



NARUC

Winter Committee Meetings

Staff Subcommittee on Rate Design

Introduction to Blockchain

Agenda

Topic
What's all the fuss about?
What is a blockchain?
Application for power and utilities
APPENDIX

A woman with dark hair, wearing a white and blue striped shirt, is smiling and holding up several yellow sticky notes. She is standing in front of a wall that is covered with many more yellow and pink sticky notes. The sticky notes have various handwritten notes on them, such as 'FTP', 'Update Website', 'Call IT guy', and 'Call IT guy about IT's computer'.

So what's all the fuss about?

Everyone's talking about it...



Everyone's (still) talking about blockchain...

"You should be taking this technology as seriously as you should have been taking the development of the Internet in the early 1990s."

– Blythe Masters, CEO of Digital Asset Holdings

" ... whether it is the virtual currency or the services around, virtual currencies [based on distributed ledgers] do have the promise of changing the world."

– Vikram Pandit, ex CEO Citigroup

"The revolution will not be televised. It will be cryptographically time stamped on the block chain."

– Dominic Frisby, Author of Bitcoin – the Future of Money

"The blockchain protocol threatens to disintermediate almost every process in financial services."

– World Economic Forum

"The technology behind bitcoin could transform how the economy works."

– The Economist

"In lots of areas, it looks like the blockchain will work and it is easy to see how it could revolutionise finance."

– Rhomaios Ram, Head of Product Management Deutsche Bank Global Transaction Banking

"Our analysis suggests that distributed ledger technology could reduce banks' infrastructure costs attributable to cross-border payments, securities trading, and regulatory compliance by between \$15–20 billion per annum by 2022."

– The Fintech 2.0 Paper: Rebooting Financial Services

If you take just one thing away today....

Bitcoin = blockchain

- **Blockchain is a technology that enables a secure, distributed ledger of transactions**
- **Bitcoin is just one particular use of this technology to create a new "crypto currency"**

Things are moving VERY quickly

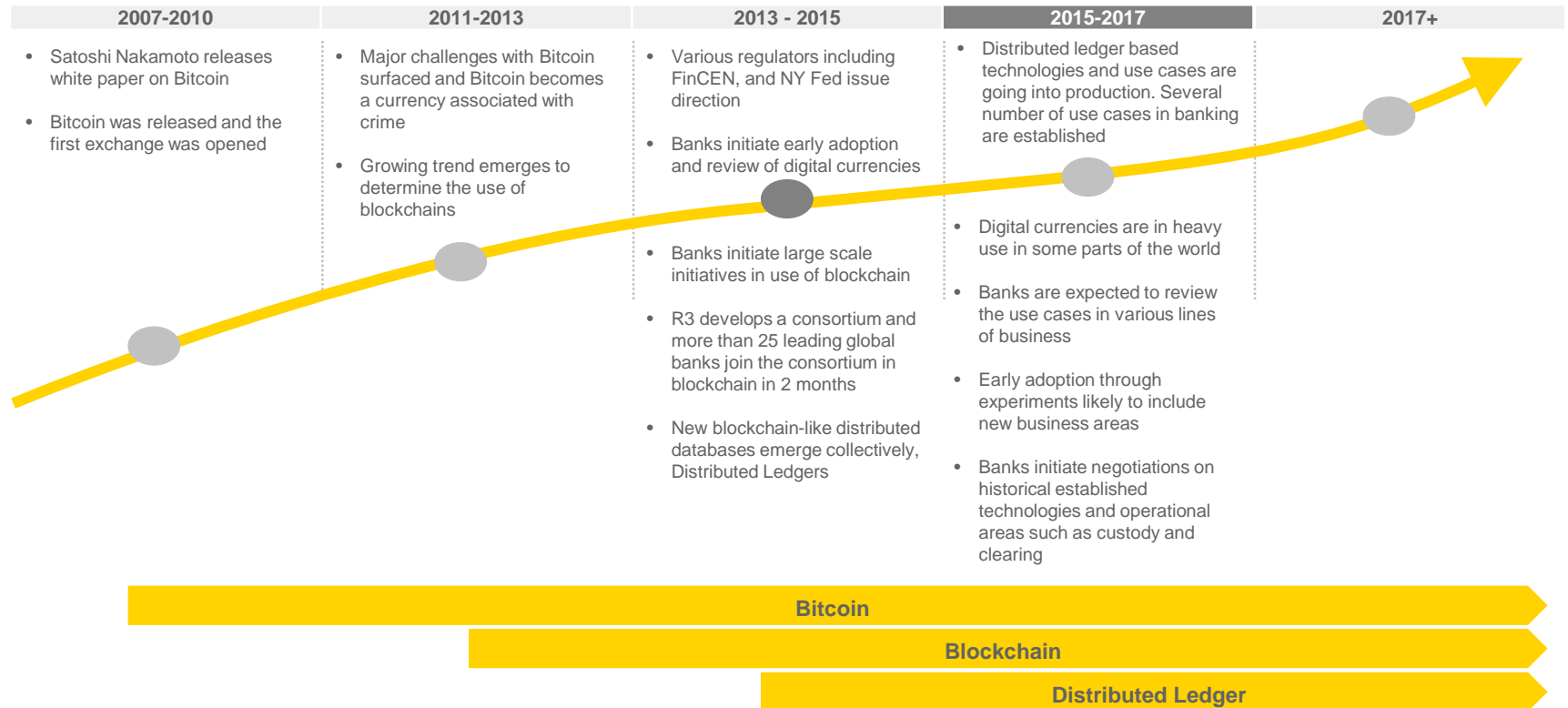
In 7 years, blockchain has moved from a conceptual paper to gaining significant real-world attention and investment.



What is a blockchain?

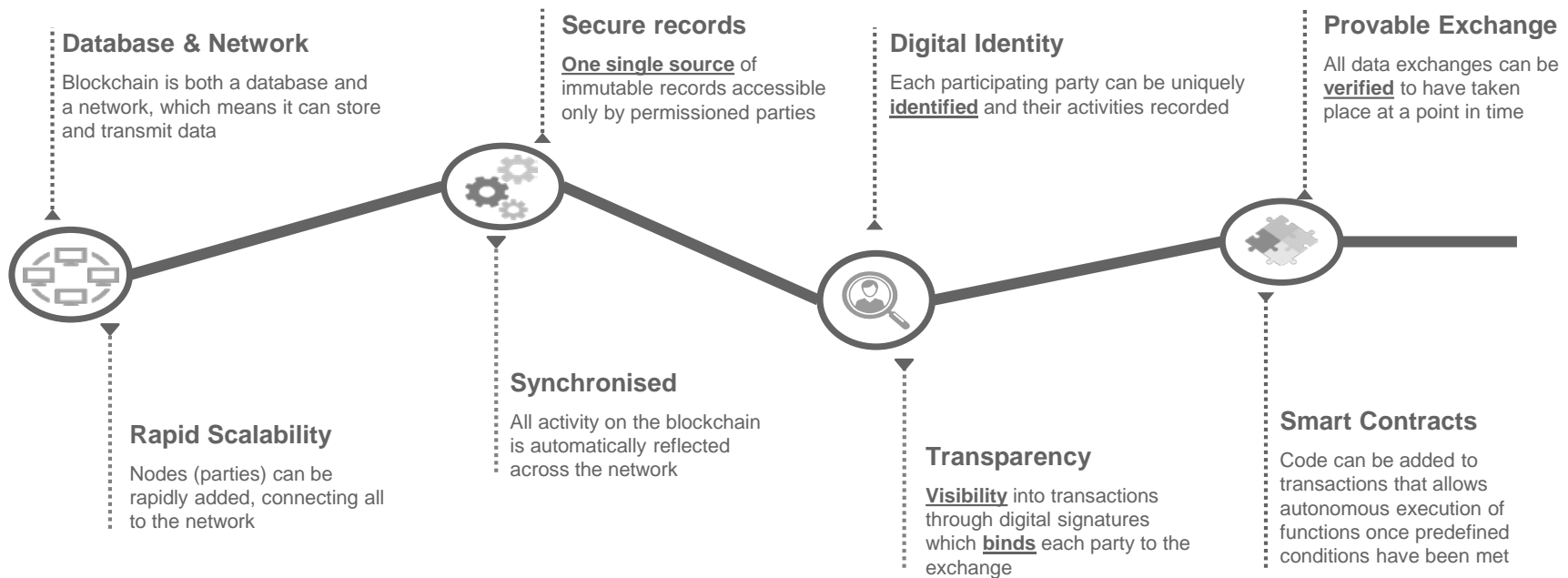


Blockchains as we know them today have had their own evolutionary process



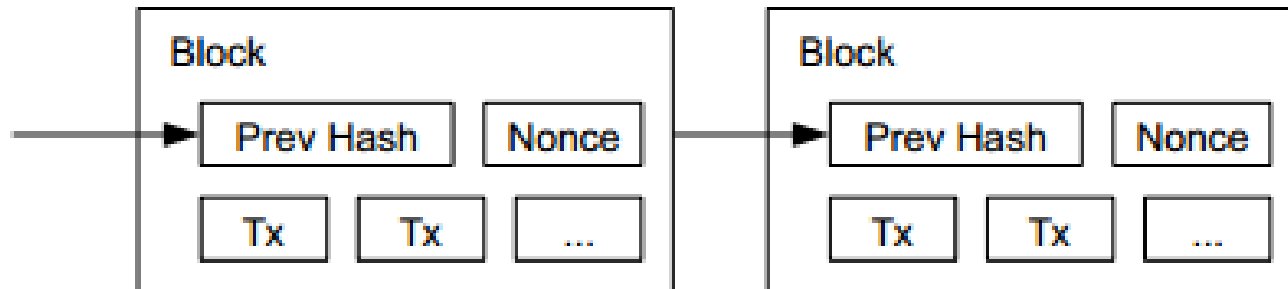
History is fun and all, but how do blockchains actually work in practice?

A blockchain is a distributed infrastructure technology held collaboratively, which enables a decentralized exchange of trusted data. It uses cryptography to allow each participant on the network to manipulate the ledger in a secure way, without the need for a central authority.



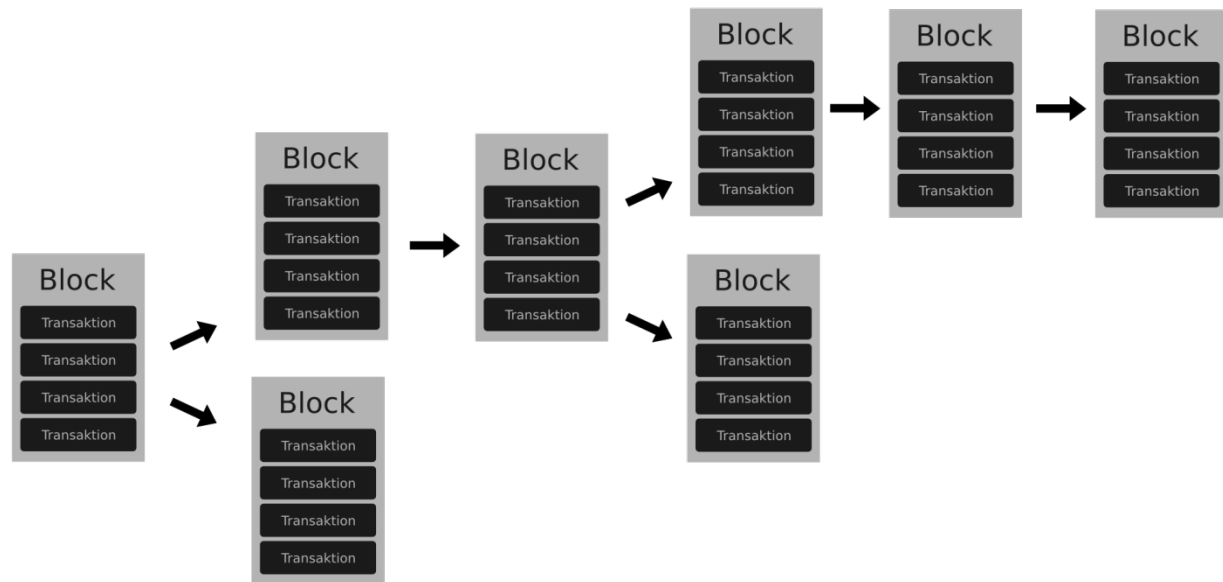
A blockchain

- ▶ A distributed, secure, peer-to-peer ledger
- ▶ Everyone in the network can hold a copy
- ▶ Contains *via*ble (proven, authenticated) transactions
- ▶ Cryptographic proof is used to validate transactions
- ▶ Transactions are grouped into blocks by all members of the network
- ▶ Hashes link the blocks, creating a chain
(The chain cannot be modified or the hashes will no longer be valid)



Building the chain

- ▶ Anyone in the network can add a block to the chain (any copy of the distributed ledger)
- ▶ New blocks must then be validated by others to be *valid blocks*
- ▶ Conflicts will occur and need to be resolved
- ▶ The longest chain rule (Bitcoin)



What does it look like

Block number	Action	What it looks like in the blockchain	Implicit balances			
			A	B	C	G
0	Starting balances	N/A	10	10	0	0
1	Alice initiates a 5BTC transaction to Gary Bob initiates a 2BTC transaction to Gary	A,G,5,[A's signature] B,G,2,[B's signature]	5	8	0	7
2	Gary initiates a 3BTC transaction to Carrie Alice initiates a 2BTC transaction to Bob	G,C,3,[G's signature] A,B,2,[A's signature]	3	10	3	4
3	Carrie initiates a 1BTC transaction to Alice	C,A,1,[C's signature]	4	10	2	4

- ▶ **Transactions are sent when the sender signs a transaction, which proves that they own the tokens that they are trying to transmit**
- ▶ **The blockchain is stored amongst many computers; consequently, any changes to a block not agreed on by a majority will be rejected**
- ▶ **In advanced blockchains, tokens may contain different types of data, and addresses may store code that can be executed when a token is sent to them**

How does this solve our problems?

- ▶ **Trust – resolved, as we now have proof of a digital identity which is distributed around the network and validated by many parties**
- ▶ **Proof – proof of work / proof of value based on multiple entities validating transactions using cryptographic techniques and reaching a consensus**
- ▶ **Digital uniqueness – a distributed ledger based on a cryptographic chain is almost impossible to forge**

A woman with dark hair, wearing a white and blue striped shirt, is smiling and holding up several yellow sticky notes in front of her face. The background is a wall covered with many more yellow and pink sticky notes. A large yellow rectangular box is overlaid on the right side of the image, containing the text 'Application for power and utilities'.

Application for power and utilities

FTP
System
file transfer

Update
website
+
blog

Get more
Toby

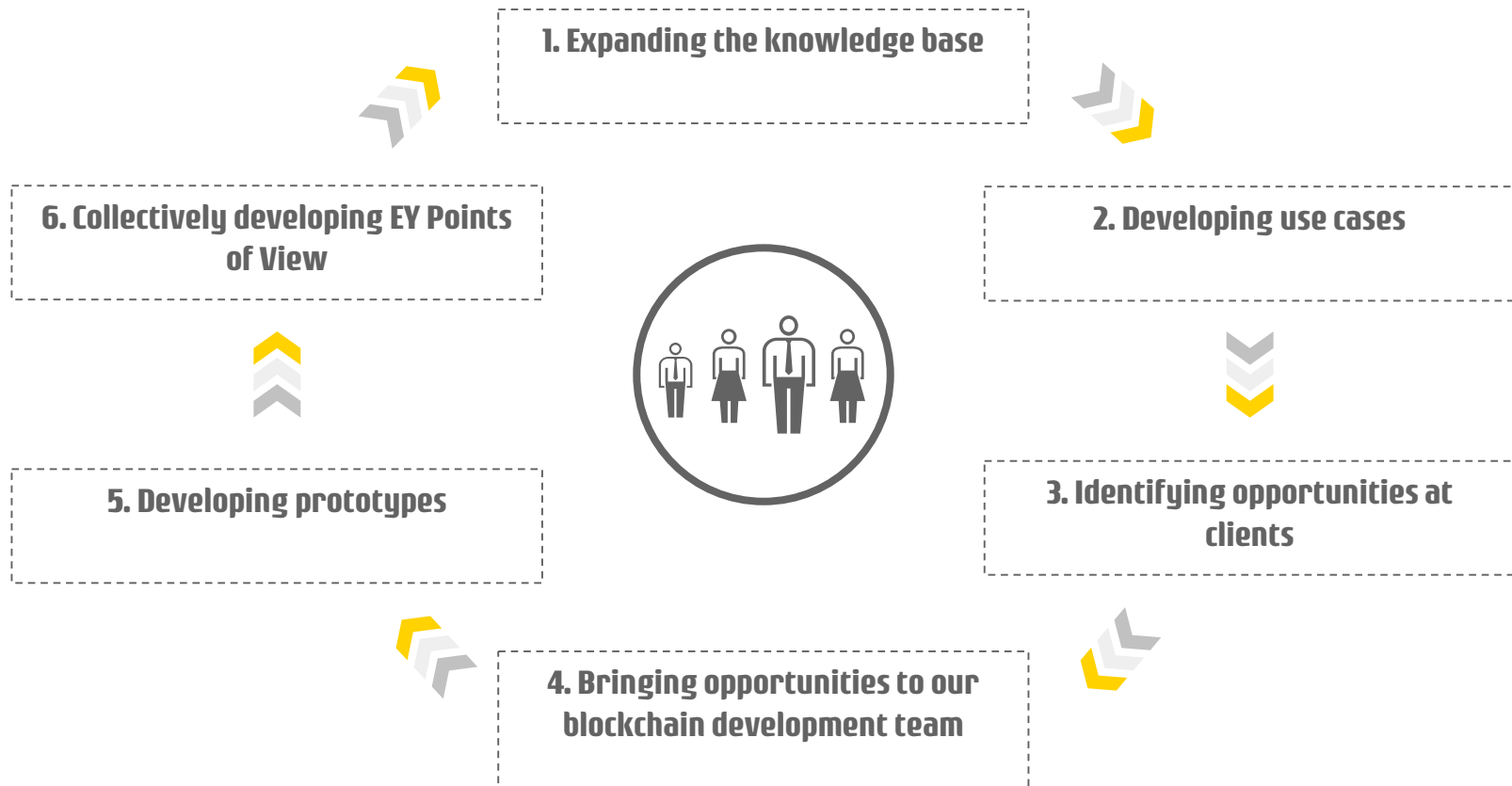
PHY
ITS
Report

Call
IT guy
about
the camera

Get the
Interview
done

EY's focus on blockchain

We are currently identifying use cases and opportunities for EY to become a leader in the development and deployment of blockchain solutions...



APPENDIX

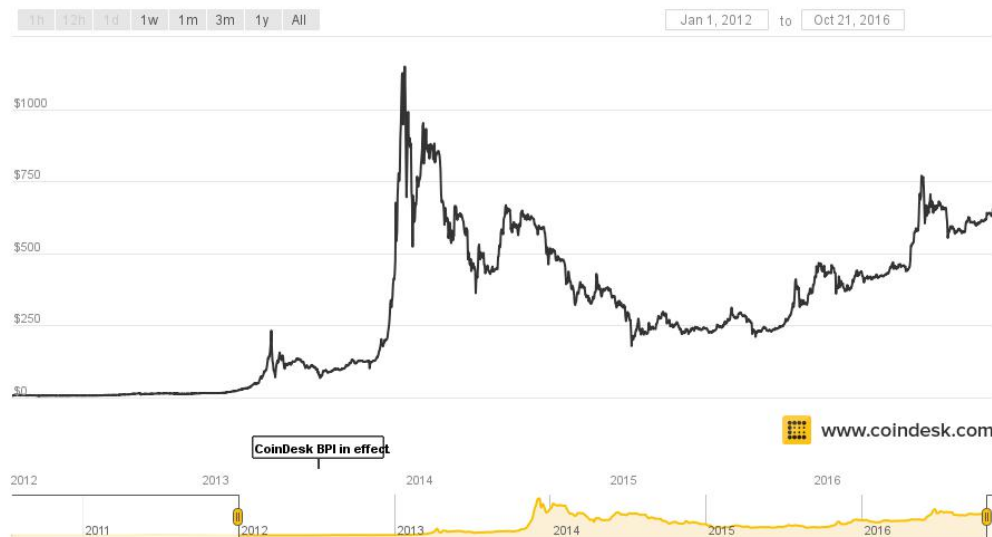


Various blockchain protocols



Bitcoin

- ▶ Bitcoin is a cryptocurrency and a payment system
- ▶ First introduced in 2008 by an unknown source
 - Regarded as the first cryptocurrency
- ▶ First use or application of a public blockchain
 - Bitcoins are the currency used to reward for processing work



Ethereum

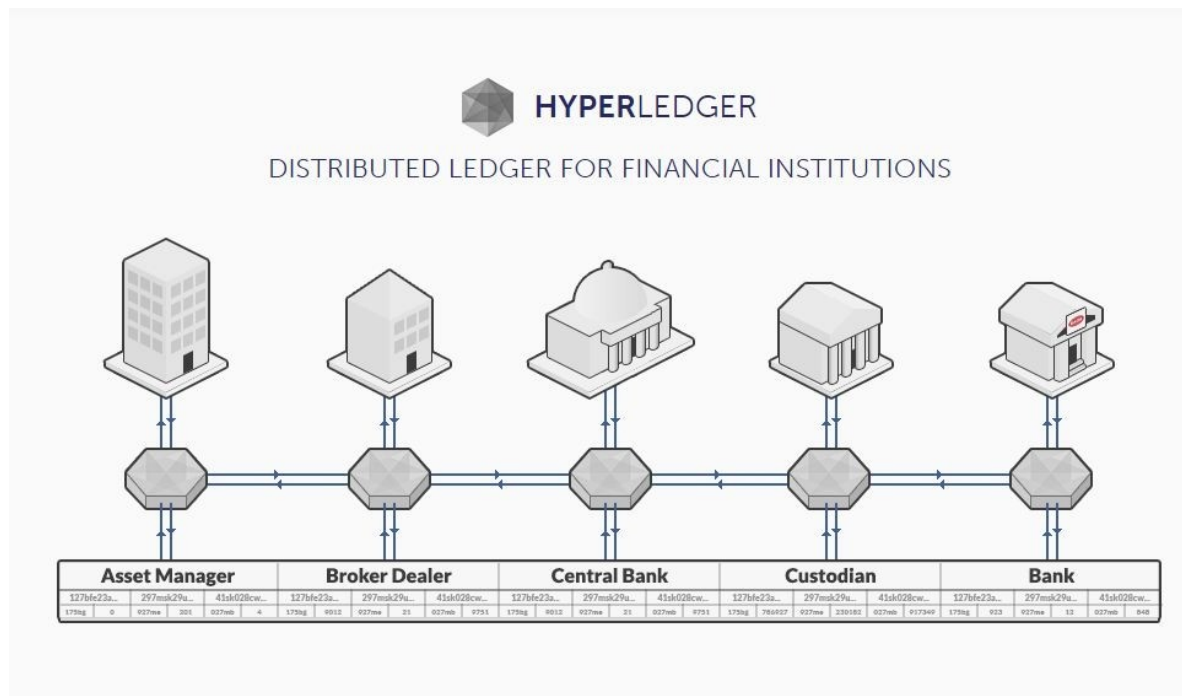
- ▶ A decentralized blockchain platform that runs smart contracts: applications that run exactly as programmed that can facilitate, verify, or enforce the negotiation or performance of a contract
- ▶ Founded in 2013 by programmer Vitalik Buterin
 - Live blockchain launched in 2015
 - Created on similar concepts of Bitcoin blockchain



ETHEREUM

Hyperledger

- ▶ The Hyperledger Project started in 2015 as a collaborative effort created to advance blockchain technology
- ▶ The project's goal is to identify and address important features for a cross-industry open standard for distributed ledgers that can transform the way business transactions are conducted globally.



Other protocols

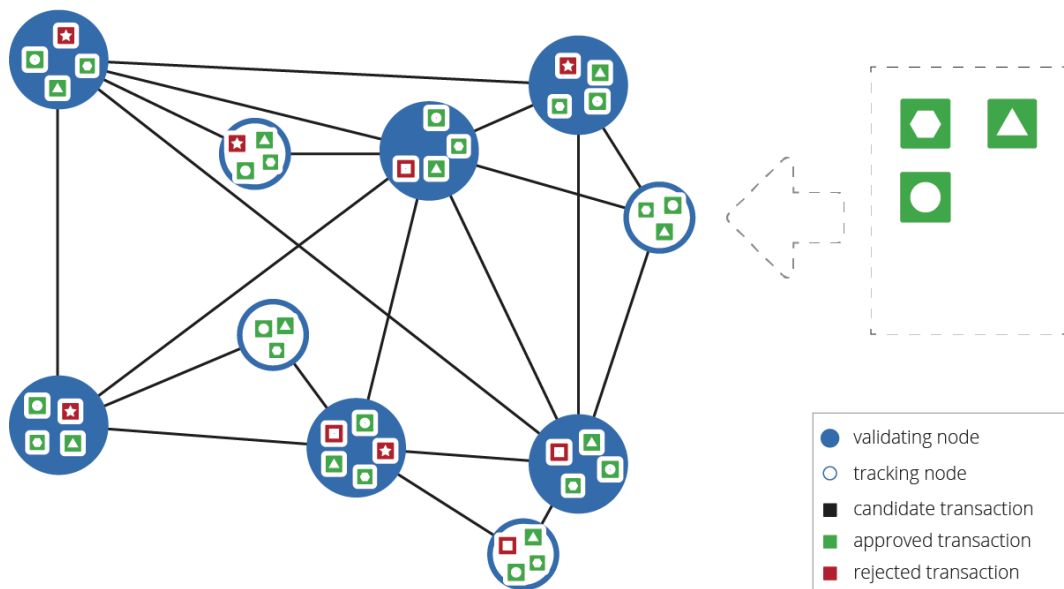
- ▶ Everledger
 - Permanent blockchain ledger for diamond asset registry
- ▶ Factom
 - Data storage through a decentralized system
- ▶ Ascribe
 - Public ownership rights assigned via the blockchain
- ▶ Blockstack
 - Decentralized internet

Consensus



Consensus

- ▶ The key part of a blockchain – agreement that transactions and blocks are valid requires consensus from multiple parties
- ▶ In a private blockchain this is relatively easy, as access is restricted and all parties have a vested interest in maintaining the integrity of the chain.
- ▶ In a public blockchain this is much more complex, and must be engineered into the solution
- ▶ Many consensus mechanisms exist, e.g. Proof of Work, Proof of Stake.
- ▶ The aim is to ensure that agreement exists on the validity of all transactions and blocks in the chain



Ripple consensus protocol

Consensus Mechanisms

- ▶ **Proof of Work** – Is a mathematical calculation that completes a block. Transactions are blocked, and a solution is difficult to find (but easy to verify) by utilizing a target state hashing model. The winner earns the block reward.
- ▶ **Proof of Stake** – Transactions are blocked periodically, and miners are given a chance to win the block (and validate transactions) based on the amount of asset they hold. They are incentivized to be trustworthy as it dictates the value of their holdings.
- ▶ There are other types (federated, trusted) and some distributed ledgers don't use any.



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LO3 ENERGY

Distributed grid solutions that bring
people, utilities and technology together

CONFIDENTIAL DO NOT DISTRIBUTE



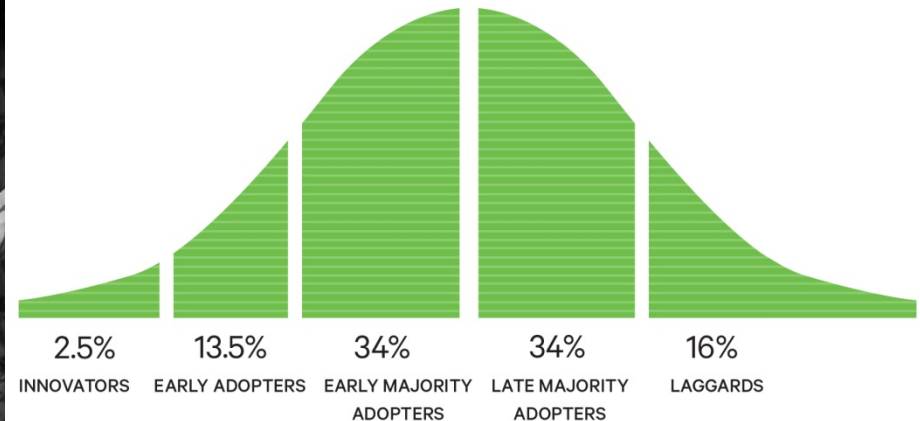
LO3 ENERGY

LO3 Energy Background

- An energy company applying well-developed strategies for market transformation and adoption of new tech
- Founded in 2012
- Company background in:
 - Energy Program Design
 - Community Engagement
 - EM&V
 - Codes and Standards
 - REC and Green Power Markets
 - Blockchain
 - Advanced Meters
 - System Architecture
 - Computation

Technology Adoption Curve

EVERETT ROGERS - DIFFUSION OF INNOVATIONS 1962





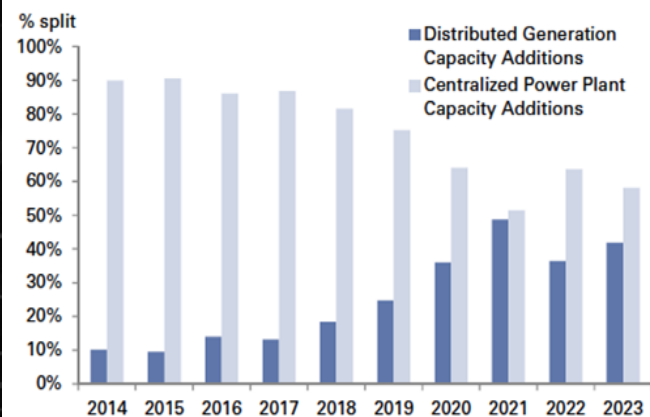
LO3 Energy Tech

- Measure energy flows and hash information to blockchain
- Patented, proprietary and UL-listed
- Next generation AMI
- Network through a variety of communication protocols and write smart contracts within the network



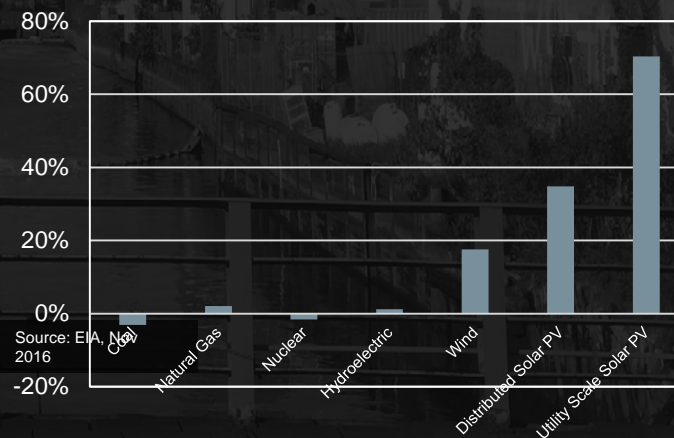
New Energy Resources are Renewable and Distributed

% of centralized generation capacity adds vs. distributed, 2014-2023E



Source: EIA.

Change in US Fuel Mix between Sept 2015 and Sept 2016



Source: EIA, 2016

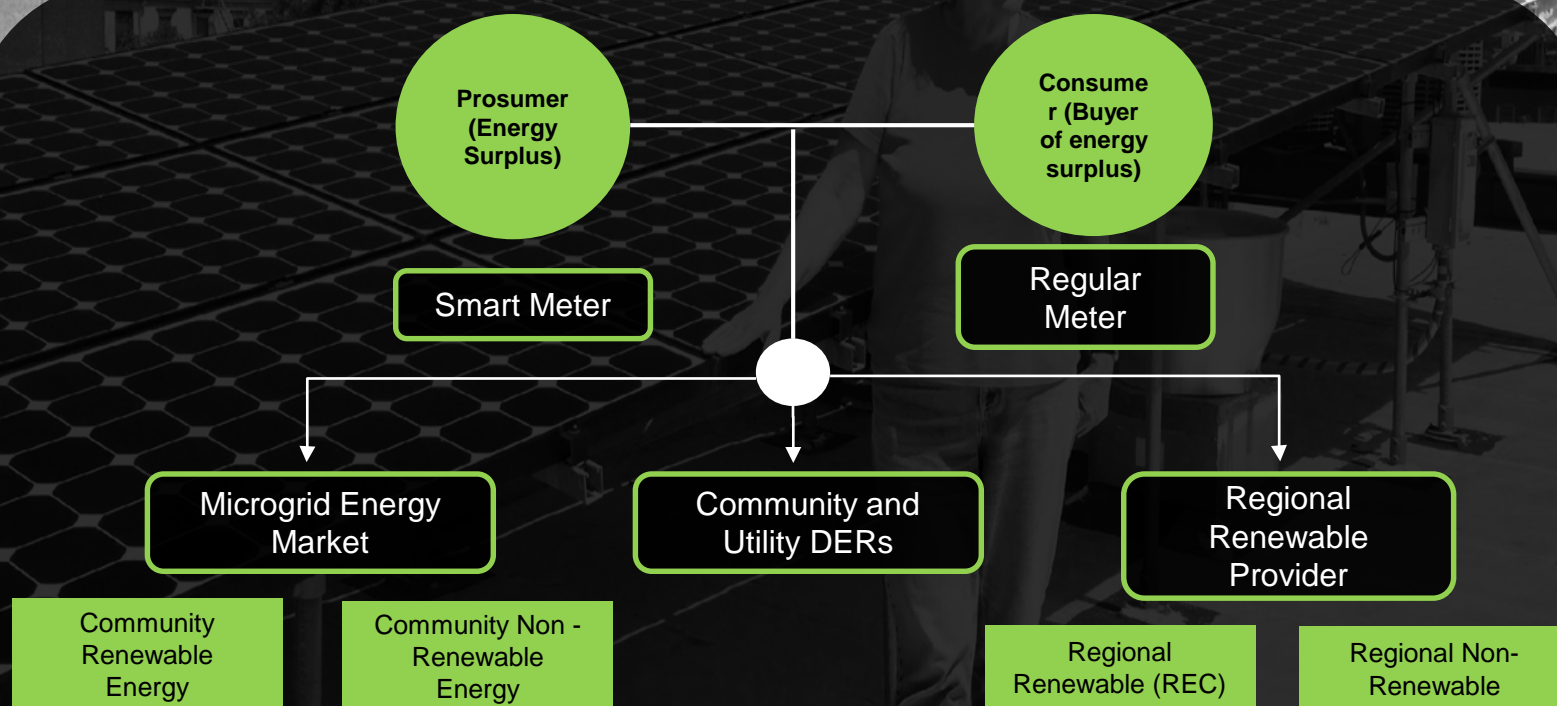
More than half of the estimated additional solar generation will be distributed, not utility scale



Problem

Utility Grid Faces Structural Issues

- Utility Grid is unidirectional and brittle while future calls for fast-acting platform that can enable 2 way flow and is resilient and adaptive
- Current utility operating models do not encourage Distributed Energy Resources (DERs)
- Major market changes underway, unprecedented shifts by utilities and market actors
- “Prosumer” movement creating pressure on existing business models
- Broad, coordinated control of small scale DERs is uneconomic
- Consumer participation in energy markets limited by regulatory barriers and solutions to facilitate secure, efficient transactions



Consumers have much more choice and can create personalized energy sourcing profiles

- Example: 80% from regional renewables and 20% from local microgrid



TransActive Grid

Milestones

Smart Meter Proliferation

- Price discovery & Energy Transaction with microgrid members
- Real-time, location based energy market

Transact on consumer **values**

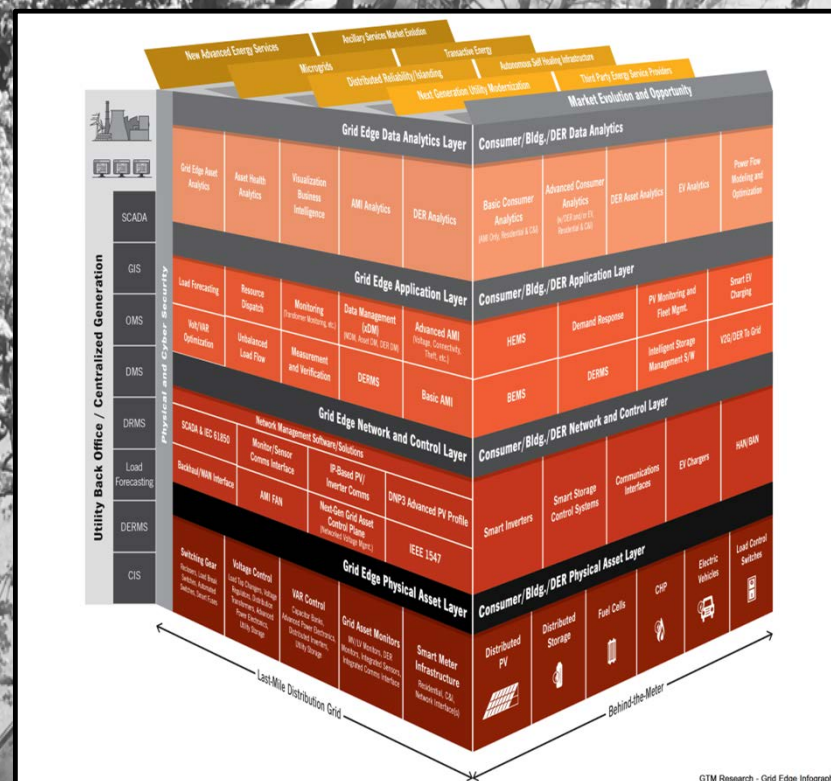
- Price, green energy, clean signals, social good
- Multi-factor tokens to encourage what you want to see in the market



TransActive Grid

Blockchain-based Microgrid Intelligence System

- Transactive, distributed intelligence system to control microgrids
- Based on open-source, cryptographically-secure protocol layer delivering military-grade cybersecurity and real-time data
- Auditable, immutable, secure device control



Community Energy – Sharing Economy



Tokenization

Tokenization of energy production, storage and consumption creates efficient **local markets**



P2P Markets

Efficient Local Markets attract investment, increase impacts and create **local value** for energy, environment and community



Prosumers

Rise of the **Prosumers** neighbor-to-neighbor, neighbor-to-business community transactions reward **local markets** and **return community value**



Community Microgrids

Reward efficiency and resiliency allowing participants to optimize **existing energy spend** according to individual **values, priorities and outcomes**



Drivers

Energy Consumers Demand New Choice and Services

69% of consumers are interested in having an energy trading marketplace

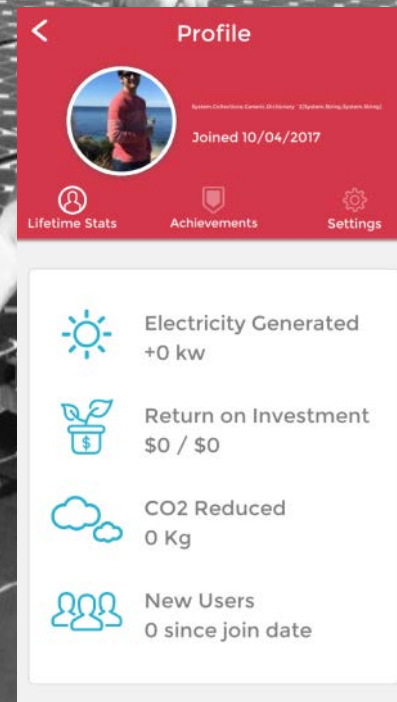
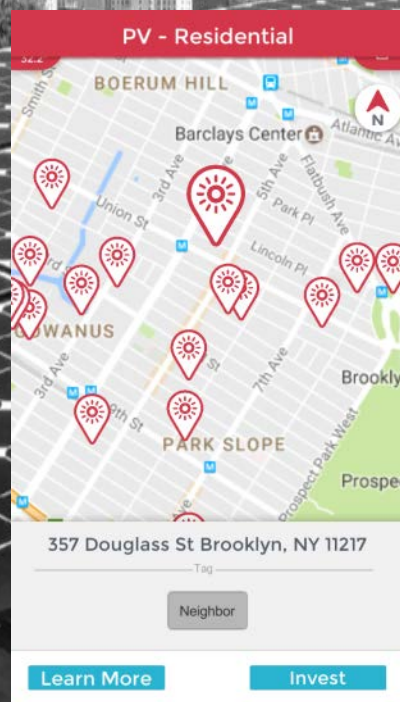
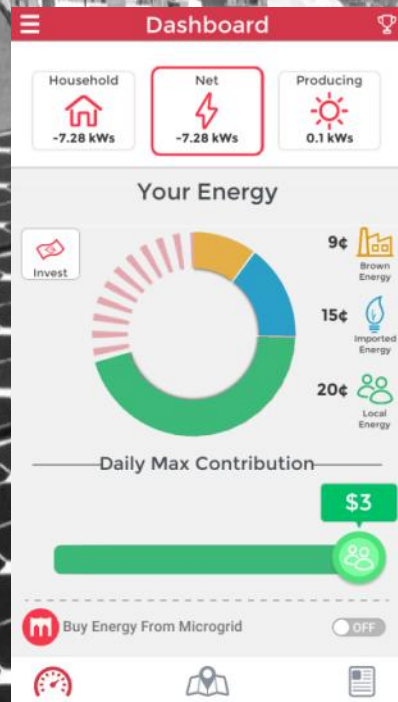
47% of consumers plan to sign up for a community solar program managed by a 3rd party and one that allows them to benefit from solar even if they do not have solar panels on their property within the next 5 years

Source: Accenture multi-year New Energy Consumer Research program: surveyed over 13,000 consumers from 26 countries from 2010 - 2016





Brooklyn Microgrid



Invest

How much would you like to invest?

Let us know how much you would like to invest. We will notify you when new solar sites are available.

Tap an investment tier to find out more?

- \$50
- \$250
- \$1000
- \$5000
- \$10000



We Choose Local Green Energy

Community Energy

locally generated with community assets

Microgrid Markets

local energy market, revenues and increased system resilience

TransActive Grid

secure platform for peer-2-peer transactive energy and markets

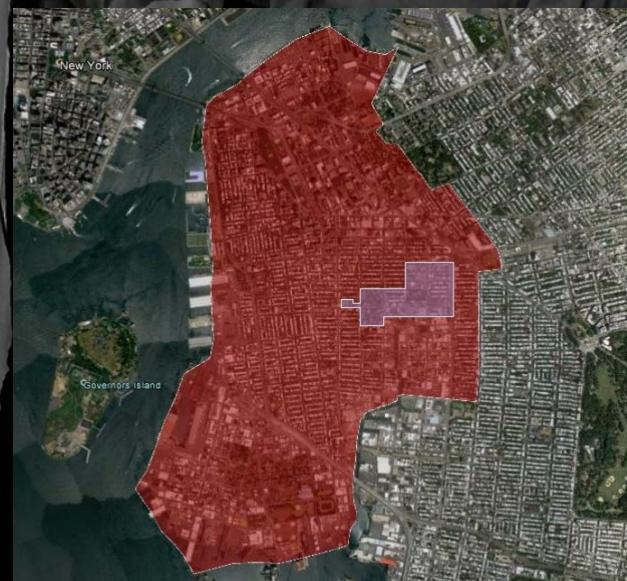




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Current Status & Next Steps

- First peer-to-peer energy transactions executed
- Pilot and use case discussions underway
- Testing new business models
- Brooklyn Microgrid pilot in development
 - Over 130 sites registered
- Partners
 - Production partners lined up
 - Controls software development underway



PARTICIPAN
BROOKLYN
MICROGRID



TRANSACTIONAL



New Technology – New
Choices – New Deal

**They are your electrons, right?
Don't forget that.**





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Hierarchical Energy Markets Enabled by Blockchain

Siemens Vision 2020: Energy Management is a Siemens focus area

SIEMENS

Global trends



Siemens Digital Grid

Digitalization

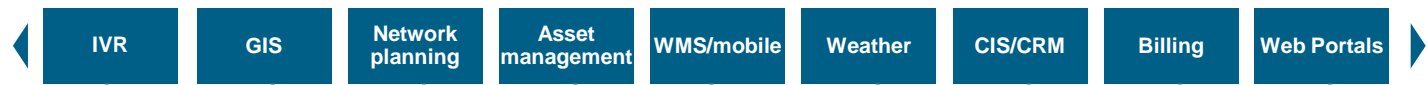
Cloud enabled applications



Public cloud



Enterprise IT



Enterprise Service Bus

PSS® & SIGUARD
Grid planning and simulation

CIM

Spectrum Power platform
Grid control applications

CIM

EnergyIP platform
Market driven applications

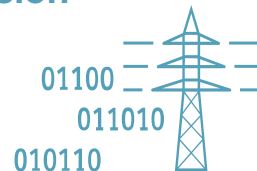
Global Interoperability: DNP3, IEC 61850 & 60870, OpenADR, DLMS, ANSI ...

Cyber security

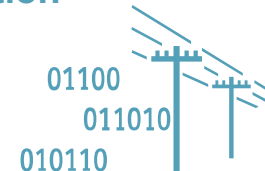
Automation

Electrification

Smart transmission



Smart distribution



Smart consumption and microgrids

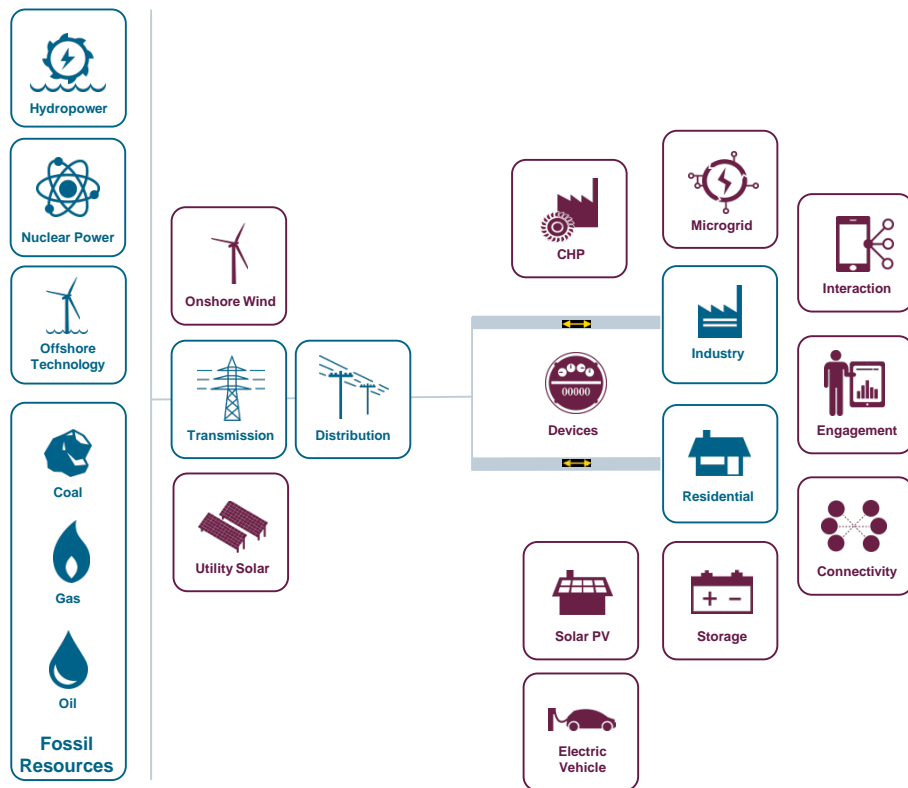


CIM – Common Information Model (IEC 61970)

The Evolving Digital Footprint Imposes New Requirements

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The New 21st Century Customer-Centric Distributed Energy Experience



Energy Supplier

The energy suppliers ensure safe, reliable, and affordable energy to their customers based on a deterministic rate base mechanism.

Energy Integrator

Driven by customer demand, energy suppliers evolve to manage intermittent energy generation from third-party suppliers and consumers.

Energy Service Provider

Rise of the Prosumer, combined with many 3rd energy choices, leads energy suppliers and integrators to become distribution network providers.

How managers in the energy sector see the future of Blockchain

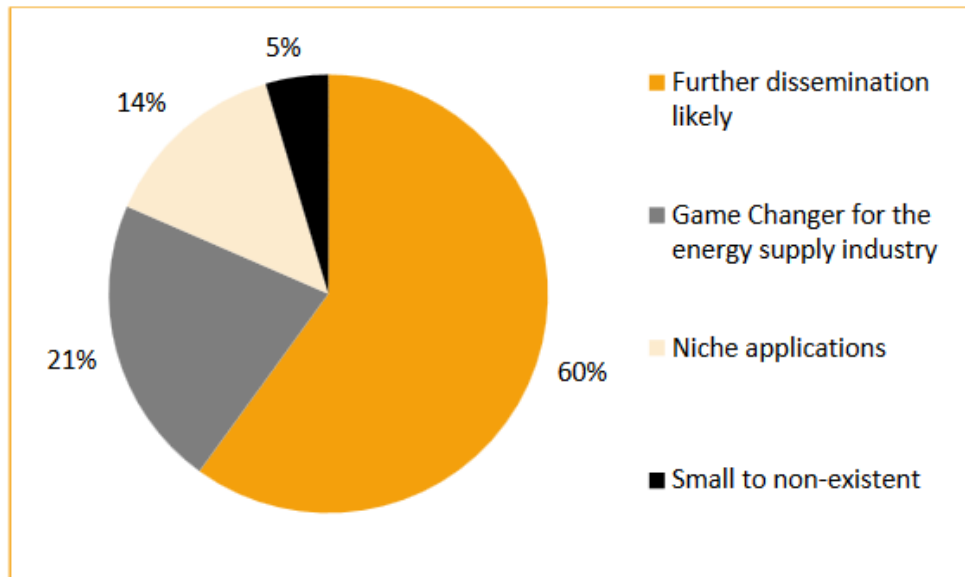


Figure 1: Potential of dissemination of Blockchain

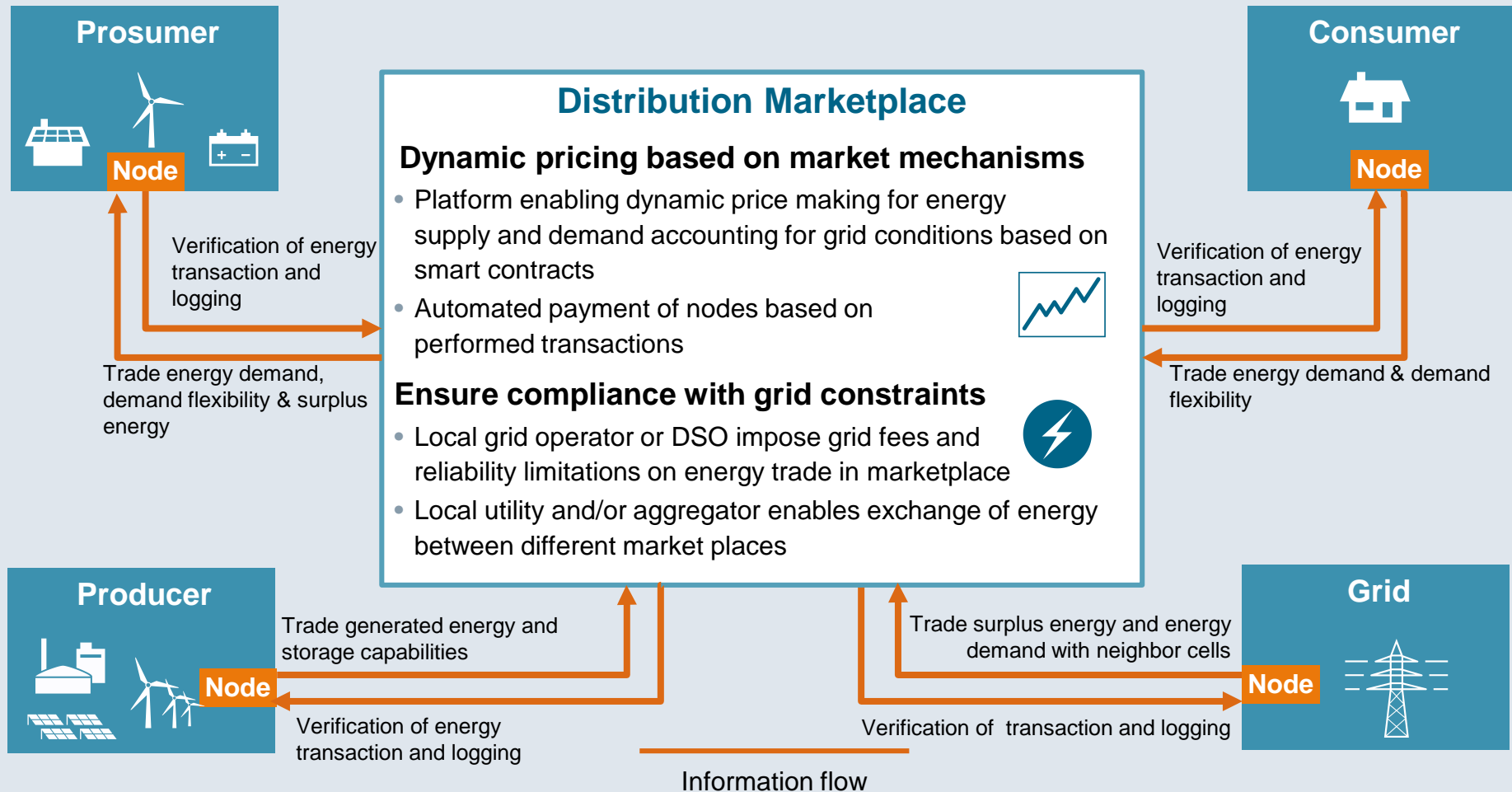
Source: dena ESMT Studie Blockchain, 2016

Unrestricted © Siemens AG 2017



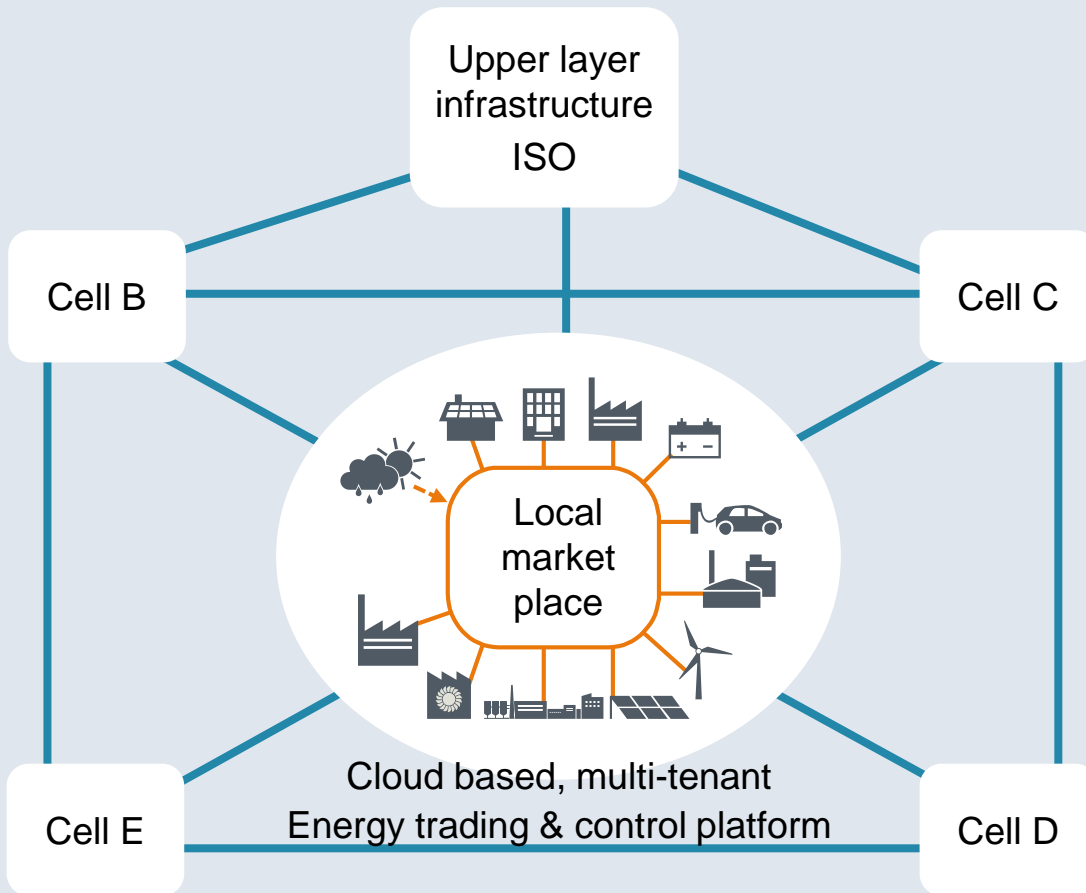
Figure 2: potential use cases of Blockchain in the energy sector.

Distribution market for P2P energy trading based on Blockchain



P2P energy trading in and between distribution grids using blockchain technology enabling robust hierarchical cell-based energy system

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Local market place can be based on:

- Grid infrastructure of one or more DSOs

Local market place can contain...

- All types of consumer, prosumers & producers
 - Individual Households
 - Commercial & Industrial Facilities
 - (local) Power plant operators
- With all types of loads, generation & storage assets
 - Photovoltaics
 - Wind
 - Storage
 - CHP
 - Biogas-PP, Gas Peaker-PP
 - Heat Pumps
 - Electric Vehicles
 - Flexible Loads

Contact page



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Economic Implications of Blockchain for Electricity Distribution and Markets

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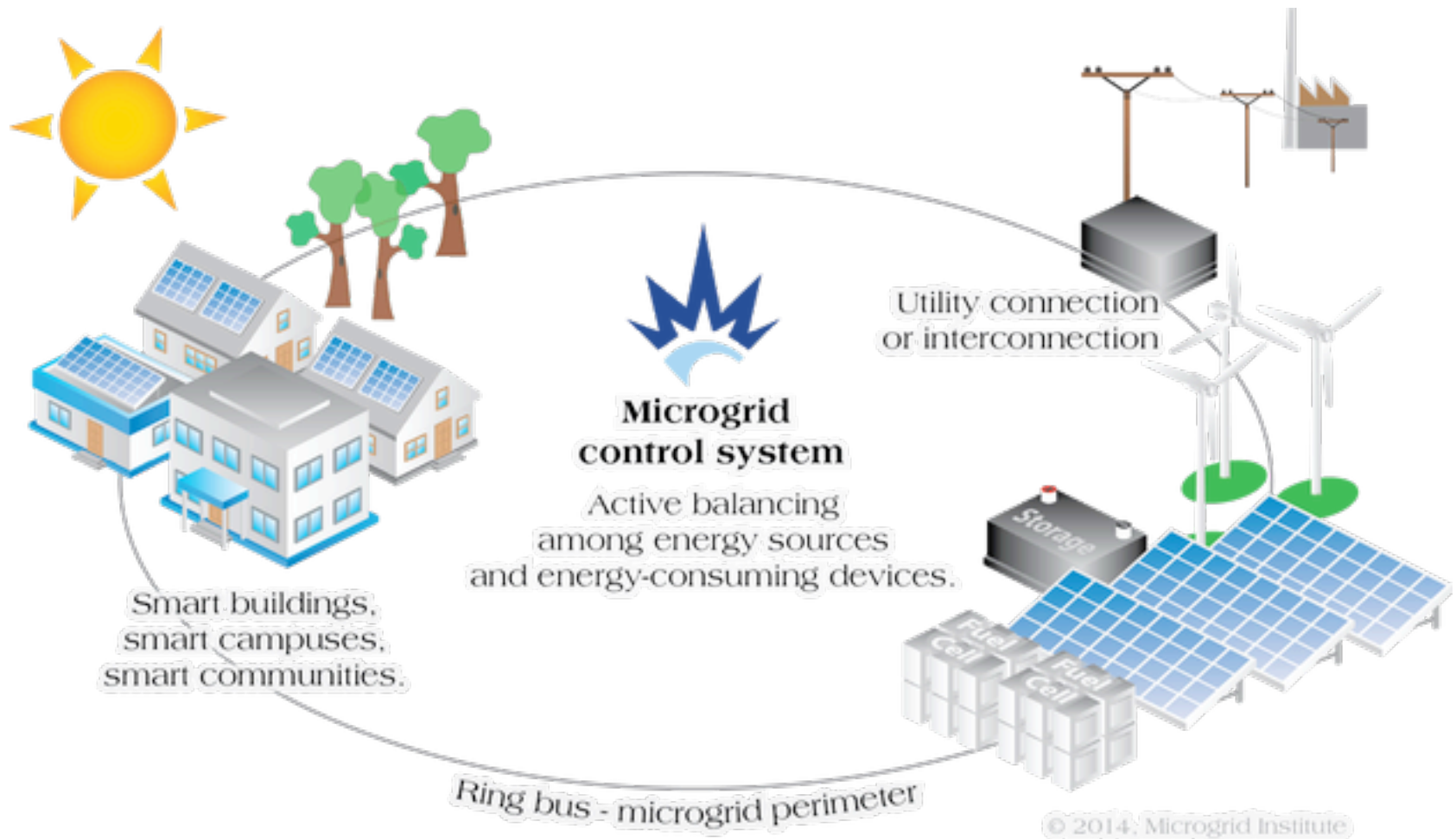
February 2017



NORTHWESTERN
UNIVERSITY



Transactive microgrids



Economics of blockchain for transactive energy

- Blockchain as transaction cost-reducing market platform
- Blockchain market platform + digital tech for sensing and automation + DERs + governance framework => decentralized autonomous retail market
- Buildings as microgrids
- Retail markets for energy, ancillary services

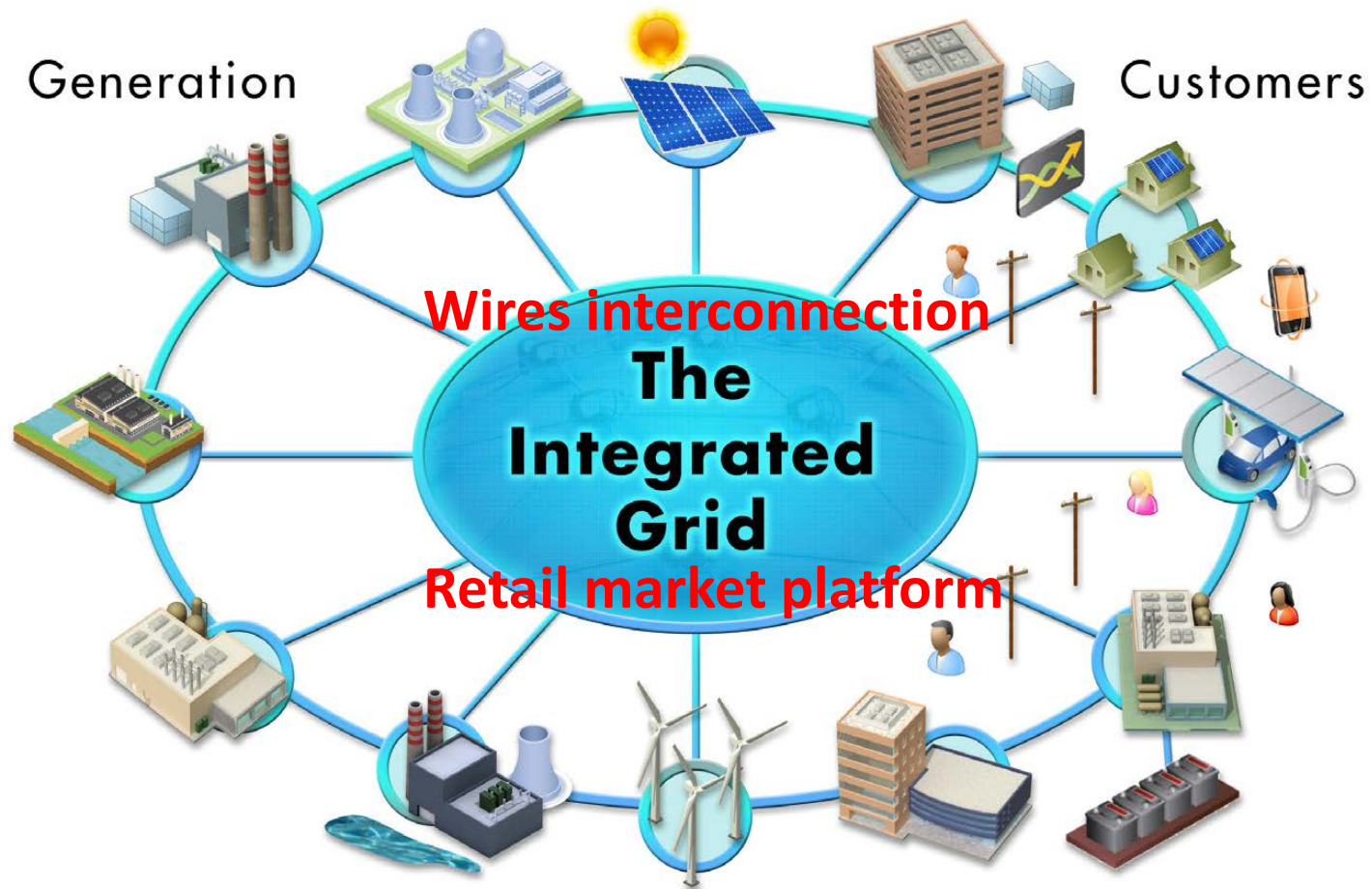
There is no innovation without experimentation



Decentralized market processes are innovation platforms



A techno-economic electricity distribution platform



Top takeaways

- Digital technologies are massive **transaction cost reducers**, and a transactive energy approach can direct those cost reductions to consumers. Blockchain platforms enable welfare-enhancing transactive energy systems.
- Blockchain-based platforms around the **distribution edge** can engage in the **experimentation** that leads to innovation. Don't perpetuate costs and entry barriers that stifle them.
- A distribution platform business model enables the wires utility to evolve into providing **grid services** to decentralized parties around the distribution edge.



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