

Ask Helseth Camilla Monrad-Krohn Candidates

Master thesis in Design The Oslo School of Architecture and Design Fall 2015

Einar Sneve Martinussen Main supervisor

Mosse Sjaastad Main supervisor

Adrian Paulsen Supervisor For any questions or requests regarding the project, please write to us.

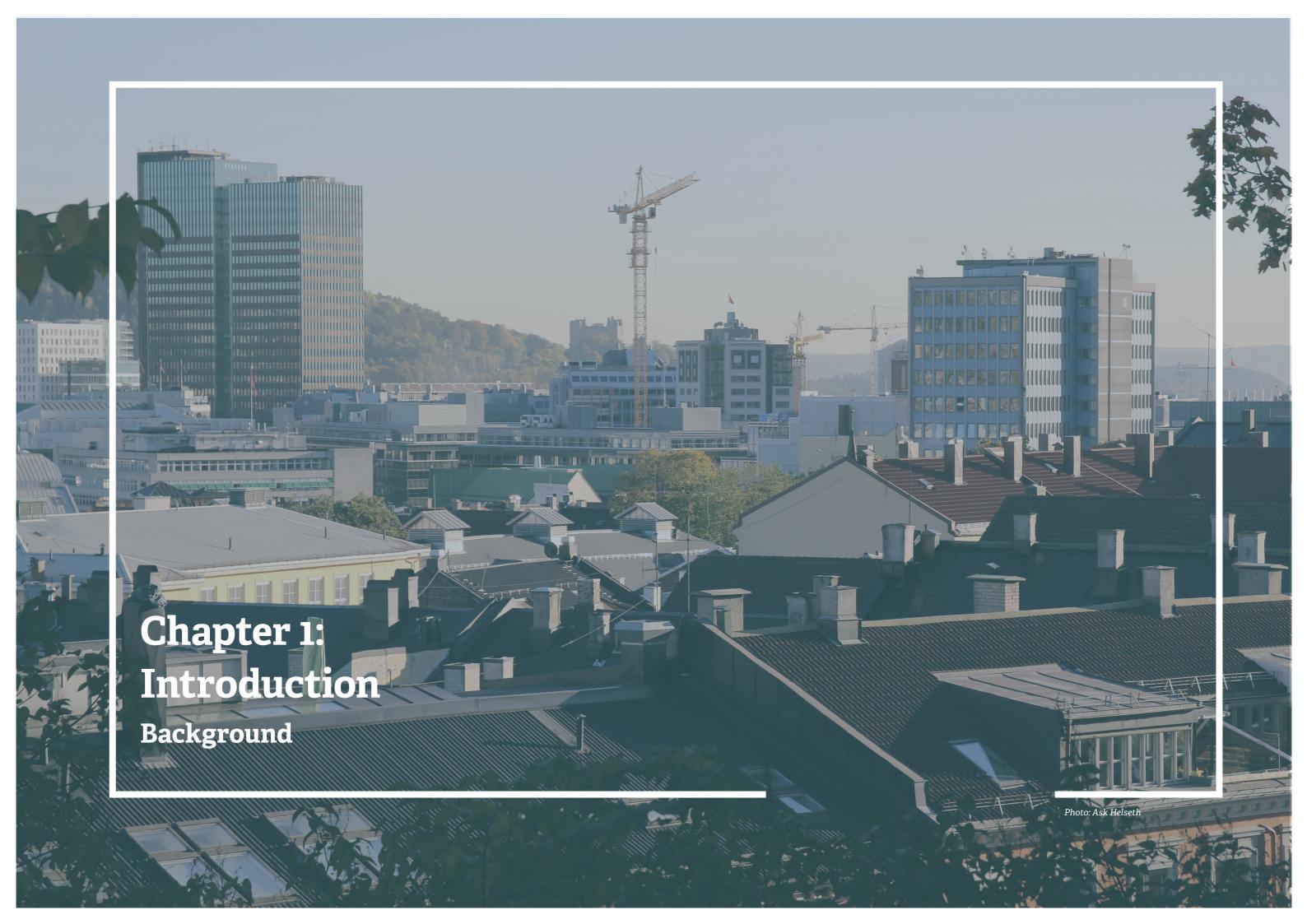
camilla.monradkrohn@gmail.com asksomebody@gmail.com

www.cmkrohn.com



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Potential Energy

Exploring service opportunities in energy producing neighbourhoods.

This project is about exploring energy-producing neighborhoods. Recent advancements in technology are enabling individuals to take charge of their own energy production. This allows us to rethink how we produce and distribute energy.

Context

We started this project with the intention to explore the service opportunity in energy-producing neighbourhoods. Access to cheaper and more advanced technology has created an environment in which more and more people take part in producing their own energy. Energy production and distribution has been a technology- and engineer-driven field. Now, more and more service

providers are seeing the potential in the market for local energy production and distribution.

Project Aim

The aim of this project is to explore the possibilities in tomorrow's energy production and distribution system. We want to investigate the service potential within a future context and see if this investigation can teach us something about today's system.

Solar Power as Technology

Harvesting energy from the sun using solar panels has become drastically cheaper in recent years, and this is the technology most adopted by smaller, local producers today. Solar power production is also easily scaled up or down, depending on the size of the project. Additionally, this type of production is renewable and can be built on existing infrastructure. Based on our research, we believe that solar panels will be the number one technology used for producing energy locally in the future.

Solar Power as an Offer of Service

There are already many services aimed at lowering the barrier of investing in local energy production. One of the services is Google's Project Sunroof. Here one can easily get an overview of possible savings by installing solar panels, and it is easy to come into contact with an installer. There are also services that offer loans, leasing or renting plans for consumers.

User Obstacles

Through contact with consumers that have invested in solar panels themselves, we realized that some of the obstacles actually lay within the distribution system itself. The system we have to-day is not built for the type of development where individual homeowners contribute to the national grid.

Understanding the Current System

Part of this project was to research the current production and distribution system. By using mapping as a method to visualize physical infrastructure, actors and cash flow, we managed to have a good understanding of the current possibilities and challenges in today's system.

Building a Future Landscape

By investigating the trends creating change, we have defined two scenarios towards which the development of local energy distribution and production could move. The scenarios represent two divergent directions based on different ownership and cultural adoption of production technology.

On-Grid: Centralized Ownership

The first scenario is the consequence of a development where the traditional electric utilities manage to keep control over all production both locally and nationally. They can offer services that are so good, there is no point using other services. An alternative is that the utilites convince politicians to use the law to stop any personal initiative. In this scenario, all production is owned by big actors, and the grid is the same model as today.

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Off-Grid: Decentralized Ownership

The other scenario is the consequence of a development where people take control over their own production. When more and more people become independent, it results in less and less people sharing the cost of the national grid. Fewer costumers would increase the cost of being connected to the grid, and more users would have an incentive to become independent. Local production can undermine the electric utilities to such an extent that the traditional actors disappear all together, and the national grid disappears with them. This is refered to by many as the utility death spiral. In a situation like this, people would have to take charge of their own energy production, and it would most probably be new actors and services on the market in order to meet the demand of energy.

Exploring the Future Landscape

We have used design as a tool to explore the two scenarios by designing service encounters based on existing actors within a future landscape. This has made it possible for us to investigate what the different scenarios entail on a deeper level.

Possibility of Change

Exploring the scenarios by designing services made it clear that we should try to combine the scenarios.

The services we created showed us that there is a

need to create an incentive to keep people connected to the grid, or else we might lose the grid altogether. This might work for some people, but it is not an optimal solution, as we saw when we explored the landscape.

A Hybrid System

We tried to design for maintaining the national grid, supporting local production and enhancing investments in renewable energy production. This is a way to keep a stable infrastructure with predictability and access for the consumer while at the same time opening up for personal initiatives, stimulating more renewable production and shifting some influence back to the users.

Arcs - The Energy Collective

We have designed a energy transaction service called Arcs. Arcs is an online market that facilitates a financial connection between personal producers and consumers. This allows users to buy energy directly from producers in their own neighborhood, using the local grid. This will make it more profitable to sell energy locally and hence stimulate local production. Arcs will buy energy from the national grid to cover the usage that it can't cover with local production. This will create a market in which the energy-producing actors we have today can create value. We hope this service example will make it easier for the decision-makers to see that there are opportuni-

ties in a hybrid system. This should, in turn, help the involved actors make more informed choices going forward.

Conclusion

In the conclution, we point to changes that can be made on a political level and by the utilities companies today. These changes will allow more local renewable energy production in the future while also maintaining the value of the grid.

We suggest the following:

- Open up for a direct sales model between private consumers and producers using modern technology.
- Make it cheaper to send electricity locally by splitting the net tariffs into one local and one national tariff.
- Change the tax model for power so that it becomes more attractive to be part of a local market.
- Have traditional power producers create value by offering stability services.
- Design services to meet the local producers and consumers needs.

Structure of the Report

This report has three main parts:

- Research the trends that are changing the way energy is being produced and distributed, and define in which direction we think the development will go.
- Investigate what the directions could entail by designing service encounters and reflecting on what they can tell us.
- Design a service to illustrate the opportunities in a hybrid system.

The Project in One Page

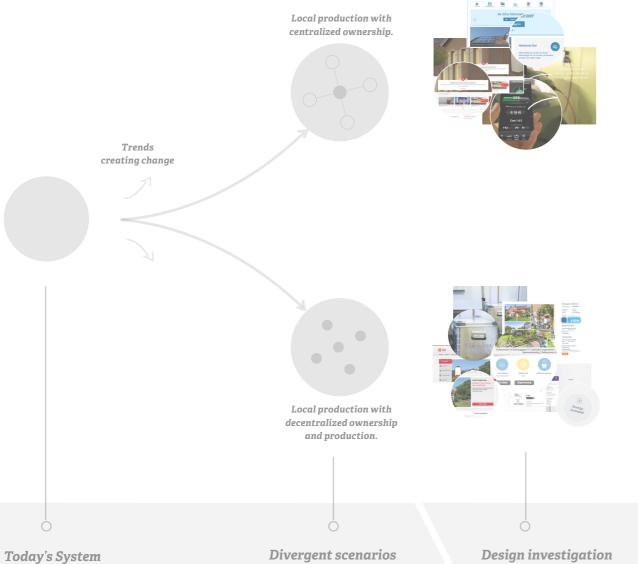
Representation of the different stages in our project.

Research and investiga-

handles local energy

production.

tion of how today's system



Using research findings to

scenarios of how a future

landscape can be framed.

define two divergent

Design investigation Designing new services to investigate this future landscape. System opportunity
Synthesize findings and
defining opportunities for a

hybrid system.

Service proposal

Designing and proposing of

Designing and proposing a service to manifest the opportunities of having personal energy production working side by side with big electric utilities.

Backcasting

Use the project to communicate with current actors, to trigger a discussion on which direction development could go. And use the design of a proposed service to show the possibility within a hybrid system.

Our Background

We want to look at the possibilities of the future, not just the limitations of today's system.

We see ourselves as service designers, and we have both completed complementary courses in Interaction Design. In the service projects we have done so far at AHO, we have communicated services through a digital touch point.

When we considered doing a project together, one of the first things we did was to find out what we wanted to learn. We wanted to explore a subject that we think will be very relevant in the future.

We decided to do this by beginning with the end, so to speak. We used our skills as designers to create a future landscape and design different fictional services in that landscape to be able to better understand it. We then identified opportunities in the future landscape and presented the opportunities by designing a service. We want to use that service to communicate to the people and actors

that influence the development going forward. In this manner, this is not a classic service design or interaction design project, but rather a project where we use design as a strategic tool to explore and synthesize possibilities and directions for the future.



Camilla Monrad-Krohn



Ask Helseth

Background / Context

Changing dynamics in energy production.

The way the world is producing energy must change (The Intergovernmental Panel on Climate Change (IPCC), 2015), and it is changing (Bloomberg New Energy Finance, 2015). As a result of government incentives and advancements in technology, more and more people are starting to utilize new technology to harvest the energy that surrounds their homes (Fraunhofer Institute for Solar Energy Systems, 2015). Ordinary people can suddenly take charge of their own energy production. More local, renewable energy production is a good development for our planet, but it is already having an effect on the traditional electric utilities around the world. These utilities are struggling to adapt to a new market where the consumers are producers (The Economist, 2013). Some utilities have already restructured to adapt to a changing market. E-ON, the biggest power utility in Germany, has changed their business

strategy drastically to adapt to the new dynamics (Drozdiak, 2015). They are now selling products for local renewable energy production.

It is easy to see that the changes are creating some challenges. But what are the opportunites? Which actors will be a part of the market, and will the traditional electric utilites manage to stay in control? Will they disappear completely? Will new actors enter the market and create new services? In this new landscape, that is yet to be defined. What kind of services can be created? How can we prepare for the changes?

This is what we wish to investigate.

The Users

This project explores the future landscape with five different users in mind.

Energy production is complicated, and many people and businesses are involved. In this project, we have chosen to look at the "user" differently than we have previously. There are five main "users" that are involved and will be affected by a change in the way we produce energy;

Local energy producers

What does development with more energy producing neighourhoods mean for the local energy producers? People that invest in personal production.

Energy consumer

The energy consumers dont't have a problem with todays system, per se, but how will their needs be met by the future system based on more local production?

Grid provider

When more people are starting to produce energy locally, what does that mean for the grid providers?

Traditional energy producers

How will the traditional energy producers fit in a future landscape with more local energy production?

The plane

Will a future with more local energy production use the resources we have in a renewable and efficient way?

Design Contribution

What can we do as designers?

The sector that delivers and distributes energy today is very big and includes many smart people and companies. So why do we believe that we as two designers can contribute anything at all?

We think that we can investigate the development of energy-producing neighborhoods in a different way by using our abilities to create something that feels tangible. Combining user insight with system understanding and design means that we can find out where we think the biggest opportunities lie within this new landscape. Further on, we can explore and illustrate these opportunities by designing communication, service encounters and interactions that draw attention to the possibilities and challenges in a future landscape. We also want to see if this investigation can teach us something about today's system.

Target Group

Who are we trying to influence?

The target group for our project will be the groups that have the most effect on the future development of energy production.

The Power Utilities

These are the actors that will be most affected by changes in the energy sector. They also have the power to influence the development, both directly by creating services and strategies and indirectly by affecting the politics.

Politicians

The energy sector is highly regulated. By using legislation and incentives, the politicians have a great possibility to influence progress in this sector.

The Users

Users are important actors, as their behavior influences the development of the system. They are the people who must adopt and take part in developing a new reality.

This is our target group, because these actors have the chance to change the direction of development in the energy sector.

Collaboration Partner

A great resource and a door-opener.

We have collaborated with Tor Krog, Head of Business Development and Strategy at Siemens Energy.

Siemens Energy is an engineering company leading the world in energy efficiency and management. They also work hands-on with many new technology advancements and big development strategies.

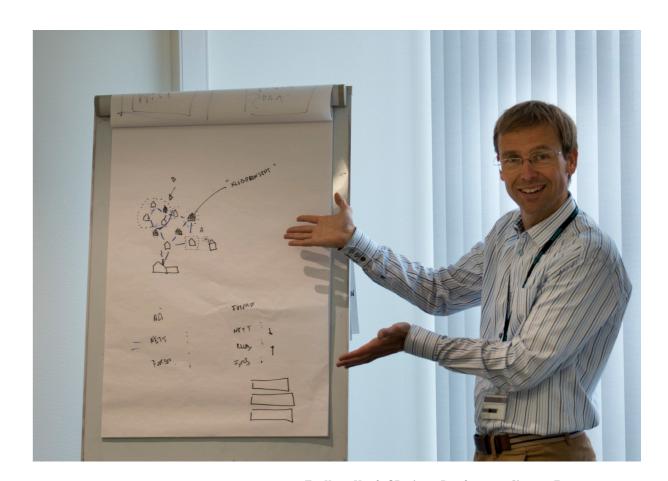
During this project, we have had five meetings with Tor. Early on Tor helped us gain an understanding of what the industry sees as possibilities and challenges in the development of more local renewable energy production.

Later on in the project, Tor helped us understand the technical barriers and possibilities in the system. In the materialization of the scenarios and the service concepts, he helped us develop them by asking critical questions and sharing reflections.

During our last meeting, we had a fruitful discussion about how to convey the project to the relevant target group.

Besides being a discussion partner, Tor has helped us by opening doors to people in high-level positions in relevant organizations. This has enabled us to discuss the subject with a range of people who have a lot of knowledge and insight on the subject matter.

We hope to continue the collaboration after our project is delivered. Our goal is to pass on our findings and reflections to a wider audience.



Tor Krog, Head of Business Development, Siemens Energy. Photo: Ask Helseth

Process Methods

Methods to understand the complexity of todays system and possibilities of the future.

Mapping

We have used GIGA mapping as a tool to gain knowledge and insight into the complexity of today's system (Systems Oriented Design, 2012). We use this tool in order to get a visual understanding of energy flow, cash flow, the role of the different actors and touch points between them and the users. We have done ZIP analysis on the maps to help prioritize where to focus our research (Systems Oriented Design, 2012). The maps have evolved throughout the entire project. We have also used it as a communication tool when meeting with experts.

Desk research

We have done desk research to get an overview of trends, service offerings and drivers for change in a European context. Since we were unsure what we were looking for exactly, the first weeks with desk research were messy and seem unstructured when we look back at it. However, we managed to obtain a good understanding of the current landscape within a couple of weeks.

Siemens Energy Infrastructure Actors Malawi Cash flows **Current system** Visiting private Meeting with interviews solar power, Multiconsult Meeting with Meeting with Technology Users (Producer of solar Meeting with Aspelinn Ramm power). Vulkan area **Political** Meeting with Trends creatstrategies Bellona fundation. ing change nergy production n Germany. Tekna Meeting with Live Work (Developed several Service offerings energy service Meeting with projects) Knut Karlsen ChyroHego **Technology** Meeting with Designit (Working with **Future** IKEA energy) landscape Desk research User experience Design oppurtunities Ownership Cultural adoption Meeting with To understand By looking at Meeting with Source 21

Meeting with

Expert and actor meetings

Meeting with experts has been essential to our understand of how the current system works. Besides our collaboration partner, Tor Krog, we have also conducted meetings with many different actors:

Per Solli, the principal of Elvebakken videregående skole, to talk about the solar panels they have installed on the school roof.

Karl Kristensen at Bellona, to get the foundation's take on the development in the energy sector.

Bjørn Thorud at Multiconsult, to get his take on the development of solar cells and the potential of the technology.

Isak Oksvold at Aspelin Ramm, to understand how they have arranged their energy-producing neighborhood at Vulkan in Oslo.

Knut Karlsen at ChyroHego, to talk about his master thesis which was on a similar topic.

Ulf Eriksen at Statkraft, to understand energy trading, and get feedback on the scenarios and on our concept.

Live Work, to get inspiration and discuss the project.

Trygve Mongstad, a solar entrepreneur, to learn about energy distribution in Malawi, where the physical infrastructure does not exist.

Designit, to learn from a project they did with IKEA about energy.

Mette Mossige, a cultural sociologist, to learn more about neighborhood dynamics.

Lundby Martin and **Tarjei Lie** at Hafslund ASA, to discuss our project.

Lars Ove Johansen and **Per Edvard Lund** at Hafslund nett, to understand more about the grid.

Some of these interviews are referenced later in the report; others have been a source for us to build our knowledge base.

User interviews

We have carried out user interviews and observations to get insight into the users' process of investing in solar power production, as well as to understand the obstacles connected to this process. The interviews have also helped us understand what drives people to be a part of the development of local production of energy.

AT-ONE

We have used the AT-ONE method as a tool to structure the research process (Clathworthy, 2014).

Sketching

We have used idea generation and sketching throughout the whole project as a method to evaluate possibilities and to achieve a broader discussion in meetings with experts, supervisors and users. This has also been used as a way to continously document our own thoughts and findings.

We have used design as a way to explore and synthezise future possibilities. By doing this, we have built arguments of the potential in a future with energy-producing neighbourhoods.

Interaction design

We have used interaction design to test the service ideas that we have had early in the project. By creating screens that represent an interface, we have been able to investigate the service potential early.

Evidencing service encounters

We have evidenced service encounters to make service ideas more tangible and easier to communicate. This has allowed us to understand future opportunities and limitations.

Service journey

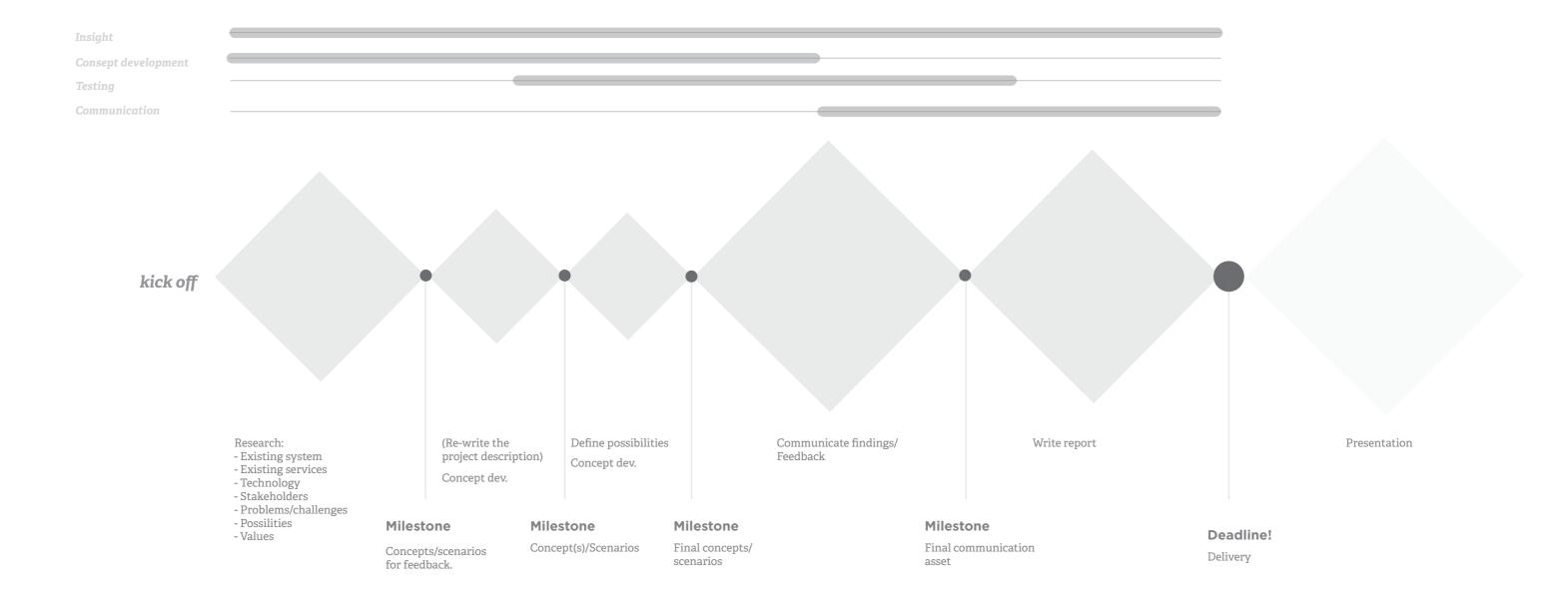
We have made service journeys of current and future services to be able to understand the differences during our processes and structure our findings.

Workshops

We have run small workshops to present our findings, get feedback, generate ideas and evaluate ideas. This has allowed us to involve other peoples's knowledge in our process.

Backcasting

We have developed a service as a way to manifest a future value proposition. This has allowed us to communicate future opportunities and values to actors in today's system. (Ebert, Gilbert and Wilson, 2009).



Our Process

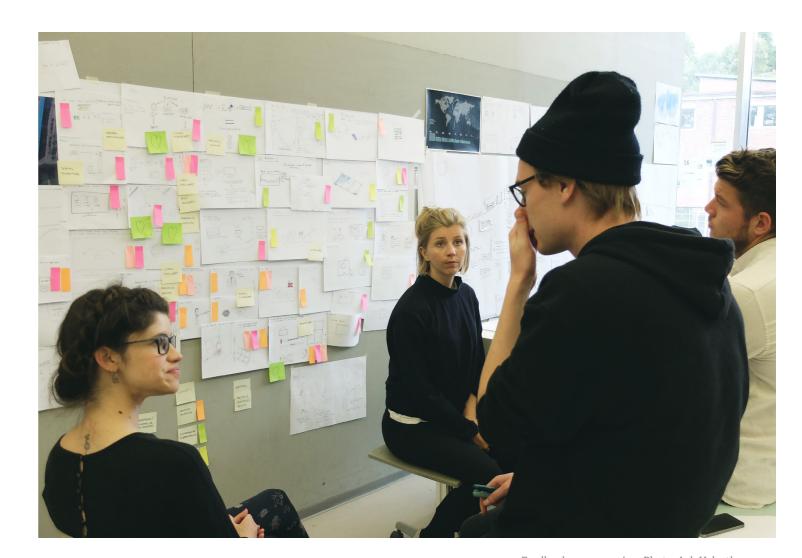
A few words on how we have managed the our project.

Besides teachers, fellow students have always been one of the biggest resources we have at school. Since we were only four Master students in our department this semester, we decided to utilize each other's resources. Since the group mainly consists of people who don't speak Norwegian, we decided to conduct our project in English in order to involve everyone in the group on all levels.

As a diploma group we also facilitated a feedback group. We invited students from the pre-diploma course to gather weekly and give feedback on ideas, check if what we were trying to communicate made sense and to discuss the projects. In exchange, we have tried to help our fellow stu-

dents in their pre-diploma process. This feedback group has been important to us and has been a very valuable asset to the project and the process.

Thank you to all who have participated.



 $Feedback\ group\ session.\ Photo: Ask\ Helseth$



Introduction

How we have stuctured the research. Understand, develop and reflect.

Starting point

The research phase was more demanding than we had planned for. Since we chose to work on a future scenario, we knew that it would be difficult, given that we were not operating with what we usually use to frame a research phase. Half of the job has therefore been to design the context in which we were operating. The context is something we usually use as a design material, as constraints that help us generate ideas, but this time we needed to create these constraints.

Finding users that could represent the "future users" was difficult as well. The latest numbers from Hafslund show that there are only 103 people who are producing energy privatly around Oslo today. Additionally, when we found people, we had to keep in mind that they are early adopters and do

not necessarily represent the user when local energy production is adopted by the masses.

Predicting development is not something that we have done before, and it was a challenge translating our research into someting that would be a useful tool to explore a future landscape. The idea of creating two divergent scenarios helped us put our research down on paper.

Disclamer:

We still do not know how this will look in the future! However, our research has provided us with a good basis for a qualified assumption.



The Infrastructure

In the current system

To be able to explore a future landscape, we needed to understand today's landscape. We started the project by trying to obtain an overview of the complexity of today's product

The development with energy-producing neighborhoods will happen sooner and make more sense in Central and Southern Europe long before it will start to make sense in the northern countries.

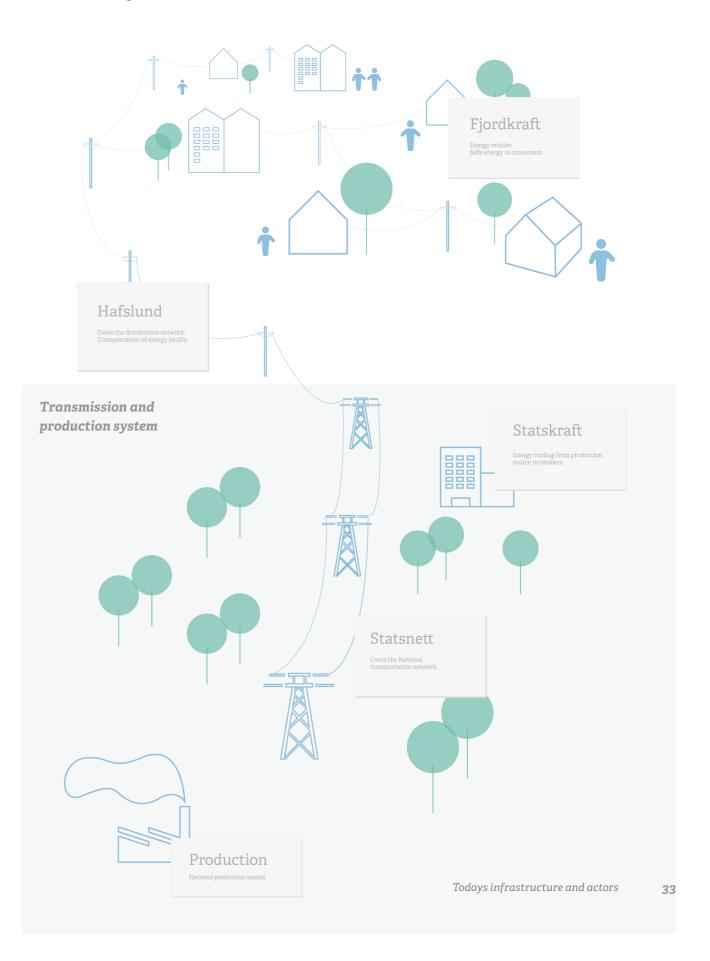
Therefore, **Europe is the main context** for this project, but it will probably be adaptable to a North American context as well.

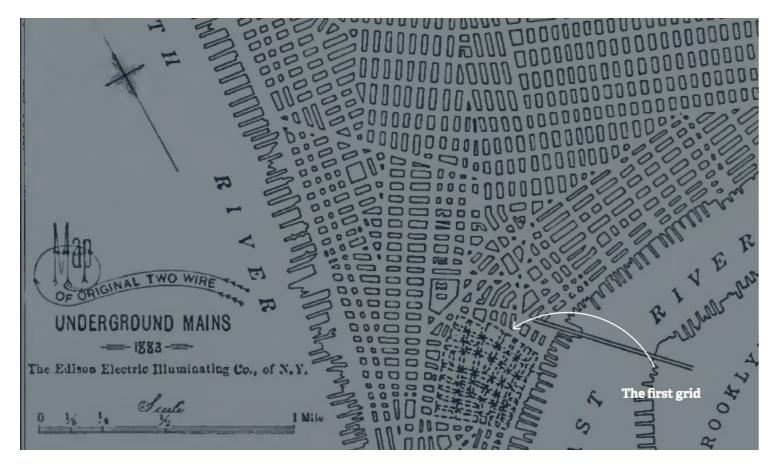
However, for practical reasons, Oslo/Norway has been our base for collecting data and talking to actors and users.

We started the project by trying to obtain an overview of the complexity of today's production and distribution system. We did this by looking at how electricity travels and what actors are involved, as well as looking at the touch points and cash flow using visual analysis.



Distribution system





The first electrical grid at Manhattan, US, 1882 (http://www.edn.com/Home/PrintView?contentItemId=4404090)

Origin of the System

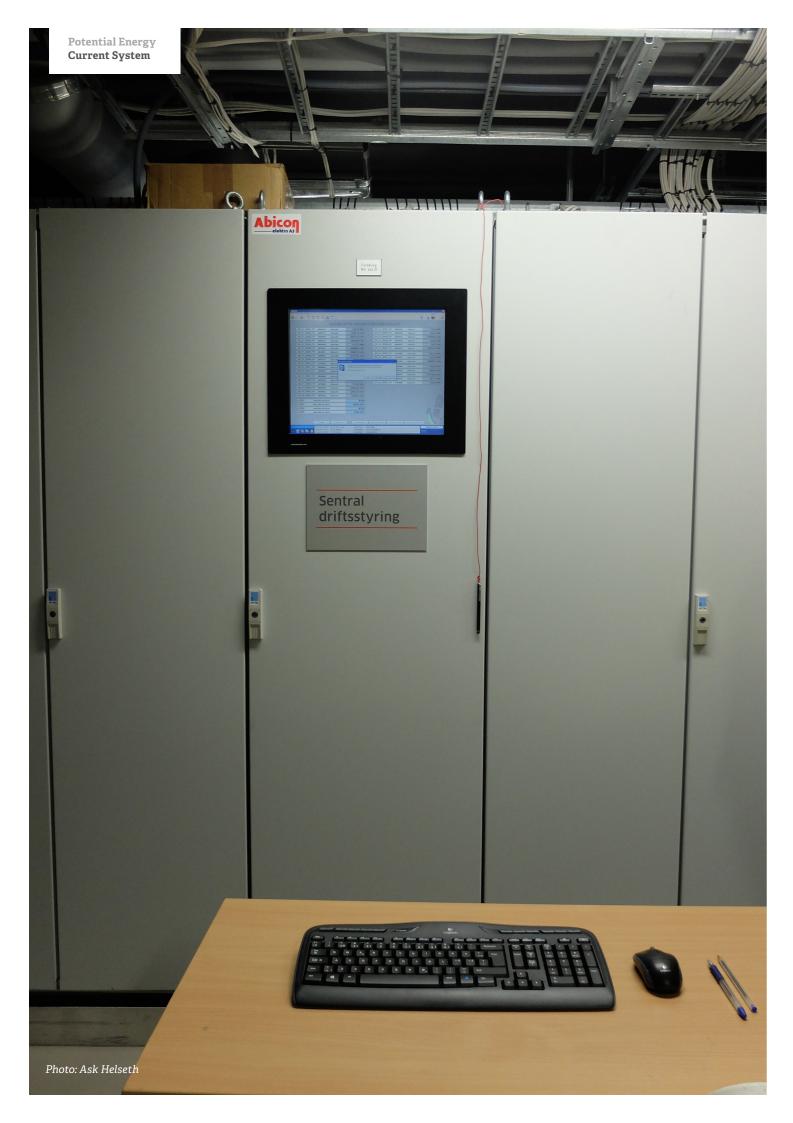
History

To understand the current system we have looked into the history of how the system was created. Thomas Edison created the world's first distributed electrical system. The map to the left shows the world's first electrical grid. The grid was built around a centralized power station called Pearl street power station, which was only about half a kilometer across. One of the main reasons for it beeing this small, was the technology Thomas Edison chose for distributing the power. He used a direct current which at the time had a limited reach (Bazerman, 2002). But at the same time, Nikola Tesla had another idea on how to distribute power over longer distances. Tesla together with the American entrepreneur, George West-

inghouse, was working on a competing system that used a different technology called alternating current. With this system he could send electricity over much greater distances, and this made it possible to move the noisy and polluting power plants away from the city and out to remote areas.

George Westinghouse's system, which was based on Tesla's technology, ended up winning the current war and has been a defining factor for our modern society.

Alternating current made it possible to move the big polluting power plants out of populated areas.



The System

How it works today

The systems constituting the norm in Europe and other developed parts of the world today are all more or less based on the system that George Westinghouse developed. It consists of four main stages: production, transmission, distribution and consumption.

Production

The most common way to produce electricity is to burn fossil fuels (ScienceDaily, 2015). In essence, a fossil fuel is concentrated sun in biomass, which in turn is concentrated by the earth's pressure and heat over millions of years. Those hydrocarbons can be burnt in order to generate heat, which again creates steam. Steam can drive a turbine, which then can drive a generator that converts the movement to electricity (Epa.gov, 2015).

Transmission

In order to transport electricity over long distances, one uses high voltage cables usually made of aluminum. This infrastructure makes it possible for production facilities to transport energy to cities or between countries. In Norway, Statsnett is the actor that owns and mantains the transmission network.

Distribution

Electricity is distributed in local networks. They are based on a radial network of cables, which means there are no parallel cables or cross connections. One can think of it as a river or a stream system upside down. In Norway, these actors are known as Hafslund, Lyse, BKK, Agder Energi, depending on where one is in the country.

Consumption

Energy is consumed all around us. When a person turns on a light, the electricity is produced somewhere else. It is hard for users to relate their energy use, which seems so simple and easy, to a complex production and distribution system.

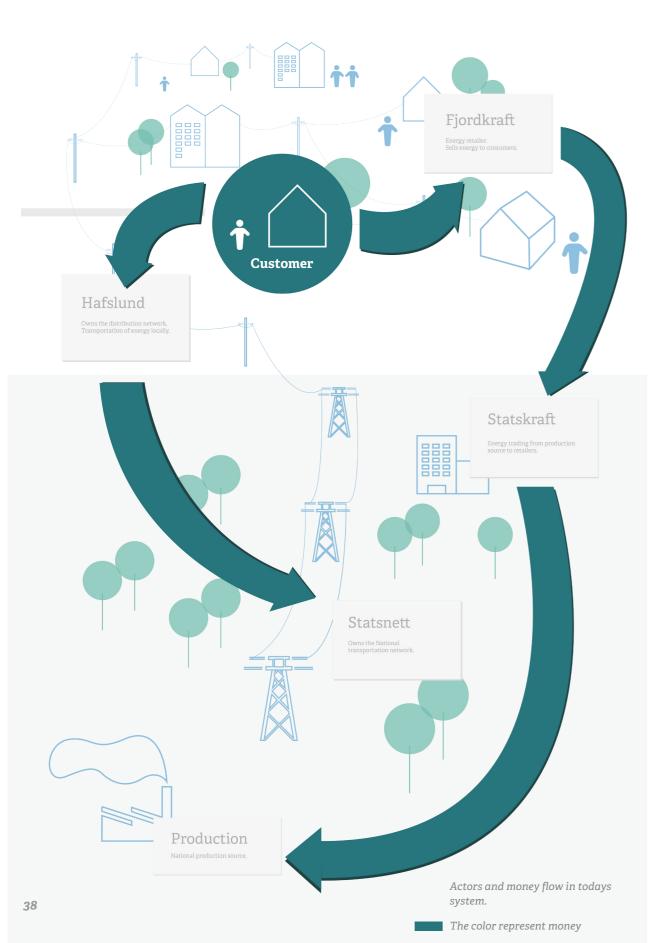
Barriers for local production

The current system is based on a model where energy is produced on one end and consumed on the other. Early on in the project, we thought that there would be a technical barrier to local energy production and distribution. However, the technical barriers are small, and, according to Tor Krog at Siemens, easily solvable. Therefore, we have chosen not to focus on that.

The physical infrastructure is not a barrier for local energy production and distribution.



Cash flow in todays system



The System

Actors and cash flow

A customer pays for electricity to two different actors. The custumer pays the energy provider (energy retailer) and the grid provider (distribution grid).

The energy provider is an actor who sells energy to consumers, but they usually don't own any kind of energy production facilities themselves. They are energy retailers who usually buy the energy from energy traders. These energy traders specialize in buying energy from producers and selling it to retailers. The trading company pays the company that actually produces the electricity. The money the user pays for the electricity itself goes through several actors that each take their share.

The consumer is also invoiced by the local net provider. This actor maintains and develops the local distribution grid. The net provider also shares some of the payment with the regional grid provider. The regional net provider maintains and develops the transmission grid. The grid provider (in Norway) has a monopoly that is regulated by the government. The government decides how much the local and regional grid provider can charge the user.

The biggest barrier in today's system is that the actors are arranged in and around a system in which the energy is transported in a top-down linear fashion. When people then start to produce electricity locally and send it out on the grid, it is fed in the "wrong" direction. The electrons will take the shortest route and end up at the nearest consumer, but the payment has to go through all the traditional electric utilites.

The traditional actors are centered around a linear distribution process.

Law and Tax

Energy production and distribution

The energy-producing sector is a very important infrastructure for countries. Power is needed to maintain industries, run hospitals, schools, banks, street lights and the modern household. It is virtually impossible to have a modern western country without electricity. Therefore, it is not hard to understand why the policymakers are holding a firm grip on the sector.

The system has worked well for several years, but it is not designed for private initiatives that produce energy locally and send energy back into a system that is mainly built for distributing energy in "one direction".

We talked to Bjørn Thorud, the Senior advisor, Dr.Ing. and head of solar business development at Multiconsult. He stated that the Norwegian

energy law created two big limiting factors for local renewable energy production. One is that you need a license to sell energy and that is hard to get. Second, you are not allowed to both produce energy and own the cables that transport them.

The law is written in a time where the technology for local renewable energy production didn't exist, and was therefore not an possibility, like today. The law is built around the linear way of producing and consuming electricity.

If one looks at the paragraph in the energy law in Norway that describes its intent and purpose, it states that the production, conversion, transmission, distribution and the use of energy shall be done in a rational way for the society (Lovdata.no, 2015). This takes into account the common and private interests that are involved.

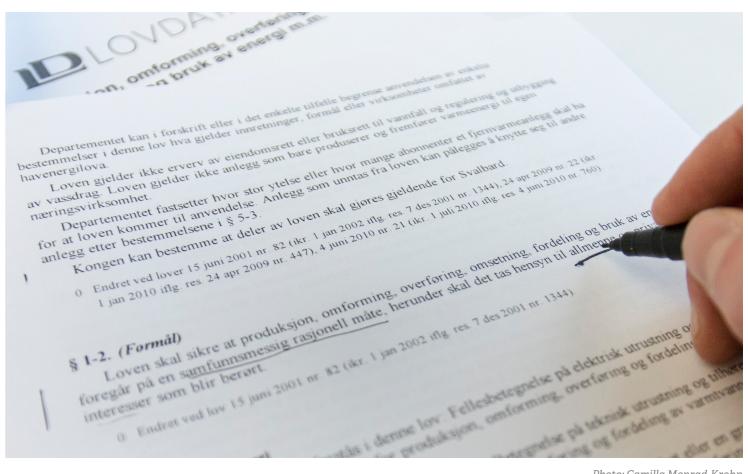


Photo: Camilla Monrad-Krohn

§ 1-2.(Formål) Loven skal sikre at produksjon, omforming, overføring, omsetning, fordeling og bruk av energi foregår på en samfunnsmessig rasjonell måte, herunder skal det tas hensyn til allmenne og private interesser som blir berørt. (1919)

The purpose of the law is for the good of the consumers, but the way it is enforced does not take into account modern ways of producing and distributing electricity.

Tax

When a consumer buys energy of the grid, the consumer must pay a tax per Kw/h.

When a local producer today produces more energy than is used in that moment, it will automatically be sold back to the grid. When the producer then later has to buy energy "back" from the grid, they have to pay a tax for that energy. This creates an incentive to create an independent system, using a battery to store energy for later use as a way to reduce the cost.

If everyone creates independent systems, the tax revenue from energy will disappear altogether.

> The law and taxes around energy production and distribution do not cater to local renewable energy production.

Summary and Reflection

Research on the current system.

In this chapter we have provided an outline of the current system for energy production and distribution. To summarize we want to highlight the following issues:

- Europe is the main context for this Master thesis, although it will probably be as relevant in the US and several other countries in the world.
- Alternating current made it possible to move the big, polluting power plants out of populated areas.
- The physical infrastructure is not an obstacle for local energy production and dristribution.
- The traditional actors are centered around a linear distribution process.
- The law and taxes around energy production and distribution do not cater to local renewable energy production.

The current system was built in a time when local energy production was undesirable. The physical infrastructure can be adapted to local production, but the main challenge is to change how the traditional actors are structured.



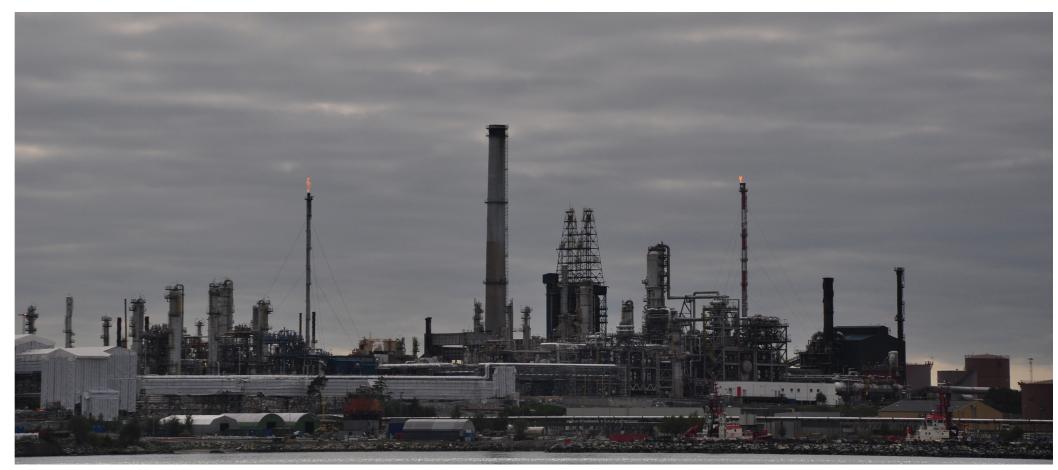


Photo: Ask Helseth

Political Forces

Climate Change

The leaders of the world stand before a great challenge: climate change. Greenhouse gas emissions must be lowered drastically. The European Union has set a goal of reducing the energy demand, 27% by 2030, and reducing emissions compared to the 1990 level more than 40 % by 2040. Politicians in some countries have decided that stimulating renewable energy production is an efficient way to reduce emissions.

The country that has pushed for this development the most is Germany. Germany has implemented a number of laws and programs towards an energy transition. This development is referred to as *Energiewende*. This program aims to transform the way Germany produces its energy. It uses different mechanisms to stimulate renewable energy production. One of the important mechanisms is "feed in tariffs". This means that personal initiatives producing renewable energy are guaranteed a certain amount of money for the energy that they can feed into the grid.

Politicians have also put in place a system where renewable energy has a "right of way" on the grid. This means that, if there is to much energy production, the energy that is produced based on fossil fuels is forced to shut down (German Energy Transition, 2015).

One criticism of these mechanisms is that they can create an imbalance in the market. During

one period this summer, energy producers in Germany using fossil fuels actually had to pay to get rid of electricity. There are also talks about paying coal power plants to stay idle and standby (The Guardian, 2015).

The mechanisms have been very successful in the sense that they have stimulated more renewable energy production (the Guardian, 2015). This has created a demand for products that can create renewable energy locally, mainly solar panels. This in turn has led to a reduction in the price of solar panels.

The current method of producing energy needs to change.



(Photo: Ask Helseth)

Technological Development

The basis for this project is the recent advancements in technology. There are three main drivers. The first one is production technology. This is essentially solar panels, or photo voltaic cells, which is the scientific name. Solar panels have been around since the 1950's. (Aps.org, 2015). The technology has always been appealing, since it is considered very clean and it has a very long lifetime (German Energy Transition, 2015). Most of the world's energy production today is based on the sun but in an indirect way: fossil fuels are solar energy concentrated for millions of years (Epa. gov, 2015). Solar cell technology is the only kind that takes the energy from the sun and directly converts it to electricity.

Up until now there have been two main barriers against broad adoption. One has been the inability to store the energy, which we will come back to later in the report. The other is that solar panels have been too expensive to compete with other ways of producing energy. However, this is changing. Government initiatives have created a bigger market for solar cells, which in turn has helped the prices go down. At the same time as the market has grown, the technology has become more mature, and the products that are being produced today are far more efficient and cheaper than even a mere decade ago.

But will the prices continue to decrease? We have strong evidence that leads us to believe so. Bjørn

Thurud, Senior advisor, Ph.D. and head of solar business development at Multiconsult, said that there is no reason to believe that the prices will not continue to decrease. The technology have a long

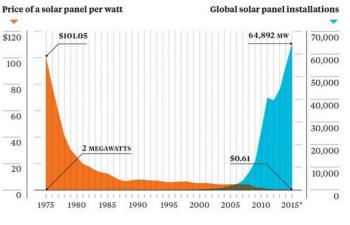
way to go before it reaches its full potential.

The numbers in the Bloomberg Energy Outlook 2015 also say that the price on energy produced with solar panels will continue to fall. If this happens, it is just a matter of time before energy production by solar panels will be cheaper than producing it by burning fossil fuel (Bloomberg New Energy Finance, 2015).

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"There's a lot of energy that's just falling on people's roofs every day» - Isak Oksvold (Director of Enviroment, Aspelin Ramm)

Using solar panels is soon to be the cheapest option for energy production.



(TreeHugger, 2015)





Tesla's power wall is build up by several cells, simular to these 18650 cells, which we pulled out from an old laptop. Photo: Ask Helseth

Teslas power wall released April 2015 Photo: https://www.teslamotors.com/powerwall

Storage

Storage is another technical development that is lowering the other main barrier for broad adoption of local energy production, namely the limited hours of sun radiation. Even though it is fair to assume that the sun will rise tomorrow we do not know if there will be a cloud obstructing it (Wittgenstein, 1961). Furthermore, one might need to use power during the dark hours of the day. Solar energy is what the experts call a Variable Renewable Energy source. This means that the energy output is variable and one cannot control it, but -

on the bright side - one can store it.

Means of storing energy has been available for a long time, but it has been expensive and impractical. These days, there are many actors offering different kinds of products that enable private producers to store energy. Most of these actors provide lithium ion batteries in one form or another. Such batteries are becoming more efficient and at the same time much cheaper (Greentechmedia.com, 2015). One of the battery providers that has gotten a lot of attention for its energy

66

storage product line is Tesla Energy (Sweet, 2015). They introduced products for the home market that were well received (Forbes.com, 2015). What is interesting is the products they offer at a utility scale at an even lower price range. The cost of storage has been halved the last ten years, and that development is expected to continue. (Straubel, 2015)

This lower cost makes it possible to use a variable renewable energy like solar cells as a main source of energy. "Batteries now contribute to bridge production and consumption, and solar energy is no longer only a supplement."-Karl Kristensen (Industry Supervisor, The Bellona Foundation)

Storage is becoming cheaper, and this makes it possible to use variable renewable energy sources as a primary energy source.

User Interviews

One of the main drivers for adopting renewable local energy is the adopters themselves. The adopters who decide to take part in local production are particularly important. Even though we have looked at the development of the local energy production and distribution in a European context, we have only interviewed local producers in Norway. Germany has numerous local households producing their own energy - 1.6 million, to be exact - versus a few hundred in Norway. For practical reasons, we needed to find someone around Oslo, and after some work we managed to come into contact with two different users who produce energy locally:

- Paul and Rita Henriksen have installed solar panels on the roof of their house in Hyaler.
- Jarl Solberg was in the process of ordering solar panels.

We did in-depth interviews with both, and our main findings are listed on the next pages.



Users' are motivated to invest in their own production mainly in order to take charge of the production themselves. By doing so, they know that the energy they use is renewable, as well as being a way to contribute to the fight against climate change. And to lower their electricity costs.

Motivating Factors for the Users

The early adopters we have interviewd highlight several motivations for investing in local energy production. One of the motivations they mention is their own curosity. They want to learn about energy production, and the technology fascinates them.

Both of the users we have talked to believe that their investment will pay off. They say that it is just a matter of time and that "you need to have a long-term investment view".

Another interesting motive for the users is that they see an investment in local renewable energy production as something they would and should naturally do to contribute to the fight against climate change. They believe that their actions are a small step towards a more sustainable world.

The latter impetus is very interesting, especially since the users we have talked to live in Norway. There are two different ways of looking at the realities of the last motive. When we had a meeting with Hafslund, they said that Norwegian electricity is 103 % renewable. Based on this, installing

more local renewable energy production, as a way to fight climate change, does not make sense. This point of view is directly related to one argument that is frequently used in cases when people argue that electric cars are dirty. They claim that if one consumes electricity in Norway, one is in fact buying electricity made from burning coal in Germany, since Norway will have to import extra enegy to cover the usage by cars.

Interestingly, both sides can use numbers to back up their arguments. However, for the users it is not about numbers and theories. It is about being absolutely sure that the power in their houses is from a renewable source.

The users we talked to are early adopters. They are interested in technology, but we do not think that their curiosity about the technology itself will be the main drive when there is a broader base of users. We do, however, think that price, access and knowledge about where and how the power is being produced will be important motivating factors in the future.







User Challenges

The users with whom we spoke said they also had some challenges:

Should I invest?

The first main obstacle was being able to understand whether local production was something they should invest in at all. Where do they start the process and how do they gain information to be able to take a well-informed decision?

The first step is to determine whether the roof is suited for solar production. Then they need to find out how many panels should be installed and how to finance it. To be able to predict the accurate financial benefit of the investment and how much the production will generate, they also need to predict the weather for the next 20-50 years as well as the energy prices within the same time frame. Then, they need to compare that with the

cost of investing up-front in the technology and installation today. The next practical step would then be to find an installer.

All this is something that users cannot predict easily, and early in the project, we thought this was the obstacle we should solve. However, a service that Google released a week after the interview addresses these obstacles, something which will be explained further later on in the report.

To whom are we selling?

The user we talked to who already had installed solar panels expressed that, after the process of installation, the most negative experience was the experience of "selling energy".

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We are selling the excess power to someone, somewhere, at a random, low price.

Paul Henriksen (Private user and producer of solar energy, Hvaler)

When a user connects a solar panel to his or her house in Norway, he or she must become part of a service called "Plusskunde" or similar services. "Plusskunde" is a service provided by Hafslund around Oslo. When users become a part of this service, they feed the power they do not consume into the local grid. Then they are paid according to the value at the national spot market, Norpool in Norway, at any given time (Nve.no, 2015).

The users felt that they were payed very poorly for the power they produced. They explained that, at the time, they bought energy at the total price of 1 NOK for one kw/h, while they earned only Local producers at Hvaler. Photo: Ask Helseth

0.15 NOK per kw/h for the energy they sold. The users did not understand why the energy that cost their neighbour (and themselves when in need of energy from the grid) 1 NOK only gave them 0.15 NOK. Where did all that money go?

They stated that they felt someone else was profiting from their production. This made them consider installing a battery so they could become more self-sufficient.

Local producers receive very little back in terms of profit when they contribute renewable energy to the grid. This creates an incentive to become more self-sufficient.

Summary and Reflection

Research on trends creating change

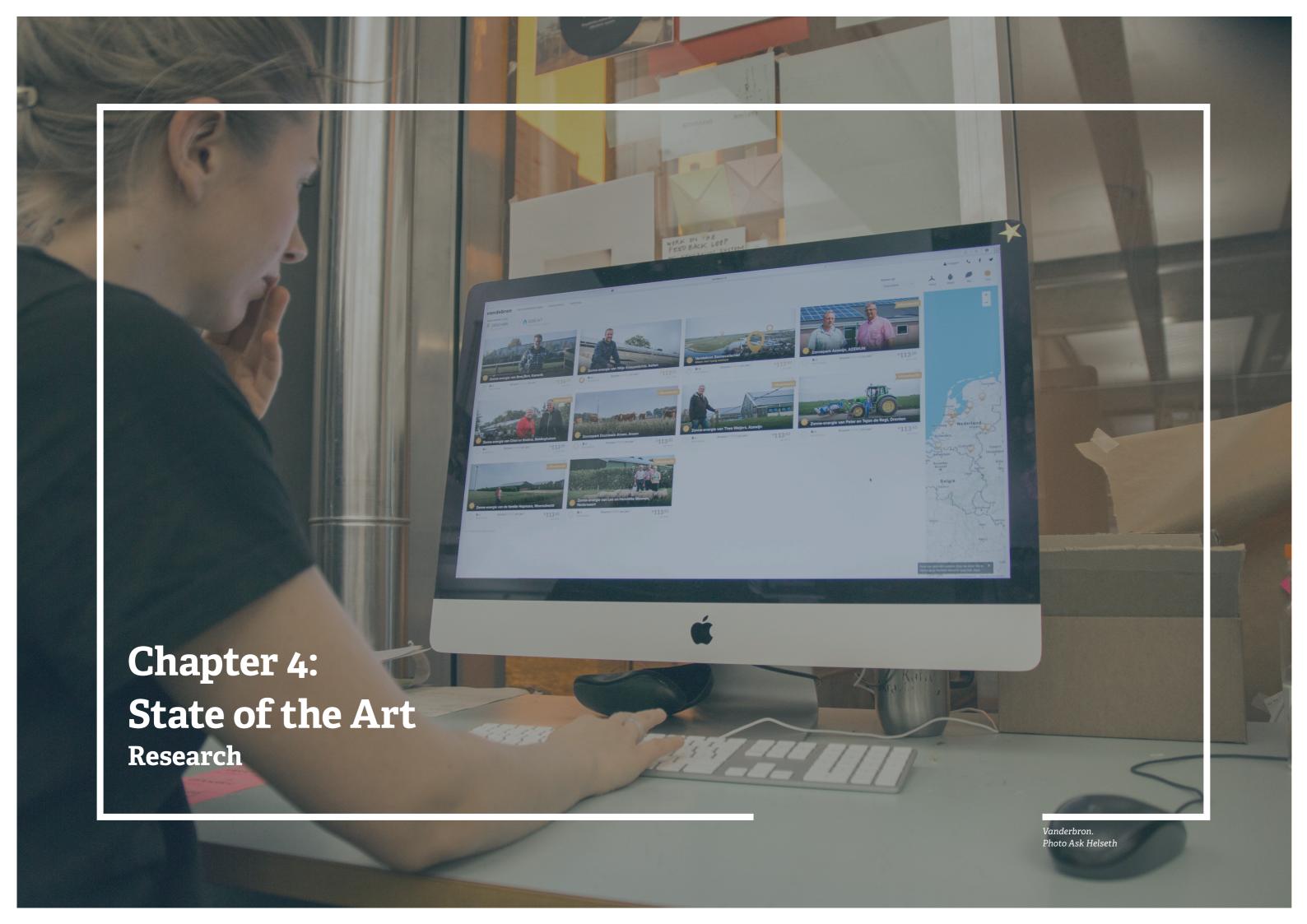
In this chapter we have provided an outline of trends creating change in energy production and distribution. To summarize we want to highlight the following issues:

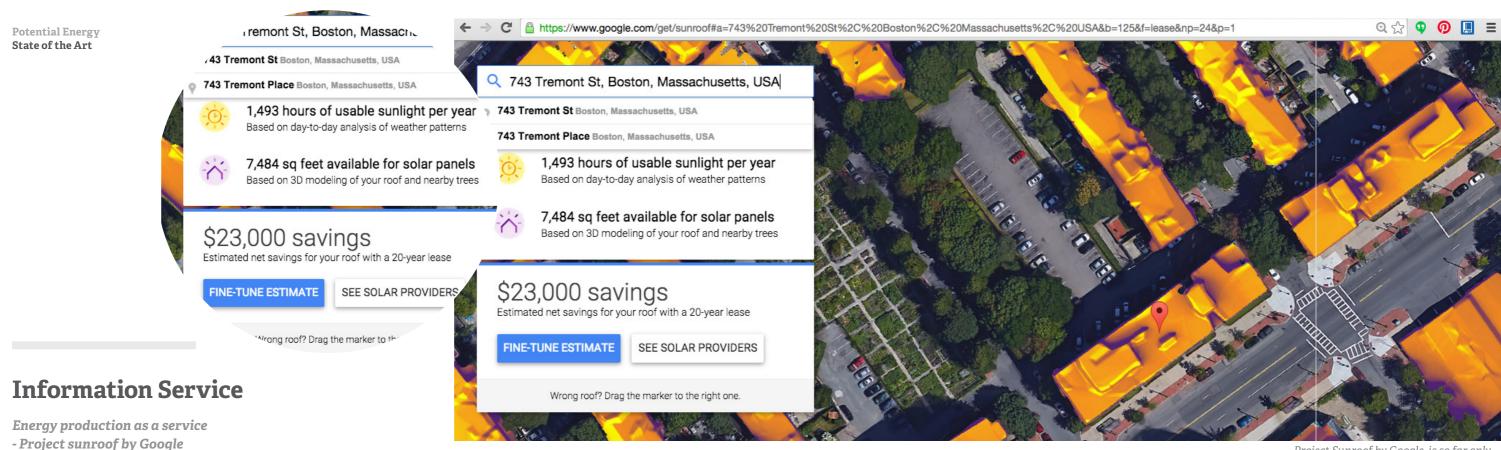
- The current method of producing energy needs to change.
- Using solar panels is soon to be the cheapest option for energy production.
- Storage is becoming cheaper, and this makes it possible to use variable renewable energy sources as a primary energy source.
- Users' motivation to invest in self-production is mainly to take charge of the production themselves. By doing so, they know that the energy they use is renewable, a way to contribute in the fight against climate change.

 And to lower their electricity costs.
- Local producers receive very little back in terms of profit when they contribute renewable energy to the grid. This creates an incentive to become more self-sufficient.

New advancements in technology enable local renewable energy production to become the primary source of energy.

Users are embracing the new technology, because it is cheaper and gives them confidence that the energy they use is from a renewable source. The distance from the production itself and where it is consumed is shorter, and it is therefore also easier to understand. However, the users have some challenges and dislike how the current energy market works for them.





Project Sunroof by Google, is so far only available in some areas in the States

One of our early ideas was to create at tool that could lower the difficulties in investing in local solar energy production by providing the user with information on production, savings, and investment plans through an accessible interface. However, in august 2015, a couple of weeks into our project, Google released a great tool that provides people with this information.

Based on maps from Google Earth, users can estimate the total sunlight a rooftop receives throughout the year and how much they can expect to save by using solar panels. Calculations can even include their current electricity bills. The clear vision on how much users can decrease their energy bill and save money is probably the biggest motivation for most people to take action.

In the analysis of how suited a person's rooftop is

for solar energy, Google uses:

- Google's database of aerial imagery and maps
- 3D modeling of the person's roof
- Shadows cast by nearby structures and trees
- All possible sun positions over the course of a vear
- Historical cloud and temperature patterns that might affect solar energy production

This proactive tool also connects people to local actors who can provide panel installation. This means that if one considers installing solar panels, the step to implement it and access to information requires far less effort. Additionally, the difficulties in investment are lowered.

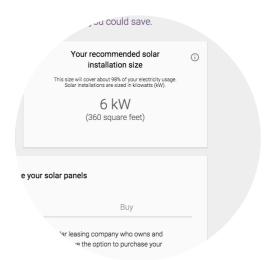
"Produce only for yourself"

One aspect we find interesting is that Google recommends that individuals do not produce more that they can use themselves. Their argument is that there is nothing in it for users if they produce renewable energy for their neighborhood to use. "We recommend an installation that covers less than 100% of your electrical usage, because, in most areas, there is little financial benefit to producing more power than you can consume." (Google.com, 2015)

This recommendation seems odd when we consider that there is likely someone in the neighborhood that can produce renewable energy themselves and would happily buy a user's excess energy. However, when the payment system for energy follows the old structure, users end up selling energy for next to nothing and buying it back for much more.

Google and other providers of information do not recommend investing in more than what you need to cover your own consumption, or less. Project Sunroof enables users to quickly make informed decisions about the benefits of local energy production.

It also points out that the financial system does not give users an incentive to produce local energy for their neighbourhood.



Energy Production as a Service

Business Development

Today, there are several services provided for users who want to produce renewable energy from solar panels on their roofs. Services facilitating community-owned solar panels are a development that has appeared in recent years. This is particularly apparent in the U.S. and the U.K. Two examples of this are the Clean Energy Collective and the Solar Trade Association. They facilitate the process of community investment in big solar cell projects (solar farms).

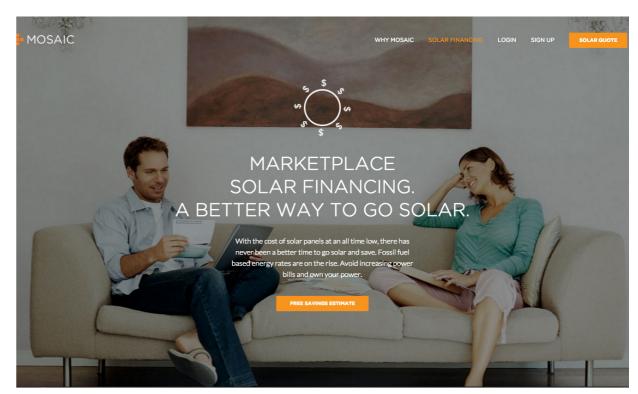
One actor that has grown quite a lot recently is Solar City (MERCED, 2015). They have started to deliver solar panels as a service rather than as a product and take control over the entire process once individuals have announced their interest. They measure the potential user's roof, plan the installation and they have their own people bring the panels and install them. They also offer financing plans. People can buy a system outright if they have cash at hand, or they can lease it and pay a monthly fee. They could also simply get a



BUSINESS & GOVERNMENT CAREERS COMPANY



SolarCity provide technology and installation for people for become local producers. www.solarcity.com



Mosaic provide solar loans to lowe the barrier of investing in solar energy. www.moisaic.com

discount on their monthly electric bill.

There are also businesses providing people with solar loans. Mosaic is a service that provides people in the U.S. with home solar loans to lower the costs of investing in solar energy.

Through a loan, they take care of the technology and installation cost for people to create their own power plant. "Mosaic's software connects investors that believe in clean energy to borrowers like you. They invest in you, you save." (Joinmosaic. com, 2015)

This service is lowering the financial toll of investment in local renewable energy production.

New services are reducing the difficulties of investing in solar energy. These services make the installation and technology more accessible, and they provide consumers with solar bank loans or facilitate their investment in others' production.

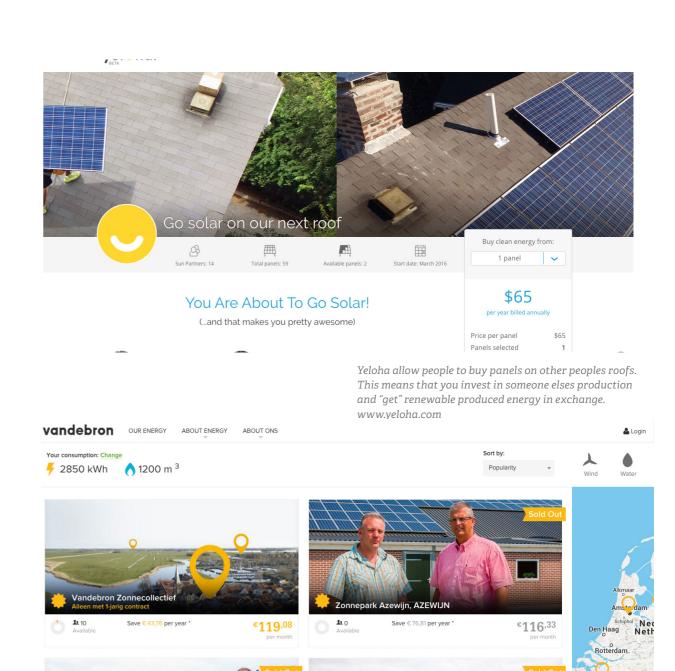
New services are trying to create a more direct market for local energy by facilitating the purchase of energy between a producer and a consumer.

Shared Energy Services

Potential of Sharing

There are also services on the market that make it possible for people to buy solar (or other types of renewable energy) without owning it themselves. An example of this is Yeloha. A service like Yeloha enables people to become a sun partner and connects them to a local sun host. This allows a person to buy solar panels on someone else's roof. By investing in others panels, the person is provided with cheaper, renewable energy through his or her existing utilities. They have also developed an app where people can follow the production of their panels.

Vanderbron is a Dutch service that allows people to buy energy directly from the source (Collaborative Consumption, 2014). The service is presented in a manner similar to services like Airbnb where one can search locations for production through a map or pictures with the people and the landscape of the production. The search is sorted by wind, water, bio and solar power sources. The interesting part is that Vanderbron are not really selling energy. They are offering a platform that allows people to buy energy directly from others. A user pays a fixed service fee to gain access to the platform, and all the money the user pays for energy goes to the person or family that produces it. Using this direct payment model makes it more appealing for people to provide renewable energy to consumers, since they receive more back on their investment.





€116,61

Vanderbron is a Dutch service, and their website is in Dutch. One can use Google Translate to understand the essentials, but we had to find an interpreter to help us translate it.

€116,61

Vandebron's distribution price model compared with the traditional price of energy in Netherlands. https://vandebron.nl/#!/

Energy-Producing Neighbourhoods

The Potential of Sharing

We met with Isak Oksvold from Aspelin Ramm at Mathallen to understand how the energy-producing system (heating and cooling) in the Vulkan area in Oslo is working.

The Vulkan area is very energy-efficient. Since the whole area is owned by one company, they have been able to build a system that allows them to create a synergy. One building produces the heat using solar energy. Another building acts as a hub and distributes that heat and coolant around the area. Under the hub, Aspelin Ramm has invested in 64 massive energy wells. The wells allow them to dump heat during summer and extract heat during winter.

It is a large investment, but since they can use wells for storage and harvest energy to cover the entire area, it pays off. This system is possible, since Aspelin Ramm has a whole set of buildings that can benefit from it while having a long-term investment plan at the same time.

View the production source and distribution at: http://www.energisentralen.no/

Systems can be more efficient as a whole if one uses several buildings to create synergies.







Summary and Reflection

Research on the state of the art

In this chapter we have provided an outline of the state of the art across commercial services and systems. To summarize we want to highlight the following issues:

- Project Sunroof enables users to make informed decisions quickly on the benefits of local energy production.
- Financial systems don't give people incentives to produce local energy for their neighbourhood.
- New services are lowering the difficulties
 of investing in solar energy by making the
 installation and technology more accessible,
 providing people with solar bank loans or
 simply facilitating the opportunity for people
 to invest in others' production.
- New services are trying to create a more direct market for local energy by facilitating the purchase of energy between producers and consumers.
- Systems can be more efficient as a whole if one uses several buildings to create synergies.

Obstacles are surpassed with new services provided by different actors. Some companies are trying to create a more fair market for local energy, but there is still room for improvement. There is a need to create a new service model that allows local producers to receive a more "fair" price on the energy they provide to their neighbourhood.



Defining a Future Landcape

Since our goal with this project is to explore what the future landscape of energy production looks like, we need to define the future landscape. We have based our predictions on a steady development of the technology. This means that we have not taken into account the "breakthroughs" one hears about in the press now and then.

Our initial plan was to define what the future landscape will look like and then explore the possibilities within that landscape. The challenge with this is, the more we understood about the development, the clearer it became that different actors have different ideas on how they think progress can go. There were two main divergent directions. Both sides had good arguments for "their" takes on where the development in energy production could go.

Therefore, we changed our approach. We decided to explore both of the divergent directions.

It is interesting that both directions are based on the same development and adoption of the production technology; the only difference is who owns the production.

Do the big power utility companies manage to keep control of production?

Or are local producers taking over the control?

In this chapter, we will explain why we think development can go toward one of two divergent scenarios.

On grid: Centralized ownership



or?



Off grid:
Decentralized ownership





On-Grid: **Centralized Ownership**

Some electric utilities are fighting to keep control over a market that has been theirs for a long time. If the electric utilities use their know-how and financial muscle and enter the market for local renewable energy, it is possible they can create services for people who want to take part in local renewable energy production. Additionally, if the electric utilities manage to make the services so desirable, cheap and easy to adopt that there is no point for the consumers to go elsewhere, then the

electric utilities can keep control over all energy production, even locally.

Since it will be more variable renewable energy (energy production that don't respond to demand), the electric utilities will need to build up buffers to handle the differences in production using e.g. batteries. The utilities can also try to regulate the usage of energy all the way down to the individual



By the end of 2014 E.ON adopted a new strategy: "Empowering customers. Shaping markets." In order to increase their share of the new local renewable energy market.

Hva er en plusskunde?

Kort fortalt er en plusskunde en kunde som på tider av året produserer mer strøm enn kunden selv forbruker. Overskuddsstrømmen selges tilbake til nettselskapet.

Hafslund Nett var det første nettselskapet i Norge som åpnet muligheten for å bli plusskunde. Vi har allerede en del plusskunder tilknyttet vårt distribusjonsnett og flere har meldt at de vil komme i tiden fremover.



Vil du bli plusskunde?

Typiske plusskunder kan være boligeiere ed solcellepaneler på taket.

Mer informasjon Enovas tilskuddsordninger Norsk solenergiforening

Teknisk kundesenter **\$** 815 70 020

Mandag - fredag 08.00 - 15.00

Slik virker ordningen i praksis

https://www.hafslundnett.no/oss/hva_er_en_plusskunde_/14398

We can already see initiatives for this development. To meet the increasing development of private people investing in solar power, Hafslund has established something called Plusskundeordning (plus customer scheme) to facilitate for the local producers to feed their excess energy back to the distribution network. Hafslund does not own the product, but they dictate the terms of how the users can sell their energy (Hafslundnett.no, 2015).

Another strategy the utilities can use is to secure the help of politicians to use legislation to ban local production and "force" people to stay connected to the grid.

Either way, what will the market look like if the big utilities maintain their control?

The electric utilities can stay in control of all production, either by offering amazing services for local production or by convincing the politicians to use legislation to ban local production.

Local production could undermine the electric utilities to such an extent that the traditional actors disappear altogether, and the national grid disappears with them. If this were to happen, people would have to take charge of their own energy production.



Off-Grid: Decentralized Ownership

The other scenario is a consequence of a development we already see today. Independentaly and of their own accord, an increasing number of people have begun to take charge of their own production. The consequence of more and more people are becoming independent is that less and less people are sharing the cost of the grid. This causes the costs to rise, and more users have an incentive to become independent. If this continues, the end result will be that no one will be part of the grid, and all the actors we know today will disappear. Since we need the big actors to maintain the infrastructure, the infrastructure will disappear with them. In this scenario, the grid has collapsed, and the consumers either need to produce their own energy or buy energy elsewhere and find a way to get it to their house.

We can already see the start of a development towards this today:

As the prices of solar panels and batteries continue to decline while the cost of being part of the grid increases, it is just a matter of time before being disconnected become the financially sound option.

Disconnecting a house from the grid entirely, using a combination of solar and batteries, will be much more relevant in Southern Europe than in Northern Europe. However, we can already see early adopters who are disconnecting their houses in Northern Europe, like Hans-Olof (see next page).

What happens if this development results in the collapse of the grid? Will people have to produce energy themselves or buy from new kinds of actors?



ager utstillingsvindu: Hans-Olof Nilsson bor i Agnesberg utenfor Gateborg. På dagen driver han et vindkraftselskap. Ellers bruker han all ledig tid på å gjøre det nybyggede huse sagbenskis av strømmettet. På kirkt es 20 mg/ bledt ende salfannere og sveligeller (2014) som shere i satting av skrefte bruker. Annelsom blit draktig

NORGES SMARTESTE HJEM

Slik skal Hans-Olof leve uten strøm til vinteren

Eneboligen på 508 kvadratmeter bruker 8.000 kilowattimer el i året. De skal svensken produsere selv.



Hans-Olof Nilssons sikringsskap er litt større enn vanlige sikringsskap. – Jeg gjør dette fordi jeg er energiinteressert, og for å vise andre interesserte mennesker at det er mulig å være sin egen el-leverandør, sier Nilsson. Foto: Jörgen Appelgren/NyTeknik

http://www.tu.no/incoming/2015/11/07/slik-skal-hans-olof-leve-uten-strom-til-vinteren

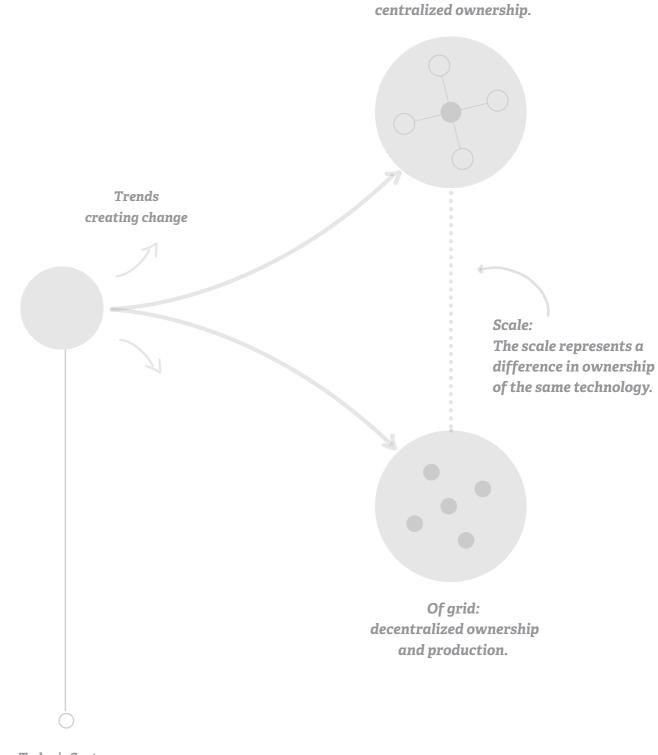


Who Owns the Sun?

When we put these two divergent scenarios on a scale, the scale represents the ownership of the energy production system. At the top of the graph, the actors that own the production facilities today keep that position and remain in control of production. In the lower part of the graph, the ownership over the energy production system is decentralized and consists of millions of independent, unconnected personal producers. The technology adopted in both scenarios is the same, but the owners are different.

To explore what this means, we will spend the next chapter investigating these two models by designing services in the two scenarios.

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On grid:

Today's System



Investigating the Landscape

In this chapter, we have investigated the service potential in the two scenarios we defined in the last chapter. We developed service concepts to investigate what the senarios entailed for the user and the system by using what we now know about user needs. We then combined that with a new landscape.

By designing services in a future landscape one can create a desire to go in a certain direction, or possibly resistance towards another direction.

The service investigation has been valuable to understand what the directions actually mean for our users.

side note

The Qualcomm Tricorder XPRIZE is a \$10 million global competition. It is interesting because what they are trying to make is technology featured in a science-fiction movie that was first aired in the 60's. A fictive device from a movie have created a desire for a technology that does not exist yet. (Qualcomm Tricorder XPRIZE, 2015)



FROM THE STATE OF THE STATE OF

Categorizing ideas. Photo: Ask Helseth

Concept Development

Process

The concepts are presented after the research in the report, but we have had a continuous development of the concepts during our process. We have developed concepts along with our research from day one. We have had continuous rounds in which we have put our ideas on the wall and discussed and categorized what function they serve as a way to generate more ideas. We have also invited fellow students to discuss the raw concepts in order to discover what people find interesting. We have over 150 different conceptual ideas behind

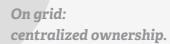
this project. From these, we have chosen nine to investigate and develop further. The ideas are described through demonstrating a service encounter. The reason we have chosen this method is that communication is the main purpose the service concepts serve. We have used the concepts to communicate where we think the future development will go and have used concepts in meetings with actors as a method to have a more concrete discussion of future development.

We have also chosen to present most of the service concepts through actors that are already familiar. (The actors are Norwegian, so it would be best for non-Norwegians to look them up on the internet if they haven't heard of them before.) The reason we have used familiar actors is to be able to give the services more weight and value by playing on the cultural understanding of actors we already know.

Service Concepts

On-Grid: Centralized Ownership

The following section contains **services we have designed** to investigate a future landscape with a grid, centralized control and ownership as we know it today.



This landscape still has the infrastructure and actors as we know them today. The utilities still have a central role in the distribution of energy to citizens. For this to become a reality, the utilities will have to adopt the technology and grasp the potential of managing different sources, including locally. This means that the utilities must take control of local production as well.

Scale:
The scale represents a
difference in ownership
of the same technology.



Of grid: decentralized ownership and production.

Offering Technology

Going forward, there will be more locally produced solar energy on the grid (Bloomberg New Energy Finance, 2015). One thing the dominant electricity utilities can do today to keep control

over all production in the future is to use their financial muscle and their knowledge in order to offer excellent services. If the services are good

enough, it would be pointless for the users to go

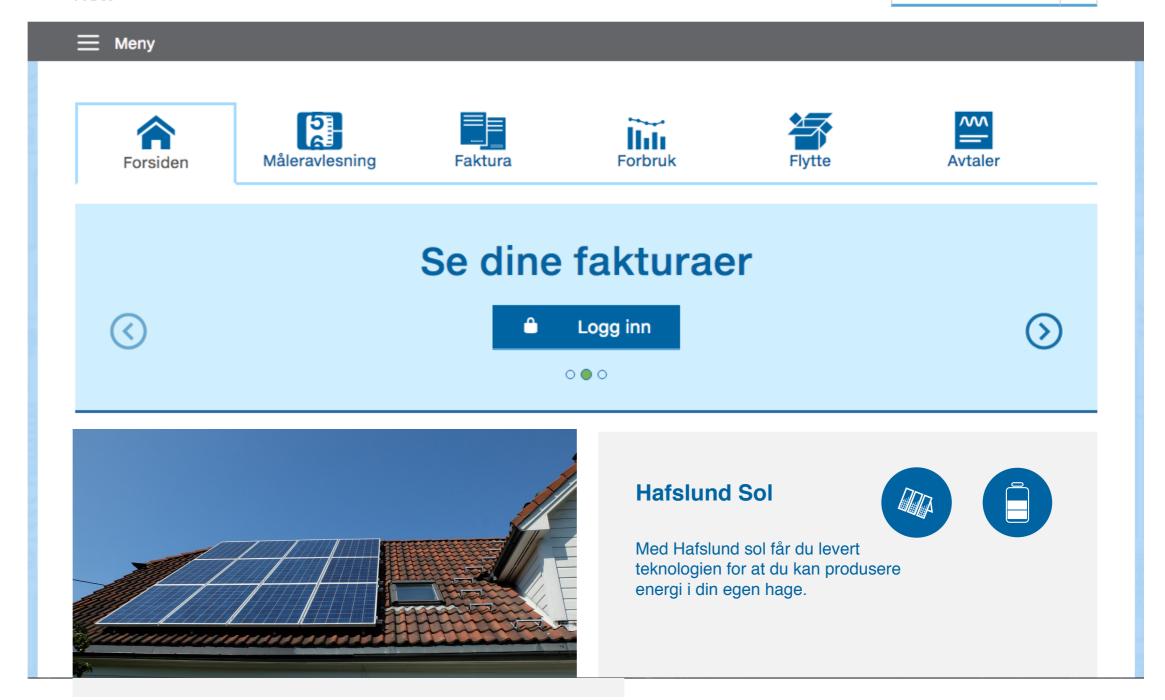
for Production

Centralized Ownership

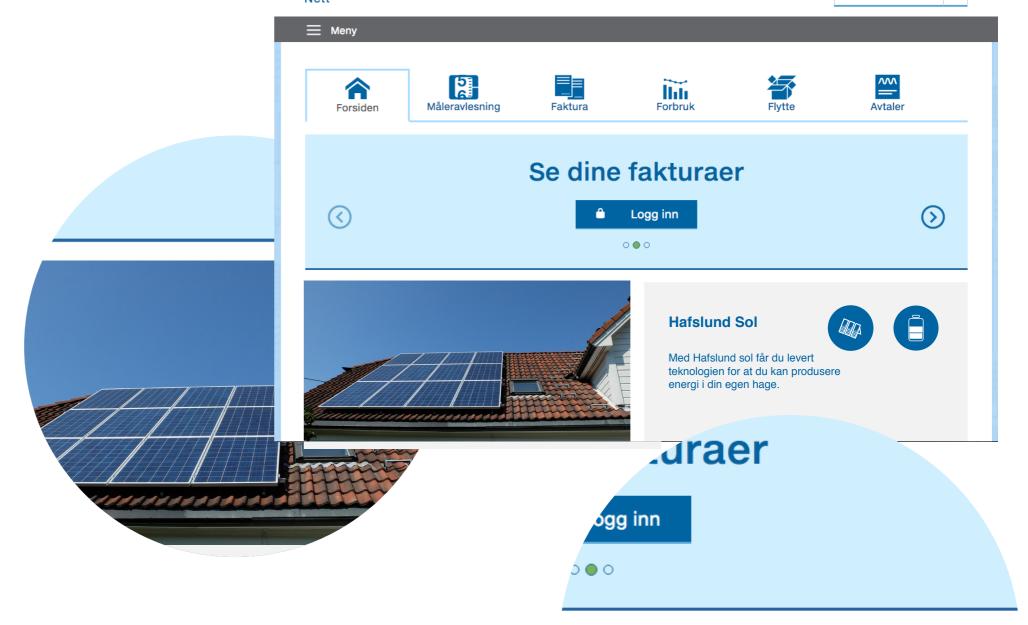
elsewhere.



Søk i hafslundnett.no



Hafslund Sun Package



Hafslund Sun Package

Centralized Ownership

The Hafslund Sun Package illustrates how electric utilities can deliver services in the future as a way to maintain control of all production, including local production. Hafslund is divided into different companies under the same name, but they are mainly known for being both an energy retailer and the owner of the distribution grid.

There is a great opportunity for Hafslund and similar actors across Europe and the U.S. They can provide services to meet the electricity demand, political goals and customers initiative to personally produce renewable energy. Through these services, they offer the consumer a deduction on their electric bill. In exchange, the utilities are allowed to use the consumers' roofs to install solar panels. Hafslund will still have ownership over the production capacity and will, in effect, sell the energy that lands on the users roofs to the user. The customer will receive cheaper and renewable energy without any active involvement.

This kind of service has a lot of potential. The demand for similar services in the U.S. shows that users are willing to have a little less profit on a solar installation if they also can avoid having to arrange and finance the systems themselves.

We have designed the Hafslund Sun Package to illustrate how electric utilities can deliver services in the future. They can also take own-

ership of local production by expanding energy

production to their customers roofs.

Hafslund Sol



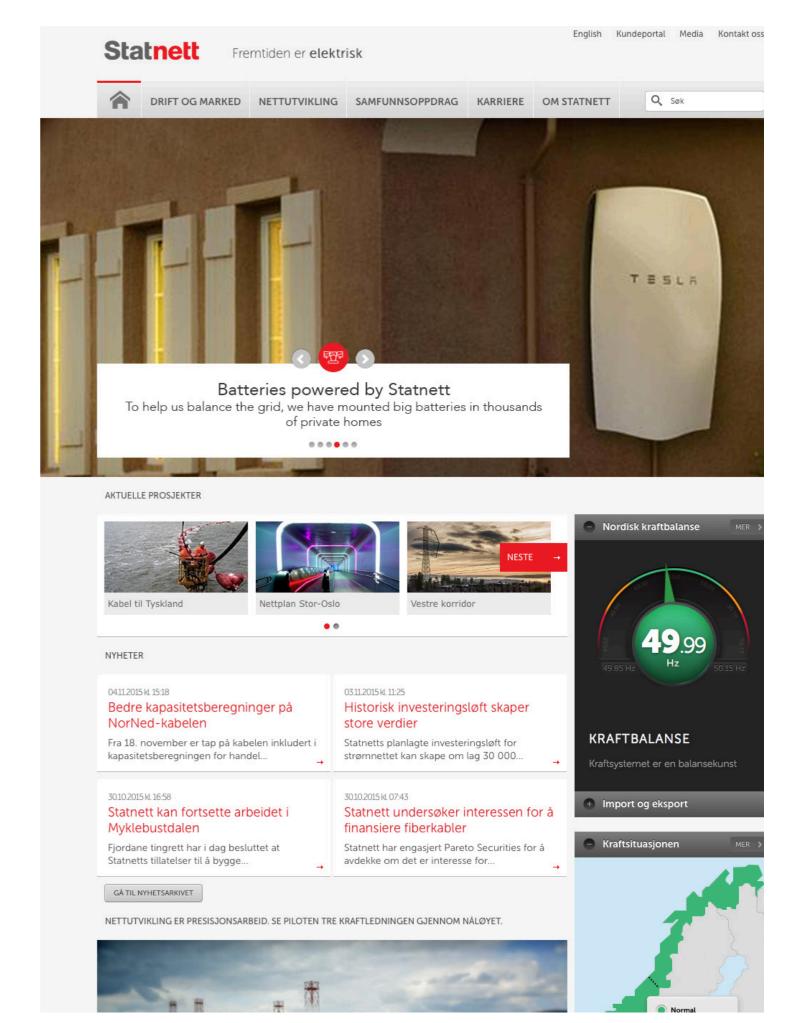
Med Hafslund sol får du levert teknologien for at du kan produsere energi i din egen hage.

Balancing the Grid

Centralized Ownership

Today's grid is built to handle the peak loads that rarely occur. This means that the grid is required to handle the stress of many people using energy at the same time, in Norway on the coldest days of winter. Due to this requirement, the grid is over-dimensioned most of the time.

Instead of constantly building up expensive and controversial infrastructure, electric utilities can use new advancements in storage technology to "shave" the peak loads (i.e. take away the periods with the most load).



Statnett Grid Battery

Centralized Ownership

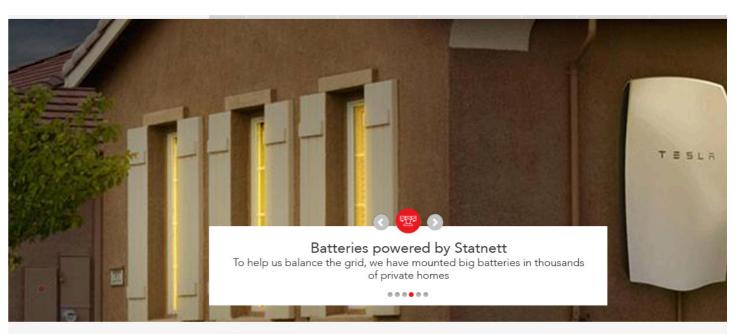
The Statnett grid battery illustrates how the owner of the national grid can meet the demand for electricity around the country while stabilizing the load in a new way. Statsnett is the owner of the national grid and is therefore responsible for expanding and maintaining the grid for distribution of energy around the country. There is great potential for Statsnett and similar actors around Europe and the U.S. to provide households with energy storage as a way to balance the grid and keep the investment costs down. In some cases, it might be cheaper for Statsnett to pay homeowners

This represents an entirely new way of thinking for the electric utilities. We think it will require a cautious approach by the electric utilities in order to obtain this kind of access to people's properties. However, we certainly think it will happen in some form at some point.

for space to install batteries in their homes instead of expanding the traditional grid infrastructure. The batteries can act as a buffer, and by doing so, they limit the pressure on the grid when it is working at full capacity (peak loads).

side note

We are not trained to do these calculations or say if they makes sense, but we did some crude calculations on the cost of building Sima-Samnanger transmission lines in Norway (a controversial new power line to secure stable power supply to Bergen). According to our calculations, Statsnett could install a Tesla home battery in every third household in Bergen for the same price.

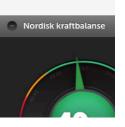




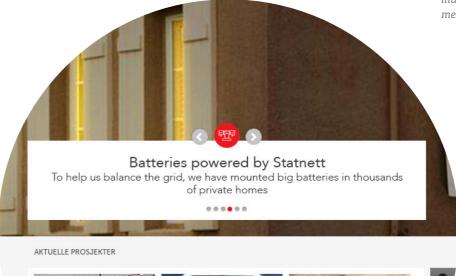








We have designed the Statsnett Grid Battery to illustrate how the owner of the national network can meet the demand for electricity.









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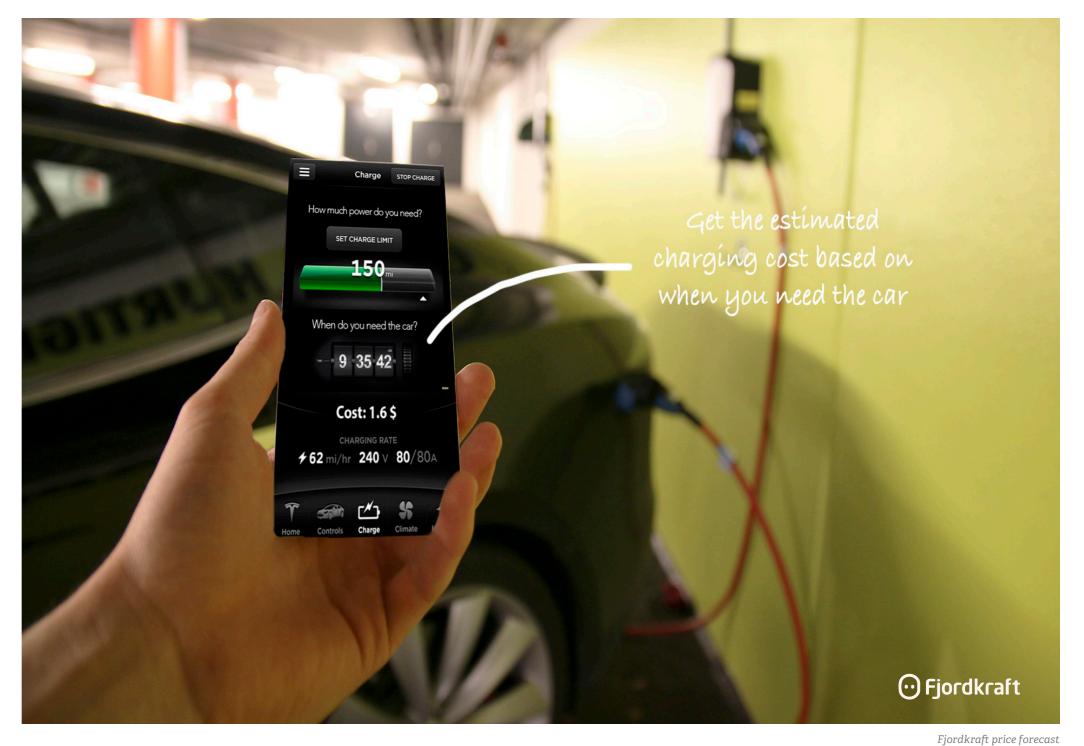
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03:11:2015 M 11:25 Historisk investerings¹/ store verdier

Affect Consumption

Centralized Ownership

With more variable renewable energy entering the grid, the electric utilities have to find ways to store energy for later use. Instead of investment in storage/batteries, electric utilities or other actors can also use technology and different price models as a way of adjusting the consumption according to the capacity on the grid.



Fjordkraft Price Forecast

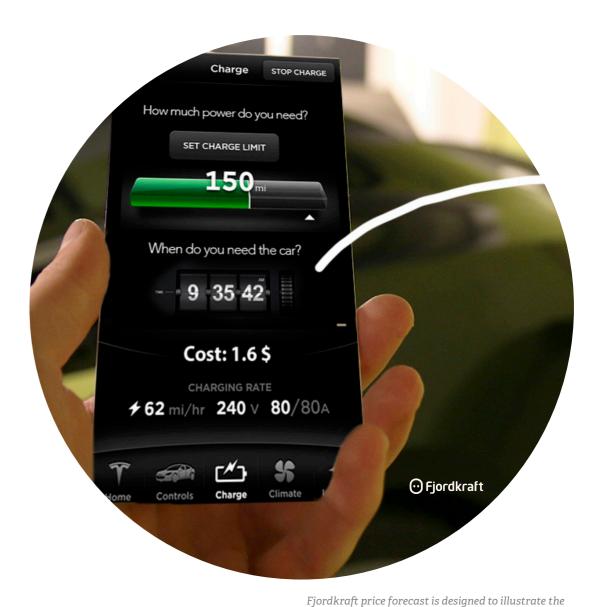
Centralized Ownership

There is great potential for retailers to make money on new service offers that advise and guide the user on their consumption. In new price models of this kind, customers pay not only for the amount of power they are using but also for the time they are using it. In this manner, the energy retailers can help people and businesses adjust the time they are using energy to lower the costumers' energy bill as an incentive.

The Fjordkraft price forecast illustrates a potential where they, as energy retailers, can provide their customers with a data stream to predict energy prices for the next 24 hours. By allowing actors such as Tesla to receive this data, they can provide the customers with useful information. For example, customers could find out when they should charge their electric cars according to energy prices and when the customers need the car to be ready to use.

By letting different devices access a data stream that predict the energy prices for the next 24 hours, it will enable a lot of devices to work in a "smarter" way.

Electric utilities can use variable pricing to affect power consumption. By doing so, they would stabilize the grid load.

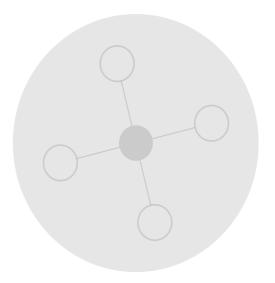


potential of providing customers with guidence on when they should use energy. Ex. charge their car.

Reflections

On-Grid: Centralized Ownership

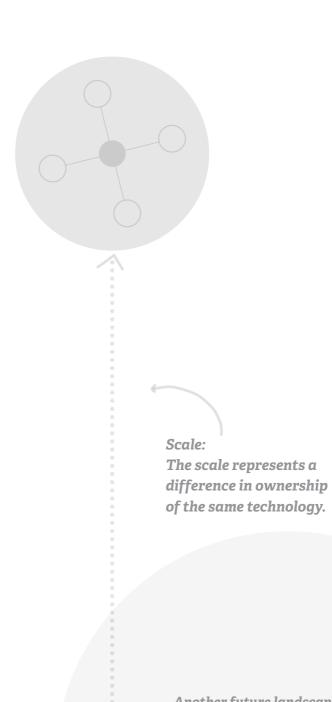
After looking at the service potential in a scenario where we only have a top-down system and big actors are in control of all production, it feels like the safer option, because it is what we are used to. However, it also hinders good, local initiatives. Based on the investigation, we think the the utilities will manage to create better services going forward. However, we find it hard to believe that electric utilities will be able to create services that answer to the diversity in the users' needs. This tells us that there will be a desire for some consumers to go elsewhere. The electric utilities can create better services, but we need to allow for different approaches and new actors to unleash the potential in local renewable energy production. It is important to allow for more private local energy production.



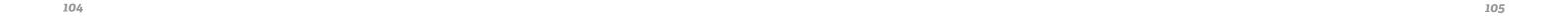
Service Concepts

Off-Grid: Decentralized Ownership

The following section contains **services we have designed** to investigate a landscape
without a grid. This scenario has decentralized
ownership over the production.



Another future landscape consists of several actors producing their own energy/electricity. The background for this is that more and more users invest in their own energy production.



Physical Energy Distribution

Off-Grid: Decentralized Ownership

A situation where energy utilities and the infrastructure we know today has collapsed will require new ways to distribute energy to people. Personal producers will have an advantage in this case by being more or less self-sufficient. However, not all houses will be suited for production.



Energy Box

Off-Grid: Decentralized Ownership

The power box illustrates a situation and a low-tech option in a scenario where people don't have the access to energy that they know today. In this scenario, not everyone will have the possibility to produce their own electricity, and therefore there will be a need to find other ways to distribute energy to private homes. There could be the potential to offer people loaded batteries in order to meet their need for electricity.

Supermarkets could distribute and sell batteries for their customers. When the battery runs low, the customer would have to take it back to the store and buy a new one. By reusing the batteries, the customer could receive money when delivering their old batteries.

side note

To our great surprise, this is how power is already being distributed in some parts of the world. We attended a talk about how to distribute energy in rural areas of Malawi. After some faulty attempts, the Norwegian solar entrepreneur Trygve Mongstad has had success with installing a single solar panel on one building in a village. As a way to lower the cost, they offered inhabitants in the village the ability to rent a fully charged battery for one U.S. dollar (Mongstad, 2015).

Even though this way of distributing energy can be more streamlined, one c ould easily argue that is very impractical, because one would have to move the energy around in a physical form.





We have designed the Energy Box to illsurate a situation where users do not have access to energy as we have today.

Energy-Independent Housing

Off-Grid: Decentralized Ownership

In a scenario without a grid, there will be a large demand for local energy. Additionally, houses that are suited for local production will become more valuable than houses that are not. This will probably affect the real estate market; people who buy homes will have to consider the building's ability to produce energy.



Velkommen til Solhauggata 17 | Idylliske omgivelser | Grønt og frodig | Sjarmerende og hjemmekoselig | Velkommen til visning





82%





Lokale produsenter

Se kart

Batteri/Lagring

Store bilder

Prisdetaljer

Prisantydning 8 600 000,-

Verditakst Lånetakst 8 600 000,- **?** 7 350 000,- **?** Solhauggata 17, 0565 Oslo

Prisantydning 8 600 000,-

Primærrom 133 m²
Boligtype Enebolig
Eieform Eier (Selveier)

Soverom



Sandra Knudsen

Eiendomsmeglerfullmektig Mobil 98 40 03 16 Send e-post Hjemmeside

Thomas Hole

Eiendomsmeglerfullmektig Mobil 40 41 07 07

Send e-post

Bestill prospekt fra tilbyder Supervisning Boligplanlegger Flere eiend. fra DNB Eiendom AS

Gi bud

Les mer om elektronisk budgiving

Visning

Søndag 20/9 1530 - 1630 Legg i kalender 2

SMS-va

Finn.no energy characteristics

Finn.no Energy Characteristics

Off-Grid: Decentralized Ownership

It is very likely that the real estate market will change in a situation where people are much more dependent on being able to produce their own electricity. Properties that already have installed the technology to generate electricity or are suited for activities such as sun production will become more attractive.

There is great potential for marketplaces like Finn.no to provide information to users who are searching for buying a house. By offering data that illustrates the potential the property has for energy production and storage, marketplaces can help buyers to make more informed choices.

This is a service that we think will be a normal part of buying a property in the future. The energy-producing capability will be an integral part of the evaluation of buying a house or apartment.



Velkommen til Solhauggata 17 | Idylliske omgivelser | hjemmekoselig | Velkommen til



Prisantydning 8 600 000,-

Primærrom 133 m²
Boligtype Enebolig
Eieform Eier (Selveier)

Soverom 3



Sandra Knudsen

Eiendomsmeglerfullmektig Mobil 98 40 03 16

Send e-post Hiemmeside

Thomas Hole

Eiendomsmeglerfullmektig Mobil 40 41 07 07

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Gi bud



Produksjon Solcellepanel



Solforhold 82%



Batteri/Lagring

ore bilder

Supervisning

In their advertisements, Finn.no will inform people about the property's equipment and its capacity to produce solar energy.

They can also provide an overview of other local producers in the area. This can be relevant in cases where neighbors distribute energy locally.



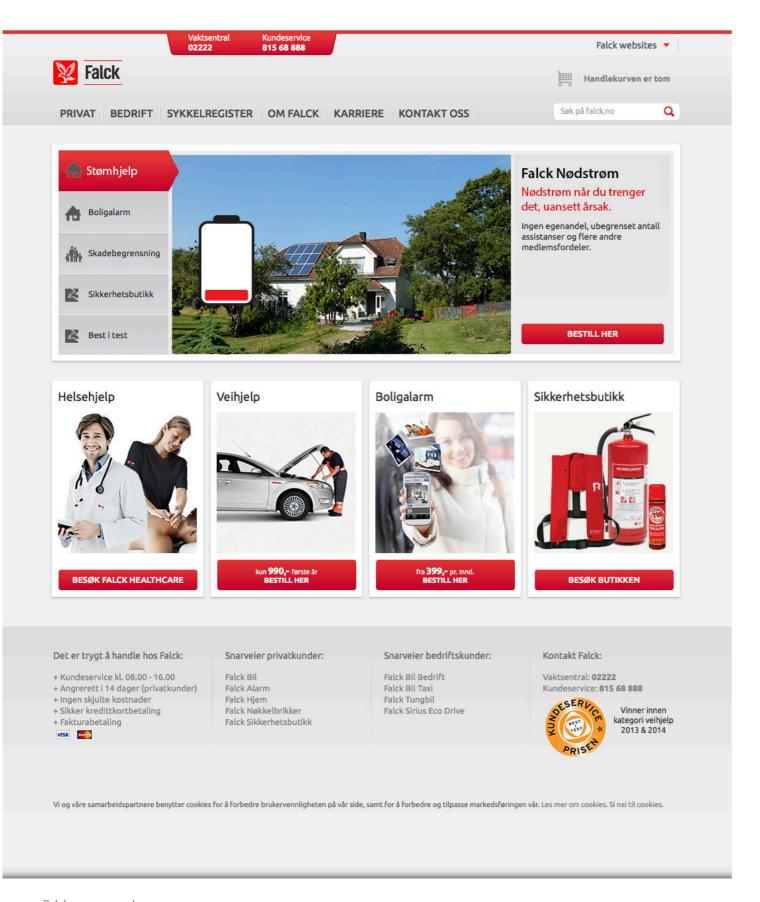
e omgivelser | Grønt og frodig | Sjarmerende og | Velkommen til visning





Lokale produsenter

Se kart



Falck energy supply

Emergency Energy Supply

Off-Grid: Decentralized Ownership

What happens if all the households produce their own energy without being connected to back-up infrastructures? What if people just use solar energy and battery storage? They would have to create a system that can deliver all the power they need at all times. It is probable that independent systems would produce more energy than they can store much of the time, and they would not have enough energy at other times. There would be the potential to provide services that offer households with back-up energy.

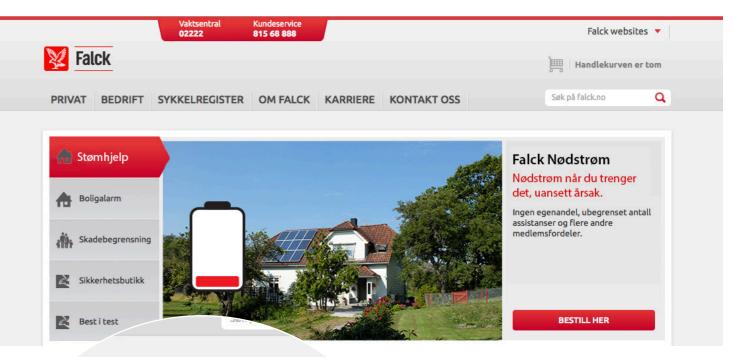
Falck Energy Supply

Off-Grid: Decentralized Ownership

Falck Energy Supply illustrates how actors can meet the demand of access to electricity at all times. It also describes the service potential in providing energy in cases where the households independent system can't deliver enough energy. By doing so, they offer customer safety. Falck is a provider of safety solutions; they offer their customer assistance and emergency services within transport, health and household security equipments. In this concept Falck offers a service where users pay a monthly fee. In return for this

fee, Falck guarantees that they will provide users with back-up power if they ever need it. Falck will bring stored energy to users' houses and provide them with energy until they have their system up and running again.

We take our constant energy supply for granted. In a situation where the grid has collapsed, there is an opportunity for the safety market to provide services that deliver an "emergency" energy supply in cases where local systems cannot meet the demand.





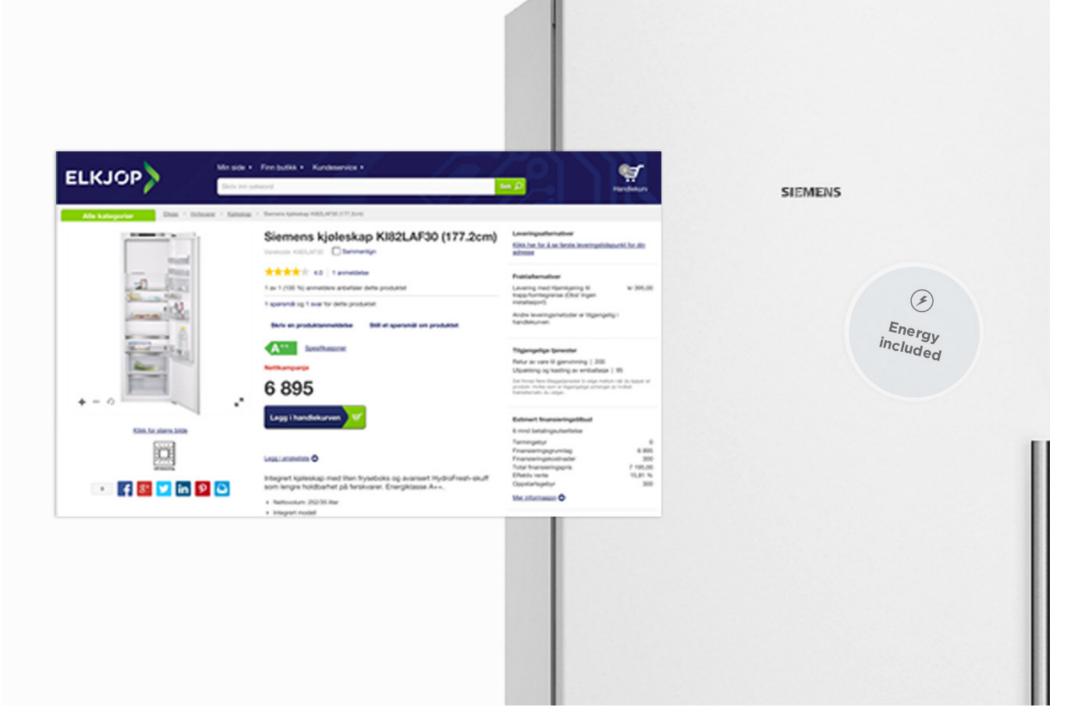
Falck offers their customers the security of always having electricity by providing emergency energy. The service is designed to illustrate the potential of providing energy in cases where independent systems cannot.

Sikkerhetsbutikk

Products with Included Energy Sources

Off-Grid: Decentralized Ownership

The lack of physical infrastructure could also be an opportunity for the actors that are currently delivering products to start delivering services instead. Actors can give added value to their products by including energy. In this manner, the buyer of the product does not have to think about collecting energy elsewhere to cover his or her energy usage.



Siemens' Energy Independent Refrigerator

Siemens Energy Independent Refrigerator

Off-Grid: Decentralized Ownership

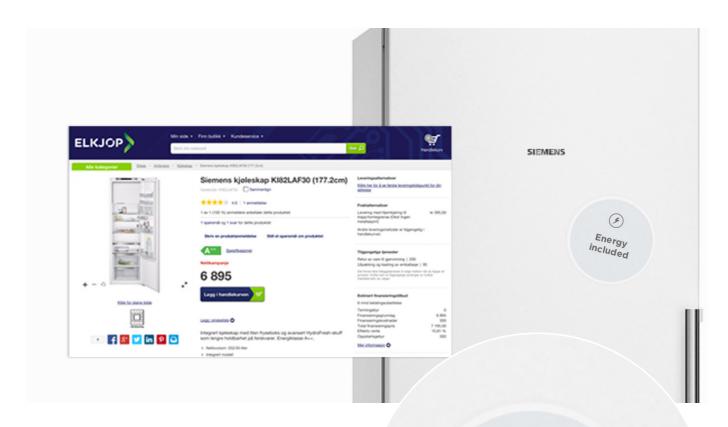
The Siemens Energy Refrigerator illustrates the potential of actors that make and sell products, especially Home Appliances, to include energy in their products. Siemens is a big, divided company. Besides working within energy, they are mostly known for providing home appliances like ovens and refrigerators. There is a great potential for Siemens and similar actors to provide services to meet the energy demand in a situation where there is no longer a functioning grid. By integrating energy in the product itself, the user will not only buy a refrigerator but also buy time of usage. By making a refrigerator truly energy-efficient, Siemens can decrease their own costs.

that lasts ten years or by having service people come and "fill" the fridge with energy from time to time. This is the same way it was done with ice before the refrigerator was invented (Telemark Museum, 2015).

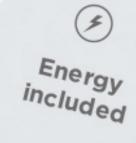
side note

By including the energy one needs to use the device itself, the customers do not need to rely on the estimated consumption calculated by the manufacturer. The recent scandal with Volkswagen deliberately manipulating the test result shows that not even the bigger, more renowned companies can be trusted 100%.

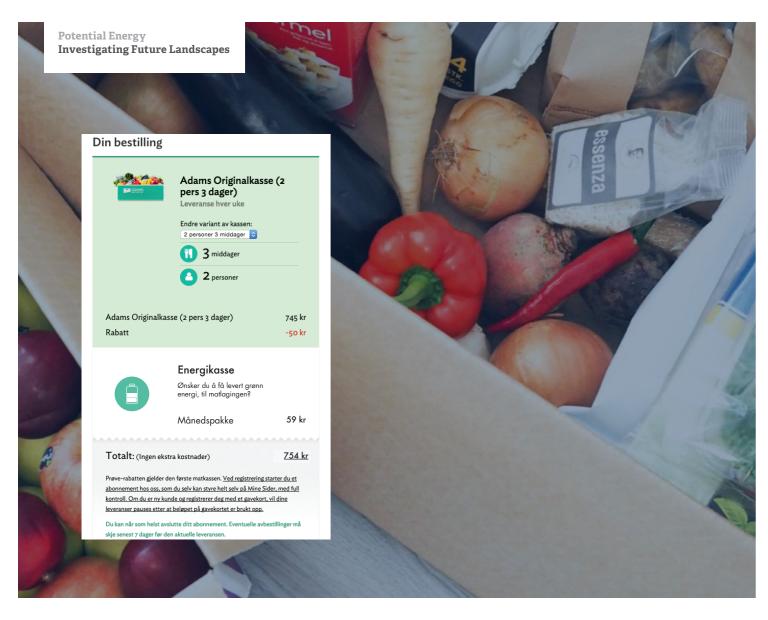
By including the energy, the users have peace of mind, because the manufacturer would take care of the cost if the product uses more energy than promised.



Siemens' Energy Independent Refrigerator.



Bundling energy with products is a very interesting service offer. It can be done as described above, but that would be quite costly. If the grid continues to be operational, Siemens could use smart meters in the refrigerator to report the power consumption to Siemens. By using this, Siemens can pay for the energy cost on behalf of the their customers.



Adams Energy Delivery Service

Home Delivery

Off-Grid: Decentralized Ownership

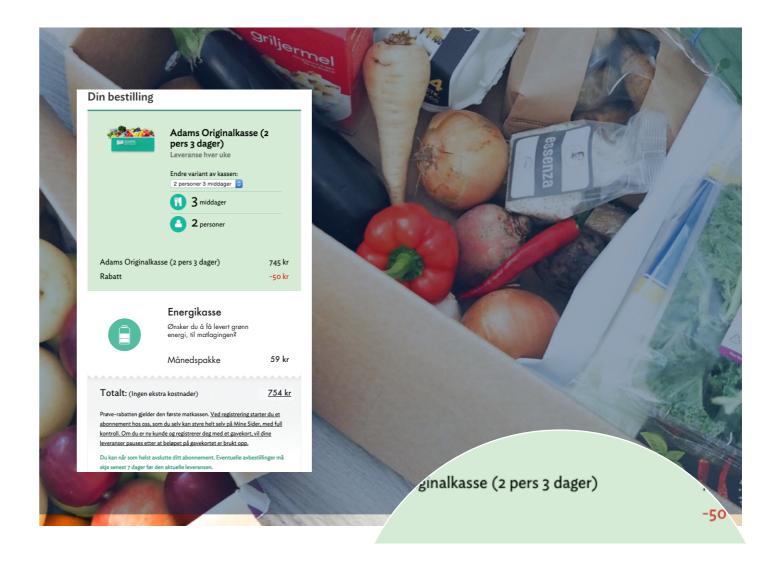
If energy utilities and the infrastructure we know today have collapsed, we can look at different ways of distributing energy. Energy deliveries can piggyback on other services that are already distributing physical objects.

Adams Energy Delivery

Off-Grid: Decentralized Ownership

Adams Energy Delivery illustrates the potential of taking advantage of a pre-existing distribution service and supply chain to provide energy. To-day, Adams Food Package is providing food delivery to the customer's door. In this concept, they also provide power as an add-on to their service. There is great potential to give added value to their service by delivering not only food but also the energy that is required to cook the food.

This is one of the concepts in this scenario that has been received with a more positive response when we have presented it. However, as a form of energy distribution, driving to every single house is very inefficient.



Adams Food Package, as we know it today, has expanded their service offerings and provided renewable energy for cooking.



Energikasse

Ønsker du å få levert grønn energi, til matlagingen?

Månedspakke

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t: (Ingen ekstra kostnader)

<u>754</u> '

vielder den første matkassen. <u>Ved registrering starte</u> om du selv kan styre helt selv på Mine ^c

SolarCity

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Solar Bonds

News

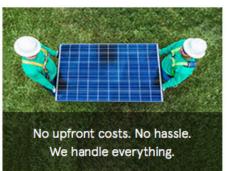
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SolarCity Dynamic Sun

Production Indicator

Off-Grid: Decentralized Ownership

In a situation where people have their own independent production system, it is convenient for the user to know how much energy they produce at any given time. Today, there are many digital services that can help people manage and understand their consumption. However, we have not found a device that can give an indication at a glance without using energy itself.

Off-Grid: Decentralized Ownership

Solar City Dynamic Sun illustrates the potential for actors that provide technology and installation for personal production to also provide added services and products. Solar City is one of America's largest solar power providers. They offer installation of solar panels to local producers as a service. This is a service provided together with a solar production system from Solar City. They measure the solar radiation on the window compared to the solar panels. Then they mount a UV-responsive film on the window that give the customer an indication of how much energy they are producing at any given time.

> Adding value by offering extra service and products can make local production become more atractive. Using a UV-responsive film is intersting, but it is must give a precise reading.

SolarCity

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Solar City provides products for their customers so that users have an overview of their energy production. The concept is designed to illustrate the potential of providing added products to local producers.

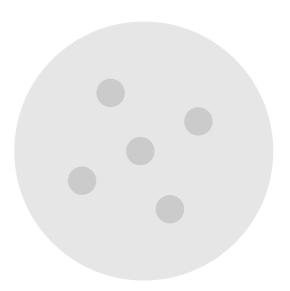
BUSINESS L RESIDENTIAL



Reflection

Off-Grid: Decentralized Ownership

After looking at the service potential in a distributed production system, we have concluded that it is hard to imagine a good system that is without big actors or any centralized distribution; A system without actors that provide an infrastructure beyond the private houses. The service potential in this scenario is distributing energy to consumers that can't produce themselves and how actors can offer services that helps consumers if local production fails or runs empty. This is something we do not have to deal with today, since we have a functional grid. The conclusion is that we should try to maintain the grid operators. A system whitout a grid can't use resources in an efficent way and many users will not have their needs met.



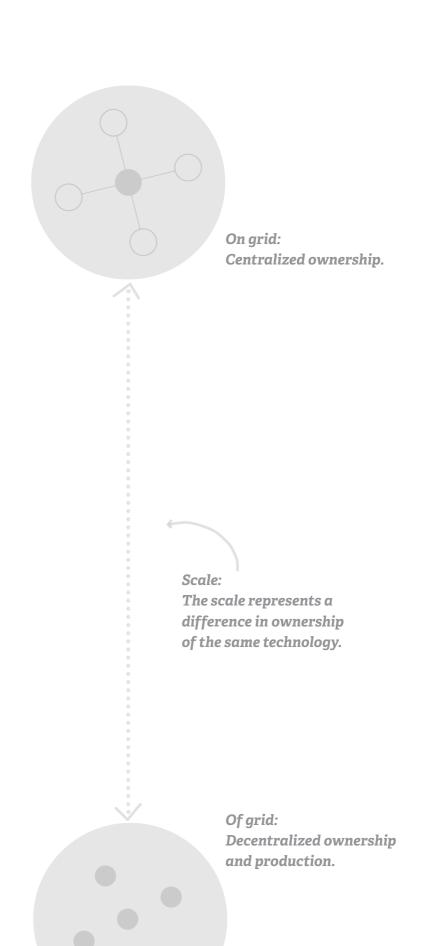
Reflection on the Scenarios

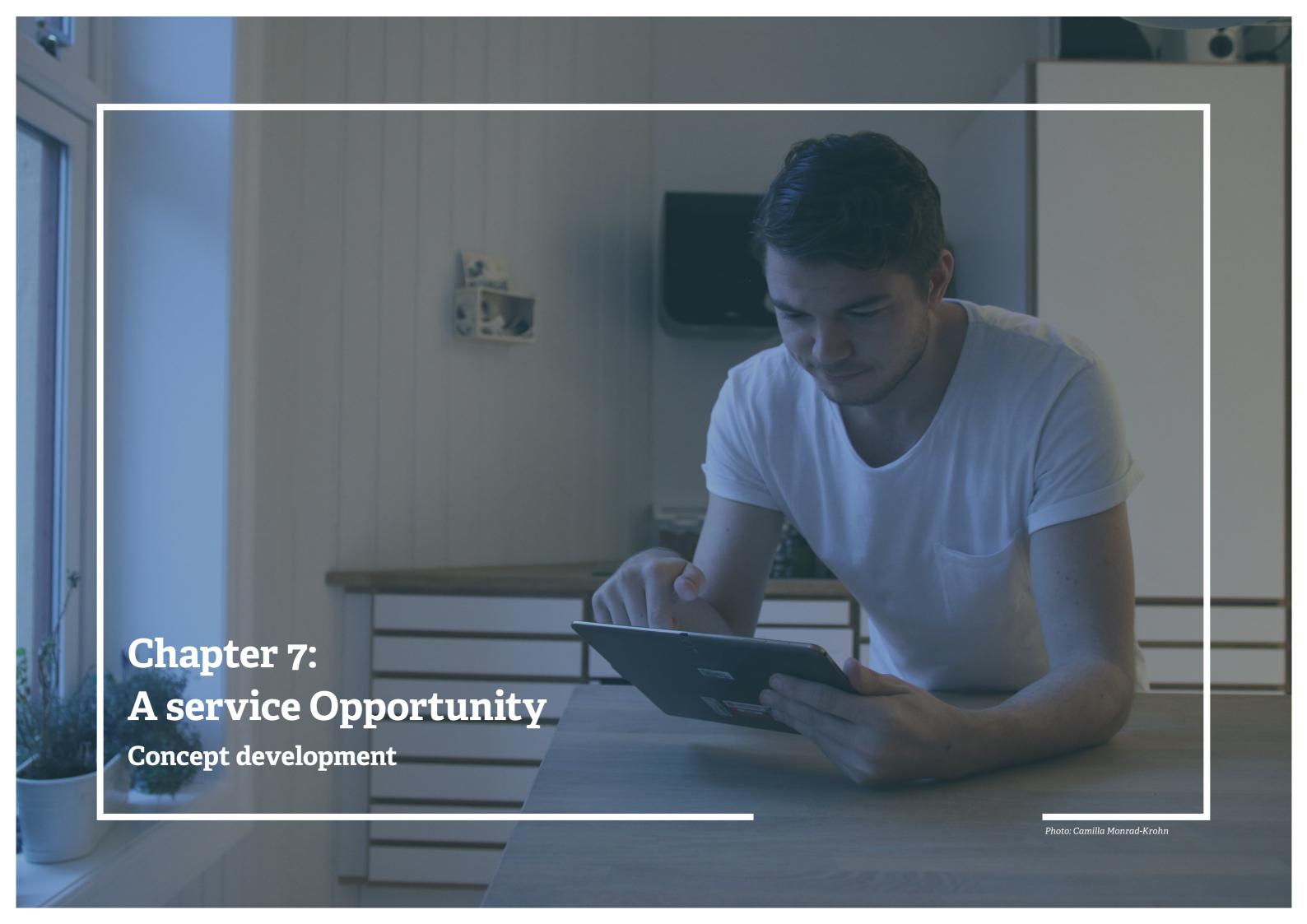
Creating the services in order to understand the different scenarios has been extremely interesting and has taught us a lot. The potential services have made it possible for us to have a discussion with actors that are involved in the business today (a net provider, an energy trader, an environmental organization, a grid operator and a global producer of hardware for the sector). We have aslo presented them for a user producing energy today.

Our key insight from this is that there is a broad consensus that both of these directions are possible. Of course, the utilities are threatened by a development that goes toward a completely decentralized system. They argue that it is possibly unstable and very inefficient. Both are valid arguments. The user we talked to was a bit more

optmistic, but they wanted to have the old actors as a safety net and as a infrastructure that allowed them to collaborate with other producers and consumers. This raises a number of questions, such as:

Is it possible to create a system that uses the infrastructure we have today? Can we facilitate stability for users who cannot produce energy themselves and at the same time provide a infrastructure that allows people to buy and sell energy from each other while enabling users who want to save money and do their part in the fight against climate change to do that?







A Service Opportunity

Manifesting the possibility within a hybrid system

In this chapter, we will not present the solution. In the previous chapters we have used design to explore and reflect. In this chapter we have used design to synthesise the opportunities we have discovered. We have designed a service concept as a way to synthesize the findings in the previous chapters. The service investigates if we can create a future where we manage to keep all the benefits of having a grid and at the same time stimulate local renewable energy production. Therefore, it needs to meet the needs of all of our five users.

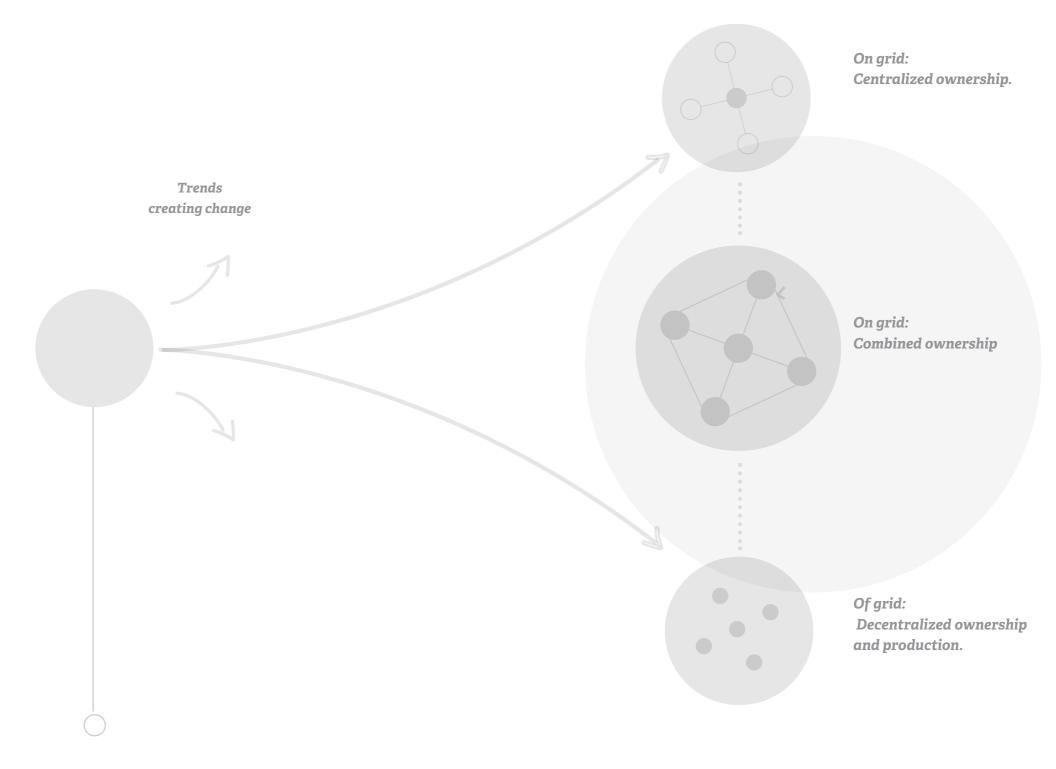
It is important to note that we do not see this service as the solution, but rather a tool to gather discoveries and direct attention towards the opportunities a in hybrid system.

Hybrid System

Based on our exploration of the two scenarios and the feedback we received when we presented them, it is clear that there is a need to strive towards a future where we keep the grid and older electric utilities while allowing private users to contribute by producing local renewable energy.

Due to this, we think that we should design for a development where we maintain the existing infrastructure. Since it is stable, this makes it easier to transport energy, and it reaches everyone who needs energy. At the same time, we want to enhance local production, because that is an efficient way to produce renewable energy. It also allows people to be more in charge of their energy and opens up for new actors and more innovation at the same time.

We therefore wanted to work towards a scenario in which we "get the best from both worlds", so it is possible to have small actors (local producers) alongside the big actors in a hybrid solution.



Today's System

The Users

This service has met five different users' needs.

Local Energy Producers

The service should meet the need for a more fair and understandable model for selling energy locally.

The users should not feel that they lose money every time they sell energy to the grid, energy that they later would have to buy back.

Energy Consumers

The service should meet the need for control over what kind of energy the individual consumes, as well as having the ability to affect production.

This is possible by providing the consumer with energy from a known source and by giving the user a chance to buy local renewable energy. The service should not have an incentive to keep the consumer's meter running.

The Planet

The service should meet the planet's need for a stable climate. The service should stimulate to more renewabel energy production in order to reduce polution and the emission of greenhouse gases.

Grid Provider

The service should meet the need for a stable revenue stream to the grid provider.

The grid is an infrastructure that provides stability and access and it should be maintained. We need to make sure to keep the grid providers operational by maintaining their revenue stream in a new service.

Traditional Energy Producers

The service should meet the need for creating value in a new market.

We think the energy producers will have to change their business model eventually and provide "buffer energy", not the bulk of it. The service should allow the energy produced to generate value by providing energy when local producers cannot meet the demand.

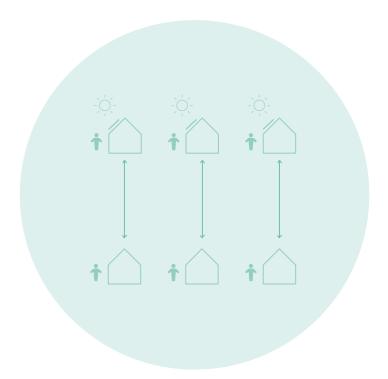


System process

An early idea was to create value for both the consumer and local producers by facilitating for peer-to-peer purchase and sale of energy using the local grid (distribution grid). The consumer would be more actively involved in choosing sources for energy production itself. Through that, the consumer would have influence on generating more renewable production. The local producer, on the other hand, would receive more profit for the energy they sold. In other words, local producers would not lose that much money every time they sold energy to the grid that they later had to buy back. This means that it will be of little value to install a private battery to store energy for later use. Local producers that invest in

batteries today can be viewed as early signs of a system with decentralized ownership and no grid. There should be a system where local producers can sell energy if they over-produce and buy energy if they consume more than their production can cover.

We tried to create a service that brought local producers and consumers together based on a peer-to-peer model. One big challenge we tried to handle was how to connect people that have the same consumption pattern. To do this, we would have needed to find producers that produced the same amount as the consumer consumed. This proved to be difficult. Since it would be impossi-



ble to match energy demand and local production perfectly at all times, we continued developing ideas on market structures. We also looked at the possibility of helping the consumer buy from several different sources, person to person. This also turned out to be very complicated and quite often demanded users' attention. Another challenge was security. It should not be evident if the local producer goes on vacation and therefore sell more energy in that period.





sources (preferances) and estimated need of energy.

Group to Group Market

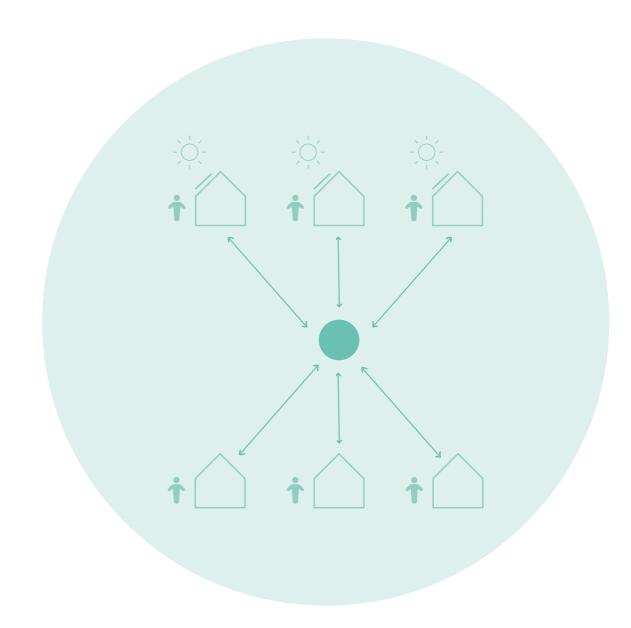
System process

We had a meeting with Ulf Eriksen, Head of Nordic & UK Trading & Origination at Statkraft, and explained our early ideas on creating a market structure that enabled direct sale and purchase between local producers and consumers. He asserted that the idea of selling energy directly was interesting, but he did not think the peer-to-peer system was practical, neither from a user point of view nor from a technical point of view. To be able to create such a market, and for it to have any sense of realism, one would need to find producers that have the same amount of excess energy at any given time, as the consumer needs energy. (The current energy system works by having many users connected, the shared number making the total usage quite stable.)

A peer-to-peer market will also require consumers to take a very active role in managing access to energy.

We therefore went back and developed new ideas. We started looking at the possibility of the direct purchase of energy between a group of local producers and a group of local consumer instead of person to person, group to group. By connecting groups, we also get more predictable usage and consumption, mainly because individual's changes have less effect on the total consumption and production.

We think this market structure has great potential. In the following pages, we will present a service concept that explores this principle.



Arcs The Energy Collective

Combining a direct market with the big actors.

We believe that allowing people to be part of a direct market will benefit today's power utilites in the long run. Arcs, the Energy Collective, gives the local producers a possibility to sell their energy on a "local market" through the existing grid. This allows them to earn money towards their investment and to buy energy from the same market when self-production does not cover their consumption.

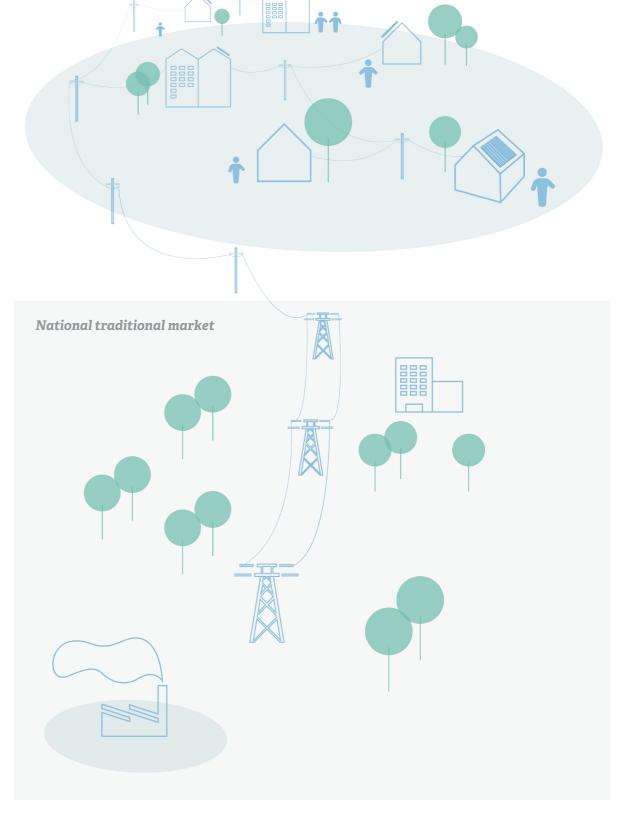
This takes away most of the value of investing in batteries and becoming independent.

By doing so, Arcs makes sure that both producers and consumers are still connected to the grid. Additionally, this gives the traditional big power producers a way to provide services through the grid.

One obvious value the traditional energy producers can create in this new market, is to meet the

demand if local production is insufficient or if all the renewable production is down due to factors such as bad weather. Arcs is creating a local market based on a direct sales model. They maintain the national market in order to cover excess demand as well as providing safety and predictability of access to energy for people and institutions that cannot produce energy themselves.





Green: Buy energy directly from renawable sources
Fair: We do not earn money on users' consumption.
Local: Use energy that is produced down the street.
Stabile: If local production can't meet the demand,
energy will automatically come from national sources.

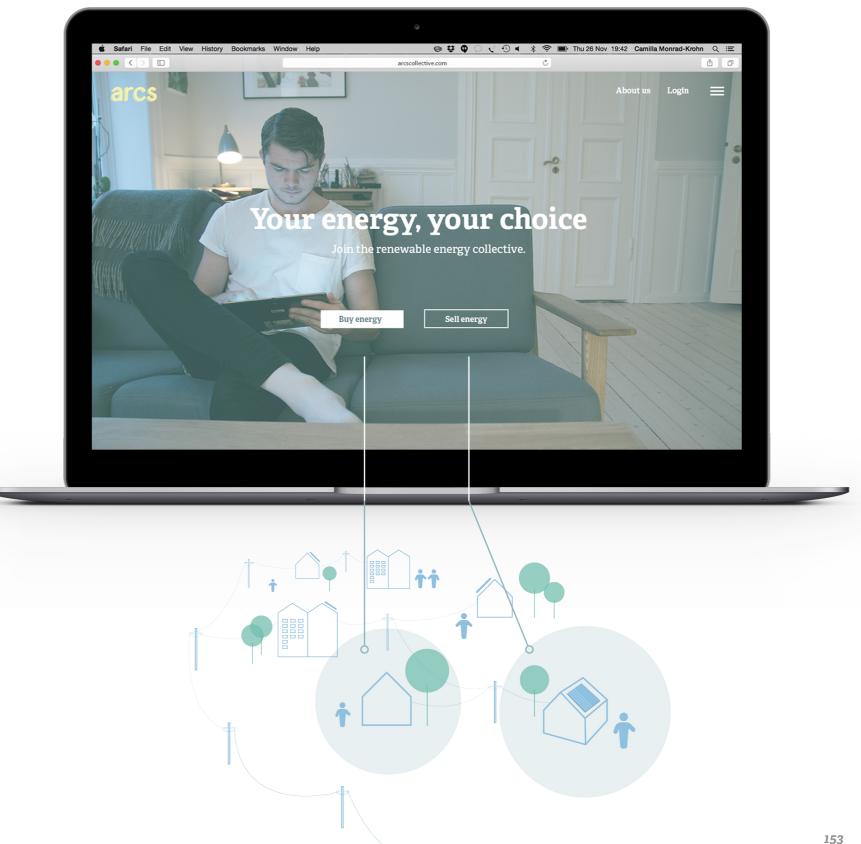
Arcsthe Energy Collective

A direct financial link.

Arcs creates a financial connection between consumers and producers. This allows the consumers to buy energy directly from a local source. The consumers can be sure that the money they spend on their energy consumption is primarily placed in renewable production. This way, the consumers themselves enhance renewable production, even if they are not producers. By doing so, Arcs gives the consumers the opportunity to affect energy production.

Arcs charges the members a fixed fee. In this way, it creates profit based on the amount of customers it has and not the amount of energy that is being sold, as opposed to how the system operates

today. The service will have an incentive to lower people's consumption and cater to more local production. Arcs will provide added value to the user through information, helping consumers understand both their production and consumption.

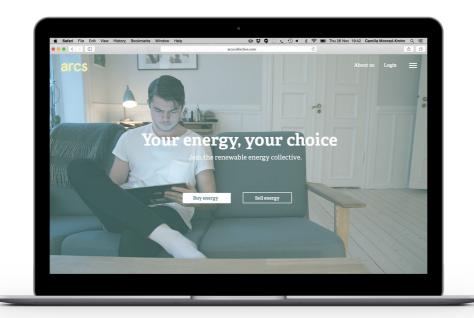


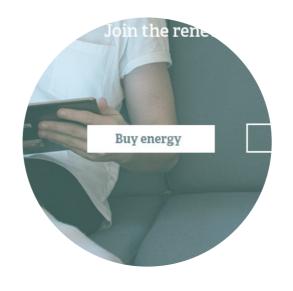
Encountering the Online Marketplace

As a personal producer and a consumer.

The online market should facilitate for both local producers and consumers of energy. The local producers and consumers will have to go to the webpage to register. The users should also receive information on what the service does for them and what values upon which it is built.

An online marketplace for people to join the renewable energy collective in order to buy and sell locally produced renewable energy.







Join, either as a personal producer or as a consumer.

Personal producer: Sell Consumer: Buy



A green choice

Buy energy directly from renawable sources

Sign up

Already a local producer?
Get more for your excess energy.

Read more

Information about the service value.



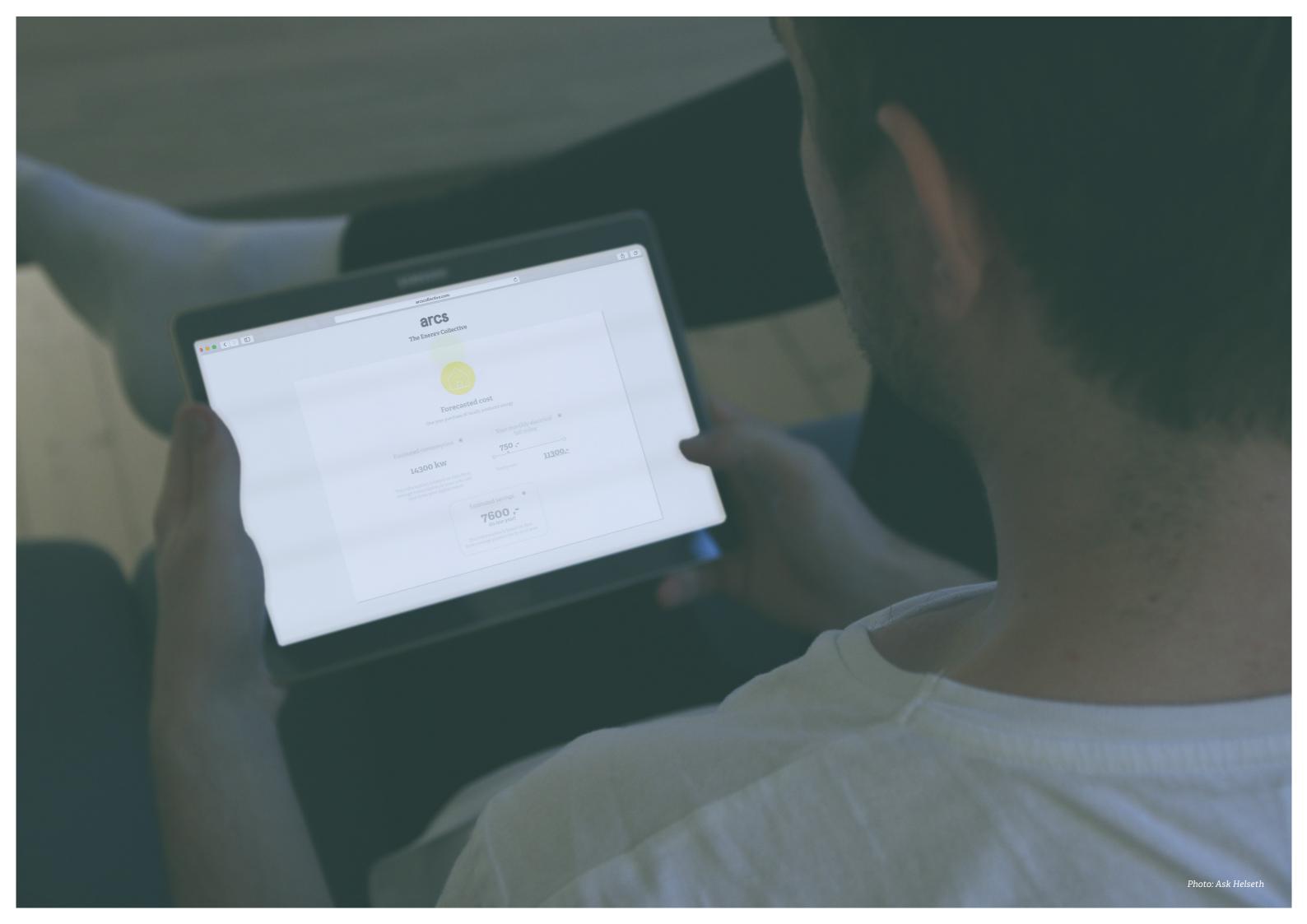
Local Producer Joining the online market place

The first encounter

Before signing up, the local producer will receive information on the next year's expected income. It is based on data from digital meters that estimate consumption (AMS) and weather data that estimates production (for example, yr.no). Arcs gives the users an estimate on how much they will produce and how much they can earn by selling the excess energy to other consumers in their area through Arcs.

AMS (Avanaserte måle og styringssystemer) are digital meters that will be installed in every household in Norway by 2019. The technology enables a real-time tracking of energy consumption and production which will be very important to this service. It is decided that data points from the meters will be centralized in a system run by Siemens. Additionally, all of the users will have ownership over the data and will be free to give other actors access.





A Consumer Joining the Online Marketplace

The first encounter

The consumer will receive information on forecasted costs. The estimated cost of one purchased year of locally produced energy.

Based on data on prices and digital meters, the consumer can receive an estimation of how much he or she consumes and how much can be saved by being a part of the energy collective.





Forecasted cost of buying local energy (one year).

Estimated consumption and information on what one pays for electricity today, in order to estimate possible savings by being a part of the Energy Collective.



Estimated savings (one year).



A Local producer uses the Online Marketplace

Keep the user informed

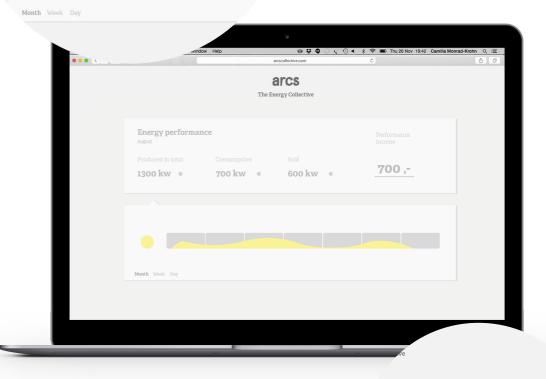
The producers should be provided with information to have a constant overview of their production and consumption. In this way, Arcs enables them to take control over their consumption in relation to their production. They should also have a clear overview of income from the energy they have sold to the market. There are several ways

the payment itself could be facilitated (monthly, daily, hourly). This is something that will have to be developed further.





Monthly energy performance.
Information on how much is being produced and how much of that is consumed.



Information on how much of the production has been sold on the market (excess energy) and the total income.

600 kw ® 700 ,-

A Consumer uses the Online Marketplace

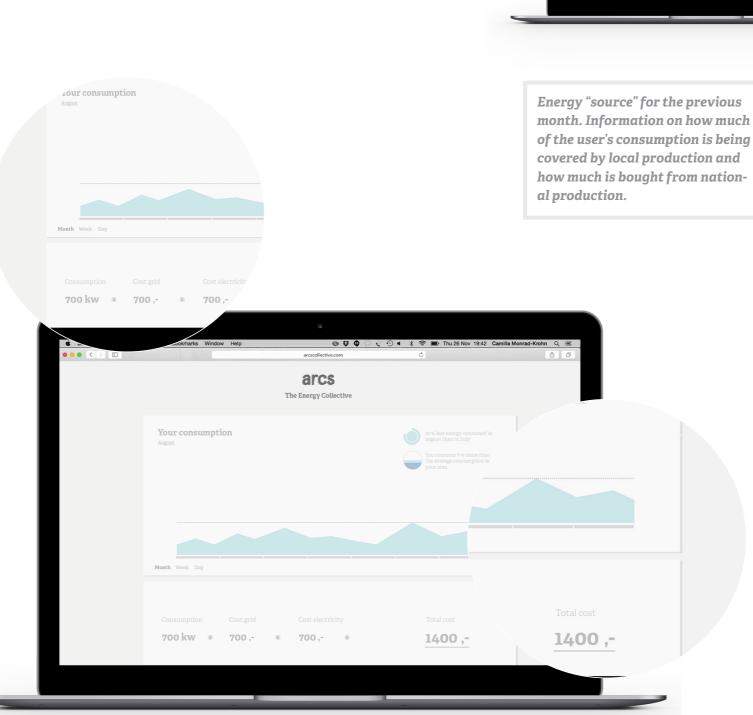
Keep the consumer informed

The energy consumers use will automatically be bought from sources in their area. If there is not enough energy from your local producers, you will receive electricity from the national grid. This is in order to maintain predictability; consumers will always get the energy they need, when they need it.

Consumers will receive a total overview over their consumption and electricity cost at all times.

They can also receive an overview of how much of the electricity consumed is accessed from local or national sources.

Provide control and awareness. Information for personal producers to understand their daily available production and consumption.



Monthly consumption.
Total cost and payments.
There are also possibilities to show consumption in relation to other average consumption quantaties in the area. Additionally, it can show how much users have consumed compared with their consumption in the previous month.

83%

17%

El\s



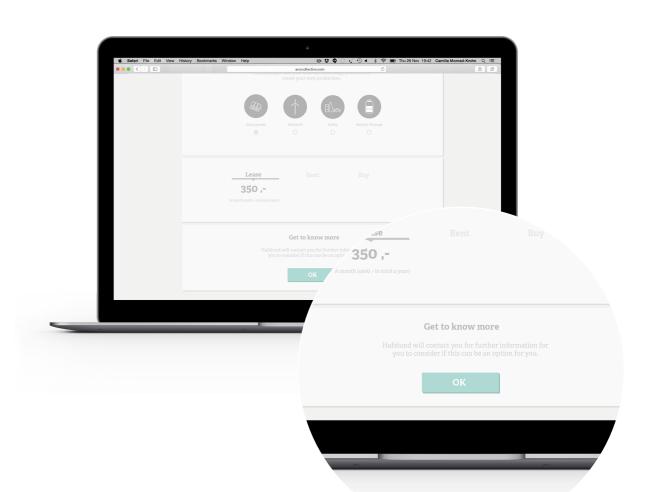
Enhance the Local Producer

Guidence to investment.

By creating a service that only profits from being a facilitator, it has no incentive to increase consumption, it can instead give added value by making people understand their own consumption.

A service that only profits from being a facilitator can encourage local producers to expand their production and invest in new or more production technology.

The service can provide information on production equipment. It can also aggregate information on actors that provide and install this equipment and help the consumers to get in touch with an peovider of local energy production solution.



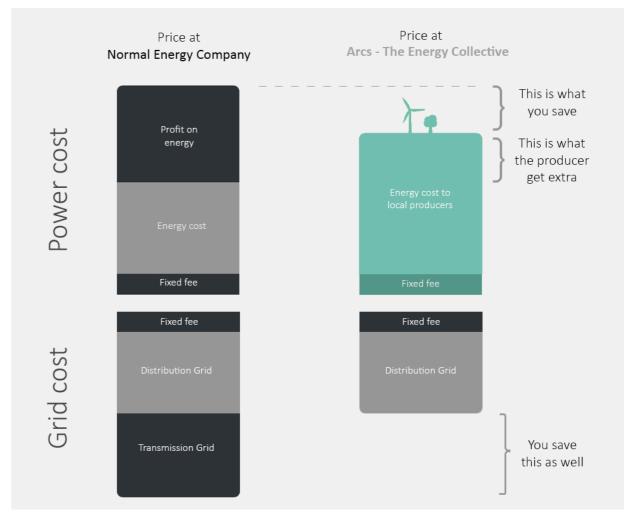
Possible Savings

Customer cost, before and after.

The price structure of the service is divided into two parts. One part is a fixed service fee; it covers the cost of running the website, collecting the production and consumption data, billing and administration. The other part is, when the consumers pay for energy, they pay the producer directly. The service only facilitates that financial transaction; it does not take a cut from the costs. The user we talked to felt that it was unfair that they had to pay the same grid fee as the energy that travels for miles before it reaches its consumer when they sold energy to the grid. Therefore, we need a system where energy that travels far will pay more than energy that comes from just down the street. This will be fairer in a sense, since one needs less infrastructure for energy to travel across the street than if it needs to travel across a country. It is impossible to say exactly what the cost is. However, one can achieve a lot

by splitting the tariff in two. Consumers pay one fee if the energy uses only the distribution grid (if it is from their neighborhood). If the energy also needs to be transported through the transmission grid, consumers will have to pay an extra fee. Doing this creates an incentive for local renewable energy production by making energy cheaper to transport since it uses less infrastructure. The legislation in the *energiloven* (the energy law in Norway) would have to change to make this possible.

When the demand cannot be met with local production, Arcs goes through the old markets just like any other energy retailer and buys energy from the traditional energy sector. The energy that is not produced in the neighborhood will probably be more expensive. We have not yet figured out how this will work for the users.

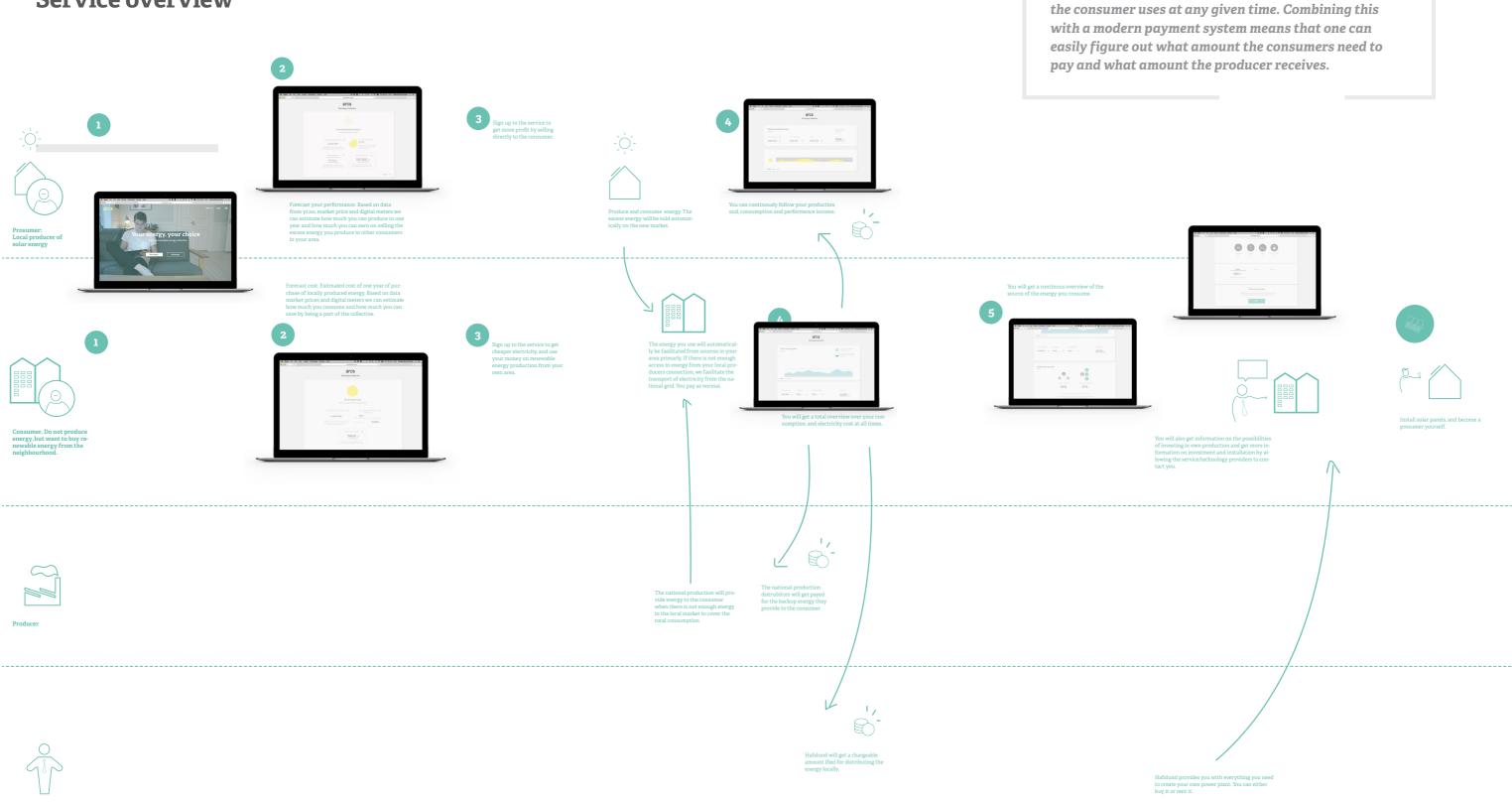


^{*} Graph inspired by Vanderbon model. http://vanderbron.nl

side note

Our reason for calling it "possible savings are based on our reserach. We belive a system like Arcs can make it more profitable for local producers and cheaper for the consumer. But when we presented it to the experts at Hafslund Nett they questioned it. We base our graph on a Vandebron price model (Vandebron, see page 66)

Service overview



By using modern ways of measuring energy

consumption and production ("smart meters", or AMS), consumers can gather information on how much energy the producer sends out on the grid at any given time.

They can also receive information on how much energy

Reflection

How Arcs - The Energy Collective - meets the user's needs.

Local Energy Producers

The service meets the local producers' need for a fair and understandable price model by using a direct sales model. It also gives the producers an incentive to contribute local renewable energy to the national grid.

Energy Consumers

The service meets the consumers' need through transparency; they know that the money they pay towards energy is going to the local renewable energy producer. The consumers will also receive tools that can help them reduce their energy consumption, since this is in the financial interest of the service itself.

The Planet

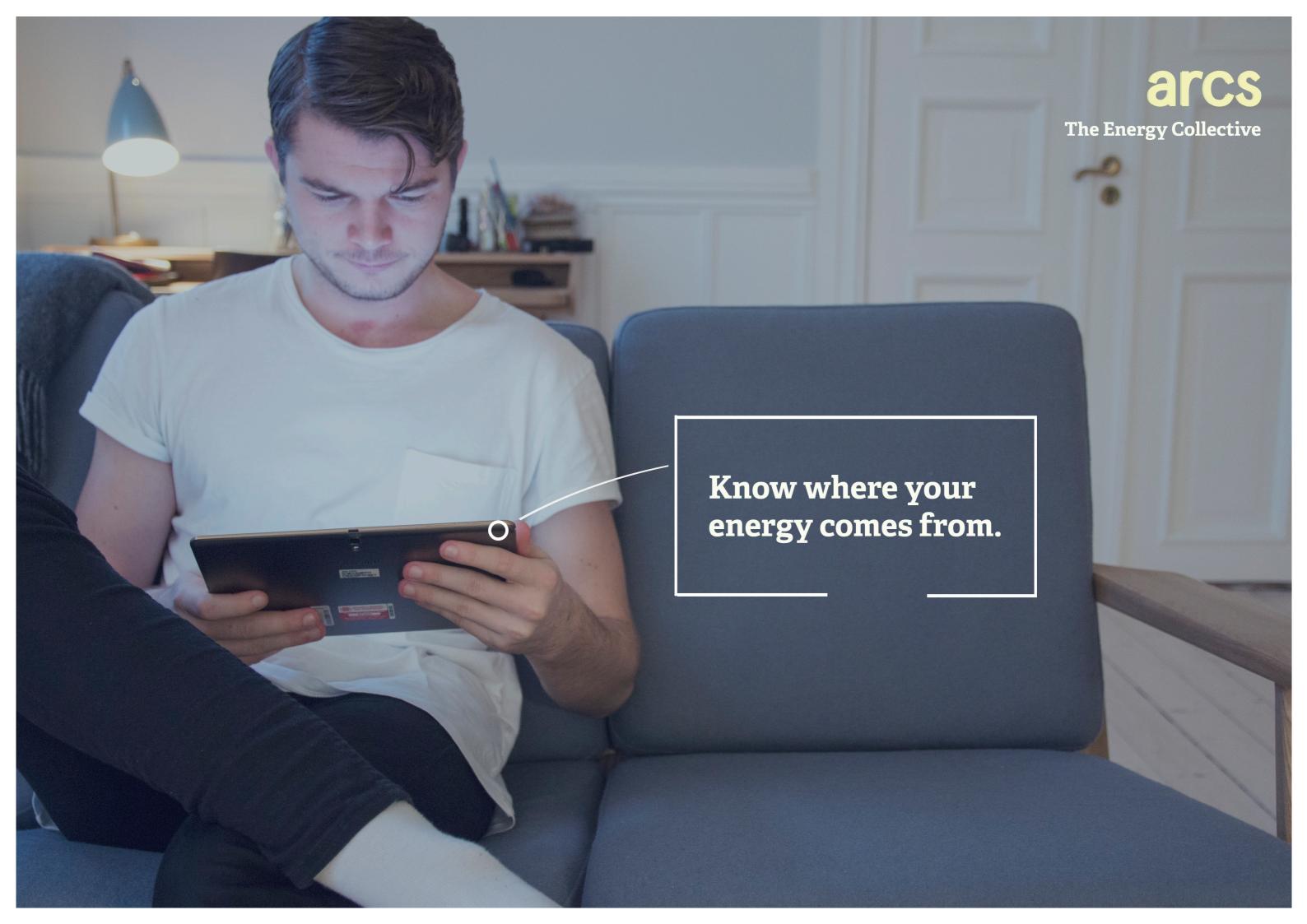
The service meets the planet's need for a more stable climate. By making local renewable energy production attractive for potential users, the use of energy from fossile fuels can be reduced. This can reduce emisson of greenhouse gasses.

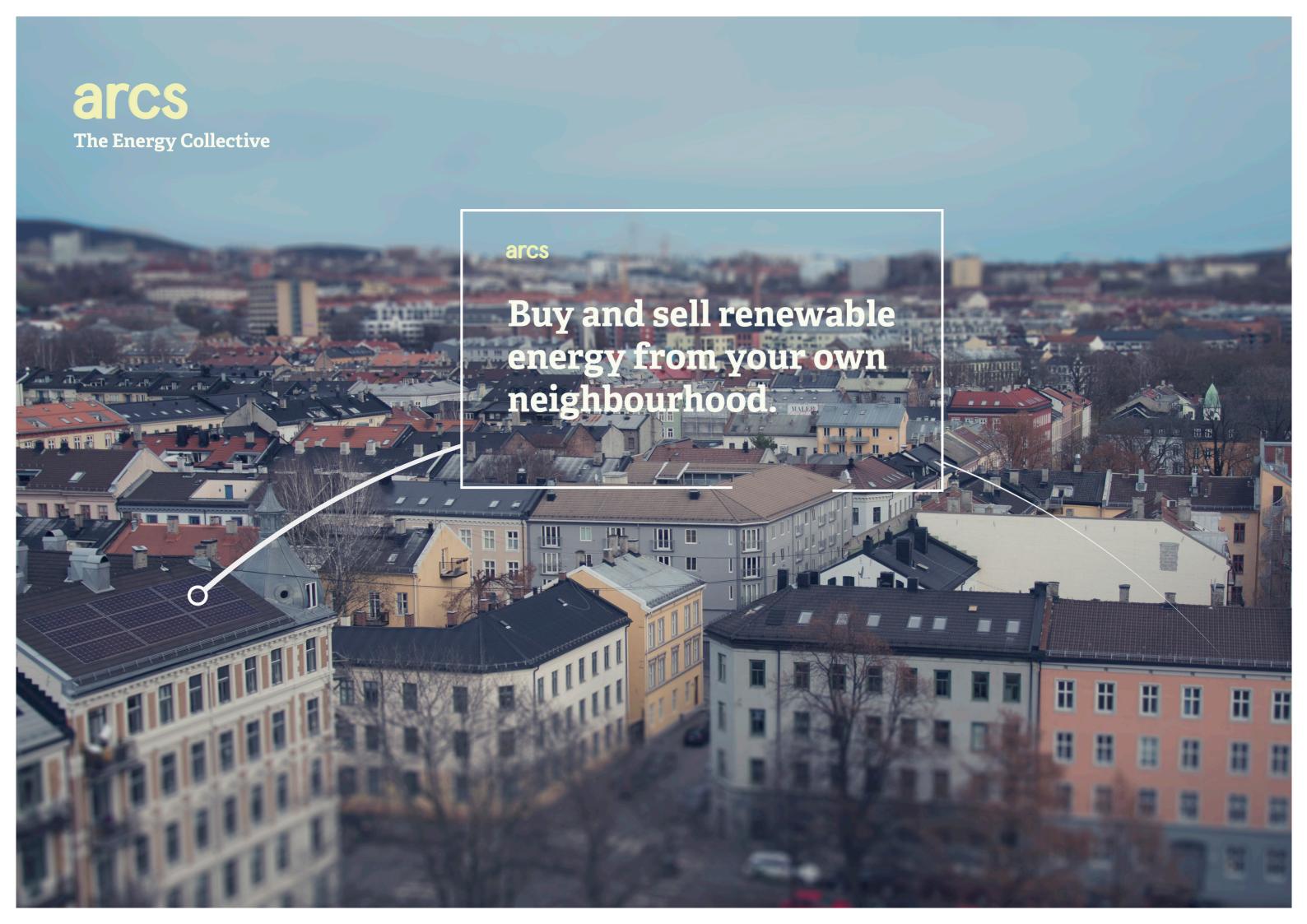
Grid Providers

The service meets the grid providers' need to keep their revenue stream. It also gives local energy producers an incentive to be connected to the grid. In turn, this makes it possible for the grid providers to keep their customer base and can continue to maintain and develop the grid. (It will probably be advantageous for the grid providers who run the distribution grid if the cost is split.)

Traditional Energy Producers

The service meets the producers' need for a role in the future landscape. It does, however require a change in the business model for energy producers. This will probably be a challenge for them, but it will be better if the alternative is that the traditional energy producers disappear completely.





Reflection

Key conclusions from the service, Arcs - The Energy Collective.

This service is just a concept, but it can teach us something. It is possible to make a service that can create an incentive for local production of renewable energy while also maintaining the grid as an important and valuable infrastructure. We think this will be good for both the local producers, the consumers, the grid operator, the big energy producers and the planet. However, if we want to see services like this in the future, a few things will have to change:

Open up for a Direct Sales Model.

Changing the legislation to allow for direct sales between private consumers and producers. This can be done by letting Arcs be the producer in legal terms on behalf of all the local producers.

Make it Cheaper to Send Electricity Locally

To stimulate local distributed production, it must be cheaper to transport energy locally. It seems natural to split the net tariffs into one local tariff that covers the distribution grid and one national tariff that covers the transmission grid. Therefore, customers only pay for the energy that travels through the distribution grid. If the energy has to go through the transmission grid as well, customers will have to pay for that, too.

Change the Energy Tax Model

The tax model of today's energy is per kw/h

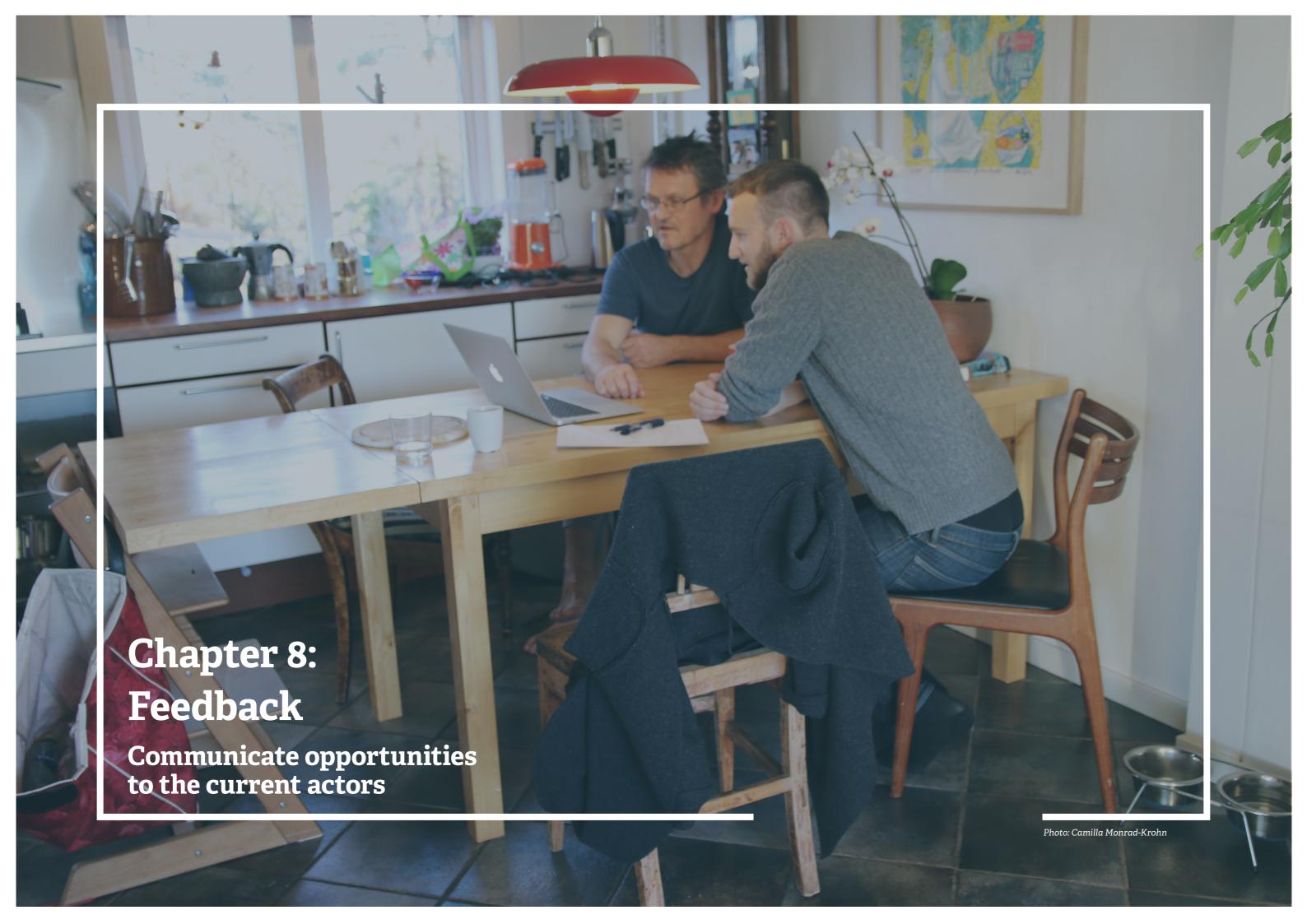
bought from the grid. Users can avoid paying the tax by making private, independent systems. A system in which the producer does not have to tax the energy he is "buying back" from the grid will slow down the development of totally independent systems. In Norway today, consumers can receive subsidies to install solar panels on their roofs. In other countries, customers are payed for the energy they deliver to the grid (feed in tariff). We think it is wiser to use that money to ease the burden of taxes on energy produced locally instead.

Change the Traditional Power Producer's Role We believe that the actors that are producing all

We believe that the actors that are producing all the energy today will need to change their value proposal. As more and more people start to produce their own energy, these actors can create value by offering safety. They have the possibility to use their know-how and financial muscle to build storage and buffer capacity more cheaply than if people do it themselves. Additionally, they could use that to offer energy when local production cannot meet the demand.

Design for people

When the actors and politicians lay the ground-work for future services in energy production and distribution, they should center it around the consumers and producers needs. This should be done with a focus on creating an understandable system. A system that provides good user experiences.



Feedback

Meeting with the target group.

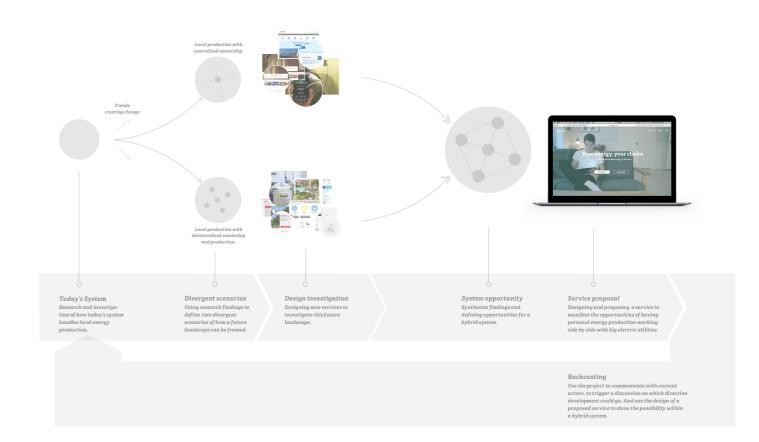
One of the goals with this project was to use our design exploration to help us understand the future landscape entails and see if it could teach us something about the current system.

We wanted to present our investigation to the people and actors that have the ability to affect future development.

To do this, we arranged meetings with people and businesses that we believe are important stakeholders.

- Hafslund ASA is one of the biggest electric utilities in Norway. They can affect the development themselves, and they are in a good position to have a saying in legislation.
- The Bollona Foundation is an NGO
 (Non-Governmental Organization) that
 works with climate change and other related
 topics. Bellona works closely with policies and
 can be a way for us to influence politicians.

 Jarl Solberg is a private producer of local renewable energy. He represents a group that can have an enormous effect on future development by adopting local renewable energy production.



(See more at page 10)

Meeting with Hafslund

We wanted to discuss our project with the people within the sector who will be most affected by a possible change.

We were fortunate to set up a meeting with Martin Lundby (Business Developer Strategy, M&A at Hafslund) and Tarjei Lie (Senior Vice President Strategy, HR and ICT at Hafslund ASA).

The meeting started with discussing the development of the energy sector; what happens if energy production is localized and distributed? We explained the two divergent scenarios that we consider to be two possible directions of development in the future.

Hafslund agreed that we may face a change in how energy is produced and distributed. They expressed that the two divergent scenarios we presented are relevant ways of framing the development.

That said, the countries in Northern Europe are probably among the last to face any changes, due to their access to cheap, renewable energy and a climate where consumption is high while the sun exposure is low. At the same time Nordic countries are quite receptible to new technology.

«We will probably not be the first country that has to take a stand on this development, but there is no doubt that we will see more of solar power plants and local production.»

We then presented our service concepts that investigates the two directions.

Hafslund thought it was interesting and that the illustrations and concepts illustrate some challenges and consequenses regarding progress towards both scenarios.

An example of this is based on the fact that people take access to energy for granted, and is not ideal to have a scenario where everyone has to spend time and effort to gather their own electricity.

Hafslund is also positive about the development of local production based on solar power. They also believe that it is important to find a solution where the stable and well-developed infrastructure we have today is put to good use while also facilitating local sustainable production through private initiatives: "We need to find a middle way".

Hafslund said that using the traditional producer as more of a provider of safety who can offer energy production when the local production falls short on covering the demand is already being done on a smaller scale.

In today's system, the power retailers send a request to the market every day saying how much energy needs to be produced for the next day. In cases where the demand is higher than forecasted, they can purchase energy from a so-called "standby source" at a higher price.

It is also interesting that Hafslund believes that the margins of the energy they sell to consumers will continue to be put under pressure. Hafslund continually develops their offerings to the customers with new product and services to meet the demand and be positioned for the future

Tarjei Lie, Senior Vice President Strategy, expressed his belief that Hafslund can choose one out of three different approaches in this development;

- Do nothing
- Be a provider
- Be an integrator

They also pointed out that one obstacle in facilitating the direct sale of energy in a Norwegian context lies within regulation. With the laws we have today, you need a license to sell energy..

To make it possible to split the cost of the grid in two, it will also be necessary to change the payment structure.

However, as they stated: «If the politicians want it, it can be done.»

It will be interesting to see which of the three approaches Hafslund chooses in the coming years.

Our take on the development is relevant. Hafslund want a future with both private local production and big professional actors that can work together. A direct sales model is interesting but they are some regulatory challenges.



Meeting with Bellona

We met with Karl Kristensen, Adviser at The Bellona Foundation, to get feedback on our project and share our ideas and concepts.

Karl used an analogy to describe our project:

"You have been able to see the development and create services before they are really needed. It is like when cars were first introduced; people in the horse industry did not understand that they needed to change their businesses before it was too late. You can now give those people a heads up."

When we described the scenarios, Karl said: "I don't think the scenario where we lose the grid altogether is realistic; it is an infrastructure that is too important for a country. If the development heads in that direction, it is more likely that the

government will take control over the grid, and instead we have to pay for it through our taxes. That said, I think we will definitely see a change when more and more people produce renewable energy locally."

Describing the new service proposal, Arcs - The Energy Collective;

"I hope the governments come to their senses soon and force the electric utilities to create a fairer model for selling renewable energy locally. If not, this is a very interesting model to stimulate local renewable energy production. Giving the producers fair payment for additional energy makes sense. Looking at how to differentiate prices of energy that has traveled far and energy from the neighborhood raises some difficult questions.

It may create an unfair situation for people living in rural areas, but would probably also stimulate local renewable energy production in a positive way."

"If this service succeeds, I expect that the concept (Arcs) will be acquired or that the big power utilities will copy it if it becomes popular. But initially it will serve as an additional way to tell the politicians and the power utilities that they have to change, and as such it could be a great tool for communication."

The project and the service proposal can be used to communicate to electric utilities and politicians today, that energy production and distibution have to change.

Jarl said that If a service like Arcs - the energy collective existed, there would be no point for him to invest in battery to become more independent.

Meeting with a Local Producer

We arranged a meeting with Jarl Solberg, with whom we have been in contact earlier in the process. He invited us to his home at Ekeberg in Oslo to take a look at his power installation. Jarl and his familiy have invested in a heat pump and solar collectors, and they are in the process of covering the entire south side of the roof with solar panels. He is interested in the technology itself, but he also concerned for the environment. "We like to be early adopters", he said. In the last conversation we had with Jarl, he explained that the decision to make this investment ocurred in the process of renovating the house. He compared the investment with switching to an electrical car when one's old petroleum-powered car must be replaced.

His feedback regarding the concept was that he found it very interesting. He explained that he is considering investing in a Tesla battery at some point. The reason for this, he explained, was that the household will not manage to make use of the

full potential of their production. He explained that they earn very little on the energy they sell in relation to what they have to pay for the same amount to get it back. This makes investing in a battery a compelling option so they can become more independent and store the energy they produce.

Today's price model creates incentives for independent systems. We suggest doing the opposite: give people an incentive to be part of the grid by offering a marketplace that makes their investment in energy production more financially sustainable.

He argued that he would not consider investing in battery if such a service existed.

Jarl uses a Excel-spreadsheet and monitors his production every month. He stated that it would be interesting to be able to see how much they actually use of the power the household produces.





Summary and Reflections on Feedback

In this chapter we have presented the outcome of our meetings with actors in the current system and their feedback on our findings.

To summarize, we want to highlight the following points;

- Our take on the development is relevant.

 Hafslund wants a future in which private,
 local production and big, professional actors
 can work together. A direct sales model is
 interesting, but there are some regulatory
 challenges.
- The project and the service proposal can be used to illustrate to electric utilities and politicians today that energy production and distibution, have to change.
- Jarl said that if a service like Arc The Energy Collective existed, there would be no point for him to invest in battery to become more independent.

Our project started some dynamic discussions in the meetings, and we are very pleased with our first attempts to convey the challenges and possibilities to our target group.



Project Conclusion

The aim of this project was to explore a subject we think will be relevant in the future. When we started, we only had a hunch that there was a change coming in the way people produce and consume energy. Now we are certain that changes are coming, and it will be exciting to follow the development in the years to come.

Defining a future landscape was challenging. We spent a lot of time doing research, and it was hard to translate that to something that was useful.

Neverthless, we managed to create a framework by defining two divergent scenarios.

Using design to investigate the future landscape made it much easier for us to understand and reflect upon different scenarios. It allowed us to reflect and discuss the potential and the obstacles that the different scenarios have. It was also fasci-

nating to see the diverse service potential in both directions.

Creating a service to synthesize the opportunities and convey them to relevant parties was an interesting challenge. It took more time than we had planned for, and we do feel that the service could have been presented better if we had had even more time. Nevertheless, it manifested the main findings of this project:

We think that it is possible to create a system in which we utilize the potential in both local renewable production and the current grid infrastructure. It allows for the consumers to engage in where their energy comes from and how it is produced while also enhancing the value of local producers. The grid operators can still have the opportunity to maintain an important infrastruc-

ture, and the traditional power producers can still create value. Overall, it will be a sustainable opportunity.

Our research shows that the infrastructure itsef can handle progress very well. However, some less tangible changes need to happen. The conclusion is that we want to see a progress where big actors and local producers create a stable and sustainable system together. For that to happen, some things must change in the energy sector:

Open up for a direct sales model.

Make it cheaper to send electricity locally.

Change the energy tax model.

Change the traditional power producer's role.

Design for consumers' and local producers' needs (see page 180 for details).

Talking to Hafslund and Bellona is the very first step towards generating discussion and pushing the political boundaries.

The electric utilities and the energy production and distribution system have so far, in large, been driven by technology. This is now changing. Peoples' needs and desire to influence is challenging the current system.

We don't think the future development is primarly being shaped by technology or the electric utilities' technical abilities to meet energy demand. To create good services in a future development, we think it is important to understanding the users' needs.



Acknowledgments

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Mette Mossige

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Live Work

Designit

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References

Aps.org, (2015). This Month in Physics History. [online] Available at: http://www.aps.org/publications/apsnews/200904/physicshistory.cfm [Accessed 8 Dec. 2015].

Bazerman, C. (2002). The languages of Edison's light. Cambridge, Mass.: MIT Press.

Bloomberg New Energy Finance, (2015). Bloomberg, New Energy Outlook 2015. [online] Available at: http://about.bnef.com/content/uploads/sites/4/2015/06/BNEF-NEO2015_Executive-summary.pdf [Accessed 8 Dec. 2015].

Clathworthy, S. (2014). How to design better services. Oslo: Arkitektur- og designhøgskolen i Oslo.

Collaborative Consumption, (2014). COLLABORATIVE PIONEER INTERVIEW WITH AART VAN VELLER, FOUNDER OF VANDEBRON - Collaborative Consumption. [online] Available at: http://www.collaborativeconsumption.com/2014/11/12/collaborative-pioneer-interview-with-aart-van-veller-founder-of-vandebron/ [Accessed 9 Dec. 2015].

Contributor, G. and Contributor, G. (2015). How Eon's Transformation Will Change The Energy Debate In Europe. [online] CleanTechnica. Available at: http://cleantechnica.com/2015/01/31/eons-transformation-will-change-energy-debate-europe/ [Accessed 8 Dec. 2015].

Drozdiak, N. (2015). Investors Cheer E.ON's Plan to Split Itself. [online] WSJ. Available at: http://www.wsj.com/articles/investors-cheer-e-ons-plan-to-split-itself-1417459383 [Accessed 8 Dec. 2015].

Ebert, J., Gilbert, D. and Wilson, T. (2009). Forecasting and Backcasting: Predicting the Impact of Events on the Future. J Consum Res, 36(3), pp.353-366.

DinSide, (2015). Betaler du ekstra for grønn strøm?. [online] Available at: http://www.dinside.no/935252/betaler-du-ekstra-for-gronn-strom?_ga=1.120618824.1313189409.1433615956 [Accessed 9 Dec. 2015].

Ec.europa.eu, (2015). EU climate action - European Commission. [online] Available at: http://ec.europa.eu/clima/citizens/eu/index en.htm [Accessed 8 Dec. 2015].

Eon.com, (2015). Strategy - E.ON SE. [online] Available at:

http://www.eon.com/en/about-us/strategie.html [Accessed 9 Dec. 2015].

Epa.gov, (2015). Steam Electric Power Generating Effluent Guidelines | Effluent Guidelines | US EPA. [online] Available at: http://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines [Accessed 8 Dec. 2015].

Forbes.com, (2015). Forbes Welcome. [online] Available at: http://www.forbes.com/sites/uciliawang/2015/05/06/demand-for-tesla-batteries-is-overwhelming-like-crazy/[Accessed 8 Dec. 2015].

Fraunhofer Institute for Solar Energy Systems, (2015).

Recent Facts about Photovoltaics in Germany. [online] Available at: https://www.ise.fraunhofer.de/en/publications/veroeffentlichungen-pdf-dateien-en/studien-und-konzept-papiere/recent-facts-about-photovoltaics-in-germany.pdf [Accessed 8 Dec. 2015].

German Energy Transition, (2015). B – Renewable Energy Act with feed-in tariffs. [online] Available at: http://energytransition.de/2012/10/renewable-energy-act-with-feed-in-tariffs/ [Accessed 8 Dec. 2015].

German Energy Transition, (2015). E – Photovoltaics (PV). [online] Available at: http://energytransition.de/2012/09/f-solar/ [Accessed 8 Dec. 2015].

Google.com, (2015). Project Sunroof | About. [online] Available at: https://www.google.com/get/sunroof/about/ [Accessed 8 Dec. 2015].

Greentechmedia.com, (2015). Tesla's \$5B Giga Battery
Factory and Deep Politics in AZ, TX, NV and NM. [online]
Available at: http://www.greentechmedia.com/articles/
read/Teslas-5B-Giga-Battery-Factory-and-Deep-Politics-inAZ-TX-NV-and-NM [Accessed 8 Dec. 2015].

Hafslundnett.no, (2015). Hva er en plusskunde?. [online] Available at: https://www.hafslundnett.no/oss/hva_er_en_ plusskunde_/14398 [Accessed 8 Dec. 2015].

Joinmosaic.com, (2015). Why Choose Mosaic | Mosaic Residential Solar Panels. [online] Available at: https://joinmosaic.com/why-mosaic [Accessed 9 Dec. 2015].

Lovdata.no, (2015). Lov om produksjon, omforming, over-

føring, omsetning, fordeling og bruk av energi m.m. (energiloven) - Lovdata. [online] Available at: https://lovdata.no/dokument/NL/lov/1990-06-29-50 [Accessed 8 Dec. 2015].

MERCED, M. (2015). Silver Lake Is Said to Invest \$100 Million in SolarCity. [online] Nytimes.com. Available at: http://www.nytimes.com/2015/11/19/business/dealbook/solarcity-investment-silver-lake-elon-musk.html?ref=energy-environment&_r=0 [Accessed 8 Dec. 2015].

Mongstad, T. (2015). One year in Malawi as a solar energy entrepreneur - University of Oslo Library. [online] Ub.uio. no. Available at: https://www.ub.uio.no/english/about/news-and-events/events/ureal/2015/trygve-mongstad.html [Accessed 8 Dec. 2015].

Nilsen, J. (2015). Slik skal Hans-Olof leve uten strøm til vinteren. [online] Teknisk Ukeblad. Available at: http://www.tu.no/incoming/2015/11/07/slik-skal-hans-olof-leve-uten-strom-til-vinteren [Accessed 8 Dec. 2015].

Nve.no, (2015). Norges vassdrags- og energidirektorat. [online] Available at: http://www.nve.no/no/Kraftmarked/Nettleie1/Beregning-av-tariffer-for-innmating-fra-produksjon/Plusskunder/ [Accessed 8 Dec. 2015].

Qualcomm Tricorder XPRIZE, (2015). Overview. [online] Available at: http://tricorder.xprize.org/about/overview [Accessed 9 Dec. 2015].

ScienceDaily, (2015). Fossil fuel. [online] Available at: http://www.sciencedaily.com/terms/fossil_fuel.htm [Accessed 8 Dec. 2015].

Straubel, J. (2015). 2014 Energy Storage Symposium - JB Straubel's Keynote. [online] YouTube. Available at: https:// www.youtube.com/watch?v=zWSox7mLbyE [Accessed 8 Dec. 2015].

Sweet, A. (2015). Tesla CEO Elon Musk Unveils Line of Home and Industrial Battery Packs. [online] WSJ. Available at: http://www.wsj.com/articles/tesla-ceo-elon-musk-unveils-line-of-home-and-industrial-battery-packs-1430461622 [Accessed 8 Dec. 2015].

Systems Oriented Design, (2012). GIGA-mapping. [online] Available at: http://www.systemsorienteddesign.net/index. php/giga-mapping [Accessed 8 Dec. 2015]. Systems Oriented Design, (2012). ZIP-Analysis. [online] Available at: http://www.systemsorienteddesign.net/index.php/giga-mapping/zip-analysis [Accessed 8 Dec. 2015].

Telemark Museum, (2015). Den siste istid. [online] Available at: http://telemarkmuseum.no/artikkel/den-siste-istid [Accessed 8 Dec. 2015].

The Economist, (2013). How to lose half a trillion euros. [online] Available at: http://www.economist.com/news/briefing/21587782-europes-electricity-providers-face-existential-threat-how-lose-half-trillion-euros [Accessed 8 Dec. 2015].

the Guardian, (2015). Germany to mothball largest coal power plants to meet climate targets. [online] Available at: http://www.theguardian.com/environment/2015/jul/02/germany-to-mothball-largest-coal-power-plants-to-meet-climate-targets [Accessed 8 Dec. 2015].

The Intergovernmental Panel on Climate Change (IPCC), (2015). Climate Change 2014 Synthesis Report. [online] Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf [Accessed 8 Dec. 2015].

TreeHugger, (2015). This striking chart shows why solar power will take over the world. [online] Available at: http://www.treehugger.com/renewable-energy/striking-chart-showing-solar-power-will-take-over-world.html [Accessed 10 Dec. 2015].

Winter, C. (2014). Germany Reaches New Levels of Greendom, Gets 31 Percent of Its Electricity From Renewables. [online] Businessweek.com. Available at: http://www.bloomberg.com/bw/articles/2014-08-14/germany-reaches-new-levels-of-greendom-gets-31-percent-of-its-electricity-from-renewables [Accessed 8 Dec. 2015].

Wittgenstein, L. (1961). Tractatus logico-philosophicus. New York: Humanities Press.

