



White Paper

Prosumer-centric, bottom-up energy networks 02/2019

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A. Analysis of regulatory situation

1. International Regulatory Developments

Key takeouts:

- Governments will rapidly implement regulation to assure fast adoption of renewables, also because of growing climate-related pressures.
- Energy provision will increasingly become distributed, as this transition path to renewables seems optimal both from a micro- and macro-economic perspective. This will disrupt many existing business models and open-up opportunities for new players and alliances.
- Many of the traditional energy stakeholders have in the past struggled to correctly anticipate the rise of renewable energies in general, and that of distributed renewables in particular. With the growing influence of digital technologies such as IoT, DLT/('blockchain'), and AI, anticipating industry trends and assuring regulatory frameworks are ready to accommodate technical innovation has become even more challenging for incumbents.
- Currently, there is an apparent need in developed countries to upgrade electricity market and network regulation. Many of the existing regulatory drivers are counterproductive and hinder a fast transition to renewables. Regulations should reflect true costs.
- Developing countries increasingly recognize that providing energy access is fastest and best achieved with a strategy based on distributed renewables. With little or no existing infrastructure, networks need to emerge bottom-up.
- In the not too distant future, electricity market and network frameworks will likely follow a bottom-up, rather than a top-down, logic – with the prosumer in the center, and network management essentially a synchronization of self-consumption optimization while utilizing minimal grid infrastructure.

In almost all countries, renewable energies rapidly gain share in the overall electricity provision¹. This is a positive development - in the wake of climate change, the daunting economics of nuclear, the unacceptable land-use related consequences of bioenergy, the lack of other ready and scalable generation options. In addition, there is a growing recognition of the importance of resilience, e.g. in the wake of extreme weather events². Distributed energy is safe, as production is disbursed into many small cells, and is thus much more resilient to damages.

But a growing share of renewables represents challenges for most regulators and grid operators. Many state difficulties of 'integrating' the 'fluctuating' renewables into their existing network management³. This challenge must be regarded in two distinct dimensions: One relates to a growing share of renewables in general, the other to a growing share of distributed renewable sources and the emergence of prosumers in particular.

For both, the fundamental challenge is the near zero-marginal cost nature of renewables⁴. This essentially means that it is difficult to introduce the right regulatory framework for a power system that is both fair and stable. While it is possible to incentivize production, the right regulatory setup to also account for storage and other grid balancing parameters is a challenge.

¹ Several sources, one example: BNEF 2018, <https://about.bnef.com/new-energy-outlook/>

² Several sources, one example: IEEFA 2018, <http://ieefa.org/solar-and-wind-show-resilience-in-face-of-hurricanes/>

³ Several sources, one example: Jean Leavy 2012, http://www.physics.gla.ac.uk/~shild/results/report_sean.pdf

⁴ Several sources, one example: Jorge Balzquez et al. 2017, <https://www.sciencedirect.com/science/article/pii/S1364032117312546>

Government-set subsidies paid for renewable power, when representing a substantial share of the overall market, start to influence market pricing. The same holds true for capacity markets – as participants know at which price additional capacity will be triggered.

In many countries, network operators and utilities begin to address network fluctuations with new, central storage infrastructure, such as grid-scale batteries. This development also occurs in the wake of economic and political pressure to close down nuclear and coal-fired plants which have traditionally been the providers of ‘stable’/‘base load’ generation. Their past stability advantage increasingly turns to a disadvantage in terms of their inflexibility to be regulated short-term alongside growing and rapidly fluctuating renewable generation.

The role gas-fired plants will play is somewhat more difficult to determine. Unlike coal and nuclear, they can contribute flexible capacity to a grid (i.e. can be turned on and off as needed). The significance of gas fired power-plants, however, will depend on their economic case (in particular vis a vis grid-scale batteries), which in turn will be influenced by prices on CO2 emissions and network regulations. While it is safe to say that gas will play some role in the transition to renewables, it seems equally safe to conclude that in the wake of increasing climate-pressure, the resulting emission reduction targets to ‘net-zero’ by 2050⁵, and the in turn likely to be expected pricing of emission in many markets, the role of gas may well be much more limited than was previously assumed. Depending on local parameters, some existing plants can be expected to play a role. The case for investment into new gas-fired power plants, however, can be regarded as becoming increasingly difficult as they represent a lock-in to future emission-generating infrastructure and thus face the danger of becoming stranded assets⁶.

The above described measures to ‘balance the grid’ in the wake of a growing share of renewables all represent top-down efforts, which fundamentally follow the existing logic of a power market with largely central production plants and a distribution grid on which power generally flows top-down from central producers to distributed consumers. Given the rapid emergence of distributed generation, however, there are significant other drivers that come into play. The ‘grid-balancing’ regulatory task is different for prosumer-generated, distributed power – which includes self-consumption. Prosumer-systems are generally designed to optimize self-consumption. They can, however, also take account of grid-balancing functions – storing energy when there is a market-surplus (low prices), and selling energy to the grid once there is demand (high prices) – or vice versa. In a distributed grid, provided the right/incentivizing network tariffs that reflect the true cost of grid infrastructure (i.e. accounting for the actual amount of network infrastructure used, the specific time and location of network usage, as well as peak power demand), prosumers can play a key role in grid balancing⁷.

Current trends indicate that for the large majority of nations, a very distributed overall energy system will likely become reality in the not to distant future⁸. This is the result of applying learning curves and integrating system dynamics that are contributed by a variety of different streams of innovation – both relating to core energy areas (PV panels, batteries, smart meters), as well as ‘digital’ ones (incl. IoT, AI, sensing, micro-payments). It is important to point out in this respect that many of the established ‘energy industry’ stakeholders (incl. IEA, WEC, energy ministries, utilities) have in the past struggled to correctly anticipate the advent of renewables. Many of their predictions have grossly underrepresented the uptake of renewables⁹. Most have now begun to incorporate technology learning curves in core energy domains, as well as the increasing pressure to decarbonize. The enabling effects of digital technology, however, seem to remain largely neglected and require considerable efforts in terms of awareness raising and capacity building.

⁵ As per IPCC’s SR15, http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

⁶ Several sources, one example: Carbon Tracker 2017, <https://www.carbontracker.org/terms/stranded-assets/>.

⁷ Several sources, one example: Applied Energy Vol. 223 2018, <https://www.sciencedirect.com/science/article/pii/S0306261918305622>

⁸ Several sources, one example: IRENA 2018, <http://www.irena.org/newsroom/articles/2018/Oct/IRENA-engages-with-Parliamentarians-to-increase-ambition-on-renewable-energy>

⁹ Several sources, one example: Energy Watch Group 2015, <http://energywatchgroup.org/energy-watch-group-study-shows-that-iea-creates-misleading-future-scenarios-for-solar-power>

Already today, renewables hold the record for producing the cheapest electricity¹⁰. While these records, and still a significant share of renewable capacity overall, are achieved by central plants (wind, PV, hydro), drivers such as PV roof and façade integration, rapidly falling home-battery prices, as well as emerging network intelligence solutions, indicate that the main growth will occur in distributed renewable systems, regulated bottom-up, managed and invested by prosumers.

The main reason for the emergence of distributed renewables are the price and security of supply advantages they offer. Distributed renewables can be seen as simply the best, i.e. lowest cost, highest quality, and also the most rapid transition to clean energy (i.e. the optimal energy 'decarbonization path'). Practically, more and more consumers will become producers of energy, and thus prosumers, over time. They will find that producing their own energy and optimizing their own supply and demand profiles (which increasingly also include EV charging) is simply the best commercial option¹¹. In addition, energy autarky can be regarded as a quality-driver of growing importance. Prosumers co-use their own, existing infrastructure (their roof and facades) for energy production – and realise that there is no better security of supply than from their own roof (or battery) straight to their own appliances (from heatpump to boiler, washing machine to EV). More and more, their different appliances will become smart, i.e. IoT-enabled. This allows them to further customize their overall demand, and optimize their own supply and storage according to the prevailing market conditions.

With today's technology and regulatory frameworks, of course depending on geography and load profile, prosumers typically can cover in the range of 50% of their yearly electricity demand from self-production¹². With more PV integration and falling battery prices, this share may be expected to increase further.

Key to accelerate adoption in general, and a grid balancing effect in particular, is the right network regulation. Many of today's prosumer systems are dimensioned to take account of the current regulatory frameworks, which generally are not favourable regarding the monetization of power fed into the grid. Rather than maximizing production, such systems may only cover parts of a prosumer's roof (and no façade elements yet) and also include only limited storage capacity. A more attractive way to trade energy with other actors through the grid will likely increase incentives for larger prosumer production and storage capacity.

While current distributed storage solutions generally only include batteries, which are best for short-term storage, distributed solutions may eventually also include longer-term storage, e.g. based on hydrogen¹³. Such storage, which may also contribute to balance the grid across seasons, may be dimensioned to suit a single household or a group of households and/or businesses at the local community level, in turn requiring new ways of joint prosumer investments and sharing/trading. A number of pioneering projects already shows what may soon be possible in this respect¹⁴.

Besides cost, quality of supply, and resilience, there are other advantages of distributed renewable systems. In emerging markets, for example, one of the key benefits of a distributed energy strategy is the speed at which remote areas can be electrified. In addition, the 'financing model' of distributed energy, with individual consumers owning/co-owning generation and storage infrastructure, is a sound one in terms of risk/reward profiles (incl. the fact that such new infrastructure is tied to existing assets and financing schemes of the consumer). It is also a logical next-stage development from the system of feed-in tariffs on which much of the initial energy transition was based on (and which already includes the logic of consumers owning and managing energy assets). Furthermore, distributed renewables lead to local value creation and cater to the continuous need for local energy service

¹⁰ Several sources, one example: GTM 2017, <https://www.greentechmedia.com/articles/read/mexican-solar-record-low-price-latin-america#gs.eUh0MD0>

¹¹ Based on various interview, incl. Stefan Meissen of Goldström 09/2018, also referencing statements made by Quartierstrom representatives in the NZZ newspaper 'Lohnt sich ein Speicher für Solarstrom', 22/09/2018, <https://epaper.nzz.ch/#article/6/Neue%20Z%C3%BCrcher%20Zeitung/2018-09-22/53/234916199>

¹² Figure is a result of different interviews conducted in the period 06/2018-10/2018 with firms offering design and implementation services for battery-empowered PV systems.

¹³ Several Sources, one example: Elektor 2018, <https://www.elektormagazine.com/news/seasonal-energy-storage-vital-for-growth-of-renewables>

¹⁴ Several projects emerging, one prominent example is the energy independent apartment building in Brütten, <http://www.umweltarena.ch/uber-uns/energieautarkes-mfh-brutten/>

provision. In the wake of 'unbundling' and liberalization developments, they will likely turn out to be a significant driver of adoption, offering a role to small local utilities which may otherwise be struggling.

Current efforts by regulators vary strongly amongst nations¹⁵. This is obvious, given the different local geographic, political, business and consumption realities. It is also a consequence of insufficient understanding regarding underlying technologies and thus of industry trends – as well as of strong lobbying power to preserve the status quo. Both of these factors represent significant roadblocks to regulatory and technological innovation. A sober analysis of the status quo regarding the readiness of frameworks to accommodate energy and technology developments reveals that far-reaching regulatory efforts are needed in literally every market. In the aftermath of IPCC's SR15 report on the urgency of climate action and the social and economic reasoning behind setting the more ambitious 1.5C reduction target¹⁶, it can be expected that policy efforts in favor of the development of renewable energies will intensify.

The following policy areas are generally relevant for all countries. Added in bullet form is the current status and expected regulatory developments:

1. Shift from feed-in tariffs to one-time investment incentives, fair and true cost tariffs/markets for buying electricity from the grid, and for selling it to the grid.
 - Temporary measures to accelerate distributed renewable generation (with decreasing significance, as renewables are becoming competitive, markets liberalizing, and prosumer communities forming).
 - Location- and time-dependent network pricing will assure that consumers invest in generation and storage infrastructure (balancing grid usage according to demand/supply).
2. Household/prosumer self-consumption rights.
 - Vary from country to country. Some policies are already implemented in the first markets.
 - Currently includes limitations based on individual buildings and 'areas'.
 - Is likely best determined by the regulatory readiness on network use per network level (community sharing below first transformer station, moving up network levels once ready).
 - Communities that sell and buy energy based on peer-to-peer logic should be able to use existing public network infrastructure and pay for that at the true cost of using it – which requires location and time dependent network pricing (incl. each actual infrastructure element utilized in the network transaction).
3. Prosumer information ownership/privacy/sharing rights in smart energy markets/grids.
 - Digitization in energy is advancing rapidly and raises many new data-related regulatory issues. Several of those remain unaddressed.
 - A good part of challenges already arises from the use of smart meters and home automation systems. IoT, DLT and AI add additional challenges.
 - Users/prosumers should be at the centre, in charge of which information to share and with whom. User/legal representative identification, device identification and user/device linking as well as payment-related issues are the key domains requiring regulatory attention. 'Smart meter' (monitoring equipment) efforts deserve particular attention (see below).

¹⁵ Several sources, one example: LSE 'Climate Change Laws of the World', <http://www.lse.ac.uk/GranthamInstitute/climate-change-laws-of-the-world/>

¹⁶ IPCC, SR15, http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

- Data marketplaces will emerge, over which prosumers can share data, buy and sell energy related data to optimize their 'prosumption' (optimizing demand and supply, selling and buying capacity). Transactions will be automated and based on user preferences. With the prosumer at the centre, and power flowing bottom-up.
- Communities of prosumers will form, together exchanging data and power in an automated way – whereby data is captured by IoT-enabled devices, shared via distributed ledgers, and analysed by AI, which in turn leads to improved household and network load management.
- Crypto/digital currencies will likely offer transaction processing advantages for distributed energy systems. The regulatory framework on their use is also relevant for energy.

In several markets, innovative energy systems are now piloted (as is the case for 'Quartierstrom'). It can be expected that important regulatory lessons will be derived from such pilot projects. This should include all of the three main policy categories listed above. Regulatory lessons may lead to policy framework updating initiatives as well as 'Sandbox' regulation for the first prosumer communities emerging.

These communities will likely include households as well as users who largely contribute power (e.g. a local hydro plant owned by the local 'utility') and others that are net consuming power (e.g. a local manufacturing firm). Communities will likely follow a predefined set of rules and may be organized in a distributed way. The need for the use of legal entities for communities to operate (e.g. a community association with local prosumers as members), as well as the remaining role of the so called 'utilities', will largely depend on the policy rules set in the above three policy areas. Also because in most markets unbundling did not reach the lowest network level, what exactly is meant by 'utility' needs to be treated with care. Depending on the specific regulatory and business context, this may include managing a large range of different energy assets and offering services which may be disrupted into individual elements, bundled differently, or become obsolete altogether as a result of regulatory and technological innovation. Important to note is, on the other hand, that independent of the level of digital/automated electricity exchange, physical infrastructure is still needed, and thus must be installed/upgraded and maintained. Taking charge of and contributing this infrastructure as a community member, likely represents an interesting ongoing role of local 'utilities' who often own the local distribution grid. The most advanced 'utilities' already offer a range of services specifically directed at prosumers (incl. the installation of PV/battery capacity for self-consumption) and have diversified into EV charging stations, appliance sales, etc.

From a distributed renewable energy perspective, bottom-up, network infrastructure and energy generation and storage facilities can be regarded as assets owned by one legal representative in the community network. Individual community members may transact directly or collectively with other community members, for which the rules will be embedded in smart contracts that are entered into and customized by prosumers by way of a digital user account. It seems feasible to anticipate that prosumer communities will emerge by joining sharing platforms (themselves associations, foundations or companies), which facilitate exchange and can act as legal representatives when the community as a whole transacts with non-community members (e.g. selling power collectively to a third party outside of the community, setting-up or maintaining joint infrastructure).

As the provision of electricity represents mission-critical infrastructure for modern societies, authorities will be inclined to proceed with caution when testing fundamentally new distribution/network management models – independent of the role of 'utilities'. As climate-pressure does call for rapid implementation, smart regulators will likely follow the route of defining quality standards (concerning data and equipment) for each network participant (from prosumers to 'utilities') and thus assure the quality of overall provision/bottom-up network management while allowing different types of energy business models.

Policy matters relating to ‘smart meters’ require particular attention. In the current implementation plans of the large majority of countries, smart meters are owned and operated by utilities. They are installed with individual network members. The data gathered by smart meters is controlled by the utility (also with respect to AI). The value of the analysis of the data the utility derives from the smart meter is used for optimizing on behalf of the utility – and not the prosumer generating the data (through her energy consumption, and with her appliances). This already today has led to consumer concerns as to privacy and data ownership¹⁷. It represents a disincentive to data sharing and is not compatible with a bottom-up, prosumer-centric network logic. What is currently regarded as a ‘smart meter’ actually represents a prosumer’s energy gateway between household/self-consumption and network usage/sharing. It is a mission-critical device that is best owned and controlled by the prosumer – as this correctly incentivizes the sharing of information and provides the right basis for fair and transparent data privacy frameworks. Gateways may need to adhere to ‘smart meter’ quality parameters and may require installation by certified personnel. They may serve to formally register individual appliances as being property of the user, by location- and hardware-based security/verification. They may also be relevant to share/monetize consumption-related data of households and companies. Communication of the energy gateway will likely take place on different levels, including the internet as well as local area networks¹⁸.

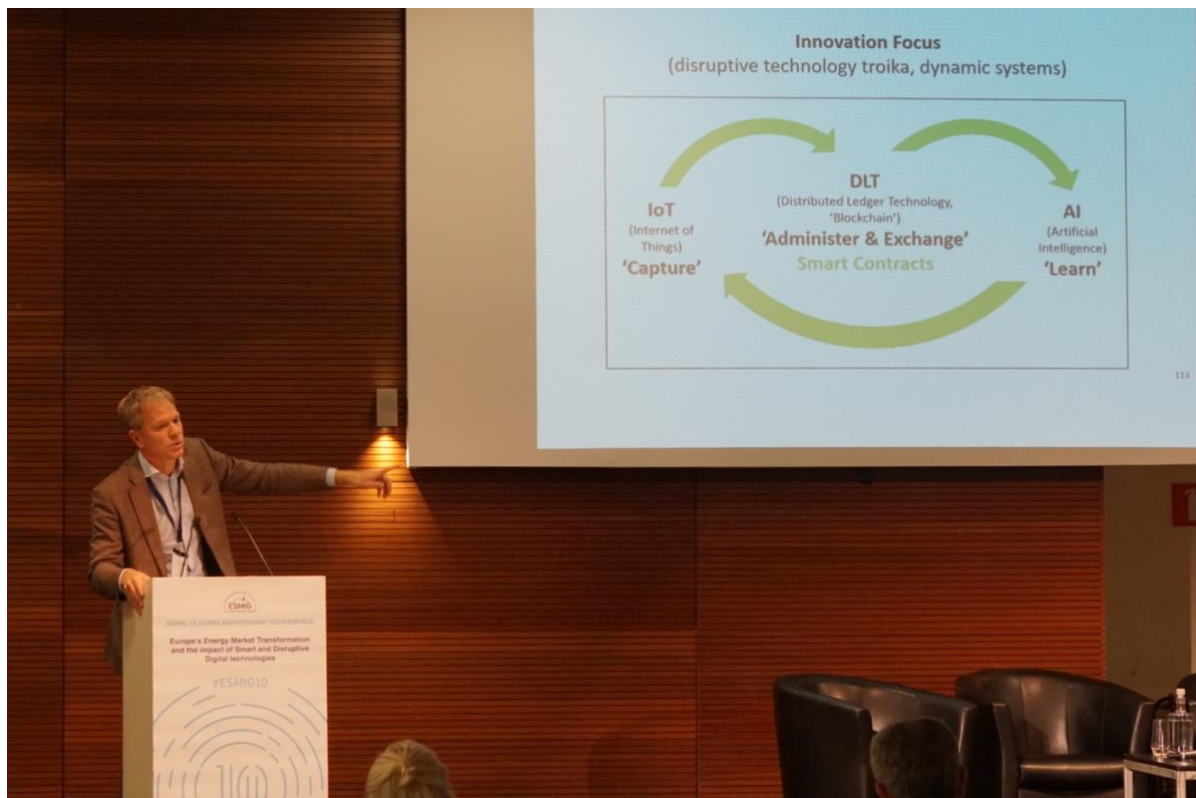


Image 1: Selber presentation at annual event of [ESMIG](#), Brussels 04/06/2018

¹⁷ Exemplary source: Patrick Collison, The Guardian, 24/07/2017, <https://www.theguardian.com/money/2017/jun/24/smart-meters-spying-collecting-private-data-french-british>

¹⁸ A prominent ‘energy-blockchain’ company recognizing the opportunity of prosumer-controlled ‘smart meters’ is Grid+, <https://gridplus.io/technology>

2. Swiss Regulatory Developments

Key takeouts:

- Switzerland is one of the world leaders regarding the readiness of distributed renewable energy regulatory frameworks in general, and prosumer-centric community models in particular.
- With the newest revision of the Federal Electricity Supply Act (consultation period ending 01/2019), Switzerland is taking another big step forward towards enabling community models.
- 'Quartierstrom', as well as selected other pilot projects, play an important role in this development. One specific result of the Quartierstrom pilot should be to provide specific regulatory input for prosumer-centric energy communities operating over public networks and priced at true cost.
- Regulators have an interest to assure that energy communities will thrive. This accelerates renewable energy adoption. In addition, there is growing recognition that technology already allows grid defection/energy-independence of individual buildings, but that due to differing load profiles and for grid-balancing functions, grid-connected sharing solutions are economically and ecologically superior to grid-defected 'island solutions'.
- Quartierstrom, depending on the specific business model and roll-out strategy chosen, will likely benefit from 'sandbox' or permanent regulatory frameworks that allow the project to scale

Switzerland is one of the countries leading with respect to regulatory readiness for distributed renewable energies¹⁹. In 2015, Switzerland has voted for a change in energy strategy ('Energiewende'), which already foresees a substantial share of distributed renewable sources.

As there are several recent descriptions of general Swiss regulatory developments, including the move to more distributed sources and relating to energy communities, this report does not also cover such topic. Most relevant in this respect is the newest revision of the Federal Electricity Supply Act²⁰.

The further focus here shall be to review regulatory options for the Quartierstrom pilot specifically. This project, as well as other pilots by federal universities, the state innovation agency (innosuisse), state-, city-, and regional firms, provide an interesting basis for analysing and anticipating how regulatory matters of distributed energy communities may evolve in the Swiss context.

The current regulatory situation can best be analysed based on two significant other pilot projects:

1. Brütten²¹ (next picture): This is the world's first energy independent apartment building. It is a modern 7-family property (incl. elevator and EV-charging in the garage), which is fully energy independent (disconnected from the grid at inauguration) and was completed 08/2016.
 - Demonstrates how far 'self-consumption' can go in a local context with currently available technology (Insulation, PV – integrated into roofs and façades, batteries, hydrogen) d.
 - Permits grid defection and equally demonstrates that such defection is neither economically nor ecologically the best way forward. Given that prosumers all have different load profiles, rather than operating grid-defected 'island solutions', they should

¹⁹ Wieland Hintz (Bundesamt Für Energie), 'Von der Energiestrategie zur Umsetzung', Push - Thema Umwelt, 3/2018, https://www.pusch.ch/fileadmin/kundendaten/de/publikationen/TU_2018/TU_18_3/tu183_inhalt.pdf

²⁰ Federal Department of Energy, 17/10/2018 (Germany only), <https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-72549.html>

²¹ <http://www.umweltarena.ch/uber-uns/energieautarkes-mfh-brutten/>

remain grid-connected and exploit the economic and ecological advantages of sharing energy.



*Image 2: Grid-defected multi-family building in Brütten, completed 08/2016
@René Schmid Architekten*

- Huttwil²² (picture below): Switzerland's first 'energy quarter' (the German term 'Quartier' stands for a defined area and compact section of a township), consisting of seven multi-family apartment buildings, twelve single-family homes/villas, and three two-family buildings. All project approvals have been received and the project is currently being implemented.
 - Example of large energy community made up of different buildings and households in one connected area.
 - Shows technical feasibility of a sizable community, questions the 'area' definition criteria of a community of connected households (with different owners and different buildings).

Reviewing Quartierstrom in this context:

- Defines 'community' as participating households on the public network of the local utility (level 7, below the first substation).
- Puts the prosumer in the center in the form of a bottom-up approach to peer-to-peer energy exchange and network management.
- Represents Switzerland's first distributed energy community operating on a public grid.

Experiences derived from the listed projects have already led to relevant regulatory developments and also point towards the likely future regulatory environment.

The opportunities of forming energy communities are already being expanded – for example to include areas divided by a public road (which is currently not yet permitted²³ but shall be as of April 2019²⁴). The Swiss authorities recognize that the country is doing 'pioneering' regulatory innovation which will

²² <http://energiequartier-hohlen.ch/>

²³ Note that this is different from Germany, where only the crossing of main roads is not (yet) permitted.

²⁴ Push Thema Umwelt 3/2018, <https://www.pusch.ch/thema-umwelt/>

‘significantly foster the development of PV’ by assuring ‘the legal basis for different property owners to form self-consumption-communities’²⁵.

It can thus be expected that the Swiss regulatory environment will be conducive to prosumer-centric distributed energy communities operating over public networks. With the newest proposition for revision of the Swiss Federal Electricity Supply Act, many necessary changes are already being addressed. The consultation period (ending 01/2019) will need to be monitored closely.



Image 3: Area network in Huttwil (rendering, currently being built), ©SmartEnergyLink

Specifically, regulatory developments may entail:

- An amended definition of who can form an energy community – shifting from an area-focus to one based on permitted public network usage. This indicates that several energy communities may emerge in cooperation with the local utilities owning and maintaining the relevant local network.
- Permitting certified energy gateways acting as ‘smart meters’ but owned by the prosumer participating in the distributed energy community. By way of the gateway, the prosumer locally identifies herself as well as her IoT-enabled energy infrastructure/appliances.
- Communities will depend on some form of management and legal representation (e.g. for selling power from the community to outside parties) and meet certain quality standards. These functions may be provided by a local utility that takes part in the community. Alternatively, local association may form (with each member of an energy community also being a member of its association). Certain management functions may be provided by service platforms offering application interfaces and ready-made smart contracts for forming communities.
- A fully liberalized energy market will allow any user to select their preferred provider of electricity. To date, this is only possible for consumer exceeding 100MWh of yearly demand²⁶.

²⁵ Quote by Wieland Hinz, Federal Ministry of Energy, part of Article ‘Von der Energiestrategie zur Umsetzung’, , <https://www.pusch.ch/thema-umwelt/>

²⁶ Federal Department of Energy, Factsheet 17/10/2018 (Germany only), <https://www.news.admin.ch/news/message/attachments/54045.pdf>

- With the support of service platforms offering efficient/quality interaction with all relevant stakeholders independent of the size of the community, it is foreseeable that these dimensional requirements for communities may change or no longer apply for those managed by certified service providers (with standardized, high quality processes for interacting with others).
- Core to community development will be fair network pricing – meaning a true-cost reflection of the actual network assets used as part of a network transaction. This means pricing must be time and location dependent (sometimes referred to as ‘power-based’ vs. ‘energy-based’ pricing). A bottom-up network logic makes sense because it puts the self-optimizing prosumer in the centre and minimizes network usage by exchanging energy locally, peer to peer. This makes economic sense, as it fairly distributes the cost of network infrastructure and optimizes infrastructure investment. For it to thrive commercially, regulatory frameworks need to assure that true cost network pricing is applied. Independent of this, existing levies additional to network usage may still be charged to communities for the electricity exchanged with parties outside the community.
- With the work on bottom-up regulatory frameworks for Switzerland, lessons may be learnt for other regulatory environments, including those of the least developed markets where the absence of grid infrastructure and utilities in many areas leaves no other choice but to regulate bottom-up. In this respect, Switzerland’s pioneering regulatory efforts in the national context may lead to significant international development contributions. In must also be noted that there are currently regulatory hurdles for the bottom-up development of energy grids in some developing markets.



Image 4: Cleantech21/Selber article in Swiss energy yearbook 'EnergieZukunft', 12/2018

B. Business model evaluation

Key takeouts:

- The energy market is rapidly changing, driven by the emergence of distributed renewable energies and the advent of disruptive digital technologies (incl. IoT, DLT/Blockchain, and AI). This leads to regulatory uncertainties but also offers unprecedented market opportunities for new and existing players.
- Quartierstrom's key objective is to enable prosumer-centric energy communities, independent of the technology engaged to do so. Given that this essentially entails the linking of *distributed* prosumers, the application of *distributed* ledger technology makes sense. Key is to select the right type of DLT, assuring appropriate consensus mechanism, interoperability with other communities, transaction speed and scalability, as well as low costs per transaction.
- Quartierstrom, in cooperation with its commercial partners, should find market potential in both developed and developing countries – in markets with or without existing grid infrastructure, incumbents, etc. The key challenge for success will not be on the regulatory front (where at least 'sandbox' regulation will likely be available), but rather on alternative solutions by competitors.
- The project's key differentiator is not so much 'being Switzerland's first local energy market'¹ but rather the first 'energy community operating over public network infrastructure'.
- Long-term competitiveness and business model success depends on rapid scale-up and thus partnering. Regulation will unlikely be a stumbling block. Specific revenue stream can be defined at a later stage.

As per the objectives specified at the outset of the Quartierstrom pilot, the project shall develop a working prototype for managing a prosumer-centric energy community. Here, the various options with respect to a business model for the pilot shall be reviewed, and opportunities to scale-up and transition to normal operations highlighted.

1. General Energy Market Considerations

The current 'energy market' is in flux. Climate-related pressure, changing risk perspectives (e.g. concerning nuclear, stranded fossil assets), as well rapid technological innovation (both concerning core energy infrastructure as well as the digital domain) lead to fundamental, disruptive changes²⁷. Traditionally, energy was regarded as a highly regulated market with considerable barriers to entry for new players. It required large investment, was strongly influenced by state and regional monopolies, and regarded to include a significant 'regulatory risk' for investors.

The rise of renewable energies, and in particular the notion that a large part of future generation and storage will originate from small distributed sources rather than large central ones, now brings forward unprecedented opportunities for new market entrants – and at the same time threatens incumbents.

Because of the important role of energy-related regulation as well as diverse geographic/climatic, social and cultural aspects, energy markets differ greatly from country to country. As a consequence (and a difficulty for traditional energy-related businesses), each national market requires a customized

²⁷ Given the urgency of action in climate, different reports emerge on the needed measures in different domains, including energy. Their analysis shows that electricity generation needs to be carbon free by 2050 and that the needed transition to reach that goal will need to be 'exponential' and will be 'disruptive'. The specifically refer to the need for technologies such as distributed renewables as well as DLT, IoT and AI. One example of such a report is 'Exponential Roadmap' (<http://exponentialroadmap.futureearth.org>).

review in terms of the feasibility of any particular energy-related business model. And, two main market-categories need to be differentiated:

- i) Developed energy markets with existing grid infrastructure and incumbent 'utilities',
- ii) Developing energy markets with no grid infrastructure and to a large extent with only insignificant incumbents.

In both of these main market categories, different energy market players may take charge of one or several functions in the energy value chain. Which function(s), depends on the prevailing regulatory frameworks, the competitive situation, as well as the particular strategy elected by the individual market player. Given the significant drivers for change regarding regulatory and technological innovation, both market categories are currently experiencing significant risks and opportunities.

2. The 'Energy-Blockchain Market'

With the generally recognized trend of energy provision moving towards distributed renewable systems, it seems logical that 'distributed ledger technology' (DLT, aka 'blockchain') is gaining attention in the context of energy. Despite this, however, it is important to note that it would be wrong to speak of an 'energy-blockchain market', for the following reasons:

- The main objective is not to apply a particular technology to the energy market, but rather to find solutions to manage the integration of distributed renewable energy sources as part of a robust and fair overall system of energy provision that allows for the rapid transition to renewable energy and will be carbon free by 2050.
- Real-world use cases demonstrate that the application of DLT is generally complemented with other technologies (e.g. dynamic web applications, smart contracts, IoT, AI). For business models applying DLT, as well as for those which don't, key is to offer a competitive value proposition independent of the technologies engaged.
- There are many types of DLT, one of them being 'the blockchain'. If at all, a business model may differentiate itself competitively by applying a specific type of DLT for specific tasks in the overall business proposition. The drivers behind the decision if and which DLT is to be applied are technical (scalability, user interface, interoperability, etc), economic (transaction costs, information sharing incentives, etc.) as well as regulatory (data privacy/ownership, quality standards, smart-meter-related issues, etc).
- According to several observers²⁸, DLT will have a far-reaching, disruptive effect on almost all industries (energy being one of them). It is compared to the internet in terms of its overall disruptive/innovation force. As was and is true for the innovation-power of the internet, however, it is wrong to think of DLT as an 'industry' or 'business model' by itself. Rather, DLT will become part of bi

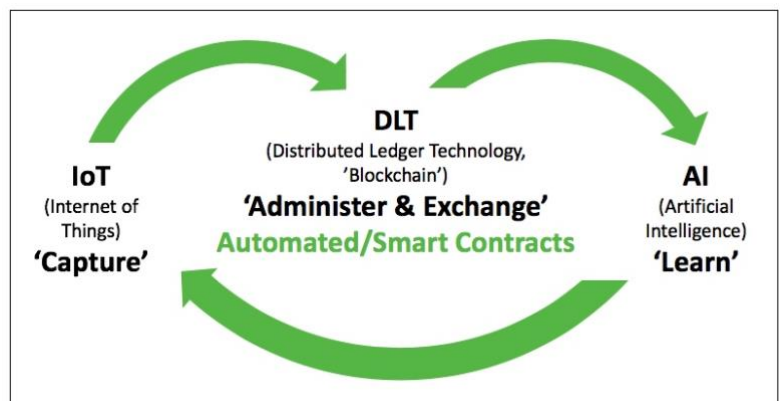


Image 5: Disruptive technology 'troika' IoT/DLT/AI, as part of the fourth industrial revolution, ©Cleantech21

²⁸ Including WEF06/2017 (http://www3.weforum.org/docs/WEF_Realizing_Potential_Blockchain.pdf) & The Economist 10/2015 (<https://www.economist.com/leaders/2015/10/31/the-trust-machine>)

actual use of the technology is integrated into a business value proposition without end-users actually realizing that DLT is involved.

In sum, this means that the Quartierstrom project shall not primarily be seen as an 'energy-blockchain' project, but rather as a 'prosumer-centric distributed renewable energy community'. As for all other projects, the decision to apply (or not to apply) DLT, is best taken on the basis of whether it is with DLT that the underlying value proposition elements can be offered in a competitive way. Thus the task is predominantly a technical one, i.e. one of translating the specifications of the value proposition.

At present, there are in excess of 200 projects/companies internationally, which broadly fall in the 'blockchain for energy' category. There are numerous papers, analysing and referencing the various types of projects²⁹.

Ongoing efforts include various value propositions – from energy wholesale trading and certificates of origin verification, to Quartierstrom-comparable community management approaches. The most relevant 'competitors' are: Energy Web Foundation³⁰, Grid+³¹, PowerLedger³², Swytch³³, MeSolShare³⁴ as well as the organizations behind selected pilot projects ongoing in Germany, in several Nordic countries, as well as selected ones in Asia and the Americas (incl. the first practical effort in Brooklyn³⁵).

For a project such as Quartierstrom, the relevant 'market' is not 'energy-blockchain' but 'prosumer-centric energy community'. This relates to both developed and developing markets. In the former, the main challenge is to enter a space cluttered with incumbents, many rules and regulations, and many of them in flux, as well as several new players entering the market. For the latter, there is little or no existing infrastructure, as well as local regulatory uncertainty beyond the energy domain. In both markets, attractive energy-community opportunities will exist, if and when the pilot is ready to scale. A solid partnership strategy is thus of decisive importance.



Image 6: Grid+ energy gateway ('prosumer smart meter')

©Grid+

²⁹ This is one example by Solarplaza, <https://ipci.io/wp-content/uploads/2017/12/Energy-Blockchain-Report.compressed.pdf>

³⁰ <https://energyweb.org/>

³¹ <https://gridplus.io/>

³² <https://www.powerledger.io/>

³³ <https://swytch.io/>

³⁴ <https://www.me-solshare.com/>

³⁵ <https://www.brooklyn.energy/>

3. 'Blockchain' or Not

In the light of 'blockchain' (i.e. DLT) receiving much attention during the past 24 months, several studies have appeared, all elaborating on when to apply blockchain and when not (generally, not just for energy). There are different approaches and methodologies to this³⁶, but they all centre around the following key questions:

- Does the business model involve a distributed set of stakeholders using common data base?
- Is there distrust among these stakeholders?
- Do stakeholders want to shape the rules with which they transact?

If the answer to any one of these questions is 'no', DLT is unlikely to be the right approach from a business model and/or a technology point of view. If any one of the answers is 'yes', DLT may represent the right approach (noting that also in such case there may be alternative technologies available).

For Quartierstrom, the above questions bring about the following answers:

- Yes, the project involves different stakeholders (different prosumers, different owners of network and other infrastructure, regulators, etc.) sharing their 'prosumption' (production, storage, distribution) data.
- Yes, the different stakeholders don't trust each other as they represent independent agents, each optimizing their role in the energy value chain.
- Yes, community members are best seen as independent peers. Together, they form the community and want to have a say in the way 'their' community functions.

It can thus be safely concluded (as well as derived from similar projects) that Quartierstrom does fit the criteria for applying DLT. Furthermore, the 'prosumer-centric' attribute in Quartierstrom's core value proposition indicates that there is a clear value of offering decentralization and a fair consensus mechanism for how individual members cooperate in the community (i.e. good reason for applying DLT), as well as how they share/monetize their consumption data.

4. Which DLT & How?

More challenging than the DLT yes/no question is the one relating to which type of DLT is best to be employed – and how to do so most effectively, in cooperation with other technologies, to arrive at a winning prosumer-centric energy community solution.

The choice of DLT fundamentally entails the selection between permissioned (only some users can join) or permission-less ledgers (anyone can join). In the light of underlying business model drivers:

- Different communities and service providers will choose different ledgers. The market will likely see both permissioned and permission-less energy ledgers. A regulator's target should be to also see transactions between them, allowing communities to cooperate and to follow the bottom-up logic for organic upwards expansion.
- One energy community (e.g. in a certain area/with a certain network usage, licensed and operating in line with the prevailing regulation) may be seen as a permissioned community in

³⁶ This is one example by IEEE, <https://spectrum.ieee.org/computing/networks/do-you-need-a-blockchain> this another by NIST <https://i.redd.it/uu0qg8t28tq11.png>

the sense that only those prosumers/users can join who are in the covered network area and operate equipment and processes that comply with regulation.

- On the other hand, it could be envisaged that there is one 'global energy ledger', ultimately open to everyone.
- Given the fact that various ledgers are currently being tested and implemented, the 'global' roll-out approach should be to allow for interoperability of ledgers, independent of whether they are permissioned or permission-less.
- A global ledger may serve as an 'interoperability-bridge' to numerous local, regional, and maybe also national and international community-ledgers emerging and cooperating by forming larger communities as they expand (and thus are benefiting from lower energy prices and higher energy provision quality as they grow).
- The best choice for the Quartierstrom pilot is to examine and test different DLT approaches. A permissioned ledger is likely the right choice for a pilot implementation.

The difficulty of selecting the right DLT approach results from the fact that both detailed technical and business-process knowhow is required. From an energy technology and business perspective, these factors are key for the right distributed ledger choice for a prosumer-centric energy community:

- **Consensus Mechanism:** How decisions on the ledger are made is relevant for operational as well as positioning matters. Transparency and fairness must prevail. How decentralization, scalability/speed and cost factors are optimized must be clearly understood.
- **Scalability, Transaction Speed:** The number of transactions involved in running a distributed energy community is likely very high. It can generally be assumed that more transactions will lead to better network management (allowing a more fine-grain tuning of loads) – and that optimal network management will depend on high transaction speeds (e.g. when working with virtual inertia).
- **Transaction Costs:** The costs of entering transactions to the ledger and of running the ledger. Given the need for a large number of transactions, the cost per transaction must be minimal.
- **Interoperability:** Likely, different stakeholders will start to form different communities, using different DLTs. A good ledger should thus be interoperable with other ledgers – those existing as well as those emerging.
- **Ledger Governance & Security:** Investing into the development of a system that works and conforms to the relevant regulatory frameworks will require considerable efforts on the part of those developing solutions. This, in turn, presumes confidence in the long-term governance of the underlying ledger technologies, as well as in the ledger's security parameters.

Important to note with respect to all these issues is the fact that different DLTs offer different ways to address transaction performance, by separating on- and off-chain transactions and by simplifying consensus. The implications of such measures, on each of the above listed performance factors, must be well understood.

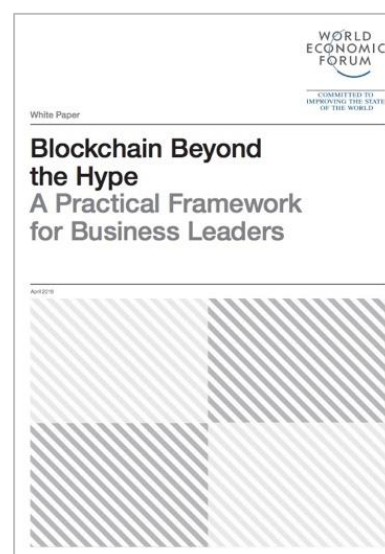


Image 7: Blockchain
Publication 04/2018, ©WEF

5. Prosumer-centric Energy Community Value Proposition

Based on the exchange with the Selber³⁷-Team of Quartierstrom-Partner Cleantech21 foundation, the value proposition of a prosumer-centric energy community is now being defined. Independent of such proposition, however, it is important to note that:

- Few prosumers make their decisions based on idealistic values, a movement at scale will only happen if/when prosumer-centric communities offer clear monetary benefits (which depends on technical and regulatory innovation).
- Energy represents a comparatively small share of a consumer's budget (be it in the household or at industry-level – with only a small number of exceptions). This implies that, while there is interest in how energy is generated, stored, and managed, such interest is likely only very high at the outset of implementing self-consumption and when joining a prosumer community. During normal use, systems will have to run in a fully automated way, not requiring user-based actions (i.e. only for certain consumption preferences falling outside the norm – e.g. having an EV fully charged prior to starting a holiday trip).
- Households and firms will become increasingly aware of the importance of privacy with respect to energy data, as well as the value of energy-related consumption data that can be captured (in particular if systematically analysed and processed).
- Bottom-up energy communities will likely emerge in both central and decentral organizational setups, meaning with or without certain master users who contribute infrastructure (such as a local distribution grid) and/or providing certain management functions on behalf of all community members (such as maintenance of shared infrastructure, buying/selling power to third parties outside the community, etc.). This implies that utilities, service providers (e.g. of an application that can be used across communities) as well as user associations (in traditional and decentralized autonomous forms) have opportunities for roles in the value chain.

The following 13 main business process elements of a prosumer-centric energy community value proposition were defined in cooperation with Selber:

1. Potential community member learns about prosumer-centric energy communities and distributed renewable energies via the website of a service provider (such as Selber), via installation partners (engaged for optimizing self-consumption), or via local utilities actively promoting bottom-up energy management.
2. Downloading the service provider's app allows the user to evaluate the potential benefits of being part of a community at the user's location (and stay up-to-date on local community developments happening).
3. A user joins a community by agreeing to do so and thereby subscribing to community rules.
4. Joining a community goes in line with the purchase of the user's energy gateway hardware (incl. professional installation of the necessary hardware to connect to any local metering infrastructure still required). The gateway is certified according to the quality standards set by the local regulator (assuring network stability in line with current smart-meters, but remaining under the user/prosumer's control and interacting with other users via the network according

³⁷ Selber (previously 'PowerID') is an energy venture by Cleantech21 and its partners. It originates from the planned cooperation between Nick Beglinger, Michael Bützer, Sandro Schopfer and Gian Carle – as per the first submission of the Quartierstrom Project. Sandro and Gian decided not to pursue commercial plans further, while Nick and Michael did. Selber thus entered into the Hack4Climate innovation program (H4C), first by representing a challenge in the H4C 2017 hackathon at COP23, and then entering the use case accelerator with an extended team. Selber performed research, partnership development (incl. Fraunhofer Institute and the International Solar Alliance), as well as different DLT tests in 2018. The Selber team is keen to cooperate with Quartierstrom during the pilot and to be part of operationalizing the knowhow gained with the Quartierstrom pilot.

to community rules). Important to note is that the gateway may also serve a user independent of community access – e.g. with respect to assuring privacy when monetizing consumption data). Key is to recognize the gateway as the prosumer centric version of a ‘smart meter’, physically and data-wise assuring user data privacy and control.

5. With the gateway and a user’s mobile phone, the user is identified/geo-located/verified.
6. With the gateway, a user registers/identifies her IoT enabled infrastructure/devices, allowing them to be managed as part of the overall community system. Existing devices with high electricity relevance (e.g. heat pump or boiler) maybe IoT enabled with hardware bridges.
7. With the combination of the gateway hardware and the community application’s software, the user has a secure way to manage her energy-related data in a dynamic way (regarding community access as well as monetizing consumption data). User data is shared via the ledger and made accessible as part of a ‘marketplace’³⁸.
8. Via a user’s account on the service provider’s app, she can customize her prosumption according to her preference (e.g. selecting between price and autarky/resilience performance, temporarily altering EV charging specifications for an upcoming long-range trip).
9. The community functions fully automated, without any further user interaction, optimizing performance according to user and community network parameters. Electricity prices are auctioned. Data is shared via a marketplace, which also integrates AI (learning from consumption patterns, optimizing individual user and network load management).
10. Via a user’s account, her own prosumption performance as well as that of the overall community network can be monitored (individual prosumers and individual communities should best start to compete for performance). This includes suggestions on infrastructure upgrades for prosumers (e.g. an additional battery lowering the prosumer’s overall cost and increasing her quality of supply) as well as for the community as a whole (e.g. a shared seasonal storage solution invested collectively by community members).
11. With the same account, the user manages a wallet, allowing her (i.e. her account) to make and receive payments from buying or selling energy and capacity from the network (from other community members or from power purchased collectively by the community from a third party (for which the service provider offers the needed legal entity and processes).
12. The user’s energy gateway also acts as a node for the distributed ledger network. Via the app, community members vote on community decisions (such as altering existing sharing rules, joining another community).
13. Via the gateway the prosumer also controls (i.e. shares and monetizes) all consumption type information gathered by the gateway (e.g. usage patterns of household devices, EV charging habits, etc.).



Image 8: Selber application visualization, underlying simplicity,

³⁸ Exemplary ‘data market place’ created by DLT solution IOTA, <https://data.iota.org/#/>

6. Specific Business Model & Roll-out Options

While the value proposition of a prosumer-centric energy community is apparent, the business model of running a single community, as well as a service solution for multiple communities, is not.

With the fundamental assumption that, under the right technology deployment (high speed, low transaction cost, straight-forward/fair consensus) and true-cost network regulation (time and space dependent), prosumer-centric energy will be the lowest cost and highest resilience option for households and businesses, below are a list of potential revenue sources. These may also be combined:

1. Simple subscription fee, e.g. by way of a monthly app subscription (noting that some user groups may be opposed to that).
2. Monetization right of selected community-generated data, e.g. overall network load – sold to regulator, new infrastructure needs – auctioned with a margin to suppliers, user consumption profiles – sold to insurers, consumer goods manufacturers, etc.
3. Margin on the power exchanged between a community and third parties (noting that communities will likely be allowed to aggregate their buying- and selling-power, as well as to freely choose their supplier (as full market liberalization can be expected to materialize soon).
4. Share of savings (and quality improvements?) prosumers benefit from by joining a community (noting this may entail methodological complexities).
5. Margin on hardware sales relating to the energy gateway (full consumer device sold to consumers, or components/chip sold IoT/component manufacturers).
6. Margin/project management fee on value added services (e.g. sales/installation of batteries and PV panels, appliance sales, EV-leasing).
7. Margin on use of (and/or capital gain on) crypto currency assets, necessary to transact in the community (with an exact 'token'/'crypto-economics' model to be specified).

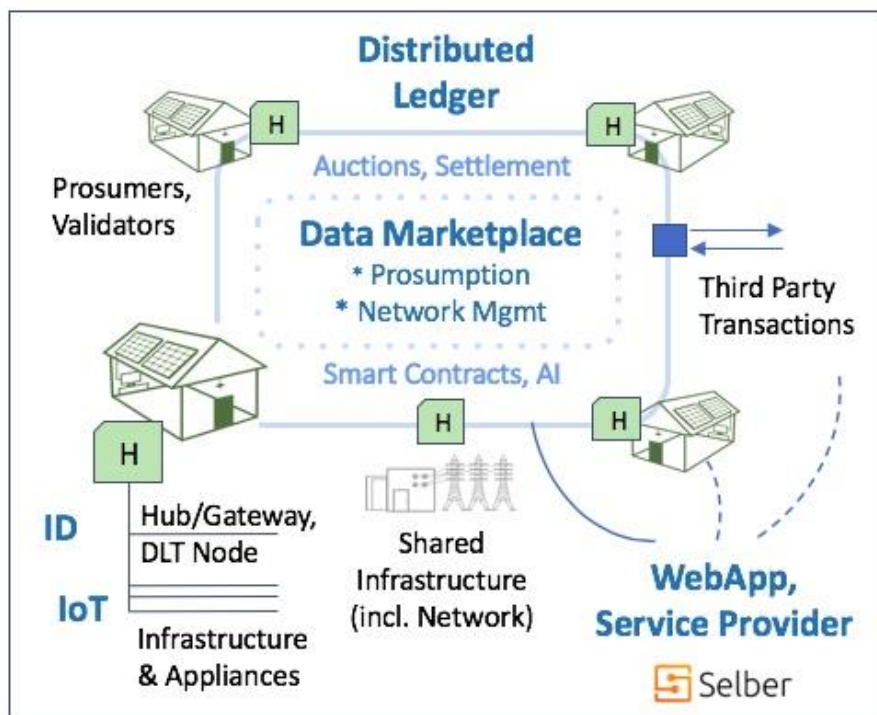


Image 9: Selber value proposition overview graph, ©Selber

When analysing these options for revenue streams and putting them into perspective with process realities and the value proposition drivers, also with respect to roll-out/scale-up, the following key business model lessons emerge:

- All revenue streams are subject to competitive pressure.
- For the overall value proposition to work best (many communities emerging, joining), and for the revenue- (i.e. data-) streams to become significant, scaling communities is crucial (leading to both, better performance and higher revenue).
- Given the importance of scale, and the size of the distributed energy market opportunity, competition will centre around scale-up. This, in turn, makes for the paramount importance of the right technology and partnering strategy.
- The business models for developed and developing markets may be partially different³⁹.
- Two main business model tasks need to be separated: (i) Developing and maintaining a suite of technologies offering a community management system, and (ii) Implementing/operationalizing the system in a particular community (such as Quartierstrom in Walenstadt).
- Prosumer-centric distributed energy communities can be expected to offer strong 'impact-' and 'crowd-investment' potential (incl. TGEs/ICOs). This indicates that also business- and roll-out models requiring substantial upfront investment are feasible.

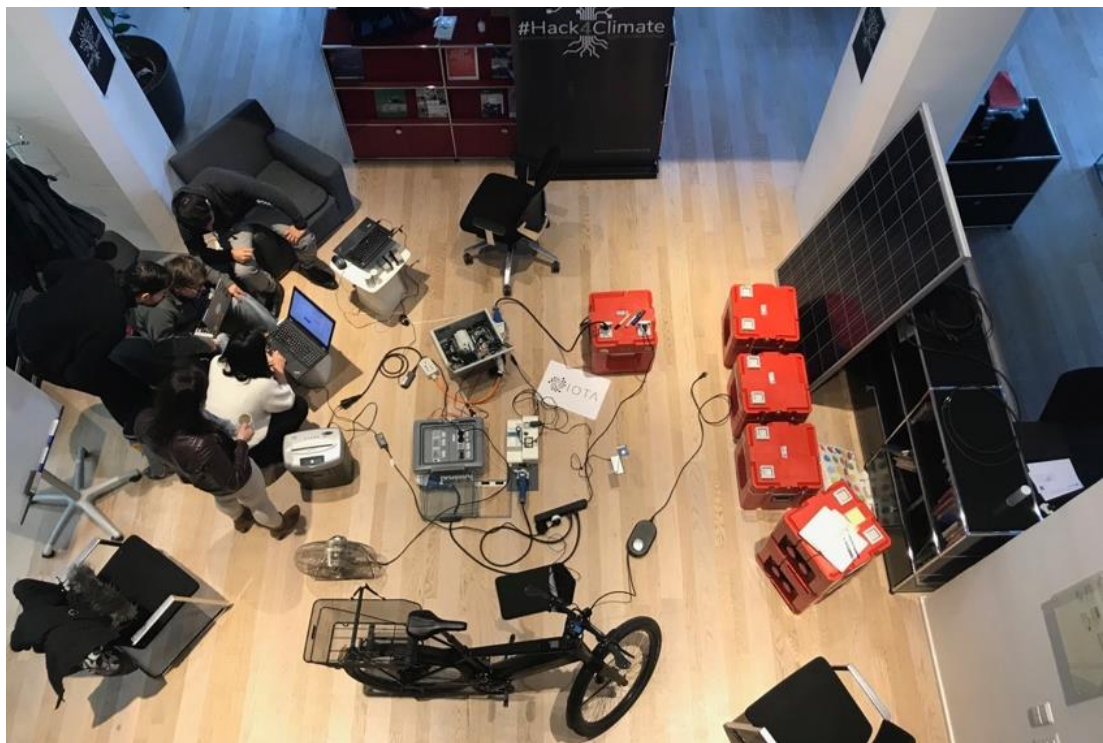


Image 10: Selber team testing at Cleantech21 offices, 02/2018

The objective of the Quartierstrom project, also in combination with other projects, is to test user perspectives and process feasibilities of different energy community value propositions. Overall, likely the best strategy will be to find the right model allowing usage to spread as quickly as possible. The

³⁹ ongoing research by Cleantech21

more data flows through the system, the better the system operates for prosumers, the better it can be optimized for network management, and the more it is worth for generating revenue.

With respect to the commercialization of the results achieved from the Quartierstrom Pilot in Walenstadt, one obvious option is to partner with Selber. The team behind Selber (picture, test set-up 02/2018), represented by Cleantech21 foundation, continues to target the development of a commercial enterprise focused on fostering distributed energy communities in developed as well as developing markets. Key team representatives have been instrumental in the initiation of the Quartierstrom pilot. Selber is linked into the #Hack4Climate Innovation Program and has access to a high-level international network.

Selber's envisaged role in the bottom-up energy value chain is to provide:

- (i) The gateway hardware (secure, open source, B2C prosumer 'smart meter' – monitoring usage patterns, interacting with the network, coordinating IoT enabled infrastructure);
- (ii) An application allowing the user to interact with the gateway and thereby control energy and energy-related data flows (through her mobile or desktop), and
- (iii) Develop predictive intelligence as well as market research products based on the data collected (anonymous, monetized on behalf of the user and fairly across users).

Selber is currently assembling the resources necessary for further pilot projects (incl. in developing markets). With the help of a few selected impact investors, long-term funding shall be sourced through a crowd sale (ICO). If and how a token shall be involved is not yet defined.

Based on its targeted value proposition, Selber anticipates revenue streams from:

- (i) Margin on hardware sales
- (ii) Potentially a subscription fee for application
- (iii) Margin on revenue generated from monetizing usage data

Lessons learnt by Quartierstrom are relevant for Selber on multiple levels. With its core mission of fostering distributed renewable energies, Selber is keen to partner with the teams working on Quartierstrom. Whenever possible, Selber will, rather than 'reinventing the wheel', build on existing development efforts, license relevant code, and work with those already involved. Given Selber's belief that bottom-up energy makes sense whether there is a 'macro user'/central-entity or a fully decentralized organization, Selber will include solutions for both. This would allow a forward looking EVU to become a Selber user/partner/licensee, with special rights regarding other user accounts, payment services, load management, etc. In its simplest form, the prosumer would make available through the secure gateway the information needed by a local utility (as the utility's smart meter would, just under the control of the prosumer). Alternatively, members of a community may set rules to maximize mutual price and quality-of-supply benefits and may vote on third party service providers to be contracted on behalf of all community members (e.g. for network maintenance, selling/buying power with other communities/other providers). In its most advance form, a new prosumer could join an existing, self-

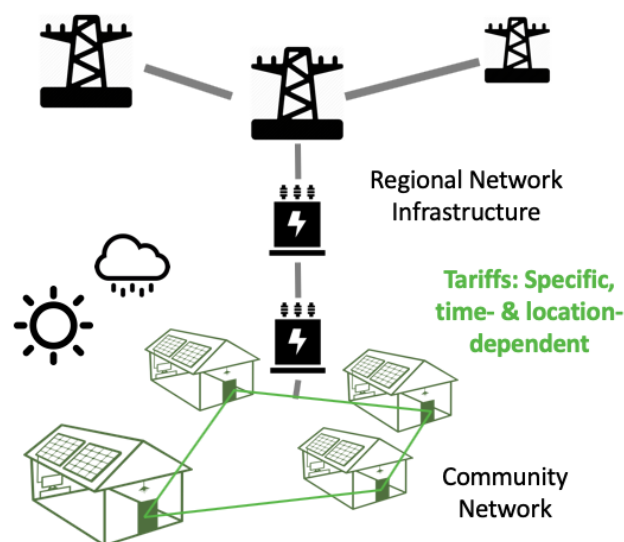


Image 11: Selber network tariff logic, ©Selber

organizing community by signing a smart contract representing the community's rules and practices. It is noteworthy that in both central and decentral setups prosumers remain in full control of their energy data, and the data flows related to monetizing consumption patterns.

In addition to Quartierstrom, Selber is currently setting up another pilot project. The different locations targeted therein could serve as new opportunities for Quartierstrom-developed systems to be deployed, utilizing Selber's gateway. At the same time, as an extension of Quartierstrom, Selber's gateway could be tested there. From an information architecture point of view, Selber intends to focus on the hardware platform and the data marketplace, and to work with different ledger/community management solutions. The collective data made available through the Selber marketplace shall be a platform for, and spur competition in, AI development.

The Quartierstrom pilot development effort could further be leveraged commercially by offering it to other EVs interested to develop/manage a prosumer community. Revenue streams could be one or a combination of:

- Consulting fee for implementing open source software;
- Software licensing fee;
- Contracting-type model, based on savings achieved.

Fundamentally, and in the long-term, the revenue potential of a bottom-up energy value proposition is a function of its price/quality offer vis a vis the prosumer. This, in turn (and apart from market movements, particular community demand/supply patterns, the weather, etc.), is heavily dependent on the cost curves for renewable storage, and prevailing network regulations. In the medium term, there are also opportunities (cost saving potential) regarding the load management of local utilities. Increasing self-consumption, more distributed storage, as well as increasingly open markets will, however, impact long-term revenue potential. The Quartierstrom pilot can and should bring forward important lessons regarding the potential of different bottom-up energy revenue sources, under different regulatory setups/different network tariffs.



Image 12: Selber Expert Session during #Hack4Climate at COP24 in Katowice, ©Selber