ENERGO LABS

Decentralized Autonomous Energy System

ENERGO

Abstract

Built for a future DAE (Decentralized Autonomous Energy Community), Energo is an ecosystem based on decentralized apps. At its core are Qtum and a decentralized system designed for the measurement, registries, transactions and settlement of clean energy in local Micro–grids.

This document envisions a peer–to–peer DAE community (Decentralized Autonomous Energy Community), where the Energo system is embedded with a cryptocurrency –––TSL, and where owners of this cryptocurrency are enti–tled to access to the distributed energy storage system.

Energo is designed for a new future of energy production and consumption. It connects energy producers of varying capacities and energy consumers of diverse needs. Clean energy is consumed first within the community; energy efficiency and reliability are increased; intermediaries of energy trading are eliminated; energy producers and retailers experience profit boosts; energy users see their cost slashed. With such a vision in mind, Energo is to channel the physical construction, informational structure and value system of the future smart grids and help bring about a truly decentralized autonomous energy community.

Energo also offers a solution to machine–to–machine energy demand. Elec–tric vehicles of tomorrow will apply its digital ID and digital wallet on the block chain to pay for the electricity it receives at any given charging station. Both the charging and payment process can be done unattended. The efficiency of clean energy supply and consumption in any given community can also be maximized.

Backdrop

The electric power industry is undergoing profound changes as we move from a centralized generation system to a decentralized, smaller–scale production model. If such a trend continues, every household will have a power–generating facility(ie. PV or CHP) installed in the near future. Those facilities will generate enough electricity to meet household demands and supply local communities with the surplus. Energy trading may thus be prompted with such a capacity enjoyed by a large number of households. Imagine a future where every house–hold has installed PV and enjoyed a power surplus which can be supplied to other users. When electricity is traded within the local community, costs of distributing power, building transmission lines, and expanding generation capacity will be significantly decreased.

What's more, such a future would fundamentally transform the renewable energy landscape, where resources and capacities are unevenly distributed. Power surplus will be consumed within the local community first, while being complementary to the original power source.

The renewable energy sector relies heavily on subsidies from pro–clean–energy governments, but these subsides are dwindling, with Germany already pulling out its subsidy. Prosumers' profits are slashed. They sell at low prices to utility companies, which in turn sell to customers at a marked up price, reaping most of the profits. Against such a backdrop, a new solution, independent of subsi–dies and guided by rules of the free market, is much needed. An electricity market, where free trading happens, benefits all stake holders [1]. Such a market is a double–edged sword in itself though, challenging and presenting new opportunities to traditional power grids, businesses and operations [2]. Our vision for a future where solar and wind power production and electric vehicles consumption are the norm, is to find better solutions to manage a massive decentralized future energy grid which can in times be unreliable. Such a vision allows participants to maximize the use of electricity generated locally and delivers evident benefits: cutting power distribution cost and energy loss; man–aging local power grid better; eventually leading to decentralized autonomous

energy communities that sit at the hearts of future smart grids and smart cities. This future also demonstrates how the development of market economy and civic society can go hand in hand. When citizens take the initiative to promote renew–able energy and display innovation in the process, the nation succeeds in its supply–end reform in the energy sector and develops renewable energy equipment and storage.

Through the Energo network, or DAE community, such a vision comes to life. The network encompasses interconnected small–scale grids, which operate in a larger region. Advanced information technologies, combined with new energy technology, such as blockchain, IOT, AI, electric vehicles, energy storage technologies, micro grids, integrate real–time flow of power, information and value transfer among producers and consumers in a complex decentralized system where energy is traded and information is managed.

[1]S. Karnouskos, “Demand side management via prosumer interactions in a smart city energy marketplace,” in IEEE International Conference on Innovative Smart Grid Technologies (ISGT 2011), Manchester, UK, Dec. 5—7 2011.

[2]X. Yu, C. Cecati, T. Dillon, and M. Simo “es, “The new frontier of smart grids,” Industrial Electronics Magazine, IEEE, vol. 5, no. 3, pp. 49 —63, sept. 2011.

[3]INTRODUCTION TO MICROGRIDS, https://www.securicon.com/sites/default/files/Introduction%20to%20Microgrids%20-%20Securicon%20-%202013_1.pdf

Why Qtum?

Quantum Blockchain is the embodiment of an internet–based value transfer agreement and a decentralized app development platform. It serves to bridge the bitcoin and Ethereum ecosystem and channel the blockchain world to the physical world.

Qtum system differs from smart contract platforms underpinned by POW, a consensus protocol constrained by resources and hardware and thus unlikely to scale up. Consensus mechanism is innately flawed due to a lack of flexibili–ty, which can be problematic because public blockchain and consortium block–chain are accessed by different entities and thus exert different requirements on consensus. Whereas Qtum system, with both Qtum public blockchain and Qtum consortium blockchain, is more flexible: Qtum public blockchain, given its degree of decentralization, low threshold for participation, secure environment and reliability, adopts the POS–based IPOS. Qtum consortium blockchain, restricted by pre–selected nodes, participated by known counterparties and subject to different consideration for consensus, adopts a blended mechanism of Proof of Time and Raft agreement to optimize computing power in any given trusted network.

Another flaw of current blockchain systems is that they are rather locked down. Most of the smart contracts have their triggering events from within the blockchain system itself instead of the outside world. There's a lack of inter–action with the physical world. With Qtum system, however, things are differ–ent. Oracle and Data Feed featured in the system enable data in the physical world to be triggering events, breaking the closed loop of smart contracts.

Energo is a consortium blockchain with myriads of the future distributed energy storage equipment as its full nodes. Energo consortium blockchain, developed in the Qtum system, can better guarantee the security, stability, and partial decentralization of the entire DAE ecosystem. It boasts superb capacity to handle the massive energy information flow and value transfer. With com–mitment to DAE development, Energo is focused on operations, applying blockchain technology first to the energy sector.

Token

Energo energy asset–WATT

WATT is a blockchain–based digital asset. Its value is backed by energy: each WATT token represents 1KWh of actual energy stored in micro grids or distributed energy storage equipment.

Energo system monitors real–time energy con–sumption through smart meters, generates WATT tokens through smart contracts and issues them to users with privately owned clean energy gen–erators.

With real–time energy consumption monitoring, by either smart meters or charging stations compatible with Energo, the system can also generate private key signature script and transfer WATT token to the designated burning address.

Energo ecosystem asset– TSL

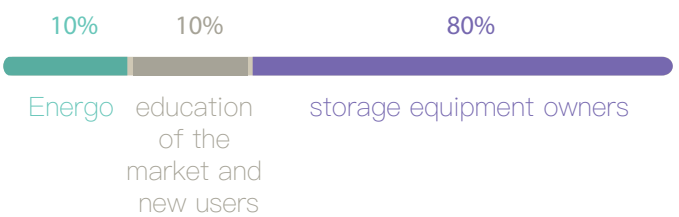
TSL (Tesla) represents its owner's access to power in distributed energy storage equipment. Future prosumers and electricity users must own TSL in order to store electricity in energy storage equipment.

To guarantee the efficient and fair use of public resources, a commission fee on the user–stored energy in the distributed energy storage equip–ment is charged every 15 minutes.

80% of the proceeds go to the storage equip–ment owners. That means energy suppliers' proceeds correspond to the percentage of stored energy he contributes to the grid.

10% goes to the purpose of educating the market and new users, for instance,TSLs of small denomination are given for free to first–time users to facilitate their experience.

Another 10% goes to Energo network. Energo issues 1,000,000,000 TSLs in total. The number of the tokens remains constant. There will be no more issuance in the future.



Decentralized Energy Exchanges

Micro grid

Before peer–to–peer energy trading becomes a reality, we need to do a small operation on current electric power system and introduce into it a new grid structure. That's how micro grid comes to the picture. Micro grid is a highly autonomous and flexible energy network, able to either work in paral–lel with national grid or in isolation. It also integrates the distributed energy generated in a given community, significantly promotes energy utilization and offers excellent reliability.

At its core is an energy storage system, which, through voltage and band management, achieves stable and quality power supply, renewable energy generation and management. The storage system facilitates peer–to–peer energy transfer (i.e. consumers can purchase stored energy contributed by prosumers). Combining IOT facilities that meet measurement requirements and technology standards of multiple countries for measurement and com–munication, the system has what it takes to bring about a decentralized autonomous energy community.

Energo is designed to facilitate renewable energy consumption, maximizing the trading of produced and stored energy and utilization of energy storage system. Therefore, unlike traditional micro grids, it prioritizes the use of renewable energy in the local community, with traditional grids playing a complementary role supplying the whole region with its backup energy storage.

FUTURE OF MICROGRIDS：https://www.marsdd.com/wp–content/uploads/2016/10/Future–of–Microgrids–CI.pdf
Basic components in microgrids：https://en.wikipedia.org/wiki/Microgrid#Basic_components_in_microgrids

Decentralized Energy Exchanges

Trading Platform

The foundation stone of any decentralized energy system is the capability of the different peers within the network to freely exchange the energy they produce and consume. This process of settlement is traditionally defined as a trading. There are different kinds of trading mechanisms being used worldwide for different kind of business, products and services. One of the key points of a trading mechanism is the pricing mechanism.

A pricing mechanism defines the principles and processes for which products and services prices are negotiated between the price asked buyers (commonly referenced as “ask” price) and the price bided by sellers (commonly referenced as “bid” price). Three of the most common ones are: auction, reverse auction and stock–markets mechanisms.

The auction pricing mechanism is commonly used by online platforms such as eBay and offline for art selling. Sellers setup a minimum price for which they are willing to sell their product or service and buyers try to outbid each other to win the auction. The buyer willing to pay the highest price for the auctioned item within the auctioning time will proceed to acquire the item and pay the bidding price to the seller. If no bids are made no transactions will be made. Auctions are a great mechanism to maxi–mize the price a seller can obtain for a specific product or service and is good for products or services with many buyers but few sellers.

The reverse–auction pricing mechanism is commonly used by governments and companies to outsource services. In a reverse–auction, the buyer defines a maximum bidding price and defines the product or service it requires. Sellers interested to win the contract will offer their product or service at a given ask price. Once all interested sellers provide their asking prices, the contract will be rewarded to the seller with the minimum asking price that fulfills the contract requirements. This is a great mechanism to minimize the price a buyer is expected to pay and is good for products or services with many sellers but few buyers.

The Stock Market pricing mechanism is commonly used by world–wide stock markets and currency exchanges and other kinds of commodities. Sellers and Buyers are expected to freely publish the amount they are willing to sell at which asking price meanwhile buyers are expected to freely publish the amount they are willing to buy at which bidding price. Following a first in first served policy, buyers

with bids higher than the minimum asking price will be able to acquire the commodity from sellers. This pricing mechanism doesn't maximize neither minimize the deal price but it is a very good mechanism for markets with many sellers and many buyers.

For a peer to peer energy trading platform we expect many buyers and many sellers' environment, this means that from pricing mechanism point of view the most suitable pricing mechanism is likely to follow the example setup by the Stock Market, but with some specific modifications to align with our specific needs.

Decentralized Energy Exchanges

Energo Pricing

Going into more detail on our selected pricing mechanism, a typical step for Stock Markets is to create the order book table.

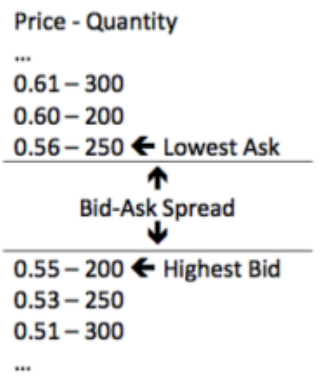


Figure 1. Order Book Example

Every order represents an acceptable price for each unit of quantity in an order. Common situation for an order book includes a "Bid–Ask Spread" area that is the price margin between the highest bid and the lower ask price. In this scenario, we will define the buying–price as the lowest ask price, since that's the price at which I currently can buy anything, and selling–price will be defined as highest bid price, as that's the most expensive price I can currently sell.

In case of our energy market we face a special situation at which energy we may want to sell may not have been created yet. This will lead into a situation where we have some overlapping between sell and buy orders.

Price – Quantity (Sell)	Price – Quantity (Buy)
...	
0.61 – 300	
0.60 – 200	
0.56 – 250 ← Lowest Ask	
0.55 – 100	0.55 – 200 ← Highest Bid
0.53 – 150	0.53 – 250
	0.51 – 300
	0.50 – 250
	0.48 – 100
	...

Figure 2. Energo Platform Order Book Example

In this case, we have some orders with asking price lower than the highest bidding price, however, the people that created those orders don't have enough energy balance to execute. In this case, if user wants to buy energy right away, they will need to match the price of the first seller with currently available energy however, we will still define market prices per the order book, regardless of energy being available or not.

Another specify of our market is energy storage. Currently energy storage isn't being manufactured at a cheap–enough price to be considered a commodity. Current energy storage prices can range between 5500$ for a 14KWh Powerwall supplied by Tesla ~400$ / KWh capacity to ~200$/KWh for utility–scale battery capacity. On top of that, not only battery creates pressure from pricing point of view but also from physical location point of view. Per BYD own website, 800KWh is the maximum capacity that can be fitted within a 40ft container with an area size of approximately 30 sqm.

Connected Houses	Average Energy Stored per Household	Battery Size [1]	Total Energy Storage Price [2]	Total Energy Storage Area
100	0.5 KWh	75 KWh	15.000 $	30sqm
100	2 KWh	300 KWh	60.000 $	
100	4 KWh	600 KWh	120.000 $	
500	0.5 KWh	375 KWh	75.000 $	
500	2 KWh	1500 KWh	250.000 $	60sqm
500	4 KWh	3000 KWh	500.000 $	120sqm

Figure 3. Price and Area requirements for different micro–grid populations.

[1] Battery size has been calculated with the expectation of being able to store 150% of the total average user energy balance.

[2] We use 200$ as the KWh capacity price. Installation costs, land costs and other secondary costs have been ignored.

On Figure 3, we can compare the total cost for different micro–grid sizes per the average energy being stored by every household. Using the 200$ / KWh price and with required capacity as 50% higher than the average balance hold by our users, the per user average stored KWh capacity goes at around 300$. This places two main priorities for us to be able to sustain the system.

First, we need to ensure that we have mechanisms to minimize the battery usage per user to avoid battery costs from sky–rocketing and consequently we will limit the maximum amount a user can store. To calculate the desired maximum balance (Bmax) per a target energy storage cost per user (Cu), and assuming users average balance to be around half the maximum, we can define the equation as:

$$C_u = (0.5 * B_{Max}) * \frac{300\$}{KWh}$$

$$C_u = B_{Max} * \frac{150\$}{KWh}$$

$$B_{Max} = C_u * \frac{KWh}{150\$}$$

Equation 1. Calculating Maximum Balance per a target cost per user.

Second, we need to ensure that users have a mechanism that allows them to sell energy automatically to avoid loss of profit. To allow users to automatically sell energy, we will use a Zero Intelligence (ZI) agent [2]. In our case, we will use a ZI for which a user can only define the target purchase and selling price and our platform will automatically buy and sell once a given balance threshold is reached and no other buy or sell order exists.

Because we have a maximum amount of energy a user can hold as balance, we may incur into a situa–tion in which users have purchase orders that are issued but can't be executed until the user's balance decreases.

Software Implementation

For our software implementation, we need to differentiate three different actors:

–Users or Agents: External actors, can operate over users' order book

–Business Logic Units: Execute, calculate or hold data regarding users' balance, orders or transaction history

–Smart Meter: Can report energy usage and energy creation and consequently increment and decrement balances.

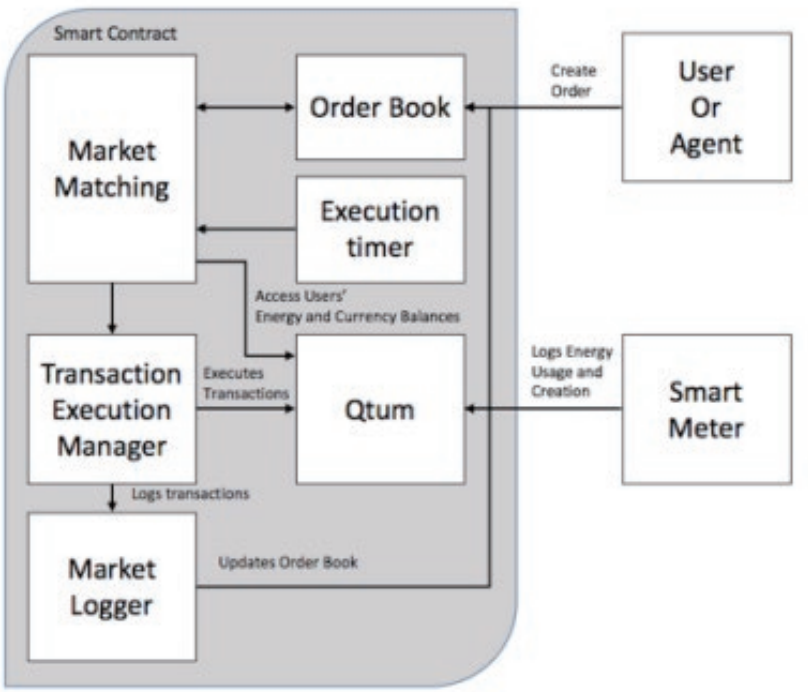


Figure 4. Market Software Implementation diagram.

On our platform, we will use the Qtum blockchain as a central data source to record and account users' energy transactions. We will consider a transaction the following actions:

–Energy being added or removed because of smart meter account

–Currency being added or removed because of users' actions

–Currency being transferred between users as energy payments

–Energy being transferred between users

We will also use a smart contract within Qtum to write and handle the different parts of our business logic.

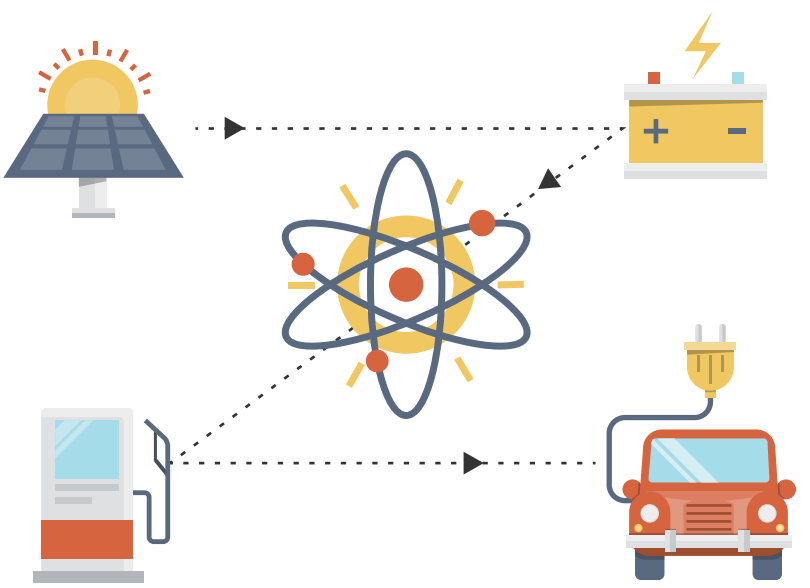
[1] BYD Utility Scale energy storage. Available at: http://www.byd.com/usa/energy/utility-ess/

[2] D. K. Gode and S. Sunder, "Allocative efficiency of markets with zero intelligence (ZI) traders: market as a partial substitute for individual rationality," Journal of Political Economy, vol. 101, no. 1, pp. 119—137,

Charging Service for New Energy Vehicles

We believe the future of electricity trading is happening not just between people, but also between machines: between electric vehicles and charging stations; robots and chargers, to name just a few.

Take new energy vehicles and charging stations, which is a typical case of energy trading. We give new energy vehicles and charging stations unique and human–like digital ID on blockchains. Since charging stations are connected to the distributed energy storage equipment in the micro grids, new energy vehicles, upon accessing charging stations in DAE communities, can fulfill the purchase in a given energy exchange and the payment to the charging station for the energy asset (using non–fiat currency), the whole process done unat–tended.Such a future enhances utilization of clean energy generated in com–munities, increases supply and makes energy source traceable, thus making new energy vehicles even cleaner. Arbitrary pricing and unfriendly payment methods will become yesterday's story. The future, through Energo's new energy vehicles charging service, sees a standard electricity price and payment method within any given community. The only difference is the service fee charged by different charging stations.



Energo Ecosystem

Energy trade and management APP

The Energo network enables users of different regions and micro girds to trade or share energy on certain APPs (Android/IOS). It's also capable of collecting data and running analysis on both production and consumption end (Q1, 2017 has already delivered that.). Going into the future, it will serve as smart home apps, controlling energy use through AI and offering meticulous energy management (This feature is expected to be launched in Q2, 2018).

Wallet

Energo wallet is an APP managing users' token asset. Users can create new accounts, transfer TSL and future tokens in the OTUM ecosystem, import or export private keys, and view the status and trading history of TSL.

Smart meters and charging stations

Energo and its partners supply smart meters and charging stations that meet the measurement requirements and technology standards of the country installing those facilities. To access Energo network and DAE community, prosumers and traditional electricity users will have to install smart meters that can run in Energo environment. Charging stations for new energy vehicles will be connect–ed to the Energo network and be upgraded to be compatible with it.

Development Process

Energolabs was found in October 2016, we have been prepared for the blockchain–related research and design as early as august and has obtained the investment of Mr.Wang Li Jie and Mr.Zhang Jun, two famous angel investors who had invested in Antshares and Metaverse. After that we got the strategic investment from Energy Blockchain Laboratory and Shougang Fund.

As a early practitioner of energy blockchain, Energolabs also appeared in Event Horizon in Vienna (February 2017) and the Clean Tech 2017 hold by ASIA DEVELOPMENT BANK in Manila(June) as guest speaker with our Startup project, promoting the DAE community based on the blockchain, which was favoured by government and energy company in each country.

In the first quarter of 2017, we have completed the blockchain Version ALPHA and the development of Energy Exchange in Android platform. The development of intelligent electric meter prototype was finished and it has been sent to Hanergy Global R&D centre for testing and adjusting in a real microgrid environment.

In the early days, we built the blockchain by ourselves and spent a lot of energy on the development of the chain itself so the chain is not influential enough, which might restrain the business advancement and ecological construction, therefore, we decide to transfer the developing basement to Qtum and reset the development process.