Examining Blockchain's Role in Reshaping Electricity Trading: Opportunities and Challenges

EED498 – Major Project End-Term Presentation

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AGENDA

Overview of Blockchain

Learnings from Europe

India Market Overview

Key Opportunities

Challenges

Distributed Ledger Technology is a database technology that reduces the need for central intermediaries

A DLT is a **LEDGER** formed by a **CONSENSUS** of **SYNCHRONIZED** and **ENCRYPTED** digital data

LEDGER

*A ledger is a **summary of data records (i.e. a database)***

ID	Customers.Company	LastName	FirstName	JobTitle	City	State/Province
2	Customer A	Badecs	Anna	Owner	Seattle	WA
3	Customer B	Gratacos Solsona	Antonio	Owner	Boston	MA
4	Customer C	Axen	Thomas	Purchasing Representative	Los Angeles	CA
5	Customer D	Lee	Christina	Purchasing Manager	New York	NY
6	Customer E	O'Donnell	Martin	Owner	Minneapolis	MN
7	Customer F	Pérez-Olaeta	Francisco	Purchasing Manager	Milwaukee	WI
8	Customer G	Xie	Ming-Yang	Owner	Boise	ID
9	Customer H	Andersen	Elizabeth	Purchasing Representative	Portland	OR
10	Customer I	Mortensen	Sven	Purchasing Manager	Salt Lake City	UT
11	Customer J	Wacker	Roland	Purchasing Manager	Chicago	IL
12	Customer K	Krschne	Peter	Purchasing Manager	Miami	FL
13	Customer L	Edwards	John	Purchasing Manager	Las Vegas	NV
14	Customer M	Ludick	Andre	Purchasing Representative	Memphis	TN
15	Customer N	Grilo	Carlos	Purchasing Representative	Denver	CO
16	Customer O	Kupkova	Helena	Purchasing Manager	Honolulu	HI
17	Customer P	Goldschmidt	Daniel	Purchasing Representative	San Francisco	CA
18	Customer Q	Bagel	Jean Philippe	Owner	Seattle	WA

EXAMPLES

- **A phonebook** is a summary of personal phone numbers and addresses
- **A balance sheet** is a summary of financial records of a business

CONSENSUS

***Algorithms** and **consensus among multiple computers** provide verification and authentication*

EXAMPLES

- **A public land register** confirms the authenticity of the ownership of a house by verifying with previously recorded transactions

SYNCHRONIZED

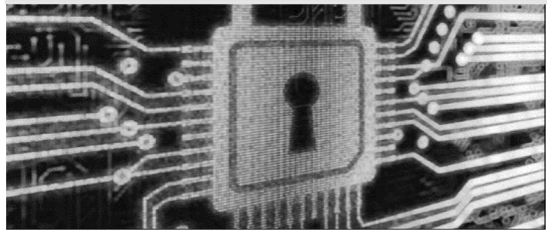
*The data records are **synchronized** to all parties **when updates occur** in the ledger*

EXAMPLES

- When **data is saved/stored in a server,** it will synchronize once updates are made
- **Google drive** will synchronize when new records are submitted

ENCRYPTED

*The data records are **encrypted by a digital key,** making every record **unique***



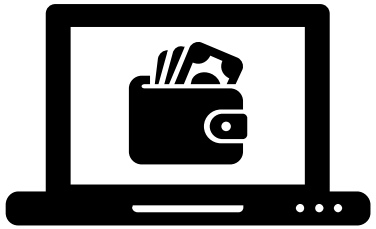
EXAMPLES

- **In credit card** payments, an algorithm masks real card number and makes the data unreadable to anyone without a proper key

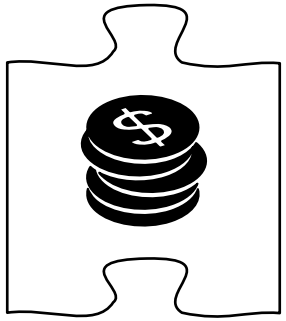
Blockchain is a **type of distributed ledger,** comprised of unchangeable, digitally recorded data in packages called blocks. It is becoming the standard and now the term is used interchangeably with DLT

Illustration of how the technology works : Payments

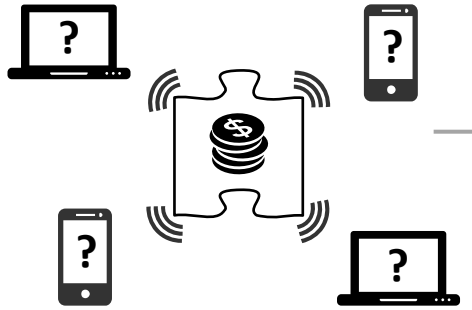
1 Alice wants to send money to Bob



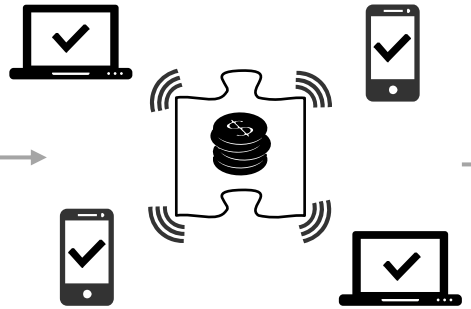
2 The first block is created online and represent the transaction



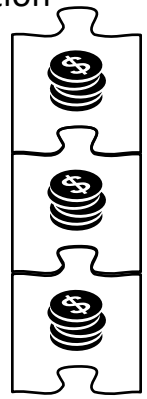
3 The block is broadcast to every party in the network



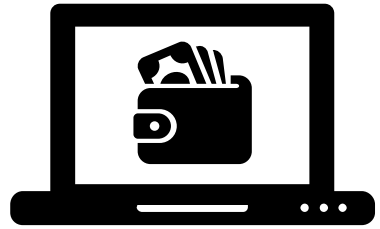
4 Those in the network approve the transaction and validate it



5 The block is then added to the chain which provides a permanent, non-repudiable and transparent record of the transaction

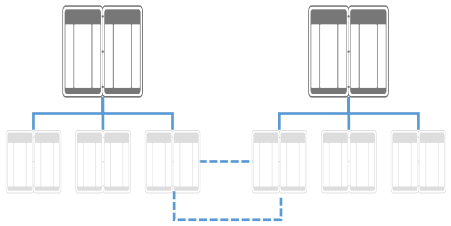


6 Bob receives the money from Alice



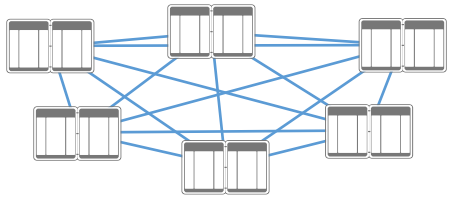
Blockchain is a type of distributed ledger; terms used synonymously

CENTRALIZED LEDGERS



- Traditional systems rely on **central authority and hierarchy** to generate trust and transfer value
- When money is passed between participants a central counterparty **records the transfer to prevent cheating**
- The participants then undertake **costly, time consuming and duplicative reconciliation** with their own systems

DISTRIBUTED LEDGERS



- A distributed ledger is a **consensus** of **replicated, shared, and synchronized digital data** geographically spread across multiple sites, where changes are **validated by the participants collectively** and **updated across the network** in near real time
- In DLT, **trust is generated from the consensus process itself** rather than centralized parties
- DLT enable users to **move value/information across one ledger** instead of across many individual ledgers
- **Blockchain** is a **type of distributed ledger**, comprised of unchangeable, digitally recorded data in packages called blocks

Distributed Ledger Technology and Blockchain definitions are not standardized.
In this deck Blockchain and Distributed Ledger Technology will be used synonymously

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Overview of Blockchain

Learnings from Europe

India Market Overview

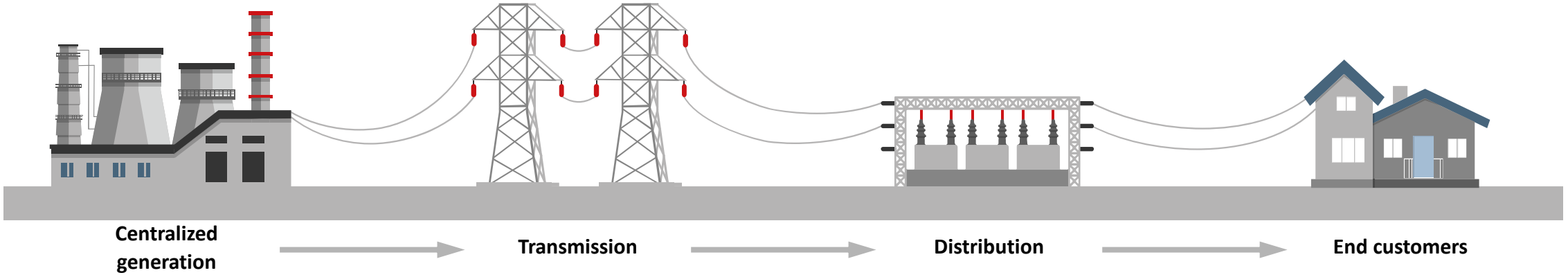
Key Opportunities

Challenges

The electricity market, is becoming increasingly complex, predominantly driven by the introduction of renewable energy sources and technological advances

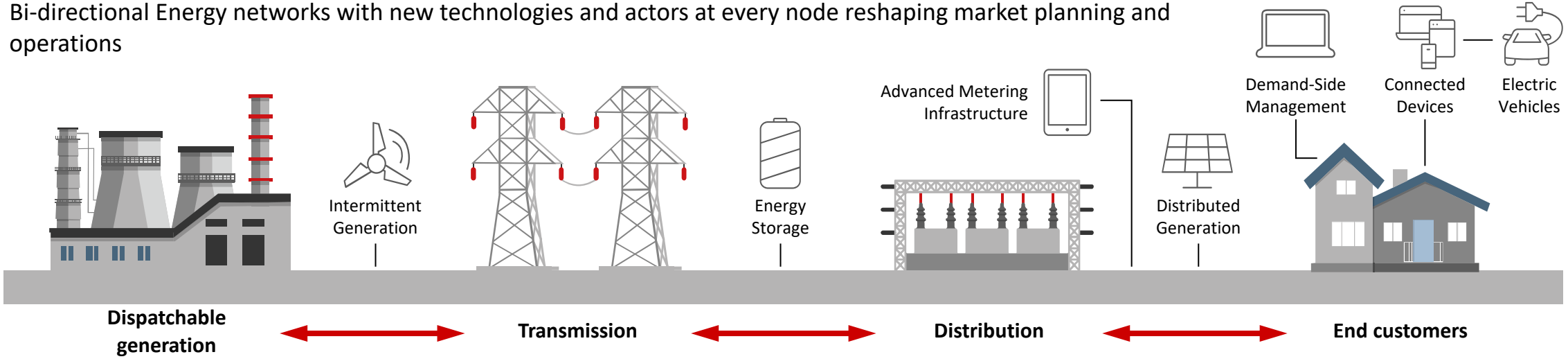
Past

A top down flow from supply to demand…



Future

Bi-directional Energy networks with new technologies and actors at every node reshaping market planning and operations



Power trading

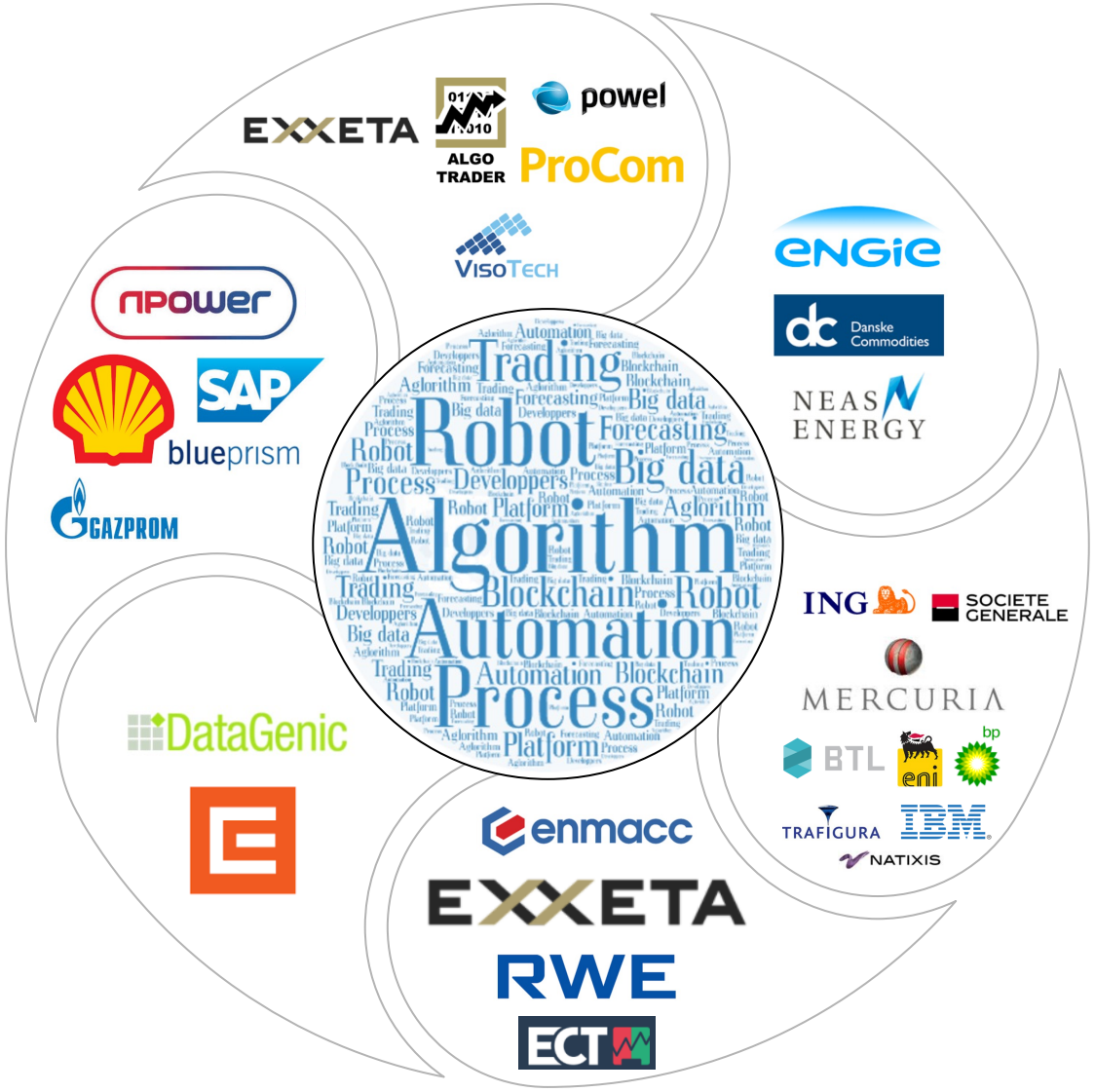
There are 5 types of players trading energy commodities

	Examples	Description
Utilities	RWE The energy to lead, e·on, EDF, VATTENFALL	• Europe's top utilities are biggest traders • Strong presence in **home market(s)** and trading linked to asset optimization
Gas and oil companies	TOTAL, Shell, bp	• **Global presence** focused on oil and gas, with possibility to leverage upstream asset positions
Major banks	Morgan Stanley, Goldman Sachs, Barclays Capital	• **Global presence**, with strong position across all main commodities markets
Hedge funds	SASCO, SKYLAR Capital Management, AC Investment Management LLC	• **Tend to purchase books previously owned by banks**, speculate on prices volatility • **Global conglomerates** with long experience in physical markets/risk management
Trading houses	GLENCORE INTERNATIONAL AG, Vitol	• **Sophisticated global players**, with increasing presence in upstream assets

Energy commodity trading markets are experiencing fundamental shifts

- Some **utilities reduced trading activities in recent years** to conserve capital, reduce regulatory pressure and exit market where trades are no longer as attractive
- However, **Markets are changing, importance of trading remains**, and utilities are the major players
- **More regulation, placing greater burden on all participants**, and influencing divestments by banks
- Major evolutions of the various commodity markets
- More transparency and competition
- Less liquidity and diversification of the funding base

Focus on Digitalization in trading across players



Automated trading:

More than 80 robots are trading on Epex spot, facilitated by new Epex API

Many new players are proposing solutions for automated trading on short-term market

In-house algorithmic trading development:

Different utilities are building their own development team to set up proprietary algorithm

Proof of concept of trading via blockchain:

First blockchain trades occurred in peer to peer trading

Proof of concept are also appearing in other market

OTC and market access platform:

New OTC platform are put in place to digitalize OTC trading

Data analytics:

Utilities are leveraging big data to create insight for trading (expl: CEZ and Datagenics)

Robot Process Automation:

Players are automating their back office and confirmation activities (customer billing, meter, account, consumption management) using Robotics Process Automation

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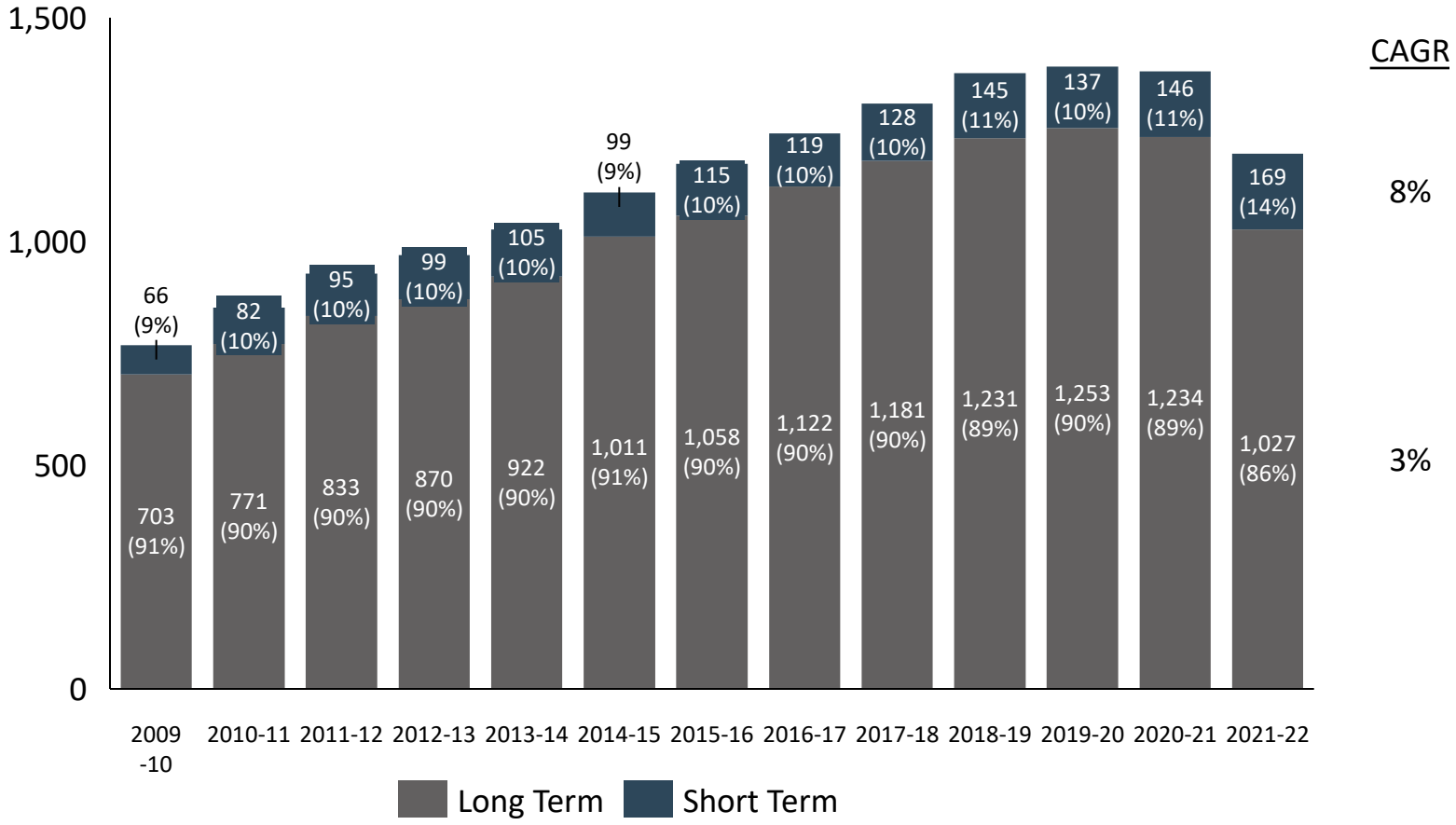
Short term trading growing faster (8% CAGR) vs long term trading (3% CAGR)

Volume of power transaction - overall (BUs)



CAGR

8%

3%

Source: CERC

Commentary

- **GoI pushing ST -** share to increase gradually to 25% in next 3 years as this **eases out payment issues**
- **Gradual drying up of long-term PPAs** inked by thermal generators with the discoms
- **High penetration of renewables** created need for flexibility
- Power exchanges have come in handy to **meet the sudden surges in peak demand** owing to their flexibility and ready availability
- **Prices in power exchanges remained below INR 3/unit^**

Majority of recent/ upcoming regulations leading to tailwinds for power trading

Regulation	Details	Commentary
Market Base Economic Dispatch (MBED)	• **Enable discoms to fulfil power demand** through a **central pool vs existing PPA regime, Phase 1 expected to begin soon** with CGSs participating in it initially → considerably **increase trading volume** in Power Exchanges	• Discoms will **need support in bidding process** and hence opportunities for automated bid platforms for discoms; post MBED it would be difficult to bid manually
Deviation Settlement Mechanism (DSM) Regulations	• **Tightening penalties on DSMs** (trading of last-minute power imbalances b/w plants and discoms) as **it threatens grid stability → complete portion of DSM to shift to exchange**	• Traders can offer **state of art forecasting tools,** which can help gencos, particularly RE, and discoms to save on DSM penalties
Over the Counter (OTC) Platforms	• **OTC will primarily be a knowledge sharing/marketplace platforms**; however, they can facilitate buyers and sellers to directly transact electricity	• This would be a direct competitor to trading market; traders are **not allowed to provide OTC platform**
REC Trading Regulations	• **Bilateral trading of RECs has been allowed** which will further pave way for VPPAs in India.	• Traders can now carry out **bilateral trading of RECs**
Trading regulations	• **Trader cannot charge more than 2 paisa** even in long term in the absence of PSM	• Negative for traders as scope for coming out ST to LT (by contracting for 13 months) is made irrelevant
Renewable open access	• Size for renewables open access to be reduced to **100 KW** *(vs 1 MW currently)*	• More opportunities for traders for **fulfilling RE demand from Corporate customers**

Note: CGS = Central Generating Stations (generating stations owned or controlled by the Central Government)

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Opportunity space highlighting key levers and enablers

Opportunities

Core Power Trading Solutions

Technology solutions
- *Energy requirement forecasting*
- *Automatic dispatching*
- *Customer billing, etc.*

Products and Services
- *Peer to peer trading pilots*
- *Regulatory publications*
- *Virtual PPAs*

New financial solutions
- *Clearing house subsidiaries*
- *Energy indexes*
- *Derivative products*

Expansion into adjacent geographies

Adjacent Services

Electricity Exchanges

Carbon Trading

Coal Exchanges
(making market more 'efficient', lower 'leakage' → helping reduce carbon emissions eventually)

Enablers

Efficient capital allocation: Working capital management

Robust GTM/ sales: Competent and motivated salespeople and capabilities with understanding of sector and regulatory environment

Regulatory resilience: Ability to tread in changing regulatory and policy scenario

Risk management: Clear and well-defined (risk) mandates and effective and efficient governance process

Various opportunities emanating on digital front

Machine learning can turn data into insights for trading decision support

Wind and solar production forecast:

Solar forecast based on customer behavior and development of installed capacity in a specific region

Short-term forecast: self-learning weather model and renewable forecasting technology

Price pattern identification:

Forward price based on cross-commodity flow ML model (gas oil, coal) and development of RES

Short-term prices: day-ahead, intraday and balancing price forecast based on historical data, fatal production and short-term load/renewables production

Load forecasting:

Long-term load forecasting computing churn rate and campaign impact based on client behavior

Short-term load forecasting: ML algorithm learning customers habits

Market data and advanced analytics to be leveraged through optimization

Flexibility Optimization:

Algorithms **optimize complex portfolio of decentralized flexibilities** (storage, EV, heating systems)

Algorithms will make **predictions to reschedule the power consumption/ generation** of many assets to minimize the cost

Predictive insights:

Algorithm-based predictions (e.g., back-testing trading strategies, algorithmic trading

Analytics to enhance decision making (e.g., real-time flows monitoring, dynamic pricing)

Decentralized flexibility:

Foresee the need of **connected decentralized flexibility** and optimize the dispatch to limit the impact on the performance and maximize revenue (e.g., Tesla optimize 500kWh storage to provide balancing services to grid managing charging planning every second)

Trading Automation tools

Trading Automation:

Predefined rules or programmable trading strategies, Integrated schedule management, Nomination to TSO under the different required formats, Rule-based management of unplanned events, VPP optimization

Decision automation:

Algorithms to **enable straight-through processing** (e.g., trading and liquidity risk analysis, trade monitoring)

Process automation:

Software bots to eliminate manual work (e.g., Automated data entry, data quality check, deal confirmation, claims management, account closing process, monthly financial reporting etc.)

Real-Life examples of DLT in Electricity Markets

	OPPORTUNITY/ POTENTIAL BENEFIT	PROJECT EXAMPLES
Wholesale energy trading	– Reduce transaction costs in wholesale energy trading	– Enerchain (Ponton) – Interbit (BTL)
Retail electricity markets	– Reduce variable costs of retail payment processing and accounting – Greater transparency into billing – Fluid energy contract entry/exit – Greater customer choice of energy supply	– Drift – Grid+
Peer-to-peer marketplaces	– Relieve stress on transmission networks – Improve DER economics – Greater customer choice of energy supply	– Brooklyn Microgrid Project (LO3 Energy) – Jouliette (Alliander and Spectral) – Verbund and Salzburg AG
Flexibility services	– Improve TSO ability to balance supply and demand	– TenneT – Electron
Electric vehicle charging and coordination	– Improve DSO ability to coordinate electric vehicle load and discharge	– Share&Charge (MotionWerk) – eMotorWerks
Network management and security	– Improve DSO and TSO network management and security	– Keyless Signature Infrastructure (Guardtime)
Environmental attribute markets	– Improve efficiency and transparency of environmental attribute markets	– SolarCoin – Ideo CoLab

Source: Lit. search

Smart Contract Algorithm in Pseudocode

Entire Code Implementation in Appendix

```
// Energy_Trade //

// Initialization
Read OA, EBoO, RVpU, SmartMeterReadings
Read BA, EBoB, QoER, TFA, BuyerCreditScore

// Calculate Requested Value (RV)
RV = QoER * RVpU

if SmartMeterReadings < MinimumThreshold {
      Build_Contract = "False"
      Msg = "Energy production below threshold, contract cannot be fulfilled"
} else {

      // Trade Execution Conditions
      if QoER <= EBoO {
            // Include credit-based transaction condition
            if (RV <= TFA && BuyerCreditScore >= MinimumCreditScore) {
                  Build_Contract = "True"
                  EBoO = EBoO − QoER
                  EBoB = EBoB + QoER

                  // Include dynamic energy balancing
                  SmartMeterReadings = SmartMeterReadings - QoER
            } else {
                  Build_Contract = "False"
                  Msg = "Transaction failed due to insufficient funds or low
credit score"
            }
      } else {
            Build_Contract = "False"
            Msg = "The owner doesn't have the required amount of energy"
      }
}
```

Pseudocode Variables

OA: Owner Address
BA: Buyer Address
EBoO: Energy Balance of Owner
EBoB: Energy Balance of Buyer
RVpU: Requested Value per Unit
RV: Requested Value
QoER: Quantity of Energy Requested
TFA: Total Funds Available
SmartMeterReadings: Readings from smart meters
BuyerCreditScore: Credit score of the buyer
MinimumThreshold: Minimum energy production threshold
MinimumCreditScore: Minimum credit score required for the transaction

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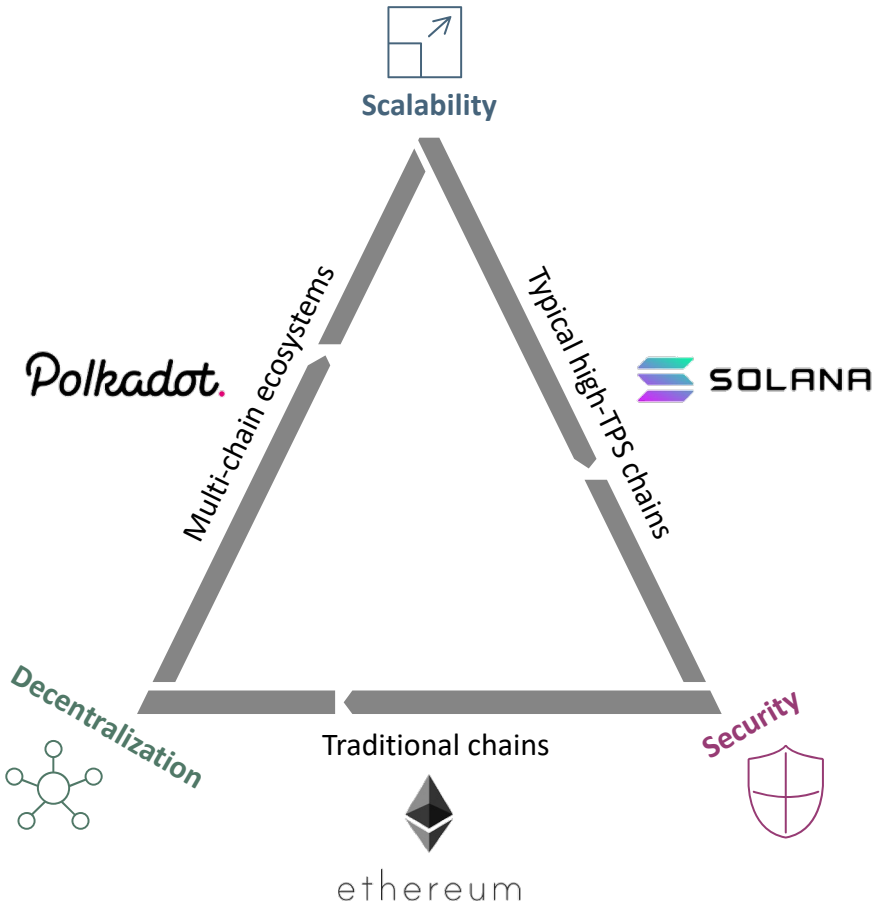
Ethereum has recently run into issues around scaling as it currently only solves 2 of three parts of the “blockchain trilemma”

“Blockchain trilemma” is a concept laying out the core tradeoffs made by blockchains



Source: Lit. search, Vitalik Buterin

Core tradeoffs are a fundamental issue in designing a chain or multi-chain environment, which have varying points of view

Concept	Description	ETH current position	Alternative chain point of view
Decentralization	• Network does not rely on a central point of control • Varies from full decentralization (anyone can be a node) to centralized (only one node)	**Priority 1** Maximize, anyone can run a node	**Decrease somewhat** with validator computing power limits
Security	• Network can operate as expected without attacks or bugs • Varies on underlying structure of code and complexity of ecosystem	**Priority 2** Optimize, but some issues in the past	**Continue to secure** as much as possible
Scalability	• Network can quickly process all requested transactions • Varies on theoretical capacity and capacity from scaling solutions	**Priority 3** Last concern, **lagging alternatives** in current state	**Increase dramatically** to enable broad ecosystem

While Ethereum traditionalists believe all three legs are critical, newer approaches like Solana are challenging this notion

Technological issues exist regarding ability to transition, scale, link, and secure DLT systems remain

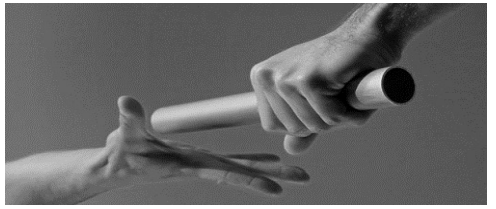
SCALABILITY AND SECURITY

- Current tech still needs work towards the requisite **capabilities** that will be required for widespread use, e.g.
  - Increase **transaction speed** for mass adoption
  - **High standards of security**/ robustness
  - **Ability to integrate with non blockchain systems** (e.g. risk management)
  - **Lower electricity consumption**

LINK TO REAL WORLD IDENTITIES

- The link between **cryptographic identities** and **real world identities** needs to be **properly managed**
- Important to strike a balance between **selective revelation of information** (e.g. credit assurance for counterparties) vs. **regulatory requirements** (e.g. anti money laundering)

TECHNICAL TRANSITION



- Transitions to new tech creates **operational risk** due to complexity of transitioning trillions of transactions
- **Inter-operability with current systems**, **compatibility with counterparties systems** and **digital readiness** are all key roadblocks to adoption

Ecosystem issues pertaining to governance and player/regulator attitudes will similarly affect DLT

REGULATION

- **Innovations in regulated industries** (e.g. Financial Services) **require explicit regulatory approval** ahead of time
- Many issues will need to be **agreed across regulators** in multiple countries and then **synthesized to create common standards**, e.g.
  - Legality of final settlements
  - Geographic location of (customer) data

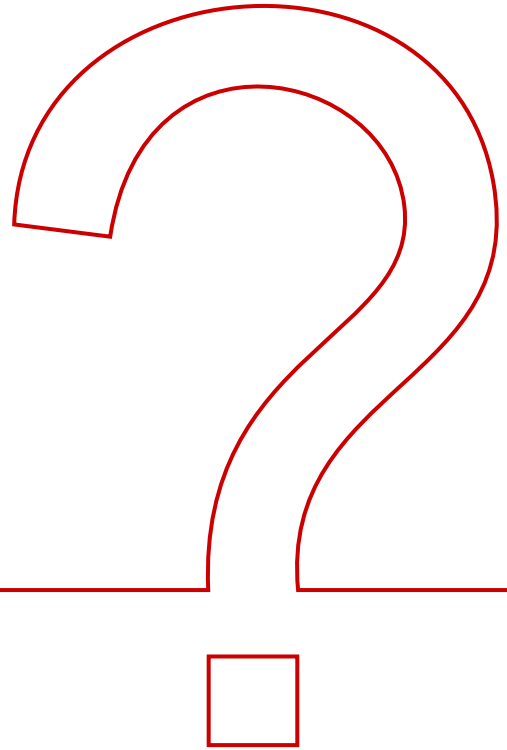
GOVERNANCE/COMMON STANDARDS

- **Industry alignment critical to adoption process** – whether or not systems are permissioned, what safeguards against error and consensus protocols are used
- These standards are **required for the interoperability** needed to service the many market players

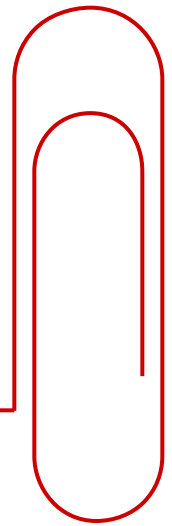
NETWORK EFFECT

- The value of DLT increases for each additional user. As the user base grows, the **resulting value is propagated throughout the network**
- For a network effect to take hold, participants must willing to accept a **common platform**
- **Skepticism** regarding committing to a single network or technology will **hinder adoption** and the resulting **scalable benefits**

Questions



Appendix



Smart Contract Code (1/3)

```
pragma solidity ^0.8.0;

contract EnergyTrade {
    address public ownerAddress;
    uint public energyBalanceOfOwner;
    uint public requestedValuePerUnit;
    uint public smartMeterReadings;
    uint constant MINIMUM_THRESHOLD = 100; // Set your minimum threshold here
    uint public totalFundsAvailable;
    uint constant MINIMUM_CREDIT_SCORE = 700; // Set your minimum credit score here
    uint public quantityOfEnergyRequested;
    bool public buildContract;
    string public errorMsg;

    modifier onlyOwner() {
        require(msg.sender == ownerAddress, "Only the owner can execute this function.");
        _;
    }

    constructor(address _ownerAddress, uint _energyBalanceOfOwner, uint _requestedValuePerUnit,
        uint _smartMeterReadings, uint _totalFundsAvailable, uint _quantityOfEnergyRequested) {
        ownerAddress = _ownerAddress;
        energyBalanceOfOwner = _energyBalanceOfOwner;
        requestedValuePerUnit = _requestedValuePerUnit;
        smartMeterReadings = _smartMeterReadings;
        totalFundsAvailable = _totalFundsAvailable;
        quantityOfEnergyRequested = _quantityOfEnergyRequested;
        buildContract = false;
    }
```

Smart Contract Code (2/3)

```
function checkEnergyBalance() internal {
        if (smartMeterReadings < MINIMUM_THRESHOLD) {
            errorMsg = "Insufficient energy production, contract cannot be fulfilled.";
            buildContract = false;
        } else if (quantityOfEnergyRequested > energyBalanceOfOwner) {
            errorMsg = "Insufficient energy balance of the owner.";
            buildContract = false;
        } else {
            errorMsg = "";
            buildContract = true;
        }
    }

    function checkTransactionConditions() internal {
        if (requestedValuePerUnit * quantityOfEnergyRequested > totalFundsAvailable) {
            errorMsg = "Insufficient funds available for transaction.";
            buildContract = false;
        } else if (msg.sender ≠ ownerAddress) {
            errorMsg = "Only the owner can initiate this transaction.";
            buildContract = false;
        } else {
            errorMsg = "";
            buildContract = true;
        }
    }
```

Smart Contract Code (3/3)

```
    function executeContract() external onlyOwner {
        checkEnergyBalance();
        checkTransactionConditions();
        if (buildContract) {
            energyBalanceOfOwner -= quantityOfEnergyRequested;
            smartMeterReadings -= quantityOfEnergyRequested;
        }
    }
}
```