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Blockchain in Energy and Utilities – A presentation for The Energy Forum

Citigroup 12/13/2018

Confidential – Not for Distribution

Agenda

Blockchain in Energy Overview

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Blockchain in Energy in 2018: By the Numbers

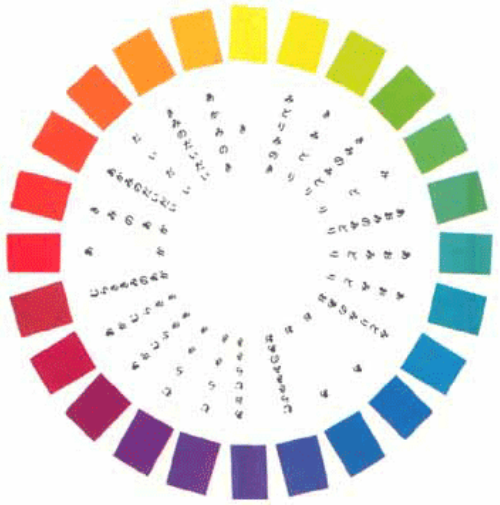
Currently **150+** startups and companies are tackling the energy market, the majority on 'decentralized markets'

Blockchain PoC maintenance rates over a two-year period are estimated at less than **12%**

80% of data in a utility is unstructured

Global penetration of smart meters is approximately **30%**

Traditional blockchain venture financing sees an average of **$3M** for early-stage deals



Over **50%** of startups are focused on Financial Services, Insurance and Government

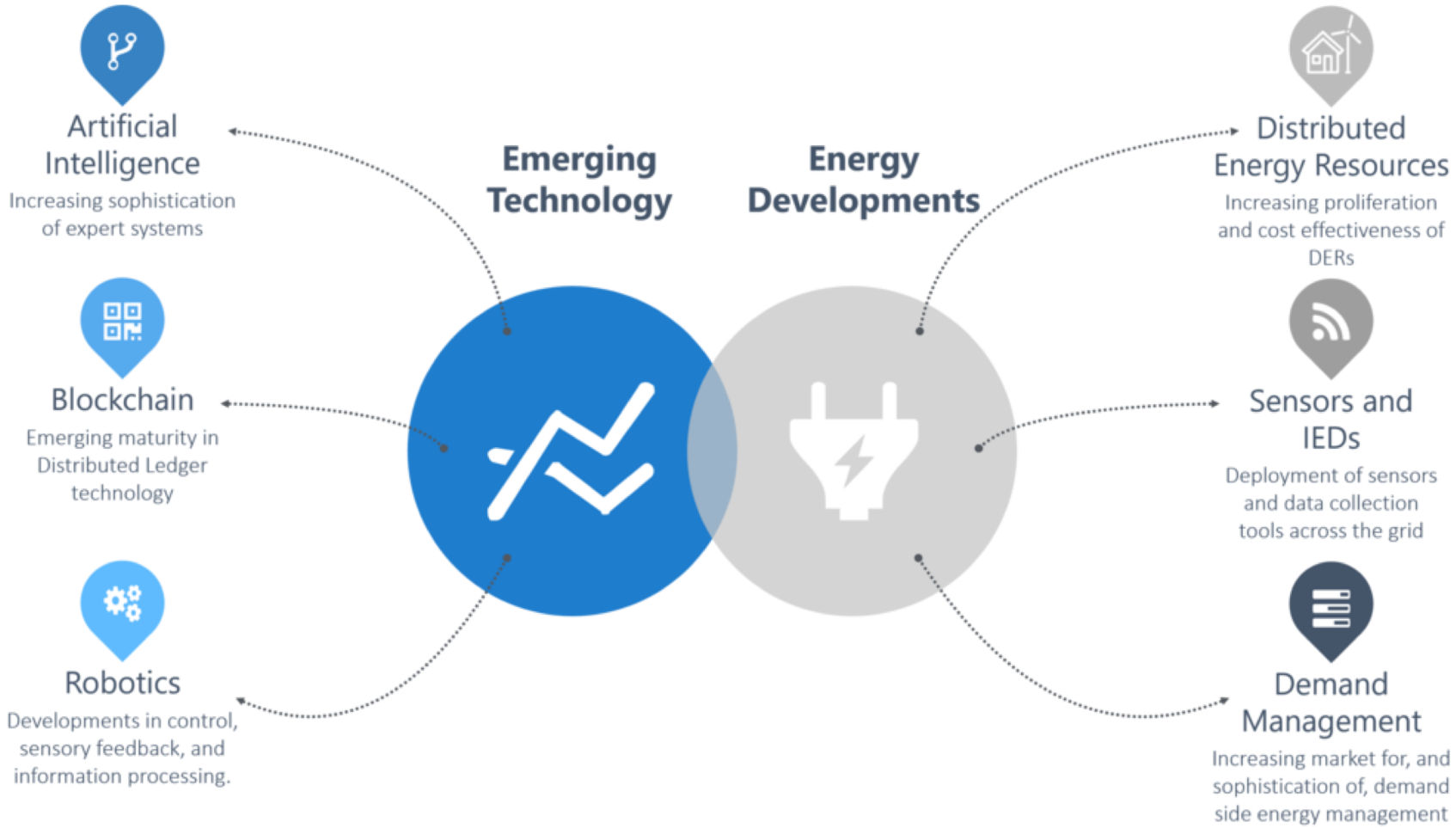
Over **¼** of energy startups have completed or a planning an ICO, with the vast majority of these founded in the past 2 years

A handful of energy blockchain firms have exceeded **$200M** in token sale proceeds

Over **50** blockchain consortia exist, 5+ in energy

Over **20** popular blockchain platforms exist with Ethereum and permissioned ledgers the most popular

Broader Context - The Fourth Industrial Revolution (4IR) and the Role of Energy



… in the future devices which auto-detect demand levels on the grid and reduce power could be powered by AI and recorded by blockchain

Evolution of Blockchain Technology in Energy and Utilities

1. Introduction

Over the past few years, developers have begun using Bitcoin's underlying technology, blockchain – for creative new applications

2. Decentralized Networks

Decentralized networks redistribute power from a central server, enabling peer-to-peer communications

3. Smart Contracts

Smart contracts are account holding objects on the blockchain containing code that can interact with other contracts, make decisions and store data

4. New Blockchain Platforms

New platforms, such as Etheruem allow developers and consumers to take advantage of decentralized networks

5. Applications

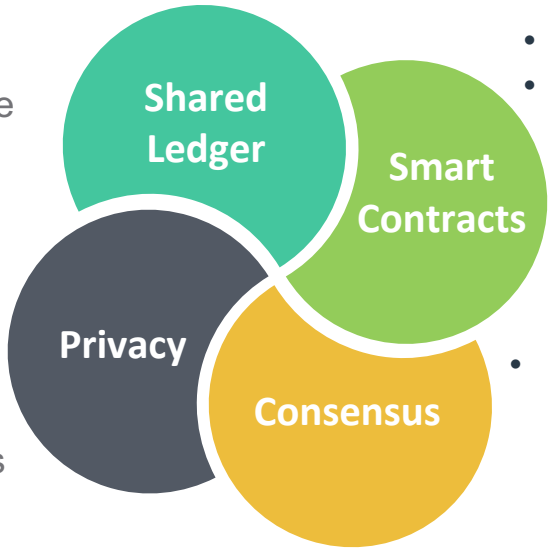
A Decentralized Application (or 'DAAP') is a piece of software consisting of a user interface (UI) and a decentralized blockchain backend

6. Energy Opportunity

Globally, current energy pilots range from P2P trading, IOT appliance level control, and bitcoin enabled bill-pay

Four Key Elements of Blockchain

- Records all transactions across business networks
- Shared between participants
- Participants have own copy through replication
- Permissioned, so participants see only appropriate transactions
- THE shared system of record

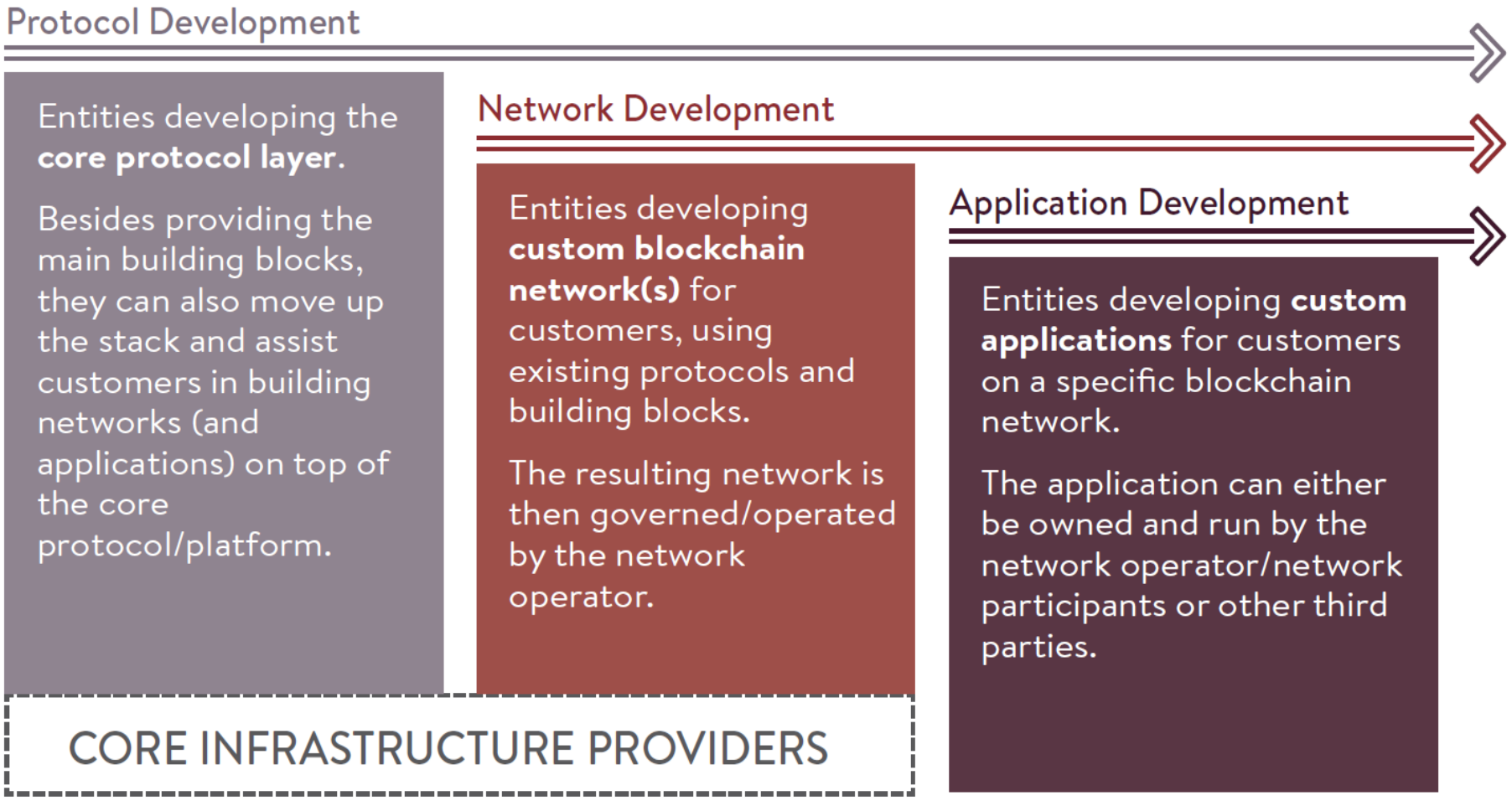


- Business rules that form the transaction
- Encoded in programming language
- Verifiable, signed& encrypted
- Guaranteed future execution
- Example: Defines contractual conditions under which corporate Bond transfer occurs

- Ledger is shared, but participants require privacy
- Participants need:
  - Transactions to be private
  - Identity not linked to a transactions
- Transactions need to be authenticated: Cryptography central to these processes

- The process by which transactions are verified. When participants are anonymous
  - Commitment is expensive
  - Bitcoin cryptographic mining provides verification for anonymous participants but a significant compute cost (proof of work)
- When participants are known and trusted
  - Commitment possible at low costs
- Alternatives:
  - Multi-signature(e.g. 3 out of 5 participants agree)
  - PBFT(practical byzantine fault tolerance) (cross-checked secure message exchange)

Overview of Blockchain Software Service Providers



Source: Dr Garrick Hileman & Michel Rauchs 2017

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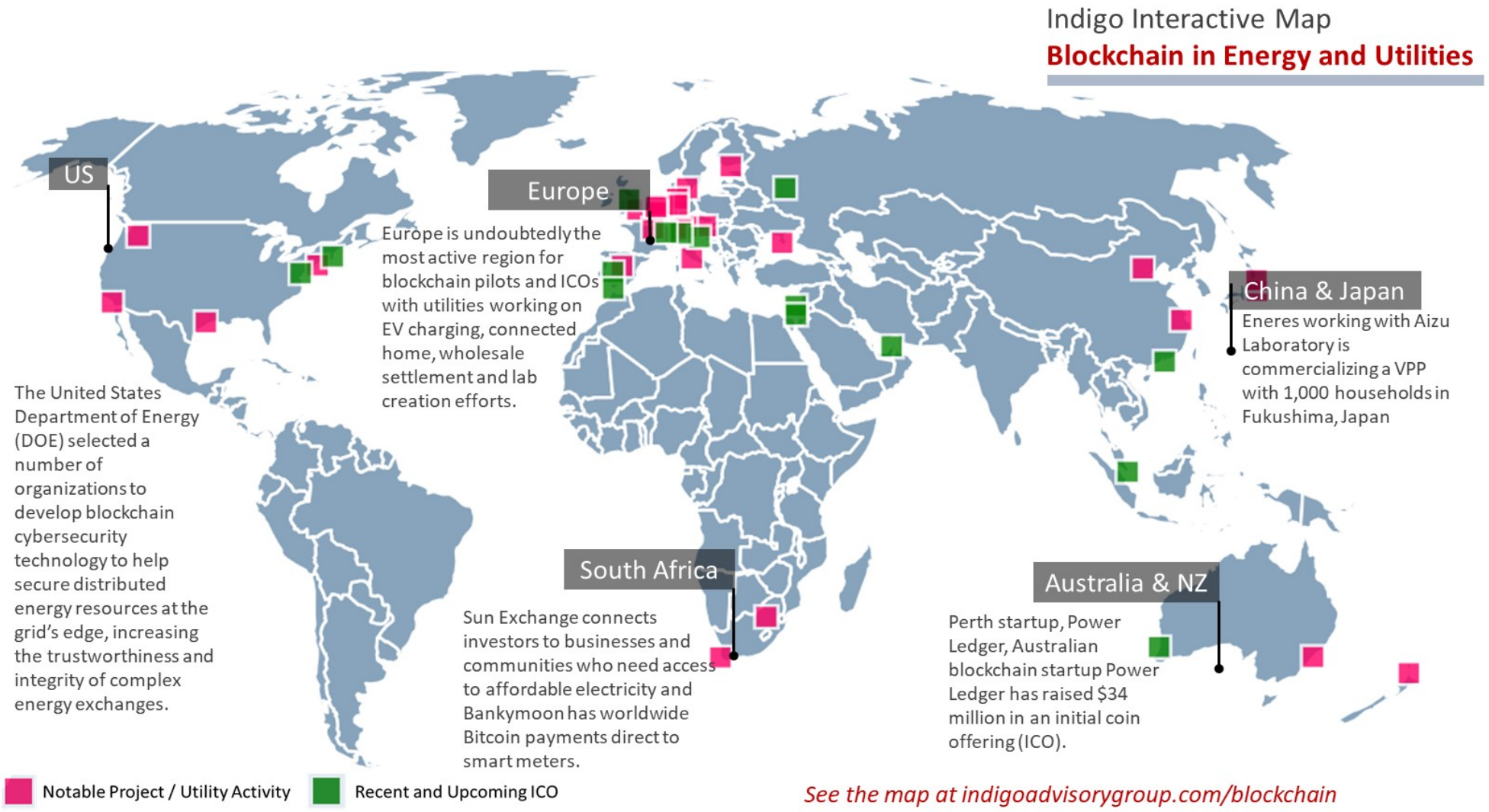
Global Blockchain Activity in Energy and Utilities



See the map at indigoadvisorygroup.com/blockchain

Indigo Stakeholder Activity Taxonomy - Blockchain in Energy and Utilities

P2P Trading & Connected Home

POWER LEDGER
Vector
CO-TRICITY
LO3 ENERGY
alliander
Fortum

EV Charge / Share

oxygen INITIATIVE
Slock.it
ZF
innogy

Consortia and Research

ENERGY WEB FOUNDATION
WANXIANG BLOCKCHAIN LABS
endesa

Bitcoin Meter Payments

丸紅株式会社 Marubeni
enercity positive energie
elegant zuivere energie
bitpay
BAS
PEY
bankymoon

Solar Cryptocurrencies

smappee

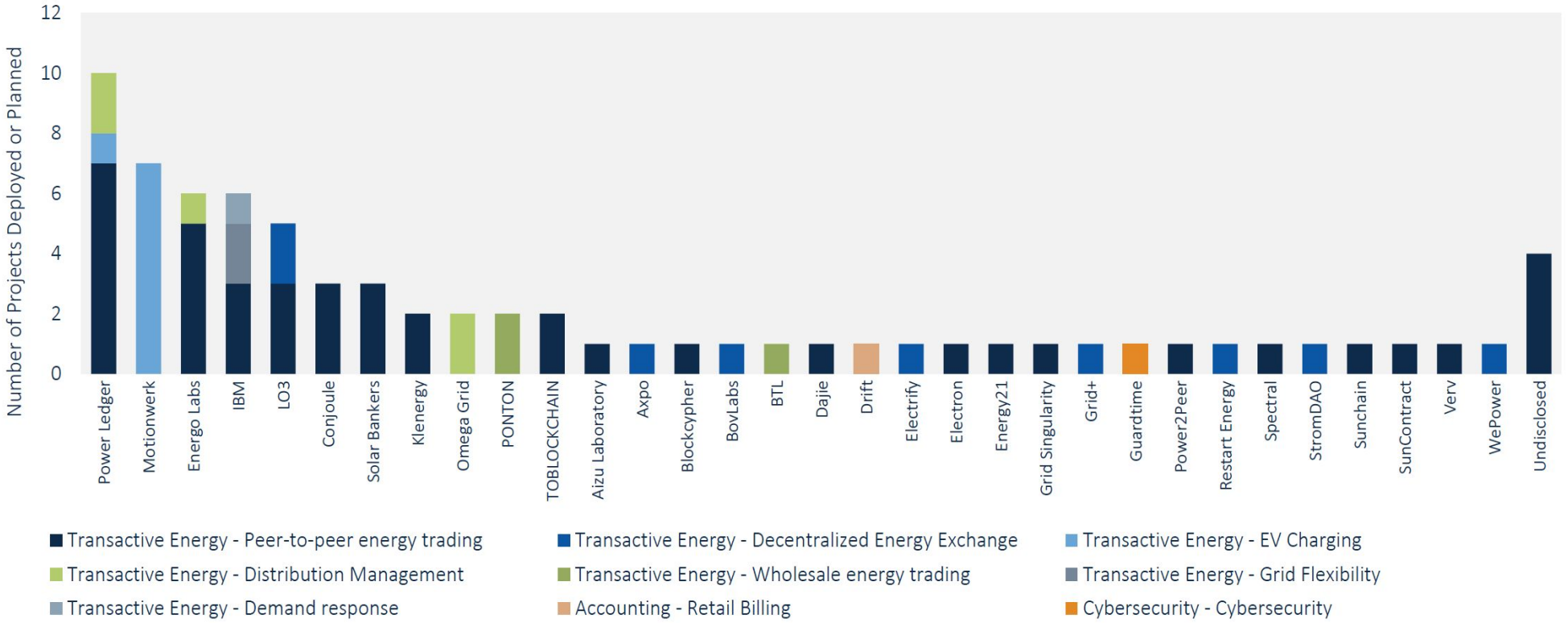
Notable Startups

Volt Markets
M-PAYG
GSy
Gem
CHRONICLED
Adpteve
FILAMENT
theSunExchange

Wholesale Trading & Smart Markets

QIWI КИВИ
NEW 4.0 Norddeutsche EnergieWende
BTL
yuso
PONTON WE ARE THE 2 IN B2B
PRIOGEN
WIEN ENERGIE

Blockchain in Energy Projects Deployed and Announced Q2, 2016 – Q4 2018



Source: GTM Research

Source: GTM Research 2018

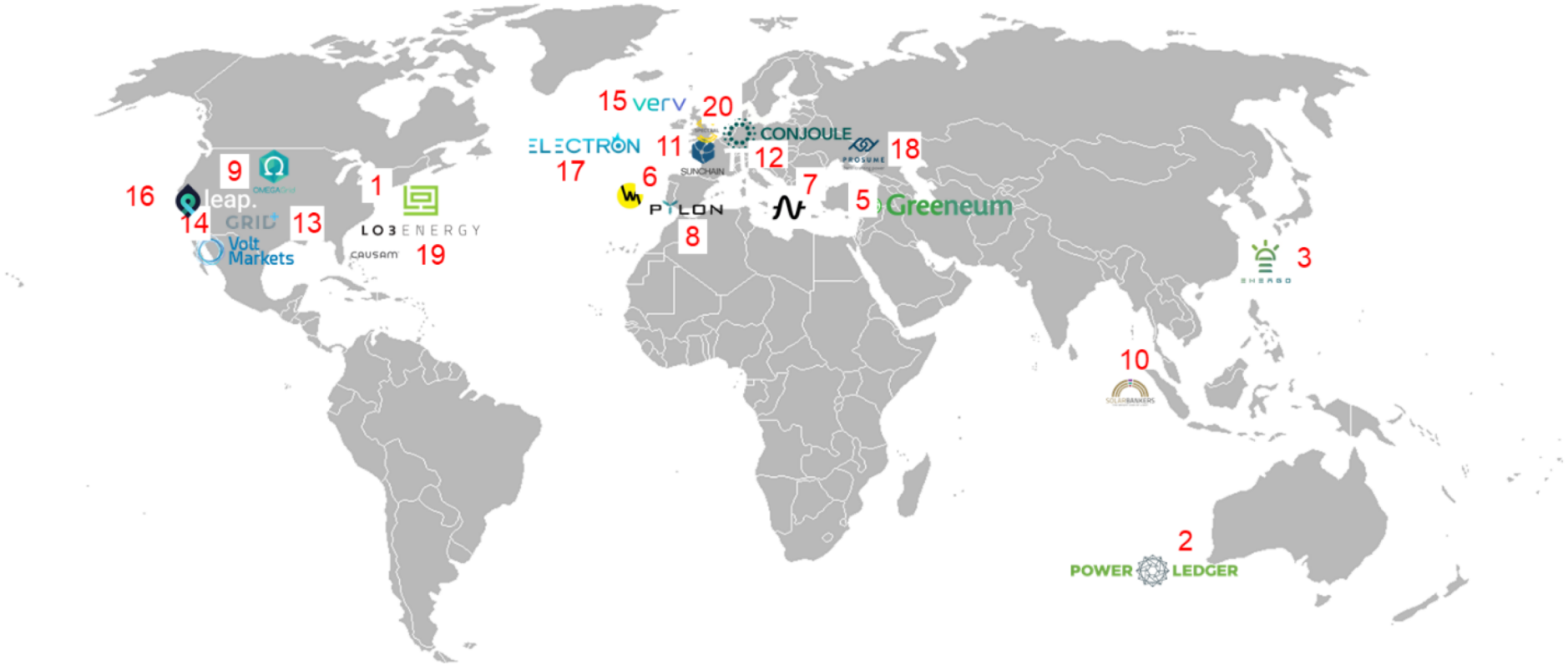
Recap: Use Cases Utilities are Examining

Specifically, we are seeing a few broad swathes of focus emerge that include, EV Roaming, Provenance / Certificate of Origin, Billing, Demand Response and Dynamic Energy (P2P Trading)

10%	20%	40%	20%	10%
Metering	Grid management	Decentralized Generation	EV Charging	IOT
Data exchange between stakeholders of Smart Grid applications, intelligent control systems, as well as the standardization of data transfers	Value exchanged between devices in the form of data, network access, currencies, compute cycles, contracts for ongoing service, trusted introductions to other devices	Real-time metering of local energy generation and P2P transaction management	Develop EV Charging Stations that use blockchain based smart contracts to authenticate users and managing the billing process	Continuous identification of new applications of blockchain for IOT and the Connected Home markets

The Most Common Use Case – P2P Trading / Decentralized Generation

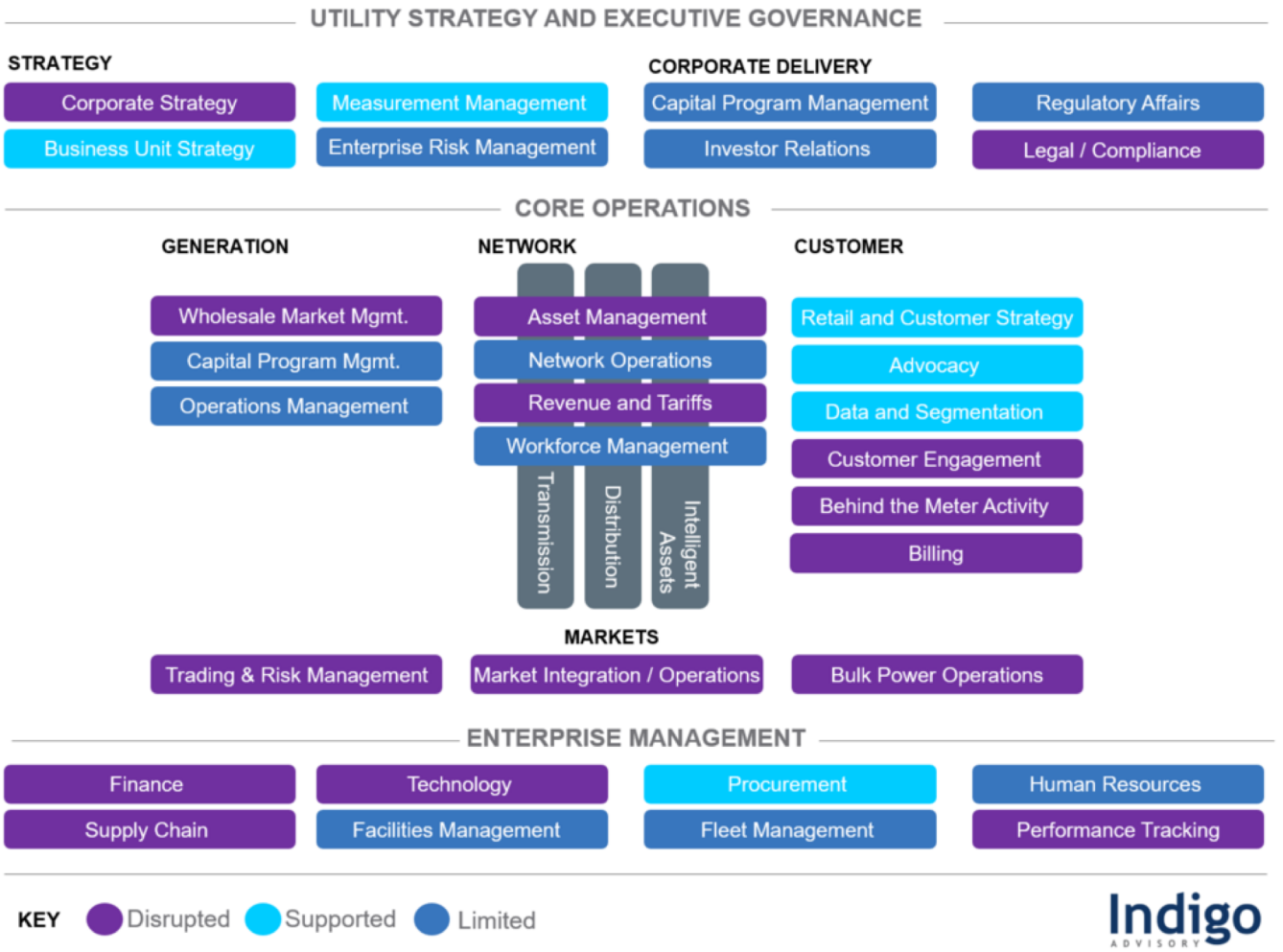
In the map below, we highlight global P2P activity. The vast majority of these are in pilot / extermination phase where a number of participants in a microgrid or at a campus are trading electricity with each other and using blockchain as the transaction management layer.



The Potential Impact of Blockchain and AI on the Utility Business Model

In reality, there will be largely three types of impacts of blockchain and AI technology on the utility value chain.

- Firstly, there will be those areas where there is *limited-to-no impact*
- *F*or other areas the technology may *support* existing processes and make them even more robust and efficient
- Finally for some areas however, we may see some level of *disruptio*n.



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NY - Joint Utility Blockchain Alignment (JUBA) Phase A

Purpose

- As blockchain technology implementations benefit from collaboration in both their use and design, the participating New York utilities are working together to understand the technology and explore how it could support shared infrastructure.

Schedule

- To achieve this, the group embarked on a 3 month + exercise with four major phases:
    1. Blockchain in Energy Introduction and Alignment
    2. Use Case Identification
    3. Use Case Selection & Design
    4. Joint Strategy & JUBA White Paper
- Central to achieving this scope was a series of workshops, held over the course of the phases.

Use Cases & Process

- We evaluated use cases in groups across organizations to identify priority use cases and high level requirements before examining specific Blockchain technologies.
- The final use case groups are Customer Management, Clearing and Settlement, Decentralized Markets, Cyber Security, DER Management, and Electric Vehicles.
- Our research inputs included external calls with vendors and thought leaders and a blockchain startup pitch day.

Project Infrastructure

- For ongoing collaboration between the utilities, the project is managed through an online wiki space in which participants collaborate.
- Indigo, a NY based blockchain and energy consulting company, is managing the workflow.

Members

- There are four members of JUBA: Avangrid, Con Edison, New York Power Authority, and National Grid, with 20+ stakeholders from a range of disciplines involved.

AVANGRID conEdison New York Power Authority nationalgrid

Moving From Phase A to Phase B

Phase A - Education, Opportunity Identification, Alignment and White Paper

Phase Gate

Phase B Deliver PoC

Phase Gate

Phase C - Field Trial

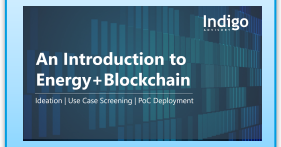
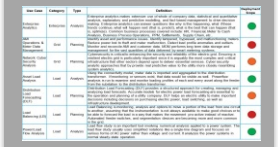
Phase

1. Blockchain in Energy Introduction	2. Use Case Identification	3. Use Case Selection/Design	4. Joint Strategy & White Paper	5. PoC Delivery	6. Field Trial

Phase Activity

• Align on the theoretical, business and technical aspects of blockchain technology, its state-of-the-art, current challenges or pitfalls and its potential in the electricity sector.	• Identify and analyze suitable blockchain use cases for the JU across utility shared infrastructure with an emphasis on innovation.	• Prioritize the use cases and design the PoC incl. actors involved, scope, budget, human and technical capabilities required, schedule, market maturity etc.	• Recommendation of a broader blockchain strategy for NY Utilities including JU White Paper for presentation to DPS and other key stakeholders.	• Finalize technical requirements, Conduct RFI / RFP process and launch PoC delivery phase, launch ticketing system and project cadence, agile delivery.	• After a PoC – project manage the process to putting real data into production in a small contained field trial (PoC is assumed to be cloud / sandbox)

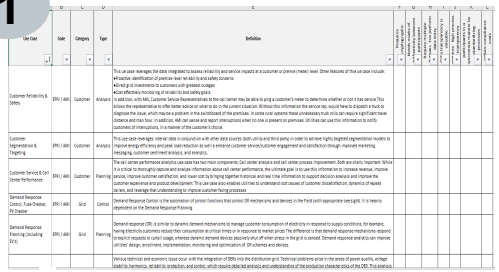
Deliverables / Outcomes

Blockchain Education 	Energy Blockchain Use Case Repository 	Select Use Case 	Blockchain Strategy 	Requirements Document 	Implement Use Case 
Launch JU Wiki 	Use Case Screening 	Functional Requirements 	JU White Paper 	Action Plan 	Move from PoC to Trial 

How We Collected these Processes and Developed Use Cases

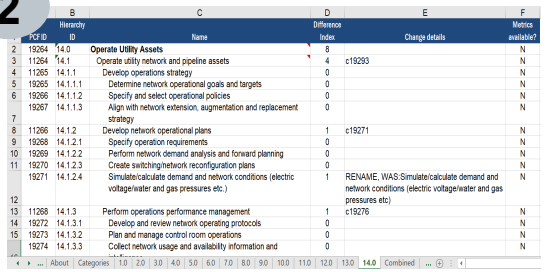
Use Case Repository- EPRI Intelligrid

1



American Productivity & Quality Center – Utility Specific Process Classification Framework

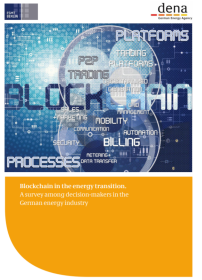
2



	B	C	D	E	F
	Hierarchy		Difference		Metrics
	PCF ID	ID	Name	Index	Change details	available?
2	19264	14.0	Operate Utility Assets	8		N
3	11264	14.1	Operate utility network and pipeline assets	4	c19293	N
4	11265	14.1.1	Develop operations strategy	0		N
5	19265	14.1.1.1	Determine network operational goals and targets	0		N
6	19266	14.1.1.2	Specify and select operational policies	0		N
7	19267	14.1.1.3	Align with network extension, augmentation and replacement strategy	0		N
8	11266	14.1.2	Develop network operational plans	1	c19271	N
9	19268	14.1.2.1	Specify operation requirements	0		N
10	19269	14.1.2.2	Perform network demand analysis and forward planning	0		N
11	19270	14.1.2.3	Create switching/network reconfiguration plans	0		N
12	19271	14.1.2.4	Simulate/calculate demand and network conditions (electric voltage/water and gas pressures etc.)	1	RENAME, WAS:Simulate/calculate demand and network conditions (electric voltage/water and gas pressures etc)	N
13	11268	14.1.3	Perform operations performance management	1	c19276	N
14	19272	14.1.3.1	Develop and review network operating protocols	0		N
15	19273	14.1.3.2	Plan and manage control room operations	0		N
	19274	14.1.3.3	Collect network usage and availability information and	0		N

Industry examples e.g. dena blockchain report from German utilities

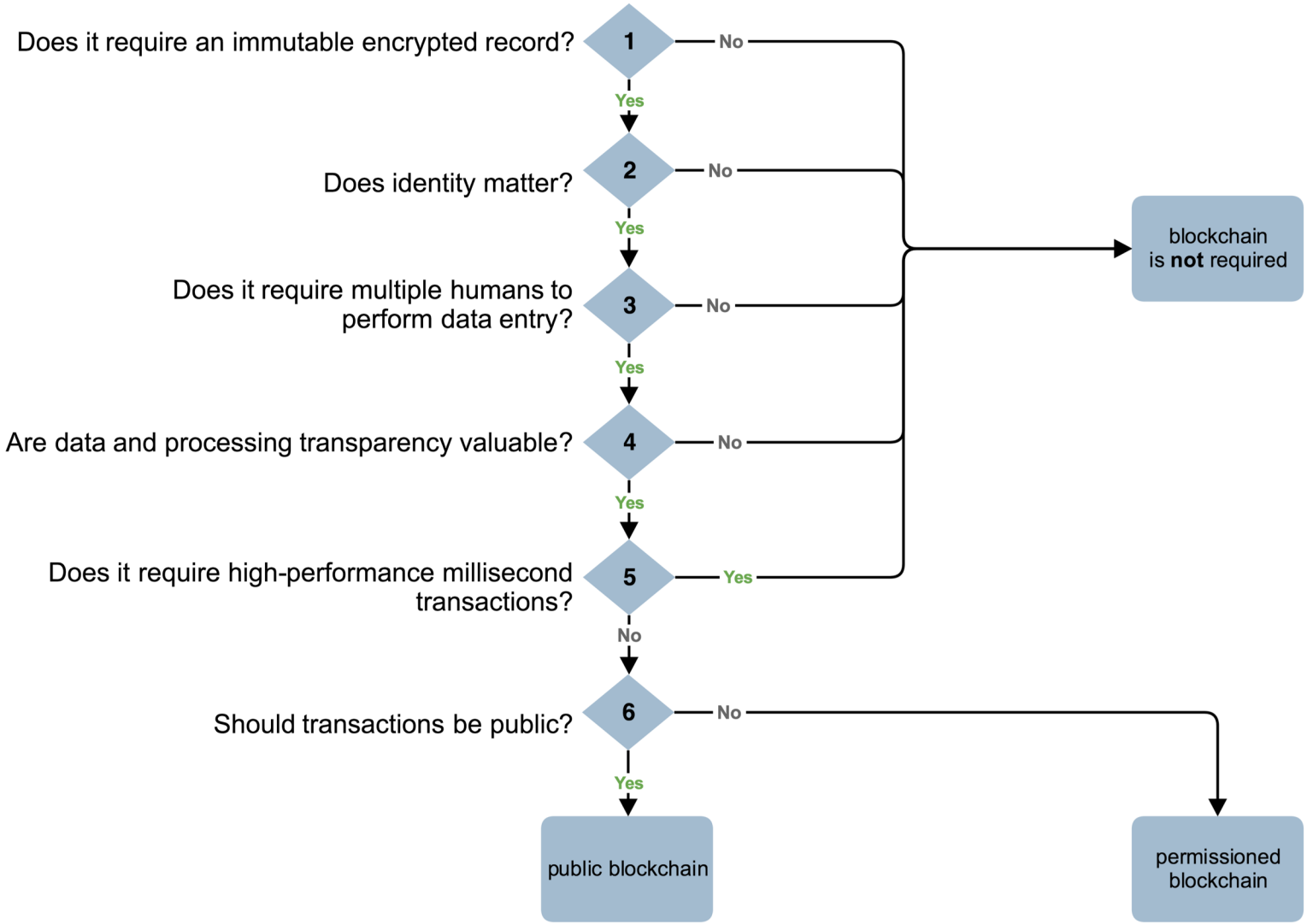
3



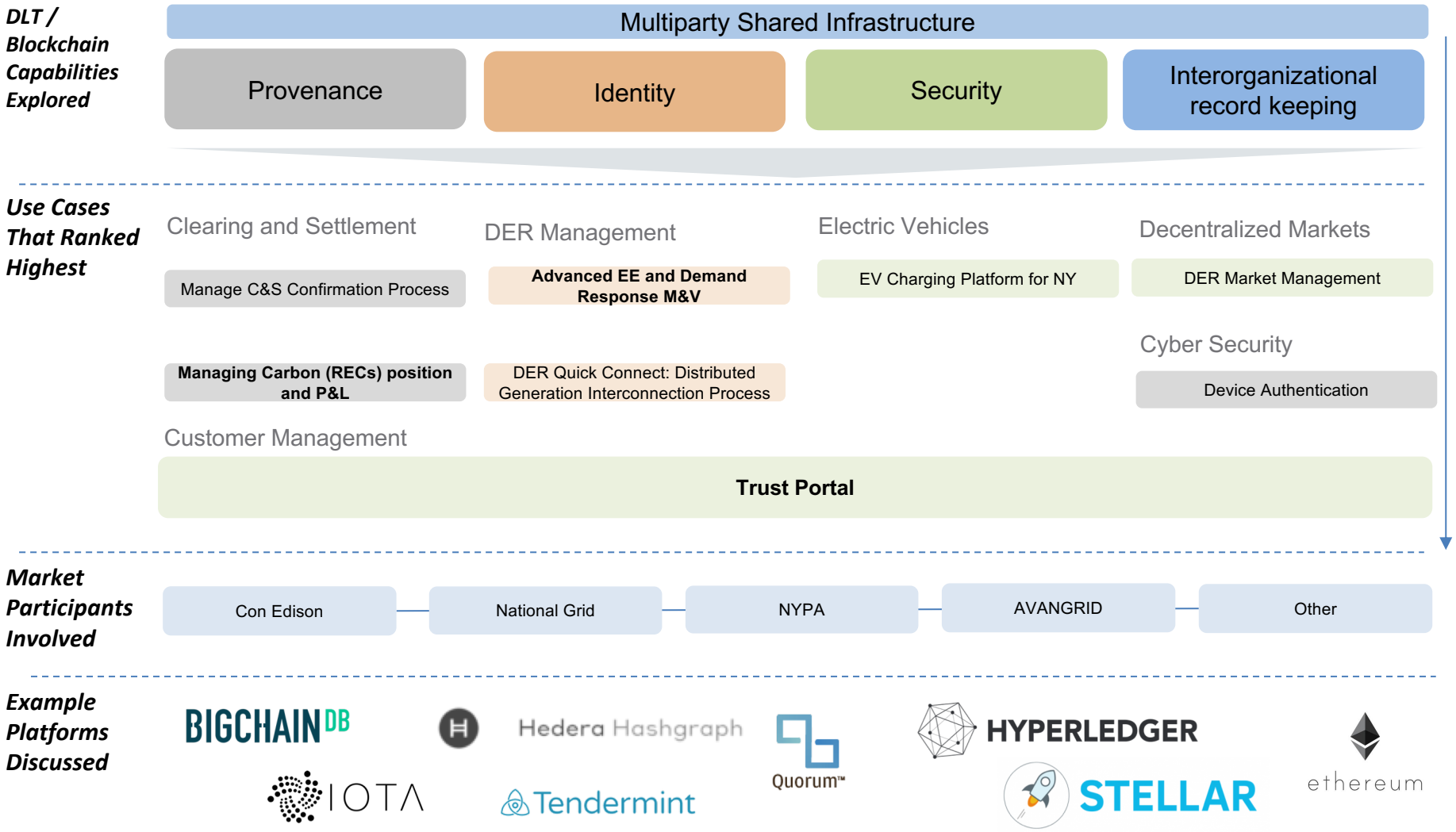
After evaluating this comprehensive set of processes and their use cases against weighted screening criteria, there are three use cases that ranked on top across our criteria:

- **Customer Trust Portal** — secure customer data sharing with third parties
- **Advanced EE and DR M&V** — recording standardized savings calculations
- **Managing Carbon (RECs) position and P&L** — enables DER certificate aggregation

Blockchain Specific Decision Tree



The Overall Outcome of Our Use Case Selection and Analysis



Moving a Use Case from Idea Through to Production

There are 4 typical steps for energy companies to launch a blockchain program

1. Use Case Identified

- Utilities that have identified a use case for a blockchain implementation will either **look to vendor** partners for a product that fits the bill, or will work to develop the technology **internally**.
- The typical next step here is to identify an architecture to address the use case. Most utilities have chosen to contract for outside help with blockchain. At this stage, a utility will also need to make a decision on a **preferred blockchain platform** be that for example Ethereum, Hyperledger, BigChain, or Tendermint.

2. Proof of Concept

- Typically, the proof of concept stage for a blockchain implementation is a **one- to-three-month exercise**. Best practice is currently to create a system that integrates into an isolated sandbox environment with a utilities data.
- In this manner, you get to see the software operate in a **simulated environment** with real customer or operational data. Importantly, this does not impact customers, but it does involve real customer or operational data and real transaction volumes.
- We recommend a cloud based solution (private or permissioned blockchain cloud) as the best venue for a blockchain proof of concept as simulations can be created without worrying about hardware or about impact to a utilities' existing network. The cloud also makes sense at this stage if there are **multiple organizations** participating in the proof of concept.

3 Field Trial

- After the PoC, the next step is to start putting real data into production in a small contained trial. In this field trial, a limited-production run with customer-facing data is stepped up to involve more customer-facing products and data volumes. This typically means a small trial with perhaps **5% of customers or operational areas**. The field trial isn't simply a proof of concept moved to production but rather a restart.
- A field trial might have completely different requirements than a POC. Once a utilities becomes comfortable with the software they're using and are happy with the testing process, they may choose to implement blockchain projects on on-premises hardware rather than in the cloud.

4. Full-Volume Production Roll-Out

- At this stage of the technologies development no utilities have reached Stage 4. **The vast majority are still in phase 2.**

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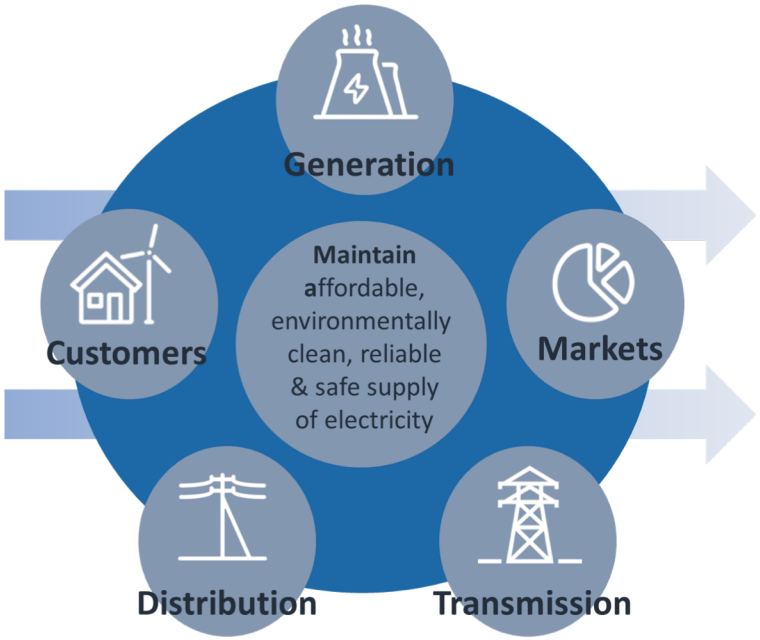
Benefits and Challenges of Blockchain in Energy and Utilities

Benefits of blockchain technology…

- Faster transactions and lower transaction costs
- Disintermediation & trustless exchange
- Empowered users
- High quality data
- Reliability, longevity and durability
- Process integrity
- Immutability and transparency
- Market and eco-system simplification



…challenges of blockchain technology

- Standards needed
- Nascent technology
- Uncertain regulatory status
- Large energy consumption
- Cost
- Control, security, and privacy
- Integration concerns
- Cultural adoption
- “Magic Middleware in the Cloud”

8 Blockchain and Energy Trends to Watch for the rest of 2018…

1. Service providers will continue to **focus on core infrastructure** such as protocol development and network development, however, much more time will be focused on actual application development to make use cases real for the sector

2. Further **sophistication in architecture** will emerge particularly around considerations such as reducing data stored on-chain and support for multiple consensus algorithms (‘pluggable consensus’)

3. The debate between open (public permissionless, public permissioned) and closed (consortium, private permissioned / enterprise) blockchains will continue with an emphasis on more **blockchain interoperability**

4. On the regulatory front we are expecting to see lessons learned from the **‘regulatory sandboxes’** that have been created by Ofgem in the UK and by Singapore’s EMA

8 Blockchain and Energy Trends to Watch for the rest of 2018 (Cont.)

5. There will be more **maturity around functional and technical requirements** and further scrutiny between using relational databases and other solutions and true blockchain solutions

6. With regards to use cases, we expect to see much more focused activity in the areas of **consortium blockchains** in wholesale market trading and demand response, EV infrastructure / EV Roaming applications, trading of renewable credits, cybersecurity and new business models in P2P trading

7. The idea of **convergence solutions** will also start to take hold where blockchain, robotics and AI solutions will combine with OEMs, DER manufactures, infrastructure providers and existing applications to further innovate energy platforms of the future

8. Finally, we expect to see much **more activity in the US** next year and rise of further geographic consortia emerge

Indigo
ADVISORY


insights@indigoadvisorygroup.com


+212 203 6144


www.indigoadvisorygroup.com


@indigoadvisory


linkedin.com/company/indigo-advisory-group