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# Financial instruments on the blockchain:
## their role in energy transactions

*By Dr. Paul Cuffe*
*UCD School of Electrical & Electronic Engineering*
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*w/ Olakunle Alao, Mahdieh Shamsi & Almero DeVilliers*

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Interests disclosure:
P. Cuffe is long ETH, REP & OMG

# First: **Bitcoin basics**

The Bitcoin blockchain is a *file*: a **shared ledger** that records every Bitcoin transaction ever (current size ≈ 300 GB)

This file is hosted across **many different computers** (c.f *BitTorrent*)

Only the creator of a Bitcoin address can **authorise spending** from that address (public/private key transaction signing)

Key innovation: the transaction record is **immutable** and can't be altered after the fact (transaction blocks linked by **proof-of-work** hashing)

# Smart contracts

The legitimacy of a Bitcoin transactions is **trustlessly validated** by a decentralised network of *miners*

A smart contract is a piece of code whose **correct execution** is likewise validated by a **decentralised network**

A smart contract runs on the '***world computer***' in a way that it **beyond human interference**

For instance, a smart contract could **escrow funds** until some condition is met

The **Ethereum** blockchain provides a flexible smart contracts platform

Just an **Ethereum address**: I can send ETH to this.
I can also interact using **defined functions.**

Etherscan

All Filters | Search by Address / Txn Hash / Block / Token / Ens

Eth: $221.72 (+5.13%)

Home | Blockchain | Tokens | Resources | More | Sign In

Contract 0xb9812E2fA995EC53B5b6DF34d21f9304762C5497

DutchX

Buy | Earn Interest | Crypto Credit

DutchX: Exchange Proxy

| | |
|---|---|
| Balance: | 0 Ether |
| Ether Value: | $0.00 |
| Token: | $639,798.18 43 |

**More Info**

| | |
|---|---|
| My Name Tag: | Not Available, login to update |
| Contract Creator: | 0xb1f919db227048a... at txn 0xb6061e32145f4b3... |

Transactions | Erc20 Token Txns | Contract | Events | Analytics | Comments

Code | Read Contract | Write Contract

**Contract Source Code Verified** (Similar Match)

Note: This contract matches the **deployed ByteCode** of the Source Code for Contract 0x4...

| | | | |
|---|---|---|---|
| Contract Name: | **DutchExchangeProxy** | Optimization Enabled: | Yes with 200 runs |
| Compiler Version | **v0.5.2+commit.1df8f40c** | Other Settings: | **default** evmVersion |

This code is **executed and verified** across the **global Ethereum blockchain.** This code exclusively **controls the tokens** within the contract.

**Contract Source Code** (Solidity)

Similar Contracts | Outline

```
/**
 *Submitted for verification at Etherscan.io on 2019-02-07
*/

pragma solidity ^0.5.2;

// File: @gnosis.pm/util-contracts/contracts/Proxy.sol

/// @title Proxied - indicates that a contract will be proxied. Also defines storage requirements for Proxy.
/// @author Alan Lu - <alan@gnosis.pm>
```

# How to think about **blockchain disruption** of energy transactions?

Sustaining Technology


*"Bitcoin has proven effective as a store of value" [7]*

*"The value of Bitcoin as store of value, medium of wealth transfer, and in future...medium of consumer exchange is indeed based on its strong and seamlessly global security" [34]*

- Cryptocurrency payment layer.
- Digital notarisation for asset management.
- Supply chain management.
- Value store of sorts.
- Generally a complimentary service.
- Piggybacks on existing infrastructure.
- Little to no involvement from existing regulators.

De Villiers, Almero, and Paul Cuffe. "*A Three-Tier Framework for Understanding Disruption Trajectories for Blockchain in the Electricity Industry*." IEEE Access 8 (2020): 65670-65682.

Graphic: Mr. Almero de Villiers

Evolutionary Technology


*"Second-generation blockchains, such as Ethereum, threaten not only to disrupt our understanding of a monetary system but could further pose serious consequences for litigators, regulators, and officials." [7]*

*"We are now seeing innovative approaches that help participants dramatically expand the scope and substance of their relationships with others, opening up new forms of collaboration..." [30]*

- Smart contract ecosystem.
- Revised and automated handling of relationships between people.
- Decentralised Autonomous Organisations
- Meta-data analytics.
- Requires significant additional infrastructure.
- Some regulator involvement.

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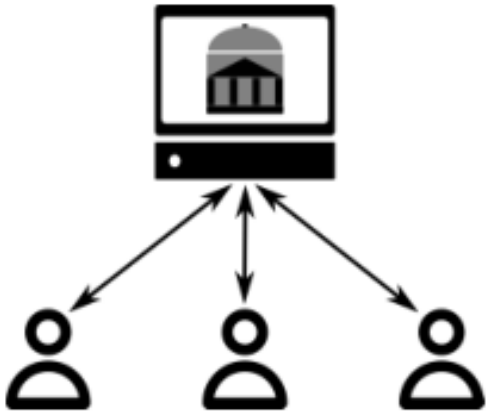
Disruptive Technology


*"...truly significant disruptions affect...entire industries and even society: former industrial leaders may vanish and be replaced by new entrants...and the new market conditions emerging from the disruption may require significant adaptations at the level of societies in terms of new institutions and regulation." [31]*

*"The reimagined technology often has little resemblance to the legacy...The melding of old and new into a completely different solution often creates whole new categories of products and services, built upon a base of technology that appears completely different." [28]*

- Blockchain-based decentralised governance.
- Total overhaul of payment and governance structure.
- Largely replaces incumbant industry, becomes the new standard.
- Considerable societal impact.
- Regulatory changes of some kind required.



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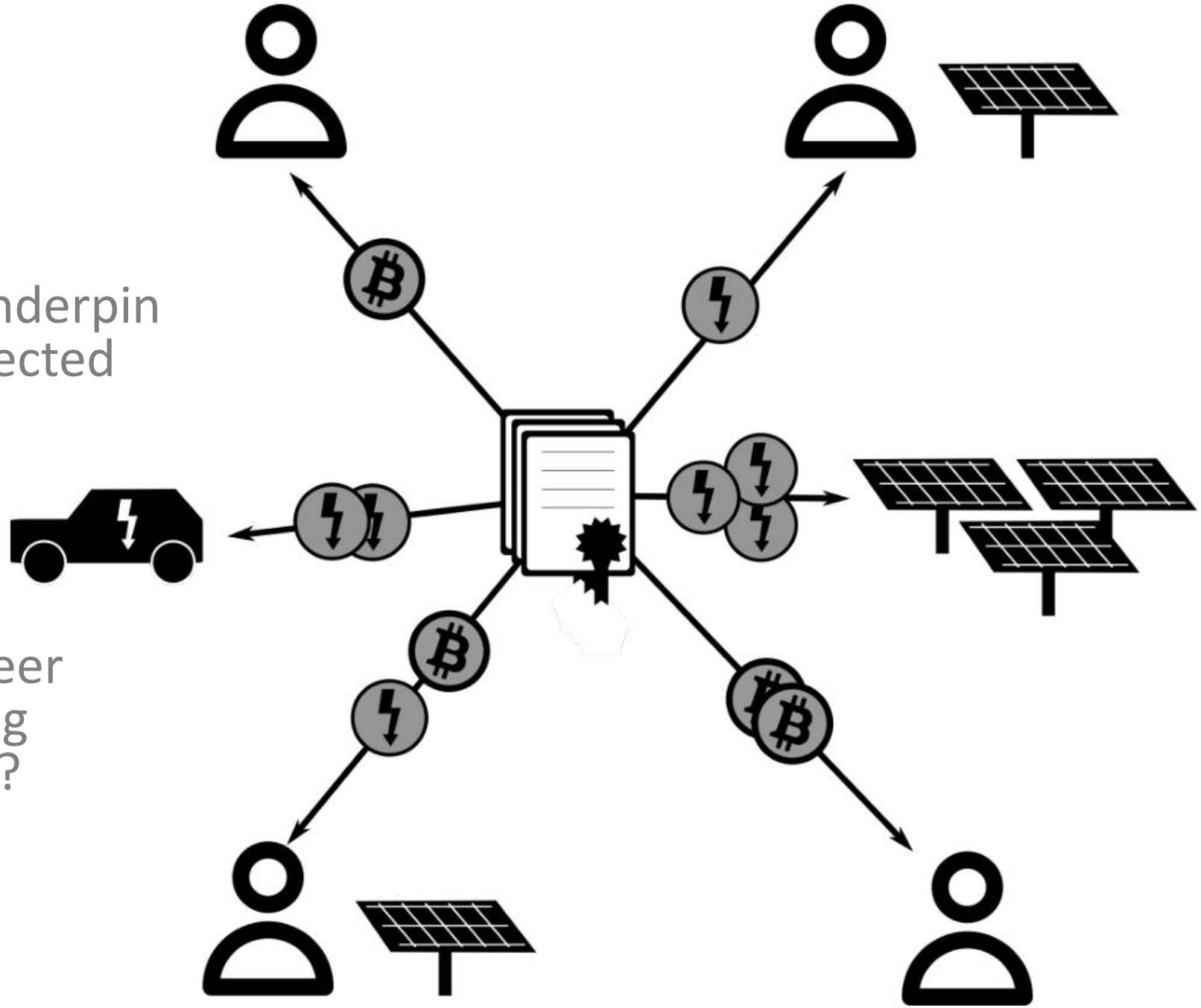
**Optimism**:

Smart contracts will underpin an **ecosystem** of connected financial products

**Skepticism**:

Why wasn't peer-to-peer trading embraced using **centralised databases**?



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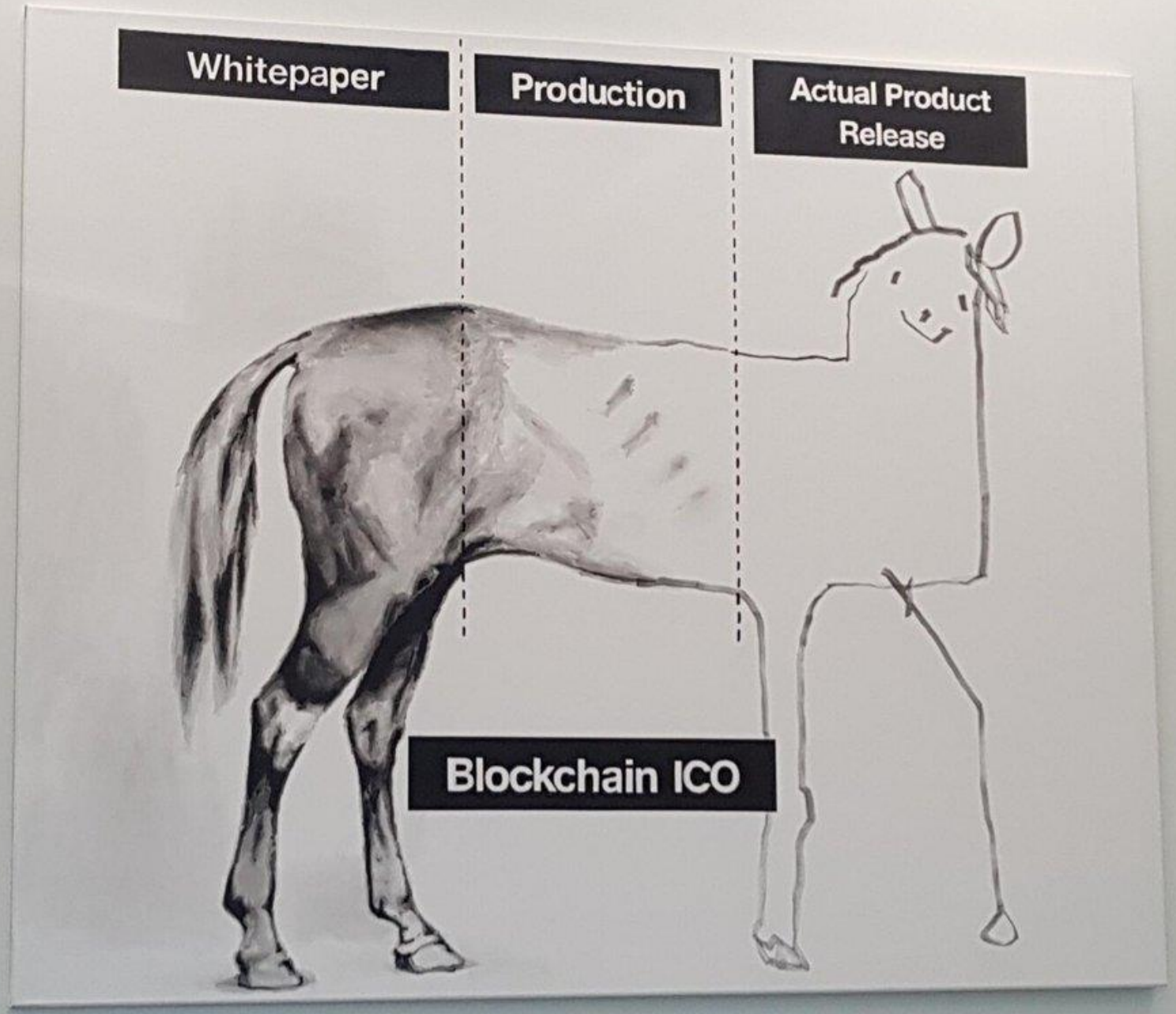

Whitepaper
Production
Actual Product Release
Blockchain ICO

Can smart contracts function as **hedging instruments** for electricity?

Accepted for IEEE EnergyCon 2020

# Towards a Blockchain Contract-for-Difference Financial Instrument for Hedging Renewable Electricity Transactions

Olakunle Alao, *Student Member, IEEE* and Paul Cuffe, *Member, IEEE*

***Abstract*—Contract-for-Difference financial instruments are available to renewable electricity generators in day-ahead electricity markets to allow them to hedge against price and volume risk, together known as *revenue risk*. Traditional CfDs while designed to hedge revenue risk, introduce other new risks such as counterparty credit, margining and third-party risks. We therefore propose a novel financial instrument – an Ethereum blockchain-based dual escrow smart contract, to serve as the mediator in a CfD agreement between a renewable electricity generator and supplier. This financial instrument addresses hedging related risks that result from traditional CfD agreements in day-ahead electricity markets. In this paper, we design the logic of the financial instrument, translate this logic to smart contract codes and demonstrate its expected performance. Overall, the proposed financial instrument has the benefits of reducing hedging related risks inherent in traditional CfDs. Likewise, it enables secure, efficient, cost-effective, consistent, reliable, transparent and frictionless transactions between contracting parties in a CfD agreement.**

***Key words*—Blockchain, Smart contracts, Renewable electricity, and Electricity derivatives**

## I. Introduction

electricity generator's revenue risk is therefore paramount, as it enhances the bankability of renewable electricity projects; hence, unlocking more debt capacity at low interest rates. The revenue of a typical renewable electricity generator in a day-ahead electricity market is mathematically shown in Equation (1):

$$\sum_{t=1}^{t=n}\left(\left(C_t^{pm}\times P_t^{pm}\right)+\left(C_t^{fm}\times P_t^{fm}\right)\right) \tag{1}$$

In Equation (1), $C$ is the contracted capacity in MWh and $P$ is the price per MWh. Superscript *pm* represents the physical market and *fm* represents the financial market. A renewable electricity generator will primarily participate in the physical market, to generate revenue to cover its marginal cost of electricity production. The physical market is however highly volatile with respect to price and volume. A rational renewable electricity generator will therefore secure its position in the financial market, by hedging itself against price fluctuations on a trading period [4]. A two-way CfD is an electricity derivative financial instrument available in day-ahead electricity markets, that guarantees stable revenues for renewable electricity

# Why hedge?

Electricity prices are **highly volatile**.

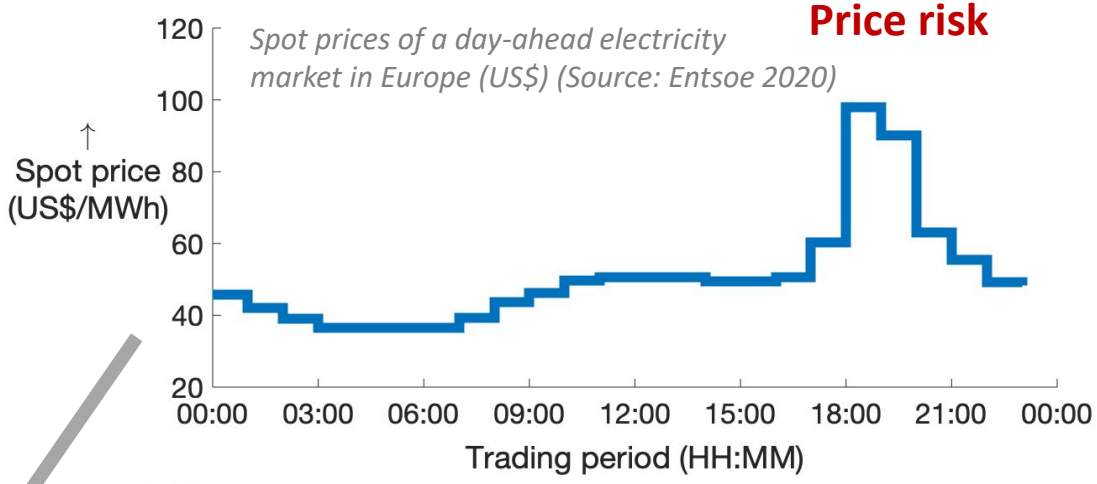
Renewable electricity generators are exposed to both **price and volume** risks.

**Revenue risk** affects the **bankability** of renewable electricity projects

**Expected revenues?**

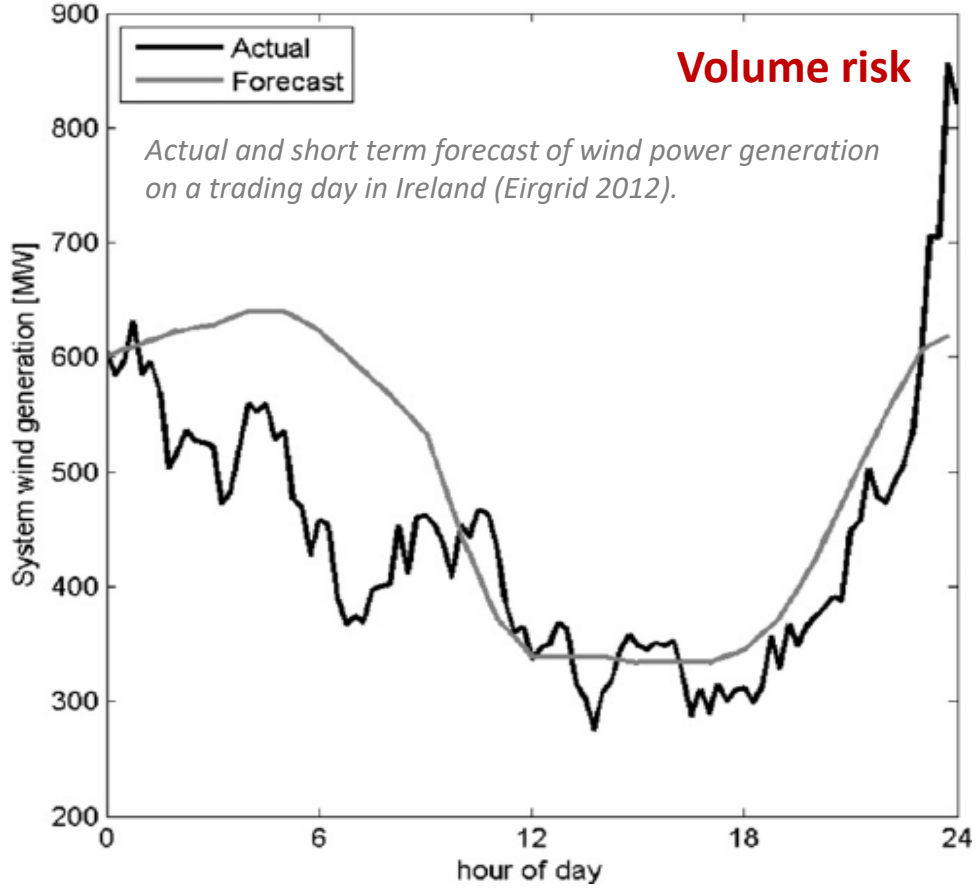
**Price risk**

*Spot prices of a day-ahead electricity market in Europe (US$) (Source: Entsoe 2020)*




**Volume risk**

*Actual and short term forecast of wind power generation on a trading day in Ireland (Eirgrid 2012).*



# Rationale

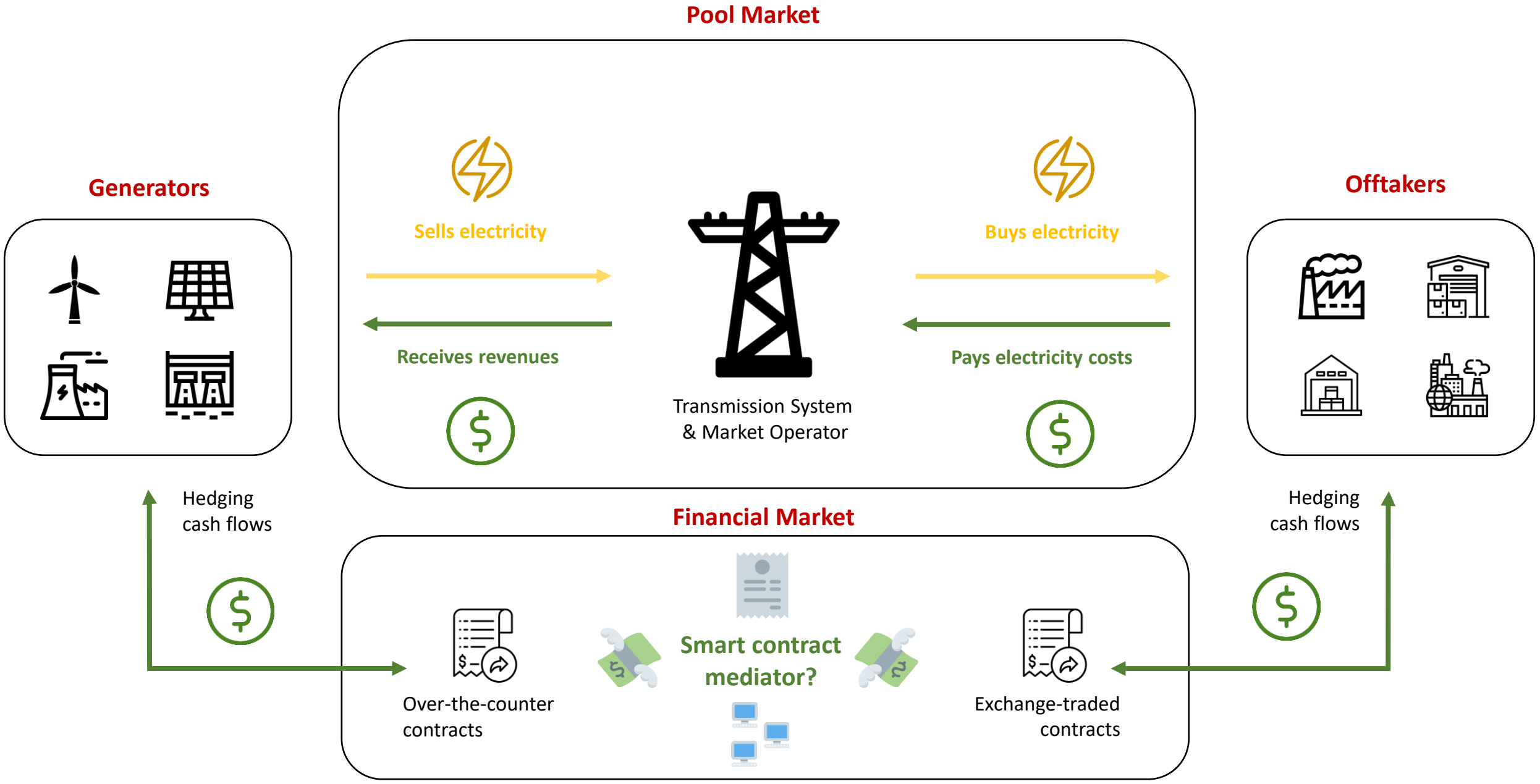
 Mature and organized **setup**

 Pure **fungible** commodity

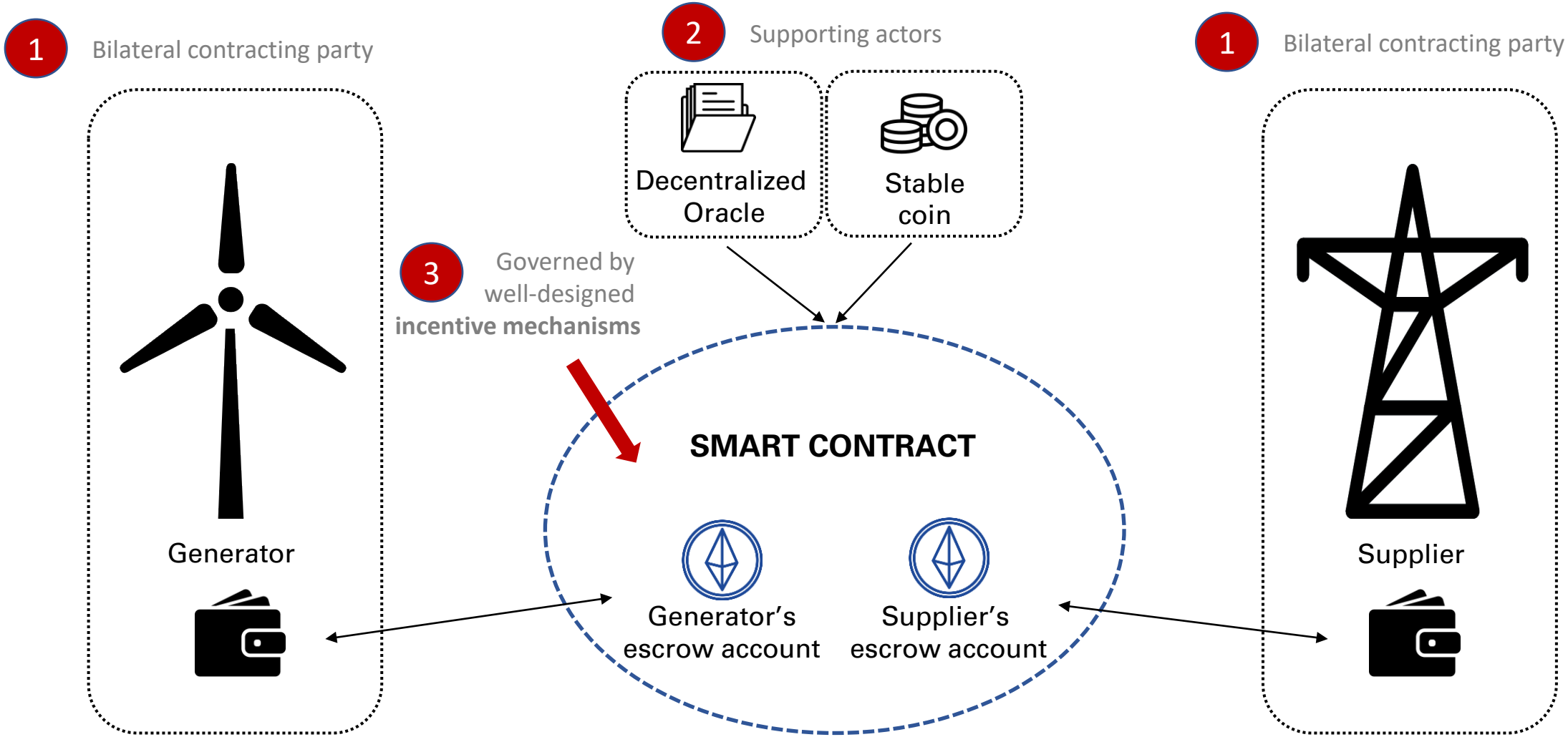
 Open and **transparently-structured** market

 Clears and settles at a **known frequency**

 Coordinated by a **single entity**.


Pool Market
Generators
Offtakers
Sells electricity
Buys electricity
Receives revenues
Pays electricity costs
Transmission System
& Market Operator
Hedging
cash flows
Hedging
cash flows
Financial Market
Smart contract
mediator?
Over-the-counter
contracts
Exchange-traded
contracts

# Design of a blockchain CfD

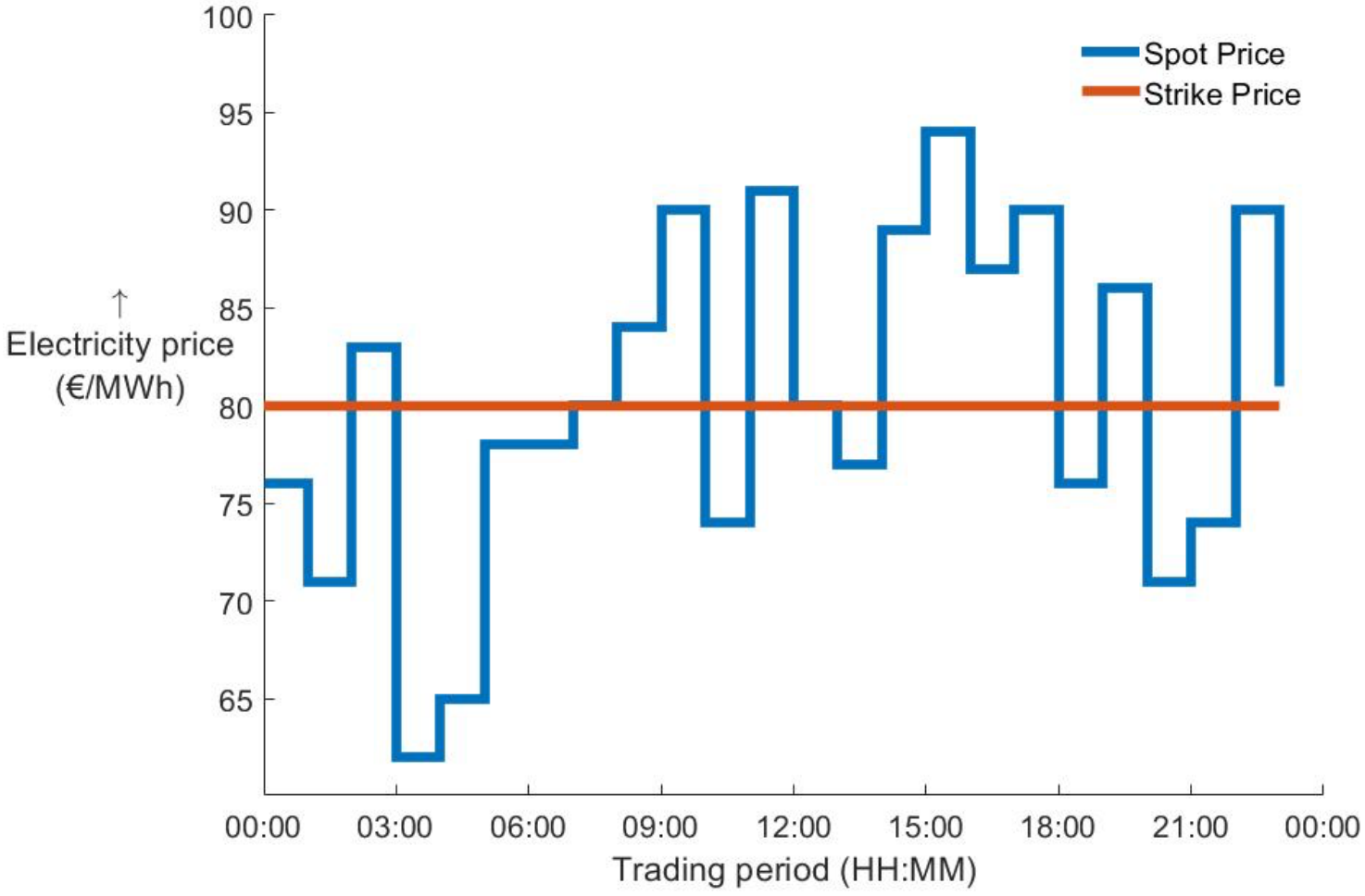


# Functioning of a blockchain CfD

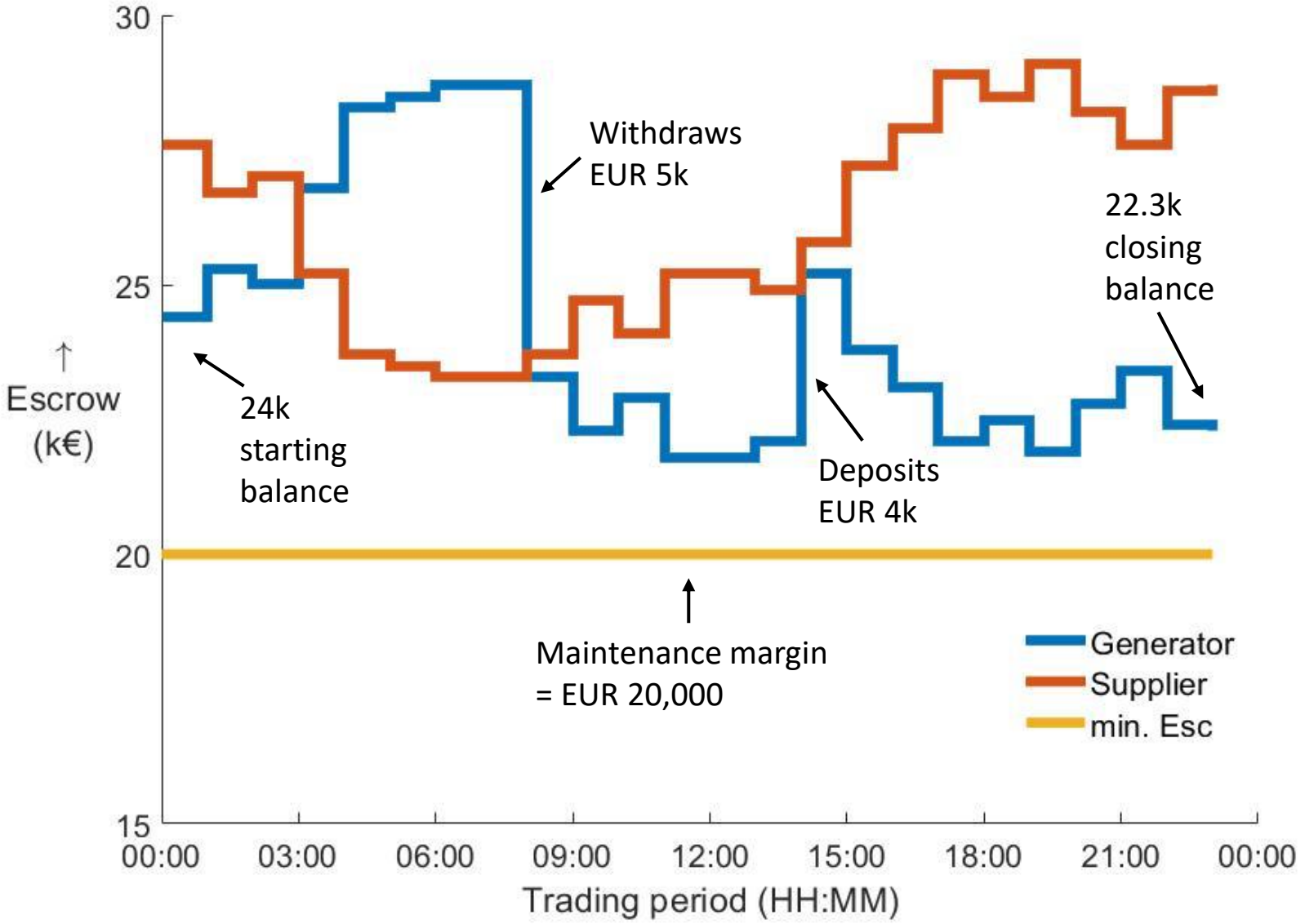
Consider a 110MW generator

On a trading day, it offers 100 MWh of energy into the physical market at EUR 80/MWh.

It also holds a **100 MWh blockchain CfD** contract with an offtaker at a strike price of **EUR 80/MWh**.



# Functioning of a blockchain CfD



Can smart contracts underpin **ownership tokens** for renewable projects?

Accepted for IEEE EnergyCon 2020

# Towards a Blockchain Special Purpose Vehicle for Financing Independent Renewable Electricity Projects in Sub-Saharan Africa

Olakunle Alao, *Member, IEEE* and Paul Cuffe, *Member, IEEE*

***Abstract*—Sub-Saharan Africa requires affordable, reliable, and sustainable electricity to boost its economic, social, and human development. The main challenge posed to the region's electricity sector is the large investment gap needed to finance new power projects. The employment of new and innovative financing options is required to bridge this investment gap. Independent power projects have become one of the fastest-growing sources of new finance in the region. However, their development is constrained by the limited availability of debt finance for project implementation. The limited capital and bureaucratic burden of traditional financial institutions coupled with the high risks in the region ensures that the debt finance required by independent power projects is raised only after an arduous voyage and at high interest rates. We address these challenges by proposing a novel decentralized finance instrument, a blockchain special purpose vehicle that streamlines the processes in the financial layer of a traditional special purpose vehicle – finance mobilization, revenue collection, and revenue disbursal. Specifically, the proposed decentralized finance instrument facilitates the mobilization of finance for the special purpose vehicle from a location-independent crowd, revenue collection from the electricity offtaker in a risk-mitigated manner, and disbursal of eventual project revenues to investors.**

***Key words*—Decentralized Finance, Blockchain, Smart Con-**

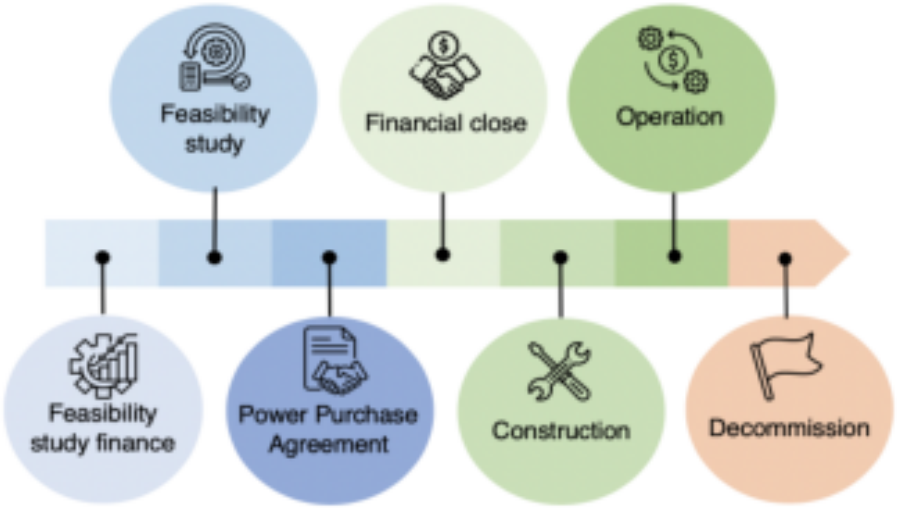



Fig. 1. Key phases of an independent power project in a typical jurisdiction in Sub-Saharan Africa

the south but overall, the pace of electrification is currently insufficient in the region [1]–[6].

Although the region's electricity sector has seen a surge in investment in the last decade, this has been inadequate

# Why alternate finance in Sub-Saharan Africa?

Low regional **capacity** and access

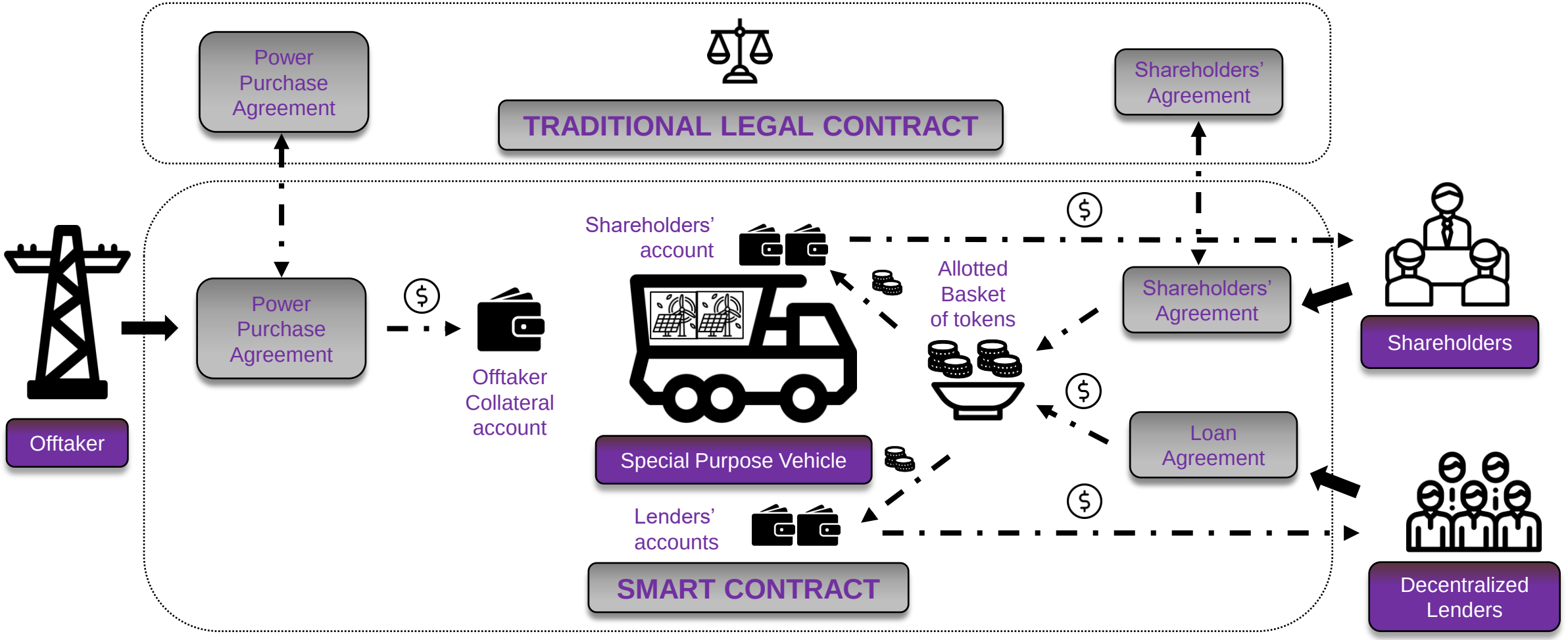
**Slow economic growth** & industrialization

Insufficient **new capacity**

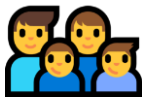
Large **investment gap**

Inadequate **government sources**

# Blockchain lending/ownership vehicle



# Conclusion



Finance mobilization is **streamlined** from a location-independent crowd

Revenue disbursal is **frictionless** and counterparty **credit** risk is reduced

Risk is distributed amongst **multiple** investors

**New risks** are introduced into the contract such as security, reliance & account risks

**Lots more research to do** on the incentives to invest and hardware oracle

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# Questions?

paul.cuffe@ucd.ie