Fighting Energy Poverty Through Innovation

Challenges Opportunities and Solutions

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Part I: Challenges

The energy sector is currently undergoing a fundamental transition. Triggered by the idea of climate change mitigation and political discussions about a nuclear phase-out, the sector has experienced a pronounced shift towards CO2-neutral power generation and energy efficiency. The European Green Deal published in December 2019, clearly mentions that the EU's energy supply needs to be secure and affordable for consumers and businesses, and in order for this to happen, it is essential to ensure that the European energy market is fully integrated, interconnected and digitalised, while respecting technological neutrality. In the same context, the proposal for a regulation of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law) considers as important drivers for achieving the climate-neutrality objective the digital transformation and the technological innovation. Hence, global power grids are undergoing transformations for the application of smart technologies as a result of policies that encourage the use of renewable and distributed resources and increase the participation of electricity consumers in energy management and production. Thus, climate change constraints as well as the recent coronavirus 2020 crisis are putting the global energy sector under the pressure of evolving and modernising at a rapid pace and on an uncommonly large scale.

Energy poverty is a condition whereby people cannot secure adequate home energy services. It is correlated with low household income, high energy costs, and energy inefficient buildings. The recent publication by the European Commission about Renovation Wave identified it as one of the three top priorities, and housing renovation the key solution to tackling it. Energy poverty is affected by multiple factors like adequate warmth, cooling, lighting, and energy to power appliances. All of them are essential services that underpin a decent standard of living and health. The evidence-based, various effects of the aforementioned interaction are felt on social, environmental, and financial levels. According to the International Energy Agency (IEA), more than 1.1 billion people do not have access to electricity and consequently lack access to services and provisions that the rest of the population take for granted. The fact that approximately 20% of the global population is deprived of access to electricity reflects the prevalence of energy poverty on a global scale as well as the magnitude of the problems stemming from this predicament.

It is evident that in regions that experience a drastic and rapid transformation of established economic structures, for example, those that are phasing out of coal as part of their energy transition, it becomes a challenging one cannot always address with conventional support schemes.

Regions that phase out coal face unique and complex challenges. They must go through a groundbreaking transformation that will change dramatically their economic and production models. In many cases, this transformation is planned to be over in very tight timelines. Moreover, the EC has committed to tackling climate and environmental-related challenges through the European Green Deal by deploying growth strategies that aim to transform societies in a fair manner. This approach is expected to infuse the notion of resource efficiency into the existing economic models and make the EU a resource-efficient and competitive economy where there are no net emissions of greenhouse gases and where economic growth is decoupled from resource use.

Digitising the energy sector is a major step forward in that direction. In order to direct the EU's economy to operational models that display sustainability and low carbon dependency, successful solutions should involve diverse, cutting-edge technologies that go far beyond the energy sector. Phasing out regions should be the driving force in implementing and cementing the policies that will deliver the Green Deal from regulation and standardisation to investment and innovation, national reforms, dialogue with social partners, and international cooperation.

In order to comply with the public demands and requirements for change and modernisation, the energy sector will have to digitise, decentralise and decarbonise.

Part I: Challenges

Digitalisation of the energy sector can improve safety, increase productivity and reduce costs. Digitalisation is essential to integrate distributed energy resources (DERs), to unlock load flexibility, to increase variability in the system, to enable people to participate in the management of their energy supply, or help them become active participants in the energy system with their own projects, their own resources, and thus fighting energy poverty and achieving energy democracy. Energy democracy is an emerging social energy trend. The democratisation of energy goes further than the technology and ownership of power generation. It encompasses access to new communications technology and the exponential growth of emerging technologies and the reduction in the cost of several complementary technologies like photovoltaic systems, battery energy storage systems, and other DERs.

The goals of establishing energy democracy and reducing energy poverty can be achieved through the utilisation of emerging technologies, such as the Internet of Things, blockchain, artificial intelligence, machine learning, big data, etc. These disrupting technologies will open the door to transition from energy monopoly to energy democracy. Such an "Energy Internet" will require automated communication between stakeholders and devices. For this to happen we need harmonised and interoperable standards, for example where network codes are concerned. Furthermore, trusted data origins will be needed to have a resilient and trustworthy foundation for the automatised communication. All these needs can be met by Distributed Ledger Technologies (DLT).

DLT technology is a digital way of recording transactions and storing a copy of the ledger in multiple sources at the same time without any central data or administration functionality. It can be applied in different sectors bringing great benefits to operations and lives, providing quicker reactions, greater transparency, and enhanced security, improved traceability, increased efficiency, and speed, or reduced costs, among other benefits. With the energy system fast transforming into one of the most decentralised industries on the planet, DLT could be seen as the missing link for other technologies, operations and practices in the energy sector (and not only) to be more efficient. It is a functional tool in digital transformation, helping other systems to scale up and down. DLT can ensure interoperability of such fragmented and diverse markets as the ones in Europe, making it easier to respond to long-term challenges such as energy poverty, or the sudden ones, such as COVID-19.

With the propagation of non-dispatchable renewable energy systems and the increased significance of post-industrial service provision companies, the old ecosystem with its centrally handled information flow no longer exists, and DLTs are a most suitable tool born out of this transition and fostering it at the same time. Moreover, real-time control and supervision play an important role in the smart energy grid's management. Due to the rapid growth in the deployment of distributed energy resources, the smart grid management problems can no longer be efficiently addressed using centralised approaches. Hence, the need for visionary decentralised approaches and architectures is widely recognised. DLT technology could facilitate a fully decentralised energy system.

Being aware of one's energy consumption behavior has become an important tool to optimise it and "make more with less", which lies at the core of improving energy efficiency and reducing the respective costs. The latter becomes crucial when it comes to those who are exposed to the effects of energy poverty, who unfortunately are estimated to be more than 34 million households across Europe, according to the newly published Renovation Wave.

Although there has been a global hype about DLTs in the past few years, this technology is still in its infancy. It has been deeply tested in terms of what it can do for the finance sector, privacy and data management, social impact in terms of charitable efforts, and even for the energy sector. Although some use cases utilise DLT to tackle energy poverty in the world (e.g. micro-grids in rural India), there has been very little research done on the topic of utilising DLT in vulnerable regions in the context of the energy transition topic as a whole. The lack of information and demonstrations in a form of real-world use cases is only one of the challenges that the deployment of DLT is facing when trying to use the technology to mitigate major global problems.

Part I: Challenges

Major challenges for the deployment of DLT:

1. REGULATORY AND LEGAL

The key for the successful adaption to the new technological conditions is the ability of governments to adopt the right policies. As emerging technologies, such as DLT or blockchain, drive new business and service models, governments must rapidly create, modify, and enforce regulations, standards and even certification programs in order not only to regulate these new technologies and create a legal framework for them, but also to protect the people and ensure fair markets while letting innovation and businesses flourish, which is hardly the case at the moment. More research on the existing regulatory frameworks is still needed, as well as access to real-life regulatory sandboxes. Regulations should target the unclear legal situation concerning the use of external data, data protection, confidentiality and legal concerns of providers, manufacturers and other stakeholders.

2. LEGACY SYSTEMS AND INFRASTRUCTURE

It is a challenge to integrate DLT solutions with existing market roles, their functions and responsibilities in liberalised energy markets. As many grids and networks are still awaiting rollout of smart devices, outdated energy sector infrastructure can heavily impede DLT implementation. The economics of DLT are also at times add odds with established business models and cannot produce real return on investment for all the stakeholders (resulting in e.g. stranded assets) when operating within the legacy systems.

3. EDUCATION AND INFORMATION FLOW, KNOWLEDGE SHARING AND EXPERTISE BUILDING

The lack of expertise and practical knowledge of the technology's mechanisms, dynamics as well as nuances (e.g. private/permissioned vs. public/permissionless) is a key impediment in many sectors, including energy. A great care needs to be taken to also break mental barriers about the technology, prevent disinformation about it, its capabilities or lack thereof, to increase trust in the technology and differentiate it from the stereotypical notion that "DLT means bitcoin".

4. FINANCIAL

There is no flexible and agile funding for the technology to aggregate partners and showcase demonstrations, since Europe is very much behind the amount of funding that goes into these innovative technologies e.g. in the USA or China.

5. INTEROPERABILITY

DLT technology suffers due to missing layers of interoperability between systems as well as conflicting standards, resulting in technological silos.

6. DATA AND PRIVACY

GDPR compliance is one of the key data and privacy related challenges that needs to be worked on.

7. SCALABILITY

Achieving performance and scalability of the DLT technology is considered another challenge.

8. ACCESS

Access to data, decentralised resources and facilities has been identified as one of the challenges to DLT implementation, especially in situations where established stakeholders hold a monopoly.

In order to utilise innovative technologies, such as DLT, to fight energy poverty, it is necessary that the technology triggers energy savings and reduces costs, triggers renewable energy production, reduces greenhouse gas emissions, increases investments in sustainable energy, and facilitates behavioural change. DLT technology has the potential to deliver more efficient, transparent and near real time transaction platforms that will unlock new business models. In the energy industry, this promise is particularly compelling when applied at the grid edge, as greater market participation and transparency are sought.

Fighting Energy Poverty Through Innovation

Opportunities and Solutions

Part II: Opportunities and Solutions

For the past few years, the energy sector and the electricity sector have undergone a severe digital transformation that affected its entire value chain. This digital reform is driven by the need to improve the safety, productivity and efficiency of the electrical grid. Moreover, the recent development of distributed energy resources created a must to introduce new digital solutions in order to accommodate these new energy technologies and unlock load flexibility as an additional degree of freedom in the management of electricity grids. Historically, the first electric grids had the form of small decentralised units at the level of towns and villages. Afterwards, with the increase of energy demand, especially after the first industrial revolution, and with the development of the alternating current and the possibility to transmit electricity over long distances, the electric grid metamorphosed into a larger scale centralised power generation model. Almost 100 years after, and following the development of distributed energy resources, the electric grid is once again shifting into a decentralised yet smarter form. Nevertheless, this change into smart micro-grids was made possible by advancing some old technologies and the appearance of new ones.

Hence, different emerging technologies have disrupted the energy sector in recent years and will continue to do so for the coming years in what has become known as the energy digital transformation. Among these technologies is the Distributed Ledger Technology (DLT), a new transactional digital platform that is decentralised, immutable, transparent, private, and autonomous and that eliminates the need for a trusted third party thus increasing the efficiency of new energy business models, reducing operation costs, maintenance and transaction costs and improving grid reliability. By merging DLT with DERs, the electricity grid can be transformed from a conventional grid into a smart platform where consumers are replaced by prosumers, where value based businesses are shifted to service based businesses and where asset focused management systems change into customer centric systems.

Energy poverty is a pressing problem affected by the complicated interaction of multiple factors, including the increase of energy prices, the high levels of unemployment, people's inability to pay their energy bills, the flat or falling income, and the slow pace at which implementation of energy-efficient measures in residencies is taking place.

In developing countries, energy poverty is primarily experienced as a lack of access to basic energy services. According to estimates published by the International Energy Agency (IEA), more than 1.3 billion people do not have access to electricity and consequently lack access to services and provisions that the rest of the population take for granted. According to the United Nations statistics, 1 billion people have access to energy services, but the services happen to be unreliable. The fact that approximately 20% of the global population is deprived of access to electricity reflects the prevalence of energy poverty on a global scale as well as the magnitude of the problems stemming from this situation. Across developed countries, Member States of the European Union included, the concept of energy poverty is perceived differently. In developed countries, energy poverty mainly suggests permanent or temporary inability to access energy services and provisions. According to the European Renovation Wave Strategy, nearly 34 million Europeans struggle with the phenomenon and its implications. Nearly one-third of households in the United States struggle to pay their energy bills. The differences were minor in terms of geography, but racial minorities were hit hardest. About one in five households had to reduce food, medicine and other necessities to pay an energy bill. Of the 25 million households that reported forgoing food and medicine to pay energy bills, 7 million faced that decision nearly every month. Seven million households (6% of the national total) reported the inability to use heating equipment because of financial constraints at some point, and 6 million (5%) households reported the loss of air conditioning.

When considering solutions on how to mitigate or prevent energy poverty utilising DLTs, these can be classified as soft measures (for example, capacity building and information provision, management and planning, practice and behaviour, policy (strategy), (alternative) financing schemes) or as technical measures (smart enhancements, refurbish buildings, enhance resilience of the infrastructure/grid, increase capacity of systems, etc.). With any emerging technology, also DLT has still a long way to be tested in real life to find out in which situations and locations it is feasible, sustainable, and contributes to solving the problems it was meant to solve at first place, without creating new ones.

Part II: Opportunities and Solutions

Below we consider the following opportunities to mitigate energy poverty:

PEER-TO-PEER ENERGY TRADING (P2P)

Emerging markets need an enabling environment that allows grids to increase their uptake and improve their management of off-grid technology. At this level, DLT can provide an environment for efficient peer-to-peer energy trading using smart contracts and IoT devices, which can lower the operational costs and maximise the uptake from these solutions by creating an open, deregulated market that only responds to supply and demand rather than a market where one entity controls the tariffs and rates. P2P energy trading is not a new mechanism. Several researches have explored it in the past. But DLT can push P2P energy trading to the next level by providing a better return for the generated excess energy, an edge for innovative retailers, along with a low-cost, transparent, secure and near real-time mode of payment.

VIRTUAL POWER PLANTS (VPP)

On another level, the multifaceted relationships among stakeholders involved in a VPP, and responding to the intermittent nature of most DERs, requires a complex administrative process that induces high operational costs, transaction fees and might create issues of trust among the parties. DLT as a platform is very well suited to manage complex transactions involved in virtual power plants while creating trust between unknown peers. It allows to aggregate of various P2P energy transactions into a virtual power plant model.

SMART METERING

Nevertheless, a P2P energy trading system can not be achieved without a smart billing system that responds to all the challenges and needs. A DLT-based smart billing system not only can decrease payment and operational costs while increasing transparency, accountability and control but also can offer a user-centric billing system in opposition to the single PoD existing conventional billing systems. Most tariff structures rely on the consumer's consumption behavior. Suppose we consider the case of a person that only uses one dwelling unit and consumes 800 kWh per month and a second consumer that uses two dwelling units with two separate meters and consumes 400 kWh in each. The first consumer will be paying more than the second consumer even though they have both the same monthly consumption since the first consumer will be charged based on high block rates. And even when checking most Demand-side management programs, the free riders issue is a main challenge. Therefore, a user-centric billing system is a must for new smart grids. And at this level DLT combined with IoT and AI can revolutionise the current energy trading models by providing energy companies with the possibility to incorporate thousands data points per day per smart meter, enabling them to offer customers a variety of innovative, dynamic services and products, while running on an efficient, fully automated process.

STREAMLINED PROCESSES

A significant portion of our electricity bill consists of regulated fees for electricity distribution, system services, market operators' fees and others. One way of reducing the bills is for organisations and utilities to improve their internal operations as well as processes across the whole energy supply chain, thus becoming more sustainable organisations. For many jurisdictions, the process of collecting energy trading, distribution and consumption (i.e. meter readings) data still involves non-automatic ways of collecting those through one database as a single point for the data collection from energy suppliers as well as consumers. Moreover, traditional energy grids have to adjust their processes to face dynamic activities on the grid in real time, while at the same time dealing with an unprecedented increase of data flow due to the rise of decentralised energy sources, mostly based on intermittent resources such as solar and wind. The intermittency of these sources generated further problems to the grid operation and balancing. DLTs can help with the operational efficiency of utilities and other energy market players, especially concerning the balancing and management of the grid, dynamic pricing system and flexibility of agreements (when it comes to demand and supply of energy) and more transparent accountancy and monitoring (decreasing corruption as well as electricity theft). DLTs enable electricity surplus or shortage to be automatically traded between the energy market players, creating a responsive trading platform.

Part II: Opportunities and Solutions

This gives power to the new type of customer, so called prosumers, who generate their own electricity and are able to provide their surplus energy to their community or those who need it. It can give them the peace of mind that their assets and green electrons that they create are used for the benefit of the broader community, utilising the existing infrastructure more efficiently and enhancing decentralised services. DLTs give them the peace of mind that all transactions are done according to their wishes and are financially awarded in a secure and transparent way. This is the democratisation of the energy trading system, which gives more control to the end-user.

GAMIFICATION AND REPUTATION-BASED IDENTITIES

There are almost 3 billion gamers in the world. One of the earliest examples of gamification of industries worth mentioning is the airlines and credit card companies, which built points systems designed to get users to spend and participate, rewarding them with redeemable prizes. Gamification provides a great tool to engage individuals around the world to participate in solving global challenges, such as energy poverty, through, for example, financial literacy. Games can simulate people's financial life so that they know what to do with the money since they've already played that out in a game. Gamification offers great means to:

- Incentivise, reward people for their activities, participation, etc.
- Teach people and demonstrate to them the various real-life scenarios through school by play, pushing for behaviour change, improving their credit scores and financial literacy, providing them with the power of knowledge and ultimately confidence and hope.

Gamification of real-life can provide a mission and a learning experience for gamers. Many companies are already using games to teach financial concepts and habits that are difficult to convey through traditional methods. Users that participate in mission-based games are rewarded with tokens that can award them, for example, valuable discounts and promotions at their favorite retailers. Those tokens can be linked to important environmental challenges, for example, by rewarding people for recycling, collecting rubbish in nature, etc., thus acknowledging these citizens for the environmental champions they are. Participants can be receiving points for their "good deeds", creating their own reputation-based identity. Those points can then be utilised, for example, as collateral in a bank when taking out a bank loan or can remove the need to transact with cash (as the Social Plastic® project does).

Gamification can benefit greatly from utilising blockchain technology since it provides speed, traceability, immutability, control, transparency, trust, security. Suppose more and more companies and organisations start utilising blockchain to reward their customers through gamification, improving user experience, engagement, and loyalty. In that case, these "gamified" services/apps may help lift people from poverty by connecting them to the global supply chains they participate in and the brands, organisations and governments that power them. Recycling waste by low-income customers, utilising gamification, is a great example of turning cyclical poverty into a circular economy. Combining the power of gamification with the various technological benefits of DLTs could also help businesses streamline their activities and consequently lower the cost of services/products to the end-consumer.

OFF-GRID, SELF-SUSTAINABLE HOUSEHOLDS AND COMMUNITIES

Self-sustainable communities, which are less reliant on the main grids (and thus not requiring costly expansion to the existing infrastructures), are one of the possible pathways to alleviate energy poverty. That applies especially to developing countries, which sometimes lack the energy infrastructure that developed countries have. On the other hand, this lack of legacy infrastructure might make it easier for those locations to adopt smaller, sustainable, innovative solutions more easily by being able to go off-grid, replacing mainly their energy and water supplies from the main grid for renewable and local alternatives. It provides the people the means and tools to take care of their own community and local needs.

Part II: Opportunities and Solutions

Blockchain can be helpful in balancing the energy supply of individual households within the self-sustainable community through energy sharing, ensuring flexible energy generation/selling and purchasing/consuming the energy, as well as exchanging both energy and associated information in multiple ways.

Prefabricated off-grid-ready homes could possibly benefit from blockchain as well. The technology could help streamline the supply chain, design documentation, planning processes, and construction contracts needed to construct those buildings, making the processes more secure and accurate. In a self-sustainable community, blockchain technology could be, for example, the means to evenly and automatically distribute payments for different uses, especially when households generate their own power and participate in the shared economy, by selling their surplus energy and receiving credits or rewards in exchange.

EDUCATION AND CONNECTIVITY

Not only mitigation activities are needed, but prevention and empowerment as well to fight energy poverty. The best prevention is in the form of education, knowledge, enabled through the Internet, and connectivity. More than 300 million young people between the ages of 15 and 24 worldwide are not connected to the Internet at school. This lack of connectivity makes them significantly disadvantaged on the job market compared to children who have good access to education, information, and digital skills, which are an inherent part of most jobs and livelihoods these days (especially due to COVID-19). Thus, the lack of connectivity creates an even further divide, the so-called digital divide, leaving behind those whom the technology should have empowered at the first place.
Connectivity is thus essential in empowering people worldwide and providing them with the knowledge on how to battle global issues, such as energy poverty. DLTs can help introduce the ability to connect people around the globe fairly and transparently to ensure all can receive (digital) education, have access to information, and are not disadvantaged when seeking a job.

CRYPTOCURRENCIES

Blockchain can help to reduce poverty by using cryptocurrencies for people who have no access to bank accounts. Possible solutions could be brought by generating new funding models, such as crowdfunding, by issuing a project-specific currency. DLTs have the potential to solve the problem of trust between individuals without going to a third party, and they also make possible new types of governance and relationships based on transparency.

ENERGY-BACKED CRYPTOCURRENCIES

The lack of financial incentives or funds is the main barrier facing the development of distributed energy resources. This challenge applies to both developed and developing countries. An energy-backed currency might be the type of incentive needed to improve the economic feasibility of renewable energy-based power generation. The concept of an energy-backed currency is similar to the gold reserves that are used to stabilise national currencies. Users are rewarded for generating energy from renewable energy resources in the form of energy-backed cryptocurrencies. The energy-backed cryptocurrency can be exchanged for other cryptocurrencies or conventional currencies. Holders can also use their energy-backed cryptocurrency to pay for products and services from participating merchants and service providers. The use of DLT for this type of application ensures that the transactions are secure, without the need of a bank or a trusted third party. Transaction histories can be shared with all community members enabling automatic verification. Further applications for the energy-backed currency or token can be explored such as using it to trade for goods and services within a certain community. Energy-backed currencies using blockchain might provide incentives for communities in developing countries, especially if combined with smart contracts and P2P energy trading within community micro-grids.

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Part II: Opportunities and Solutions

On the gates of the fourth industrial revolution associated with a global trend towards a decentralised energy grid, DLT forces itself as the technology that can move the energy system from its centralised form to a smart decentralised network.

Nevertheless, DLT infiltration will be met with resistance because it represents an extreme change to the current method of doing business, especially by eliminating the need for trusted third-party intermediaries. The first stage of intermediaries phasing-out was initiated with the Internet, and DLT is considered its second stage. Yet this resistance might be less ample in developing countries than in industrialised ones. Future interconnected energy markets will certainly rely on decentralised, democratic, and resilient electricity trading, and as a game-changer, DLT is an ideal vehicle for improving millions of people's quality of life and fighting energy poverty while promoting energy democracy.

Finally, despite all challenges, there is a growing certainty that DLT will revolutionise the energy sector. While the world is heading towards a more decentralised decarbonised energy system, DLT can certainly advance the development of distributed energy resources, especially in developing countries.

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