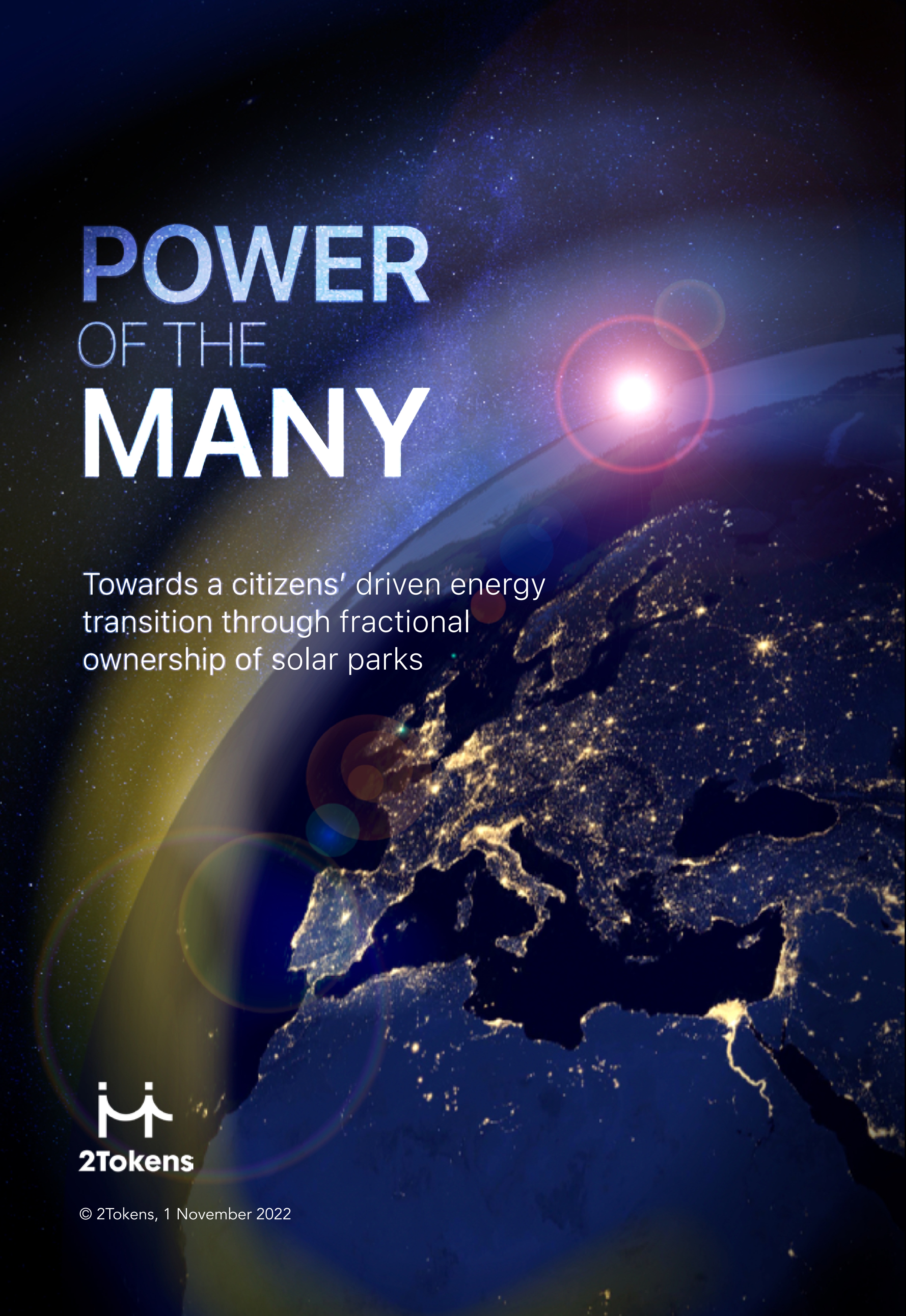

POWER OF THE MANY

Towards a citizens' driven energy transition through fractional ownership of solar parks

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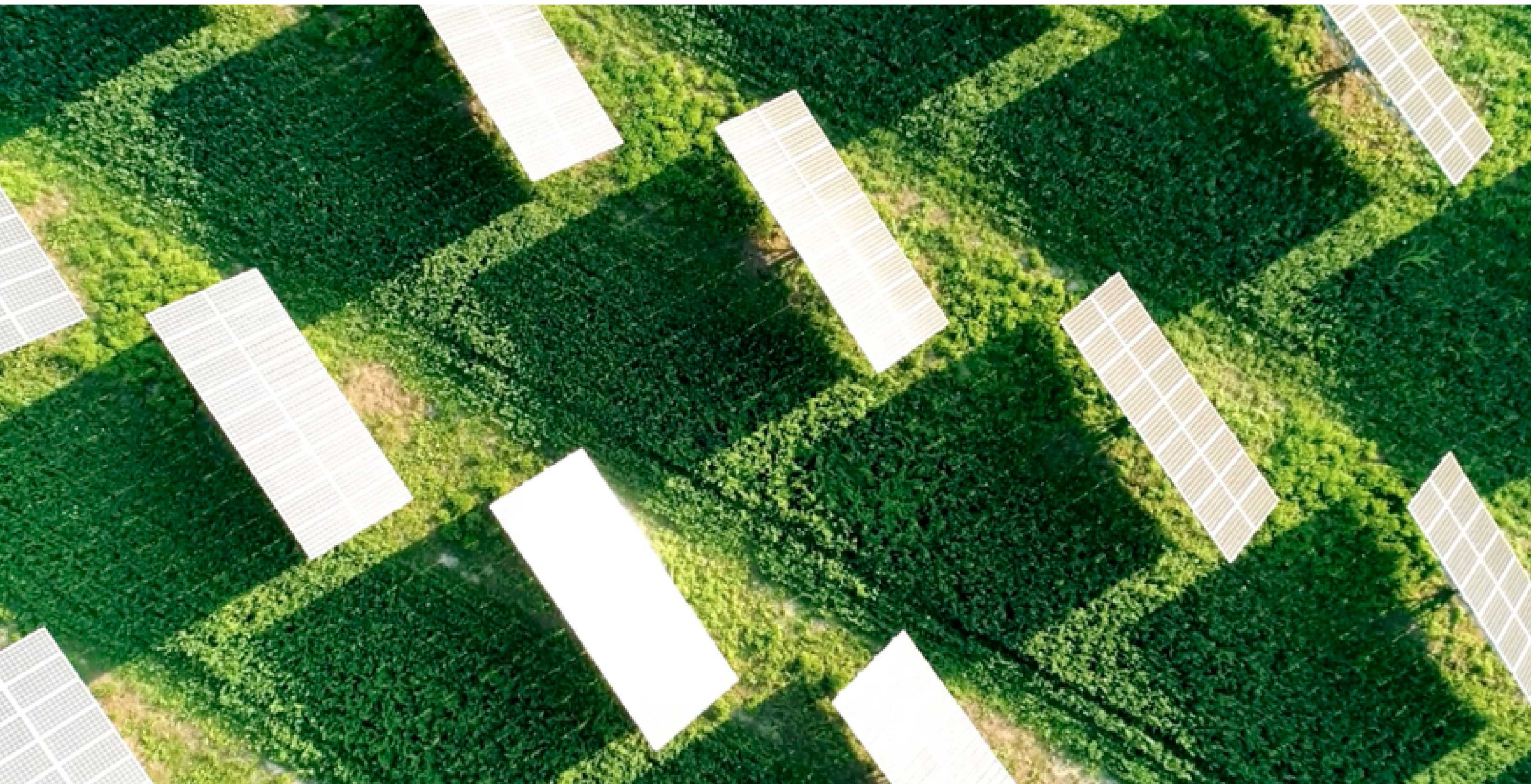

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1 INTRODUCTION

With pride, we present to you the Whitepaper Power to the Many; Towards a citizens' driven energy transition through fractional ownership of solar parks.

In 2015, 193 countries ratified the Paris Agreement with the aim of strengthening the global response to climate change. The objective of the energy transition is to reduce energy-related greenhouse gas emissions to mitigate climate change. In response to the war in Ukraine, the European Union aims to increase the target for renewables further to 45% by 2030. Solar has become one of the world's cheapest sources of energy generation. There are several issues with scaling solar though.

We envision a decentralized energy system in which people are empowered as prosumers in so-called Energy Communities: a novel way to engage citizens in the energy transition. Solar investments via Energy Communities lowers NIMBY (not-in-my-backyard) behavior, supports inclusion, avoids larger inequalities caused by the energy transition, and improves their skills. This puts the control of electricity generation back in the hands of many by making citizens active participants in the energy transition. Energy Communities also enable citizens who cannot install rooftop solar - because of multi-dwelling buildings, monuments, or other restrictions - to enjoy the benefits of (co)owning solar energy installations. Our solution increases solar uptake while cutting consumers' bills, lowering energy poverty, and increasing energy security and independence as a side effect.

This Whitepaper is made by the Energy Working

Group of 2Tokens. The group kicked off in 2021 and concluded the first phase in summer 2022. The finalization of the first phase provides a way to tokenize solar parks. This Whitepaper does not describe the way the initial offering of tokens is executed, nor the way secondary trades will be settled. The team is fully aware of the fact that decisions concerning this topic have regulatory consequences. Different solutions will be considered as part of Energy Working Group Phase II.

The Energy Working Group will continue to develop novel tokenization ideas in the energy sector. In Phase II, we will tokenize the offtake of a solar park, including the energy generation itself, data collection and management by tokenization of Guarantees of Origin, Renewable Energy Credits, and other data streams, new forms of energy balancing, and smart grid management; energy governance; etc.

This Whitepaper shows how we aim to empower local stakeholders in financing and managing community-owned solar parks. We will describe the underlying motivations and technology stack choices of the Energy Token project for fractional ownership of solar parks.

In chapter 2 we show that the European Union promotes to put citizens at the center of the energy transition. This happenes through the support of community energy, local ownership, and the transformation of energy consumers to prosumers. It is supported in The Netherlands in the Dutch Climate Agreement (Klimaatakkoord), in which the environmental and market parties agreed to ensure that renewable energy projects on land will work together on an equal footing in development, construction and operation. This translates into a balanced distribution of ownership in an area, aiming at 50% ownership of both production and offtake by citizens and companies in the proximity of a solar park or wind park from 2030 on.

Our solution is described in chapter 3. The Fractional Ownership for solar parks envisions the creation of an ecosystem in which solar panels belonging to a solar park are tokenized and owned by multiple investors. These tokens are initially offered by the asset manager. After a token has been sold for the first time, it can be traded among buyers and sellers. To do so, a platform where these kinds of transactions can be made is provided and a secondary (liquid) market for tokens is enabled.

The use of panel-level data imbues property rights and live metadata tagging of green energy (Proof of Origin). This enables more democratic access to project finance opportunities for asset and off-take, thanks to the disruption of entry access barriers allowed by fractionalized ownership. This can boost individual and community ownership of solar parks. An open and decentralized digital platform for the energy sector provides the smart contract mechanism to store decentralized identities and their credentials, and facilitates on-chain verification and transactions between parties. This is detailed in chapter 4.

Chapter 5 focuses on the regulatory hurdles. A token represents rights attached to ownership of a solar panel. However, the possibilities to separate a solar panel from the solar park are limited. A solar park must act as a single legal entity to enter legal obligations such as land rights. Therefore, we propose the separation of legal and economic ownership. This means that a token represents economic ownership rather than legal ownership of a solar panel.

In the last chapter we describe the tests, minimal viable product, and future developments. To prove the feasibility of the project, we have implemented the fractional ownership model using the concepts and models described in this Whitepaper. A small rooftop solar site enabled the idea to go from a concept to an actual physical project. Currently, we expand the MVP to 200 panels on the rooftop of The Green Village in Delft to allows external investors to join in on the project. This will prove that the concept can be easily rolled out on a much larger scale as well. After outlining the need to accelerate the pace of the energy transition and the renewed role citizens must have to achieve this objective, we present the business case for fractional ownership of a solar park and tokenization of solar panels. Finally, we present a high-level overview of the Fractional Ownership Framework.

A note about the issues with some blockchains and energy consumption for maintaining these blockchains. We simply propose to solve this issue by choosing or building a technology stack that is net-zero or close to net-zero.

2 THE ENERGY TRANSITION, SOLAR DEPLOYMENT, AND CITIZENS' PARTICIPATION

2.1 WHAT IS THE ENERGY TRANSITION AND WHY DOES IT MATTER?

In 2015, 193 countries ratified the Paris Agreement with the aim of strengthening the global response to the threat of climate change, by limiting the global average temperature increase to well below 2°C, as well as pursuing efforts to limit the temperature increase to 1.5 °C. A major element in the achievement of the Paris Agreement goals is the reduction of greenhouse gas emissions from energy generation. The growth of renewable energy - including solar and wind, is pivotal to reducing the emissions needed.

According to the International Renewable Energy Agency (IRENA), the energy transition is a pathway toward the transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. Its overall objective is to reduce energy-related greenhouse gas emissions to mitigate climate change. In this pathway, renewable energy and energy efficiency measures are key as they have the potential to achieve 90% of the required emission reductions. But the current pace of the energy transition is in no way aligned with the urgency, as 2028 marks the year in which we will have exhausted the emissions budget to stay within 1.5 degrees (Bloomberg NEF, 2021).

The political instability between Russia and the European Union is speeding up the road to energy sovereignty further. Russia's unprovoked war against Ukraine has highly impacted the world's energy system, with energy prices climbing and the need for energy security increasing. And although this should be yet another reason to speed up the transition to clean energy, fossil fuels have regained lost territory. In this context, the need is ever more pressing to act now for a 1.5°C-aligned and just energy transition that leaves no one behind.

2.1.1 CLIMATE COMMITMENTS AND A CITIZEN-POWERED GREENER EUROPE

The European Union recognizes that climate change represents a major risk. To mitigate this risk, the European Union adopted the European Green Deal with the aim of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The Green Deal calls upon a multitude of different actors to achieve these goals, including (local) governments, businesses, financial institutions, project developers, utility providers energy firms and consumers.

The European Commission has launched the European Climate Pact which aims to empower citizens to contribute to a greener Europe. The energy transition must be just and inclusive, put people first, and bring together citizens in all their diversity. To do this well, it is essential that the environmental impact of production and generation is known.

2.1.2 RENEWABLE ENERGY AND SOLAR: THE ENERGY TRANSITION IN EUROPE

The global energy arena is rapidly changing. The cost of wind power, solar power, and storage technology has reduced sharply over the last few years - increasing the economic attractiveness of the low-emission energy sector transitions through 2030. Solar has become one of the world's cheapest sources of energy generation, although there are challenges, like insufficient production, and the geo-political risk that the majority of solar panels are manufactured in China. Renewable energy sources counted for 37% of the electricity consumption in the European Union in 2020. Solar power is the fastest-growing source (Bloomberg NEF, 2021), and a Solar Surge is underway globally.

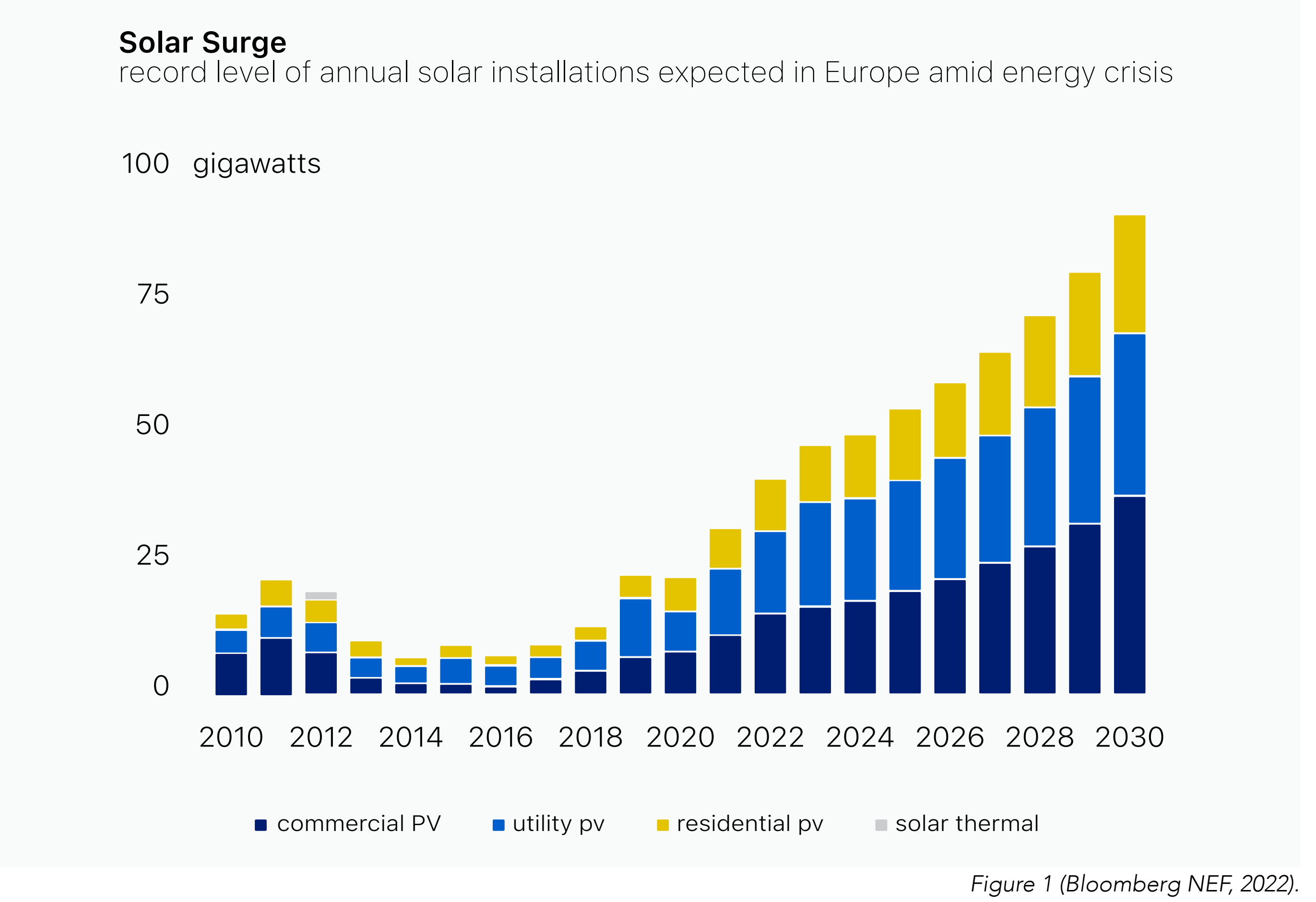

Figure 1 (Bloomberg NEF, 2022).

This BloombergNEF forecast matches the **High Scenario** forecast from SolarPower Europe, published in 2021 ([EU Market Outlook for Solar Power 2021-2025]())

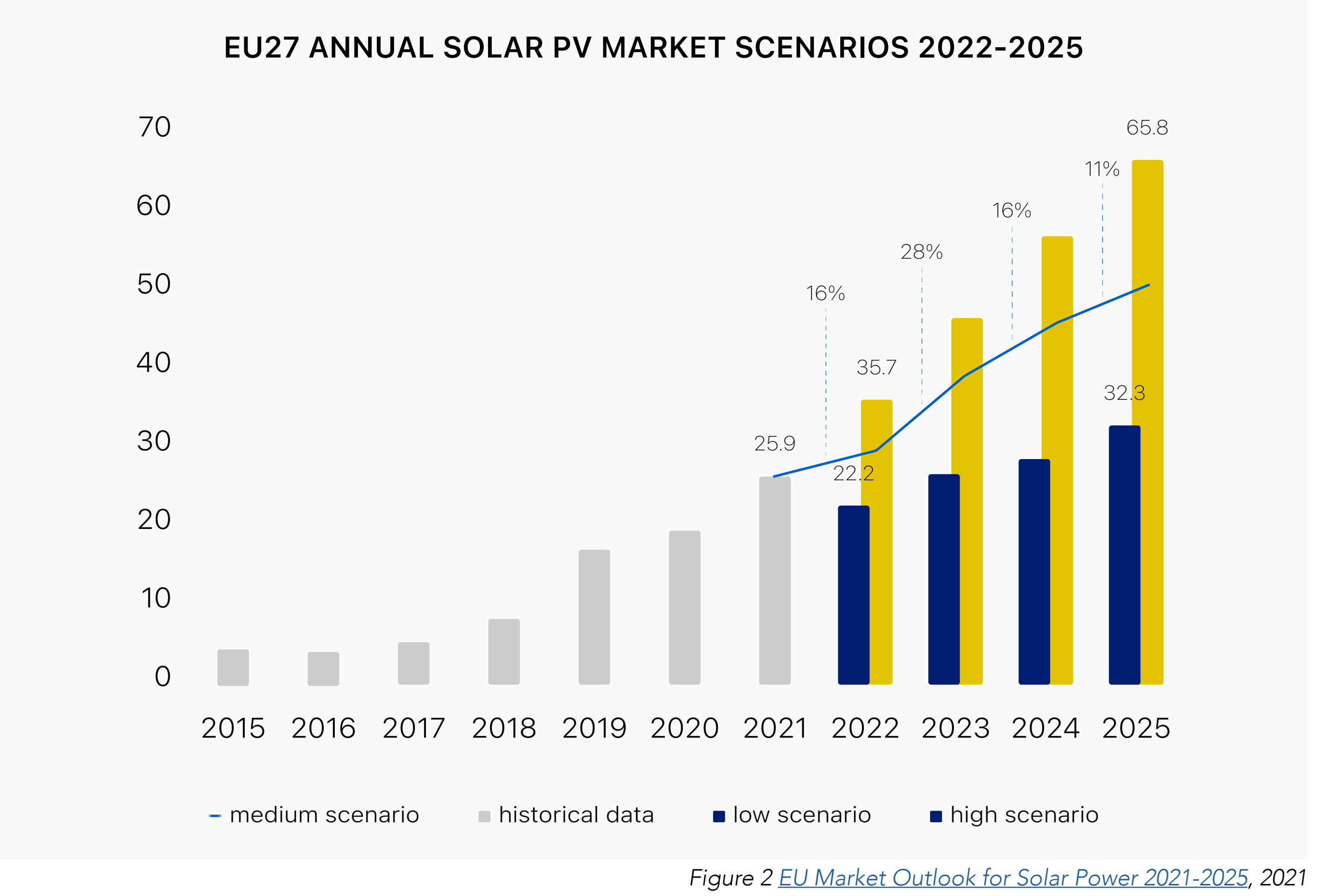

Figure 2 EU Market Outlook for Solar Power 2021-2025, 2021

In May 2022, in response to the war in Ukraine, the European Commission proposed to increase the target for renewables to 45% by 2030; this is recently backed by the European Parliament. This would bring the total renewable energy generation capacity to 1236 GW by 2030.

2.2 THE CURRENT PROCESS FOR THE DEPLOYMENT OF SOLAR ENERGY

- In most situations, the process of building a solar park follows the next steps:
- The creation of a solar park is initiated by a developer or community
- The developer sources land for a new project. This land is either bought or leased
- The developer raises loans to finance the development of the project. These loans are usually obtained from private and industry investors (if the project is bankable)
- To bring a project to "shovel ready," Grid Connection and Environmental and local municipality Development Approvals have to be secured.
- Subsequently, a project will be engineered, developed, & built (the Engineering, Procurement, and Construction process).
- In the process of building a solar park, the solar panels & inverter systems are connected to the grid by the Distribution Network Operator (DSO)
- When the solar park is ready for commission, the ownership of the park is completely transferred from the developer to the asset manager.
- Developer: develops the park upfront (equity investment)
- Banks and industry investors: provide the capital needed for Engineering, Procurement, and Construction
- Landlord: owns square meters (hectares) where the solar park is installed
- Distribution System Operator: distributes energy in a geographical area to energy customers.
- Asset Manager: manages a solar park and offers a portfolio of services to stakeholders of the park. refer to: SolarPower Europe (2020), Asset Management Best Practice Guidelines Version 2.0 Asset Manager: manages a solar park, and offers a portfolio of services to stakeholders of the park.
- Energy customer: customers of energy, with a bilateral Power Purchase Agreement (PPA).

2.3 WHAT ARE THE PAIN POINTS & BOTTLENECKS?

There are, however, several issues with scaling solar.

1. Nimby (not in my backyard) behavior from local stakeholders
2. Major investments are needed in outdated electricity grids across most Western jurisdictions
3. The law doesn't cater for fractional ownership
4. Regulatory challenges: the difference between movable and immovable property

2.3.1 NIMBY

There is a lack of public acceptance for large scale energy projects such as solar parks. When solar parks are imposed top-down to communities, people feel excluded, leading to the so-called Nimby (not in my backyard) behavior that blocks or slows down investments.

To overcome these challenges, the European Union promotes to put citizens and consumers at the center of energy transition, through the support of community energy and local ownership and the transformation of energy consumers to prosumers. This is picked up in several member states. It is supported in The Netherlands in the Dutch Climate Agreement (Klimaatakkoord), in which the environmental and market parties agreed to ensure that renewable energy projects on land will work together on an equal footing in development, construction and operation.

Figure 3: Simplified Process Flow of building a solar park

This translates into a balanced distribution of ownership in an area, aiming at 50% ownership of both production and offtake by citizens and companies in the proximity of a solar park or wind park from 2030 on.
Promoting decentralized renewables moves the control of energy investments away from big, centralized producers and distributors to city, village, and community scale initiatives, as well as prosumers. This is a game changer, especially for a constrained grid, remote cities, low-income communities, as-well-as for developing economies.

Fractional ownership of solar parks by local communities lowers the negative responses from local stakeholders. With community engagement, the entry barriers tend to go down, allowing for more democratic access to project finance opportunities for renewable asset and their off-takes. This can boost community ownerships of solar facilities. The effect of the networked transparency enables a new level of bankability for solar assets, creating a simple financing model to facilitate utility-scale solar networks in the same way 2G and 3G networks facilitated the widespread uptake of mobile phones.

2.3.2 MAJOR INVESTMENTS ARE NEEDED IN THE OUTDATED GRID

In Europe, centralized energy generation has been the norm since WW-II. It involves the generation of electricity by a few large power plants with massive power grids to facilitate energy distribution nationwide. This generated electricity is then transported over a distance to consumers through electric power grids. Access to electricity is expanded by extending the electric power grid to new (remote) areas. Currently, the European distribution grids connect 260 million customers and transports 2700 Terawatt-hour of electricity annually over 10 million km of power lines, and millions of substations managing the transformation between high, medium, and low voltage levels - which is required in order the deliver electricity to home owners and business.

The electrification of our economies is essential for the energy transition. A centralized energy system requires huge investments in power grids. The European Commission estimates that until 2030 over €70 billion is required for grid expansion plans. And this updating of the grid will not be able to handle the growth of renewable energy generation that will be required in order to meet the targets agreed in the European Green Deal. The bi-directional and variable energy flows and the increasing electricity demand, however, urges for a dramatic increase in closer monitoring, control, and analysis of the energy flows in general.

The future energy system will have a strong decentralized component. This is due to the decentralized spread of new renewable energy sources, decentralized batteries (stationary or in electric cars), and the electrification of loads. Decentralized electrification involves generating electricity at or near the place where it will be used. Imagine renewable energy sources that cater for local markets, like a neighborhood, an industrial park, or a village. In this situation, most energy produced is used locally, and only the surplus energy or access energy due to daily and seasonal mismatches needs transportation over the grid. This can be further balanced by using decentralized storage, like batteries, or by using surpluses for local hydrogen production or other useful purposes that can be switched on and off as required depending on electricity demand.

2.3.3 EVERY SOLAR PARK HAS A SINGLE OWNER

The current structure favors one single or a small group of wealthy owners of a solar park. It is not conducive to support fractional ownership. The same is true for trading among different owners. Furthermore, there is no uniform legal definition of tokens in Europe; therefore, we actively challenge the European policymakers who are responsible for our laws and regulations to support our endeavors to make this project feasible.

2.3.4 REGULATORY CHALLENGES: MOVABLE VERSUS IMMOVABLE PROPERTIES

A solar panel is considered movable property. A person can own a solar panel and easily move this asset around. However, when attached to the ground and solar grid, it is considered immovable property. This situation can be compared with the analogy of a brick and a house. A brick is easily movable. However, when put into a house, it becomes immovable, and it's impossible to merely own that brick. In essence, this implies that fractionalized ownership of a single solar panel, which is part of a solar park, is not possible.

To overcome this historic challenge of immovable property for a solar park, the following solution is proposed. A citizen owns a certificate of a share, and the amount of shares is equal to the number of solar panels. The reward (revenue from the solar panels) is based on a virtual panel and the total revenue of the solar park. This means that every solar panel provides an equally divided revenue, based on the average revenue per solar panel.

2.4 TOKENIZATION AND ENERGY: A PERFECT MATCH

The Energy Workgroup of 2Tokens is a carefully selected multi-disciplinary group – with entrepreneurial, economical, regulatory, policy, hardware, software, and research backgrounds - that collectively cracked this nut. The Energy tokenization working group envisions an eco-system in which solar panels belonging to a solar park are tokenized and owned by multiple investors, including small investors living in the proximity of a park.

The impact model proposed aims to link technological innovation, energy decentralization.

The model proposed in this whitepaper aims to link technological innovation and energy decentralization, to support the European Green Deal objectives and foster community empowerment. Fractional ownership, tokenization of assets, and blockchain/distributed ledger technology are disruptive key enabling components aimed at achieving our goal.

We will use a holistic approach based on the 5 Ds:

1. Decarbonization: renewable energy is the center of the proposed solution
2. Decentralization: community control of energy generation and consumption
3. Digitalization: the creation of a smart infrastructure that allows access to solar park investments to micro, small and medium investors
4. Democratization: increased access to solar investments and local energy generation and consumption, thanks to the disruption of entry barriers allowed by fractionalized ownership. This will boost individual and community ownership of solar parks. This enables a new level of bankability for solar assets, creating a simple financing model to facilitate utility-scale solar networks
5. Diversity: the tokenization of data will allow fractional ownership of solar panels that can be bought by local communities via the creation of energy cooperatives

2.5 THE BUSINESS CASE

The advantages of tokenization are leveraged by tokenizing solar panels belonging to a solar park. The concept allows:

- New investors to enter the market for renewable energy. These new participants create improved liquidity in a market that is traditionally illiquid since large investments are required to build a new solar park
- Buyers and sellers to trade their tokens in an easy fashion (and thus solar panels) on a secondary market using one of several digital asset exchanges that now exist. An easy, transparent, and secure environment for this kind of trading is created
- Unlocking of new value streams. By tokenizing the assets and the offtake of a solar park, new business models become available. This includes the energy generation itself, data collection and management by tokenization of Guarantees of Origin, Renewable Energy Credits, Granular Certificates, and other data streams, new forms of energy balancing and smart grid management, energy governance, etc. Note that this will be developed in Phase II.

This Whitepaper does not cover the way tokens are issued and traded among buyers and sellers in detail. The first phase of this project, which is described in this Whitepaper, is an essential step for the creation of the envisioned ecosystem. In the following phases, different solutions for the initial issuing of the tokens and secondary trade will be considered.

2.6 WHY BLOCKCHAIN?

In a post-COVID world, most organizations have implemented some form of intelligent digital workflows. At the same time, there is a pressing need to collaborate in ecosystems. A logical next development is called 'multi-party intelligent workflows', according to IBM's paper on Virtual Enterprise.

To provide provenance, reduce information asymmetry, and enable these innovative new collaborations, blockchain IT has proven the most suitable solution. Trust in the ecosystem can be supported by having access to data beyond the traditional point of contact in the value chain as all relevant data can be accessible in a highly transparent nature to those parties that need it.

The inclusion of a blockchain layer means that the data that is being validated, as well as the transaction validating this data, is contained in the same distributed ledger. The use of a blockchain enables the creation of a 'single source of truth' containing all relevant information, such as the current owner of the solar panel, where and when the power was created. This digitization also allows for the easy and transparent transferal - and therefore tracking - of solar panel ownership and yield within a cryptographically secure environment. This distributed data structure will be accessible by all relevant parties without making any sensitive information publicly available.

Of course, the question arises: why use a blockchain at all when creating a digital solution? A blockchain - given its distributed nature - allows a digitization solution to sidestep the issue of trust by replacing the Trusted Third Party with verifiable software, requiring no trust to be placed in any additional parties. The use of blockchains also offer all relevant parties greater transparency so building more trust in the data. Furthermore, utilizing blockchain technology allows for the inclusion of tokenization into any technology solution - a solution that will be discussed below. Before discussing this however, a broader point must be made regarding tokenization as an approach.

Blockchains will be the 'glue' connecting the Future Energy Grid - Blockchain (sic) "... provides mathematical proof about the state of data, and it's commonly associated with cryptocurrencies, but cryptography and consensus mechanisms underpin this. At the end of the day, it's to build a trusted relationship." NREL Panel via Forbes Article, May 22, 2022

Tokenization - the creation of an abstract representation of an asset - is often associated with a particular blockchain. Given the nascent status of blockchain technology, this is to be expected: each blockchain developed its own token framework independently. As such, each is suited to different environments and has different characteristics. Therefore, this means committing to a specific blockchain early on in a project can be prohibitively restrictive over the course of a project's lifespan.

3 FRACTIONAL OWNERSHIP OF SOLAR

3.1 INTRODUCTION

The Fractional Ownership for Solar projects envisions the creation of an ecosystem in which solar panels within a solar park are tokenized and owned by multiple investors. These tokens are initially offered by the asset manager. After a token has been sold for the first time, it can be traded among buyers and sellers on a secondary market and thus help to create greater liquidity than is the usual case with the way many existing renewable energy projects are financed.

Trading a token representing a solar panel essentially means trading the claim on the offtake revenue of a particular solar panel. To be precise: An (micro)investor owns a certificate of a share, and the amount of shares is equal to the number of solar panels; The revenue of solar panels is based on a virtual panel and the total revenue of the solar park. This means that every solar panel provides an equally divided revenue, based on the average revenue per solar panel. The performance of the solar panels is tracked to precisely determine this revenue. It also allows for understanding the exact amount of energy produced by the solar park.

By providing this ecosystem, smaller investors can gain access to buying and selling assets either initially when the solar park is raising capital, or later in the secondary market, thus democratizing the energy market.

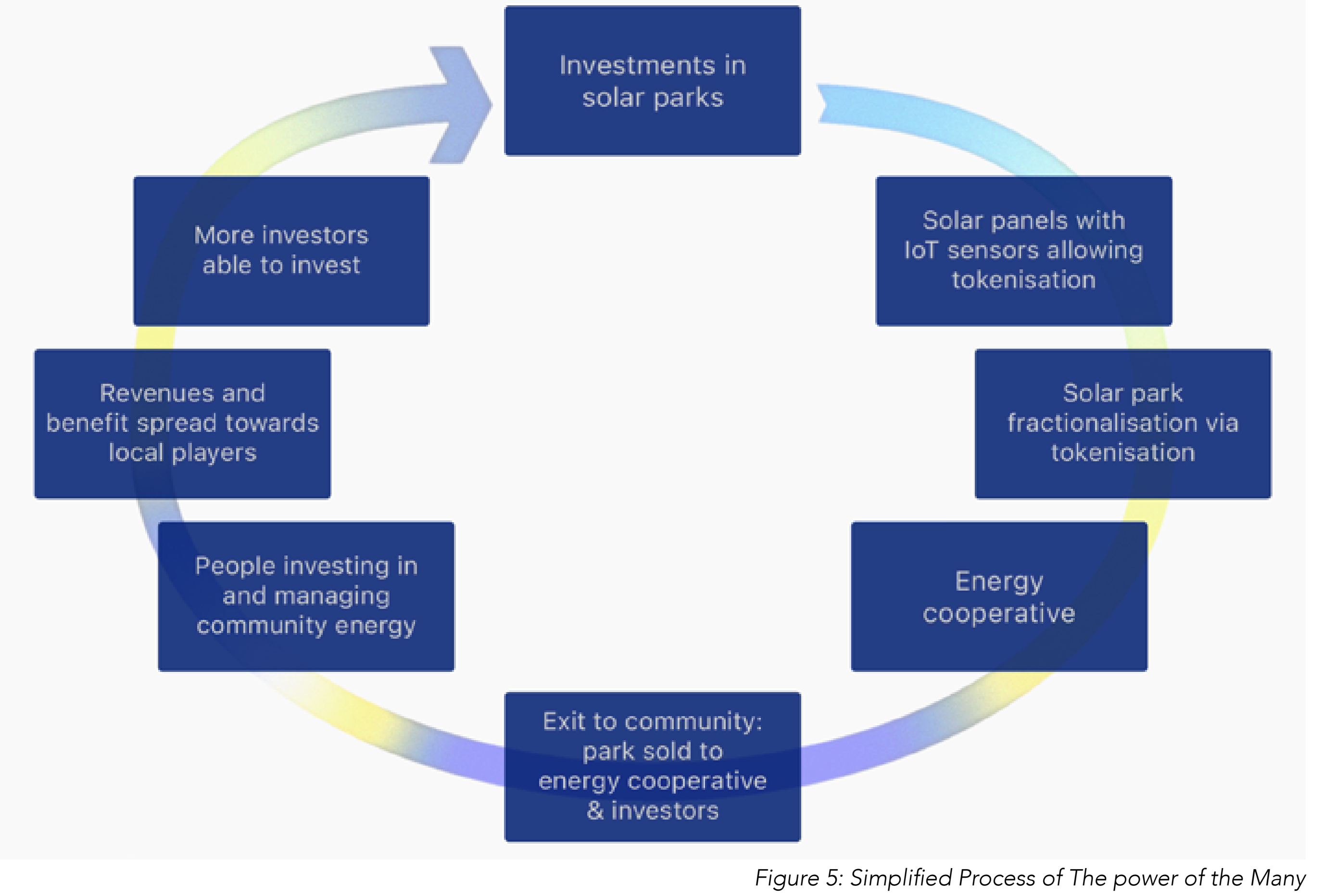

Figure 5: Simplified Process of The power of the Many

3.2 THE STORY OF ALICE AND BOB

The following example briefly describes the practical value this ecosystem provides:

- ALICE and ROSA are small investors living in MYVILLAGE. They both lend €10,000 to solar park builder SUNNY-BV via crowdfunding platform SOLAR-CROWD.
- SUNNY-BV uses the funds to develop the fully Unity-IoT-sensor enabled solar park in MYVILLAGE.
- From day one of the operational park, SUNNY-BV gets and may give insight in electricity production, Guarantees of Origin, Renewable Energy Credits, and other data from the park.
- After 2 years, SUNNY-BV sells Solar-Park-Security-Tokens (fractions of the solar park) on secondary markets. In this case, SUNNY-BV sells the security tokens to companies and small investors in MYVILLAGE.
- The loan of ROSA is paid back with interest. ALICE chooses to convert her loan into Solar-Park-Security-Tokens, regulated by a smart contract on the Solar-Park-Security-Tokens platform.
- The solar park provides energy via MYVILLAGE-ENERGY-COOP to companies and households in its proximity. BOB-THE-BUILDER-BV chooses to buy energy from MYVILLAGE-ENERGY-COOP.
- ALICE and ROSA are members of MYVILLAGE-ENERGY-COOP too. ALICE has an electrical car; she charges her car at any local EV-charger with her own energy. All members of MYVILLAGE-ENERGY-COOP are always able to understand the exact amount of energy produced and consumed by their own park in real-time.
- On sunny days, the solar park produces more than the local needs; the excess electricity is stored in Unity-IoT-sensor-enabled batteries or used for local hydrogen production. BOB-THE-BUILDER-BV uses the hydrogen for fueling its machines. ALICE uses the energy for heating up her house at night-time.
- On cold winter days, the park produces less than the local needs. This is partly solved by (demand management) where prosumers agree to remotely switching non-critical electrical appliances off. The rest is bought via the main grid. Happily, the gridlines are sufficient because of the lower need due to the local solar park.
- Thanks to Solar-Park-Security-Tokens, the MUNICIPALITY-OF-MYVILLAGE can estimate how much is produced and when. This allows MUNICIPALITY-OF-MYVILLAGE to make proper policies to transition and become climate neutral.

3.3 THE USE CASE OF FRACTIONAL OWNERSHIP OF A SOLAR PARK

The use case Fractional Ownership of a solar park quickly circles around the question of what the word 'fractionalized' means. In our approach we considered the following ways of fractionalizing:

1. Financial
2. Power capacity
3. Physical solar panel

Traditional solutions are based on financial fractions by allowing shares. This is the approach Wien Energy took in their first community-owned solar project in Vienna. The power capacity for solar panels expressed as watt-peak (also called the nameplate capacity of each panel) was considered but was not selected as the first concept to tokenize. This is mainly because environmental factors influence the actual energy being generated over time. Each Panel will have a different production profile. This idea is hard to grasp for most.

The Fractional ownership in this Whitepaper selected the physical solar panel as the unit. As an example, a 5MW solar park can easily hold 10.000 panels; each panel having a fraction of the solar park as a single panel seems an easy-to-grasp concept.

The process overview provides a schematic overview of the capital project phases and

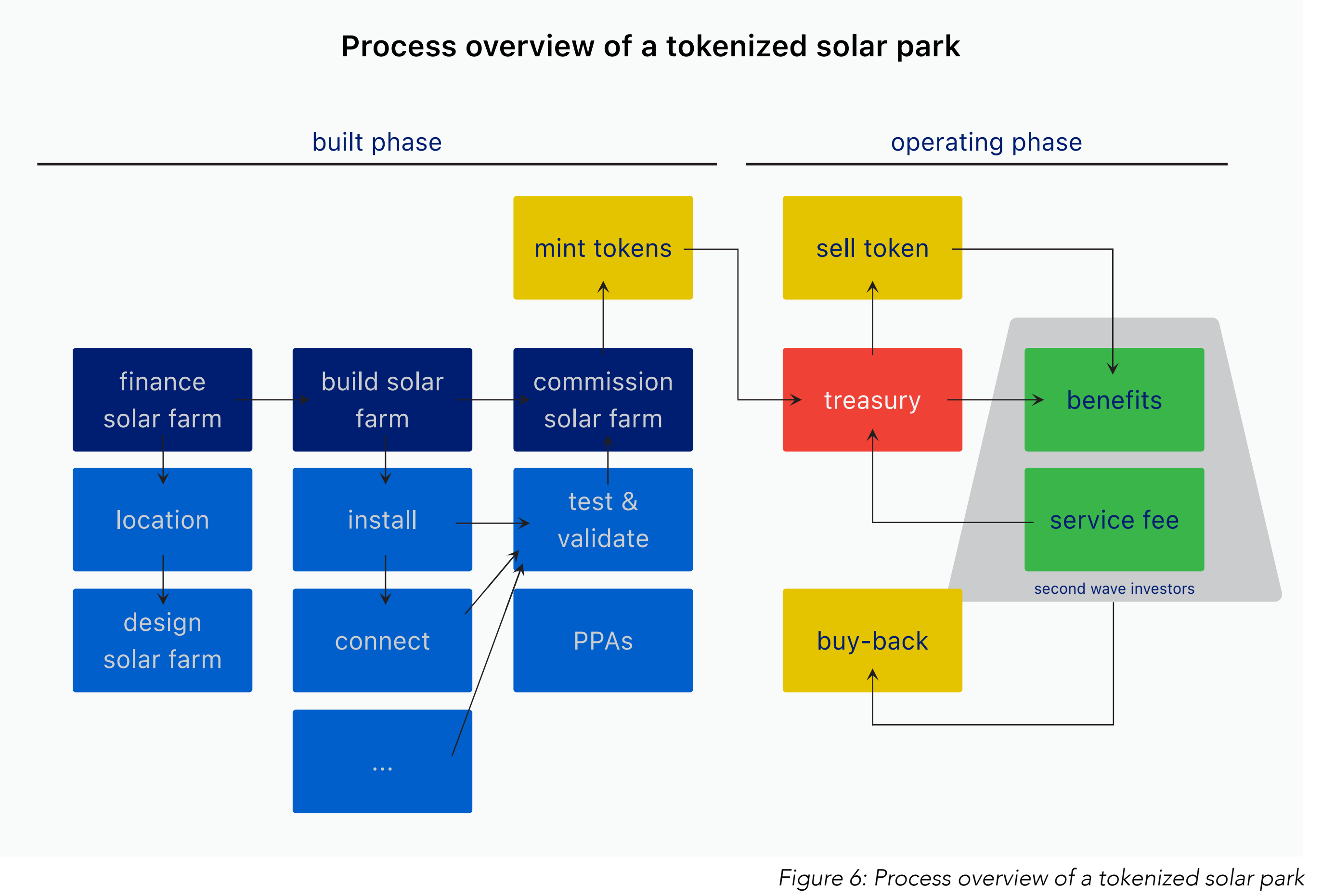

Figure 6: Process overview of a tokenized solar park

their major process components. The tokens representing the fractions of the solar park are created once the solar park has been commissioned. During the operating phase of the park, the tokens may be traded on secondary markets. The benefits received by the (fractional) owner need to be defined and could have a monetary value or the raw offtake from the solar panel in kWh.

3.4 DEVELOPMENT OF ECOSYSTEM

The development of the ecosystem is modeled based on an evolving value network. An extensive analysis of the evolution of the ecosystem is found in Appendix A. The ecosystem will evolve in three phases which are briefly described:

1. Bootstrap phase
2. First-year
3. Subsequent years

3.4.1 BOOTSTRAP PHASE

The first phase of the energy tokenization project is the bootstrap phase where the solar park is initialized. The ecosystem represented in the value model does not include buyers of metered panels yet, but merely the actors participating in the initialization. The goal of this phase is to have the solar park ready to be sold (fractionalized) using tokens in the following phase. At the end of the bootstrap phase, the developer will hold both the solar panels as well as the respective tokens.

3.4.2 FIRST-YEAR

This phase marks the first year in which the solar park and its infrastructure is operating and generating solar energy. It is characterized by two things: 1) the solar park is connected to the grid and has started generating and supplying solar energy, and 2) all panels are transferred from the developer to the special purpose vehicle (SPV)/ asset manager or to the respective solar panel owners.

3.4.3 SUBSEQUENT YEARS

The following years differ from the first year since the panels are not under the management of the developer, nor does the developer participate elsewhere in the eco-system. Therefore, the developer is not anymore present in the ecosystem. Figure 7 is a simplified value model representing the subsequent years.

3.5 HIGH-LEVEL ARCHITECTURE

In the years after the commission of the solar park (subsequent years), five important value streams occur. These streams are financially settled and represent transactions between actors of the ecosystem and are depicted by colors in Figure 7. An extensive analysis of the ecosystem and value streams during all phases of the existence of a solar park is found in Appendix A.

- Blue: the energy customer pays money to retrieve energy in return.
- Green: the solar panel owner pays a fee to retrieve the management service of the asset manager. This management service allows the asset manager to enable the solar panel to generate electricity.
- Orange: the asset manager pays a dividend to the solar panel owner based on the performance of the solar park. The dividend is paid to the holder of the token representing the solar panel.
- Yellow: the asset manager pays rent to the landlord for the land that the solar park is built on.
- Purple: the asset manager pays money to the DSO to have the solar park connected to the grid.

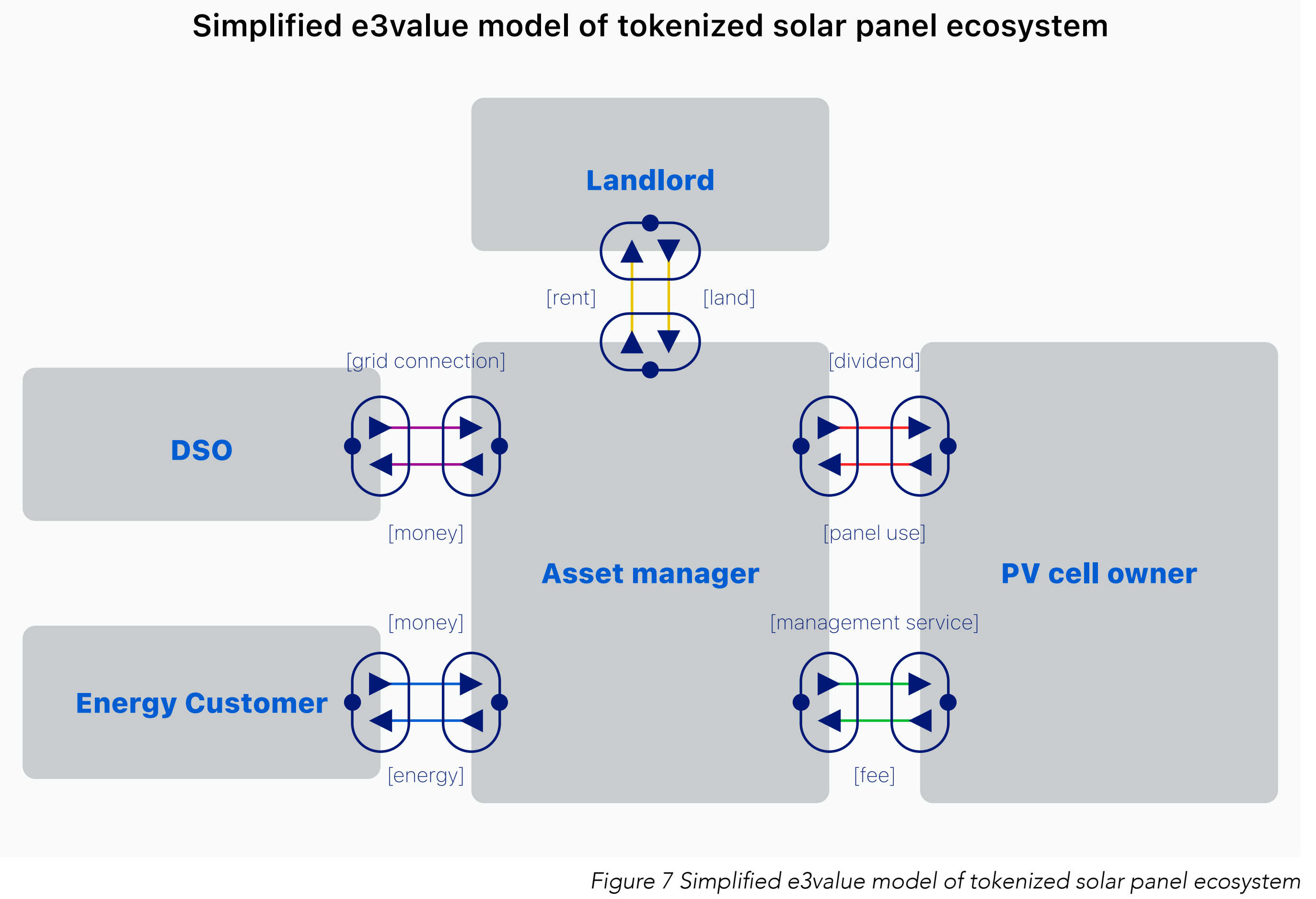

Figure 7 Simplified e3value model of tokenized solar panel ecosystem

4 TECHNOLOGY

Humanity is only able to succeed with the green transition if renewable energy becomes predictable, easy to manage, and connected. A platform that leverages extremely precise data from Internet-of-Things sensors installed on solar panels and other devices brings this future closer.

4.1 HARDWARE

SUNIFIED's Unity-IoT-sensor represents the next generation of digital sensor technology, able to deliver high-fidelity data from solar panels that have never been possible to collect before. This sensor is also referred to as a Crypto Anchor. The use of these sensors per panel will enable solar parks to become high-fidelity solar-data oracles.

The use of panel-level data from datagrams (per sensor) imbues property rights, and the structure of these datagrams flows live metadata tagging of green energy (Proof of Origin). The blockchain aggregation of these datasets and rights enables more democratic access to project finance opportunities for assets and off-take, thanks to the disruption of entry access barriers allowed by fractionalized ownership. This can boost individual and community ownership of solar facilities. It also creates data transparency by providing clarity and transparency on where green electrons have been produced, their quantity, production conditions, electron ownership, and where the electron went.

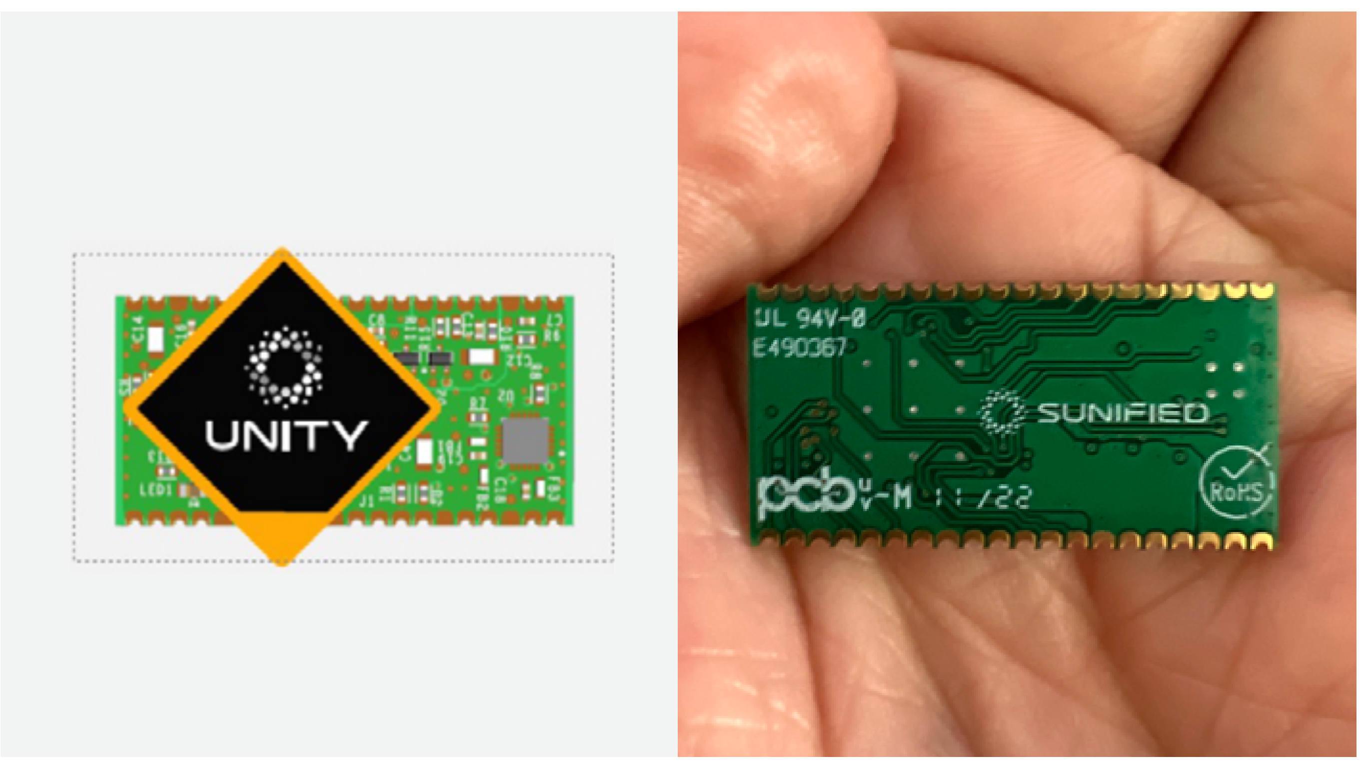

Figure 8 Sunified UNITY A – Crypto Anchor

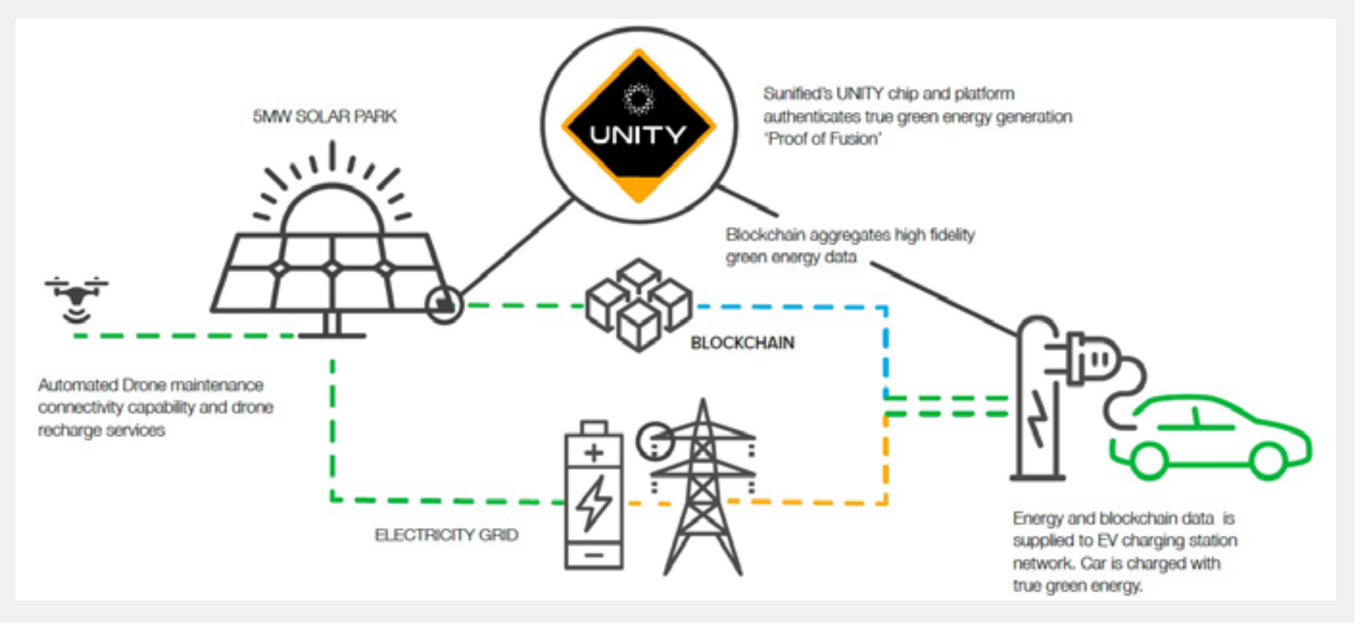

figure 9 hardware

4.1.1 UNITY-IOT-SENSOR

Sunified's Unity-IoT-sensor is the next-generation digital sensor technology. It is able to deliver high-fidelity data from solar panels that have never been possible to collect before. The Unity-IoT-sensors are intended to make every Solar panel and stakeholder a 'SMART' device or user. The use of the Unity-IoT-sensor will enable the solar parks to become high-fidelity solar-data centers. It creates a distributed root of trust in any device in the energy ecosystem, including solar panels, downstream to batteries, Substation edge-computers, and EV chargers.

The simple metaphor for this is an ordinary SIM card. The SIM in your phone allows your carrier (e.g., T-Mobile) to trust your mobile phone to connect to mobile networks. The SIM acts as an anchor and provides a billing hook on the customer platform to track calls and charge the subscriber accordingly for call & data usage. The same concept works for the Unity-IoT-sensors. The approach is to use the sensor to provide the Solar Panel's Digital Identity, (DID) and then anchor the analog-to-digital measurements of Voltage, Current, and Temperature to the individual panel that provides the energy flow from the DC energy side of the solar grid to the inverter for conversion to AC Energy that is exported to the grid.

The Unity-IoT-sensor utilizes advanced Bluetooth mesh telemetry and so-called electronic Integrated Circuit Cards chips (eSIM) to host enhanced Elliptic-curve cryptography (ECC) and other deep-tech crypto methods. The Unity-IoT-sensor pre-processes raw signals into data fields, where the sensor payload is encoded bitwise into a datagram standard. When the sun rises, and the panel energy flows, the Bluetooth application sets up a hardware secure [Identity-Based Encryption (IBE)] virtual tunnel service to the edge nodes via the UNITY gateway or edge-computer.

Crypto-Anchor protocol primitives, enable a hard binding to each solar panel serial and batch details and UNITY module's MAC address and Unique ID device. At the point of manufacture, cryptographic key and serial number secure parameters are stored inside the Crypto Anchor. Each sensor dataset broadcasts out to the data concentrators at the edge as the data fabric propagates across the mesh.

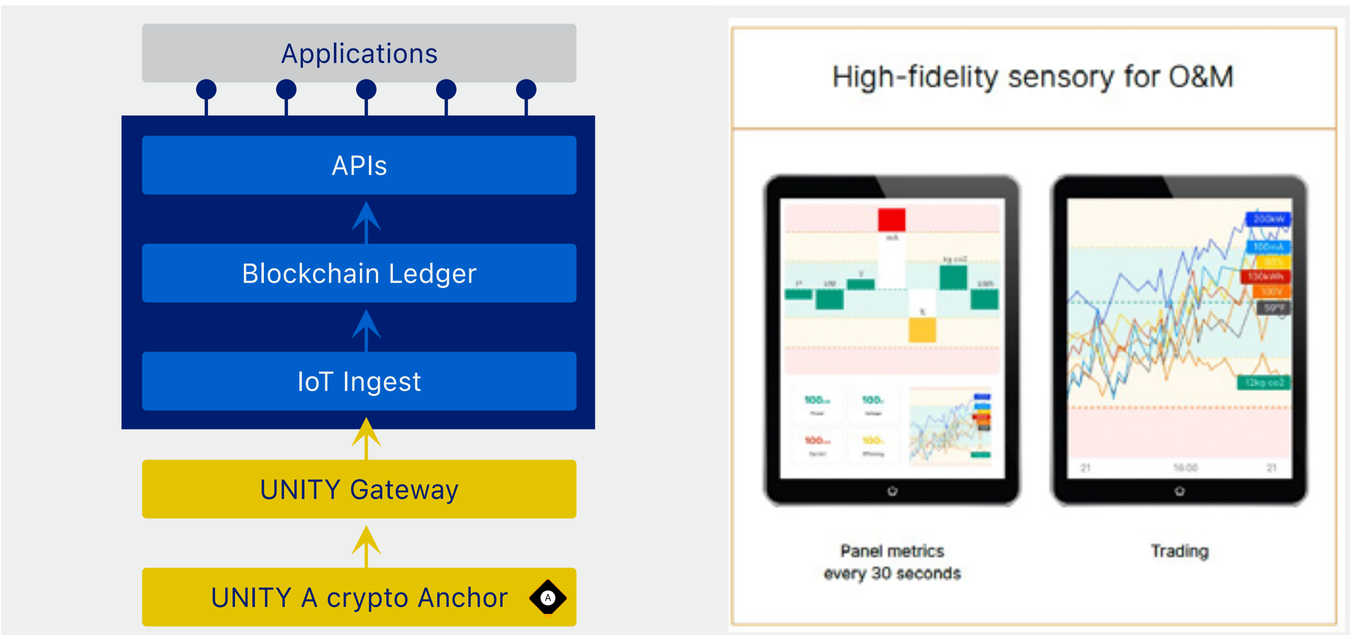

figure 10 high-fidelity sensory for O&M

All datagrams are verified, decoded, reassembled, and collected in 'Edge Node & RTU Gateways'. These are hardened industrial-rated Linux Single Board Computers with solid-state drives and redundant data paths.

figure 11: The MyPower gateway of RIDDLE&CODE and the RTU Q7 gateway Bausch Datacom

This flow of energy generation data (wrapped up in datagrams) is posted to a blockchain ledger and to a machine learning ingest data path. The blockchain ledger acts as the de facto 'Ledger of Record', is being stored at multiple locations using military grade cryptographic technology and offers the additional feature of having built in disaster recovery.

The distributed oracle service is published periodically to the Public Chain and the Industry Public Oracle (published every 5 minutes) becomes Aggregate Proof or master of all cryptographically of on-chain sensor data. The Data Lake and the high resolution "witness proofs" reside at the Edge Compute Sunified Gateways at the Solar Farm.
The distributed oracle service is published periodically to a public blockchain. The Industry Public Oracle is published every 5 minutes, and becomes the Aggregate Proof or master of all cryptographically of on-chain sensor data. The Data Lake (repository of data stored in its natural/raw format) and the high resolution "witness proofs" reside at the Edge Compute Sunified Gateways at the Solar Farm

4.1.2 ADVANTAGES

Existing solutions do not provide a panel-level data oracle; instead, they trust and use smart meters as their data source, which provides aggregated data (on the whole solar park). They are vulnerable to attacks as they exist at the connection point between the solar park and the grid.

NOTE: Most solar parks track only current and voltage at a string (with one proximity sensor - PLC per 10 or more solar panels) or string combiner box (one PLC sensor per 100 panels) aggregate level. Only once enough solar panels are defective, the Operating and Maintenance crew reacts after alerts or reports showing a maintenance need. Typically, the Operating and Maintenance service will use a drone with an infrared camera and/or ad-hoc infield metering is required to locate the faulty panel for even higher cost debugging & troubleshooting, leading to higher Operating and Maintenance costs.

Sunified's increased data granularity, machine learning insights, predictive maintenance, coupled with a rich data API platform, greatly reduces Operating and Maintenance costs.

Sunified's Module as Service vision will enable non-traditional commercial distribution models, which could eliminate the need for upfront capital for panel-level sensor deployment.

Other advantages are the 5-7% increase in park yield for project owners; (just by letting the Operating and Maintenance operators know when to clean or service a solar panel). The generation of high-fidelity, high-granularity data for the management of distributed resources; and a cybersecurity layer to an increasingly digital, complex, and vulnerable power grid.

Asset Managers and Energy Traders Investors can base their decisions on precise data, with green energy production that can be monitored in real-time.

4.2 TECHNOLOGY: THE PLATFORM

The data from the Unity-IoT-sensor fuels an open and decentralized digital platform for the energy sector in support of a low-carbon, customer-centric energy future. In essence, applying one of these sensors to a solar panel allows the panel to become a smart panel. Key functions of the platform are:

- Providing the smart contract mechanism to store decentralized identities and their credentials
- Facilitating on-chain verification and transactions between parties
- Executing smart contracts that are used in decentralized applications, SDKs (Software Development Kit), and utility packages

The Platform has three layers that work together to provide an end-to-end ecosystem for developing and deploying decentralized applications on a chosen Distributed Ledger Technology (DLT). These components are separated according to their function and purpose in the stack, to allow future users to implement individual pieces. Some components are free-standing applications, others are modules, libraries, or SDKs that support applications and/or can be integrated into the technology stack.

4.2.1 TRUST LAYER

The chosen Distributed Ledger is the foundational 'trust layer' of the stack.

- DLT is mostly open-source software that uses blockchain architecture for vertical and horizontal scaling of Decentralized Applications (DApps).
- DLT supports core functionality that allows businesses and individuals to create blockchain-based applications in a way that is similar to web-based applications, like secure access and authentication, permissions, data hosting, usage management, and communication between the DApps and the Internet.
- DLT is supported by a web toolkit store that aims at hassle-free app development.

4.2.2 UTILITY LAYER

The utility layer allows for application development to integrate clean energy assets, investors, customers, and marketplaces. They provide common, shared, protocols for identity, communication, and information exchange through:

- Identity and role-based access management to markets and applications - for organizations and applications that are anchored on the chosen DLT
- Decentralized messaging - between assets (and users) that operate at different levels of the grid, often with no existing communication protocols
- Caching and name-spacing for accessible user experience and optimal querying of DLT in applications

4.2.3 APPLICATION LAYER

The application layer represents Software Developer Kits (SDKs) and applications that address the main use case in this Whitepaper: Facilitating clean energy purchases. To support these use cases, the Platform facilitates investments through identity and access management platforms, and provides software toolkits to develop open, scalable marketplaces for renewable energy certificate tracking and tracing and eventual sales.

Another part of the application layer is an open exchange and/or marketplace. Based on the peer-2-peer protocols and swap smart contracts our partners can build an exchange or marketplace where sellers and buyers are supported in finding each other and support trades happening. Chapter 6 describes the current state of the trading possibilities in more detail.

5 LEGAL ASPECTS AND CLASSIFICATION

A token represents rights attached to ownership of a solar panel. However, as an individual solar panel is part of a larger solar installation of which integrity must be respected, the possibilities to separate a solar panel from the installation must be limited or prevented. A solar park must act as a single legal entity to enter legal obligations such as land rights, permitting, grid connection, Energy Guarantees of Origin, RECs and/or energy attribute certificates (EACs), Operating and Maintenance, and financing. Typically, this is achieved by setting up a legal entity that serves as a special purpose vehicle that will hold all project rights and serves as a contracting party.

Therefore, full legal ownership of a solar panel would limit or prevent the operation of a solar park if this would enable the free transfer of legal ownership. In practice, a separation of legal and economic ownership seems more feasible. This means that a token would represent economic ownership rather than legal ownership of a solar panel. It can be legally structured by issuing certificates of shares in an SPV which develops and operates the solar park whereby a certificate represents a solar panel and entitles a holder to all economic costs and benefits of such solar panel.

5.1 LEGAL DEFINITION AND QUALIFICATION OF THE ENERGY TOKEN

At the moment, there is no uniform civil law definition of tokens in Europe. The European. Commission presented a proposal for the

Regulation on 'Markets in Crypto-assets (MiCa)' that defines 'Crypto-asset' as a digital representation of assets or rights that can be transferred or stored electronically using distributed ledger technology or a similar technology'. (Art. 3 para 1 cl. 2). This is largely inspired by Liechtenstein law. Liechtenstein became one of the first countries in the world to introduce a legal definition for tokens. 'Token' is defined as information on a Trusted-Technology-system that can represent claims or rights of membership against a person, rights to property, or other absolute or relative rights and that are assigned to one or more TT-identifiers.' (Art. 2 para 1(c) Token and TY Service Provider Act (TVTG).

The energy token is an extrinsic token as it represents rights and derives its value from an external asset, a solar panel, which is part of a solar park whereby the solar park is operated by an SPV. Tokens that do not have to represent rights are intrinsic tokens.

The token must be financially fungible to enable disposal and transfer, whilst at the same time, it must be suitable for representing ownership rights regarding a particular solar panel with a unique identification number. In other words, the token is a digital representation of analog rights that cannot be transferred without the token. The person with the right to dispose of the token must be considered the lawful holder of the right.

As part of the legal structuring, a tokenization clause must be agreed upon: 'Transfer of rights will only take place via a token, payment only to the person with the right of disposal over the token'.

If a unique token identification number is created, it will be easy to find the token via an internet search or by scanning a QR (Quick Refence) code on the solar panel whose rights have been tokenized. The debtor would only make payments to the person with the right of disposal as agreed.

5.2 ANALOG & DIGITAL RIGHTS REPRESENTED BY THE TOKEN

The energy token represents ownership of a certificate of a share in a legal entity (SPV) owning and operating a solar park equivalent to one solar panel. Therefore, it is necessary that the legal entity holds the following project rights:

- **Land rights** allow the use of the land to the SPV for installing and operating a solar park during the lifetime of the project
- **Permitting rights** allowing the SPV to install and operate a solar park on the secured location
- **Grid connection and transport agreement** which entitles the SPV to connect the solar park of a certain maximum capacity to the public grid and to transport electricity with a certain maximum capacity over the grid
- **Energy off-take agreement** (PPA) whereby the SPV sells the electricity to an off-taker
- **Green certificate off-take agreement** whereby green certificates generated by producing solar energy are sold and transferred by the SPV
- Subsidy rights granted by a government agency to the SPV to produce solar energy
- **Engineering, procurement, and construction agreements** whereby an EPC contractor supplies EPC services to the SPV
- **Operation and maintenance agreement** whereby an Operating and Maintenance service provider provides its services to the SPV during the lifetime of the solar park
- **Financing agreement** pursuant to which equity of deb finance is provided to the SPV by equity investors of debt financiers.
- **Asset management agreement** whereby an asset manager deals with day-to-day operation of the solar park and have access to the primary Data Rights from UNITY sensor
- **Data Rights agreement** whereby secondary and super-distribution rights UNITY datasets and algor insights are sold as a subscription to: a) Energy Traders so they can offer Solar Futures and Contracts for Difference CFDs on the solar park b) Renewables Insurance and Green Bond Funders as live Solar Park Asset Rating Service and Operating and Maintenance Event Log c) Panel Rating Agencies for solar panel in-field vendor comparison service.

5.3 TOKEN TAXONOMY FRAMEWORK

The single solar panel token represents rights to a subsequent fraction of the solar park, which can be sold and transferred. As a single isolated panel will have reduced economic value, the right to have it connected to the mounting brackets and a live wire to connect to the inverter and grid is a tightly connected aspect. We use the term usufruct to represent the service by the solar park operator to have the panel operated, including cleaning and site maintenance to enable the solar panel to generate electricity.

The asset token represents a single solar panel out of a solar park. The solar park consists of many solar panels that are the same type and model. Each solar panel has a serial number as a unique item as properties. And now I will drink my expresso. The result of defining the token based on the Token Taxonomy Framework is described in 6.3.1 in more detail.

5.3.1 THE TOKEN BASE

Question	**Answer**	**Remarks**
Is the asset interchangeable?	Yes, each panel has the same economic value. Only a serial number can tell them apart.	Like a bank note with a unique serial number.
Can the asset be divided?	No, the asset itself cannot be divided.	A single solar panel is the unit represented by the token.
Is the asset one of a kind?	No, it is not one of a kind	

Table 1 Defining The Token Base for Fractional ownership of a panel

5.3.2 DISCOVERING BEHAVIORS

To be able to discover the relevant behaviors, we asked ourselves the following questions:

Question	Answer	Remarks
How do users typically interact with the token?	The interaction is centered around the creation, transfer of ownership, and destruction of the asset.	
Who maintains the asset ownership?	The ownership changes between the users based on predefined contractual rules.	The asset manager always has the possibility to view tokens belonging to a solar park.
How do the users identify it?	Each asset has its own unique serial number	
Is there an element of risk management involved?	Yes	
Is it unique?	No	Every token belonging to the same solar park holds the same characteristics
Does the asset need to be created on demand, or is the asset ever taken out of supply because it transforms?	The token is created after the panel is connected to the grid. The token is burned when the panel is retired.	

Table 2 Discovering Behavior

The behaviors required to support the use case are quite basic as well:

- Mint (creating a token)– at commissioning the park
- Transfer – combined with solar panel transfer
- Burned (destroying a token)– decommissioning of the solar park

The properties are the following:

- Park ID
- Serial number
- Brand
- Model
- Type
- Link to usufruct token

5.4 INTERNATIONAL TOKEN STANDARD

ITC	Dimension	Category	Sub-category	Identifier
	Economic purpose	Utility token	Ownership token	EEP220
	Industry	Transportation and Warehousing		EIN08
	Technological Setup	Non-Native Protocol Token	Non fungible token (ERC721)	TTS42B
	Legal claim	Absolute rights token	Ownership token	LLC33

Table 3 international token standard

6 THE MINIMUM VIABLE PRODUCT AND NEXT STEPS

6.1 THE MINIMUM VIABLE PROJECT

To prove the feasibility of the project, we have implemented the fractional ownership model using the concepts and models described above. A small rooftop solar site enabled the idea to go from a concept to an actual physical project.

A Minimum Viable Project has been created consisting of the following components:

1. A small rooftop solar site with 9 panels
2. A SolarEdge inverter and IoT API
3. An Ethereum test network Rinkeby
4. A MetaMask wallet

6.1.1 WALLET/DASHBOARD

All the components come together in a single platform where both platform owners, as well as investors, have transparency and access to data which shows the solar energy that is being generated. An investor can see the performance of purchased solar panels on a dashboard. To view the dashboard as an investor, it's required to connect with a MetaMask wallet that holds one or more tokens. The dashboard holds information on the wallet address, the number of assets in possession, the performance of the owned panels, and the level of verification. Figure 10 provides insight into the investor dashboard. In the

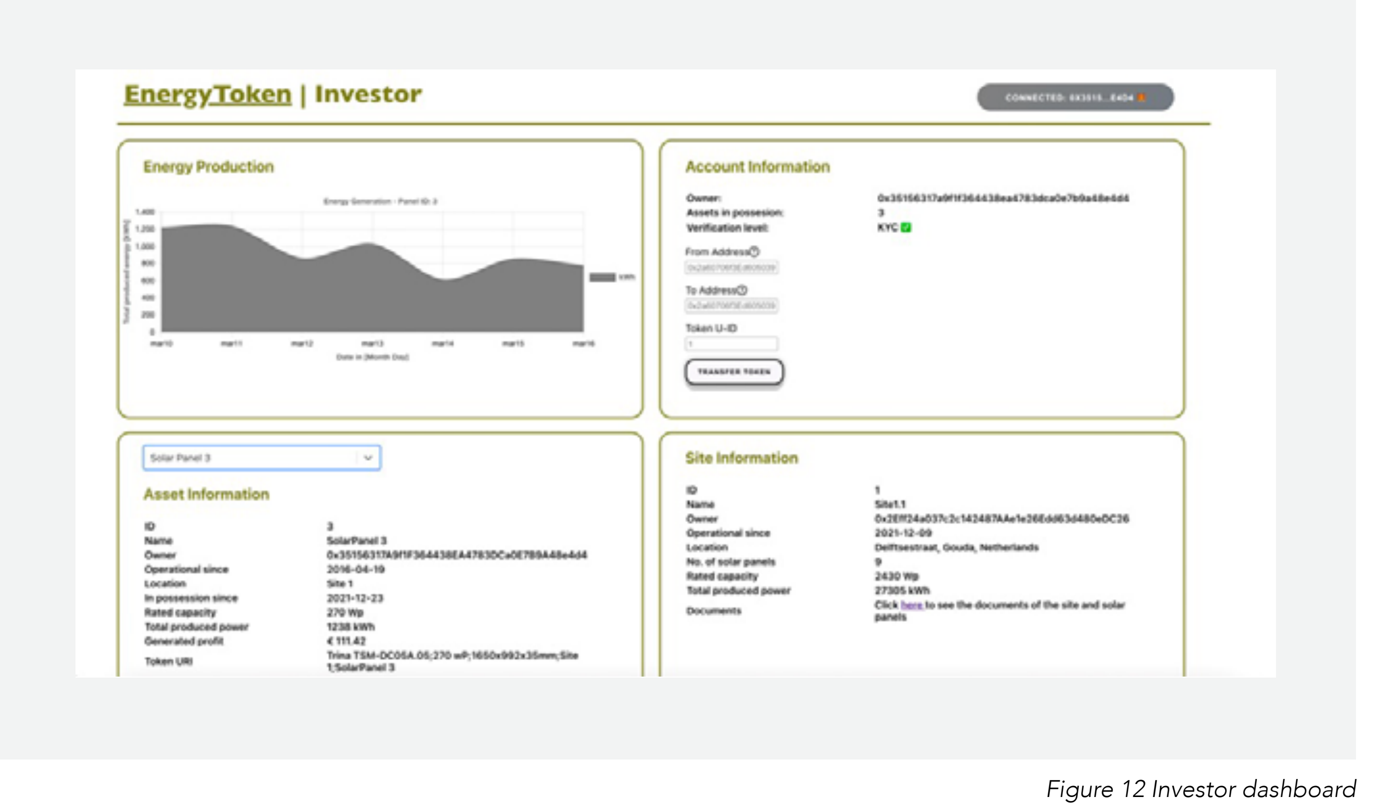

Figure 12 Investor dashboard

dashboard, fictitious numbers are shown.

Like the investor, a platform owner has access to a dashboard to view the performance of a complete site. In this Minimum Viable Project, the platform owner is responsible for the minting, burning, and transferring of the tokens. In the example provided in Figure 11, the site called 'Site 1' holds three solar panels. The platform owner has insight into who is owning these panels in the bottom right of the dashboard. The owners are depicted as a wallet address in order to comply with data protection regulations, not by the name of the owner.

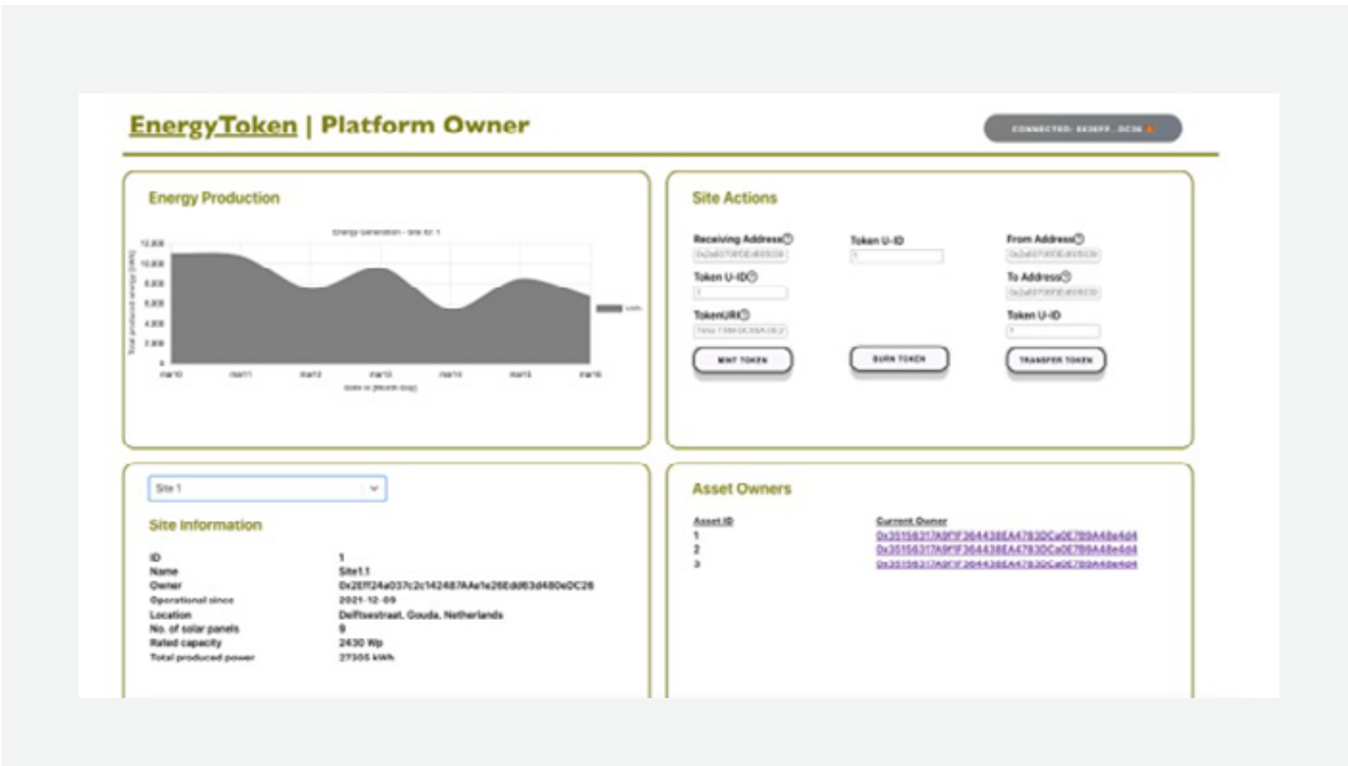

Figure 13 Platform owner dashboard

6.2 THE FIRST REAL-LIFE TEST: 200-PANELS AT THE GREEN VILLAGE

The idea of expanding the concept to a larger real-life test emerged during the Minimum Viable Project. A Minimum Viable Project of 9 solar panels proves that the team can tokenize solar panels. However, by doing so, the project remained 'internal'. Expanding the Minimum Viable Project to 200 panels allows external investors to join in on the project. This will prove that the concept can be easily rolled out on a much larger scale as well.

In the second half of 2022 and 2023, we will tokenize the 200 solar panels on the rooftop of The Green Village. In this project, 2Tokens, BlockLab, and Sunified will jointly demonstrate that individual trade of individual solar panels in a solar park is possible in both a test and operational environment.

With the Unity-IoT-sensors delivered by Sunified and the blockchain platform developed by BlockLab, we can create the so-called Energy Security Tokens. With such a token, an individual or company can safely buy and sell (a part of) a solar park. This offers a solution for people and companies that cannot install their own solar panels. It helps to fund medium-sized solar parks that are less attractive to institutional investors who usually look to make larger investments because of the due diligence costs that their internal guidance require.

In addition, the sensor also allows better monitoring of income generation and maintenance requirements. This will be developed further by the 2Tokens Energy Workgroup in Phase II and which will be published in the second quarter of 2023.

6.3 THE NEXT STEP: OUTLOOK

This Whitepaper describes the first phase of the project. From the start of this project, the scope of this Whitepaper is clearly defined: to tokenize the ownership of solar panels. The scope of Phase II is set to ‘tokenizing offtake’.

The progress that was made during the first phase generated interest from many stakeholders, in the EU and internationally. This broadened the scope of Phase II. The team critically considered all the new ideas that been created over the past months buy the MVP.

The main goal of Phase II is still to tokenize the offtake of a solar park. This includes the energy generation itself, data collection and management by tokenization of Guarantees of Origin, Renewable Energy Credits, and other data streams, new forms of energy balancing and smart grid management, energy governance, etc. Completing this challenge is another step in the goal of democratizing the energy sector. This will allow citizens to use the energy that has been generated by solar panels they own directly.

APPENDIX A
E3 VALUE MODEL

APPENDIX A.1 EXTENSIVE E3 VALUE MODEL

APPENDIX A.1.1 ACTORS

Actor	Explanation
Energy customer	(Large) customers of energy, with a bilateral Power Purchase Agreement (PPA)
Distribution System Operator	Distribution of energy in a geographical area
Government	Tax collection, incentives for renewable energy (not in the model yet)
Landlord	Owner of square meters where solar panels are installed
Asset manager	Manages a solar park, and offers a portfolio of services to users of the park
Solar panel ownership	Owns (a fraction of) solar panels and wants to get revenue by exploitation
Investor	Capital providers to buy solar panels
Inverter producer	Provides the inverter
Materials producer	Provides material (brackets, etc..,) to build a solar park
Panel Producer	Provides solar panels
Metering producer	Provides trustworthy energy meter for each panel
Developer	Develops the park upfront

APPENDIX A.1.2 INITIALIZATION E3 VALUE MODEL

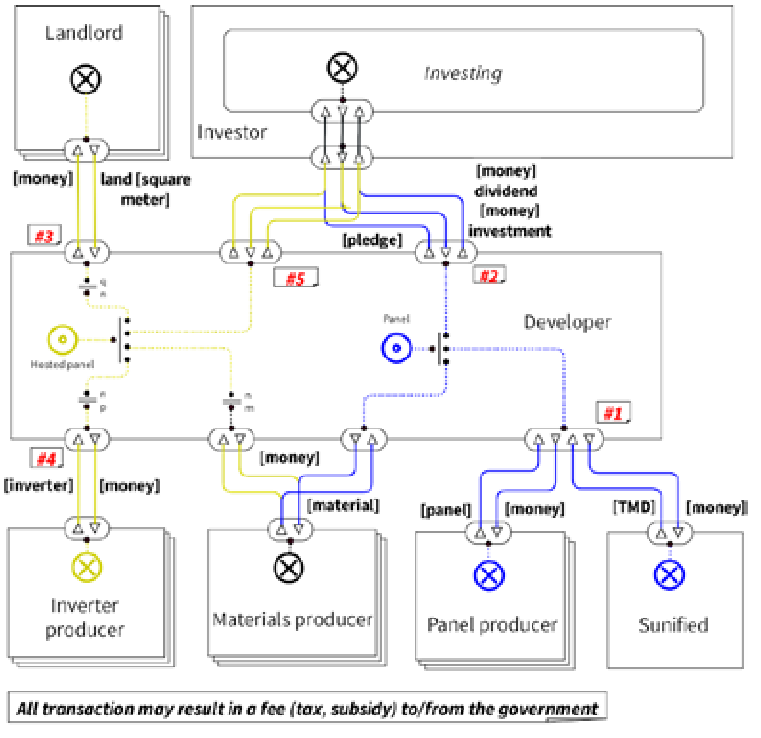

Figure 1 Initialization e3value model of tokenized solar panel ecosystem

APPENDIX A.1.3 DESCRIPTION

If Figure 1, the value model is shown for period 0. This period comprises the upfront investments, setting up the solar park before the park start starts to produce energy.

The developer buys one or more panels from a panel producer for a fee and a trusted metering device from Sunified that will be connected to his solar panel (e.g., by the developer itself, or an assembler (not included in the model)). The solar panel and the trusted metering device are only bought in combination (indicated by the four ports in the value interfaces of the solar panel owner) (see #1). In other words: in this business model, it is not possible to deploy solar panels without a trusted metering device.

A developer attracts funding from an investor (initially Catena, but in the future possibly others too) (see #2). An investor provides money to the developer, and if a developer owns the panel, he pays a dividend (or interest) to the investor. Also, the investor has the right to pledge on the solar panel/trusted metering bundle, which is granted by the developer to the investor. This secures the interests of the investor,

Additionally, the developer does the following:

a. Acquire square meters from the landlord (see #3)
b. Obtain the inverters (and related equipment) to connect the solar panels to the grid (see #4).
c. Obtains investment money from the investor to cover upfront expenses (see #5).

APPENDIX A.1.4 INITIALIZATION VALUE STORIES[1]

a. Set up the solar park. The asset manager acquires land for putting solar panels and an inverter to connect them to the grid, using money from the investors. In return, the investors receive a pledge that this money is used to generate dividend.
b. Assemble solar panels. The developer acquires a panel, enabled with the Unity-IoT-sensor, and other materials and assembles them into a metered solar panel in the solar park. The money is supplied by investors who receive a pledge in return.

APPENDIX A.1.5 INITIALIZATION QUANTIFICATION

	Type	Element	Quantification
	Revenue creation by owning a solar panel		
	Customer need	Revenue by solar panel	1 during the time period the solar panel owner participates in the plan (e.g. multiple contract periods)
#1	Value object/transfer	Panel (Developer <->Panel producer)	1 panel
#1	Value object/transfer	Money (solar panel owner <->Panel producer)	Price for 1 panel
#1	Value object/transfer	Trusted metering device (Developer <->Sunified)	1 metering device integrated with the panel
#1	Value object/transfer	Money (solar panel owner <->Sunified)	All additional materials needed to deploy one panel.
	Value object/transfer	Material (Developer <->Materials producers)	Price for all materials required for one panel
	Value object/transfer	Money (investment) (Developer <-> investor)	Amount of money to buy 1 panel
#2	Value object/transfer	Money (dividend or interest) (Developer <-> investor)	Total amount of money to be paid to investor (e.g. dividend or interest) during the time period the owner has the panel, valued at period 0.
#2	Value object/transfer	Pledge (Developer <-> investor)	1 certificate/contract that the panel is the pledge
#6	Value object/transfer	Money (investment) (investor<-> solar panel owner)	The remaining amount of money the owner has to pay to the investor if he sells the panel

	Plant-wide materials		
	Customer need	Materials	Number of panels
#4	Value object/transfer	Inverter (developer <-> inverter producer)	1 inverter
#4	Value object/transfer	Money (developer <-> inverter producer)	Price for 1 inverter
	Value object/transfer	Material (developer <->Materials producers)	All additional materials needed to deploy one panel.
	Value object/transfer	Money (developer <->Materials producers)	Price for all materials required for 1 inverter
#5	Value object/transfer	Pledge (developer <-> investor)	Pledge for the investment
#5	Value object/transfer	Money (investment) (developer <-> investor)	Amount of money to buy 1 inverter + materials

#5	Value object/transfer	Money (dividend or interest) (asset manager <-> investor)	Total amount of money to be paid to investor (e.g., dividend or interest).
	Cardinality dependency	n:m dependency	The number of panels (n) that can be handled by the number of inverters (m)
	Cardinality dependency	p:q dependency	The number of panels (p) that need a number (q) of materials

	Land		
	Customer need	Materials	The land needed for a park in square meters
#3	Value object/transfer	Land (developer <-> inverter landlord)	1 square meter land
#3	Value object/transfer	Money (developer <-> inverter landlord)	Price for 1 square meter land

APPENDIX A.2 YEAR ONE E3VALUE MODEL

APPENDIX A.2.1 DESCRIPTION

The first year that the value model is into operation is special because we assume that in this first year, the assets of the developer are transferred to the asset manager (inverters and other mounted materials, collectively called infrastructure) and the solar panel owner respectively.

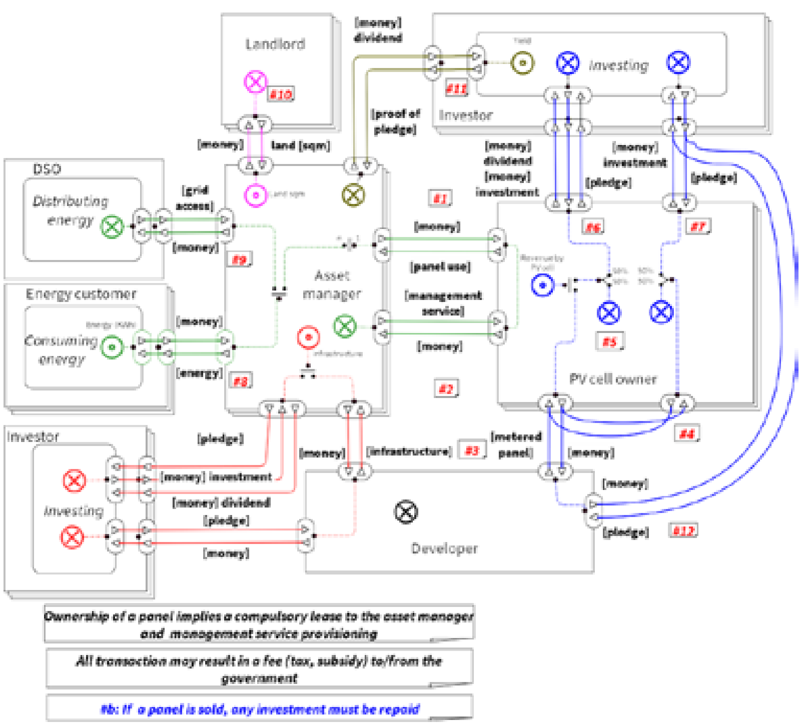

Figure 1 Initialization e3value model of tokenized solar panel ecosystem

The model has an underpinning idea:

a. The solar panel owner is the owner of the panel (at the name suggests), but
b. The solar panel is used by the asset manager to generate electricity and the owner receives a fee for that, which is related to the yield of similar solar panels in the solar park (see #1).
c. The asset manager is the owner of the inverters and related materials, which together form the infrastructure to mount panels and connect them to the grid.

Granting the asset manager the legal use right has the following advantages:

a. The asset manager can average the yield of a set of panels, such that the solar panel owner does not run the risk that his individual panel underperforms (as compared to other panels). This is risk reduction for the solar panel owner.
b. The solar panel is still owned by the solar panel owner, which effectively removes the solar panel from the balance sheet of the asset manager and allows the asset manager to run an efficient operation.

The solar panel owner pays a fee to the asset manager for a number of services (cleaning the panels and the area, access to the grid, inverters, assembling the panel and trusted metering device, data connectivity, etc.) (see #2).

There are two ways for the solar panel owner to obtain a panel. First, he can buy the panel from the developer (see #3). This is the first time that the installed panel will be sold. Second, he can buy the panel from another solar panel owner see #4). In both cases, the prospective owner can fund the panel himself (see #5) or attract funding from an investor (see #6). In case of an investor, the solar panel owners is obliged to offer pledge. Similarly, if a solar panel owner sells his panel, and the panel was funded by an investor, the owner repays the remaining investment, and the pledge is returned (see #7).

Apart from the above, the asset manager does the following:

a. Selling the generated energy of the panels he manages to energy customers via bilateral Power Purchase Agreements (PPAs). In a later stage, energy might also be sold using more advanced price formation and match-making mechanism (e.g. various kinds of markets and derivates) (see #8)
b. Having connectivity to the grid via a Distribution System Operator (DSO) (see #9)
c. Using square meters from the landlord (see #10)
d. Obtaining the infrastructure from the developer (see #13), and obtaining investment money to do so (see #14). Accordingly, the developer repays his loan to the investor and is returned the pledge (see #15).

APPENDIX A.2.2 FIRST-YEAR VALUE STORIES

a. Consuming energy. An energy customer buys energy from the asset manager. The asset manager uses the solar panels leased from solar panel owners to generate energy and uses the services of a DSO to distribute the energy to the customer. To maintain the solar panels, the asset manager performs services for the solar panel owners. Quantitative scenario information:
   - One lease contract with a solar panel owner facilitates many generated KWHs by these leased panels.
   - Question: is there a fixed tariff per contract period (vastrecht) and a flexible fee, depending on the amount of electricity distributed?

d. Revenue creation by owning a solar panel.
   A prospective solar panel owner invests in a solar panel. The prospective owner obtains money from an investor, in return for a pledge to use this money to generate revenue from solar panels and to pay a dividend to the investor from this money. Alternatively, the prospective solar panel owner uses their own money to buy solar panels.
   The prospective solar panel owner then buys the panel from the developer. Alternatively, if the prospective owner buys an existing solar panel from a current owner, the current owner transfers ownership in return for money and, if applicable, pays back any investment money to investors in return for the pledge.
   Quantitative scenario information:
   - 50% of the owners invest in panels using their own funds; 50% needs funding from an investor.
   - The asset manager rents land from a landlord.

e. Renting land. A landlord rents land and receives a fee for that.

f. Obtaining infrastructure. The asset manager obtains an investment, gives a pledge (the inverters plus related materials installed), and pays a dividend (or interest). The developer repays the investment to an investor and obtains the pledge in return.

APPENDIX A.2.3 FIRST YEAR QUANTIFICATION

	Type	Element	Quantification
	Consuming energy		
	Customer need	Energy	# KwH per contract period
#8	Value object/transfer	Energy (customer<->asset manager)	1 KwH
#8	Value object/transfer	Money (customer<->asset manager)	Price for 1 KwH
#9	Value object/transfer	Grid access (asset manager<->DSO)	1 KwH distribution
#9	Value object/transfer	Money (asset manager<->DSO)	Price for 1 KwH distribution
#1	Value object/transfer	Panel lease (asset manager <-> solar panel owner)	1 contract period panel lease
#1	Value object/transfer	Money (asset manager <-> solar panel owner)	Price for 1 contract period panel lease
#2	Value object/transfer	Management service (solar panel owner<-> asset manager	1 service provisioning per contract period
#2	Value object/transfer	Money (solar panel owner<-> asset manager	Price for 1 service provisioning
	Cardinality dependency	n:1	#(n) KwH/contract generated by one panel

	Revenue creation by owning a solar panel		
	Customer need	Revenue by solar panel	1 during the time period the solar panel owner participates in the plan (e.g. multiple contract periods)
#3	Value object/transfer	Panel (solar panel owner <-> Developer)	1 metered panel
#3	Value object/transfer	Money (solar panel owner <-> Developer)	Price for 1 metered panel
#4	Value object/transfer	Panel (solar panel owner <-> solar panel owner)	1 metered panel
#4	Value object/transfer	Money (solar panel owner<-> solar panel owner	Price for 1 metered panel
#6	Value object/transfer	Money (investment) (solar panel owner <-> investor)	Amount of money to buy 1 metered panel
#6	Value object/transfer	Money (dividend or interest) (solar panel owner <-> investor)	Total amount of money to be paid to investor (e.g. dividend or interest) during the time period the owner has the panel, valued at period 0.
#6	Value object/transfer	Pledge (solar panel owner <-> investor)	1 certificate/contract that the panel is the pledge

#7	Value object/transfer	Money (investment) (investor<-> solar panel owner)	The remaining amount of money the owner has to pay to the investor if he sells the panel
#7	Value object/transfer	Pledge (investor<-> solar panel owner)	1 certificate/contract that the panel is the pledge (e.g. for new investor)
# 12	Value object/transfer	Money (Developer <->Investor)	The remaining amount of money the developer has to pay to the investor if he sells the panel
# 12	Value object/transfer	Pledge (Developer <->Investor)	1 certificate/contract that the panel is the pledge (e.g. for new investor)

	Renting land		
# 10	Value object/transfer	Money (Asset manager <->Landlord)	Price for 1 squared meter
# 10	Value object/transfer	Land (Asset manager <->Landlord)	1 square meter

	Obtaining infrastructure		
	Customer need	Infrastructure	1 (per asset manager)
# 13	Value object/transfer	Infrastructure (Asset manager <-> Developer)	1
	Value object/transfer	Money (Asset manager <-> Developer)	Total price for the infrastructure
# 14	Value object/transfer	Pledge (Asset manager <-> Investor)	1 certificate/contract that the infrastructure is the pledge (e.g., for new investor)
	Value object/transfer	Money investment (Asset manager <-> Investor)	Total amount of money needed by the Asset manager to buy the infrastructure
	Value object/transfer	Money dividend (Asset manager <-> Investor)	First term of money to be paid to obtain the investment
# 15	Value object/transfer	Money (Developer <-> Investor)	The remaining amount of money the developer must pay to the investor if he sells the infrastructure
	Value object/transfer	Pledge (Developer <-> Investor)	1 certificate/contract that the infrastructure can serve as pledge (e.g., for anew investor)

APPENDIX A.3 STEADY-STATE E3VALUE MODEL

APPENDIX A.3.1 DESCRIPTION

In Figure 3, the steady model is shown for years 2 ..n. The difference with the first-year model is that the developer completely disappeared, e.g., the infrastructure is handed over to the asset manager, and all the solar panels are sold at least once (namely from the developer to another solar panel owner). For the rest, the model is the same as the first-year model.

APPENDIX A.3.2 STEADY-STATE VALUE STORIES

- All value stories of the first year are applicable, except the obtaining infrastructure story, which is replaced by
- Dividend because of park investment. An investor invests in the infrastructure of the park (excluding the panels themselves) and receives a dividend or interest for that.

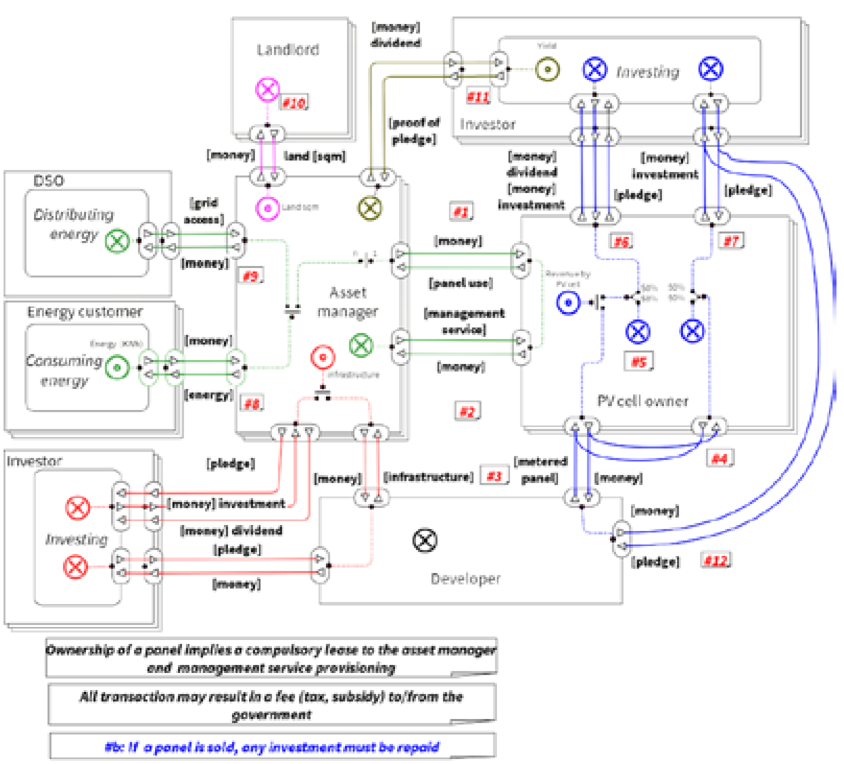

Figure 3 Steady state e3value model of tokenized solar panel ecosystem

APPENDIX B TOKEN TAXONOMY AND CLASSIFICATION

The InterWork Alliance (IWA) has been set up to facilitate multi-party digital interchanges. Such interchanges require a trusted, agreed-to representation of value, and correlating contractual agreements. Unfortunately, technological disparity across platforms creates so-called digital siloes in which data is 'trapped', and so inhibits the level of interworking necessary for web-scale adoption. There needs to be a unified approach where all parties work together to build out an ecosystem that is global.

The IWA is an independent, technology-neutral, cross-industry association determined to tear down these siloes by simplifying and standardizing how multi-party interchanges are accomplished amongst disparate technology platforms across use cases such as global sustainability, supply chains, healthcare, and more. IWA is the non-profit custodian of the Token Taxonomy Framework, and its membership includes industry heavyweights such as Accenture, IBM, Microsoft, Nasdaq, and R3.

APPENDIX B.1 SOLAR PANEL TOKENIZATION AND TOKEN TAXONOMY FRAMEWORK

The single solar panel token represents rights to a subsequent fraction of the solar park, which can be sold and transferred. As a single isolated panel will have reduced economic value, the right to have it connected to the mounting brackets and a live wire to connect to the inverter and grid is a tightly connected aspect. We use the term usufruct to represent the service by the solar park operator to have the panel operated, including cleaning and site maintenance to enable the solar panel to generate electricity.
To analyze the fractional ownership (and solar panel token), we follow the steps as described in the Token Taxonomy Workshop. Those are:

1. Asset Ideation
2. Defining the Token Base
3. For discovering behaviors

APPENDIX B.1.1 ASSET IDEATION

The asset token represents a single solar panel out of a solar park. The solar park consists of many solar panels that are the same type and model. Each solar panel has a serial number as a unique item.

APPENDIX B.1.2 DEFINING THE TOKEN BASE

To be able to define the token base, we must ask ourselves several questions as listed in

Question	Answer	Remarks
Is the asset interchangeable?	Yes, each panel has the same economic value. Only a serial number can tell them apart.	Like a bank note with a unique serial number.
Can the asset be divided?	No, the asset itself cannot be divided.	A single solar panel is the unit represented by the token.
Is the asset one of a kind?	No, it is not one of a kind.	

Table 1 Defining The Token Base for Fractional ownership of a panel

APPENDIX B.1.3 DISCOVERING BEHAVIORS

To be able to discover the relevant behaviors, we asked ourselves the following questions.

Question	Answer	Remarks
How do users typically interact with the token?	The interaction is centered around the creation, transfer of ownership, and destruction of the asset.	
Who maintains the asset ownership?	The ownership changes between the users based on predefined contractual rules.	The asset manager always has the possibility to view tokens belonging to a solar park.
How do the users identify it?	Each asset has its own unique serial number	
Is there an element of risk management involved?	Yes	
Is it unique?	No	Every token belonging to the same solar park holds the same characteristics
Does the asset need to be created on demand or is the asset ever taken out of supply because it transforms?		

Table 2 Discovering Behavior

The behaviors required to support the use case are quite basic as well:

- Mint – at commissioning the park
- Transfer – combined with solar panel transfer
- Burned – decommissioning of the solar park

APPENDIX B.1.4 PROPERTY SETS

Version 1.0 of the Token Taxonomy Framework

defines the following property sets:

SKU and Files.

The properties are quite basic as it has:

- File
    - Park ID
    - Park details
- SKU
    - Serial number
    - Brand
    - Model
    - Type
- Verified Link to operator token

APPENDIX C INTERNATIONAL TOKEN STANDARD

The International Token Standardization Association (ITSA) e.V. is a not-for-profit association of German law that aims at promoting the development and implementation of comprehensive market standards for the identification, classification, and analysis of distributed ledger technology- and blockchain-based cryptographic tokens. As an independent industry membership body, ITSA unites over 100 internationally associated founding members from various interest groups, including industry associations, banks, stock exchanges, start-ups, universities, research institutes, law firms, tax advisors, and other industry stakeholders.
In order to increase transparency and safety in global token markets, ITSA currently develops and implements the International Token Identification Number (ITIN) as a market standard for the identification of cryptographic tokens, the International Token Classification (ITC) as a standard framework for the classification of cryptographic tokens according to their inherent characteristics, and the International Token Database (TOKENBASE) as standard for the qualitative and quantitative analysis of these tokens. Besides these projects, ITSA facilitates the internal exchange of thought through working groups as well as the setup of country and city charters. Externally, ITSA represents the interests of its members and acts as a sparring partner for standardization bodies, regulators, and government agencies.

APPENDIX C. 1 INTERNATIONAL TOKEN IDENTIFICATION NUMBER (ITIN)

The International Token Identification Number (ITIN) is an open market standard for the unambiguous and secure identification of distributed ledger technology- and blockchain-based cryptographic tokens. An ITIN is provided upon request as well as proactively by the International Token Standardization Association (ITSA) e.V. It assigns each token a unique nine-digit identification number, which comprises a randomly generated eight-digit Token ID (two four-digit blocks separated by a hyphen) and a one-digit Checksum that ensures the correct communication of the identifier (also separated by a hyphen from the two four-digit blocks). As an arbitrary alphanumeric identifier, the capital letters do not follow any encoding system and have no inherent meaning. The letters ‘I’, ‘L’ and ‘O’ as well as the numbers ‘0’ and ‘1’ are excluded to avoid confusion. All English three- and four-letter words such as for example ‘ONE’ or ‘COIN’ are excluded too to ensure maximum fairness at generation and assignment. The special alphanumeric structure of the identifier allows for the identification of over 850 billion cryptographic tokens and thus caters to the future needs of a global tokenized economy.

APPENDIX C.2 INTERNATIONAL TOKEN CLASSIFICATION (ITC) & DEFINITIONS FOR THE ENERGY TOKEN

The International Token Classification (ITC) is a holistic standard framework for the classification of distributed ledger technology- and blockchain-based cryptographic tokens according to their inherent characteristics. The first version of the ITC has already been applied to more than 800 cryptographic tokens and shall provide clarity and transparency for all market stakeholders involved. It follows a synoptical design based on the current research landscape as well as existing best practices and builds on a flexible and extendable 360-degree approach, which employs different dimensions to describe a token’s properties. The dimensions are clustered in four-dimensional groups that cover Economic (E), Technological (T), Legal (L) and regulatory (R) aspects of a cryptographic token. Within these groups, the initial version of the framework features Economic Purpose (EEP), Industry (EIN), Technological Setup (TTS), and Legal Claim (LLC) as the first four dimensions that each feature a multitude of token categories and sub-categories. Future versions of the ITC will present more dimensions in order to capture other characteristics of tokens, but also more detail in each dimension through the addition of new categories and sub-categories or a further differentiation of existing ones (e.g., a breakdown of sub-categories into distinct groups).

APPENDIX C.2.1 ITC CLASSIFICATION

ITC	Dimension	Category	Sub-category	Identifier
	Economic purpose	Utility token	Ownership token	EEP220
	Industry	Transportation and Warehousing	-	EIN08
	Technological Setup	Non-Native Protocol Token	Non fungible token (ERC721)	TTS42B
	Legal claim	Absolute rights token	-	LLC33

APPENDIX C.2.2 ITC DEFINITIONS

Dimensions		
Label	**Identifier**	**Definition**
Economic Purpose	EEP	This dimension describes the reason for a cryptographic token's creation by the issuer from an economic perspective. In its current version, the ITC differentiates between the categories payment (EEP21), utility (EEP22), and investment (EEP23), which all offer various sub-categories with more detail. Many cryptographic tokens (especially Utility Tokens (EEP22)) feature many different functions and thus serve different economic purposes. Therefore, the classification of a cryptographic token according to this dimension focuses on the primary economic purpose of a token. If such primary purpose is not clearly stated by the issuer, the team of researchers classifying the token decides on the most important feature of a token and determines its primary economic purpose on that basis.
Industry	EIN	This dimension describes the industry that a cryptographic token is intended to be used in by the issuer. The categories of this dimension are based on the North American Industry Classification System (NAICS) to allow for enhanced comparability and reference. Within these general industry categories, sub-categories provide for token market specific differentiation. By default, Payment Tokens (EEP21) are assigned to the sub-category Payment Services (EIN10A) within the industry category Finance and Insurance (EIN10). However, if a Payment Token (EEP21) is intended as a means of payment within a specific industry, the respective industry category should be adjusted. Moreover, Investment Tokens (EEP23) are usually not assigned to Finance and Insurance (EIN10) but to the industry category that the token issuer is active in.
Technological Setup	TTS	This dimension describes the technological properties of a cryptographic token and provides information on its level of implementation. In the current version of the ITC this dimension differentiates two cases: a cryptographic token that is native to a distributed ledger and thus forms an integral part of it, and a cryptographic token that is not native to the distributed ledger but implemented through a Crypto-Economic Protocol on top of it. Currently the first category (Ledger-Native Token (TTS41)) does not feature any sub-categories, but it will soon distinguish between the type of ledger that the token is implemented on (e.g., blockchain, directed acyclic graph (DAG), etc.). The second category (Non-native Protocol Token (TTS42)) already features the Ethereum ERC20 and ERC721 token standards as sub-categories and will soon encompass other protocol standards too.

Legal claim	LLC	This dimension describes what right a cryptographic token does provide its owner with. Currently, it features three distinct categories: tokens that do not provide its owner with any right except to the token itself (No-Claim Token (LLC31)), tokens that provide its owner with relative rights towards a third party (Relative Rights Token (LLC32)), and tokens that do represent absolute rights (Absolute Rights Token (LLC33)). As most Utility Tokens (EEP22) and Payment Tokens (EEP21) are issued in a decentralized way and without legal claim to a central counterparty, they generally form part of the first category (LLC31). Currently there are only a few Investment Tokens (EEP23) on the market, but by definition most of them provide some sort of relative right(s) towards a natural or legal counterparty and thus classify as Relative Rights Tokens (LLC32). Since most jurisdictions currently still do not allow for the management and transfer of absolute rights (e.g., ownership rights) through distributed ledgers, the last category of Absolute Rights Tokens (LLC33) is currently rather future-oriented.

Categories		
Label	**Identifier**	**Definition**
Utility Token	EEP22	A Utility Token is intended to provide a certain sort of utility or right to the token holder within a clearly specified environment (e.g., decentralized network, third-party ecosystem, business relationship or jurisdiction).
Transpor-tation and Warehousing	EIN08	The category Warehousing and Transportation covers business sectors ranging from logistics, pipeline and freight transportation, passenger transportation and (inter-)urban transit systems, harbor, and airport operations, packing and crating, as well as relevant support activities.
Non-Native Protocol Token	TTS42	A Non-Native Protocol Token is a cryptographic token that is implemented through a Crypto-Economic Protocol on top of a distributed ledger. As such, a Non-Native Protocol Token is not an integral part of the distributed ledger on which it is implemented.
Absolute Rights Token	LLC33	An Absolute Rights Token provides its owner with absolute rights (right in rem) to the token and its underlying asset or value (e.g., intellectual property rights or ownership of material objects). With the transfer of the token to a new owner, the absolute rights are also transferred to this owner.

Categories		
Label	**Identifier**	**Definition**
Ownership Token	EEP22O	An Ownership Token is created for the purpose of managing and transferring the ownership of material or immaterial goods. Thus, an Ownership Token can represent an absolute legal right with regards to intellectual property or material objects within the environment of a certain jurisdiction, but also ownership of a unique item within the environment of a decentralized network or computer game with no legally binding relative or absolute rights attached.
ERC721 Token	TTS42B	This sub-category represents Non-Native Protocol Tokens that are issued on the Ethereum blockchain and created by use of the ERC721 token protocol standard.