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Asset-Backed Tokens of Guarantees of Origin from renewable energy sources

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1 Introduction

The advent of the distributed ledgers technology which sets forth cryptocurrencies as alternative assets and blockchains as alternative payment systems have opened new vistas vis-à-vis access to finance through the creation of peer-to-peer primary (for issuance) and secondary (for exchanging) markets among others. Bitcoin and cryptocurrencies alike have been widely criticized for their ambiguous speculative nature due to the absence of an underlying value or at least of the property of convertibility. As the blockchain infrastructure advances, development of market designs on top of the layer of these distributed systems applied to the real economy, and energy in particular are systematically researched.

Motivated by this leading (peer-to-peer) financial technology, we inquire how could stakeholders in the renewable energy sector (consumers, suppliers, investors / producers) widen the availability of low cost funds to boost infrastructure investments while further diminish market information inefficiencies. The purpose of this paper is to devise an asset-backed token (ABT) cryptocurrency which combines two features. First, that of a financial instrument, thus it is debt (IOU) offering a return upon exercise whilst can be traded via the blockchain system. Second, that of commodity-money relying on the highest quality of collateral (energy consumption), thus it is able to store value and circulate for the acquisition of goods in tandem with traditional currencies. ABTs are issued by energy suppliers to foster sustainable investments in the renewable energy sector. Agents are asked to transfer part of their bank account balances to decentralized e-wallets denominated in ABT at parity with the economy's functional currency.

In principle, consumers act as bankers for that they choose which investment opportunities with benevolent cause to support without departing from liquidity for that these ABT readily pay off invoices. In effect, borrowers originate alternative deposits of arguably liquid, close to risk-free, positive rate of return, and high marketability nature by their own making capital intermediaries (banks) redundant. The understanding of this alternative scheme can bee seen most clearly by taking a market application with additive economic elements. Having said that, we propose asset-backed tokens to the fast moving renewable energy sector currently at the stage of transition towards decentralization with a special focus on the guarantees of origin certificates (usually denoted as GoOs or GOOs or GOs) market. These markets were originally developed to address the problem of information asymmetry in energy production and consumption from renewable sources. In this way, producers incur investment costs and expect (ex-post) to sell these electronic documents via mostly over-the-counter bilateral trades. In turn, producers receive an additional income by consumers who benefit from the generation of positive externalities to the environment. Contrary to this, under the proposed ABT scheme, the premium directed to producers of renewable energy who could also be producers-consumers (prosumers) by self-financing the establishment of housing solar power systems is ex-ante paid in the form of lower capital cost.

Lastly, notice that the object of such a title is to relate some characteristics of alternative asset-backed tokenization (ABT) via distributed ledgers with these of asset-backed securitization (ABS) via centralized highly regulated markets. The structure of this paper is as follows. The next section delivers the related literature. Section 3 discusses the construction of the ABT both from the supply and demand side. Then, an application with a focus on the complexity of the energy sector is shown. In addition, we cite the accounting mechanics. In section 5 we compile the benefits, limitations and variations after which we conclude.

2 Literature

The distributed ledgers literature, though in its infancy, has been already prompted to explore the potential of alternative investment opportunities (Chuen et al., 2017; Cahill et al., 2020) and alternative market designs (Cong & He, 2019). This work aims at contributing to this research agenda with an applied focus on the renewable energy sector. At most, inquiries into the possible adoption of the blockchain technology by the energy sector have been submitted from the technical viewpoint. Researchers recognize the current trend towards community energy and anticipate the spread of producer-consumer (prosumer) based systems disrupting the traditional uni-directional and centrally organized paradigm (Green & Newman, 2017).

From the economic policy perspective, McKenna (2018) is not convinced by the decentralization hype and argues the lack of economic scale effects while admits the critical role that energy batteries are going to play in building autonomous-communities as their prices continue to fall. Several studies are ongoing on suggesting incentive mechanisms for promoting green energy (Zhang et al., 2018) and direct trading between producers and consumers via micro-grid networks (Mengelkamp et al., 2018). The latter is open to debate for that current legislation in many countries forbids peer-to-peer energy trading. Regulatory issues in blockchain technology collected from case studies are presented by Yeoh (2017) whereas Diestelmeier (2019) discusses specialized topics in energy policy.

Recently, research on cryptocurrencies has entered into the empirical energy finance literature. As expected, the main body of the literature examines financial markets and price discovery associating energy commodities with cryptocurrencies (Ji et al., 2019; Okorie & Lin, 2020). Other studies investigate the evolution of marginal energy costs incurred during the expensive mining operation in cryptocurrencies such as Bitcoin (Kristoufek, 2020). Several studies investigate the effectiveness of the newly established GO markets (Söderholm, 2008; Raadal et al., 2012). For Mulder & Zomer (2016), current GO market designs have failed as a policy instrument to foster investments in the renewable energy sector.

From the previous narrative, a new research agenda on the intersection of energy markets with (decentralized) information (smart) system designs is looming anew (He et al., 2020). We follow the recent contributions in presenting energy blockchain-based market designs. An interesting approach for decentralized energy trading is found in Faizan et al. (2019) who also places emphasis on the design of cryptocurrencies with underlying assets. In the literature, the idea of cryptocurrency as guarantees of origin is likewise found in Castellanos et al. (2017) who attempt to simulate a green certificate market by bypassing energy providers. Our approach is different for that the role of energy providers is essential in rendering ABTs liquid money upon their issuance. While each country in Europe is obliged to run a certification scheme, countries are free to choose their own system design which has led to differences with respect to quality assurance and market organization (Hulshof et al., 2019). Some countries adopt common standards while there are a few that do not allow the export of certificates. The leverage of the proposed blockchain-based market design wherein claims for guarantees of origin certificates are recorded is that can further encourage international cooperation.

3 Asset-Backed Tokens (ABT)

A fundamental decision firms facing is whether the source of financing should be in the form of debt or equity. Cryptocurrencies could challenge the traditional pecking order theory (Myers & Majluf, 1984) and raise funds via an alternative decentralized apparatus. This process is colloquially called Initial Coin or Token Offering and in the literature is systematically examined (Hacker, 2019). Broadly speaking, (a) cryptocurrencies allow to issue and exchange units of value and (b) the blockchain permits to record the exchange of these (unique) units of value in a transparent, private and safe way through a distributed accounting system that cannot be tampered with. In this work, we set up an initial offering in the form of ABTs.

3.1 A conceptual framework

In today's investment paradigm, credit lines most often involve the provision of collateral by the borrower to the banking institution. In doing so, the latter issues a debt security (and debits assets) and simultaneously creates a deposit (and credits liabilities) on its balance sheet. The borrower receives traditional cash in electronic form which is convertible to cash at hand (coins and banknotes). As the borrower expects to collect future and uncertain receipts from customers, the principal is periodically, thus not one-off, charged with an interest rate and related commission fees.

Assume that a firm in the productive economy is in shortage of funds. To deal with this, it offers a discount for settling invoices outstanding. Thus, for the acquisition of its assets (goods) embedded in an alternative electronic media of exchange referred to as asset-backed tokens (ABTs). Interested parties, therefore, can exchange their deposits in traditional cash held in commercial banks for these asset-backed tokens at parity. By way of example, an agent could be indifferent between possessing (a) 1.000 in euro held at Bank X and (b) 900 in euro held at Bank X and 100 in ABT (at parity with the functional currency) in decentralized e-wallets readily acquire goods either the ones to which are backed or even others. This is possible as ABTs enjoy wider acceptance. Later on, we shall show how this takes place. In both cases, total assets sum to 1.000 in euro. For the holder of the asset, however, the discount represents an implicit rate of return. In other words, if we provide a market design able to render ABTs with high velocity in circulation, thus demanded for fulfilling the transactions motive (for payments) or/and the investment motive (for trading the discount), then we have successfully devised money (cash at hand) that pays interest. In effect, this locks the ABT's purchasing power against the functional currency in the economy with which evolve *pari passu*. This notion is not new for that existing centralized electronic payment systems and e-wallets offer discounts which effectively stand for higher purchasing power, thus a return. But, these are not assets for that cannot be traded.

3.2 Supply perspectives in designing the ABT

Two types of elements constitute the economic nature of a cryptocurrency which have not generally been distinguished, but which it is critical to distinguish. First, cryptocurrencies are either (a) decentralized or (b) centralized (IOU) for that there is an entity to assume obligation as the issuer (of the so-called Tokens). Second, cryptocurrencies' supply schedule either follows (i) quantity rules or (2) price rules. In our work, we develop a centralized Token which follows a price rule. All the same, ABT's exchange rate arrangement may take two forms. We use the following notation. Assume that the functional currency is i=euro, j=ABT and k is a good (or a bundle of goods). The monetary price of good (k) expressed in units of currency (i) is as follows:

$$p_{i,k} = \frac{\text{x units of currency euro}}{\text{1 unit of good k}}$$

The value in exchange of currency i (denoted as q) is the reciprocal function of the above equation and measures the purchasing power of the currency. Furthermore, the price of currency i (price currency) in terms of currency j (base currency) is the nominal exchange rate offered at issuance:

$$e_{i/j} = \frac{\text{x units of currency euro}}{\text{1 unit of currency ABT}}$$

The value of exchange (e') between these two currencies is again the reciprocal of the above equation. In other words, $p * e'$ expresses the monetary price of x units of good k in units of currency ABT. We have now introduced into our market nexus the ABT for the first time, and we are able to show how the originator can construct the ABT exchange rate arrangement. The are two available iterations in arranging the cryptocurrency's exchange rate. The first, is to fix (p) the price of the underlying good (divisible in units) and let the value of exchange rate float (e'). In this event the ABT retains stable purchasing power (q) for that the ABT holder has the right to purchase the good k in the future at the price determined today irrespective to spot price fluctuations. It offers, therefore, inflation protection. It is a forward contract without a specific delivery date and in the discussion section further considerations are presented.

The second option suggests letting the price float (p) whilst fixing the value of exchange (e') between the euro and ABT through the establishment of a discount rate. This means that the ABT is granted with higher purchasing power relative to the anchor (the euro) over the bundle of goods k. Hence, it is not stable in purchasing power (q fluctuates) with respect to the price level. Both options have pros and cons. For the remaining of this work, we delve into the analysis of the second case.

The ABT is protected from *seignorage*, at least in its theoretical construction, by the availability of short-term collateral. The issuer cannot "print" at will thus money supply is bounded. The upper bound of the value of the available collateral for tokenization equals to (a) accounts receivable denoted (A/R) outstanding on the balance sheet at time t and (b) projecting revenue (R) for a defined period

(0, t). Hence, this method is forward looking. The shorter the time frame (0,t) the lower the risk of failing to immediately convert ABT to media of exchange. In mathematical notation:

$$\text{ABT: } \Sigma_0^t R + A/R_t$$

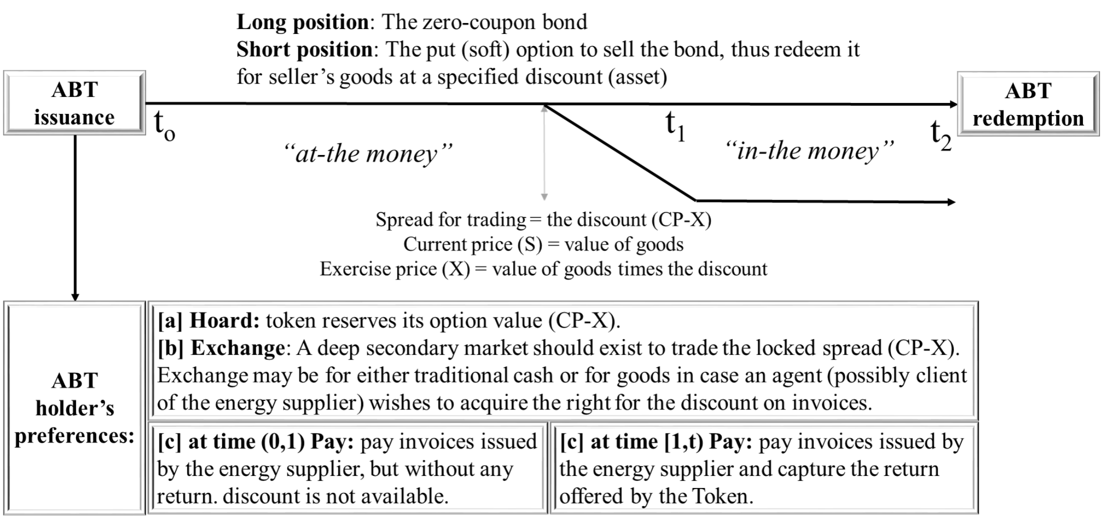
As pointed out, this condition is embedded so that the Token plays a dual role. That of an alternative investment (risky) asset that can yield a return by financing a project in the foreseeable future. And that of liquid money, thus an asset that can render the previous mentioned investment risk close to zero for that is always fully collaterized. This means that in the event of collective exercise of all circulating ABTs in exchange for goods (soft option), this obligation can be met in full. The idea is to open-up funding in this way to embrace geographically distanced legal and natural persons (individuals) to place their cash equivalents (bank deposits) on balance sheets that have a two-tier meaning for them. It remains open to debate that in our ABT economy, consumers store savings in decentralized e-wallets that directly finance investment opportunities of their choice able to provide future consumption while ABTs being uninterrupted in meeting the transaction motive.

3.3 Demand perspectives & pricing the ABT

Valuation issues in asset-backed tokenization are complex. The fundamental variable that drives this market is the discount which is set by the originator beforehand. What is the appropriate level of the discount offered considering that it reduces the level of sales and, therefore, profits? The theoretical details of deriving ABT supply functions as well as demand functions are extensive and are outside the scope of this introductory work that aims to present the main concept. It can be briefly said that supply is conditional on the trade-off between the discount which plays the role of alternative financing cost and the lending (after-tax) interest rate to account for the tax shield offered by the traditional banking sector. In the discussion section, a basic proposition is derived.

We turn, next, to the investment mindset. Looking at the ABT as option-like asset, note that the exercise price matches with the initial outlay when the agent was asked to change her bank deposits to ABT deposits. This means that there is not exercise price to pay later. A critical aspect is the time frame of the option. First, we propose a perpetual option otherwise we depart from the concept of money which does not expire. If, in other circumstances, the ABT incorporates an expiration date then this would render it a pure financial asset. In this case, the characteristics of money are canceled for that the latter never expires. Second, the cut-off t_1 set by the originator and written on the blockchain's smart contract corresponds to the required time that the investment needs to start paying off. In more detail, between the time frame t_0, t_1, the ABT is "at the money" since the discount is not available. ABT behaves like traditional cash for paying energy consumption provided by the ABT originator. But, it can be exchanged for goods in the economy for that the wider the clientele base of the originator the higher marketability of the ABT by taking advantage of network effects of these retail and wholesaling chains. Later on, under the application to the energy sector section (ABT circulation) we further elaborate on this while Appendix A illustrates an example. It is conceivable, of course that time t_1 onward, we deliberately violate the no-arbitrage assumption by setting the ABT "in the money" (discount is effective). The next figure displays a pricing framework and the key valuation components.

Figure 1: Pricing the ABT



This alternative asset can be viewed as a hybrid zero-coupon convertible bond with an embedded soft provision for that it can be redeemed for the acquisition of originators' goods since it resembles an IOU financial instrument. In this model, we do not incorporate a hard provision in the sense of being convertible (back) to traditional cash in order to depart from the operations of traditional electronic banks which are strictly regulated by central banking. Notice that the acquirer of the ABT need not only belong to the clientele list of the originator. Since the asset is issued at par (at parity with the functional currency), there is a well-defined future discount spread available for trading by other depositors (not customers) motivated by this investment opportunity. This is critical in creating a deep and liquid market. Furthermore, note that there is a partial exercise right for that the option is divisible in decimals in contrast to traditional convertible bonds.

At the end, as soon as it meets its last function as means of payment, the ABT is withdrawn from circulation (in the blockchain language these Tokens are "burnt", thus sent to idle e-wallets without private keys). The above conclusion, although self-explanatory, can have a proper defense with a numerical example. Assume that the originator determines the discount factor at close to 0,95 by offering 5% discount on current (spot) prices. Also, assume that the current value of an invoice is 100euro. The unity of the purchasing power parity linking the exchange rate with the two price levels is deliberately violated (recall that the nominal exchange rate equals 1 at issuance). The cost of paying in euro is higher. Contrary, the purchasing power of the ABT relative to the euro allows to settle payments at lower rate. Hence,

$$\epsilon_{i/j}\frac{p_i}{p_j} = \frac{euro}{ABT}\frac{\frac{ABT}{\text{1 unit of k}}}{\frac{euro}{\text{1 unit of k}}} = \frac{95}{100} = 0,95$$

This equation is fundamental and merits further examination. This difference is by reason of the existence of the discount attached to the ABT that the above violation of the unity should adhere to at issuance. This is, therefore, agreeable to, our intention to render the ABT with a higher purchasing power with regards to the functional currency (euro). Hence, ABT is more valuable than traditional cash at issuance. In the secondary markets, it is expected that as agents trade the spread yielded by the future discount the real exchange rate will make the above equation to get closer to unity.

But a focal component is the intrinsic value derived from the additive economic elements of the market design, if applicable. ABTs come with an applied case, that is the value of guarantees of origin certificates. Should we anticipate these ABT to trade at premium (above par) rather at discount? Again, this will be determined by the secondary market. For if there exist a premium, this may influence the decision on the discount rate set by the issuer.

4 An application to the energy sector

This section puts the substance of our ABT model. An application to the energy sector is discussed combined with a blockchain-based market design of the guarantees of origin certificate market.

4.1 ABTs for financing energy from renewable sources

In infrastructure financing, investors raise debt and equity capital via Variable Interest Entities (VIE) established as special project vehicles (SPVs) under national regulatory frameworks. Investors are usually a subsidiary firm of an energy group which also includes an energy supply subsidiary. We discuss the establishment of an alternative blockchain-based funding scheme as a way-out. Through the tokenization process, the underlying good is energy consumption measured in kWh (divisible in decimals) provided by energy utilities. Traditional asset-backed securities (ABS) and the most important fixed-income case of mortgage loans are related to durable long-lived assets. This incorporates risk due to the passage of time. The comparative advantage of energy production being the underlying asset lies with its immediate consumption whilst in the last years the issue of energy storage in batteries is advancing. In ABTs, the underlying is, therefore, short-lived readily to settle outstanding invoices. This fuels with liquidity the ABT while arguably pushes risk closer to zero, for that represents direct claims on the underlying asset. In contrast, typical ABS schemes are not claims sine they are associated with the future uncertain cash flows generated by the underlying risky security.

This is the main point in tokenization brought forward by distributed ledgers. An alternative financing method in close resemblance with asset-backed securities wherein the underlying asset is issuer's goods. By holding money in these decentralized e-wallets, the depositor earns a real rate of return higher than central bank's cash (coins and banknotes) and commercial bank's electronic deposits. The inherent motivation for the firm is to enable stakeholders to participate in energy production and distribution from renewable sources without the abrupt notion of speculation associated with investments. It is self-evident, that producers and investors gain leverage when consumers of the energy community are willing to hold ABTs rather than exercise the option to settle payments. To sketch this idea, the graphical illustration in Appendix A overviews how the primary (for issuance) market is initiated and how the secondary market (for exchange) successfully operates as marketability unfolds. In sum, the ABT phases include:

1. **ABT issuance** commences with the exchange of traditional currency with a Stablecoin cryptocurrency via a digital exchange. Smart contracts only communicate with cryptocurrencies and for that reason another crypto-asset is required, preferably one stable in price. When Stablecoins are sent to the smart contract on the blockchain, ABTs are returned at parity with the functional currency. The originator receives the Stablecoins in a digital wallet and can consequently exchange these for traditional currency so as to initiate the investment plan. Unless, someone in the ecosystem is willing to accept Stablecoins as means of payment. The amount raised stands for a hybrid form of debt. The issuer should recognizes a liability account on the balance sheet equal to the amount raised during the Initial Offering process.

2. **ABT circulation** is guaranteed by the energy supplier who accepts the token as media of exchange for invoices outstanding. The Token's value is derived in the first instance from the right to pay for energy consumption. Notice, however, that as the Token circulates among the chain of clientele

networks, wider adoption for payments for other goods is possible by other merchants who are willing to accept it. In appendix A we graphically show this network with an example. The energy supplier has three customers designated as “A”, “B” and “C”. “B” is also customer of “A” and the latter can easily exchange the Token for the former goods (say coffee). However, “C” who sells apples (and recall that this is a regular customer of the energy supplier and needs the Token to lower her unit cost) does not have a direct business relationship with “A”. The latter is not his customer. Nonetheless, “D”, a customer of both “A” and “C” is the appropriate link in this chain for the token to circulate. This highlights network effects spawn by each merchant clientele and the fact that the token becomes widely accepted money and not an idle claim against an energy supplier. A critical issue is under which tax and accounting framework this promissory note can circulate. The concept is not new. It bears resemblance to *bills of exchange* issued and circulated. Only that, there are important differences which current legislation does not cover. Additional considerations about this analogy are explained under the accounting mechanics section.

3. **ABT redemption** occurs by sending ABT to a specific wallet without private keys whereby these are withdrawn from circulation (“destroyed”) in accordance with the smart contract “Burn”. In its aftermath, the consumer receives the relevant units in guarantees of origin certificates, from another smart contract “GoOs” which automatically communicates with the previous one. The delivery could be automatically (on-chain) done via digital badges sent to the sender. The fundamentals of this procedure are reviewed in the section that follows.

Post-redemption (post-burn) circulation is open to discussion. As the Token continue to enjoy acceptability and marketability, the issuer may (a) issue new Tokens again in exchange for traditional cash, thus competing commercial banking or (b) use these ABTs (without attracting new funds in euro) to pay expenses and wages empowering the penetration of the ABT in the economy. This happens as long as employees would be indifferent between salaries (a) paid in euro and

(b) paid partly or fully in ABT (again at parity with the functional currency in the economy). The functional currency in this setting remains the euro with the prevailing role of the unit of account. Only that now another media of exchange circulates in tandem with the functional currency lowering the demand for new money (in functional currency) via the bank loan generation process. In this way, the issuer is freed from traditional banking borrowing and controls an alternative funding scheme that permits holders to earn an arguably risk free (for that the ABT is presumably fully collaterized with goods) interest rate (the discount).

4.2 ABTs for guarantees of origin certificates

In Europe, the first market of guarantees of origin certificates were established in 2001 (Hulshof et al., 2019). The regulative framework enacted in 2009 by the EU Renewable Energy Directive (2009/28/EC) aimed at specifically addressing information asymmetry between producers and consumers. A most recent development was in 2018 following the approval of the Renewable Energy Directive (REDII). But, existing conditions have rendered guarantees of origin certificates a mere communication tool only available for large-scale firms and limited to households whilst failing to directly link producers, consumers and investors. Households do not have direct access to support such projects with benevolent cause. The main way is the acquisition of shares which can be cumbersome in process and maintenance, risky and long-lived investment. Usually, this profile does not match with low-income depositors that are simply interested in supporting renewable energy schemes in a modest manner, thus not craving for speculative investment returns. Forthcoming energy policy changes such as the arrival of bilateral contracts between suppliers and producers and even peer-to-peer trading call for assessing the impact on existing markets.

Today, producers of energy from renewable sources are periodically granted with guarantees of origin certificates which usually represent one megawatt-hour of electricity produced. Note that these come out in large quantities and are not divisible. The cryptocurrency technology allows to render these divisible. Guarantees of origin are market-based assets electronic documents which are measured (metered or calculated), issued and canceled in a registry centrally administrated by a state-owned body. This is the way to ensure that only sold once and that there is no double counting. Apparently, this issue welcomes decentralized blockchain applications. But, here, we let the State to retain its institutional role by controlling the smart-meters, at least for the time being. This means that smart-meters record production levels of green energy and consumption of energy on a permissioned blockchain, thus upon invitation (by the State) and not truss-less like Bitcoin.

In a nutshell, the level of production communicates with the smart contract which accumulates the claims for certificates. The amount of ABTs redeemed for energy consumption reduces the amount of certificates which are canceled, thus sent to consumers (always measured in an agreed unit of account that can be lower than current megawatt-hour). Thus, the blockchain challenge is to convert off-chain information (thus measured outside the blockchain) to on-chain. A few more words about the non-monetary asset (GoOs) issued by the smart contract on the blockchain. The level of production accumulates on the blockchain ledger via smart-metering. So, the smart contract GoOs collects two on-chain information namely (a) balance of accumulated energy production brought forward (AccP) and (b) amount of outstanding ABTs, thus the ones that have not been yet exercised (OutABT). Based on these, the smart contract computes an output, that is a conversion ratio as follows

$$\text{conversion ratio}_t = \frac{AccP_t}{OutABT_t}$$

For simplicity, let's assume for now that this energy facility has been fully funded by ABTs. The ownership of the facility, as usual, rests with the energy group. The conversion ratio calculates how many certificates each ABT holder is entitled to receive at any point in time. Thus, in the simplest case, if the accumulated production amounts to 10.000kWh and the ABTs outstanding (net of the ABT's already exercised) amount to 2.000 then the conversion ratio is 5. If the consumer decides to redeem 300 ABTs, then the amount of green certificates that the smart contract will return is equal to 1.500 representing 1.500kWh. The consumer has provided resources in the production of 1.500kWh irrespective to her own quantity of energy consumed. There are stakeholders that prefer energy-efficiency by lowering their energy consumption but this should not be attached to claims on green certificates. Members of the green energy community need financing incentives to boost energy production from renewable sources. Not measured in terms of consumption expended or the ability to pay for a certificate. This proposed market design amends these inefficiencies. Replaces the concept of green certificates as a marketing expense for large-scale firms with an alternative banking scheme controlled by consumers who support green energy. The intuition is a market-design wherein buying a certificate should express a commitment to support the production of energy from renewable sources.

For the next period, accumulated production (AccP) is reduced by the amount of 1.500 as previously computed whilst new production accumulates. Similarly, the amount of outstanding ABTs (OutABT) is reduced by the amount of ABTs exercised in the previous period, thus 300. Appendix B illustrates the market design with another numerical example. It is worth adding that in this complex market design long-term investment in green energy (thus, holders that do not exercise the option) is encouraged for that leads to higher claims on green certificates. This means a link is established between green energy stakeholders (funding), production and consumption.

What is not clear-cut and affords a better starting-point for a discussion is the timing to exercise the option with regards to the amount of certificates to be received. Once again the information required is the price of the underlying asset. Assume that the asset's spot price (green energy acquired by the supplier) is 1 euro net of discount for that we are paying with 1 ABT. Then, the consumer is entitled to receive 1 green certificate. Put it differently, the conversion rate should be equal or higher than unity from the consumer standpoint of view to make sense. Otherwise, the production has not been able to produce the sufficient amount of green energy claimed by the consumer according to her committed funds. This formula can hold variable the claims on green certificates, thus determined by prevailing market conditions (spot prices) rather than set in advance (thus, fixed) the amount of certificates that each ABT is entitled to. By linking the certificate with consumption, in practice we have tacitly agreed, to fall back on what on what is, in truth, an existing market reality. The essence of this lies in relinquishing every marketing value on the certificate in favor of lower cost of capital for the producer and direct access to the certificate to households.

4.3 Accounting mechanics

The scope of this section is to present the implied accounting mechanics under a proposed financial reporting framework. From the accounting viewpoint, there is nothing discussed about the treatment of centralized Tokens. In ABTs, the first transaction implicates the receipt of funds by the issuer. The details of the accounting and tax implications are important and are left for further research. Below, we discuss a working financial reporting framework. Note that all accounts are expressed in the functional currency. The main questions are the next two.

[A] how transactions are recorded at issuance on the balance sheet?

[B] how marketability is established?

The answer to the first question is not straight-forward. The ABT is a liability by all means, however, in resemblances both to (a) Unearned Revenues, thus advances or pre-payments for goods and (b) traditional bonds and lending facilities. The second question deals with the matter of how this contractual obligation can be exchange (ABTs). Bond are usually traded in organized secondary markets and comply with strict regulation. The ABT could be viewed as a private debt, a lending facility between the firm and a person either natural or legal, that is transferred via bills of exchange. Although, bills of exchange are governed by existing local Commercial Law frameworks according to which these promissory notes (a) are not divisible and (b) can only have physical substance since no provision for their issuance in digital form exist, we throw this idea for further consideration by policy-makers. Blockchain systems can facilitate the transfer of privately issued debt. This treatment requires red tape procedures such as tax stamps, loan contract which can be done off-chain as usual. Having said that, by combining the above concepts we recognize a short-term liability account that is associated with the issuance of ABTs and correspondingly bills of exchange (IOU).

Let's shift our attention to a practical example. Assume that a consumer sends to the smart contract X units of euro (and receives ABTs).

The steps are the following. All amounts in euro for that it assumed to be the functional currency.

1. Issuance: Execution of smart contract and collection of the other cryptocurrency (stablecoin) amounting to X units of euro. A hybrid liability account (possibly under the Unearned Revenue account) should be credited. This is a debt facility, a loan that pays no interest and does not expire whilst can be transferred via bills of exchange.

2. Exchange: Stablecoins are sent to the SPV (previously could have been exchanged for traditional cash in a digital exchange). We skip for now the entries relating to how the issuer (energy supplier) transfers the money (X) to an SPV vehicle (the energy producer) that will undertake the green energy investment in the form of equity or debt. For simplicity we assume the first case (account: Participation in Associates). The second case could be more complex for that intra-group settlement entries may be required so that pre-tax income for each firm (supplier and SPV) is properly reported.

3. Billing: We assume that the holder exercises the put option at a later date when the discount is applicable. The holder is billed for the purchase of goods and informs the vendor that will pay with tokens (either partly or in full). Invoice at current (spot) net prices is denoted as S (VAT excluded) and the discount rate as d. Hence, S*(1-d) equals $\frac{X}{(1+VAT)}$ and VAT stands for the Value Adding Tax applied to the net price (including the discount) of the underlying good. Thus, X settles both the net sales value as well as any direct taxes.

4. Settlement: Token holder partly pays with tokens

Practically speaking, energy supplier's (and investor in the SPV) statement of financial position (SOFP) and Income Statement (IS) would look like this.

Table 1: Transactions (Tx) and accounting entries

Account	**Tx1: issuance**	**Tx2: exchange**	**Tx3: billing**	**Tx4: settle**	**Balance**
SOFP: Intangible Assets	Debit: X	Credit: X			0
SOFP: Accounts Receivables			Debit: X	Credit: X	0
SOFP: Participation in associates		Debit: X			X
SOFP: Debt (ABT)	Credit: X			Debit: X	0
SOFP: VAT payable			Credit: X(1-1/(1+VAT))		X(1-1/(1+VAT)
IS: Sales			Credit: X/(1+VAT)		X/(1+VAT)

As long as that the holder does not redeem the ABTs, then the cash flow benefits for the energy supplier and producer are indisputable. The later in time this happen the more likely is that the investment in energy production has been completed and started to generate cash flows so that option exercise does not expose the issuer to liquidity problems. This cash flow matching is critical. Given the above considerations about the impact on the statement of financial position and the income statement, we should consider the cash flow statement as a final step. The matter that arises is under which activity the ABT components fall. The discount on net sales affects operating activities for that revenue is reduced by that amount. The creation and the amortization of the liability account could be classified as financing rather than operating activity. This hybrid contractual obligation retains features from bonds and unearned revenue (pre-payment for goods). This is open to debate and requests a more comprehensive analysis.

5 Discussion

A very logic question that arises is why we need an alternative financing scheme? The practical excellence of this work lies in developing an alternative investing and saving instrument that can operate in tandem with the economy's functional currency. At the same time introduce a form of competition to banking's lending activities. Together with this, blockchain-based, thus incentive-based peer-to-peer market designs can resolve market inefficiencies as the ones discussed in the case of guarantees of origin from renewable energy sources. Some issues raised earlier call for a more profound discussion with regards to the benefits, limitations and extensions of asset-backed tokens.

5.1 Benefits of ABTs

Since, therefore, the main argument of ABTs is that provide benefits, we should enumerate these. Thus, exemplify how the issuer and the holder become better-off compared to raising bank loans and holding checking accounts respectively. In dealing with the idea that a firm can raise capital at lower cost, we should get closer to a quantitative definition of this benefit. While this calls for the development of a formal theoretical model, we can arrive at a basic proposition relevant to future research. In reckoning the profit maximization problem, it is ease to state that the firm should be indifferent between (a) the reduction in sales incurred by the discount and (b) the after-tax borrowing cost, thus adjusted for the tax shield. So, from an income statement perspective assuming a time interval (0,t):

$$P_t(1-d)Q_t = P_tQ_t - i(1-T)P_t(1-d)Q_t$$

where P times Q is the amount of the invoice without the discount (P is the Current average Price and Q the quantity), i is the lending rate, d is the discount and T is the tax rate (lower than unity). In mathematical notation, from the above equation the discount can be expressed as:

$$d < 1 - \frac{1}{1+i(1-T)} \Rightarrow d < \frac{i(1-T)}{1+i(1-T)}$$

Hence, the upper bound of the discount is always less than the nominal borrowing rate due to the tax shield. The lower bound is obviously zero. It is recommended for future study to develop a complete model to address other factors such as the cost of production and the price elasticity of the good and the restrictions imposed by the amount of available collateral. The next table summarizes the most important repercussions.

Table 2: Benefits of ABT

Benefit (side)	**Description**
A. Reduction in cost of debt: **(For the Issuer)**	The issuer reduces its working capital needs and its dependency in bank borrowing availability by raising funds in advance. ABT issuance may be periodic to meet liquidity needs. Effectively, it plays the role of a peer-to-peer credit instrument that is only once charged (when discount is exercised) compared to bank loans which charge fees and interest rate as long as the credit line remains open. Banks are let to focus on financing large scale investments,
B. Reduction in transaction cost: **(For the Issuer)**	The reduction arrives in the form of lower fees for payments. Every cryptocurrency comes in with a distributed payment system either embedded (when cryptocurrency run in a built-in blockchain) or circulating in a surrogate blockchain (like the case of most tokens issued and exchanged on other blockchains). Today, firms receive funds via points-of-sale, credit cards and remittances which include different kinds of transaction fees and rates.
C. No interest bearing bank deposits earn a rate of return related to the issuer's goods produced: **(For the Holder)**	Banks offer time deposits readily buy goods, yet remain idle and do not offer an interest rate to micro-depositors. By exchanging traditional deposits for tokens, the holder does not apart from the much wanted properties of money. He can liquidate at any time his token in the secondary market to anyone and receive in exchange either traditional cash or goods from producers that accept the energy ABT (or even other tokens issued by other firms). Note that the issuer could also claim the role of "buyer of last resort" to enforce tokens convenience yield and diminish possible liquidity traps due to unanticipated wide spreads.
D. Increase in positive externalities: **(For the Holder)**	The blockchain stimulates transparency in identifying uses and sources of funds. The ABT's digital footprint can show budget appropriation as well as how the budget was dispersed in meeting the initial purposes for which the receiver of funds was entitled to use the proceeds. This can be of high-adding value, particularly for donations, charity funding and state-owned organizations.

With regards to environmental, social and governance (ESG) topics and the last benefit mentioned, adoption of ABTs can be anticipated in philanthropies and the non-profit sector. Financing such organizations with funds that are associated with the consumption of specific bundle of goods and not financing through traditional cash which can be vaguely and improperly dispersed could be of high importance for this sector and the general public that wishes to contribute resources. Finally, ABT holders may favor good governance by not exercising the option or even express opinion for bad governance (possibly because the issuer has failed to fulfill the green energy objectives) by massively exercising the put option. This would create liquidity constraints.

5.2 Limitations of ABT

In large part, the introduction of another asset that consumers need to hold in an e-wallet adds complexity and increases transaction costs. What happens if more issuers come in? Our assumption of existence of a deep secondary market wherein the ABT circulates as means of payment utilizing the issuer's clientele, can become more plausible as the issuer's clientele base is substantially large.

Another critique is that this proposed ABT is limited to micro-finance and cannot cover the needs of capital-intensive projects. This is true on account of the constraint imposed by the convertibility option prior to investment's ability to generate cash flows. As we depart from this *liquidity premium* offered from the issuance of the ABT and therefore embed to the derivative later exercise date, then this is possible though the role of currency diminishes. The success of the ABT is tied with the holders' motivation to support the green investment and not to exercise the option at least until project's completion. Furthermore, the sales discount is an apparent constraint for succeeding high volume ABT leverage.

In a more practical sense, when talking about collateral within this asset-backed tokens framework it is critical to solve the issue of who can guarantee that the underlying collateral such as accounts receivables (invoices already issued) are not already pledged to other credit lines. For asset-backed securities this a deterministic factor enforced by strict regulation. For asset-backed tokens which are of lower volume and short-lived this is expected to be a stochastic one. This means that since the market is decentralized, the issuer carefully controls the money supply in order to satisfy requests for ABT redemption at any time rendering this asset with money properties for that this is tacitly related to the firm's going concern assumption.

Talking about regulatory matters, it should be clear that ABTs are closer to cash at hand (coins and banknotes) than financial assets for that all cryptocurrencies' issuance is irreversible. While re-issuance of securities and bank deposits is possible following owner's identification, this is not the case. If the holder disposes the private keys with which can access these digital assets, this is similar to loosing coins and banknotes from a physical wallet.

In last, there is the issue of the utopia of decentralization. In our distributed ledgers environment, a central operator still plays a vital role. Guarantees of origin certificates are measured via smart-meters only that these belong to the State. In this frame, verification is assumed to be exogenous. An issued body controlled by the authorities is still required. Only that, in this case the cancellation can be made via the blockchain while this market design can have an international character rather than national connecting consumers, investors, producers and suppliers.

5.3 Varieties of ABT

In this work, we explored a short-term alternative financing tool wherein supply either expands by the issuer (firm) or contracts by the holders when tokens are redeemed ("burnt"). On the other hand, the close to 100 per cent collateral target fuels the token with marketability, thus liquidity. To extend, more complicated and possibly more interest arrangements can be further researched. An issuer faces the following additional perspectives:

1. instead of the price-rule propose asset-backed tokenization under the quantity rule. But, this requires that the underlying good is divisible itself, and in turn meets the qualities of money. Hence, the issuer locks the future selling price of the good and the holder its future acquisition price. The Tokens resemble a call option with exercise price the current selling (spot) price.

When in the money, the holder is inclined to exercise and gain the implicit return of the discount. In this frame, the Token is inflation-protected. If selling prices soar in the future, so does Token's option value. Note also that selling price is not unique for that customers face different billings. But, what about issuer's profitability? As long as the issuer can hedge all related input costs, then the profit is locked as well. However, this is not easy in the enterprise world, especially due to the existence of fixed cost.

2. relax the redemption assumption by introducing an upper time frame bound but this cancels the concept of money (immediate convertibility for goods) as earlier said. However, this would leverage the amounts that the Token can raise at the expense of liquidity that money offers.

3. add the option of converting the ABT back to traditional currency. This feature would directly relate to "electronic money issuer" business activities that are supervised by central banks as mentioned. On such assumptions, firm get closer to commercial banking's fractional reserve operations.

4. relax the reserve requirement (100 per cent backability). In this frame, a money multiplier will increase the units of tokens issued giving nice ideas for further research.

5. ABT is not offered at par rather pays a fief in kwh (feudal lord). Thus, the holder is credited with more units of the underlying good on account by the mere message of time similar to traditional banking's saving interest rate. This incentive may refrain the holder from exercising the ABT.

6 Conclusion

Since ever societies have relied on middlemen (traditional banking) to hold deposits in electronic form, appraise investments and issue loans to finance selected business opportunities. In that event, the emergence of cryptocurrencies, in turn, at least outwardly challenges and as though may supplant the established traditional investment practices for that can transcend money and capital markets in an imperative way. That is to say, this financial technology gives the possibility of directly linking producers / investments (in need for funding at lower cost of capital) and consumers / savings (holding deposits readily purchase goods) while regulatory defects that impair market design efficiency are addressed.

This paper presented an application of blockchain-based market design of asset-backed tokens (ABT) to the energy sector with a focus on the markets of guarantees of origin from renewable energy sources. This sector is suitable for that consumption of energy is a basic consumable good while the production of green energy is actively endorsed by the public. In this innovative scheme, the State maintains its vital role by controlling the smart-metering procedure. The banking sector also maintains its dominant position in the financing of risky long-lived infrastructure investments which relates to banking's portfolio management activities in issuing new deposits (via loans) rather than managing existing deposits. The latter can be partly done by ABT depositors. Perhaps, following the notion of prosumers (producer, consumer), it appears that ABTs can submit the alternative notion of prosumor (producer, consumer, investor).

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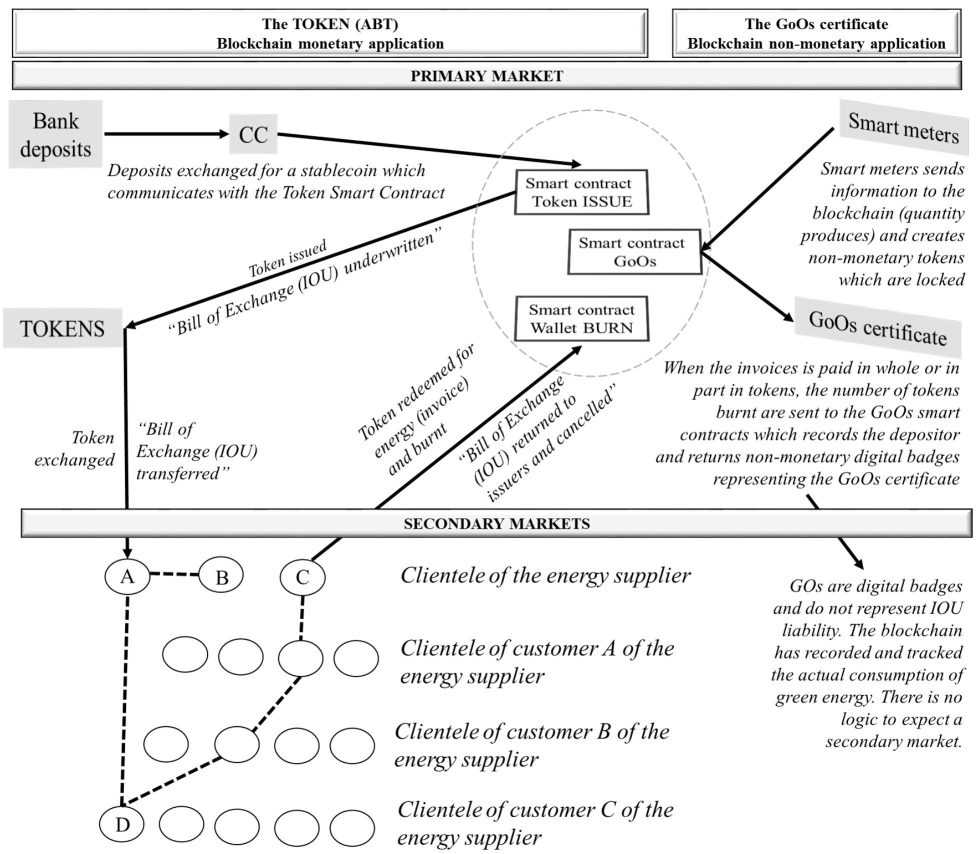
Appendices

A

The monetary application: ABTs

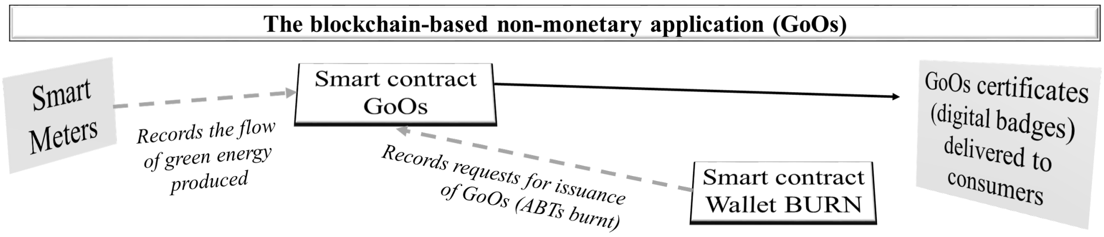
Figure 2: Schematic illustration of ABTs primary & secondary markets



B

The non-monetary application: GoOs

Figure 3: Guarantees of Origin certificates on the blockchain



Time	t_A	t_B	t_C
Accumulated Production (prior plus new) in kWh Opening balance	0	0 + 1.000 = 1.000	900 + 8.100 = 9.000
ABTs outstanding Opening balance	(issued:) 5.000	5.000	4.500 – 1.000 = 3.500
Conversion ratio	-	(1.000/5.000) = 0,2	(9.000/4.500) = 2
ABT burnt		500	1.000
Accumulated Production (prior plus new) in kWh Closing balance	0	0 + 1.000 – (1.000/5.000) * 500 = 900	900 + 8.100 – (9.000/.500) * 1.000 = 7.000
ABTs outstanding Closing balance	5.000	5.000 – 500 = 4.500	4.500 – 1.000 = 3.500
GoOs delivered to consumers	0	0,2 * 500 = 100 kWh	2 * 1000 = 2.000 kWh