Verv VLUX Whitepaper

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The Evolution of Energy

vlux

Version 2.0

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Company financials are available on request. Please email *ito@verv.energy* and we will respond with an NDA. Once we receive the signed NDA we will share further financial data.

List of Abbreviations

AI: Artificial Intelligence
AWS: Amazon Web Services
CAD: Consumer Access Device
DER: Distributed Energy Resources
DR: Demand Response
DSO: Distribution System Operator
DNO: Distribution Network Operator
EV: Electrical Vehicles
IoT: Internet of Things
ITO: Initial Token Offering
NILM: non-intrusive load monitoring
P2P: peer-to-peer
TOU: Time-Of-Use
VHH: Verv Home Hub
VTP: Verv Trading Platform
V2G: Vehicle-to-Grid

Glossary

Blockchain: a distributed, digital ledger in which transactions made are recorded chronologically, and secured using cryptography

Prosumers: households who both produce (generate) and consume electricity (e.g. with rooftop solar PV)

Fiat: government-issued currency (e.g. US Dollar, British Pound)

Smart Contract: self-executing digital contracts that execute when a set of pre-defined conditions have been satisfied

Summary

Since 2009, Verv has achieved significant traction in the UK energy industry for its patented disaggregation technology that provides households with a detailed appliance-level understanding of their electricity use. Following the successful launch of the Verv Home Hub (VHH), we plan to extend its functionality through the rollout of the Verv Trading Platform (VTP), a blockchain-powered energy trading platform that is being built to enable households and energy consumers to trade electricity in a peer-to-peer exchange.

This whitepaper has four main objectives:

1. Show the need for change in the energy sector
2. Demonstrate why Verv believes a peer-to-peer blockchain-powered platform is the right solution to the problem
3. Show why Verv believe they are the right company to provide the solution at the right time
4. Outline Verv's plans and progress to date, for making the VTP platform a reality

The VLUX platform is a work in progress. This whitepaper represents Verv's current thinking on how the technology should be used and deployed. Technical and theoretical developments in the blockchain community are occurring at rapid pace, and Verv intends to incorporate new ideas and thinking as they emerge, should they support the overall objectives and goals of the VLUX platform.

In Section 1, we provide an overview of the energy industry, and introduce the VHH, a non-intrusive load monitoring (NILM) device that samples electricity data at frequencies up to 5 million times greater than traditional smart meters. This paper demonstrates why Verv believes through their existing hardware, ultra-high resolution energy data, deep learning, and AI capabilities, they are uniquely positioned to provide an industry-leading energy trading platform.

Section 2 explains how key industry challenges (increasing renewables installation, population, and electrification of heat and transport) are placing greater strain on the electricity grid, and why Verv believes a peer-to-peer energy trading solution will create an efficient market framework that empowers consumers to respond to energy infrastructure requirements (for example, by installing PV panels, batteries or providing demand response capacity).

In Section 3, we illustrate how a peer-to-peer based sharing economy has opened up new opportunities in other industries, and show that with recent cutting-edge technological advances (blockchain, IoT, AI, machine learning), we believe a sharing economy for the energy industry is a viable reality.

Sections 4 and 5 provide a technical overview of the VTP system, followed by our proposed business model. We discuss how the blockchain trading system works, and how we expect key stakeholders will benefit from the platform. Given the existing presence of Verv in the UK, this paper is focused on the UK for the first deployment of VTP, with a view to move quickly to Germany and the USA in the near future. Our long-term vision will be to provide a global electricity trading platform.

Sections 6 and 7 provide an overview of Verv's existing business and achievements in the domestic energy space, and an introduction to key team members, advisors, and project partners.

1.0 - The Evolution of Energy & Verv

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1.1 Background

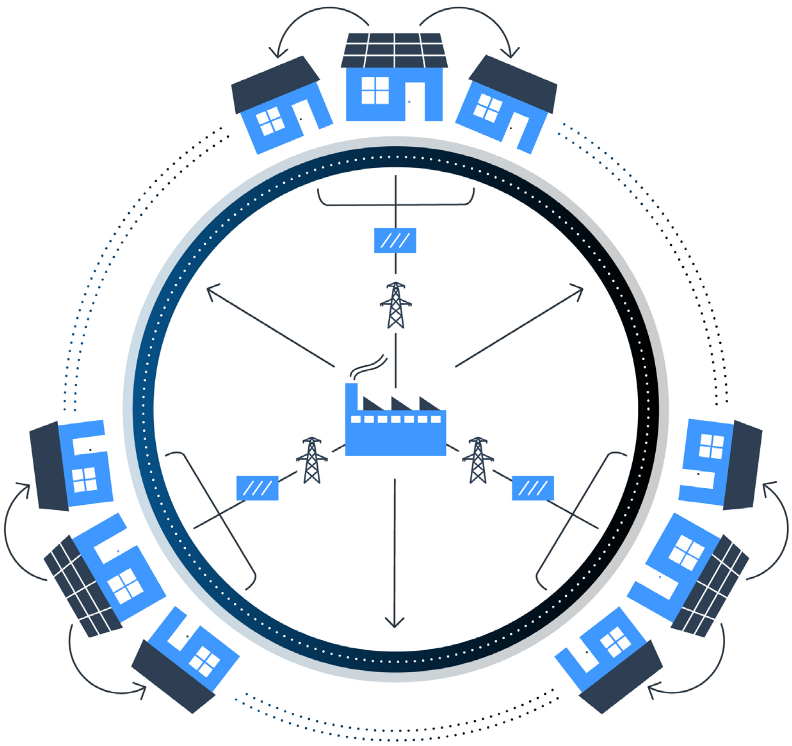
Electricity is a critical form of energy, powering our electronic devices, lighting, heating and cooling systems, household appliances, and the Internet. Most of us cannot imagine a day without electricity – and when blackouts occur, our economy, society, and public infrastructure grind to a halt.

Yet, though many of us take our electricity supply for granted, there are significant problems that Verv believes need to be addressed.

The majority of our electricity is generated by dirty, inefficient, and expensive energy systems,[1] causing health problems and exacerbating climate change.[2]

Across the world, the present industrial structure is formed largely by vertically-integrated utility companies and network operators. With energy systems centrally controlled, these companies have a strong influence over how, where, and at what cost electricity enters our homes.

However, with increasing penetration of micro scale renewables,[3] growing public pressure around climate change, and advances in digital and communication technologies, Verv believes the democratisation of our power systems is rapidly becoming viable.



Verv believes a transition to an empowered and sustainable energy future can be accelerated by focusing on four critical factors at the grid edge:

1) Access to granular information; in particular, understanding the drivers of electrical demand

2) Provision of domestic energy storage

3) Maintaining compatibility with grid incumbents

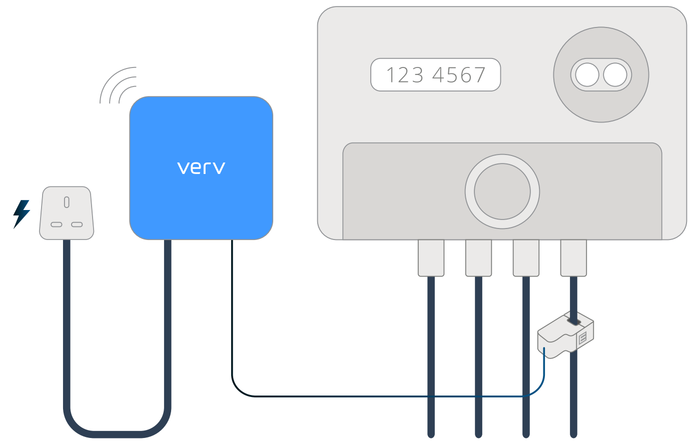
4) Automated and secure trading of energy at the grid edge via a traceable medium, blockchain.

The company believes a peer-to-peer trading platform provides the most effective and future-proof way to democratise our electricity system: by empowering households to sell their excess energy from solar PV or home batteries in an open marketplace, the correct market incentives can be put in place to support a long-term energy infrastructure evolution. Our proposed Verv Trading Platform (VTP) provides a blockchain-powered platform where energy can be traded with low transaction costs. As the percentage of intermittent renewable energy increases to meet our global carbon targets, Verv believes that reducing transaction costs is essential to support the grid-edge trading needed to balance demand against supply.

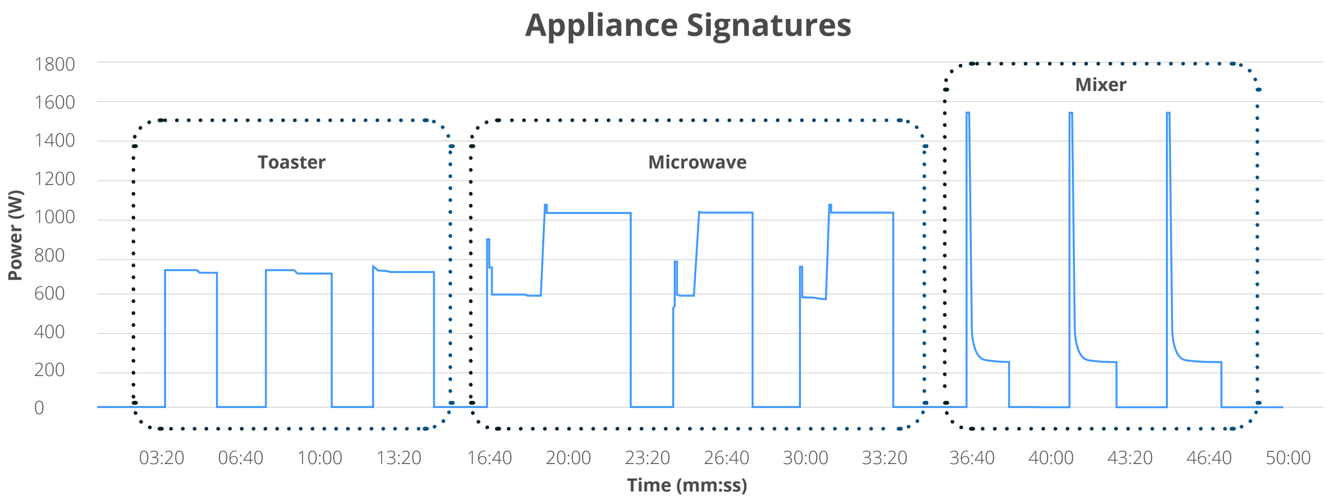
Together, Verv believes the Verv Home Hub (VHH) and VTP present a powerful solution to enable decentralised control and production of energy at the grid edge. The VHH, a patented non-intrusive load monitoring device, is already available for sale in the UK, with further international orders placed. The device combines Verv's ultra-high resolution electricity sampling capability, with an ability to be upgraded to enable peer-to-peer energy trading. Combined with Verv's patented technology for appliance use disaggregation, Verv believes the VTP can provide the most competitive and advanced technological offering for a decentralised energy trading platform.

1.2 Introducing Verv

Verv's core product (VHH) is a patented, self-install energy hub that samples a home's electricity consumption approximately 5 million times faster than a smart meter.[4]



It uses machine learning algorithms to derive a real-time profile for key household appliances – providing homeowners with a view of their electrical appliances' current status (i.e. on/off) and condition (e.g. operating at 95% efficiency).



The next generation VHH with a Consumer Access Device (CAD) is expected to be available for less than £100. VHH has been designed to connect to the cloud via Wi-Fi network and provide users with a central hub for controlling other cloud-connected smart appliances. Verv is starting to build considerable market traction, with hundreds of VHHs already sold, and pre-orders being developed in the thousands from organisations / users seeking:

- A breakdown of their individual appliance costs, their deviation to the UK average, and ROI calculations to recommend upgrades to the latest eco products
- Predictive maintenance alerts for key appliances (i.e. letting you know your fridge is about to break down before it does)
- Control and communication with smart appliances and smart home products like Amazon Echo

The next generation VHH (due for release in Q2 2018) has been designed with a government-standard Zigbee communications chip which will enable it to function as a consumer access device (CAD). This CAD has also been designed to connect directly with smart meters for Verv to be able to control and switch tariffs on behalf of the consumer. CADs are newly-mandated household devices showing actual tariff rates in £ / kWh from the UK national roll-out of smart meters. Combined with consumption pattern data and peer-to-peer energy trading, the next generation VHH is expected to enable each household to procure electricity from the cheapest energy provider.

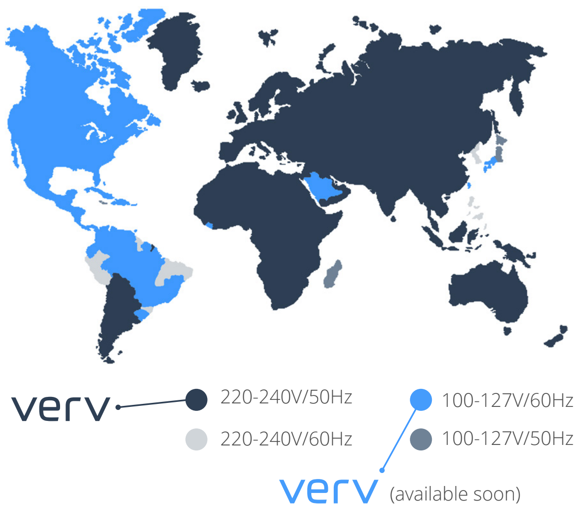
On the rollout of smart meters, Centrica's director of technology was quoted in *The Times* stating,

"What we call a smart meter today is pretty dumb. It's dumb because the amount of signals it takes is like one every ten seconds... When something new comes in [with reference to Verv] we have to recognise there is something better. We have to find a way of opening it up so it can be put in." [5]

The map shows the expected compatibility of the Verv unit globally. Countries shaded in dark blue should in most cases be compatible with VHH, requiring only a plug change for the mains socket where applicable. By the end of Q4 2018, Verv plans to launch a modified system suitable for rollout in the USA and Canada.

The system has been designed so all owners of a VHH can receive a remote firmware upgrade that enables them to start trading on the VTP system.

Active selling of VHHs is an important precursor to Verv's energy trading platform: it provides early adopter feedback, and improves the machine learning algorithm through collecting multiple household usage datasets.



The VHH's advanced disaggregation ability combined with AI has been designed to enable the generation of accurate consumption forecasts generated in real-time. Verv believes these demand forecasts play a critical part in ensuring a smooth transition to a decentralised, bi-directional energy system. Verv believes their existing technology and capabilities in energy data monitoring and analytics provides an unparalleled advantage over current competitors. Where a number of competitor offerings rely on smart meter data to track electricity flows, Verv's patented technology provides ultra-high resolution readings that enable disaggregation of electricity readings, and identification of key electrical appliances in the household.

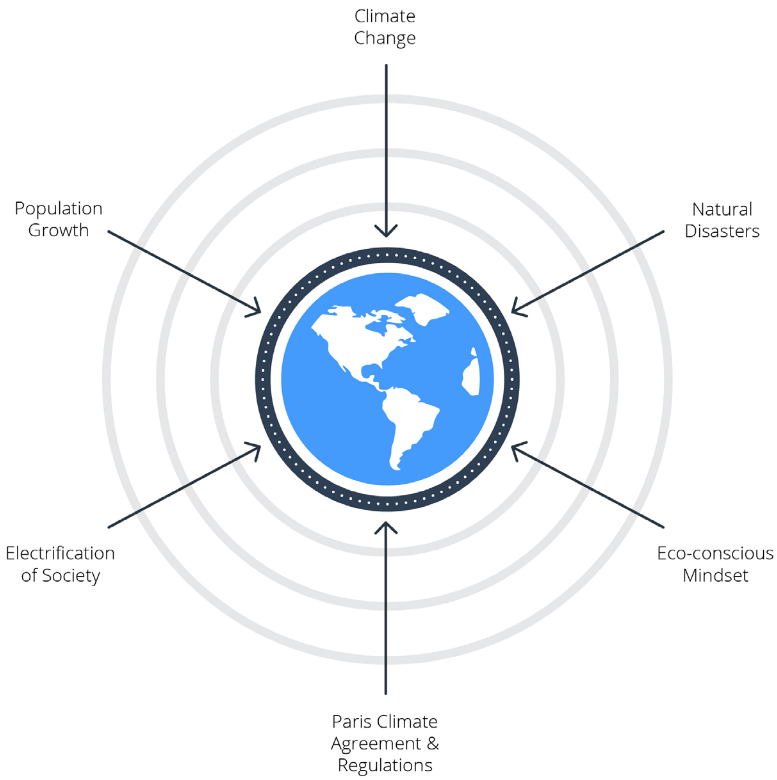
To provide a comparison with the retail industry, the difference is between knowing the total value of customer spend, and having detailed, item-level transaction data for each customer. We believe the former enables rough prediction of how much a customer might spend in the future; and that the latter enables more powerful and accurate predictions that take into account customer purchasing habits, behaviour traits, exogenous factors (e.g., weather, special events), and clustering of customer preferences and tastes.[6]

For example, smart meters would be able to tell 1.5 kWh of energy was used between 12:30pm and 1pm; whereas Verv has been designed to tell whether it was a kettle and a washing machine, or a dishwasher and hair straighteners, as well as how long they were switched on for. With more detailed knowledge of user behaviour, Verv should be able to make better predictions for optimised energy trading decisions.

2.0 - Industry Overview & Market Trends

Over the coming decades, energy systems around the world will face significant challenges from increasing electricity demand, changing sources of generation, ageing infrastructure, and disruptive technologies.[7]

Climate change has been recognised as a global threat, and concerted action to reduce greenhouse gas emissions has led to significant technological developments in renewable technology, electric vehicles (EVs) and electricity storage. The Paris Agreement commits 194 countries to dramatically reduce their carbon emissions, and the impact of climate change mitigation is expected to have profound consequences on electricity systems across the world.[8]



For example, global leaders are actively seeking solutions to the widespread adoption of EVs and electric heat sources, as these will cause significant demand balancing and transmission challenges at critical points throughout the day. Supply is shifting towards a growing base of intermittent renewable power that cannot be switched on or off to meet demand.

Left unaddressed, Verv believes the increased strain on our electricity grid could result in more power outages, higher bills, or both.[9] At the same time, the economic and social cost of just a few seconds power outage is increasing,[10] with an expected growing multiplier effect of negative consequences.

Verv believes a sustainable, secure, and resilient electricity system is critical to the success of any society and economy - particularly as we grow increasingly reliant on technology and our smart devices. Under this lens, changes in supply and demand of electricity could present a significant challenge for the future, as well as a potentially valuable opportunity to upgrade our electricity grid for the 21st century. Governments around the world have acknowledged the need for investment and development of a smart and flexible grid.[11]

Verv believes the future grid should:

- Support the transition towards a smarter, more sustainable and flexible energy system
- Empower consumers to take control of their energy suppliers
- Encourage technologies that allow consumers to generate, store, and trade their own electricity in a cost-effective and affordable way
- Provide opportunities for entrepreneurship and innovation

	Status Quo		Recent changes & Intensifying Trends
Supply of Electricity	Centralised, demand-led electricity generation Electricity losses from long-distance transmission	→	Increasing small-scale, local generation, storage and distribution
	Carbon intensive sources of power	→	Increasing renewable power generation
Demand for Electricity	Variable consumption of energy that fluctuates across the day Globally, 1.1bn without access to electricity	→	Increasing population Increasing demand for and access to electricity Increasing electrification of heating and transportation

2.1 Generation

Historically, electricity generation has been a centralised, carbon-intensive process. Large power plants would generate electricity by burning gas, oil and coal. Scale was critical: larger power plants could be more efficient, so power generation was predominantly centralised by large utilities then distributed to the end user. While such generation has the advantage of allowing supply to follow demand, Verv believes such energy generation technologies are unsustainable in the long-term, which is leading to an increased focus on alternative renewable generation technologies. Governments are also looking to improve security of supply, by increasing domestic generation and reducing reliance on foreign energy imports, which may pose political risks or increase dependencies on foreign countries.

Increasing Renewable Generation

Technological developments in renewable energy (in particular, solar and wind power) have accelerated[12] rapidly to address the growing need for a clean and sustainable source of power. Globally, microrenewables and distributed energy resources (DER) continue to fall in price, reaching price parity with fossil-fuel electricity, and making their widespread adoption accessible to the mass consumer market.[13] For example, rooftop solar in the US is now cost competitive with most utility prices,[14] which has resulted in microgeneration communities emerging across the country, from New York to California. In Spain, renewable energy capacity accounted for more than 45% of total national installed capacity by 2016[15].

These changes have led to a growing body[16] of **prosumers**: households and small businesses, traditionally consumers of electricity, who are now producing electricity. Excess electricity that has not been used by the owners can be fed back to the grid and used by other households. For a typical household with solar panels, 20-40% of energy generated is not used by the prosumers, providing a growing source of grid capacity.[17] While this generation is low carbon, it is intermittent, requiring demand to follow supply. This then requires higher levels of sensing, storage, and control to support successful grid integration.

2.2 Transmission

Energy Losses Through Transmission

Existing transmission infrastructure was built to connect large power stations with households across the country. These large power stations were typically built in remote locations far from densely populated areas as they were dirty (coal) or potentially dangerous (nuclear), posing dangers to human health. Others were situated close to fuel sources (e.g. coal mines) to minimise cost of fuel transportation.

However, electricity transmitted across these distances results in energy losses and greater cost to the consumer. According to the International Electrotechnical Commission (IEC), losses from centralised generators to the consumer ranged between 8-15% because of the 'joule effect', where energy is lost as heat in transmission cables and substation transformers.[18]

Local generation of renewable power can reduce wasted energy, as electricity needs to be transmitted only a short distance before use, reducing the overall cost and increasing the efficiency of the energy system.[19]

The Potential for Blackouts

Further, the traditional electricity grid infrastructure relies on long power cables running across the country, which are vulnerable to disruption from falling trees or adverse weather conditions.[20] One collapsed power line can cause disruption for thousands, and restoration of power can take days. A natural disaster that brings down power lines can disrupt power supplies for thousands of households, lasting days or weeks (see box).[21]

A local, more decentralised energy system could provide an alternative source of electricity during a centralised power outage and could limit the impact of blackouts. Households looking for a more robust and resilient energy supply have already been adopting microgeneration solutions to provide backup power during central power outages.[22]

Estimates show that short blackouts cost the US approximately $110 billion every year.

To highlight just three natural disasters in 2017/8:

- Storm Eleanor caused power outages to over 75,000 homes in the UK and Ireland;
- Storm Irma resulted in blackouts for over 6 million homes in the USA, some left without power for over a week;
- Hurricane Maria left parts of Puerto Rico without power for more than 4 months.

2.3 Energy Consumption

Despite efforts to reduce energy consumption and improve energy efficiency, a growing population and the electrification of transport and heating is expected to increase demand for electricity through to 2050. Total UK domestic annual electricity consumption is estimated to increase from 112 TWh today to 132 TWh in 2050, with peak electricity consumption anticipated to increase from 65 GW today to 85 GW by 2050.[23] Global electricity consumption is set to double in the next 40 years.[24]

Increasing Population

A growing population base should result in higher electricity demand. In the UK, population is expected to increase from 66m to 75m, and in the USA from 320m to 390m by 2050.[25] Globally, population is forecast to grow by 2bn people to 9.8bn in 2050.[26] Importantly, access to electricity is also expected to increase: where 1.1bn are currently without access to electricity, forecasts expect that figure to drop to 400m by 2050.[27]

Electrification of Transportation

By the end of 2018, the cost of owning an electric vehicle (EV) is forecast to reach parity with combustion engines.[28] With driving range extending and charging infrastructure booming, estimates indicate that by 2025, one in six cars purchased will be an EV, building from an existing two million EVs on the road globally.[29] While a growing fleet of EVs will add to demand for electricity, they also present opportunities for providing balancing services. All EVs have a battery which should be capable of removing or providing electricity to and from the grid, according to demand and supply needs at that time.

Electrification of Heating

To meet climate change goals, industry experts believe gas-powered heating systems will need to be electrified before they can be decarbonised. In the UK, for example, National Grid have estimated the number of gas boilers will have to reduce from 22 million today to 7 million by 2050.[30] Many of these boilers will have to be replaced with electrically-powered air, water, and ground-source heat pumps which offer significantly improved heating efficiencies. To reduce their carbon impact, they will have to run on renewable electricity.[31] Verv believes this will to result in an increased demand for electricity, particularly during existing peak hours of demand, placing further strain on existing grid and supply infrastructure.

2.4 Challenges and Opportunities for Tomorrow

Verv believes the convergence of increased intermittent renewable energy generation and higher electricity demand, operating on an ageing transmission and distribution network, poses a challenge for network operators trying to balance supply with demand. Solar and wind power can only be generated when the sun is shining and the wind is blowing, irrespective of electricity demands at that moment in time. The result is a growing operational challenge for electrical power system controllers and increasing strain on grid infrastructure.[32] Left unaddressed, expensive infrastructure upgrades will be required, resulting in potentially higher future energy bills.[33]

There have been a number of proposed solutions to the challenges facing the electricity grid: installing additional battery capacity, increasing local generation of renewable power, developing microgrid solutions, increasing demand response (DR) capability, and developing peer-to-peer trading capabilities.[34]

Of these, Verv believes peer-to-peer energy trading provides the critical service of consolidating these disparate solutions and optimising the economic efficiency of the system. Verv aims to enable participants who develop battery capacity, add microgeneration solutions, or provide DR services to trade their generation and storage capacity on the peer-to-peer platform. Verv believes consumers will be incentivised to use energy at a time that places less strain on the grid, driving a virtuous cycle of additional revenue, engagement and innovation.

Towards a sharing economy and peer-to-peer trading

In recent years, the sharing economy has become the new normal,[35] disrupting many incumbent industries and providing more choice on the market. Where private assets were previously left underutilised, the sharing economy has enabled individuals and households to monetize existing assets, improving resource efficiency,[36] increasing market competition, and providing better outcomes for consumers. AirBnB and Uber have developed global networks of peer-to-peer resource sharing, and many others (HiyaCar, JustPark, Lyft) are following quickly behind.[37]

The success of the sharing economy is also due in part to the customer's interest in provenance and understanding the complete supply chain of consumer items. From chocolate and coffee beans to the latest smartphone, consumers want to know their purchases have been sourced from ethical, sustainable and environmentally-friendly origins.[38] Globally, "Buy Local" has become a powerful slogan for small and growing businesses, as customers look to support communities and individuals, rather than corporations.[39]

As the peer-to-peer, sharing economy becomes more mainstream, its application to the energy sector has already begun in communities around the world.[40] Verv believes the potential benefits of innovation are significant: households can procure their electricity from other households with solar power, for lower prices, more sustainable outcomes, and clear knowledge of where their money is going.

The value of this opportunity is clear. In the past 24 months, several companies (e.g. LO3, Grid+, Power Ledger) have announced plans to develop peer-to-peer energy trading capabilities. Verv's new VTP product will build upon their previous proposals – but with our existing VHH hardware, technology, and ultra-high resolution energy data, Verv is hopeful in its ability to provide a more effective and compelling solution, particularly over competitors using smart meter technology. Through a single product, Verv intends to offer a combined value proposition: providing detailed energy disaggregation information, services derived from the data (e.g. fire safety alerts), and energy trading capabilities.

AirBnb for the electricity sector?

AirBnb has enabled owners of prime real estate to earn money from fully utilising their assets – at the same time providing new accommodation options for other consumers.

In the same way, a peer-to-peer energy trading solution could create new opportunities for local businesses to grow: owners can install solar panels to generate electricity on underutilised land and building surfaces; and batteries can be installed in unused cupboards.

Additional income generated can supplement owners' income, while improving the sustainability of our electricity system. The sharing economy has already generated many new business models, and Verv believes its application to the energy industry presents an exciting new opportunity.

Features and trends	Potential effect	Potential impact on utilities and traditional grid	Potential impact on the individual consumer	Potential impact on governments	How Verv believes a peer-to-peer energy trading solution would help
Increasing population and increasing electrification	Additional demand on grid infrastructure, adding greater pressure to ageing infrastructure	Requires costly infrastructure upgrades resulting in lower profits and higher cost to customers Traditional utilities are more likely to invest in carbon-based generation technologies – due to existing infrastructure and capabilities	Higher electricity bills	Political unpopularity from high energy costs	Better financial incentives would encourage households and small businesses to invest in generation and storage capability, increasing overall system capacity and efficiency
Existing long-distance transmission networks and an ageing infrastructure	Vulnerable electricity transmission network, risking blackouts if disrupted		Higher electricity bills Risk of blackouts and brownouts disrupting day-to-day life	Political unpopularity from high energy costs Risk of blackouts and brownouts disrupting economy and society	Encourage local generation of electricity: reduce load on long-distance transmission networks and provides local backup for electricity in case of blackout
Carbon-intensive generation technologies	Contributing to climate change and environmental impacts		Higher electricity bills and lack of sustainable energy supply options	Political unpopularity from high energy costs Failure to meet international agreements on climate change action (e.g., COP21 Paris agreement)	The majority of small-scale electricity generation is based on renewable technologies, reducing the carbon intensity of electricity generation

3.0 A Peer-to-Peer Energy Trading Solution

Peer-to-peer is not just about social good and sustainability: Verv believes it also makes economic sense. For the majority of households, price is the leading factor that determines their choice of energy supplier. Surveys have shown that cost savings and lower prices are the primary reason for changes in energy suppliers.[41]

In our view, peer-to-peer energy trading presents an exciting option that enables consumers to benefit from their neighbours' excess energy from microrenewables and/or energy storage. We expect the benefits for both parties entering into an energy trading exchange to be significant.

In the UK, households with solar panels are paid 5.0p for every kWh of solar electricity they sell to the grid (an export "feed-in-tariff"). At the same time, their neighbour pays an average 14.3p per kWh to buy electricity from an energy retailer.[42] With peer-to-peer trading, they can potentially meet in the middle, e.g. buying and selling for an average of 11p per kWh, including transmission and distribution fees.

Regulations surrounding transmission and distribution fees will vary significantly by country, and Verv is committed to working closely with government bodies and regulators to introduce appropriate fees given the characteristics of the electricity trade. While current legislation in most countries does not accommodate the ability to determine transaction fees on a trade-by-trade basis, Verv believes there is appetite in the industry to change current fee structures.

Verv believes distribution and transmission fees should reflect the actual use of the network: if electricity is traded locally, within a single building, during off-peak hours, charges should reflect the reduced strain placed on the electric grid. Verv expects Network operators should be aligned with such goals: encouraging local generation and consumption of electricity during off-peak hours will reduce the load on the network.

In our example, the prosumer potentially receives greater income from their renewable power sources and the consumer potentially pays less for their electricity. Therefore, both parties should benefit financially, and the transactive efficiency should be improved, due to shorter distances from power generation to consumption.

While household solar installation has been growing,[43] Verv believes the existing pricing system currently creates disincentives for households to install capacity beyond their single household's consumption levels. California Solar Initiative encourages "right sizing" of installed solar capacity, as net metering regulations stipulate self-generated solar power can only be used to offset energy bills, but not generate additional revenue.[44] In the UK, households that sell electricity to the grid are paid 60-70% less than the retail price of electricity, resulting in a typical return on investment (ROI) of 14 years.[45]

Households can also benefit from installing batteries where time-of-use tariffs (ToU) are available. ToU tariffs (where cost of electricity is higher during peak hours, and lower during off-peak hours) are already widely used in California and Hawaii, and are increasingly common in the UK.[46] With peer-to-peer trading, households should be able to charge their battery during off-peak hours, then sell electricity to other households during peak hours. In doing so, they should have the ability to generate revenue, reduce electricity costs for other consumers, and help the grid to balance its supply and demand.

A peer-to-peer energy solution is designed to enable consumers to buy electricity from each other, encouraging future investment in small scale renewables and battery storage. Verv believes this empowers households to take active control of their electricity supply, create new business opportunities, and support the transition to a more responsive, flexible, sustainable electricity grid.

3.1 Why now and why Verv?

In the past, Verv believes such peer-to-peer energy trading would have been infeasible, due to the complexity of monitoring and confirming energy and financial exchanges. Where assets like spare rooms and parking spaces could be considered comparatively easier to track and control, electricity could be considered much more complex.

Monitoring electricity flows on a second-by-second basis and faster requires complex sensors and advanced data processing. Control of electrical appliances is currently predominantly manual. Electricity consumption occurs every second of the day for 365 days a year, generating an incredible amount of data. Ongoing electricity purchases require an extensive number of transactions, for which Verv believes traditional reconciliation and auditing via intermediaries can be onerous and costly.

However, technological advances in recent years have paved the way to make peer-to-peer energy trading a compelling and exciting reality. In particular:

- Digitalisation of the energy industry and continuing advances in IOT and semiconductor technology (in line with Moore's law) has made ultra-high resolution non-intrusive load monitoring of electricity an affordable reality

- Developments in blockchain technology have provided a means of digitally tracking and authenticating transactions, removing the need for intermediaries who increase the cost of these transactions

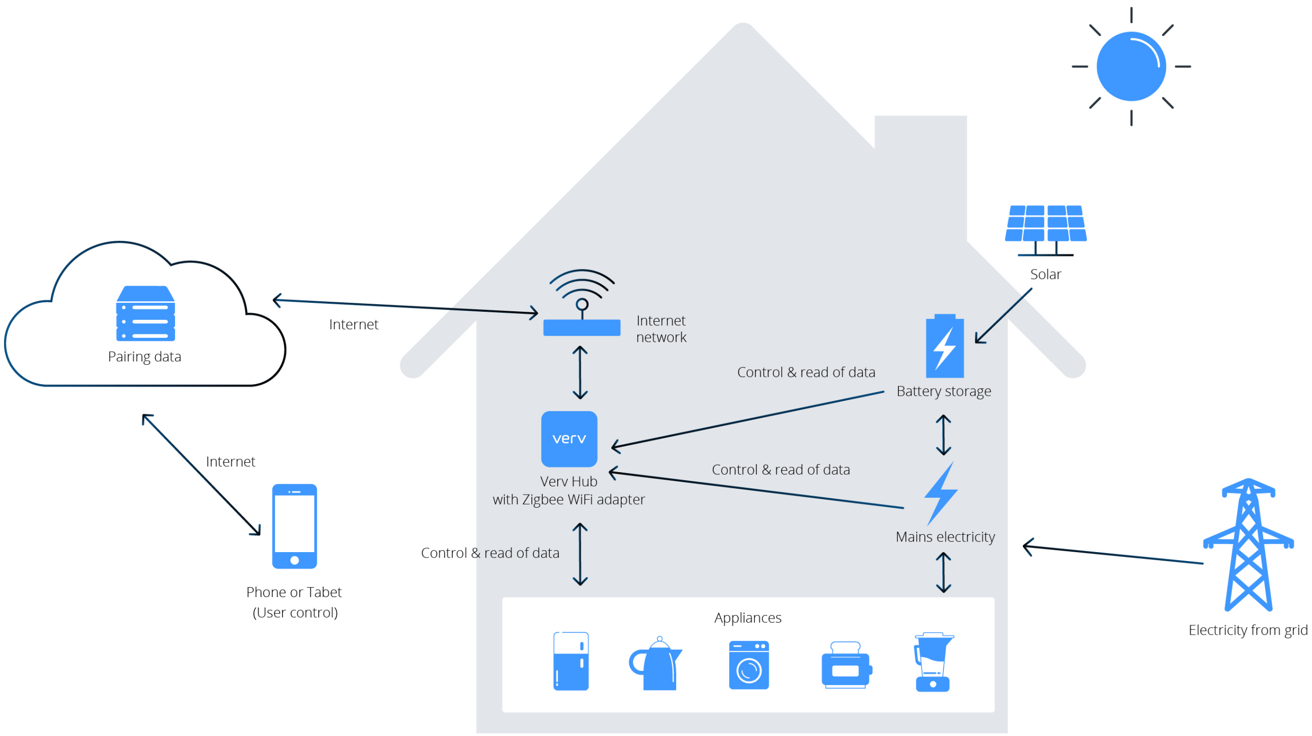
- Advances in deep learning and AI algorithms enable complex analytics on consumption patterns to be generated, enabling accurate predictions of consumption and optimisation of energy trading.

In the following section, we will describe these technological developments in greater detail. Verv believes each of these technologies has reached a level of sophistication and mainstream adoption that has driven down cost, and improved accessibility and ease of implementation.

While Verv shares some characteristics with other proposed P2P platforms, Verv is focused on differentiating itself through high frequency sampling of electricity and applying deep learning AI via the VHH to generate consumption and generation forecasts of an advanced nature, which can optimise the pairing process for energy trades. According to information in their whitepapers, a number of competitors are still developing and testing their hardware needed to enrol customers onto their platform;[47] Verv, on the other hand, already has a commercially-ready hardware unit with corresponding software and data processing capabilities. Having been at the forefront of key data sampling technologies since 2009, Verv has an established track record of accelerating innovation within the energy sector.

3.2 Digitalisation of Energy and IoT

The electricity sector has been undergoing a rapid digital transformation.[48] The recent International Energy Agency (IEA) flagship 'Digitalisation and Energy' report noted that: "Investment in digital electricity infrastructure and software grew over 20% annually between 2014 and 2016, overtaking global investment in gas-fired power generation."[49] Widespread installation of measurement instruments (e.g. smart meters, Verv Home Hubs) and cloud-based communication platforms are facilitating a new, smart ecosystem that could provide autonomous, inter-property exchange.



Broadband and 4G (and soon 5G) are widely available, the cost of connecting is decreasing, and an increasing number of devices are manufactured with built-in sensors. Application programming interfaces (APIs) mean disparate systems can autonomously communicate. For example, Amazon's Echo can be integrated with Hive's Smart Home control systems, so users can ask Amazon's Alexa to switch off the heating, or turn off the lights – without having to go through a Hive interface. These developments provide an opportunity for high resolution data to be recorded in real-time, transferred to the cloud for processing, and the analysis presented to users or automated response systems.

In relation to energy, these technical developments should mean that participants within an IoT network are able to understand (with detailed granularity and without human intervention) how, where, and why their energy is transacting. Combined with control systems, Verv believes IoT extends the technical capabilities of domestic energy storage to 1) connect PV arrays to batteries, and 2) communicate when to store / discharge electricity. Verv believes such control capability will enable users to maximise revenue and ensure their storage requirements are met, while optimising battery life and condition.

In parallel, the market for storage technologies has been expanding. In 2016, the domestic market for storage grew by 284%, and is expected to reach an installed capacity of 40 gigawatts by 2022.[50] Combined with falling costs per kWh of capacity (with some companies expecting to achieve $100/kWh in 2019[51]) and battery advancements in density, compactness and safety, the co-location of storage systems is quickly becoming an essential add-on for households installing small-scale renewables.

Verv believes the VHH is the perfect counterpart to the growing digitalisation of energy, providing industry-leading energy consumption data that is able to inform the monitoring and optimisation of battery usage. For consumers, remote sensing should be able to tell them whether their neighbour's infrastructure has the capacity to supply cheaper electricity; for prosumers, which households have demand for their excess energy.

In combination with its analytical capabilities, the future VHH has been designed to communicate directly with smart plugs and smart appliances, enabling households to control their appliances remotely and/or automatically via pre-set machine-to-machine (M2M) controls. This functionality is expected to enable home energy systems to be programmed to switch smart appliances on/off depending on real-time electricity capacity and prices. Verv believes IoT and AI make executing peer-to-peer energy transactions at the grid edge technically feasible, and an increasingly practical option.

3.3 The Blockchain Future

Current financial transactions rely heavily on intermediaries such as banks and utility companies, who build trust and reliability into the transactional process through authentication and record keeping. Historically, digital transactions for assets (money, stocks, energy) have been particularly reliant on intermediaries as the ability to duplicate digital data (either intentionally or unintentionally), would enable users to spend the same unit of value more than once. In a peer-to-peer transaction, without intermediaries accountable for managing the transaction, it would be difficult for the exchanging parties to authenticate the trades. However, Verv believes blockchain solves this problem.

At its essence, blockchain is a distributed ledger or decentralized database that maintains immutable digital records of ownership and transactions. Instead of a central administrator using a relational database, a distributed ledger has a network of replicated ledgers, synchronized via the internet and visible to anyone within the network. Blockchain networks can be private with restricted membership (like an intranet), or public and accessible to any person in the world (like the Internet). As the trading platform is distributed across multiple nodes, blockchain technology ensures integrity and reliability of the ledger without the need for a third-party intermediary.

Considering the number of transactions and participants in a peer-to-peer energy trading system, Verv believes blockchain is integral to the feasibility of the platform through enabling all parties to minimise transaction costs, improving the economics for all involved.

Verv's in-house team of blockchain developers have developed a blockchain platform, which Verv expects will enable users to trade electricity on the Ethereum platform. The platform has been designed for flexibility, with the intention of allowing additional use cases to be easily incorporated.

3.4 Artificial Intelligence (AI) / Machine Learning

Advances in machine learning and AI have over the past few years transformed many industries, improving predictive capabilities and providing better models of human behaviour. For example, the development of complex machine learning algorithms has enabled retailers to predict customer activity, understand trends in consumer purchasing behaviour, and adapt advertisements and content for customers' individual preferences.

Verv believes these advances can be applied to the energy sector, using algorithms to disaggregate electricity data to appliance use information, and providing better predictions of energy use behaviour. Under this lens, Verv believes machine learning will become a critical enabler for energy trading and the balancing of supply and demand of electricity.

Verv's embedded AI has been designed to build on IoT's passive sensing and control functionality, through deriving patterns and relationships from multiple datasets to guide the flow of energy in its most economical and sustainable form. The datasets Verv's AI has been designed to draw from include:

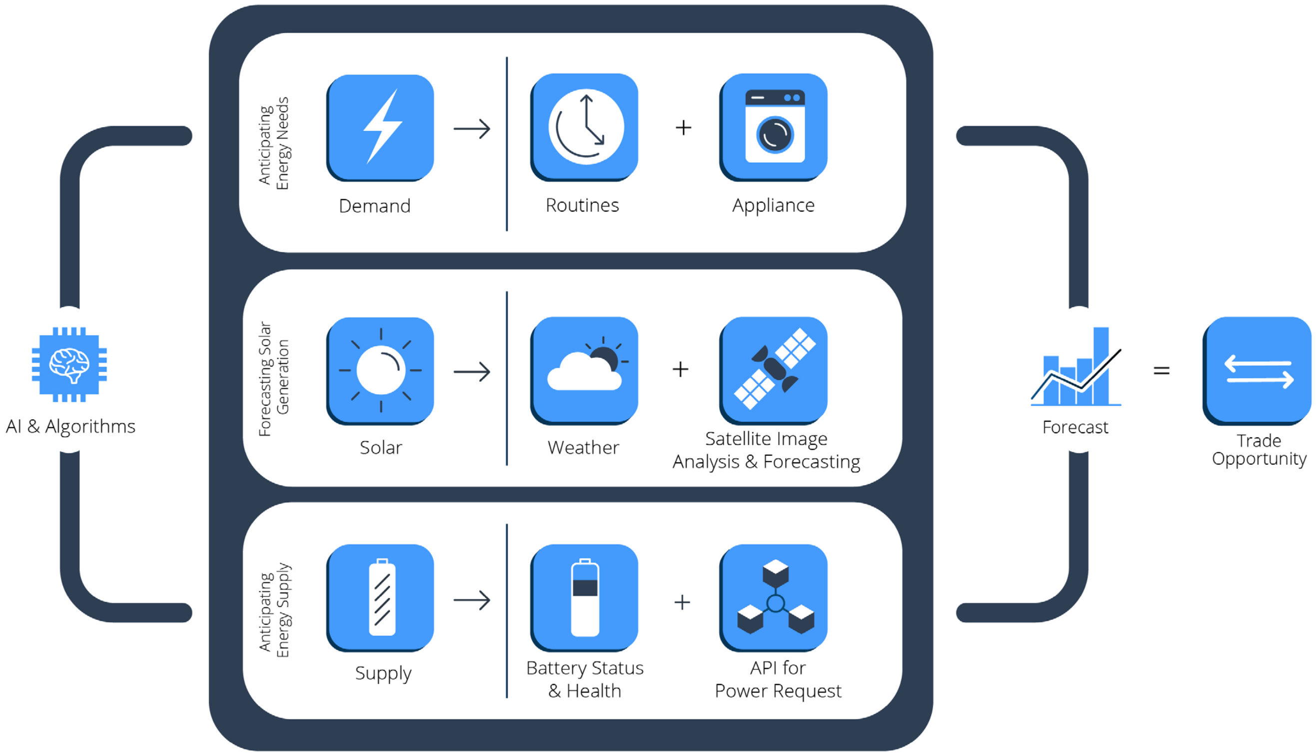
1) Granular detail on household electrical activity, both on i) appliances and ii) microgeneration/storage assets (capacity, performance, state of charge)

2) External factors influencing electricity generation/consumption, specifically weather forecast data, geolocational data, satellite data on cloud coverage and opacity.

Verv has designed the system to process these data feeds with neural networks, which are being trained to identify inter-connected patterns so that Verv's forecasts for generation, consumption, and battery activity can be continuously improved. Verv expects this to result in the efficient utilisation of electrical infrastructure, and therefore provide an assurance that the generated kWhs will be traded at the right time for the best economic return.

To achieve this, the VHH has leveraged key developments in machine learning, particularly deep learning. VHH's existing presence in households means that Verv has an extensive dataset of detailed appliance-level energy usage, enabling it to train powerful models of consumption behaviour.

Further, Verv expects the AI algorithms should be able to learn not only customers' electricity consumption behaviour, but also their patterns of engagement with energy trading. Rather than requiring ongoing input and decisions from the user, it is anticipated that the algorithms will learn how the user interacts with the platform to provide a customised experience that ensures long-term, sustainable customer engagement.



4.0 Introducing the Verv VLUX Blockchain Framework

By combining innovations in machine learning, blockchain, IoT, and energy storage, Verv hopes to lead the development of peer-to-peer energy trading. The VTP has been designed to facilitate trading at the grid edge. Prosumers selling electricity are expected to receive a better payback, incentivising installation of renewable infrastructure and storage; consumers should be able to diversify their electricity supply, purchase energy at lower prices, and may also be incentivised to consume electricity during off-peak hours, or when renewables generation is high, which in turn should mitigate the variability in peak consumption and renewables generation.[52]

Using proceeds from the Initial Token Offering (ITO) and the value of aggregated data, Verv aims to fund a freemium model for the VTP, providing participants the option of using the VTP with no platform cost.

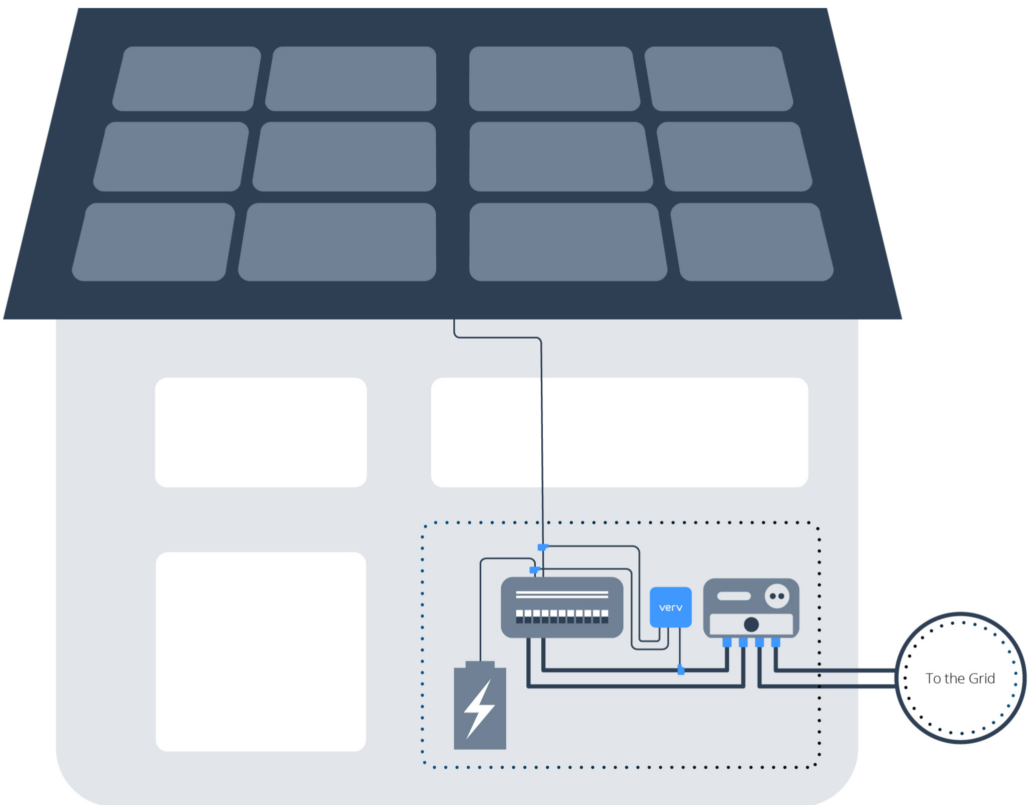
4.1 Getting set-up on the VTP Network: a household's point of view

Imagine a street with 10 houses, where only a few houses have PV panels and electric storage.

At certain points of the day:

- Households with PV panels are generating more than they can consume and are selling the excess to the grid, at an export ("feed-in") tariff of 5p/kWh
- Other households have electricity demand, currently purchasing electricity from conventional energy suppliers at 14p/kWh

After taking into account transmission fees, payable to transmission and distribution system operators, there might be additional margin for prosumers to receive a higher rate for their generated electricity, and for consumers to pay less than 14p/kWh. Furthermore, feed-in-tariff rates have been declining globally, which Verv believes increases the importance of providing households with a peer-to-peer trading alternative. Recognising the imbalance and opportunity, this community implements a system for trading this surplus solar energy.

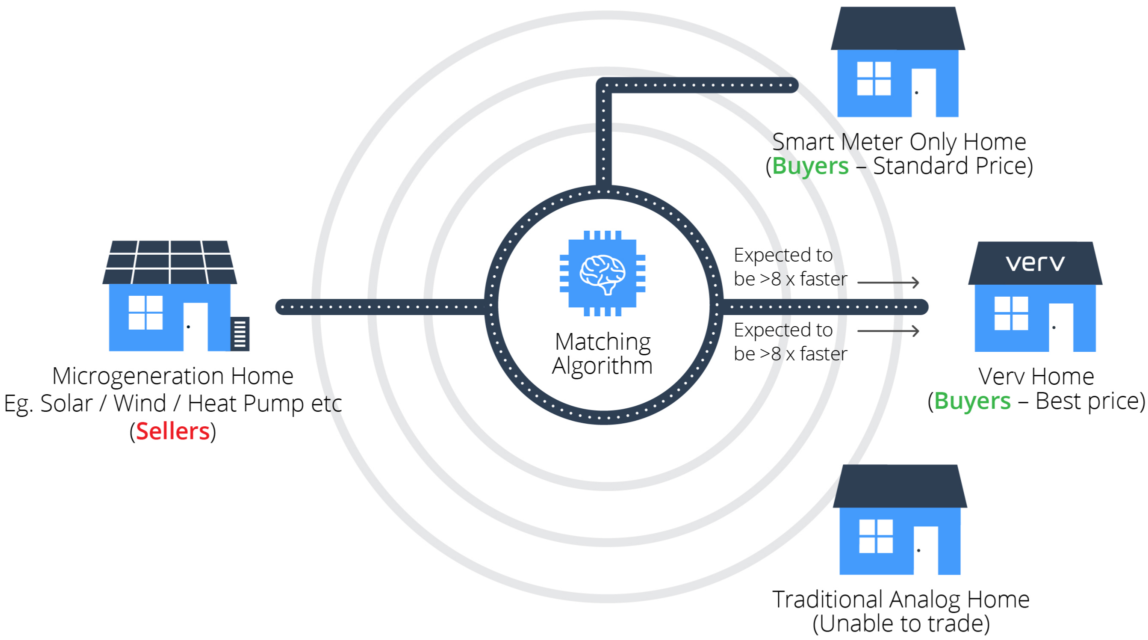


Prosumers within this community install a VHH, with current clamps attached to their main electricity meter, their PV array, and their battery (if present). The Verv app registers the prosumers to the VTP platform.

Consumers within the network can either install a VHH (with current clamps attached to their main electricity meter) or they can use their existing smart meters to initiate a data feed to the VTP.

4.2 Peer-to-Peer trading on the VTP Network

VTP's provision of a premium peer-to-peer trading experience begins with the collection of electricity consumption data to build up a history of each household's electricity use at the appliance level. Verv's expertise in appliance-level power signature identification is expected to produce more accurate, real-time consumption forecasts, resulting in a system with an expected inherent information-first advantage. Verv believes that more accurate forecasts on future energy requirements help the consumers' VTP systems trade faster and further ahead, and should help prosumers' VTP systems maximise their generation/storage assets for maximum economic utility.



To illustrate the trading system, consider just two houses: one with PV/energy storage (Alice) and another without (Bob).

The energy trading process below may appear complex, but in practice it is anticipated that users will simply have the option to set their preferences in the VTP app (if they choose), and we anticipate that all trading will occur automatically without user intervention. In this example, Alice has set her VTP system to ensure her battery always retains at least 50% charge, and the minimum sell-price is 10p/kWh. The VTP algorithms are being designed to automatically optimise trading to maximise revenue and minimise costs.

The software on Alice's system has been designed to recognise that if her battery has no stored electricity, and the solar PV is not generating electricity, she will have to purchase electricity from her electricity supplier for a higher price. Bob does not have generation assets, therefore his system's AI will only be able to consider his future demand forecast.

In order to decide whether energy should be transacted, the Verv AI is being developed to take into consideration:

- Current battery state of charge
- Maximum battery capacity
- Forecast household demand for electricity
- Forecast generation of electricity from solar panels
- Any additional input parameters set by users (e.g. minimum kWh charge of battery at all times, or maximum trade amount)

Step-by-step guide of trade matching algorithm

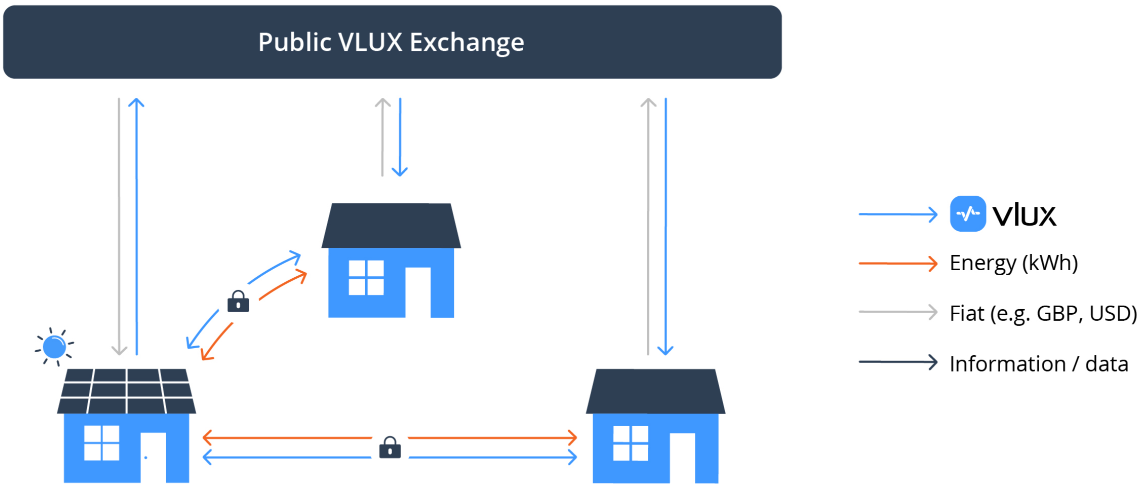
- At 7am, the sun is shining and Alice and Bob's VTP systems begin analysing the next 4-hour period.
- Alice's VTP system highlights a time window during the next 4-hour period where she can sell 1 kWh.
- Bob's VTP system sees this capacity on the blockchain, and as his current cost of electricity from the grid is 14.3p/kWh (average unit cost of electricity in the UK),[53] the system places a bid of 7p/kWh for Alice's surplus.
- Alice's VTP system has already developed an optimal trading strategy for the best usage of her assets, so her system automatically places an ask of 13p/kWh (including associated transmission and network costs).
- During this first period of trading on the blockchain, no match is made.
- Without a match, Bob's system increases his bid. Similarly, Alice's system decreases her ask. This process continues until Alice's system's ask matches Bob's system's bid, and a smart contract is formed.
- Having verified Bob has transferred the required money to the escrow, the VTP's proof of delivery system verifies that 1kWh of electricity has left Alice's house, and 1kWh has entered Bob's house.
- The smart contract executes when proof of delivery has been confirmed: Bob's payment is made to Alice, with any other transaction costs transferred to the relevant parties.

In the example above, trades took place four hours in advance, however, with more data to refine Verv's algorithms, the forecasting and trading time window can increase. Greater forecast accuracy is expected to enable households with Verv units to trade further ahead each day, enabling further optimisation of trading decisions, which could allow households to capture the best prices for their system.

The description above illustrates how a single trade occurs; the following section explains how the trade fits within the larger VTP ecosystem.

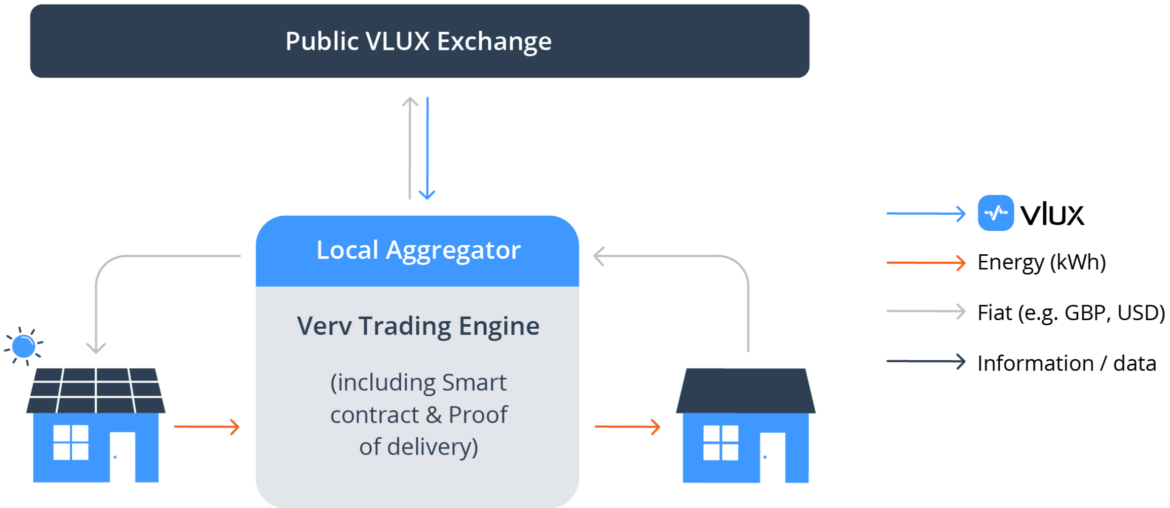
4.3 A system perspective: the VTP and token ecosystem

Consider now a group of houses looking to trade with one another. For peer-to-peer trading to occur without a trusted third party, the community uses a blockchain platform with a smart contract. The smart contract allows two parties to enter in a trade agreement, and for the agreed funds to be held in an escrow while the exchange of energy takes place. However, as fiat cannot be used in the smart contract, each participant will have to trade tokens with a public exchange for use on the platform. Verv has introduced the VLUX token to enable energy trading within the VTP blockchain platform.



The diagram above shows a simplified representation of how such a system would work. However, in this system, each household would have to purchase VLUX tokens from a public exchange continuously, which would incur additional broker / exchange transaction fees.

To avoid this, the VTP introduced local aggregators into the system. The aggregator purchases VLUX tokens from the public exchange and makes them available for prosumer and consumer households to use within their local area. Households will simply have to ensure they have the required fiat funds or billing permissions in their account, and have switched on the VTP trading capabilities. Everything else will be automated.



A more detailed overview of the system is provided below

The ecosystem

VLUX Token

- VLUX tokens will be utility tokens providing participation and reward capabilities within the VTP. Every transaction that takes place on the VTP requires VLUX tokens. Local aggregators are required to stake VLUX tokens to access the platform, reducing token velocity and the number of VLUX tokens in active circulation.

- VLUX tokens will be purchased on the public token exchange by 'local aggregators' to enable energy trading within a local trading community (see below).

- VLUX tokens may be traded on the public exchange for fiat, or they may be redeemed for other goods and services (e.g. in-app upgrades, VHH add-on services), or to purchase VHHs for friends and family. All VLUX token holders will receive a code for 10% discount off the retail price of a VHH at the conclusion of the main token sale.

- VLUX tokens can also be provided as reward for developing VHH and VTP capabilities, in innovation contests, or for winners of Verv-hosted hackathons.

- Some percentage of proceeds from platform fees will be exchanged for VLUX and could be potentially burned in a smart contract. Burning VLUX will increase the scarcity of the tokens.

- Through a local aggregator, consumers and prosumers are not required to purchase VLUX tokens directly from a token exchange to participate on the platform: any interaction with VLUX tokens will be automated through the VTP software. As prosumers and consumers exchange fiat and VLUX tokens instantaneously at spot prices, they should not be exposed to volatility in VLUX token prices.

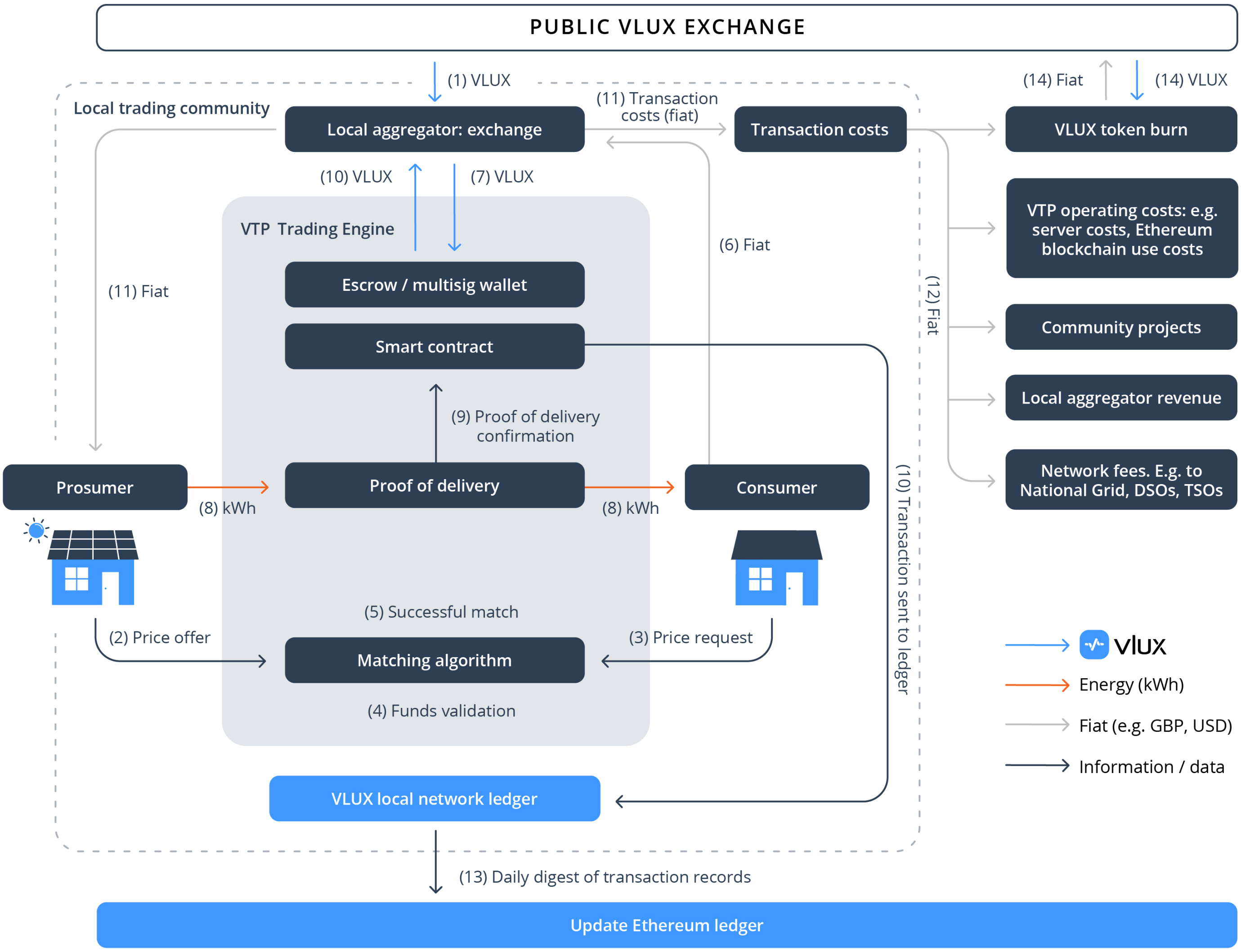
- In the long term, if, as expected, electricity systems become more deregulated and regulations change to accommodate peer-to-peer trading, prosumers and consumers will be able to buy VLUX tokens directly to trade with one another. If they choose to, they will be able to purchase VLUX tokens and create/join their own user communities.

Local Aggregators

- Local aggregators provide a broker function for each local trading network, enabling prosumers and consumers within their network to trade electricity on the VTP. Local aggregators provide VLUX tokens for households to use within their local trading community.
- Local aggregators can be, for example, utility companies (e.g. British Gas), commercial electricity generators (e.g. AWS Power, Orsted Energy), or community groups (e.g. Hackney council housing blocks).
- Each local aggregator community will contain approximately 100-500 households; if the community grows beyond 500 households, it will be split into two communities according to households' postcodes, etc. By capping the size of local communities, this limits the size and complexity of the local blockchain ledger. These communities are expected to be local in order to minimise grid transmission costs.
- Local aggregators can set a local aggregator fee for all transactions that take place within their local trading community.
- The system will allow real-time trading across multiple local communities and aggregators should they choose.

Prosumers & Consumers

- The interaction of the prosumers and consumers with the VTP is intended to be as minimal as possible. Users will have to opt-in to the VTP, and may set some parameters (e.g. trade only PV energy, battery maintains at least 50% charge). All further trading will be automated, without intervention from the user.
- Prosumers and consumers' devices agree a trade in fiat (e.g. USD, GBP), however, the transaction will require VLUX tokens to be executed: this will occur behind-the-scenes, without prosumers and consumers needing to be aware of the use of VLUX tokens.
- As the VHH generates more energy use data, the VTP's neural network algorithms adapt to user behaviour and preferences, providing a consistent trading experience, increasing product relevance, and avoiding user disengagement.
- The first 200,000 VHHs will be sold with an amount of VLUX tokens pre-loaded. These tokens can be exchanged for credit when the user joins the platform, or used to redeem a range of Verv in-app upgrades providing additional services and functionality.


PUBLIC VLUX EXCHANGE
(1) VLUX
Local trading community
Local aggregator: exchange
(11) Transaction costs (fiat)
Transaction costs
(14) Fiat
(14) VLUX
VLUX token burn
(10) VLUX
(7) VLUX
VTP Trading Engine
(6) Fiat
VTP operating costs: e.g. server costs, Ethereum blockchain use costs
(11) Fiat
Escrow / multisig wallet
(12) Fiat
Community projects
Smart contract
Local aggregator revenue
(9) Proof of delivery confirmation
Network fees. E.g. to National Grid, DSOs, TSOs
Prosumer
Proof of delivery
Consumer
(8) kWh
(8) kWh
(10) Transaction sent to ledger
(5) Successful match
(2) Price offer
(3) Price request
Matching algorithm
(4) Funds validation
vlux
Energy (kWh)
Fiat (e.g. GBP, USD)
Information / data
VLUX local network ledger
(13) Daily digest of transaction records
Update Ethereum ledger

To illustrate the VTP trading in greater detail, consider a single local aggregator in the diagram above. Note that we anticipate that steps 2-12 will be automated by the Verv trading engine, and will not require active input from any of the participants (i.e. prosumers or consumers).

(1) First, a local aggregator will have to create a local trading community. A local aggregator purchases VLUX tokens from a public token exchange.

(2) With an established local trading community, consumers and prosumers are able to trade with one another. A prosumer has a kWh energy surplus and the VTP automatically places an offer ("ask") to the matching algorithm to sell a kWh at a particular price, which includes any associated transaction costs.

(3) A consumer has a kWh energy requirement and the VTP automatically places a request ("bid") to the matching algorithm for a kWh at a particular price.

(4) On receiving a request, the matching algorithm validates that the consumer has the funds, either via prepaid fiat in the consumer's VTP wallet, or via a billing relationship, to pay for and fulfil the request for 1 kWh.

(5) On a successful match of requests, the order is sent to the trading algorithm for fulfilment.

(6) Energy trading within the VTP must take place with VLUX tokens. The consumer sends the agreed amount in fiat to the local aggregator, and the local aggregator provides VLUX tokens to enable the transaction.

(7) The consumer's VLUX tokens are held in escrow until exchange of energy has been verified.

(8) A kWh is sent from the prosumer to the consumer.

(9) When this exchange is confirmed by the VTP (through "Proof of Delivery"), the smart contract executes the transaction.

(10) VLUX tokens are released from the escrow. The VLUX local community ledger is updated.

(11) The corresponding amounts of fiat are sent to the prosumer and the local aggregator to cover grid and transaction costs. Operating fees cover any server, processing, and Ethereum blockchain costs associated with the transaction. Where the local aggregator has an established relationship with transmission and distribution operators (e.g. if they are an existing energy retailer), they may decide to pay the electricity transmission and distribution costs directly.

(12) All relevant fees are distributed to the involved parties, e.g. network fees, local aggregator fees, tax, and Verv platform costs.

(13) On a daily basis, the VLUX local community ledger publishes a digest of all transactions to the public Ethereum ledger.

(14) Verv plans to operate a freemium model for the VTP. A portion of fees collected from paying users will be committed to community, not-for-profit projects, and/or will be exchanged for VLUX tokens to potentially be burned.

Note that VLUX tokens are returned to the local aggregator by the end of the trade, so they will not need to continuously purchase VLUX tokens.

Where appropriate, trading may occur with digital representations of tokens or fiat, to accommodate the technical requirements of the platform.

4.4 The development of the VTP platform

The current depiction of the VTP platform illustrates energy trading between households within the same local trading community. However, the goal of the platform will be to integrate all participants such that generated electricity can always be traded on the VTP, reducing the likelihood of a non-match.

Trading between participants will occur according to a hierarchy that optimises for transactive efficiency, taking into account network relationships.

For example, the hierarchy might be:

Trade within same housing block, with same electricity retailer

Trade within same housing block, across different electricity retailers

Trade within same distribution network, with same electricity retailer

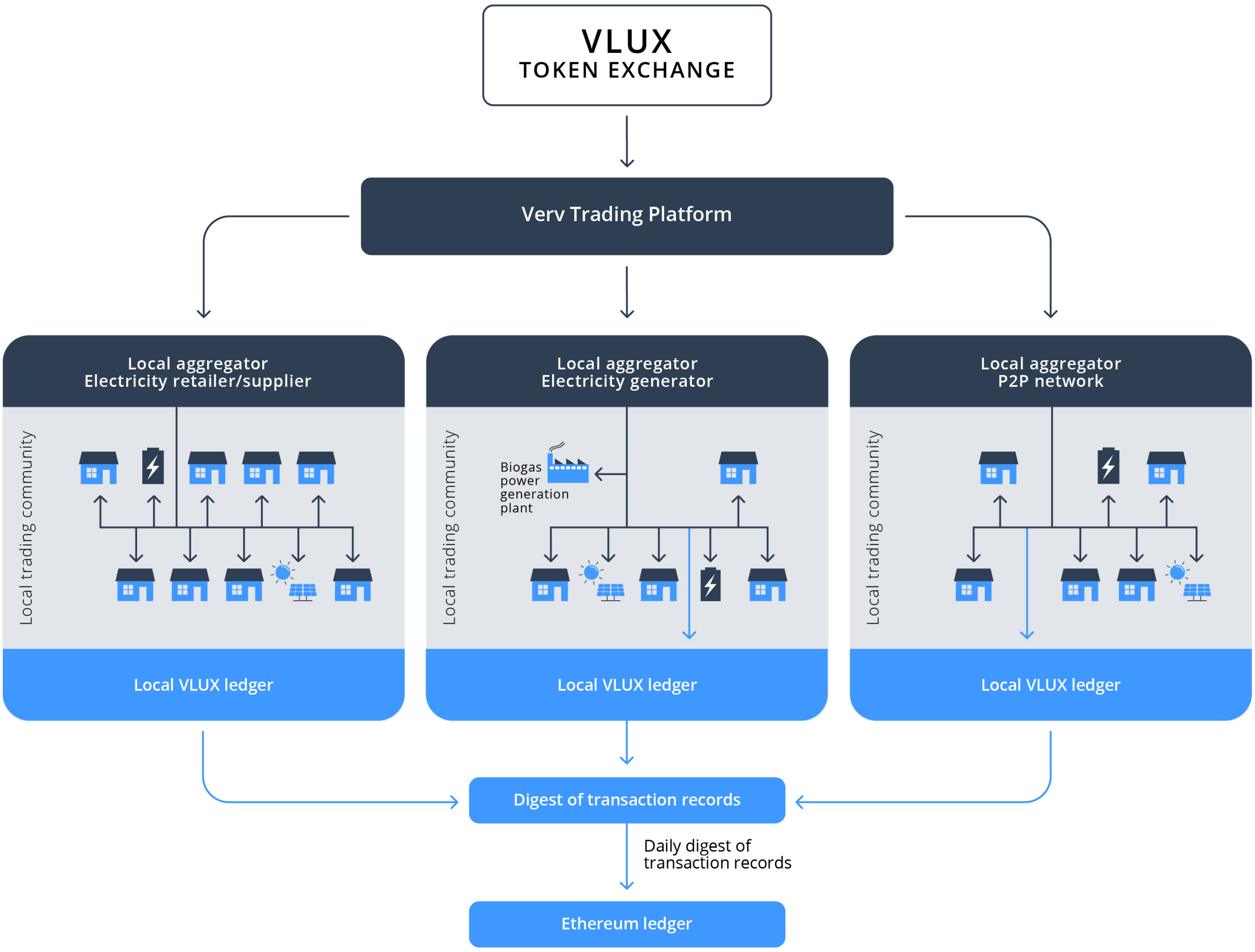
Trade within same distribution network, across different electricity retailers

Trade across different distribution networks, with same electricity retailer

Trade across different distribution networks, across different electricity retailers

Verv intends for the platform to be flexible and easily scalable. Verv believes the aggregator model enables the platform to be customised for varied use cases, e.g. used by electricity retailers vs. housing estates vs. EV charging, while using hash functions and transaction digests to reduce the volume of data stored on the public Ethereum ledger.

As the platform develops, more transactions take place, and more participants join the platform, Verv will adapt the VTP to accommodate new use cases, which will affect the value of the token. In the future, Verv plans for a minimum committee of five experienced specialists (including industry experts and academics) to manage the VTP. This may include a further token burn and mint function, modified smart bonds, or a staking function.



VLUX
TOKEN EXCHANGE
Verv Trading Platform
Local aggregator
Electricity retailer/supplier
Local trading community
Local VLUX ledger
Local aggregator
Electricity generator
Local trading community
Biogas power generation plant
Local VLUX ledger
Local aggregator
P2P network
Local trading community
Local VLUX ledger
Digest of transaction records
Daily digest of transaction records
Ethereum ledger

4.5 VTP Platform Technical Details

For VTP's initial system, the platform will use the Ethereum blockchain to create smart contracts and verify the ledger. The system has been designed to allow for a flexible transition in the future to the optimal stack and toolset depending on the reliability and access speed required.

Ethereum is Verv's current blockchain of choice due to its global traction, high calibre team, and flexible, open source software. Verv's customised version of the Ethereum blockchain maintains immutability of trading records through digesting all VTP token activity back to the public Ethereum blockchain. We have designed the system with the intention of being able to adapt the VTP from Ethereum to another public blockchain platform in the future.

We are planning to utilise a Proof of Authentication framework to validate blocks on the local community ledger. Initially, local aggregators will be able to act as the 'authenticators' and will be rewarded for validating blocks and penalised for not validating blocks correctly.

Top Layer		
Graphic User Interface (GUI)	APIs	Customer Accounts

Middle Layer		
Web3	Custom Energy Prediction Engine	Solar Irridation Prediction Engine
Smart Battery Controller Engine	VHH Core Engine	Oracles
Trading Strategy Engine		

Lower Layer
Ethereum Blockchain Custom Built

Technology Details

- Programming languages: Python, JavaScript
- Smart contracts written in Solidity
- ERC20 token standard

System Security

- 256-bytes encryption for data transfer from AWS to VHH
- SSL certificate security
- Transactions processed on the box, mitigating exchange tamperability
- Operating System and memory on VHH are encrypted by AES
- Multi-key signature capabilities for customer accounts

Frequently Asked Technical Questions on VTP

> How does Verv avoid the problem of network congestion on the blockchain ledger?

- Because of the local aggregator model, it is expected there will be a limited number of people trading within each blockchain. Each local community is forecast to consist of 100-500 households: as uptake increases, more communities will be automatically created based on geography.

> How is the system expected to verify the energy transfer has taken place?

- Our proof of delivery is in the Verv system and it is done by using the Verv current clamps to monitor the battery, solar PV, and home's electricity meter (or smart meter).

- In this, Verv may function as a notification service provider, (similar to an Energy Contract Volume Notification Agent (ECVNA) in the UK). Using the VHH's energy monitoring capabilities, Verv will be able to track the flow of energy through the main meter, distributed energy sources, or any installed batteries.

- We are using a proof of delivery method which should be able to monitor and verify that the energy has been transmitted from one premise to another, helping to reduce the risk of tampering. The verification needs to combine the feed-in-tariff with the solar output and battery charge/discharge data and monitoring.

> How much does it cost to transact on the VTP blockchain?

- There is the cost associated with VTP digesting its data back to the public Ethereum blockchain, and which is covered by Verv's transaction fees.

- The electricity cost of running the current VHH, which already provides all the energy saving tools and individual appliance breakdowns plus the existing blockchain operates at approximately 2.5 watts, will be absorbed in the consumer's electricity bill, costing approximately£4/year. The VHH Real Time Display is expected to save homeowners an average of 10% in energy bills through behavioural changes, eco product and efficiency recommendations. With advances in distrubuted ledger technology, we are expecting individual blockchain nodes to decrease their power requirements for running the blockchain over time.

4.6 Additional VTP applications

The previous sections have illustrated the value of the VTP for peer-to-peer trading; however, applications can be more diverse, with other stakeholders participating in the system. For example, electric vehicles charging providers may be able to act as aggregators, and distribution network operators can purchase bespoke demand response services from the VTP. The VTP has been designed with the intention of providing a flexible and multi-purpose platform, which Verv believes will provide a future-proof solution to the forthcoming changes to the energy sector.

Electric Vehicle (EV) charging

By 2025, industry experts estimate that one in every six cars will be an EV.[54] With such rapid adoption, their integration with the electricity grid is forecast to become increasingly important. First, the grid will need to accommodate the additional demand for electricity required to charge EVs. Second, EV batteries can provide critical balancing services to support distribution system operators (DSOs).

The development of a vehicle-to-grid (V2G) network could enable energy stored in EV batteries to support the electricity network when demand is high, and for EV batteries to be recharged during times of low demand. Bidirectional energy flows from EVs to the grid could provide additional grid stability and greater system resilience. V2G networks are being tested globally, with projects underway in countries from Germany and Denmark, to the USA.[55] In the UK, the government has committed to providing almost £30m of funding to develop V2G technologies,[56] and UK Power Networks is currently running four projects to test the viability of V2G technologies.[57]

The management of EV charging infrastructure is expected to be critical. It is expected that charging providers will need to co-ordinate a large network of charging nodes, which may be owned by a number of independent actors.[58] EV owners may be able to set a range of parameters to ensure their requirements are met, for example:

- Battery has a minimum level of charge (e.g. to complete a specific trip from work to home)
- Battery only charges during certain time periods (e.g. during off-peak hours between 1am and 5am)
- Battery only charges at a slower rate (to spread draw from grid over a longer time period)
- Battery charges in specific locations that have lowest grid demand

Verv plans to provide valuable support in:

- **Providing a central marketplace and platform** for charging providers, prosumers, EV owners and DSOs to co-ordinate prices, demand, capacity, and demand response (DR) services
- **Monitoring batteries state of charge:** providing EV owners with a view of their current battery state / vehicle range
- **Optimising battery charging/discharging:** balancing the requirements of an EV owner with optimum charging patterns for the EV charge provider
- **Streamlining the transaction process:** providing a low-cost, efficient, and automated means of settling transactions for each charging/discharging event

Charging providers may be able to become an aggregator and EV owners may be able to pre-purchase energy on the VTP platform and trade energy throughout the day, optimising for prices, grid demand, and their specified requirements. They may also be rewarded for parking their cars in areas of excess demand or excess supply, to provide additional local battery capacity – similar to Uber's use of surge charging in peak geographical areas.

DNO / DSO services

Distribution network operators (DNOs) are responsible for maintaining distribution infrastructure. With increasing local renewable electricity generation needing proactive management, their role has expanded to include systems operations through new digital toolkits that communicate between the network's main nodes.[59]

Distribution system operators (DSO) provide a medium for grid participants to be financially compensated when supporting a balanced network. For example, 1) Incentivise reduced consumption (i.e. ensuring key electrical appliances are turned off at peak demand points throughout the day), 2) incentivise micro renewables actively feeding back to the grid, 3) incentivise consumers to place increased draw on the grid through turning on their high draw electrical appliances, 4) incentivise those with storage systems to manage their charge/discharge in consideration of the wider network.

With the VHH's AI capabilities and ability to provide ultra high-resolution, real-time data, Verv is hoping to be able to provide DSOs with real-time updates and forecasts for electricity demand, microgeneration, and storage utilization. Detailed electricity data and accurate consumption and generation forecasts can help DSOs reduce operational costs by enabling them to utilise lower cost demand response capabilities. Through the VTP platform, DSOs could financially incentivise householders to turn on/off key household appliances and storage facilities throughout the day, to ensure the network is balanced based on its current generation activity. As smart plugs and smart appliances become more common in households, automated domestic demand response is anticipated to be a powerful service that can significantly support DSOs in managing network constraints, avoiding network reinforcements, and balancing the grid.

Carbon monitoring

The VTP is being designed to track every kWh of electricity traded on its platform, from point of generation to point of consumption. With its electricity monitoring, verification process, and immutable blockchain ledger, Verv should be able to provide monitoring and reporting services for organisations' electricity consumption, renewable generation, and EV fleet usage.

The robust supply of information accessible to anyone within the commercial VTP framework can potentially support carbon traders and provide organisations looking to offset their carbon with a verified source that should stand up to regulatory scrutiny. The reporting process may also provide automated carbon emissions reporting for compliance with government environmental schemes, such as ESOS (in the UK), and ISO 14000.

Microgrids

Microgrids are localized groups of distributed energy sources and loads that typically connect to and operate in parallel with incumbent centralized grids (macrogrids). Traditionally, they have been co-ordinated according to geography or function (e.g., a university campus, residential neighbourhood). Fully disconnected microgrids are referred to as islanded.

Microgrids are expected to play an increasingly important role in government energy policy,[60] due to their ability to provide energy resilience and mitigate against a community's vulnerability to power outages, ageing grid infrastructure, and exposure to energy imports. Investments in microgrids are expected to grow at a CAGR of 12% (2016-2022)[61], and with 1.1 billion people lacking access to electricity globally, estimates suggest 50 to 60% of additional generation required will be supplied by microgrids.[62]

However, in order for microgrids to be globally scaled and considered a reliable backup to centralised grids, the issue of autonomous voltage and frequency control must be overcome.[63] This occurs when the microgrid becomes unbalanced (i.e. power not being generated at the same rate as demand), and the system's voltage frequency deviates its target value. Communities will require dedicated microgrid controllers to ensure voltage and frequency control is managed.

Verv believes the VTP and VHH monitoring can help to manage autonomous balancing, providing critical services to support the roll-out of microgrids across the world.

Tokenisation and monetisation of data

Verv believes the combination the VTP and the VHH will generate extensive amounts of data which should be of significant value to many stakeholders, for example, utility companies, energy traders, consumer companies (e.g. Amazon, Samsung), and distribution and transmission network operators.

As the VTP platform develops, energy consumption data and energy transaction data could be tokenised and integrated into the VTP. With the VHH's ability to disaggregate energy use by appliance, the VTP will have access to extensive datasets on appliance use within households, for example, appliance performance, reliability, and patterns of usage.

Currently, appliance manufacturers sell electrical appliances to retailers and have limited visibility on how the appliances are used in their customers' homes, but the VHH could provide manufacturers with great insight into appliance use and performance beyond the factory door.

Furthermore, detailed patterns of appliance-level energy consumption can provide distribution and transmission network operators with more accurate predictions of electricity requirements, and therefore optimise electricity generation and storage accordingly. It could further enable them to segment customers according to appliance use patterns and, for example, encourage energy use behaviour changes that support the grid balancing requirements.

Verv believes that energy use data and energy trading data have significant value that is currently under utilised and under recognised. The combination of the VTP and the VHH provides the ability to unlock this value, and the tokenisation of data allows for easy access to these datasets.

Households who are willing to share their anonymised data, and individuals and organisations who provide data cleaning and processing services could be rewarded in VLUX tokens; organisations may purchase energy use data or information using VLUX tokens. Verv intends to fully integrate the VLUX platform with energy data. Households, companies, and organisations who wish to sell or purchase data will be required to stake VLUX tokens for access to the platform, and VLUX tokens are required to purchase data.

All data has been designed to be anonymised and Verv will take the utmost care to ensure that all data protection laws and regulations are adhered to.

5. VTP Business Model

If the ITO is successfully closed, Verv intends to develop a freemium business model, which would provide all users the option of accessing the platform for free, with the option of purchasing additional features, services, or capabilities. In the long term, we estimate costs will be c.1% of total transaction value.

5.1 Value Propositions

Verv believes the VTP will have many applications and benefits for a range of stakeholders within the energy ecosystem. The benefits of peer-to-peer trading combined with Verv's high resolution electricity data extends beyond households and prosumers, to network system operators and electricity suppliers.

A summary of key stakeholders and how Verv believe they will benefit from the VTP is shown below:

Stakeholders	Benefit
Households – consumers	• **Bill savings:** Verv estimates consumers will save approximately £50 per annum from existing electricity bills (exc. cost of hardware device) • **Incentivise local generation of energy**
Households / SMEs – prosumers	• **Additional revenue generation:** Verv estimates owners of 4kW solar microgeneration units should be able to earn an additional £40-70 p.a. • **Reduces payback time:** better monetisation of surplus kWhs over the feed-in tariff
Small scale generators	• **Additional revenue generation:** revenues are expected to be higher than those received on the wholesale electricity market • **Reduces payback time:** improved profits are expected over wholesale market prices
Community groups	• **Promotes social cohesion:** prosumers and consumers can support community programmes, schools, community buildings etc. by selling or buying electricity from community groups • **Improves community electricity resilience:** encourages installation of community microgeneration and storage, providing emergency electricity provision during blackouts
Retail energy suppliers	• **Reduces bad debts:** as the VTP is token-based and users purchase tokens in advance of use, bad debts are expected to be reduced for trades on the platform • **Real-time billing reconciliation:** blockchain transactions are expected to be verified on an on-going basis, helping to remove delays between electricity consumption and billing • **De-centralised platform for local, sustainable electricity:** VTP provides a de-centralised source for purchasing electricity with verified provenance
DSOs / DNOs / System Operators	• **Condition monitoring and predictive maintenance:** Verv's high frequency sampling of electricity generates advanced power quality information (e.g. information on voltage frequency / harmonics), which can be used by network and system operators to pre-empt potential problems before they occur • **Capacity, balancing and DSR services:** VTP is expected to function as a central platform of supply and capacity which can provide additional capacity, network balancing and demand response (DR) services

Government / Regulators	• **Meeting decarbonisation targets:** improved incentives for renewables generation will encourage installation, helping to meet decarbonisation targets • **Increased consumer choice:** greater competition in what may be considered a traditionally concentrated market in many countries, resulting in more choice and better outcomes for consumers
Additional use cases	• **EV charging payment solution:** EV charging providers should be able to use the VTP to make payments between charging infrastructure providers, electricity generators, and EV users • **Microgrid balancing and monitoring services** • **Carbon accounting services:** with a comprehensive view of the provenance of electricity and kWh traded, the VTP should be able to automate carbon reporting and accounting for companies and organisations

5.2 Customer Segments and Distribution Channels

Verv believes early adopters are most likely to be:

1) Those who will benefit most economically from VTP utilisation (i.e. users with microgeneration or energy storage)
2) Sustainable / eco-conscious communities with existing microgeneration
3) Low-income / price-sensitive households
4) Early-adopters of cutting-edge tech products

The roll-out for VHH and VTP is expected to be co-ordinated such that VHH customers can further reduce energy costs by sourcing competitively-priced and sustainable electricity on the VTP, while the VTP will benefit from a growing VHH user base and more participants on the platform.

We are in the process of developing key relationships across our core distribution channels, and which should enable rapid access to a large group of users, who are most likely to benefit or take interest in the VTP.

Early adopter clusters	Anticipated benefit of Verv product offering	Planned VHH distribution channels
1) Users who benefit most economically from VTP utilisation	• VTP should increase income from renewable and storage assets • VTP should reduce payback time for further investments	• Battery and home storage solution providers (e.g. Tesla's Powerwall, Powervault) • Solar panel installers (e.g. SolarCity)
2) Sustainable / eco-conscious communities with existing microgeneration	• VTP should increase income from microgeneration sources and improve the business case for installing more renewable and storage capacity • VHH should help community households use less electricity and save money	• Community groups (e.g. Repowering London) • Community-based organisations (e.g. schools and hospitals)
3) Price-sensitive or low-income households and small businesses	• VHH should help households consume less electricity • VTP should help households source the cheapest electricity	• Insurance companies • Utility companies / energy suppliers (e.g. British Gas, Good Energy, Ecotricity) • Community groups
4) Tech early-adopters	• VHH and VTP should provide industry-leading cutting edge technology in NILM, data disaggregation, blockchain & AI	• Direct to customers (B2C) via online retailers (e.g. Tesco Direct and Amazon) and in-store sales (e.g. electronic retailers)

Progress in the UK

Building on the successful launch of the VHH, Verv has already established relationships with retailers and key distribution channels. In particular:

- **Utility companies:** Verv has received funding from Centrica (owners of British Gas) and is in the 'proof of concept' trial stage with a number of electricity retailers looking to provide their customers with a VHH
- **Insurance companies:** Verv is in advanced discussions with a number of international insurance companies looking to provide their customers with a VHH. With the VHH's ability to disaggregate electricity use, it could help households identify when electrical appliances have been left on or are malfunctioning, preventing fires before they start
- **Retailers:** VHH is already available for sale on Amazon and Tesco Direct's online stores
- **Battery providers:** Verv has partnered with Powervault, who will provide batteries for a peer-to-peer energy trading trial in Hackney, London
- **Community groups:** Verv is working in collaboration with Repowering London to trial a peer-to-peer energy trading trial in a community housing estate in Hackney, London

We anticipate a growing market for peer-to-peer energy trading, as the number of renewable domestic installations in the UK continues to rise: currently there are over 800,000 properties with PV panels in the UK, and this is expected to continue growing at 30% year on year.[64]

Beyond the early adopter phase, Verv will focus on developing partnerships with providers of essential householder services: internet and phone providers (Virgin Media, Sky), water companies, local councils, and major utilities. At this point, Verv plans to offer channel partners a white-labelled app.

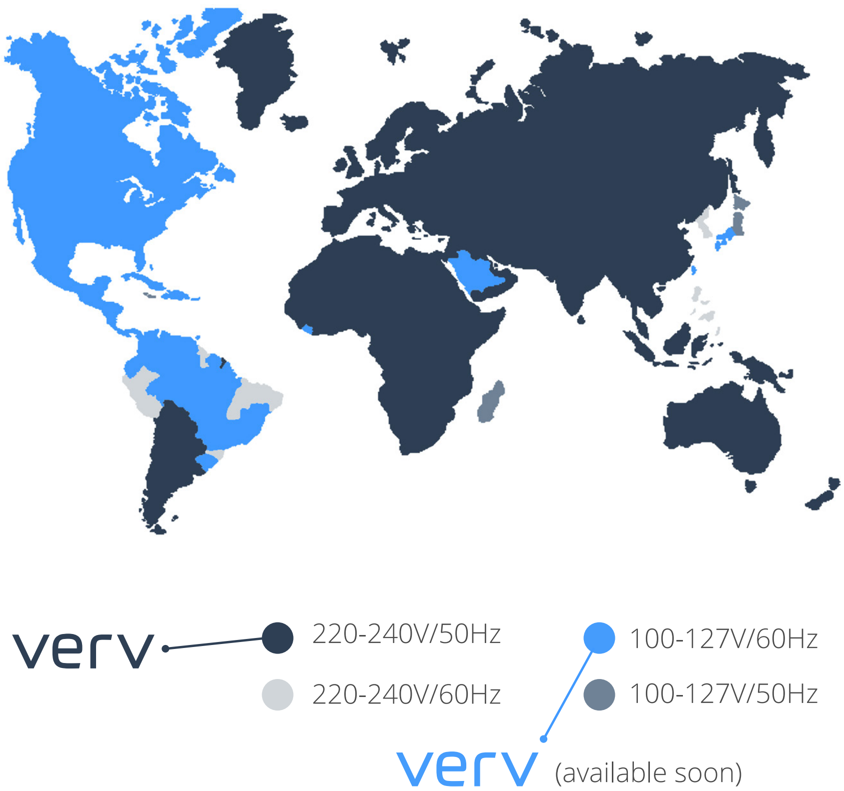
Verv is actively providing thought leadership to determine the appropriate level of regulation for peer-to-peer energy trading in the UK, and has been selected to participate in the Ofgem Sandbox, a programme launched to investigate the effects of peer-to-peer trading on the energy industry.

International expansion

Following a successful roll-out of VTP in the UK, Verv plans to expand its footprint internationally. Globally, there is significant potential for peer-to-peer energy trading, with an existing 1.3m household solar installations in the US, 1.5m in Australia, and 1.7m in Germany.[65]

The Verv hub should be compatible with most of the geographies displayed in dark blue through changing the plug for the mains socket. By the end of Q4 2018, Verv has plans to launch a modified system suitable for rollout in the USA and Canada.

Peer-to-peer energy trading will have to be adapted to comply with country-specific regulations and fee structures. From a legal standpoint, Texas, Germany and Australia are some of the major markets currently de-regulating their energy industries to allow peer-to-peer trading.



5.4 Competition

Many blockchain energy trading platforms have launched in recent months (e.g. WePower, Grid+, PowerLedger), proposing similar platforms to enable peer-to-peer energy trading. Verv believe they have a competitive edge over existing competition for the following reasons:

- Existing patented VHH system capable of high resolution energy data collection, with integrated in-box data processing capabilities. This is expected to reduce data upload requirements, speeding up transfer to cloud while sampling data at high frequencies
- Existing distribution channels and key partnerships for the expansion of VHH and VTP user base
- Existing capabilities in energy demand and generation forecasting using machine learning algorithms
- Existing datasets on household energy use patterns, solar generation, and battery activity
- Existing patented algorithms for energy data disaggregation, providing appliance-level information on energy use
- Integrated deep learning and AI capabilities, utilising ultra-high resolution data, that can enable better energy use prediction, and therefore optimised energy trading decisions

Based on information available in competitors' published whitepapers, Verv believe they are the only platform with an existing, commercially-developed, stand-alone hardware product that has an in-built high-speed data processing and trading capabilities, and associated machine learning AI which is ready for immediate deployment.[66] Verv believes this provides a critical first-mover advantage which will enable accelerated product development and customer acquisition.

Company	Verv	LO3 / Brooklyn Microgrid	PowerLedger	Grid+	WePower	Irene
Product offering	Peer-to-peer energy trading platform	Peer-to-peer energy trading in microgrid	Peer-to-peer energy trading platform	Functions as a utility company / energy retailer	Functions as a utility company / energy retailer	Functions as a utility company / energy retailer
Hardware requirements	VHH available for sale Integration to smart meters optional	Custom build hardware used in Brooklyn; Developing TAG-e hardware to enable trading	Requires smart meter integration	Developing hardware: a "smart energy agent"	Requires smart meter integration	Requires smart meter integration
Machine Learning / AI capabilities	Integrated to core product	None explicit Strong focus on data collection	N/A	AI optimisation planned to start 2019 Q4 onwards	Longer term plans for AI/ ML integration ("Storm" period)	Machine learning used for weather-related forecasting
Geographical focus	UK initially, followed by USA and Germany	USA	Australia	USA	Lithuania	UK/France initially
(Long-term) Commercial focus	Platform	Platform	P2P trading	Platform	Financing platform	Utility provider
Public blockchain platform	Ethereum	Ethereum	Ethereum	Ethereum	Ethereum	Stellar
Tokens	VLUX	XRG	POWR, Sparks	BOLT, GRID	WPR	Tellus
ICO raised	-	n/a*	A$34m	US$40m	US$40m	n/a*

*at time of writing

5.5 VTP Technical Development Roadmap and Commercial Plans

Development of the VTP started in late 2016, with 2017 seeing rapid expansion of research and development efforts with the collection and analysis of data from a number of test sites. The VTP is currently in active development for roll out at the first UK blockchain peer-to-peer trading trial in Hackney, London in March 2018.

An outline of Verv's technical roadmap and key targets are provided below:

Q1 2018	Trial Launch	Launch of first blockchain peer-to-peer energy trading held in Hackney, London, UK, in partnership with Re-Powering London. Installation of hardware and recruitment of participants at trial site.
	Public Blockchain	Transactions will be visible on the Ethereum public Testnet (Ropsten).
Q2 2018	Technology Development	More advanced electrical generation and consumption prediction algorithms introduced into live system. Verv's combined three channel CAD units deployed.
	Blockchain	Transition to a private permissioned blockchain, minimizing carbon footprint of the blockchain solution.
Q3 2018	Engaging Early Adopters	Planned roll out of energy trading platform to early adopters for trial.
	Scheduled Beta Test of Macro Blockchain	A blockchain of blockchains containing digests of transactions is expected to be rolled out to our trial sites.
Q4 2018	Product Development	Planned automatic integration of the VTP into next generation of Verv units, available for public roll out in 2019. Planned international system established.
2019	Full Scale International Rollout	Foundation fully operational, International rollout. Inclusion of next generation of Apps and third party services.

Verv is planning on using the funds over a 3 year period to develop all the features, functionality and current ideas of the platform.

2018 – Core targets

• Sell 12,000 VHHs which can receive automatic firmware updates to begin trading on the VTP

• Extension of Hackney trial to include more households

• Roll-out of three phase solution, which is compatible with European electrical system

• Launch of solution compatible with USA electrical system

• Launch energy bill minimisation API, with automatic tariff switching and/or VTP trading

• Establish first international commercial partners

• Develop control system for individual appliances

2019 – Core targets

• Extend trading platform to accommodate energy trading between 50,000 homes

• Develop software which enables automated control of household electrical appliances, to minimise energy costs

• Develop demand-side response product offering

5.6 Simulated Energy Trading Across 60 Homes (Spring 2017)

Verv's first blockchain project was funded by the Energy Entrepreneur's Fund from BEIS (UK Government Department for Business, Energy and Industrial Strategy) to extend the capability of the Verv's domestic hub with peer-to-peer trading functionality.

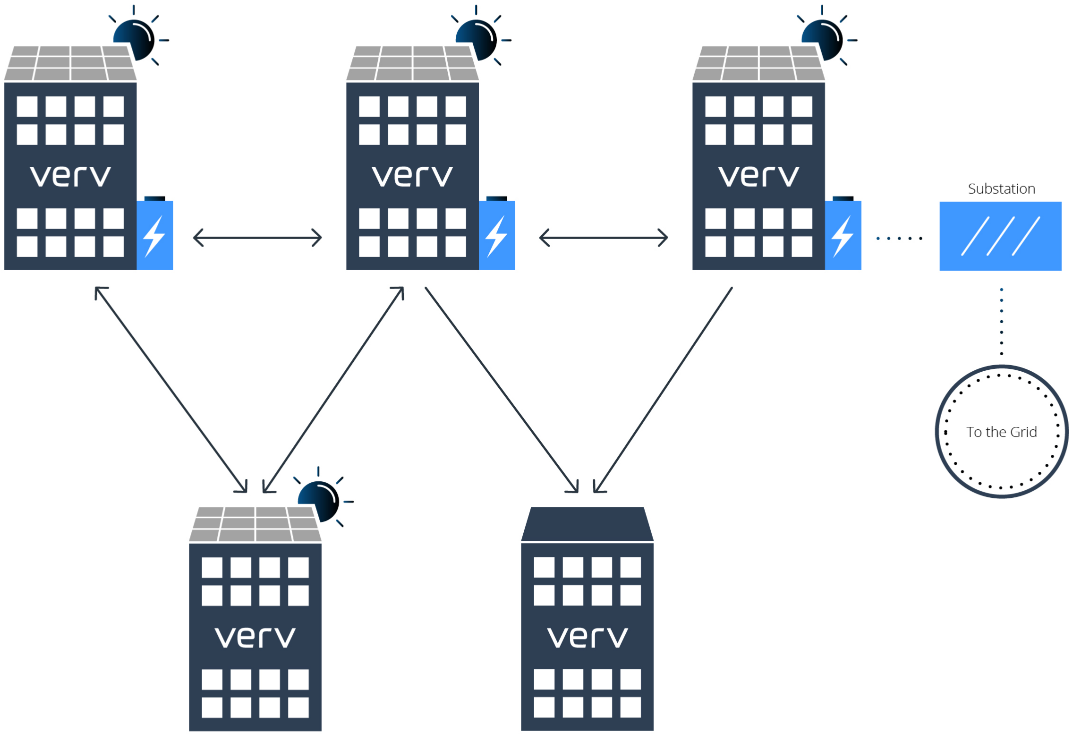
The project is focused on applying machine learning to the VHH data feeds, to build up a detailed real-time picture of household electrical activity, and thus pinpoint the sources of generation and consumption. When this data is combined with a blockchain-based trading platform, it is expected to enable electricity to be securely traded in real time at kWh granularity.

In this project we have built a full version of the alpha VTP trading algorithm and have been simulating it across 60 homes with onsite storage and solar generation. Our simulations allow us to determine potential trading levels, system economics and algorithm efficacy. Learnings from this project are being applied to our pilot demonstration project in Hackney (see below) to refine our primary blockchain algorithm.

5.7 Verv's Hackney Project

In November 2017, Verv created the UK's first energy trading community at Hackney's Banister House estate. The initial field-trial, delivered in collaboration with Repowering London will be the first-time energy has been legally traded in the UK through a blockchain-based energy trading solution.

Verv (VHH with additional blockchain functionality) are being installed in 40 participating flats to allow community residents to share lower cost renewable energy between one another at a significantly reduced rate, as well as benefit from the functionality of Verv's home energy assistant (providing real-time cost updates for key appliances, safety notifications if appliances are left on, and alerts if white goods are deteriorating).



Development of Verv's blockchain-based community energy trading further supports the pioneering work of Banister House Solar - the UK's largest community energy scheme for social housing. Prior to Verv, with the support of Hackney Council, Banister House Solar installed PV systems onto 17 blocks that make up the housing complex.

The trial will also install communal battery storage provided by Verv's partner Powervault. The batteries enable storage of solar energy for later use, or to trade between flats.

This project was started by a £100k government grant from Innovate UK, who have encouraged research on blockchain within Ofgem's regulatory sandbox. This project has also been supported by UCL's Energy Institute's LoLo CDT in Energy Demand.[67]

6.0 Milestones, Awards, & Achievements

Green Running (*brand name Verv) was founded in 2009 by Peter Davies. The initial focus was on reducing energy consumption within the commercial market; supporting hotels, restaurants and manufacturing plants to lower their energy bills, encourage behavioural change among their employees, and achieve sustainability targets.

At this time, smart meters and half-hourly meters had begun to penetrate the domestic market. However, the information they provided was considered insufficient for encouraging long-term engagement and behavioural change.

With over a decade of experience in high-frequency data acquisition (while building engineering test and measurement consulting company, Austin Consultants), Peter and his specialist team were able to develop a non-intrusive solution for sampling electricity meter data at extremely high frequencies. The data resolution their technology generated enabled the team to create algorithms capable of identifying the unique energy signatures for key domestic electrical goods as well as provide their corresponding usage information in real-time.

Having patented this technology, a range of commercial energy monitoring products were developed and sold to Energy Managers and Facilities Managers within the hospitality and manufacturing sectors (often to support their ISO: 27001 Environmental Policy thanks to its real-time feedback on electricity usage).

For their work in this sector, Green Running won a project with Scottish Power Networks and Scottish & Southern Power Networks' through an Energy Innovation Grant to build out their capabilities for substation and grid monitoring. The outcome of this project was a successful understanding of the issues facing the DNOs from a power quality and blackout perspective, caused by individual large appliances. In 2014, success in these verticals led Green Running to becoming a finalist for 'Best Smart Grid Innovation' as well as being nominated for the 'Rising Star Award' in the Energy Awards.

The results of this project, combined with a domestic smart home product plan helped to attract the interest of many of the UK's major utility companies and result in Centrica (owners of British Gas) providing seed funding in July 2015 to develop a smart home energy assistant product for the domestic market.

2015 (second half)

- Received seed funding from Ignite (the social Impact arm of Centrica PLC, parent company of British Gas).
- The Verv smart home product is featured as a showcase in the BT IoT lab.

2016

- Peter Davies (CEO) won Innovator of the Year in November 2016 at the Business Green Awards, and was named one of the Top 50 Entrepreneurs in the last 15 years by SETSquared, with an award made in the House of Commons.
- Smart home product won Best Product Demonstration at the 2016 European conference on Non-Intrusive Load Monitoring (NILM) in London.
- Raised an additional angel round from:
  - Ian Marchant (ex-CEO Scottish & Southern Electricity)
  - Charlie Crossley Cooke (Founder of Opus Energy which sold for £326 million in 2016)
  - Jeremy Oppenheim (Ex McKinsey Partner and Co-founder of VC fund SystemIQ)
  - AU Capital Partners

2017

- Developed sales channels through sales to energy companies, British Gas, EDF, Ecotricity, Good Energy, and Scottish Power Energy Networks.
- Developed sales in the insurance market, counting Allianz among Verv customers.
- Developed consumer sales channel to BT, Tesco Direct, and Amazon.
- Four patents on Condition Monitoring, a Smart Plug and Product Recall functionality.

2017
Verv Blockchain

- Filed a patent for P2P blockchain in July 2017.

- One of only four companies to receive a £150k grant from UK Government Department for Business, Energy and Industrial Strategy 'Energy Entrepreneurs' fund to simulate Verv's blockchain-based peer-to-peer energy trading solution across the UK.

- Set up an ongoing monitoring of 60 homes each containing solar generation and local battery storage. Invited to present multiple times to Ofgem as part of a select panel of the UK's major industry blockchain energy players.

- Used the VHH to conduct in-depth analysis on leading key domestic battery manufacturers (Tesla, Sonnen, Powervault) to determine which were most suitable for peer-to-peer energy trading.

- Implementation of what is expected to be the UK's first blockchain peer-to-peer energy trading community on London social housing. The project, delivered in collaboration with Repowering London, is expected to be the first time energy is traded in the UK through the blockchain-based peer-to-peer energy trading solution – Verv 2.0, providing cheaper energy to the residents at Hackney's Banister House Solar. This project has been shortlisted for participation in Ofgem's Sandbox programme.

2017
Verv AI

- One of a few companies in the UK selected to be on Google Campus' Launchpad, Google's global startup program, as well as Amazon's Launchpad.

- Voted one of the top 50 AI companies by Silicon Valley media company CIO Story.

- Maria McKavanagh (COO) was nominated as one of the most influential women in UK Tech by Computer Weekly.

- Raised £1.1 million in an equity crowdfunding round on CrowdCube, bringing on board over 1000 investors under a nominee structure.

- Received the first ever Innovation award from Electrical Safety First at their 7th annual product safety conference.

- Won 3 Business Green Awards:

  - **App of the year:** For the way in which Verv taps into big data in the home and present it to the consumer in a way that's simple and easy to understand.
  - **Future city technology of the year:** For the peer-to-peer energy trading solution developed for the smart home hub, Verv 2.0, in order to increase access to low carbon energy and reduce energy costs.
  - **Technology of the year:** The highest overall award of the evening which recognised Verv's game-changing technology.

- Awarded an Innovate UK grant (with sister consulting company Austin Consultants) to develop accurate and cost-effective power generation forecast data using satellite image processing and machine learning techniques.

2018

- Selected as one of the top 15 energy start-ups globally at Free Electrons Accelerator programme

- Conducted first peer-to-peer trade using blockchain in the UK

7.0 - Team, Advisors and Project Partners

7.1. Team

Leadership

Peter Davies - CEO
A serial entrepreneur with an engineering background and a degree in computers, electronics and communications engineering. Peter was the founder of Austin Consultants, the UK's highest certified LabVIEW Consultancy specialising in automated measurement, analysis and control systems for the likes of Rolls-Royce and Mercedes Benz F1. Peter won Innovator of the Year at the 2016 Business Green Technology Awards.

Conrad Spiteri - CTO
Conrad has spent 15 years perfecting the tech product development process and carries an impressive portfolio of products and patents, believed to have reached a user base in the millions (physical unit sales and app downloads). He has a Masters' in Robotics, and is finalising his PhD in Planetary Robotic Vision Processing for Terrain Assessment and a degree in Industrial Electronics. Prior to Verv, Conrad was the Technical Director at Y-CAM Solutions.

Michael Jary - Managing Director
Michael has over 10 years of experience in the energy sector, and was the former Director of Connected Homes at SSE. He holds an MBA from Warwick Business School.

Steve Foster - CFO
Steve has over 20 years' experience in senior financial roles, mainly in the energy sector. He has worked for E.On UK, the private-equity backed business Welsh Power Group and from 2011 to 2017 was the Finance Director of the B2B energy supply business Opus Energy Ltd.

Maria McKavanagh - COO
Most recently nominated by Computer Weekly as one of the top 50 Most Influential Women in Tech, Maria was formerly a Field Sales Engineer at National Instruments and holds an MEng degree in Electronic Systems Engineering.

Key Technical Personnel

Andrei Baloiu - Lead Blockchain Developer (Solidity)
Andy is the lead blockchain developer for the VTP, bridging the gap between blockchain and IoT. He has worked on blockchain projects within the Innovation Centre of Excellence at RS Components and has won several blockchain hackathons. Andy has more than 5 years' experience in full-stack development and holds a BSc in Electrical Machines Engineering and a MA in Design.

Jonathan Dennis – Team Lead Disaggregation
Jon is the Disaggregation Team Leader on the Machine Learning team, developing the data processing and learning algorithms for the VHH. He has been with Verv for over 2 years, with 5+ years' industry experience in developing machine learning solutions for real world problems. He previously worked at the Institute for Infocomm Research (Singapore) developing robust audio and speech recognition algorithms. It was in Singapore that he completed his PhD at Nanyang Technological University making advances in robust audio recognition. He also holds a first class MEng degree in Engineering Science from the University of Oxford.

Lionel Ward – Team Lead Deep Learning
Lionel is a Deep Learning Specialist in Verv's Machine Learning team, applying cutting edge techniques from AI to solve problems in energy monitoring. Lionel has 2+ years industry experience, and Master's degrees in Machine Learning and Electronic & Electrical Engineering, both from UCL. Lionel is proficient in Japanese, having completed an exchange year in Japan.

Matt Mottram – Team Lead Machine Learning
Matt is a Team Lead in Machine Learning, working on appliance disaggregation and condition monitoring. Prior to joining Verv in 2016, Matt was a postdoctoral research scientist, having received a PhD in high energy physics from UCL.

Yi Jean Chow – Blockchain Product Manager
Yi Jean is a Product Manager on the Blockchain team, developing the commercial strategy for the VTP product. She has 2+ years of experience in strategy consulting and operations consulting, and previously worked as an energy analyst, conducting building energy efficiency audits. She holds a BA in Chemistry and Physics from Harvard University, and an MSc in Economics and Policy of Energy and the Environment from UCL.

Gavriel Landau – Blockchain Project Manager
Gavriel is a Project Manager within the team, managing a spectrum of projects, including the trial of our peer-to-peer trading platform within a social housing estate in Hackney. He has 4+ years' experience as a consultant for Accenture, working in commodities trading and risk management. Gavriel holds a BSc in Business and Management from Aston University.

Anas Almharat – Data Scientist Team Lead
Anas is a data scientist on the blockchain team, developing energy consumption prediction algorithms using deep learning. Anas' scope of expertise spans across different areas of artificial intelligence with a focus on behaviour accommodation and reasoning under uncertainty. Before joining Verv, he was the chief data scientist at CypherAPP, developing machine learning solutions to account for mental health well-being for young people in the UK. Anas holds a PhD in probabilistic graphical modelling.

Sam Fiddis – Blockchain Developer
Sam is a blockchain developer, working on the synchronization of energy discharge with token trading on the Ethereum Blockchain. He has a wide range of experience including accounting and HVAC engineering. He holds a double degree in Mechanical Engineering and Science (major in Mathematics and Physics) from Monash University and an MSc in Computer Science from Imperial College London, where he helped to develop a proof of concept Ethereum-based student funding DAO (Decentralized Autonomous Organization).

7.2 Advisors

James Cameron – Chairman
James has been Chairman of the Overseas Development Institute; a member of General Electrics's (GE) Ecomagination board, and Chairman of Agrica; GSCM; and ETIndex. Previously he co-founded and chaired Climate Change Capital (CCC), which became a thriving merchant banking and investment business employing 150 people with $1.5 billion under management. He was a member of the UK Prime Minister's Business Advisory Group during the coalition government and named Leader of the Year at the 2013 BusinessGreen Leader awards.

Ewald Hesse
Ewald Hesse leads the Grid Singularity venture. He has extensive experience in the energy sector and acute interest in distributed business models. He served as regional director at Andritz Hydro and is the Vice President of the Energy Web Foundation.

Francis Griffiths – Director
Francis is VP of Sales and Marketing Worldwide at National Instruments, a multinational company with global operations and revenues in excess of $1.2bn. He is responsible for global sales, support, marketing and business operations for the Americas, Europe and Asia-PAC. He is also a Board Member at Cardiff University.

Academic

Professor David Shipworth
Professor of Energy and the Built Environment at UCL Energy institute, works falls into two related areas: Demand side management and occupant thermal comfort in buildings.

Professor Furong Li
Professor Furong Li is a lecturer at the University of Bath, secretary of the IEEE Power System Economics Committee and co-chair of the Prize Paper Nomination Committee for the Power System Economics division of IEEE.

Notable Equity Investors

Charlie Crossley Cooke
Chief Executive & Owner of Opus Energy Group Ltd. (until being acquired by Drax for £340m in 2017). Mr. Crossley Cooke was responsible for the growth, strategic direction and operational management of the group. He has over 10 years' experience in the energy trading and retail sectors.

Ian Marchant
Chief Executive Officer of Scottish and Southern Energy (SSE) from 2002 until 2013.

Jeremy Oppenheim
Ex-Senior Partner at McKinsey, where he founded their Sustainability and Resource productivity practice. He is a currently at Systemiq VC investing in sustainability oriented ventures.

7.3 Project Partners

Blockchain Partners

Blockchain Reserve
Blockchain Reserve's mission is to set the gold standard for legal, ethical token issuances. With a reputation for working with the very best companies looking to run token sales, predominantly with companies that have existing products, revenues, institutional backers and a genuine need for a token.

ZKlabs
Zero Knowledge Labs performs auditing, smart contract development and crypto R&D for Ethereum-related projects.

8.0 - VLUX Token Launch

To establish a blockchain trading platform, Verv will be holding an Initial Token Offering (ITO) to sell VLUX tokens for use on the platform. Verv believes the benefits of holding an ITO are three-fold:

- Accelerates funding to further develop the platform and attract the best talent
- Provides us with the independence to build a trading platform that is truly consumer and end-user focused
- Generates global and high-profiled PR and marketing coverage for the Verv Trading Platform.

8.1. The Token

VLUX is a utility token which Verv expects to enable token holders to participate in our energy trading network we are developing. It will be an ERC20 token with a limited supply. We have discussed the technical details of the token and our trading network in depth in Section 4, however, there are some key aspects worth reiterating here.

Energy and data cannot be traded without VLUX

Tokens are required for every single transaction within our network. Consequently, as our company grows and the number of organisations, consumers, prosumers and partners using the network increases, the demand for the token will also increase. Energy and data cannot be traded on the platform without the staking of VLUX tokens, which reduces token velocity and the number of VLUX tokens in active circulation.

Token burn function

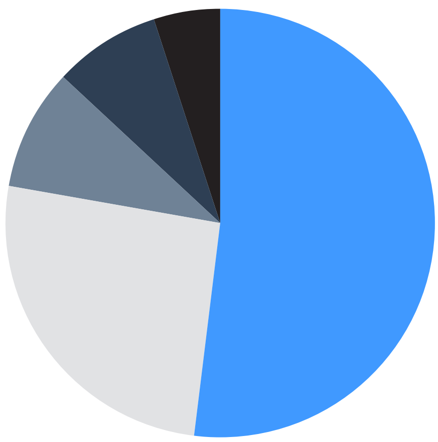
Every trade within the network will have a margin between the bid and sell prices which is used to cover transaction, transmission and tax costs. A majority of trades, after accounting for these costs, will still have a profit margin. This profit will be used in part to fund community projects, or potentially exchanged for VLUX to be burned. As the trading platform grows and the number of trades taking place increases, the number of VLUX tokens that could be burnt will increase, reducing the limited supply of tokens.

8.2 Token Allocation

During the token sale event up to 70% of the total supply of VLUX tokens will be distributed to the public, up to 10% will be reserved for distribution among the first 200,000 VHH units sold, and the remaining tokens will be kept by the company. Of the expected 20% of tokens kept by the company, 10% will be kept for the Verv float and original contributors, and 10% will be reserved for future growth. Tokens will not be able to be used in the trading network until the full launch of the VTP, currently scheduled for the end of 2018. Their primary utility before the launch of the platform will be the ability to buy Verv hubs.

8.3 Funds Allocation

The funds raised from the ITO will be used to accelerate development of the VTP. 47% will be reserved for engineering, software, research and development, to continue building our blockchain trading technology and patent portfolio. 21% of the funds will be reserved for user acquisition, and building on our track record of delivering high impact, high value partnerships. 10% will be used to subsidise the cost of the first 200,000 VHHs, accelerating adoption of the VTP. 9% of the funds will be allocated for ongoing operations / admin, with a further 8% used for legal costs. 5% will be reserved for contingency.



- Engineering, Software, R&D
- User Acquisition & Customer Education
- Ongoing Operations & Admin
- Legal Costs
- Contingency

8.4 Our Token Sale Approach

Verv's aim is to distribute VLUX to as widespread a group of participants as possible, enabling everyone, regardless of the potential size of their contribution, to participate in the benefits of a decentralised energy grid and our trading network. Verv aims to conduct our token launch in a manner consistent with absolute best practice, taking into consideration input from top advisors, utilising tools of key partners, and implementing the highest security standards.

It is important to allow key strategic partners to back our token. To assist us in developing a global energy trading network and VLUX economy, we will be raising pre-sale funds subject to lock up clauses to support the stability of the token during its initial months and years. These token owners will not be able to trade their tokens on the public exchange for a pre-determined period of time.

Verv is looking to raise up to 70% of the tokens available in the ITO during the private pre-sale, with the remaining tokens potentially sold in the public sale. Verv is looking to raise approximately up to GBP£25m over the entire token sale event, including both the pre-sale and the public whitelist.

8.5 The Pre-sale

Our pre-sale is limited to participants looking to contribute a minimum of GBP£25,000. Verv expects the majority of these VLUX tokens will go to long-term strategic partners, with conditions that require VLUX to be locked up and vested for considerable periods of time. There will also be a limitation on total number of tokens that can be sold per day per account to minimise volatility in prices.

8.6 The Public Whitelist

The plan is that the main public sale of VLUX will occur via a whitelist running over three days. Contributors who have registered to the whitelist will be guaranteed an allocation in the first 24 hours of the main sale subject to a maximum contribution to ensure a fair distribution for registered contributors. By running a whitelist, we are able to distribute token ownership fairly, mitigate the risk of network congestion caused by the token sale, and avoid potential human errors that can arise due to a rushed purchase of tokens.

First day whitelist contributors will receive a a token bonus. Any remaining unsold VLUX tokens will be offered to the public on the third day.

8.7 The Future Economy

Verv believes the VLUX token launch will generate a vibrant peer-to-peer energy network, enabling token holders to save money on their electricity costs. Verv believes the network utilises surplus energy and reduces energy waste, which is a problem prevalent in current energy distribution systems.

We believe that as we bring new partners and energy providers on board, adding additional energy generating units across the grid to our trading network, the energy evolution will accelerate and the value of VLUX increase. Verv believes strategic partnerships, including key partnerships we already have in place, will allow our VLUX economy to make step-change improvements, as we connect large networks of consumers and prosumers to the VTP.

Verv will publically announce our intention to sell any tokens prior to sale on a token exchange.

Conclusion

In response to the challenges facing the existing energy system, Verv believes a peer-to-peer energy trading platform is needed to provide a sustainable, democratized and economically efficient electricity grid. Building on the successful roll-out of the Verv Home Hub, we are developing a blockchain energy trading platform that will enable users to trade excess energy with one another. Verv believes a peer-to-peer system will encourage investment in sustainable energy generation and storage, and engage users to improve the resilience, reliability, and affordability of our electricity system.

This whitepaper outlines the key components of our plans to make the Verv Trading Platform (VTP) a reality, and the upcoming initial token offering for the VLUX token will provide supporters with an opportunity to accelerate in the future of the energy system. As the platform develops and its user base grows, Verv believes the value of the VLUX token will increase.

At its core, the VLUX token is required to enable users to trade electricity on the peer-to-peer VTP. The platform has been designed to make the trading as simple as possible, with automated trades occurring without user intervention. The VTP is expected to optimise trading strategies using Verv's energy demand and generation predictive algorithms, which should enable households to minimise their household energy cost while purchasing electricity from renewable sources.

Verv believes the VTP will provide the flexibility and capability to integrate many use cases, including electric vehicles charging, demand response services, carbon monitoring and reporting, and data and information provision. We believe the strength of the VTP will increase with each additional use case, generating greater utility and value for the VLUX token.

Central to Verv's competitive edge is its focus on existing hardware capabilities and integration as a home energy manager into consumers and prosumers' households. Verv believes their existing capabilities in non-intrusive load monitoring, energy data disaggregation, machine learning and AI, provide a clear foundation for developing an unparalleled peer-to-peer energy trading platform. With support from industry experts in FTSE 100 companies, Verv believes their energy trading blockchain is positioned to lead the shift in making energy affordable, decentralised, and decarbonised.

Associated Risks

Risks associated with energy industry regulation on peer-to-peer trading
The energy industry is a highly regulated sector, and the success of a peer-to-peer trading solution will require co-operation from energy regulators around the world. If governmental authorities do not agree to permit peer-to-peer energy trading, the mechanism of the trading platform may have to be modified, requiring corresponding changes to Verv's execution and roll-out plan. While a number of energy regulators appear to be encouraging innovation in peer-to-peer energy trading (for example, with the introduction of the Ofgem Sandbox in the UK), if regulation is changed to prohibit peer-to-peer trading in the future, the utility of the platform could be significantly reduced.

The proposed structure of the current peer-to-peer trading business model relies on utilisation of existing grid infrastructure, which are owned or managed by distribution and transmission network operators, and distribution and transmission system operators. In the event that network and system operators do not permit peer-to-peer trading to occur on their network, or charge a prohibitively high fee for use of their network, this would pose significant risk to the economic viability and scalability of the peer-to-peer trading model.

Risks arising from the energy industry and energy market
The energy industry and by extension the Verv Platform (the "Platform") is subject to a variety of state and international laws and regulations, including those with respect to health and safety, environmental issues, competition, and customer due diligence procedures, privacy and data protection, consumer protection, data security, and others. These laws and regulations, and the interpretation or application of these laws and regulations, could change. In addition, new laws or regulations affecting the Verv Platform could be enacted, which could impact the utility of VLUX in the Verv Platform. Additionally, Verv Platform users are subject to or may be adversely affected by industry specific laws and regulations or licensing requirements. If any of these parties fails to comply with any of these licensing requirements or other applicable laws or regulations, or if such laws and regulations or licensing requirements become more stringent or are otherwise expanded, it could adversely impact the Verv Platform and the VLUX, including its functionality to obtain or provide services within the Verv Platform. These regulatory changes in the energy industry could negatively impact on the value of the VLUX tokens.

Risks associated with uncertain regulations and legislative actions in relation to issuing and trading cryptographic tokens
The regulatory status of cryptographic tokens, blockchain, and distributed ledger technology is unclear or unsettled in many jurisdictions. It is difficult to predict how or whether legislatures or regulatory agencies may apply existing regulation or implement changes to law and regulation with respect to such technology and its applications, including the Verv Platform and VLUX tokens. Regulatory actions could negatively impact the Platform and VLUX tokens in various ways, including through a determination that VLUX tokens are a regulated financial product or instrument that attracts registration or licensing requirements, or prohibiting their transfer, sale or offering. These potential changes in how VLUX tokens are regulated could negatively affect their value.

Risks associated with uncertain regulations and legislative actions in relation to buying and selling energy with cryptographic tokens and blockchain technologies
It is possible that certain jurisdictions will apply existing regulations on, or introduce new regulations addressing, blockchain technology based applications, which may be contrary to the current setup of the Smart Contract System and which may result in substantial modifications to the Smart Contract System and/or the Verv Platform, including its termination and the loss of VLUX for the user. Additionally, regulation of proposed activities of the Verv Platform is currently uncertain. It is not known what regulatory framework the proposed Verv Platform and associated activities will be subject to, the nature and obligations that will be imposed on the Company in order to comply with any such regulatory framework or when/if the Company will even be able to apply to be regulated, or successfully obtain the necessary licences so that it may lawfully carry out its proposed business activities.

Verv may cease operations in a jurisdiction in the event that regulatory actions, or changes to law or regulation, make it illegal to operate in such jurisdiction, or commercially undesirable to obtain the necessary regulatory approval(s) to operate in such jurisdiction. The Platform could be impacted by one or more regulatory enquiries or regulatory action, which could impede or limit the ability of Verv to continue to develop the Platform. For example, regulations could be introduced to prohibit peer-to-peer trading of electricity with decentralised and distributed ledgers, which would prohibit Verv from operating in those jurisdictions.

Risks associated with limited track record

The token and the Platform will be newly created entities without track record in blockchain peer-to-peer trading platforms, therefore heavily dependent on the experience of the leadership and advisory group. The token and the platform is therefore subject to the business risks and uncertainties associated with new business enterprises, including the risk that the platform and token will not achieve their roll out objectives, and that the value of the VLUX token could decline substantially.

Risks associated with the development of the platform

The Platform is currently under development and will undergo significant changes before release and over time, including a change in direction at Verv's discretion. Although Verv intends for VLUX tokens and the Platform to follow the specifications set forth in the whitepaper and intends to take commercially reasonable steps toward those objectives, Verv may have to make changes to the specifications of VLUX tokens or the Platform for any number of legitimate reasons including, but not limited to, a change in the design, implementation plans and execution of the implementation of the Platform for global release. Moreover, we may not be able to retain full and effective control over how other participants will use the Verv Platform, what products or services will be offered through the Verv Platform by third parties, or how third-party products and services will utilize VLUX. This could create the risk that the Platform or VLUX tokens, as further developed and maintained, may not meet expectations either at the time of purchase of the VLUX token or in the future.

While Verv will make reasonable efforts to complete the Platform software for release, due to circumstances beyond Verv's control it is possible that a limited release occurs or a functioning operational Platform may not be created at all.

Risks associated with use of software within the Platform

Despite Verv's best efforts to develop and maintain the Platform, it is still possible that the Platform will experience malfunctions or otherwise fail to be adequately developed or maintained, which may negatively impact the Verv Platform and VLUX, and the potential utility of the VLUX, including the utility of the VLUX token for obtaining services and/or offering rewards and/or being used in the manner intended at the time of the Token Sale, causing the value of the VLUX token to fall. The Verv Platform relies on software and other technology which may malfunction and/or work in a manner that is not intended, resulting in loss of VLUX and/or access to the Verv Platform.

Risks associated with hardware (Verv Home Hub)

Verv intends to integrate the Verv Home Hub (VHH) with the Platform, using the VHH to provide measurement, monitoring, and control capabilities to facilitate peer-to-peer trading. In the event the hardware malfunctions (for example, through inaccurate electricity readings, intentional tampering to change electricity readings, or complete hardware failure), this could impact the reliability and credibility of the platform. This may result in lower utilisation of the Platform, and may adversely impact the value of the VLUX token. Verv intends to ensure VTP compatibility with other hardware devices (for example, smart meters) which should mitigate the adverse impact of VHH malfunctioning.

Risk of insufficient interest in the platform

It is possible that the Platform will not be used by a large number of businesses, individuals, and other organisations and that there will be limited public interest in the use of VLUX tokens for peer-to-peer energy trading. Such a lack of interest could impact the development of the Platform for release.

A lack of prosumers could result in low supply of electricity through the platform, which may result in higher trading prices. A lack of consumers could result in low demand of electricity, which may result in lower trading price. Both scenarios could reduce the financial incentive for a group of users to participate on the Platform, and may adversely impact demand for, and the value of, VLUX tokens.

Verv cannot predict the success of its own marketing efforts or the efforts of other third parties. It is possible that, due to any number of reasons, including without limitation, the failure of business relationships or marketing strategies, that the Verv Platform and all subsequent marketing of the sale of VLUX tokens from Verv, may fail to achieve success, and this could damage the value of VLUX tokens.

Risks associated with changes in market trends

The Platform is a new product, thus contributing to price volatility that could adversely affect the value of VLUX tokens. There are many factors affecting the further development of the cryptographic token industry, as discussed throughout this section. These risks can include, but are not limited to, changes in consumer demographics, public tastes and preferences; general economic conditions; and the regulatory environment relating to the Platform, VLUX tokens and other tokens.

Risk associated with changes in market competition

The proposed value of the VTP is in part reliant on the cost differences between prices received by prosumers in selling electricity to the grid, and the prices paid by consumers when purchasing electricity from traditional suppliers. If energy suppliers reduce their prices, offering lower and more competitive rates, then the economic value of purchasing electricity through the VTP will be diminished. Similarly, if regulation increases the feed-in-tariff or similar payments to consumers, then the benefit and value of the VTP will be diminished. These changes could result in lower utilisation of the Platform, risking shut down of the Platform if long-run system costs cannot be covered.

Risk of alternative platforms

It is possible that alternative platforms could be established that utilize the same open source code and protocol underlying the Platform and attempt to facilitate services that are materially similar to those intended to be delivered through the Platform. The Platform may be in competition with these alternative platforms, which could negatively impact the Platform and VLUX tokens.

It is possible that a competing cryptographic token other than VLUX tokens could have features that make it more desirable to the cryptographic token user base, resulting in a reduction in demand for VLUX tokens, which could have a negative impact on the use and price of VLUX tokens generally. It is possible that a comparable product could become more popular due to either a perceived or exposed shortcoming of the Platform that is not immediately addressed by Verv, or a perceived advantage of a comparable product that includes features not incorporated into the Platform. If this product obtains significant market share, it could have a negative impact on the demand for, and price of VLUX tokens.

Risks of mining attacks, hacking, cyber threats and security weaknesses

As with other decentralized cryptographic tokens based on the Ethereum ERC-20 protocol, VLUX are susceptible to attacks by miners in the course of validating VLUX token transactions on the Ethereum blockchain, including, but not limited to, double-spend attacks, majority mining power attacks, selfish-mining attacks and race condition attacks. Any successful attacks present a risk to the Platform and VLUX Tokens, including, but not limited to, accurate execution, recording of transactions involving VLUX tokens and expected proper payment operations.

Hackers, individuals, other malicious groups or organizations may attempt to interfere with the Platform or VLUX tokens in a variety of ways, including, but not limited to, malware attacks, denial of service attacks, consensus-based attacks, Sybil attacks, smurfing and spoofing. As the Platform is based on open-source software, there is a risk that any party may intentionally, through the actions set out above, or unintentionally introduce weaknesses into the core infrastructure of the Platform, which could negatively affect the Platform and the value of VLUX tokens.

Risk of incompatible wallet service

The wallet or wallet service provider users select to receive VLUX into must conform to the ERC20 token standard in order to be technically compatible with VLUX. The failure to ensure such conformity may have the result that you will not gain access to your VLUX.

Risk of exchanges

Cryptocurrency exchanges on which VLUX tokens may trade may be relatively new and largely unregulated and therefore may be more exposed to fraud and failure than established regulated exchanges. If the cryptocurrency exchanges representing a substantial portion of the volume in VLUX token trading are involved in fraud or experience security failures or other operational issues, this may result in a reduction in the price and can adversely affect the value of VLUX tokens. A lack of stability in the cryptocurrency exchanges and the closure or temporary shutdown of cryptocurrency exchanges due to fraud, business failure, hackers or malware, or government-mandated regulation may reduce confidence in the Platform, result in greater volatility in the price of VLUX tokens and harm the value of VLUX tokens.

Risks associated with markets for VLUX

The Company may choose not to facilitate any secondary speculative trading or any such external valuation of VLUX. Furthermore, to the extent that any third party ascribes an external exchange value to VLUX (e.g. as denominated in a crypto or fiat currency), such value may be extremely volatile and diminish to zero.

VLUX tokens are not offered by the Company or its affiliates on an investment basis, and cannot guarantee token value will increase with time.

Risk of uninsured and transaction losses

Unlike cash reserves held in bank accounts or accounts at some other financial institutions, VLUX tokens are uninsured unless you specifically obtain private insurance to insure those held by you. In the event of loss or loss of utility value, there is no public insurer or private insurance arranged by Verv to offer recourse to you. VLUX token transactions are irrevocable. If VLUX tokens are stolen or incorrectly transferred, such transfer may be irreversible. Cryptographic token transactions are not reversible without the consent and active participation of the recipient of the transaction or, in theory, control or consent of a majority of the processing power on the host blockchain platform. Once a transaction has been verified and recorded in a datablock that is added to the blockchain, an incorrect transfer of a VLUX token or a theft of a VLUX token generally will not be reversible and there may be no compensation for any such transfer or theft. Such loss cause individual token holders to lose their tokens.

Further, any incorrectly executed VLUX token transactions could adversely affect the value of VLUX tokens if, for example, confidence in VLUX diminishes as a result of lost tokens.

Risk associated with private key(s)
VLUX tokens may be stored in a wallet or vault. The wallet will hold a private key, or a combination of private keys, required to control and dispose of the VLUX tokens stored in your digital wallet or vault. Any loss of requisite private key(s) associated with your digital wallet or vault storing VLUX tokens will result in loss of such VLUX tokens. Without an accurate record of the private key or password used to access the private key, this may lead to the loss of VLUX tokens.

Any third party that gains access to a private key may be able to gain access to a user's VLUX tokens. The loss, destruction, loss of access or data loss relating to a private key, may be irreversible and could adversely affect the value of the Platform and overall VLUX tokens.

Risks associated with the Ethereum protocol
As VLUX and the Platform are based on cryptocurrency protocols, any malfunction, unexpected functioning, forking, breakdown or abandonment of the Ethereum protocol may have a material adverse effect on VLUX or the Platform, including, but not limited to, impacting your ability to transfer or securely hold VLUX. Such impact could adversely affect the value of VLUX.

The Smart Contract System concept, the underlying software application and software platform (i.e. the Ethereum blockchain) is still in an early development stage and unproven. There is no warranty or assurance that the process for creating VLUX will be uninterrupted or error-free and therefore there is an inherent risk that the software could contain defects, weaknesses, vulnerabilities, viruses or bugs causing, inter alia, the complete loss of contributions and/or VLUX.
Further, advances in cryptography, or technical advances such as the development of quantum computing, could present risks to VLUX and the Platform by rendering ineffective the cryptographic consensus mechanism, that underpins the Ethereum protocols.

Risk of an unfavourable fluctuation of Ether and other currency value
Verv intends to use the contributions received to fund the development of VLUX, the Verv Platform and various other operating expenses. The contributions received will be denominated in ETH, and may be converted into other cryptographic and fiat currencies. If the value of ETH or other currencies fluctuates unfavourably during or after the Contribution Period, the Company may not be able to fund the development of, or may not be able to maintain, the Verv Platform in the manner that it intended.

Risk of extreme token price volatility
VLUX tokens are not intended to represent any formal or legally binding investment. Cryptographic tokens that possess value in public markets, such as ETH and BTC, have regularly demonstrated extreme fluctuations in price over short periods of time. Exchanges are independent of and not operated by Verv, therefore use of exchanges is at your own risk and Verv cannot and does not guarantee market liquidity for VLUX tokens and therefore there may be periods of time when VLUX tokens are difficult to buy or sell.

Additionally, due to different regulatory requirements in different jurisdictions and the inability of citizens of certain countries to open accounts at exchanges located anywhere in the world, the liquidity of VLUX tokens may be markedly different in different countries and this would likely be reflected in significant price discrepancies. Many factors may motivate large-scale sales of VLUX tokens, which could result in a reduction in the price and adversely affect the value of VLUX. Cryptographic tokens such as VLUX tokens, which are relatively new, are subject to supply and demand forces based upon the desirability of an alternative, decentralised means of transacting, and it is unclear how such supply and demand will be impacted by geopolitical events. Large-scale sales of VLUX tokens would result in a reduction in the liquidity of such tokens.

Risks involving cloud storage
Verv uses a decentralised cloud storage service to host the Platform and related applications. The Platform is therefore susceptible to a number of risks related to the storage of data in the cloud. Such data may include large amounts of sensitive and / or proprietary information, which may be compromised in the event of a cyber attack or other malicious activity.
Similarly, the Platform may be interrupted and files may become temporarily unavailable in the event of such an attack or malicious activity. As users can use a variety of hardware and software that may interface with the Platform, there is the risk that the Platform may become unavailable or interrupted, based on a failure of interoperability or an inability to integrate

these third-party systems and devices that Verv does not control with the Platform. The risk that the Platform may face increasing interruptions and additional security vulnerabilities could adversely affect the Platform, and therefore the future utility and value of any VLUX tokens. There is also the risk of Verv suffering a data breach and loss of personal data in this way, which could result in legal action against it by individuals, customers or regulators.

Risks arising from taxation

The tax characterization of VLUX tokens is uncertain in many jurisdictions. Participants must seek your own tax advice in connection with purchasing VLUX tokens, which may result in adverse tax consequences to you, including but not limited to withholding taxes, transfer taxes, value added taxes, income taxes and similar taxes, levies, duties or other charges and tax reporting requirements. Participants bear the sole responsibility for any taxation requirements, in purchasing and holding VLUX tokens.

Risk of hard-fork

The Verv Platform will need to go through substantial development works as part of which it may become the subject of significant conceptual, technical and commercial changes before release. As part of the development, an upgrade to VLUX may be required (hard-fork of VLUX) and these upgrades may mean, if you decide not to participate in such upgrade, that you may no longer be able to use your VLUX and any non-upgraded VLUX may lose its functionality in full.

Financial risks

Even though financial projections for Verv's business have been compiled with the utmost care and attention, there can be no assurance that such projections will be achieved. The actual financial outcome is dependent on future assumptions coming to fruition and could be materially different from the projections. Other factors such as competition and costs associated with Verv's operation could have a significant impact on its financial results. This may undermine public confidence in the Platform, resulting in fewer users and lower token value. Extreme financial difficulties may result in dissolution of the Company and the inability to continue development of the Platform.

Through a strong system of corporate governance and risk management policies and procedures including dynamic financial simulations to rapidly changing environments, together with prudent investment policies, the company minimises these risks.

Risks arising from lack of governance rights

As ownership of a VLUX token confers no governance rights of any kind with respect to the Platform or Verv, all decisions involving the Platform or Verv will be made by Verv at its sole discretion, including, but not limited to, decisions to discontinue the Platform, to create and sell more VLUX tokens for use in the Platform, or to sell or liquidate Verv. These decisions could adversely affect the Platform and any VLUX tokens you hold.
Verv expects to use the proceeds of the Token Sale to continue its business and the development of the Platform, but this may not be the case in the future.

Risk to change of token design/use

The company holds the right to change, modify and hard fork the token into a format that it feels is best for the company and/or future of the token. This could mean adding a new mining function to incentive rollout or changing the structure of the token completely and how it is used, utilised or other. The company needs this flexibility due to the lack of firm rules in regulation and a continued learning of the company and changing of the industry. This could include adding future innovative tools that may not yet be built or just known to the team in the market that might help shape the future of the token.

Risk of intellectual property rights claims

Intellectual property rights claims may adversely affect the company and operation of the Platform. Third parties may assert intellectual property ownership claims relating to Verv's hardware (VHH), or the holding and transfer of cryptographic tokens and their source code. Regardless of the merit of any intellectual property claim or other legal action, any threatened action that reduces confidence in the Platform's long-term viability or the ability of end-users to hold and transfer VLUX tokens, may adversely affect the value of VLUX. Additionally, a meritorious intellectual property claim could prevent you from accessing the Platform, holding or transferring your VLUX tokens.

At present, Verv has no reason to believe any such claims are likely to be brought against it.

Risk of dissolution of the Company or network

The creation and issue of VLUX and the development of the Verv Platform may be abandoned for a number of reasons, including any of the risks described in this section of the whitepaper. Under such circumstances, the Verv Platform may no longer be viable to operate, and the Company may dissolve and may not be able to continue the development of the Verv Platform. There is no assurance that, even if any such Verv Platform is partially or fully developed and launched, you will receive any benefits through VLUX that you hold, and the value of the tokens may reduce to zero.

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