Commonwealth environment for digital energy business

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Abstract

We develop a commonwealth environment for digital energy business on the Ethereum blockchain. The environment intended to serve as open tools and common building blocks, driving interoperability among decentralized applications (dApps) that incorporate energy services functionality. Accounting and micropayments are executed by a system of Ethereum smart contracts and state channels that are publicly accessible, free to use and that any dApp can hook into. DApps built on top of the based infrastructure can use common services and have architecture with local regulatory requirements. The use of regulatory features at the application level does not harm the rest of the participants and the Token Model. The platform remains neutral. Decentralized governance is used to continuously and securely integrate updates into the base infrastructure without disrupting dApps or end users.

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1 Background and Markets

There are drivers, which lead unprecedented redistribution of value in energy sector toward connected customers and so create market for digital ecosystems as a mean to make it happen.

1.1 Unprecedented growth of "New Stranded" assets

Amount of connected assets installed on consumer's side, which are flexible in their power consumption or generation patterns and easily and remotely controllable, is growing exponentially.

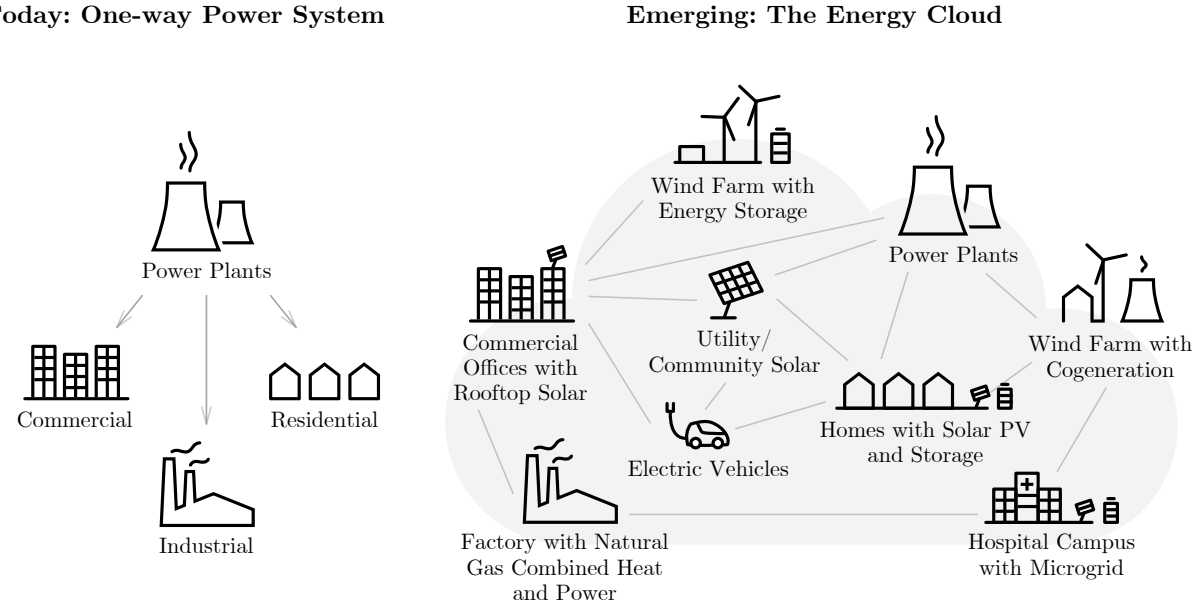
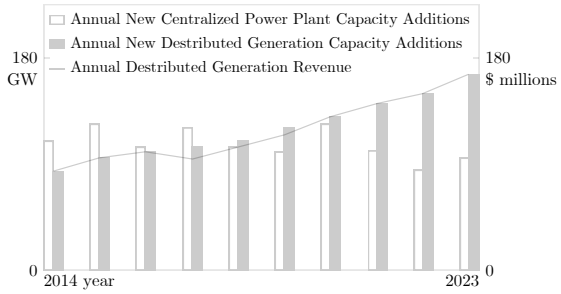


Figure 1: Growing amount of "new stranded" assets on consumer side within exclusive power markets (source: Navigant, 2016).

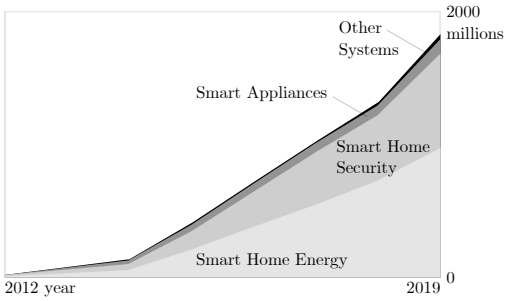
The most important include:

- IoT controlled equipment in buildings;
- distributed generation (both fossil fired and renewables);
- distributed home and commercial power storage;
- e-cars.

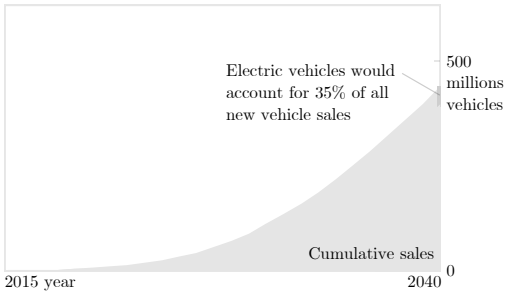
This equipment already has inbuilt features, which allow much more economic grid planning and operations through geographically targeted, scalable and timely responsive ways of fully decentralized generation and grid balancing, compared to centralized model with large incremental capacities, exclusive rules and very long lead times within conventional centralized systems. However, these assets are currently excluded from providing services back to grid. Instead of being rewarded, asset's owners are penalized by conventional utilities for their peaky and flexible demand (e.g. in form of "stand by" grid charges for consumers with own generation, like rooftop solar or small scale CHP, for example in US, or increased capacity payments to maintain "expected grow" in regional power demand for 10–15Y in advance, e.g. in Russia and UK). We call this phenomena "new stranded" assets. This creates "double" economic inefficiency in power systems as beside locking potential on consumers side investments, which are already done, consumers are forced to pay utilities twice for construction and operations of new centralized assets to maintain grid reliability, what would otherwise be available for free, if dispersed assets are integrated. Dropping costs of distributed power generation, storage and IoT has increased the amount of stranded investments of consumers to a critical mass over just last 5 years.



Distributed generation VS Centralized Power Plant
(source: Navigant, 2015)



Global Connected-home device shipments
(source: ABI Research, TechNavio, BE intelligence estimates, Pike Research)



The rase of electric cars
(source: Bloomberg New Energy Finance)

Figure 2: Growth of "New Stranded" assets.

1.2 Power Trading is Dead: conventional markets fail to provide security of supply

The electric loads and generation in power systems are no steady, but fluctuating within days and seasons depending on various factors as day of the week, outside temperature, wind speeds or type of economic activities carried out in the particular region. In the classic energy planning energy consumption is assumed stochastic (not controllable), so the to maintain power balance any time System Operator has to maintain high reliability margin by boosting installation generation and transmission capacity to provide redundancy for the worst case. So administrative and economic arrangements are needed to balance supply and demand: power trading and capacity markets

Power trading, thus selling and buying timely dependent amounts of energy priced $/kWh, is the most common and sophisticated mean to balance supply and demand in fossil fueled powered systems. However, it loses any sense in systems dominated by zero carbon and thus zero marginal costs generation as renewables and nuclear. Figure 3 visualises this transition at German Power Market, showing that for periods of high renewable generation competitive prices goes to zero or negative values. This reveals critical changes to traditional energy planning paradigm:

- **Power maybe an abundant** resource, thus consumers may be paid to consume more to avoid imbalance at the moment, when it is excessive
- **Even, when power generation is scare wholesale power trading value is close to nothing** as even now under moderate renewables penetration over 80–90% of energy supply costs are fixed and so are not subject of competitive forces within current market model (mind the difference between average wholesale price of 30.0EUR/MWh and average retail charge of 300.0 EUR/MWh paid by final consumers, including T&D, green fees, security reserves, tax and other system management costs)
- **Further penetration of renewables will increase fixed costs in power system closely to**

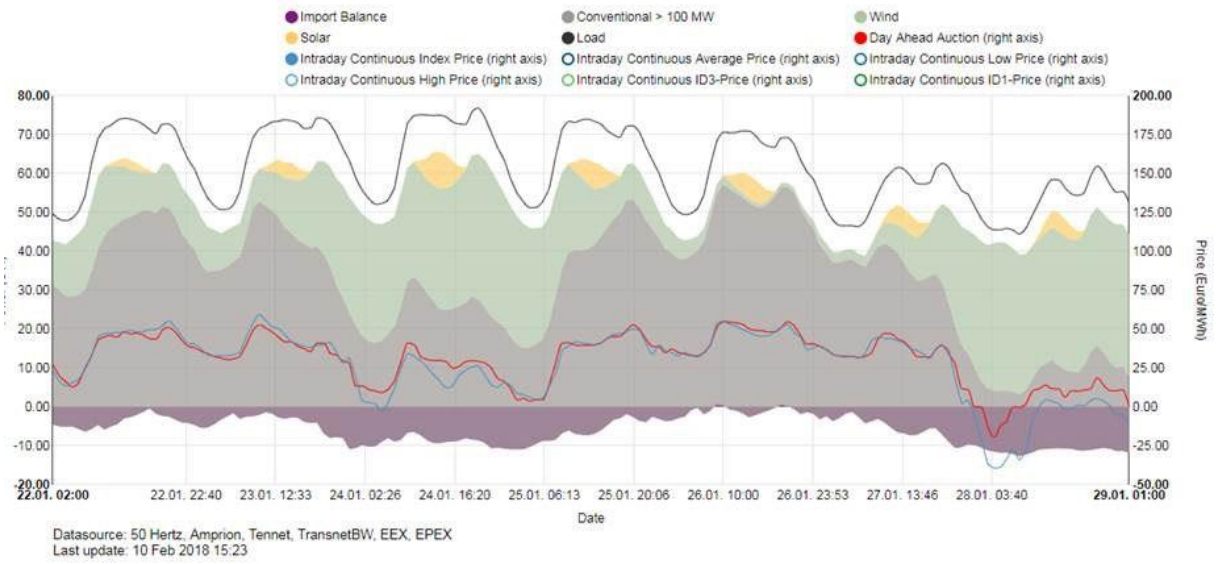


Figure 3: Example negative spot prices on German Power Exchange in Jan 2018 during high renewables generation periods (source: https://www.energy-charts.de).

> **100%**%[1]. So we don't need power at all neither #wholesale nor (!what a surprise!) #Peer2Peer, which is broadly promoted by Blockchain Energy startups as a breakthrough remedy as this is a try to rebuild old "steam engine" with 3D printing, thus mindless repeat of old business models with new tech.

As the energy becomes abundant, generation stochastic and costs fixed, it is apparent that new market models has to be governed by Flexibility Concept, focused on when and how energy is consumed, prosumed or generated, instead of how much.

There are reasons to expect, that exactly here blockchain is capable to deliver value, as this allows to structure fully distributed flexibility pools, where every connected device may call or offer flexibility to others, maximizing value of the shared economy of distributed energy resources across the globe.

The other conventional mean of market regulators is to overcome "power market failure" in maintaining reliability margins by introducing so called "capacity markets", thus a guaranteed annual payments nominated as $/MW to large centralized generators based on "ready to dispatch" capacity seems to face its limits very soon as well.

This type of arrangement has been introduced in US in early 2000-s, in Russia in 2008 and recently in UK shows that capacity markets may not provide sustainable solution for the long term, which could be called "Reserve Margins Failure":

- **physical impossibility to install sufficient reserves** of large generation units to cover expected peak load of the future, e.g. installed capacity of full e-car fleet electrification of a country may reach 10-time installed capacity of power system[2];
- **increasing economic inefficiency** to manage evolving consumers load patterns by busting conventional reserves, as this results in lowering assets utilisation rate, increasing "tax burden" trough fixed tariffs and errors in centralized assets location planning; Lack of economic incentives to maintain existing assets non-competitive pricing at zero marginal offerings become "rule" for existing plants bidding[3];

[1] For German market according to BDEW average retail process for residential and industrial consumers are 170–290 EUR/MWh compared wholesale power price of 31–33 EUR/MWh in 2014–2017. Fixed amount includes T&D costs, taxes, but "green" tariffs and system services and is increasing over years.

[2] Russian case: 42 mio cars × 80 kW = 3.300 GW, 35 Mio tone fuel per annum = 90 TWh/a electric equivalent; Installed capacity and generation of Russian power system 244 GW and 1050 TWh/a.

[3] UK capacity market learnings:

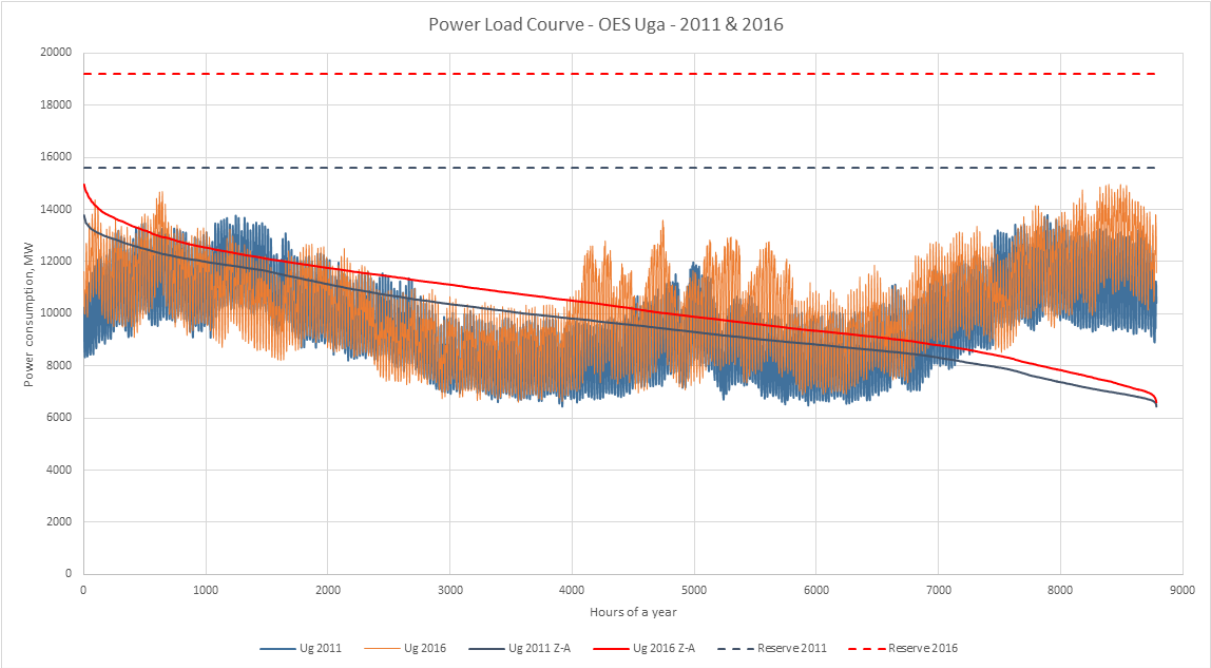


Figure 4: Annual load pattern becoming peaky and increasing capacity margins as response in Southern Power System of Russia 2011–2016 (source: SO UPS).

- **blocking emerging and disrupting technologies** to compete for years through long-term agreements on the market, usually 10–15Y, to construct and provide payback of new large centralized assets, e.g. nuclear units, disregarding if this capacity is required or not.

There is a growing awareness in very different nations globally that centralized market and governmental authorities are missing to provide acceptable solution[4] to provide secure, affordable and environmentally sustainable power supply.

As the energy becomes abundant, load patters increasingly peaky, but controllable and costs fixed, it is apparent that new market models has to be governed by flexibility concept, focused on when and how energy is consumed instead of how much.

1.3 Global Social Call for "Inclusive Energy"

Over last decades, it has been believed that high-tech infrastructures are subject for wealthy developed markets only. Penetration of cheap and reliable digital technology makes emerging markets to lead transformation.

Looking at global power markets through the "Price vs. Risk" lens, we see business case for "inclusive" digital energy paradigm on various markets:

- Provide "bankable" electrification solutions for developing nations with growing demand, socially governed low power prices and high capital risks (e.g sub-Saharan Africa, India)
- Socio-economically acceptable opportunity to maintain "lights on" with in flat demand countries with evolving power demand (e.g. Russia, Turkey)
- Manage penetration of zero carbon technologies e-car and renewables full penetration within large legacy centralized large power generation and transmission.

https://www.greentechmedia.com/articles/read/lessons-learned-uk-capacity-auction#gs.d5RWVKs.

[4] On the new EU electricity market design: "we see that Member States (EU) have a declining confidence in the ability of markets to deliver security of supply" http://energypost.eu/the-new-eu-electricity-market-design-more-market-or-more-state/.

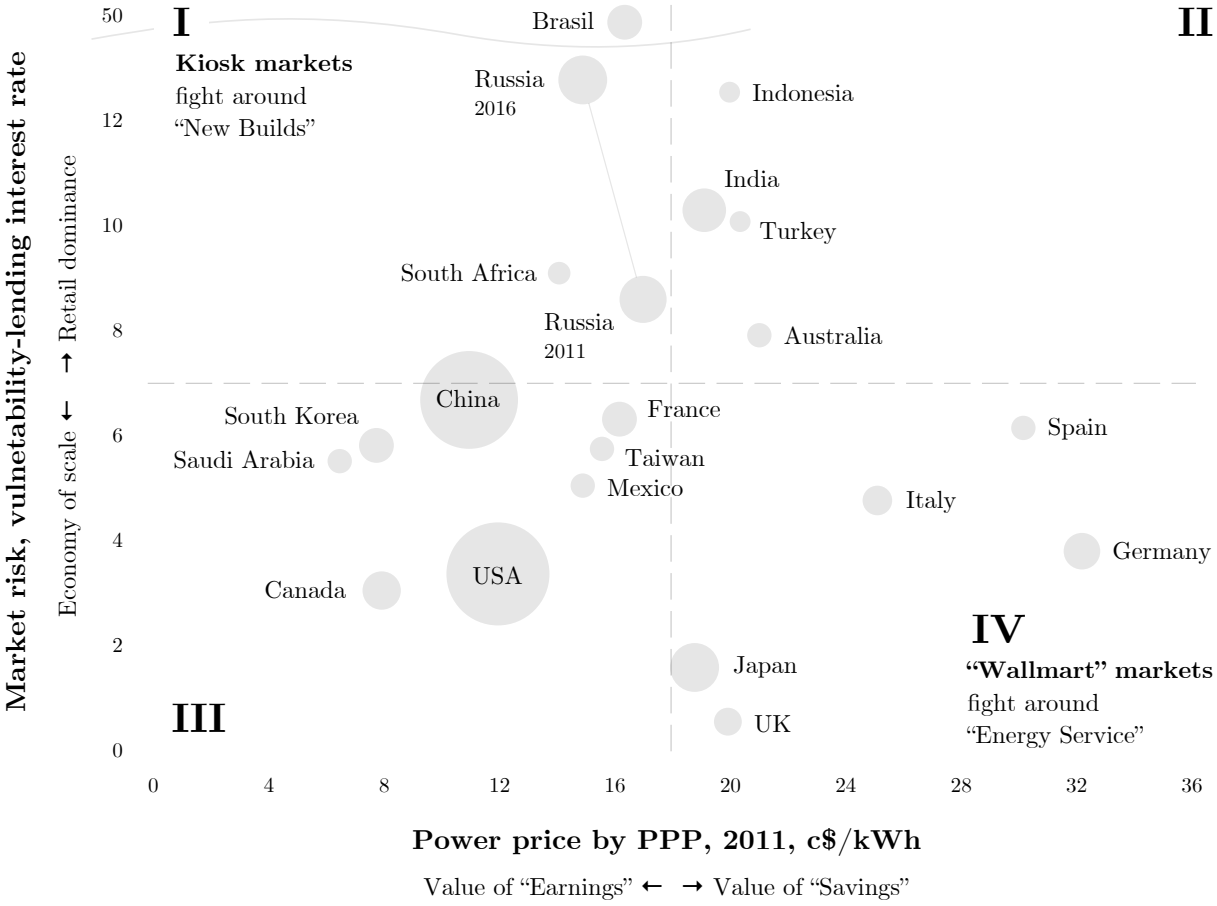


Figure 5: Segmentation of power markets to Price vs. Risk (source: WB, Arup).

So disruptively new energy ecosystem of stakeholders interactions has to come to balance clean, reliable and affordable energy future. We call this new paradigm "Internet of Energy" — the way to build consensus in a very fragmented and dynamic energy future in a fully distributed way.

1.4 Need for Commonwealth Platform creation

We believe, that blockchain technology provides powerful, unique and unprecedented instrument to allow this new fragmented world to come to the new balance. However, blockchain in energy is in its infancy, no one has so far developed mass-market applicable solution providing:

Knowledge Synergy: common development environment leverages from collaboration of technical talents and avoid duplication of work and resource invested by creation of basic elements, needed by every digital application and create standards

Resolving incumbent's conflict of interest: concentration of technical and financial resources is needed for development and testing. This usually concentrated in hands of incumbents utilities as source of conflict of interest. Non-for-profit body for system development is key to overcome this.

Creating trust and transparency: Blockchain energy once reaching market maturity will control globally the most critical infrastructure — electricity supply. So this becomes "nuclear weapon of modern" — too powerful to become concentrated in hands of one nation or corporate body. Thus an independent overseeing body from independent and trusted persons and organization has to be engaged from start to guaranty open, transparent and inclusive governance of the system

This is why we create a global independent commonwealth ecosystem to allow others to build trusted open source digital energy systems and services easily around the globe to provide.

2 ØNDER Platform

A decisive condition for the development of the new electric power industry is the change in the model of interaction between retail market subjects, the deregulation of economic relations, the creation of simplified interfaces for technological and information interaction, the creation of mechanisms for recording and distributing the economic effect.

ØNDER's mission is to bring key capabilities of blockchain technology — security, self-management, self-sovereign identity, economic efficiency — to the power industry. We expect that the greatest value will be obtained in greenfield deployments, where there is a free field for market experiments. However, we realize the value of legal regulation in such a sensitive for the human wellbeing area, and expect to be maximally compliant with existing legal codes.

To fulfill the mission, we will develop a set of tools for energy applications — for creating and operating in self-regulating markets for electricity, power and ancillary services, and will also offer a number of services to expand the functionality of such applications.

ØNDER ecosystem will be composed of the following layers: Services, Commons, Core.

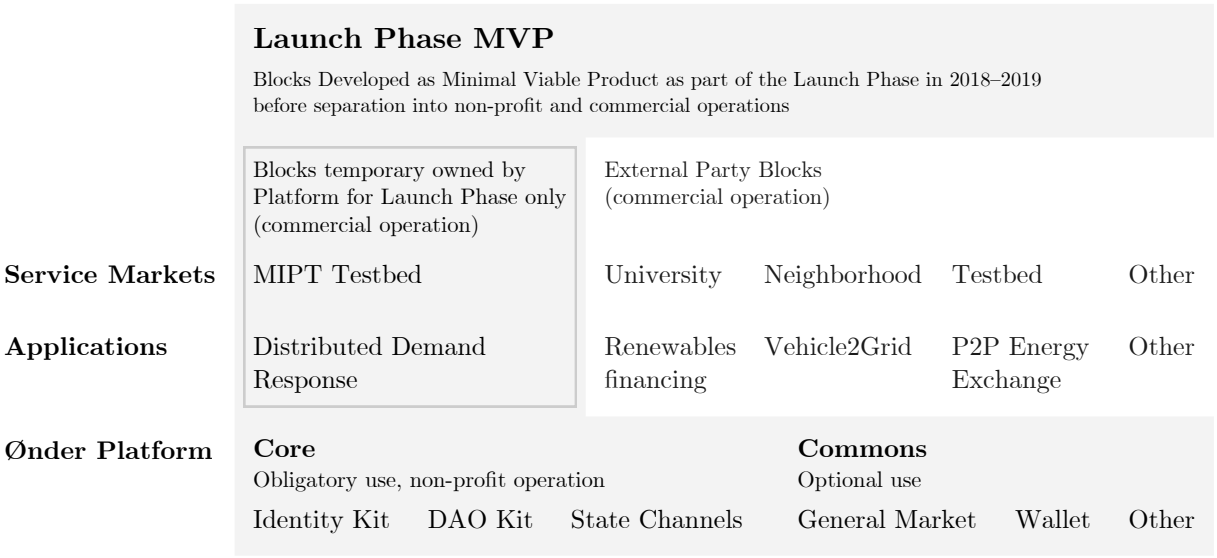


Figure 6: Functional Structure of the ONDER ecosystem.

2.1 Functionality development Plant

Platform functionality is developed in two sequential steps

1. **Launch Phase "Common Non-Profit & Commercial"**: to create, test and launch platform we develop bottom-up distributed demand response service as minimal viable product. In this phase commercial and non-profit Blocks are developed and owned by platform before separation into non-profit and commercial operations.
2. **Operating Phase "Separate Non-Profit & Commercial"**: once platform is launched and fully operational all Level 2 and 3 blocks will be separated and sold to independent commercial operators with platform controlling only non-profit commonwealth core and commons functionality to avoid conflict of interest.

2.2 Level 3 Users Testbed

Unique proposition of the platform is availability of a test bed with integrated real life test users, participating either as non-profit and partly as commercial arrangements

- Region #1 1.000 localized test users — this is geographically limited pool of users in one location
- Global 100.000 dispersed volunteers (Residential and Commercial & Industrial consumers) to test application across different regulatory, geographic, cultural and economic environment
- Other regions and pool types will be included in later phase Testbed pool will be accessible for 3rd party developers to test new applications and services

2.3 Level 2 Commercial Application Store

- Distributed Demand Response
- Renewables Financing
- Vehicle To Grid
- Building to Grid
- Appliance to Grid
- Fiat Exchange
- AI for self-organizing grid mapping and metering
- AI dynamic diversity for grid planning
- Other applications

At this layer, there are commercial services that all market participants can develop.

Commercial services use the features of Level 1:

Commons: it is applied if necessary, own decisions can be used.
Core: basic unchanged platform infrastructure.

Tools and application development capabilities have sufficient flexibility for the accounting various requirements and restrictions according to the territorial and regulatory features in the service distribution area. For regulated markets it is possible to run application, that could check and issue special certificate for services run on the territory of regulation (data storage rules as example).

However, accounting for regulatory features at the service level does not harm other participants and Token Model. The platform remains neutral.

2.4 Level 1 Blocks: Core & Commons

Commons: Third party developed components could be used.

- Payment Channel Hubs
- Generic Market App
- Low-Volatile Tokens App
- App Store
- Wallet: Vynos
- Other Commons could be added as defined by platform operating management

Core: Platform infrastructure could be changed by platform developers team only. Common for all applications.

- State Channels
- Identity Kit

- DAO Kit
- App Kit
- Metering Kit
- Additional Commons: only included as part of the consensus change management procedure

2.4.1 Core

The layer provides foundational technology for the ecosystem. These will be open source and free to use.

State Channels
The technology allows secure exchange of blockchain assets, and execution of smart contracts off-chain, thus consuming no gas. The state channels smart contracts manage opening, closing, and settlement of peer-to-peer exchange. One can transfer custom assets, and apply exquisite dispute resolution mechanisms while using the same set of abstractions. We plan to use the generalized state channels framework developed by Machinomy, and enrich it with industry-specific subchannel contracts.

Identity Kit
Identity Kit is a basis for mapping virtual entities onto the real world. Meter producers will use it to attest genuineness of a meter. A user will attest ownership rights for the meter, which serves a basis for meter-to-meter payments, as it allows to elevate a metering dispute on a human level. Identity Kit will use a set of contracts on Ethereum to build a registry of the system actors which links their Ethereum addresses to off-chain data they have on IPFS. There are different types of identity attestations, so we plan to add a TCR-like structure on top. It will make the participants of the system responsible for their actions regarding identity.

DAO Kit
Decentralized autonomous organization is a way for structuring a particular energy market. It is collectively governed, and collectively owned. The Kit provides a user with means to create a DAO, set the governing rules and monetary policy for its token. It provides Ethereum smart contracts, as well as user interface necessary to facilitate participation in the DAO.

App Kit
An application is attached to the market to add value to it. App Kit provides with interfaces to build such an application. It contains set of contracts to attach the app to DAO, provides UI framework for interacting with the application, and real-time asset exchange component based on state channels. We are contingent on what other components should we provide based on ecosystem participants feedback.

Metering Kit
User's actual interaction with the energy markets is mediated by an electricity meter. We do not force our users to install a specific meter. Instead we maintain the protocol of communication between the user, the meter, the DAO, and the applications. Metering Kit facilitates the protocol on meter level. It is a set of libraries to easily integrate a 3rd party hardware device into the platform. It combines Identity Kit with State Channels, and user interfaces.

2.4.2 Commons

ØNDER Commons layer will offer end products, not SDK. Its goal is to facilitate usage of the applications on the platform, and complement the applications created. Some of the components provide paid services. Others, like Wallet are free.

The sole purpose of the Commons is to bootstrap the ecosystem. We embrace competing services on the platform. It is highly likely some time the alternatives will render the Commons obsolete. Until that happens we will provide the Commons as a service of last resort.

Payment Channel Hubs
Payment Channel Hubs provide a medium for asset exchange between the participants, allowing them to process payments through state channels for a fraction of the cost of traditional payment processors. State channels allow one to group a series of asset exchanges into a single blockchain transaction, thus avoiding fees and mining times on each exchange. It allows one to overcome an inherent blockchain limitations regarding time, and scale it to be useable for the real-time energy markets.

Generic Market App
The App serves as a real-time market maker for energy trading. We do not think energy trading per se makes any sense, yet it is a necessary basis for more advanced services. We envision more market maker apps available from 3rd parties. Recognizing that, we will provide a generic market maker app to be a market maker of last resort.

Low-volatile Tokens App
The platform operates multiple tokens: one token per market. It could be problematic for an ordinary user to keep track the changing value of her assets. We will provide a low-volatile token linked to USD for the user to link assets in the energy system to the outer world monetary equivalent. This lifts a burden of thinking in multitude of tokens from the user's shoulders, while leaving the market mechanisms intact. Maintaining a low-volatile or stable token is a tough task. We expect partnering with existing stable coin providers like Dai or Fragments.

App Store
We think a famous slogan "There is an app for that" could be applied for an advanced energy market ecosystem. App Store will provide a user with selection of energy apps based on her location, market participation, energy resources, preferences, et al. At first the list will be completely centralised and will be curated by the platform management. At that stage we retain the right to apply fees for app promotion. As the platform moves closer to a self-sustaining stage, we will rebuild the App Store as a curation market.

Wallet
The Vynos wallet is historically the first Ethereum wallet with support for payment channels. It is web-browser-based, and lives in an iframe. It does not need any extension or separate application to download. Developed as a collaboration of Machinomy and SpankChain, it fundamentally changed interaction with adult websites. It replaces passwords, usernames and credit cards all at once.

We are going to embrace the approach, and move further with Vynos wallet accompanying it with a compatible mobile wallet. The mobile wallet would allow us to lessen restrictions on UX of the apps. That make the wallet a center of a user's digital ecosystem on all the devices, effectively adopting the wallet for a purpose of Self-Sovereign Identity.

3 Strategy

In 5 years we are going to involve 20 mln active participants in ØNDER ecosystem.

We suppose, that different players can gain their own profits from using ØNDER platform:

- **Smart cities projects holders.**
  Get opportunity to use many technologies by installing one metering and communication infrastructure for all of them.
- **New energy tech companies.**
  Access to a lot of customers in all projects; get more value for their products through interaction with other companies APIs
- **Incumbent Energy Business.**
  Run new models with cooperation with new tech companies.Transit to data oriented business. Cheap options for choosing new services for partnership. Build common services on new technologies easy with building blocks from platform.
- **Active consumers and prosumers.**
  Optimize energy system using cost; Use top tech solutions; develop energy market technologies by choosing best applications from many

3.1 Non-profit model

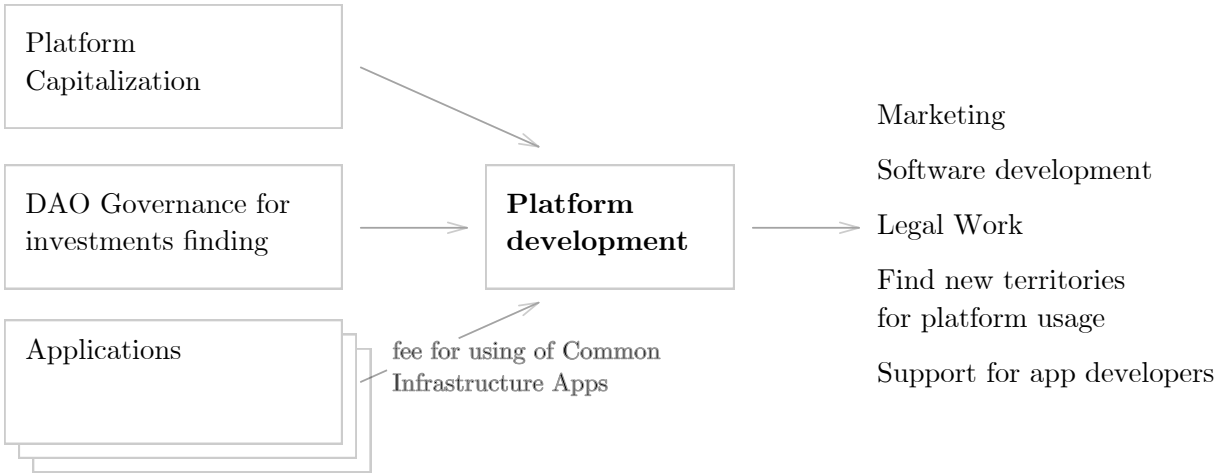


Figure 7: Non-profit model.

Steps on the way:

Stage 1. Test in the fields. 2018

On this stage we offer MVP for owners of smart cities and smart districts project to integrate ØNDER software. We cooperate with other companies which want to test their solutions in new energy market to get synergetic effect of cost saving on the building of infrastructure of metering and accounting. Also we test our

1. Build MVP (Core + Commons + p2p trading, distributed demand response)
2. Make 2–3 test projects in Russia to prove model and show values for all players (Latin America as option)
3. Develop and add more services with commercial companies (commercial monitoring services, data storage and processing, traditional utility services, mobile app for customers)

Stage 2. Distribution. 2018–2019 year

ØNDER growth on this stage depends on the number of smart districts or smart cities projects that will use platform. Our goal is to find 10–20 project, install required infrastructure and run stack of services to

test our vision of easy transition of services from one area to another.

Having several successfully launched projects with developers of smart cities we will confidently offer to tech companies use this infrastructure to their businesses.

Also on this stage we expect interest from Incumbent Energy Business to connect their basic services to platform through agents, or event to write their own applications for platform infrastructure.

Stage 3. Scale effects. 2020 and beyond

On this stage competition between different business models for energy services would lead to optimal energy distribution system. Service providers, prosumers and consumers will gain effects of interaction between thouthands of participants.

When effectiveness of model with commonwealth platform will be obvious governance model could be shifted to owners of tokens and period consensus oriented government will start.

4 Token Model

4.1 Expediency of issuing tokens

The issuance of our own infrastructure tokens is conditioned by the need to create an internal economy in the ecosystem that will establish transparent and fair relations among all participants comprising the system.

4.2 Principles

ØNDER economic model is designed around few core principles. **A token is a unit of system's value**. The token model is a market design for energy industry, which end goal is to maximise a human wellbeing. Minimisation of energy costs, capital expenditures for building a new power capacity, or CO2 emissions are proxies for that in a particular setting. The token model **optimises for human wellbeing**. That also means, the model should **allow for a multitude of service markets to thrive**, as the wellbeing means different things in different contexts. Finally, the token model **must support building of a service market from scratch**.

4.3 DAO on DER tokens

DER is the base currency of the ØNDER ecosystem. It powers the network and provides an objective baseline for the valuation of the local service market currencies. ØNDER will mint a finite supply of 1,000,000,000 DER. For creating local service markets, ØNDER will develop a Service DAO Kit which allow DER holders to lock down their DER tokens to create a service DAO, which mints a local token that represents value of the service market. The local currency is designated further as S^* token. The service DAO provides a governance and accounting mechanism for the service market. It could be peer-to-peer energy trading, distributed demand response, flexibility management, vehicle-to-grid flexibility services, or financial services like low-volatility price targeted tokens.

We impose a special structure for the release of new tokens, so as to ensure the sustainable development of service markets, in such case we respect the possibility of the collapse of service markets, our model

takes into account this scenario too. Therefore, our model takes into account all stages of the life cycle of services.

4.4 Multi-token economic model

4.4.1 General construction

ØNDER utilizes a multi-token economic model, consisting of $N + 1$ tokens, beginning with DER token:

- DER is a staking token which can be utilized to mint alternative tokens offering specific payment and governance rights throughout the ecosystem. DER also serves a base unit of value in the ecosystem. The model is designed to abstract away ecosystem-wide coordination processes from the service market design.
- S* token is backed by DER tokens and any ecosystem assets that the DAO have ownership of. This reserve allows the users generate S* by a continuous token model. The DAO provides an autonomous market-making function. It mints and destroys S* tokens as indicated by non-linear bonding curves.

A continuous model has three main benefits:

1. Instant liquidity for all the S* tokens through the calculated reserve price,
2. Indication of the local service market value,
3. Value based on tangible results rather than speculation.

Users allocate DER into service market DAO according their goals, which generates S* at a predefined rate. A standardized issuance structure provides a uniform measure of value between the service markets. More DERs and other assets staked in the service market DAO correlates to a higher value of the market.

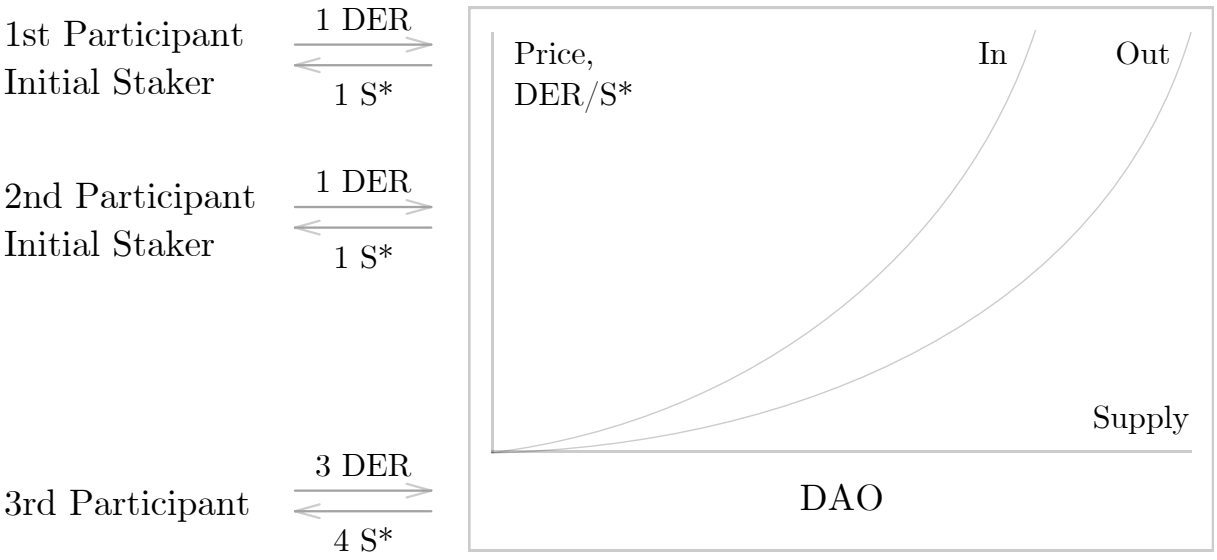


Figure 8: Cryptoeconomic model

4.4.2 S* Generation

S* is generated continuously in exchange of DER tokens. In order to mint S*, holders needs to stake DER tokens to the Service DAO. The exact amount of S* generated by the transaction is known prior to the users decision. This number is determined by the In bonding curve on DAO creation time and implemented by a smart contract.

A user could transfer DER token out of the DAO in exchange of S* according to Out bonding curve. Difference between In and Out curves incentivises the participants to grow the service market, as one gains from selling S* only if the tokens supply increases. A participant earns more S* by providing more value to the market. One could sell energy, power, negative power in case of demand response, energy quality balancing, etc. in exchange for S* tokens, or directly stake DER to the service DAO. A consumer pays for the service in S* or DER or another ecosystem service' token.

S* total supply increases in exchange of DER staked to the service DAO. That reflects total value of the service market. Non-linearity of S* price related to staked DER helps avoid a financial pyramid. Value of the market is expected to develop in continuous contraction-expansion cycles when reaching maximum growth.

4.4.3 Transaction Fees

A service DAO might specify a fee structure for a transaction to support the market infrastructure. In addition to a static fee structure, the service market DAO could employ a 3rd party real-time service provider. The fees are denominated in S* tokens. ØNDER retains a right to charge a small fee that go to Creators Fund for the market contracts it provides. Amount and timing constraints regarding the Fund fee are to be determined later, according to the Governance Model.

5 Governance Model

5.1 Organizational level

We believe, that blockchain technology provides powerful, unique and unprecedented instrument to allow this new fragmented world to come to the new balance. However, blockchain in energy is in its infancy, no one has so far developed mass-market applicable solution providing:

Knowledge Synergy: common development environment leverages from collaboration of technical talents and avoid duplication of work and resource invested by creation of basic elements, needed by every digital application and create standards

Resolving incumbent's conflict of interest: concentration of technical and financial resources is needed for development and testing. This usually concentrated in hands of incumbents utilities as source of conflict of interest. Non-for-profit body for system development is key to overcome this.

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This is why we create a global independent commonwealth ecosystem to allow others to build trusted open source digital energy systems and services easily around the globe to provide.

5.2 Technological level

After the Ethereum contract will be deployed in core network, its logic can not be changed. The new Smart Contract will be developed due to update the protocol and allow organizing good management in updating the protocol. DER tokens will be used to manage the decentralized mechanism for updating the protocol and developing new solutions. For the first it will be common with signatures , then on its basis

will be created a more complex DAO. The Smart Contract will be accessible in public. There will be no mechanisms which exploit one group at the expense of another.