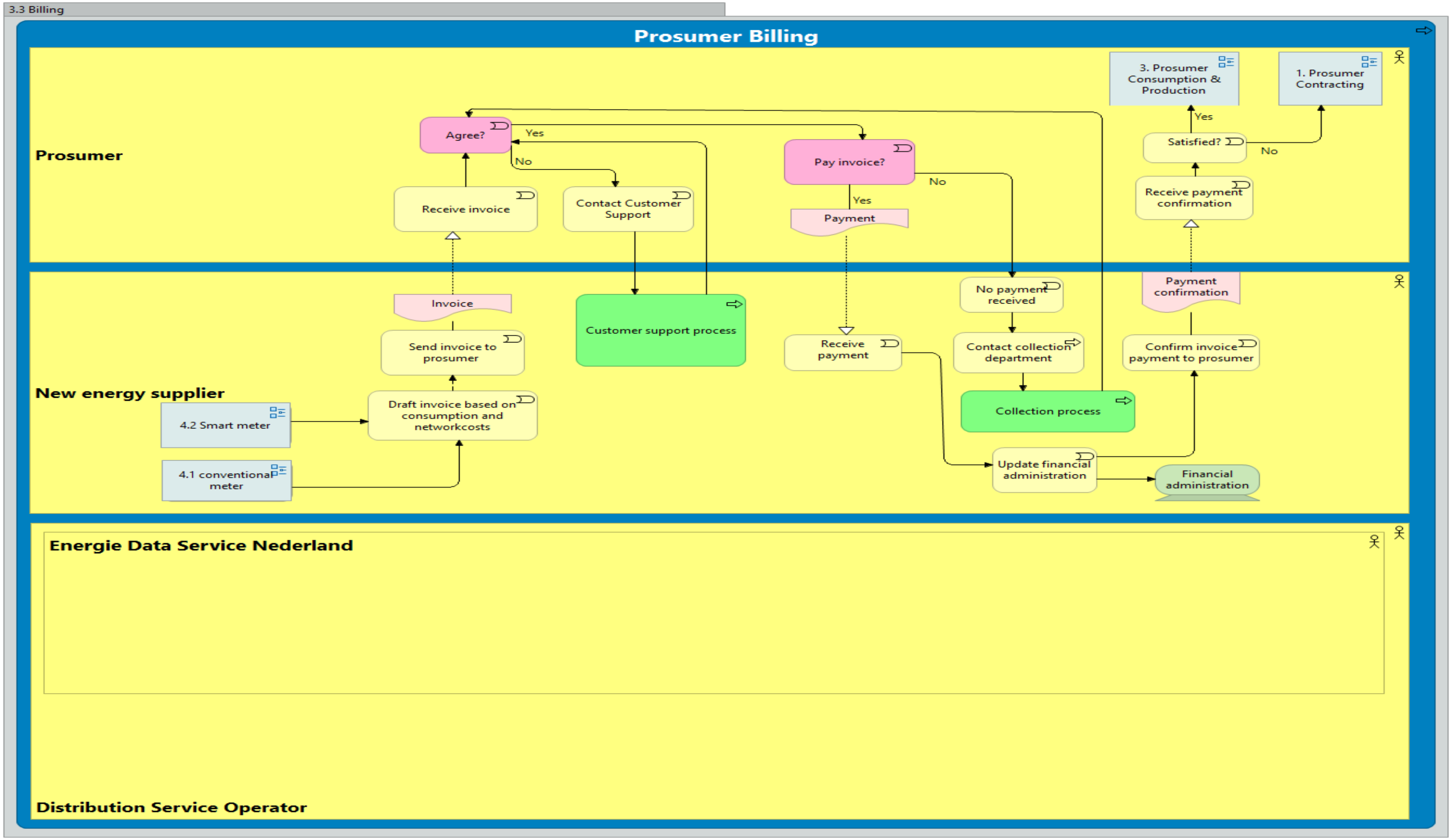

Figure 60: Post-validation Billing LARGE

Scenario 1:

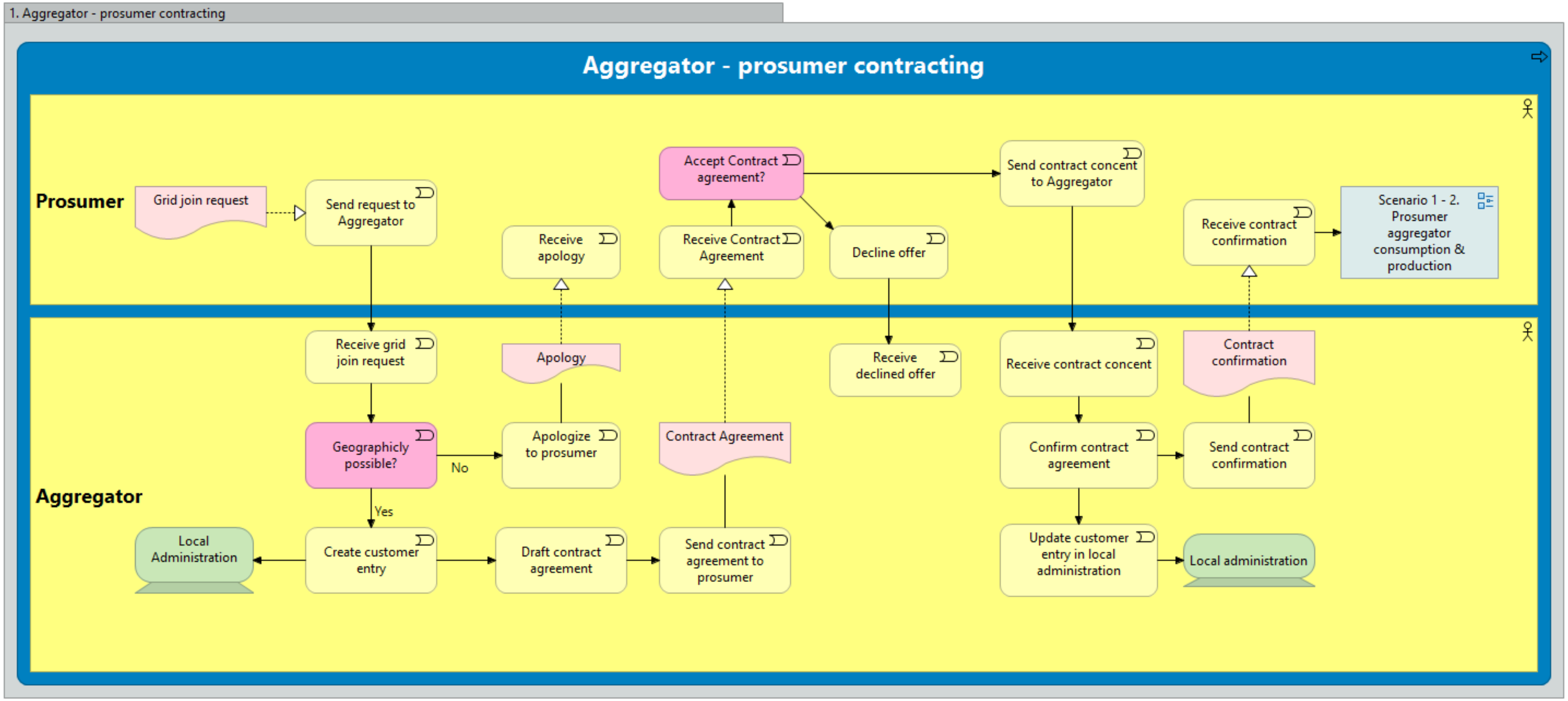

Figure 61: Scenario 1 -1. Aggregator - prosumer contracting LARGE

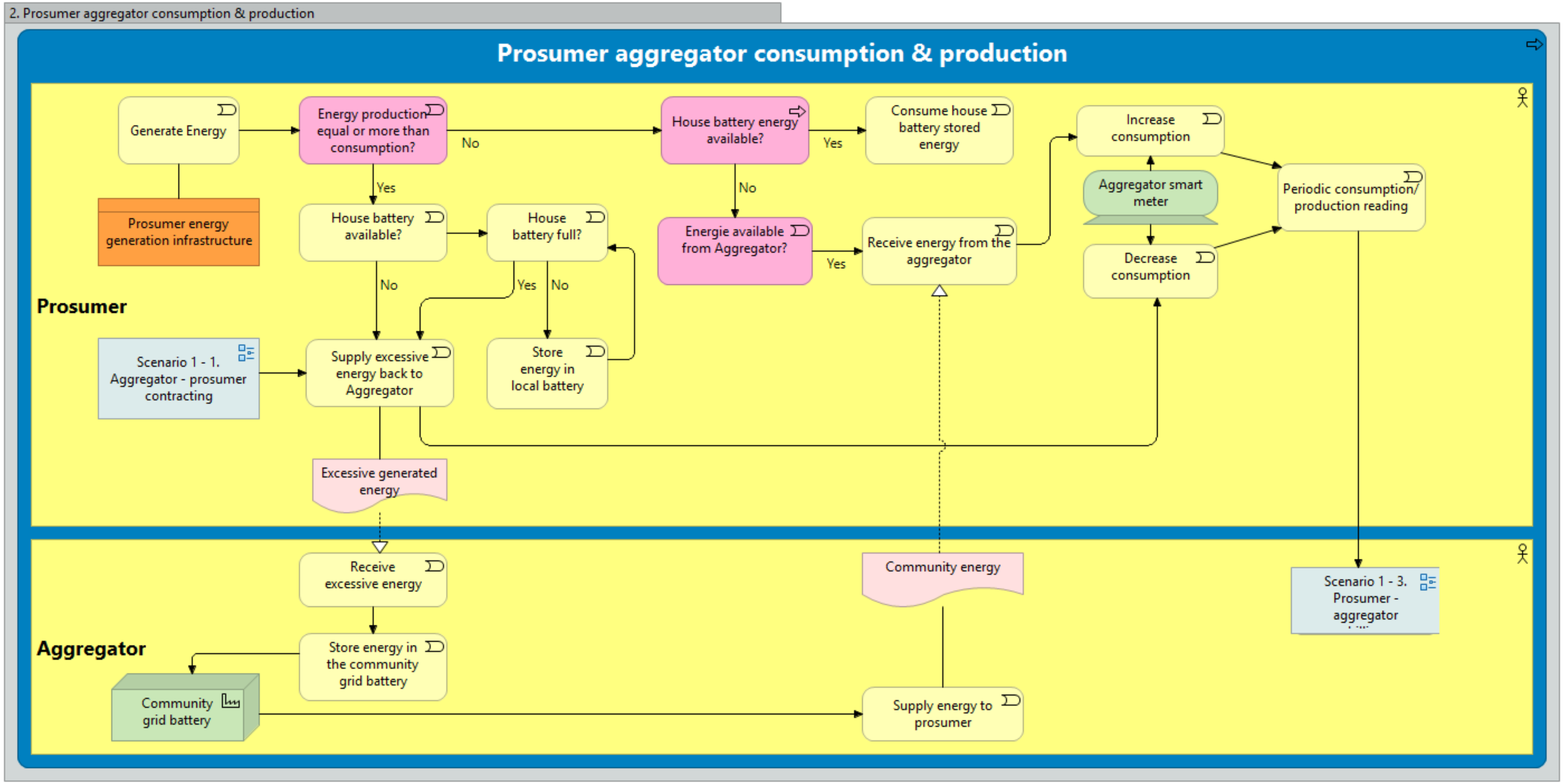

Figure 62: Scenario 1 - 2. Prosumer - aggregator consumption & production LARGE

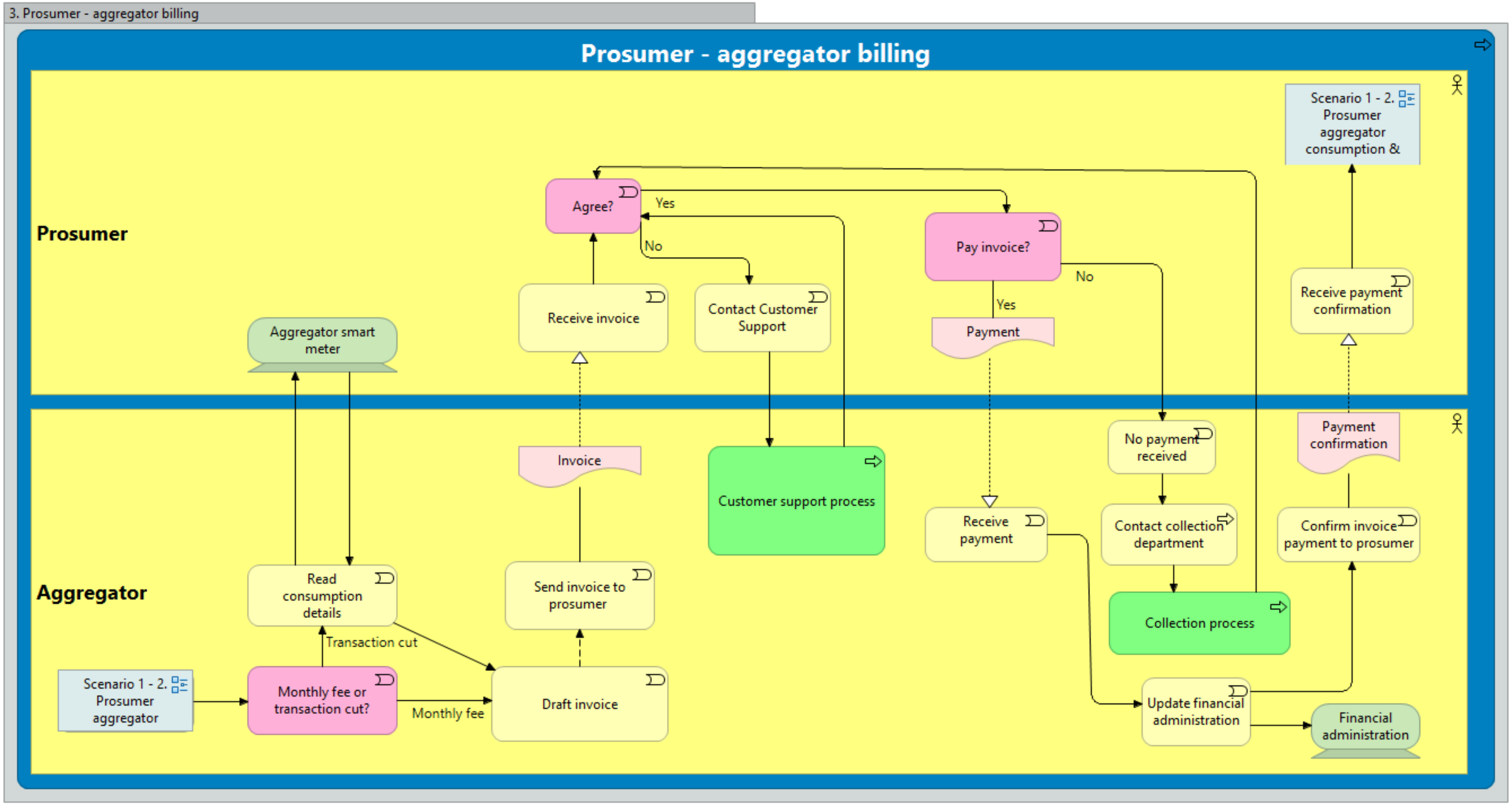

Figure 63: Scenario 1 - 3. Prosumer - aggregator billing LARGE

Scenario 2:

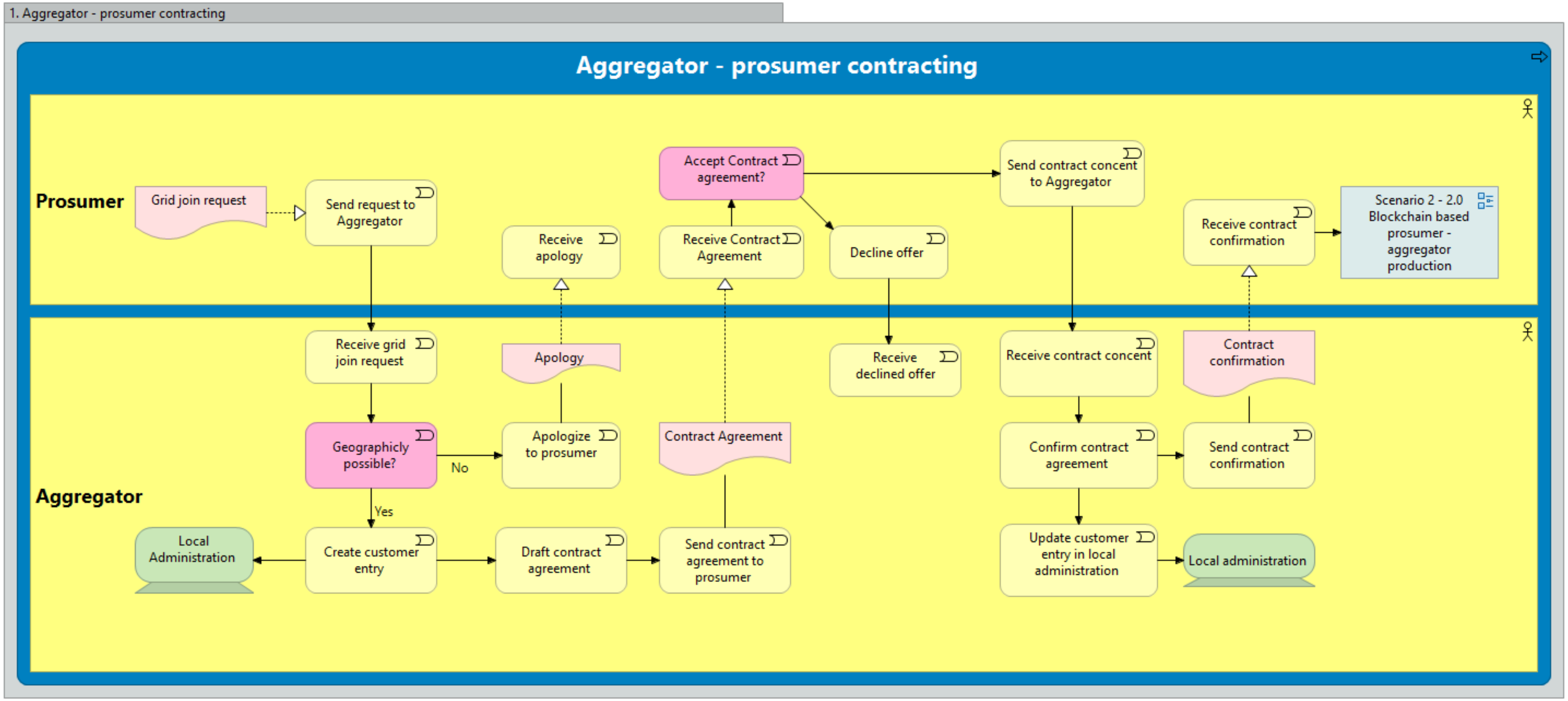

Figure 64: Scenario 2 - 1. Aggregator - prosumer contracting LARGE

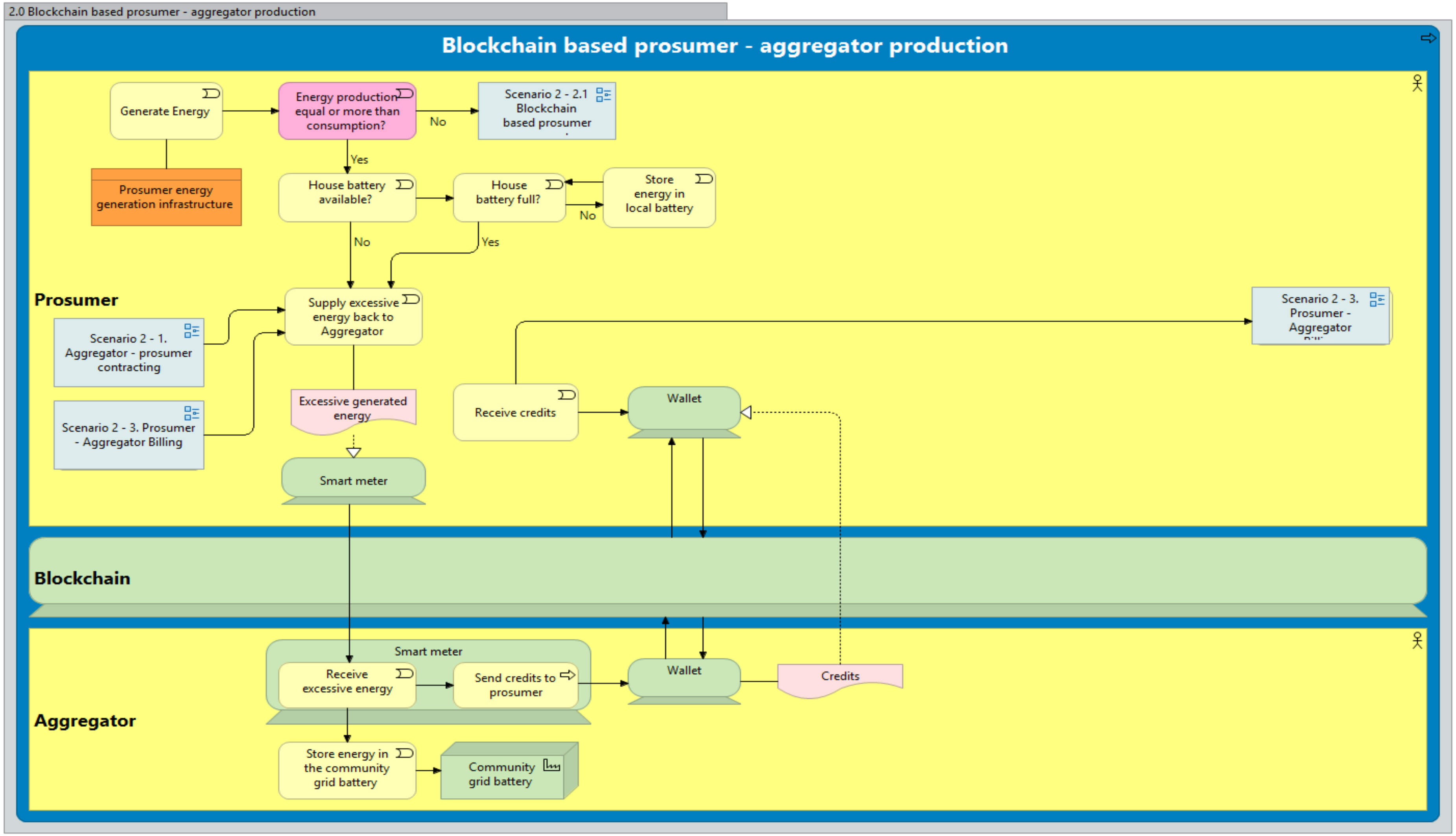

Figure 65: Scenario 2 - 2.0 Blockchain based prosumer - aggregator production LARGE

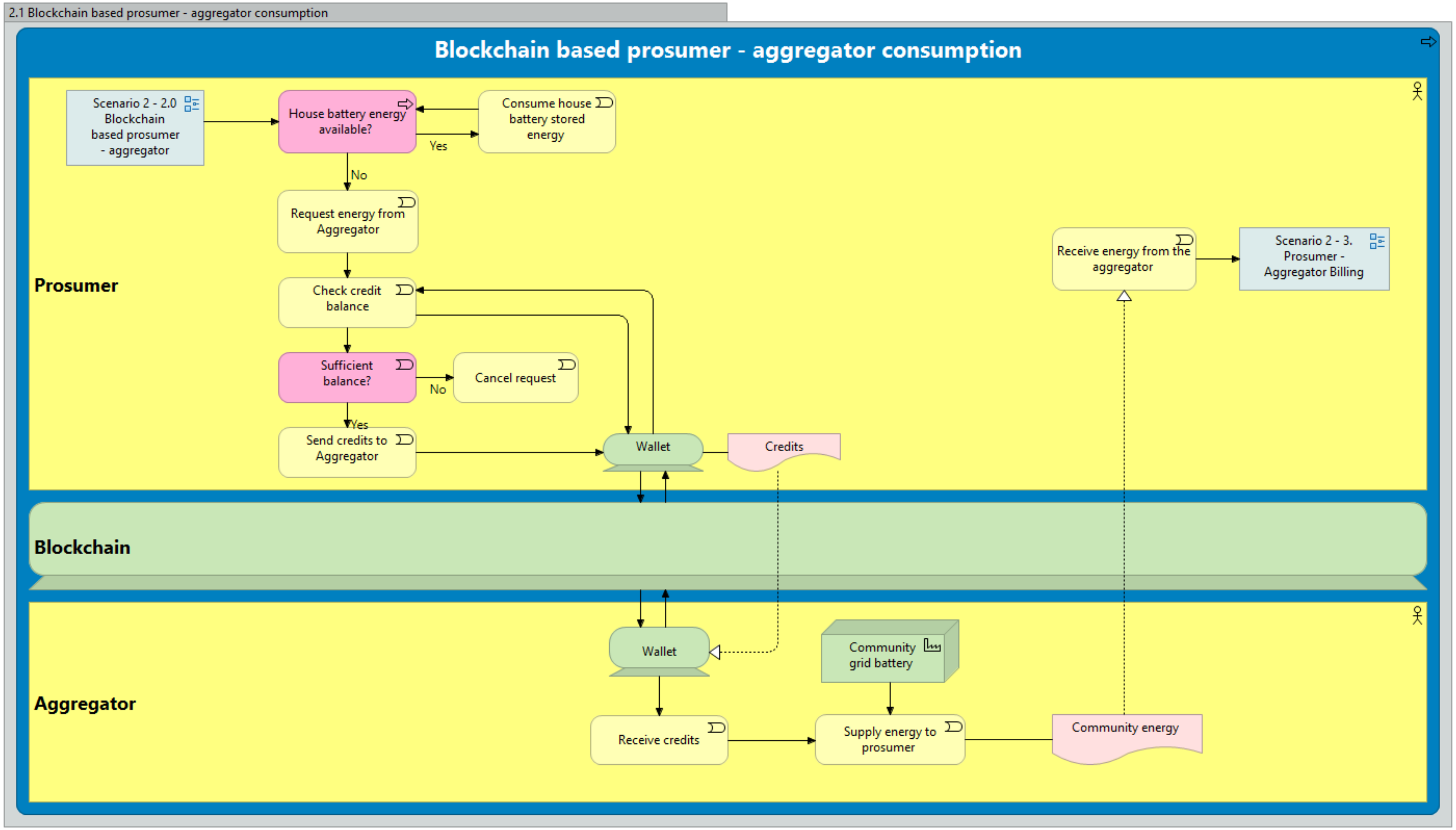

Figure 66: Scenario 2 - 2.1 Blockchain based prosumer - aggregator consumption LARGE

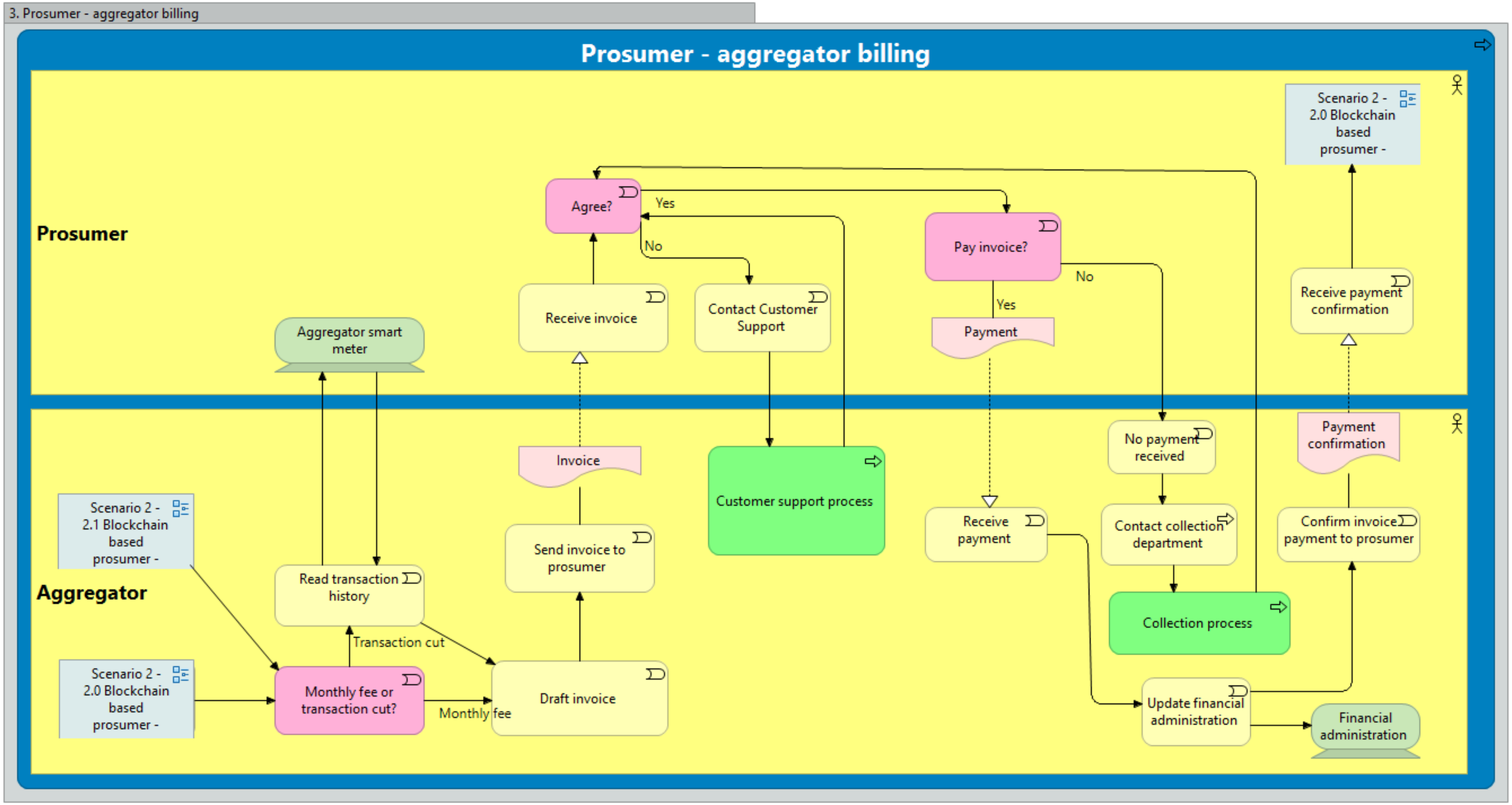

Figure 67: Scenario 2 - 3. Prosumer - aggregator billing LARGE

Scenario 3:

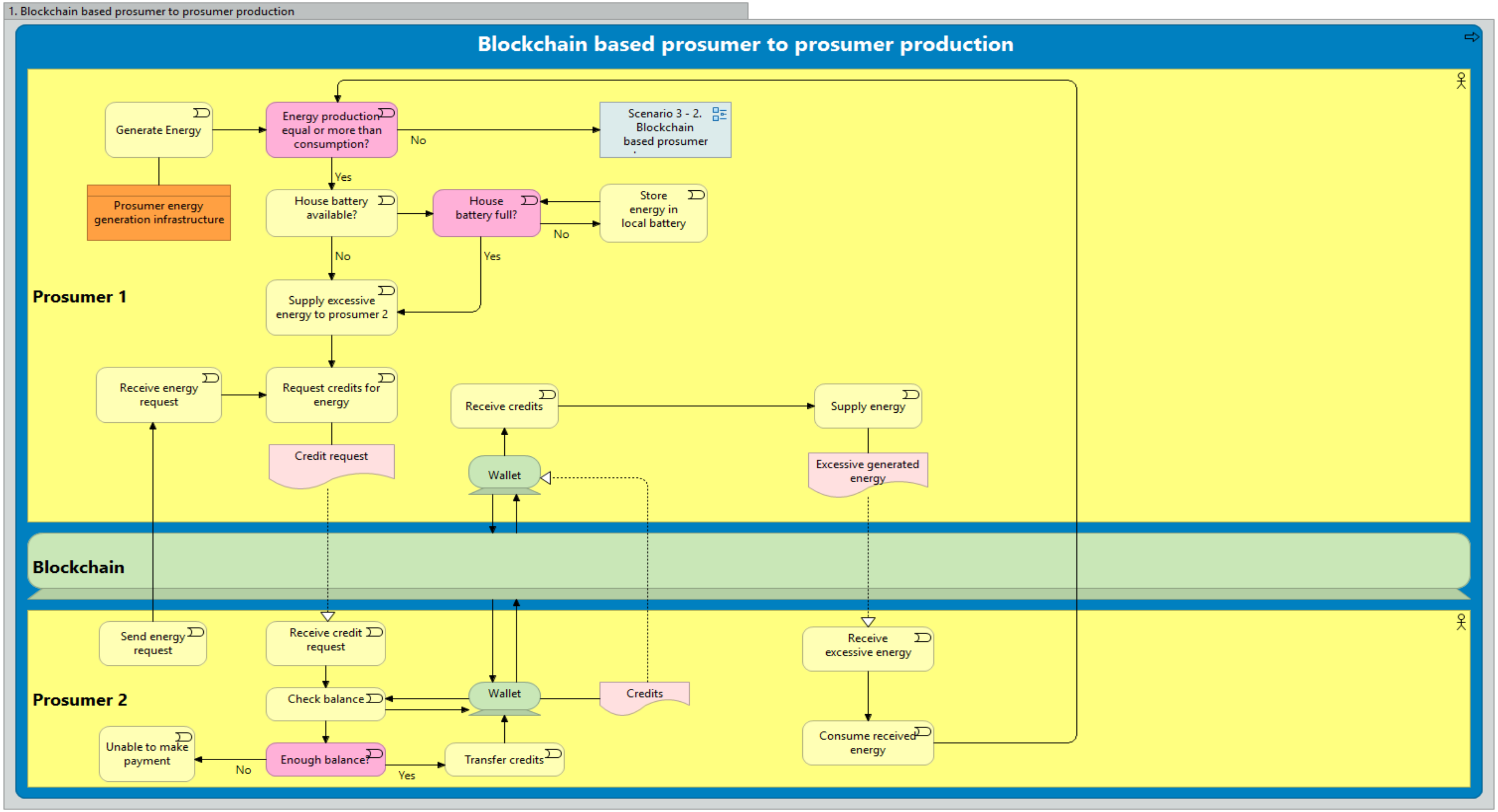

Figure 68: Scenario 3 - 1. Blockchain based prosumer to prosumer production LARGE

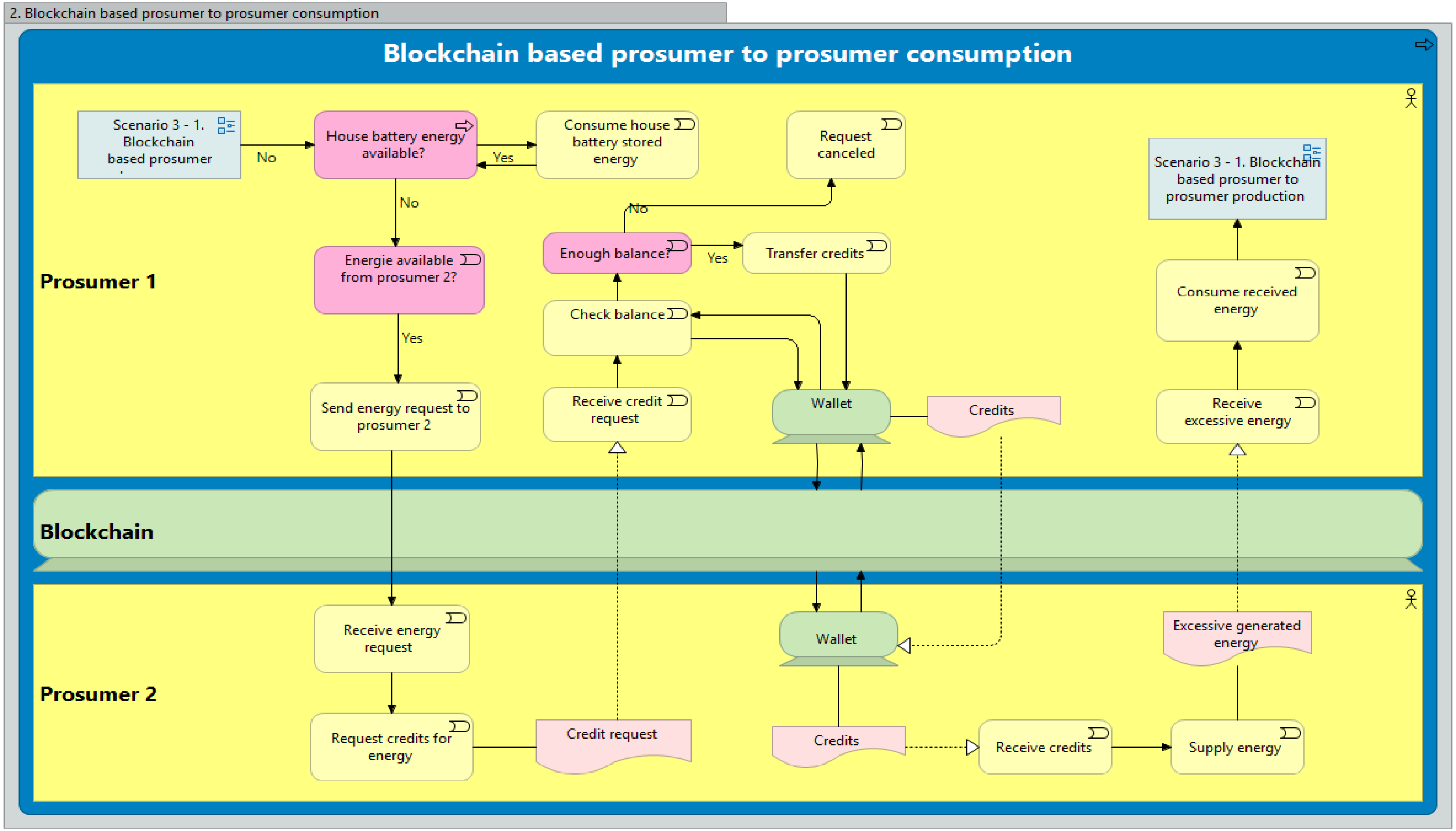

Figure 69: Scenario 3 - 2. Blockchain based prosumer to prosumer consumption LARGE

Scenario 4:

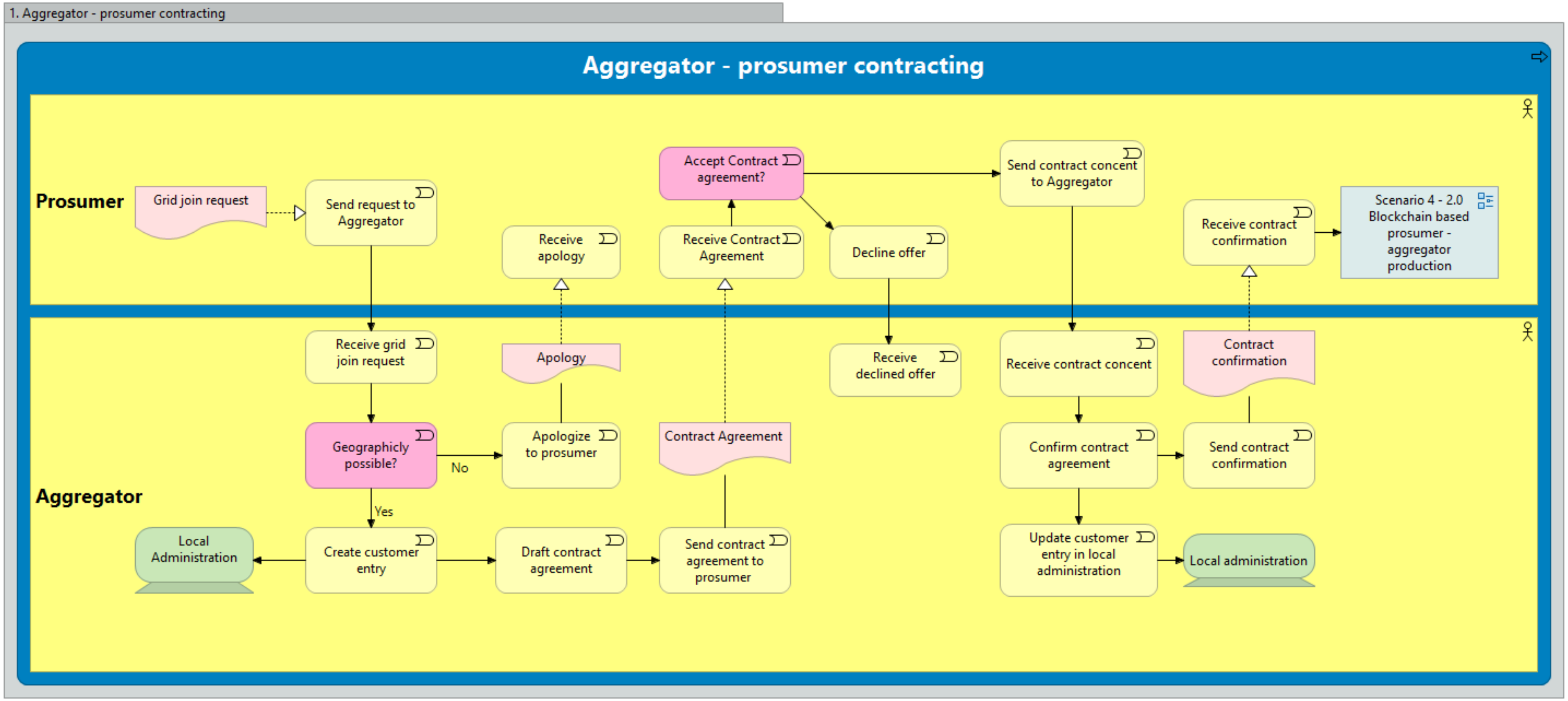

Figure 70: Scenario 4 - 1. Aggregator - prosumer contracting LARGE

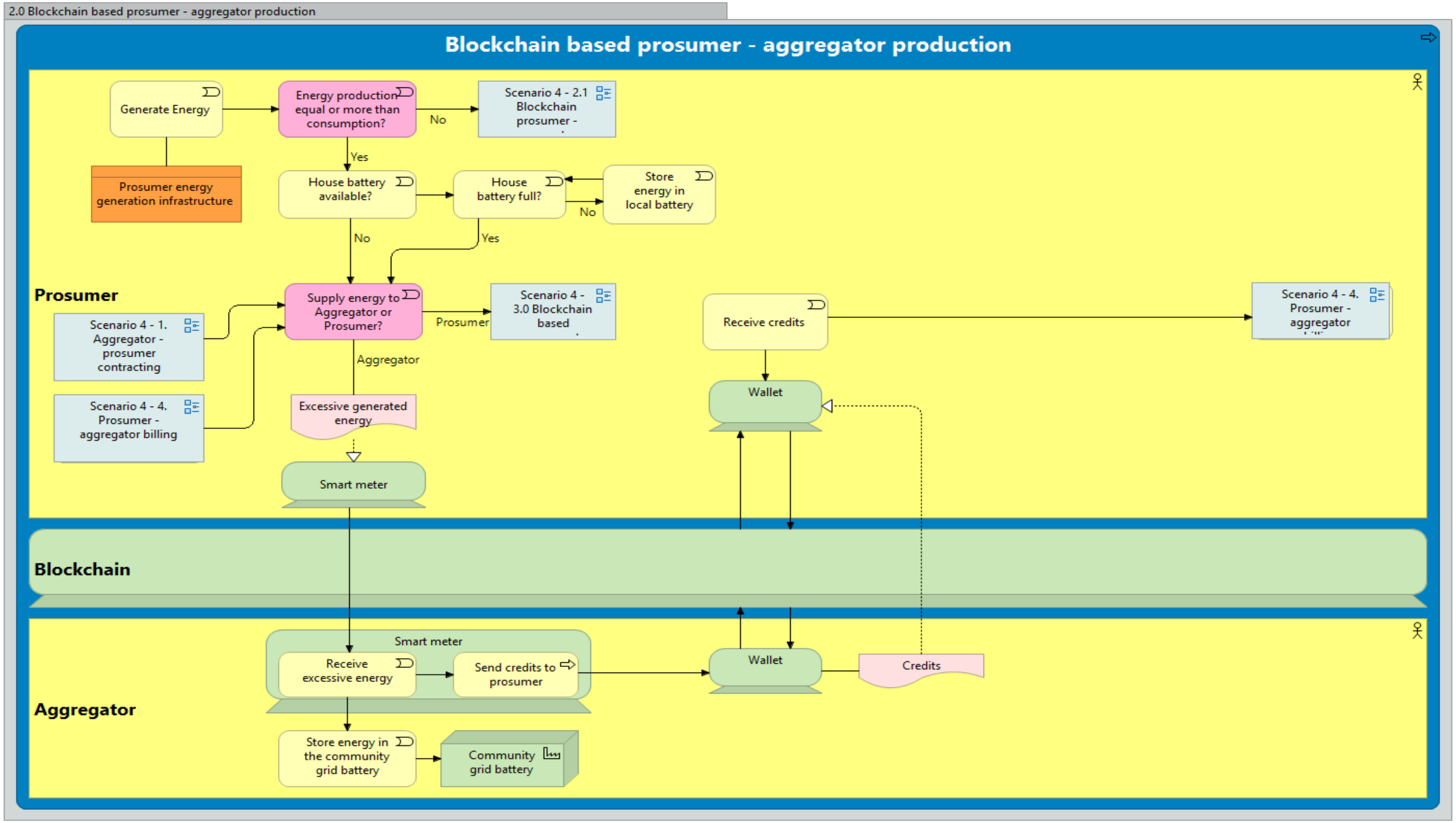

Figure 71: Scenario 4 - 2.0 Blockchain based prosumer - aggregator production LARGE

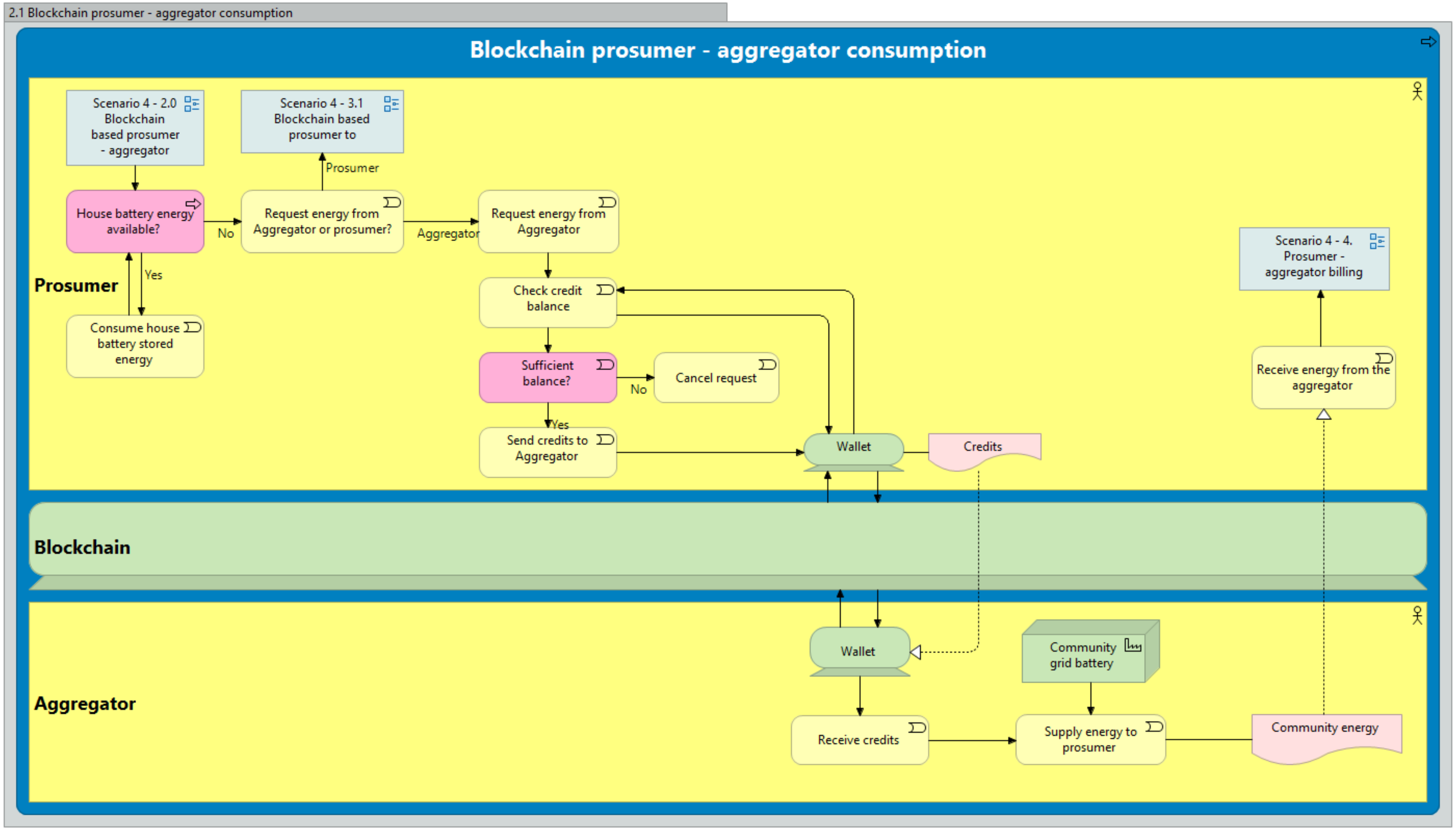

Figure 72: Scenario 4 -2.1 Blockchain based prosumer - aggregator consumption LARGE

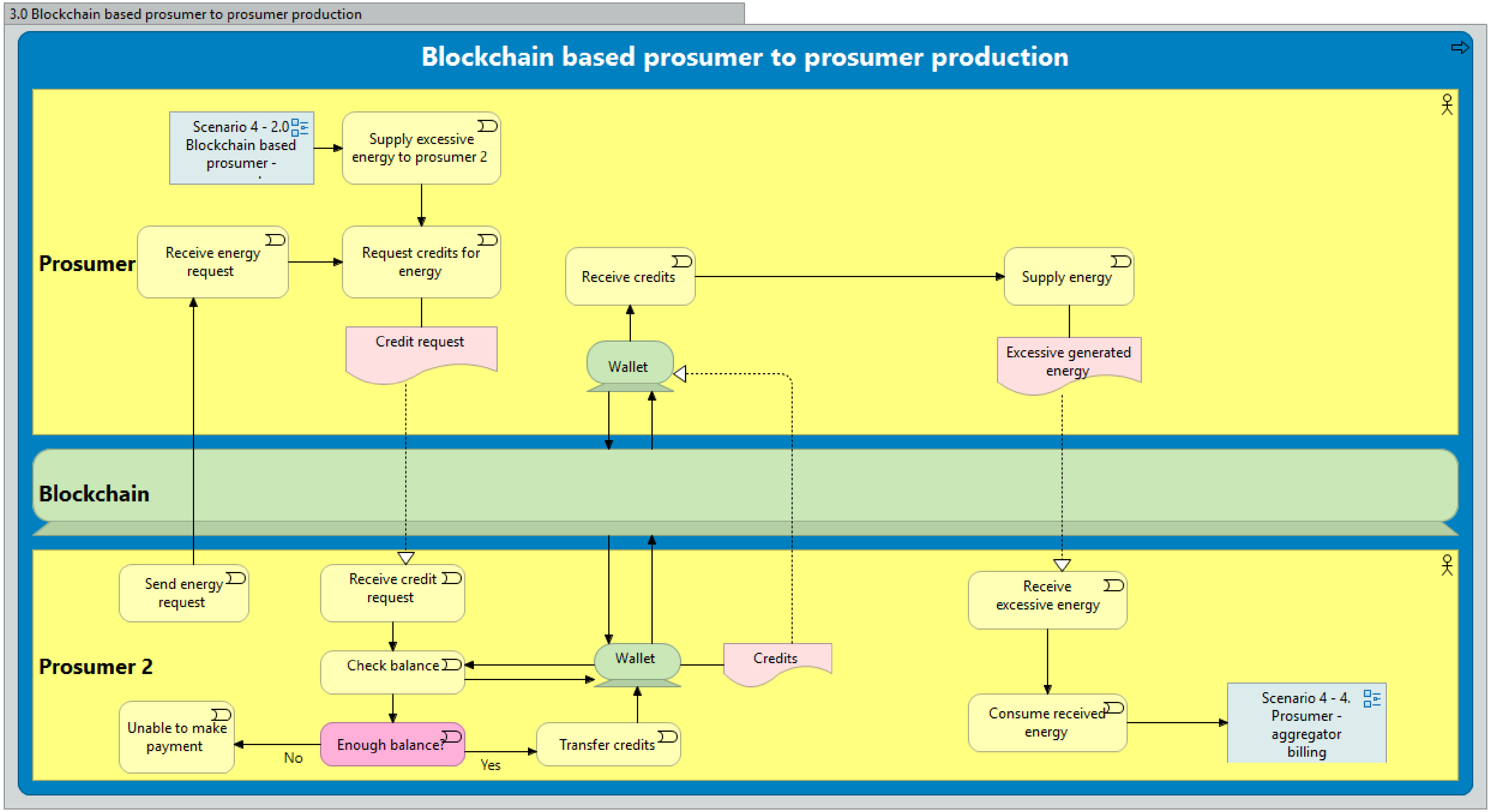

Figure 73: Scenario 4 - 3.0 Blockchain based prosumer to prosumer production LARGE

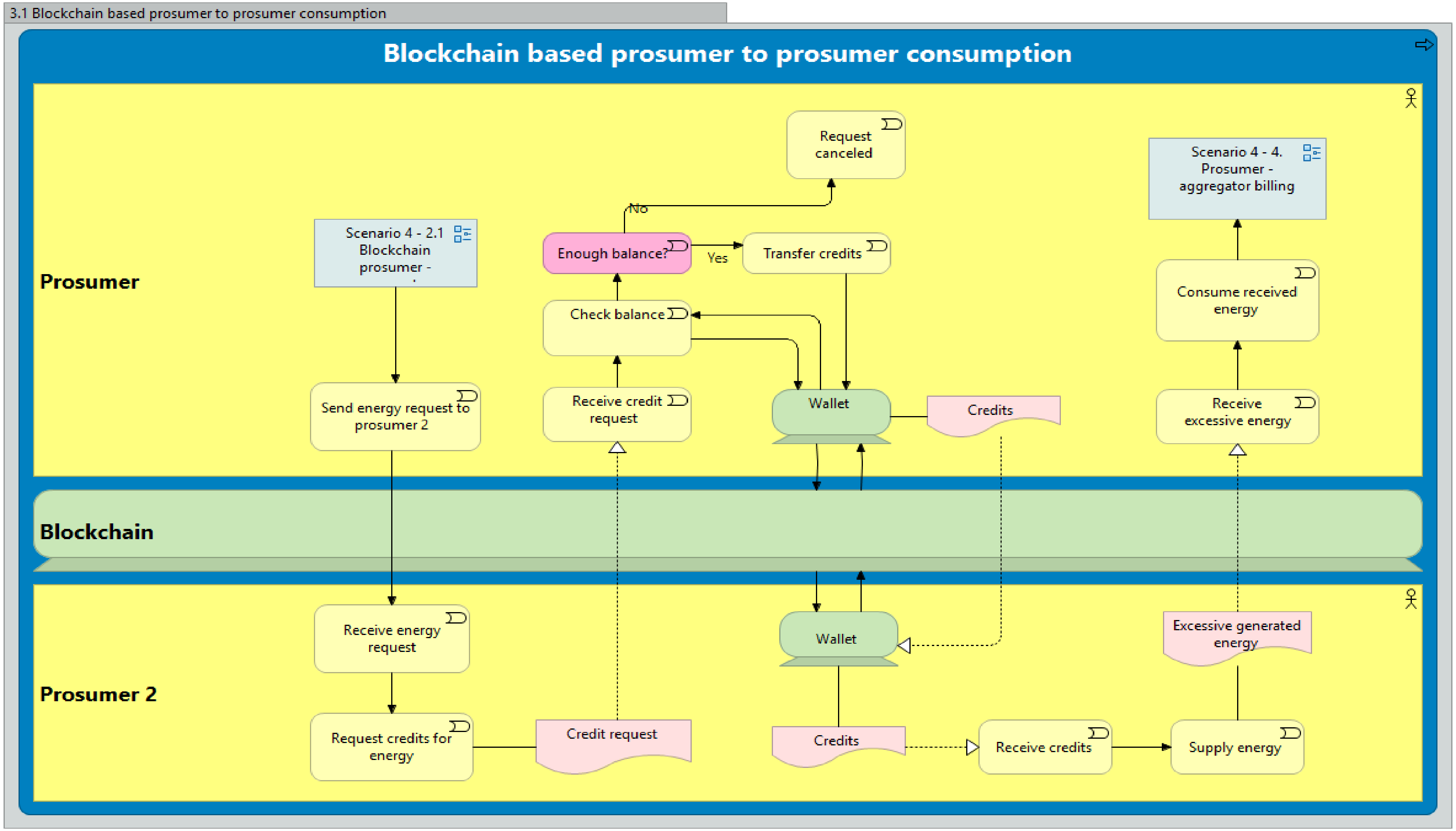

Figure 74: Scenario 4 - 3.1 Blockchain based prosumer to prosumer consumption LARGE

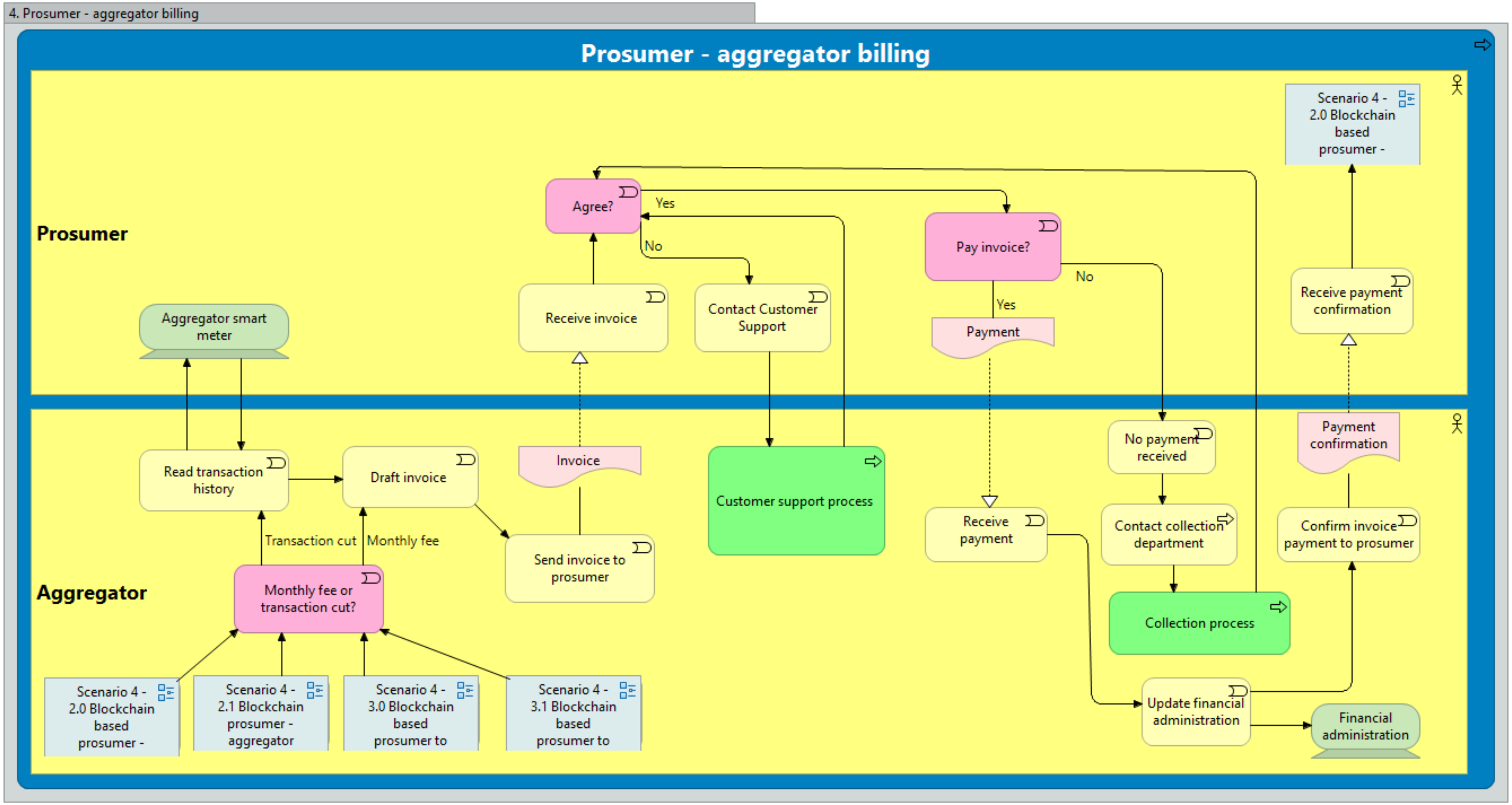

Figure 75: Scenario 4 -4. Prosumer - aggregator billing LARGE

Appendix D: Interview protocol

Interview questions

Subject: Traditional processmodel validation

Intro

- Ask concent for recording the interview
- Research into disruptive or fundamental changes in the energy industry
- The shift from centralized to decentralized (Consumer – Prosumer)
- Describing current prosumer – energy supplier processes
- Designing new blockchain based processes

Questions:

1. During my research into the processes between energy suppliers and prosumers and in the scope of value and energy transfer, I came across three processes; Prosumer Contracting, Prosumer Energy Consumption & Production, and Prosumer Consumption Metering and Billing. Is my view of these processes complete, or are there other core processes that I'm missing?
    a. If so, which processes are these;
        i. What is the core of these processes
        ii. What are the process objectives
        iii. Which actors are there in this process
2. Would I be possible to walk through the prosumer contacting, prosumer energy consumption & production, and prosumer consumption metering and billing processes, and verify if the written process steps are the same in practice?
    a. Prosumer Contracting
        i. Contract end register?
    b. Prosumer Energy Consumption & Production
    c. Prosumer Consumption Metering and Billing
3. Are there verification moments where for example, the consumption data received from a DSO gets verified by the energy supplier or is the data always perceived as correct?
4. What are the statistics on the decision boxes? How often does which path gets chosen?
5. What is the timeframe between the steps in these processes and what happens when these timeframes are not met?
    a. Prosumer Contracting
    b. Prosumer Energy Consumption & Production
    c. Prosumer Consumption Metering and Billing