Using blockchain tech to decarbonize, digitize, and decentralize electric grids worldwide

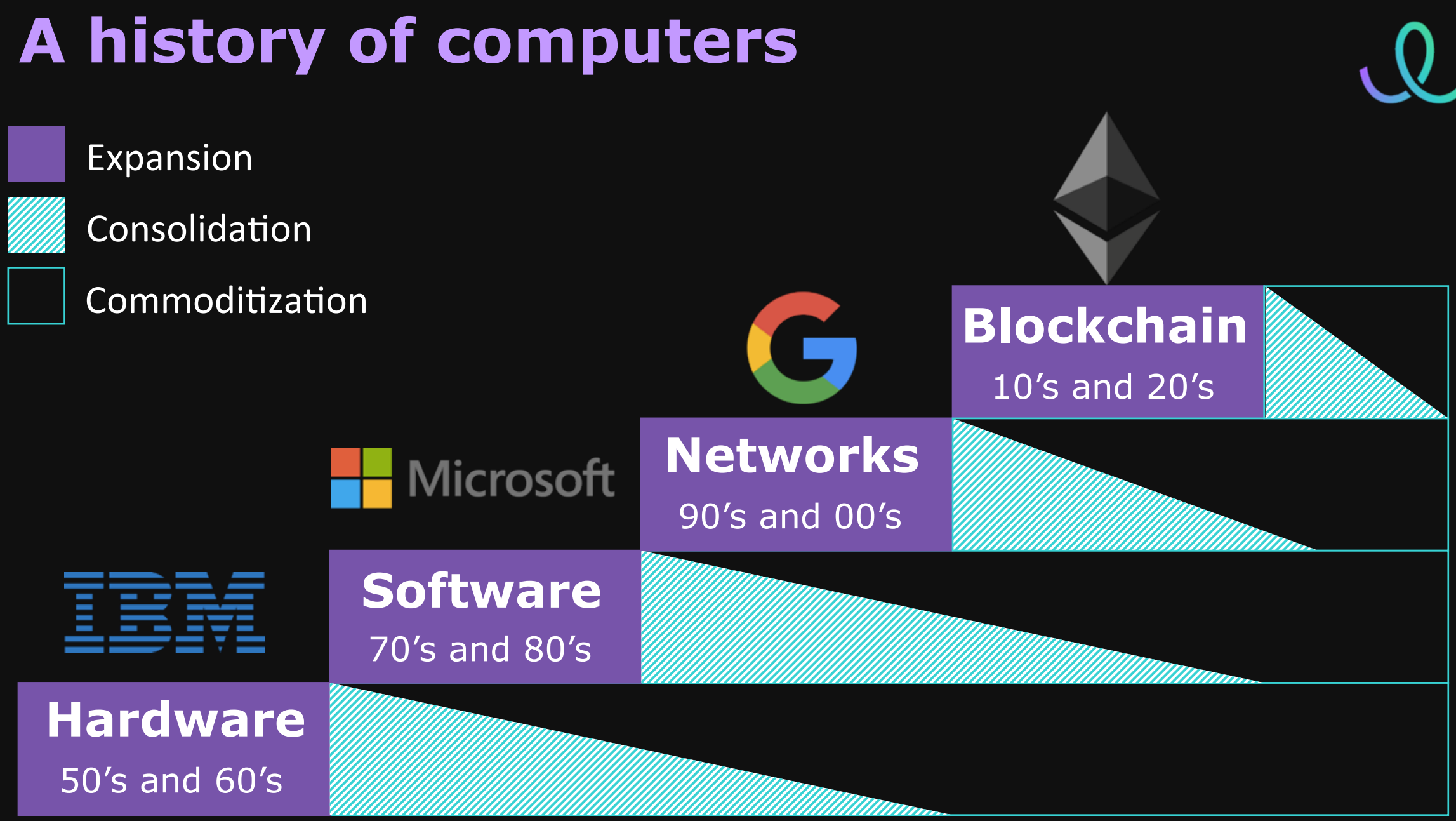
30 October 2018

Presentation for *Transportation Supercluster Monthly Review*

Doug Miller

energy web
FOUNDATION

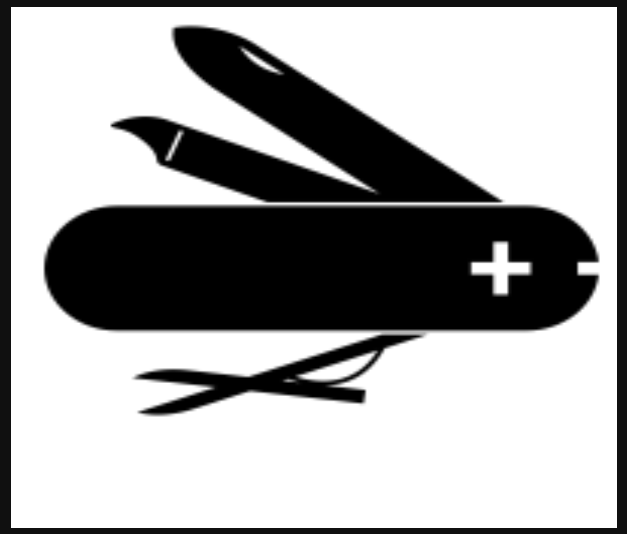
A history of computers



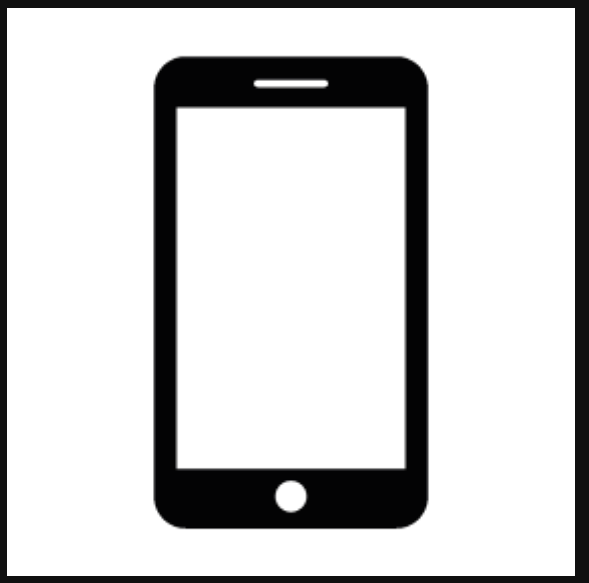
Blockchains are decentralized networks

Time

Single Purpose



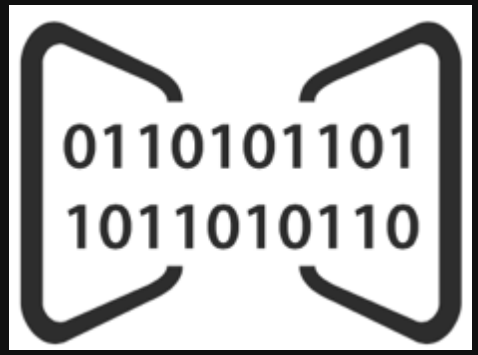
Multi-Purpose



ANY purpose

Blockchains are decentralized ~~networks~~ *computers*

Interactions



Create user accounts

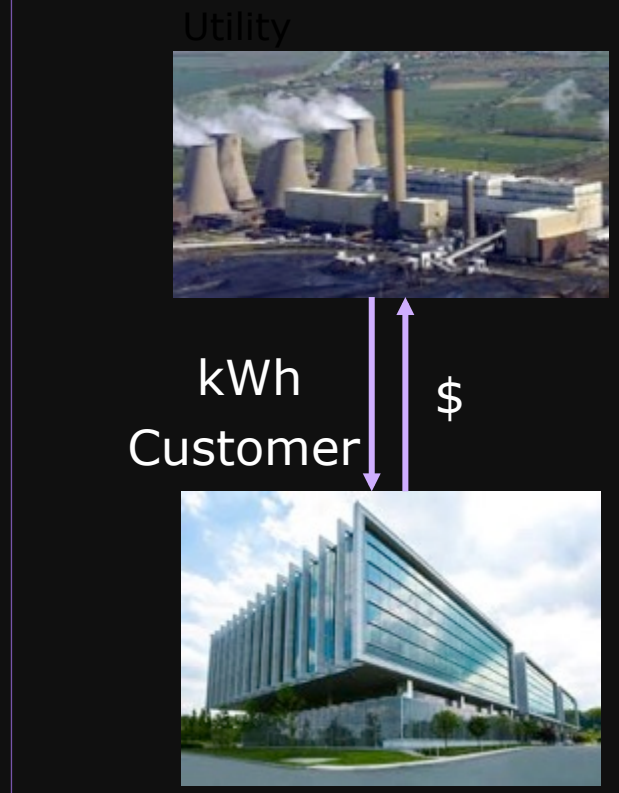
Read and write data securely

Write and run programs

The Energy Transition

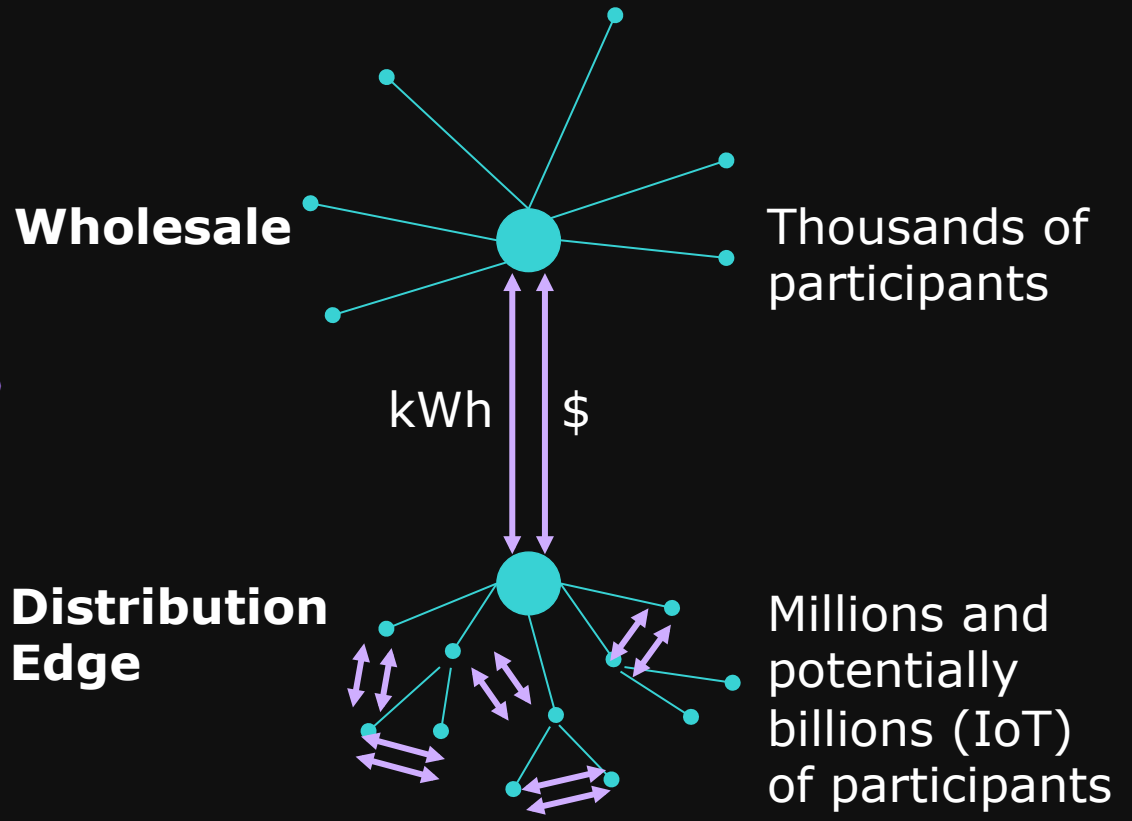
20th-century models clashing with 21st century technologies

Legacy system architecture



Unidirectional flows of electricity and money

Emerging system architecture



Multidirectional, complex flows of electricity and money

Blockchain's value proposition: digital DNA for the energy sector

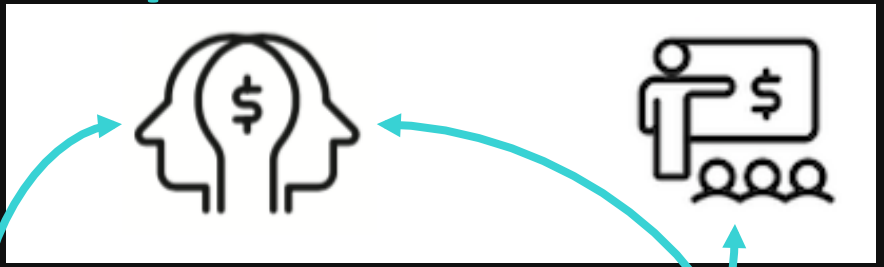
- Trustless
- Guaranteed
- Tamper-proof
- Automatic

Agreement

+

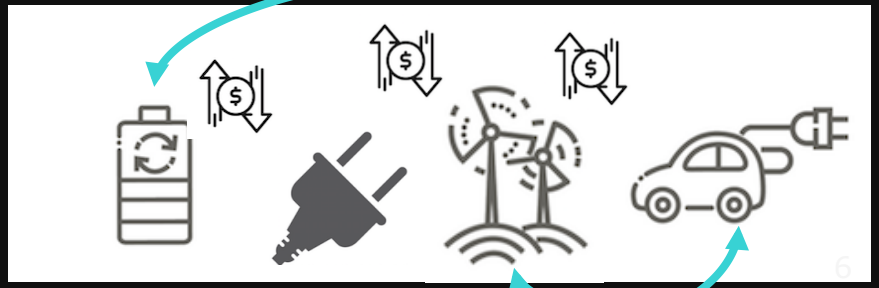
Execution

People



Organizations

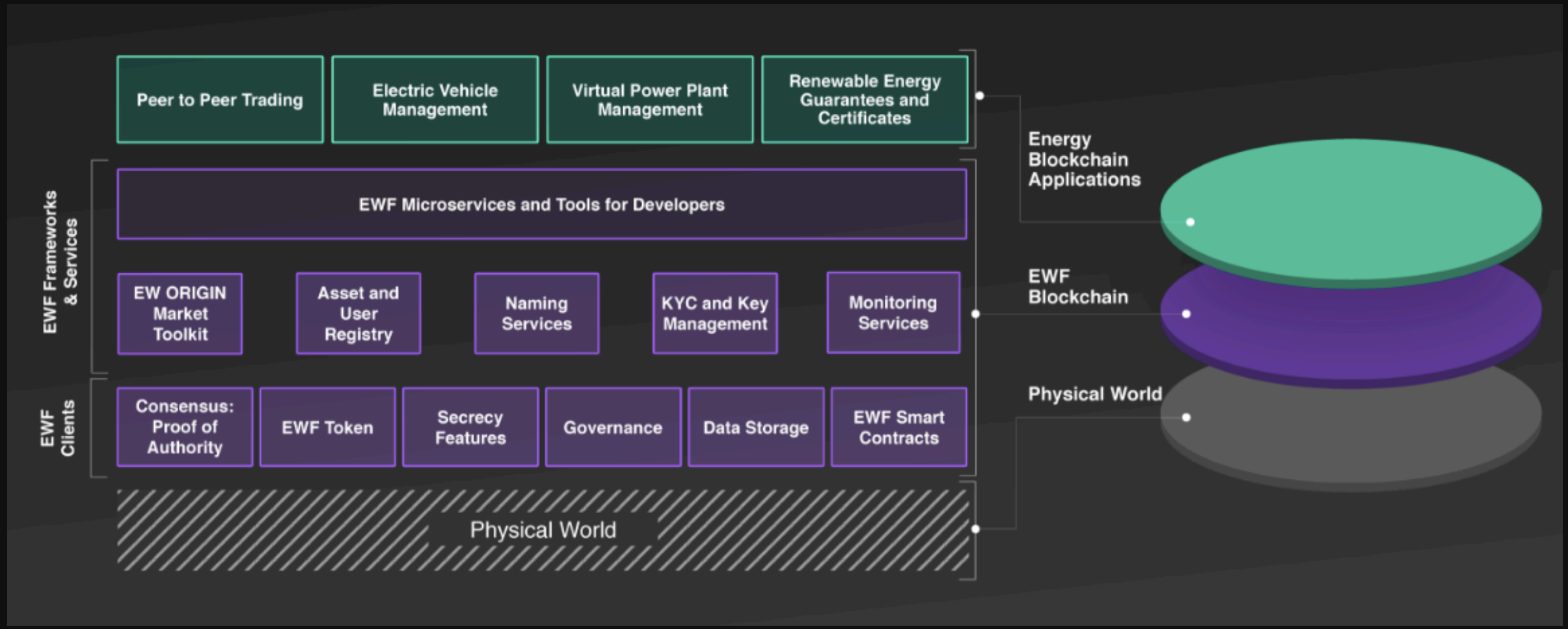
Machines



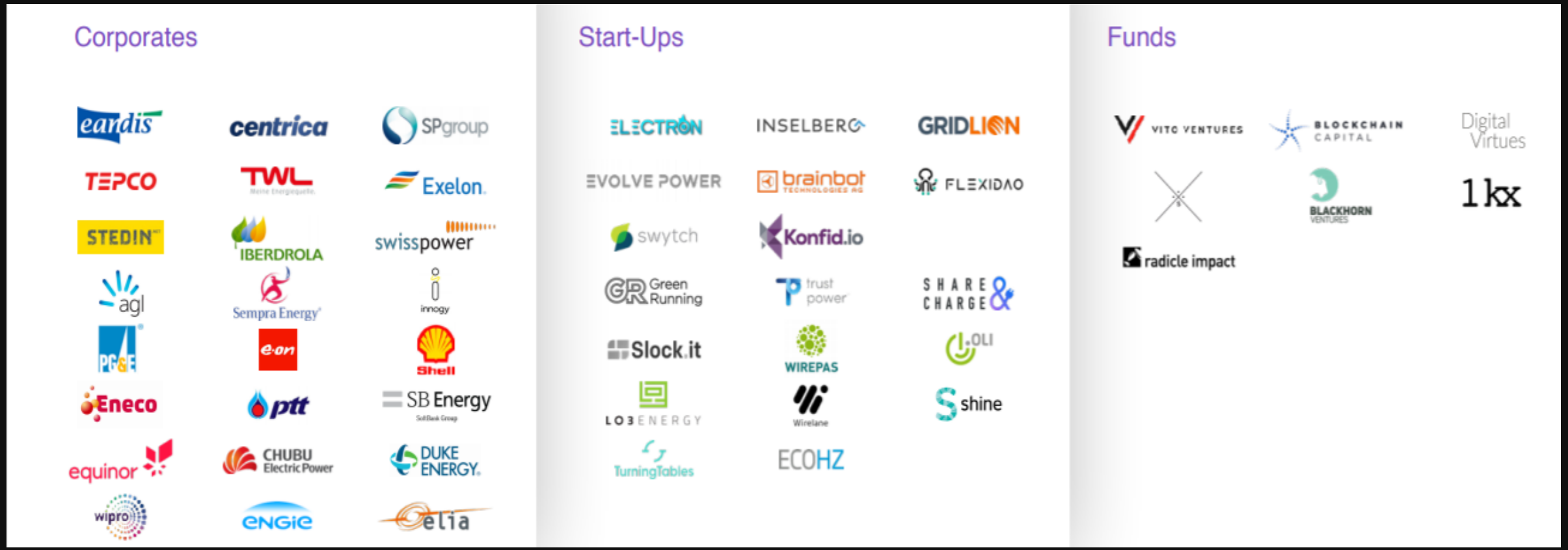
Energy Web Foundation (EWF) is leveraging blockchain to enable and accelerate the global clean energy transition

EWF's mission	**Enabling and accelerating the transition to a democratized, decentralized, decarbonized, and digitized electricity grid**. EWF achieves this by creating the virtual infrastructure—a shared digital DNA for the global energy industry—that serves as its foundation.			
Pillars of EWF's work	**Core Technology** Developing a high performing core blockchain technology fit for energy sector applications	**Ecosystem** Facilitating, educating, and incubating a diverse ecosystem in support of the technology	**Regulatory Engagement** Educating and engaging with regulators to inform regulatory integration	**Application Acceleration** Supporting EWF Affiliates to launch early applications and spur market growth

EWF is developing core infrastructure and services for blockchain in energy

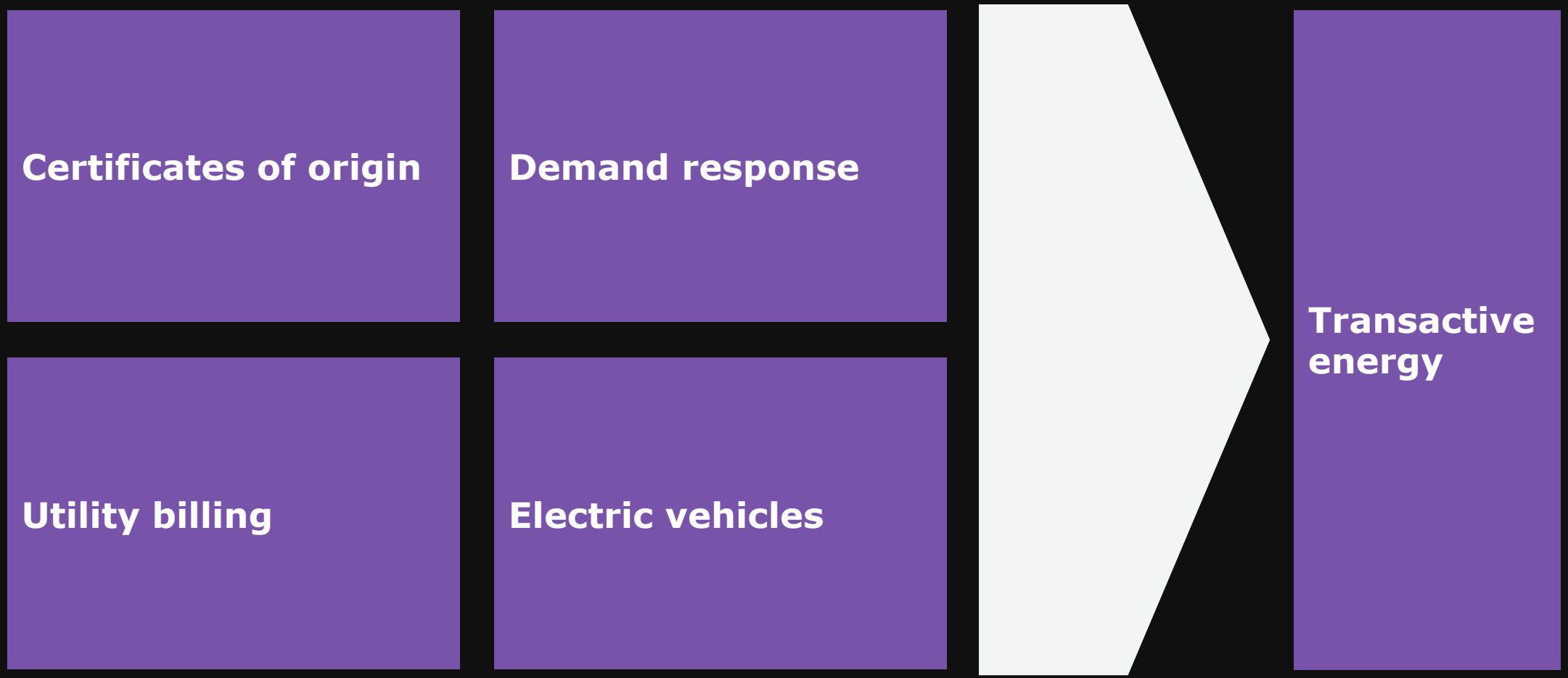


EWF has assembled an ecosystem of 70+ market participants from across the globe



EWF is accelerating the development of the most valuable blockchain-based energy sector dApps

EWF's ecosystem has prioritized these five application domains:



EWF is supporting 15+ Affiliate projects in 5 use case domains

Certificates of Origin	ENGIE, ORIGIN, Statoil, SPgroup, Exelon, ptt Group	• End-to-end decentralized application enables any trusted renewable generator to sell green attributes peer to peer over blockchain. • Multiple market demonstrations at Event Horizon 2018
Demand Response	elia, TWL Meine Energiequelle.	• Automate contractual relationship management, measurement & verification, and financial settlement • Reduce time from 2 months to minutes
Utility Billing	centrica, e·on, TEPCO	• Decentralized meter registry with digital ID to track relationships between consumers, meters, and buildings
Electric Vehicles	SHARE & CHARGE, PG&E	• Inter-network charging settlement; creating certified "green product" at charge points; enabling peer-to-peer charge sharing to increase asset utilization
Transactive Energy	STEDIN.NET	• EWF building open-source TE simulation environment • Stedin working on layered energy system demonstration project in 2018

EWF has shared v1 of EW Origin with the public and showcased several pilots—with more currently in development

Use scenario	Generator		Buyer
Green attribute ownership transfer based on demand of buyer	Engie	→	Microsoft
	SP Group	→	DBS
	TWL	→	E.ON
Consumption-based ownership transfer	German households	→	Grid Singularity
Tracking battery off-take vs. injection	Sonnen	→	Sonnen

These examples involved real companies with real physical assets and actual, real-time generation and consumption data, but no financial transfer

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EW Origin is an end-to-end, open-source, blockchain-based toolkit for REC, GO, I-REC trading, tracking, and reporting

Key benefits of EW Origin		
Hourly kWh data uploads	Disintermediated and consistent UX	Greater automation
Interoperability with EVs, batteries	Plug-and-play adaptability	Aggregation and other new features
Avoided marginal CO_2 emissions info	Lower transaction costs	Reduced barriers to entry

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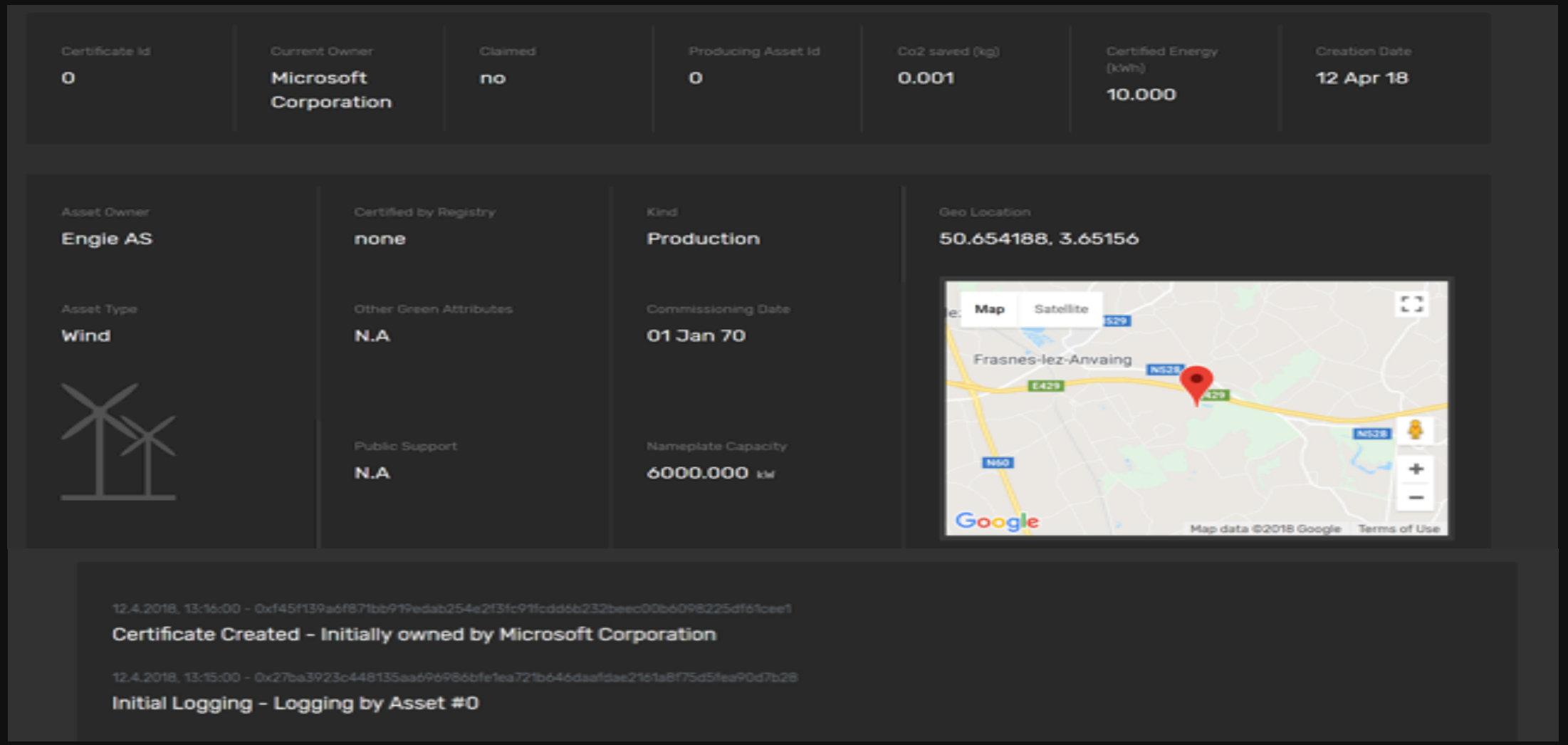
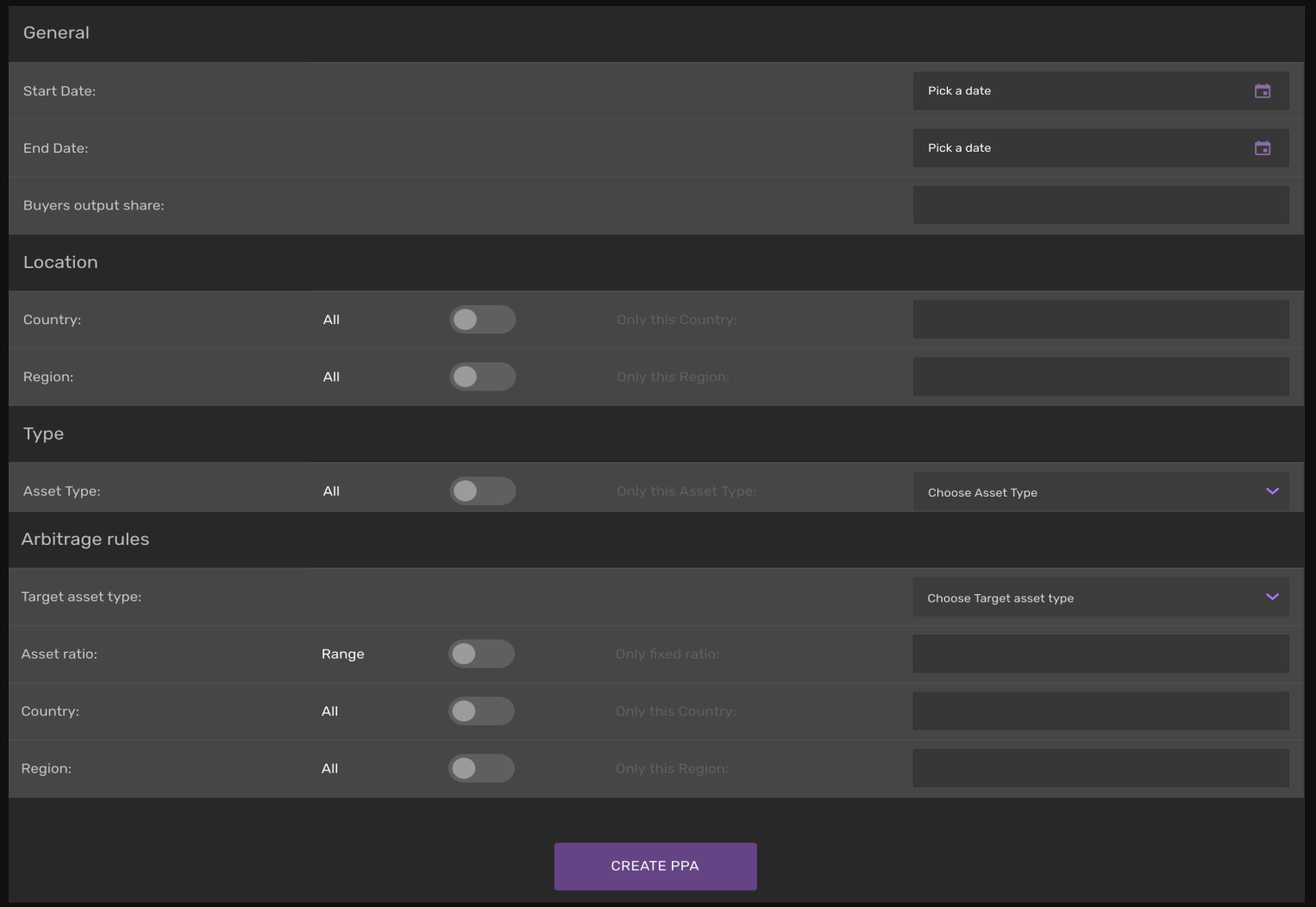
EW Origin enhances transparency, modernizes user experience, and increases access for renewables markets



EW Origin will support advanced deals like PPAs and enable aggregation for smaller market participants



EWF is developing an open-source reference implementation of the EW Origin toolkit for PJM GATS in collaboration with PJM EIS

EW Origin "Market Toolkit"
Framework and tools providing various features for a marketplace for trading RECs, GOs, and I-RECs

EW Origin "Issuer Toolkit"
Framework for issuing and tracking ownership for RECs, GOs, and I-RECs at the kilowatt-hour (kWh) level

EW "Registry"
The global EWF asset registry where all assets, devices, and users are documented and where the provenance of renewable production information at the kWh level are documented

EW Origin Full Reference Implementation
Combines the Market Toolkit, Issuer Toolkit, and Registry in a single reference implementation in one market that ultimately any issuing body or registry can reference, modify, and adopt

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Research efforts are underway

- EWF collaboration to perform hardware-in-the-loop testing & grid simulations
- Demonstrating device-level blockchain transaction capabilities

- Independent research & publications on blockchain's cybersecurity benefits
- EWF performing advisory role on keyless signature infrastructure project

- D3A: decentralized, recursive grid simulation
- LINK: Device connection standards & architectures

Q&A

- **What questions do you have about EWF or EW Origin?**

Thank you!

Doug Miller
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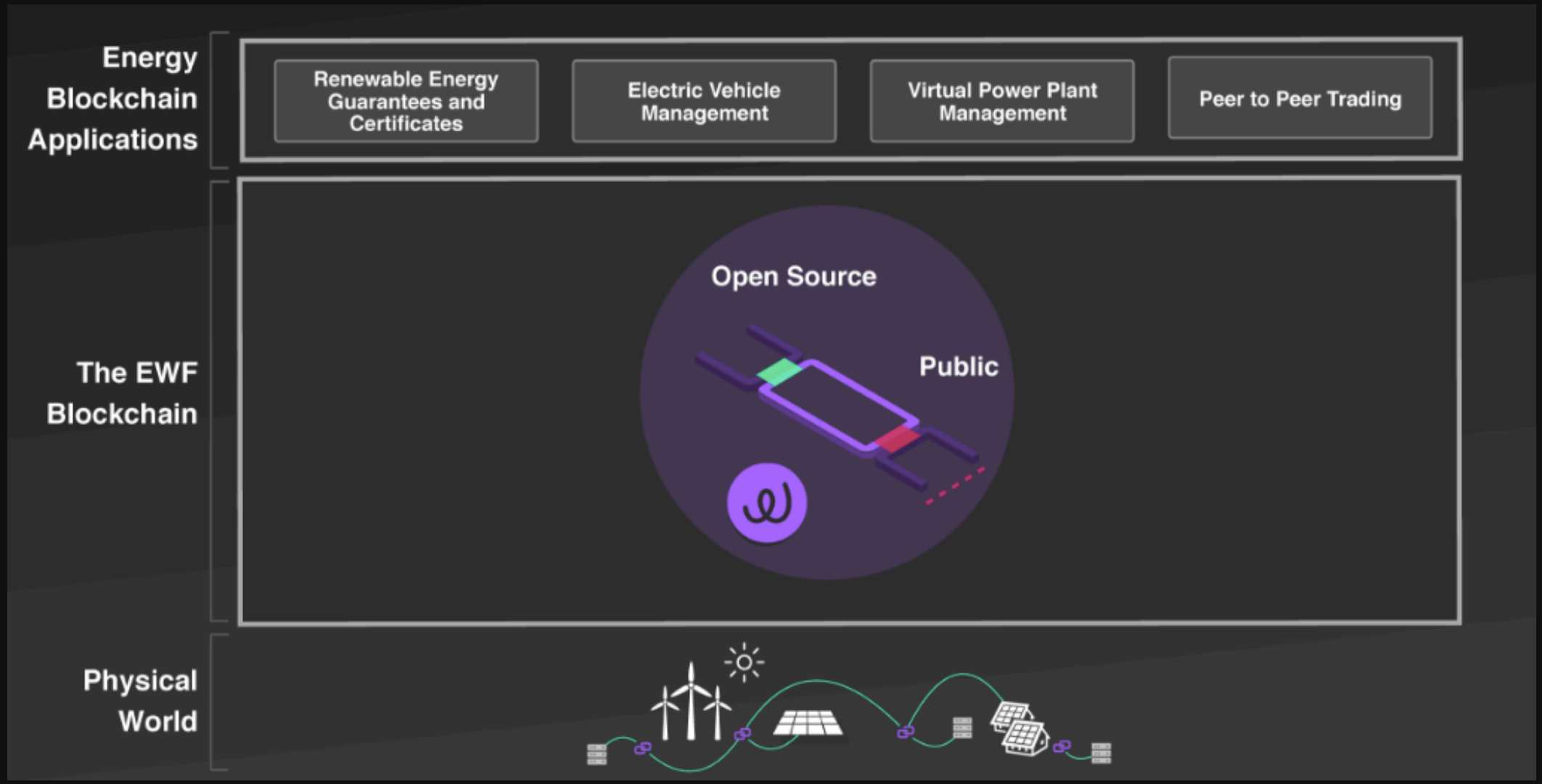
Appendix

The overall energy-blockchain technology stack



Three things to consider when selecting use cases

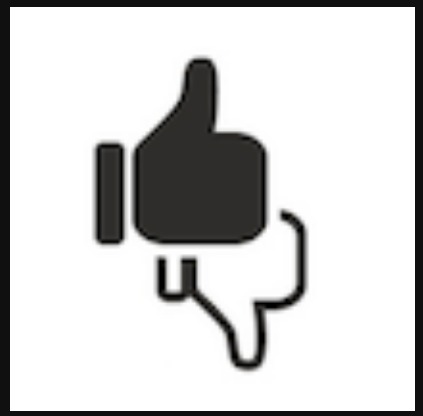
1	Are there multiple parties that need to **validate**, and **act upon**, data? ✓
2	Is it market-stifling for a single entity to "own" data? ✓
3	Does a decentralized architecture provide **efficiency**, **cost**, and/or **resilience** benefits? ✓

How much time, money, and effort is spent...

Performing M&V

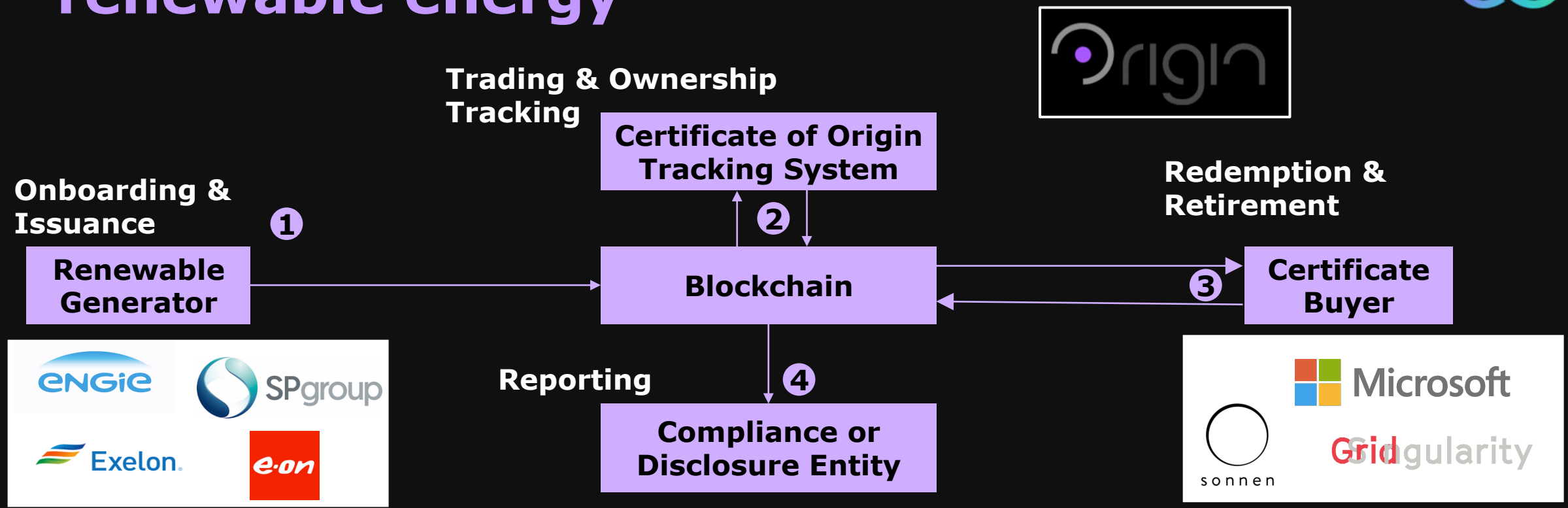
Verifying & enforcing contracts

Reconciling data between parties



Performing financial settlement & billing

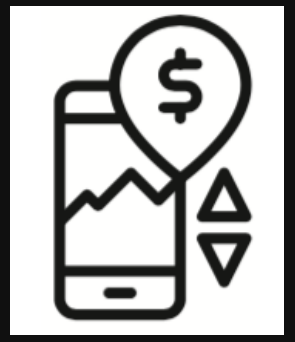
Expanding and simplifying the market for renewable energy



- Lower transaction costs
  - Faster execution (minutes - not weeks)
  - Reduced working capital requirements
  - Reduced labor
- Increased transparency
- Increased cyber-security

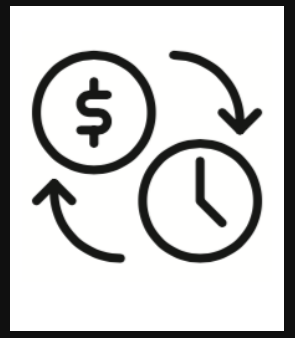
- **Expand market participation on both buyer and seller side**
- **Incentivize development of RE with particular attributes**
- **Improve auditing of CO2 emissions and RE generation – without NEM**

Supporting new EV products and services



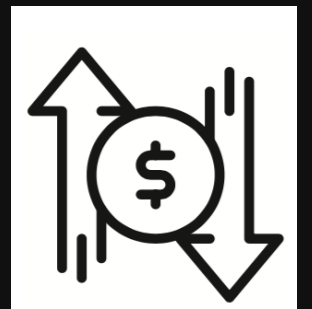
Open-source settlement engine for inter-network charging

Premium green product driven by traceable CO/ RECs



Advanced pricing (LMP+D) and automated demand response

Peer-to-peer charging & mobility services



Seamless e-mobility experience for customers

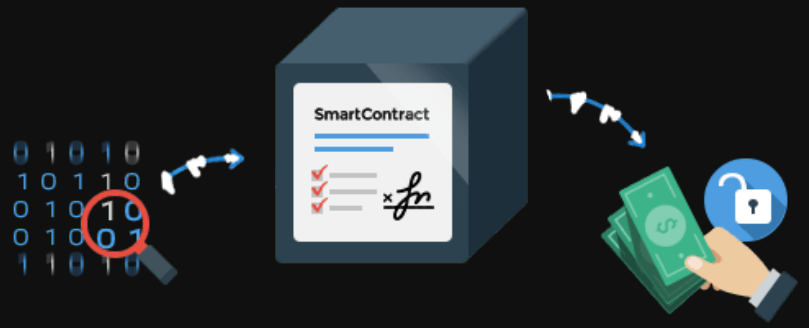
Streamlining contract management and settlement in electricity markets

Demand Response

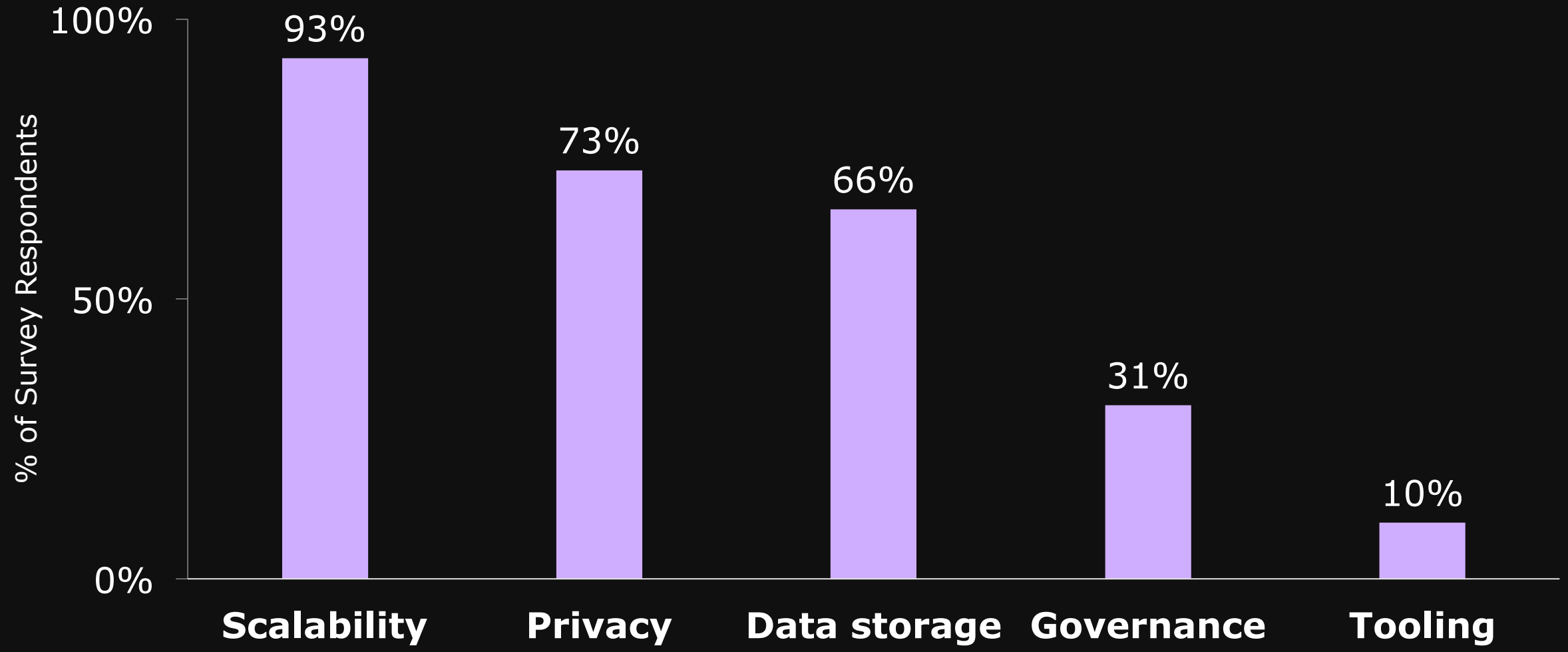
- Reconcile contractual, M&V, and performance data between flexibility resources, aggregators, DSO, and balancing parties
- Reduce settlement time from 2+ months to < 1 day
- **Lower overhead costs → expand market participation to larger number of smaller resources**

Distribution Networks

- Localized peer-to-peer day-ahead market model enabling customers to monetize at two campus facilities
- Using data from wifi connected home devices (Battery, PV, Dishwasher etc.)
- Match bids and execute settlement between peers and DSO

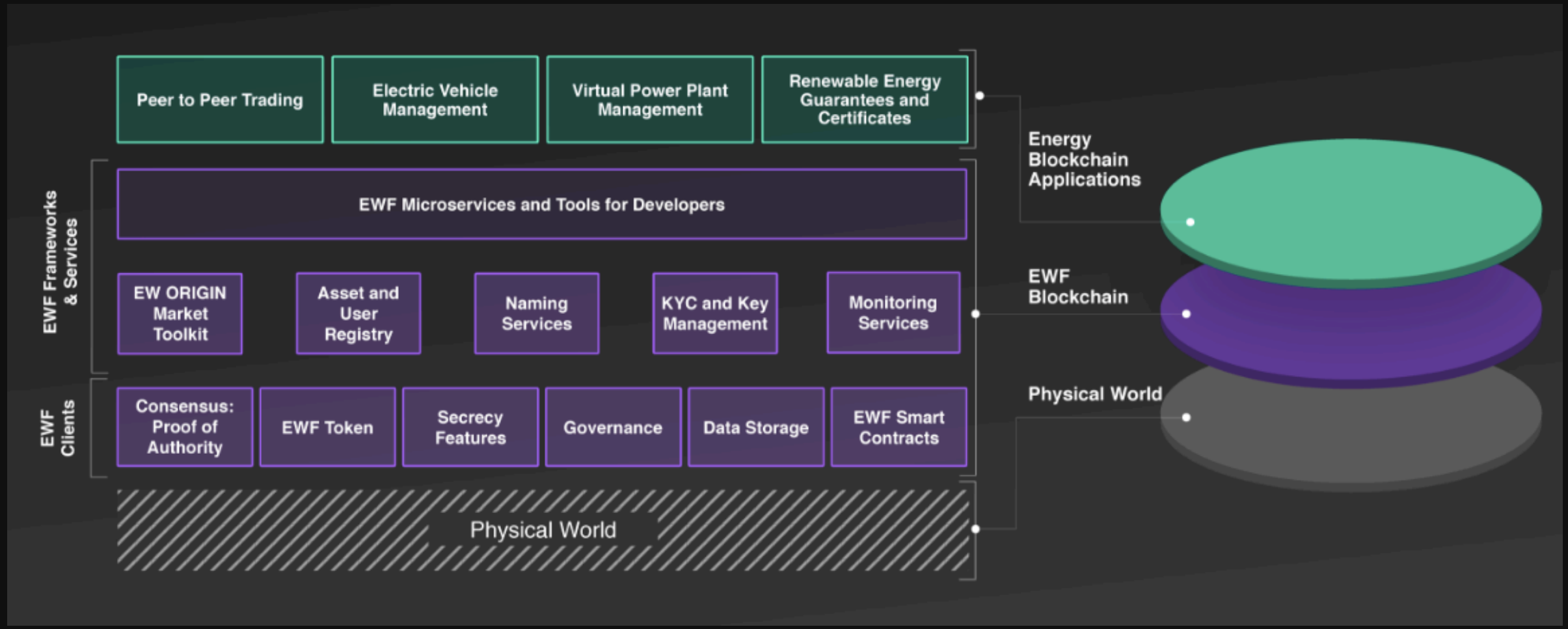


Technical challenges currently inhibit mass adoption of blockchain applications



Source: EWF Survey results from 93 blockchain / energy startups

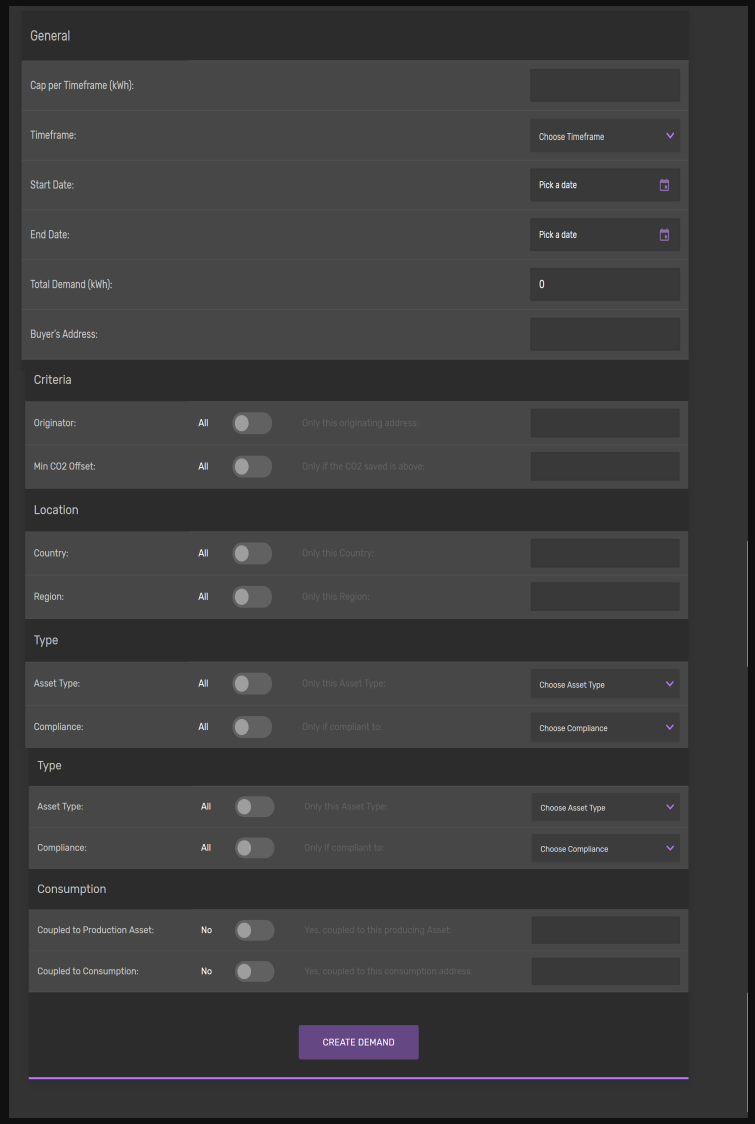
EWF is developing core infrastructure and services for blockchain in energy



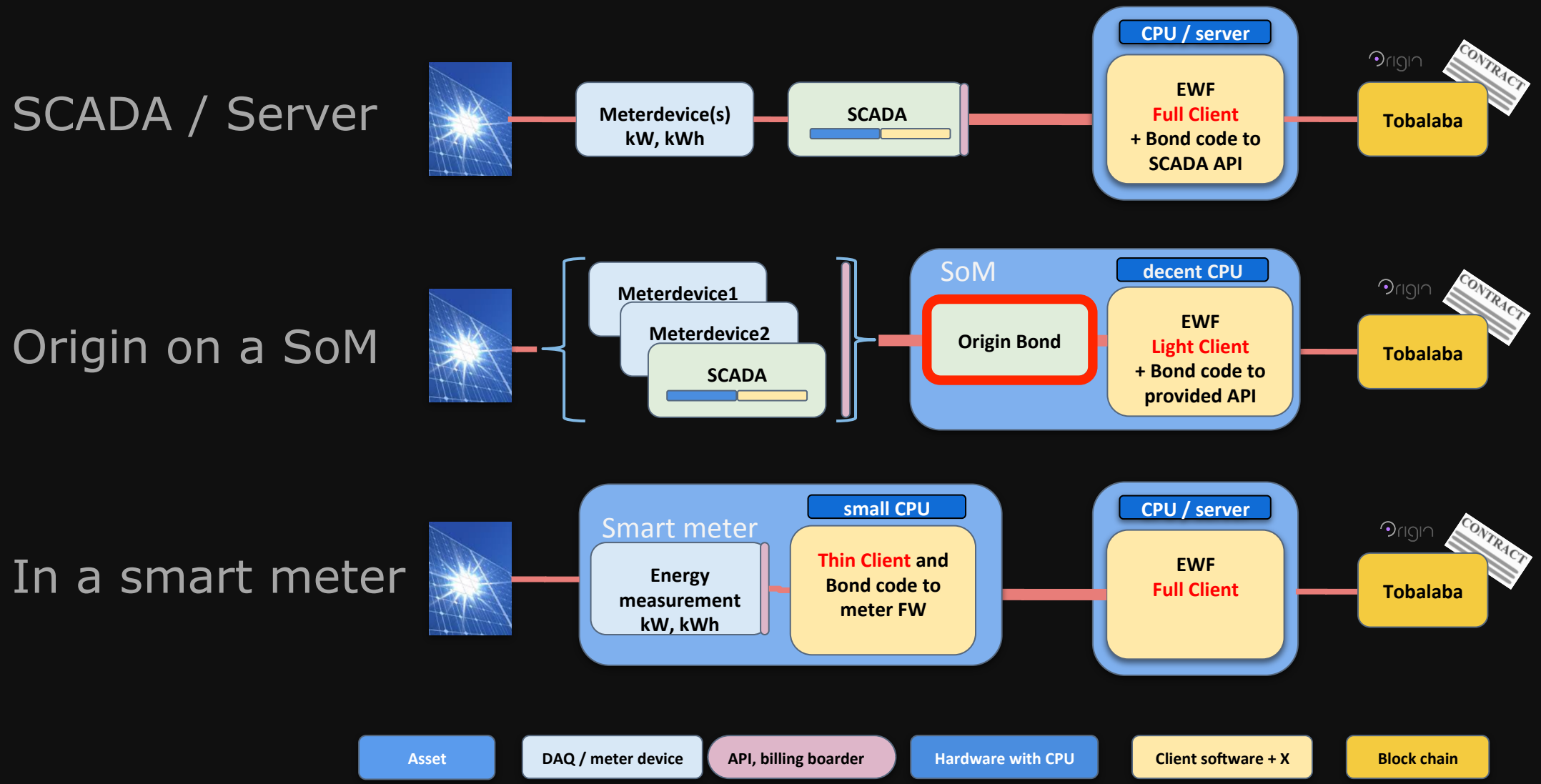
EWF released v1 of EW Origin in April 2018

Current EW Origin Capabilities

1. Onboard renewable generation and energy consumption assets
2. Onboard generators and buyers
3. Onboard renewable energy demands
4. Upload kWh generation data (“tags”)
5. Transfer ownership of available tags by matching with onboarded demands
6. Claim (and retire) tags
7. Generate certificate from claimed tags
8. Send reports containing certificate(s)

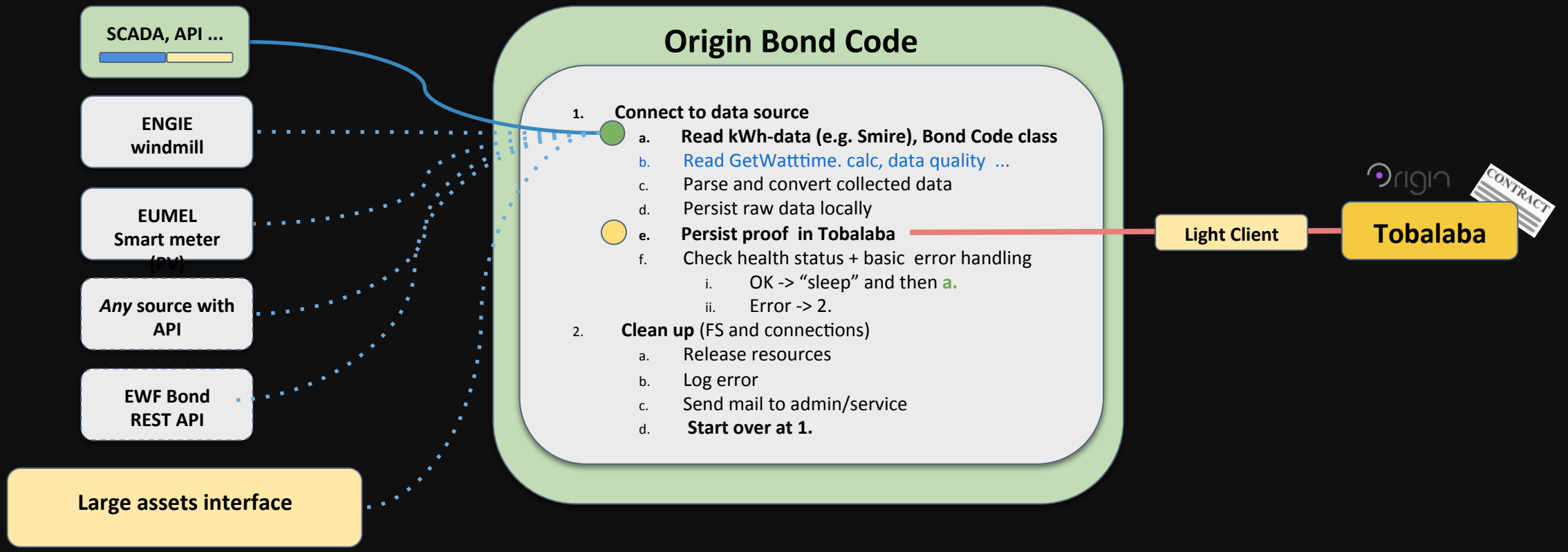


EWF developed reference implementations for different device connection scenarios



EWF has cultivated strong interest in EW Origin pilots among Affiliates and others

The EW Origin Bond Code takes energy data at kWh level and puts persistent data on light client

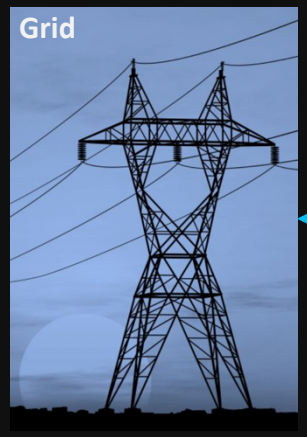


-> A sequencer with a modular energy data interface

EWF is using the Artik 710 device as a powerful SoM to securely host the EW Origin bond code and EWF light client

Processor	
CPU	8x ARM® Cortex®-A53@1.4GHz
GPU	3D graphics accelerator
Media	
Camera I/F	4-Lane MIPI CSI
Display	4-Lane MIPI DSI up to FHD@24bpp
Audio	I²S audio interface
Memory	
DRAM	1GB DDR3 @ 800MHz
FLASH	4GB eMMC
Security	
Secure Element	Secure point to point authentication and data transfer
Trusted Execution Environment	Trustware
Radio	
WLAN	IEEE 802.11a/b/g/n/ac
Bluetooth	4.1 (Classic+BLE)
802.15.4	ZigBee/Thread
Power Management	
PMIC	Provides all power of the ARTIK 710 Module using on board bucks and LDOs
Interfaces	
Analog and Digital I/O	GPIO, I²C, SPI, UART, SDIO, USB 2.0, JTAG, Analog Input

EWF is using ResinOS to support EW Origin bond code, EWF light client, and "watchdog"



Metering

Any **ORIGIN** ernery data source/sink with verified metering

kWh

Artik710

Origin Bond Code
Container 1

Watchdog module
Container 2

Light-Client
Container 3

Tobalaba

Persistend data: Config files + ID
- all private stuff (Node ID, 0x0deadbeaf…)
- local kWh history storage, status, error log, ...
Shared data volume 1

resin.io device supervisor

resin os

balena
Docker-compatible, edge optimised container engine
userspace
systemd, NetworkManager, dnsmasq, etc
Linux kernel
customised for the CPU architecture & device hardware

Watch dog
(OS level)

Network
(LAN, WIFI, GSM, LTE, …)

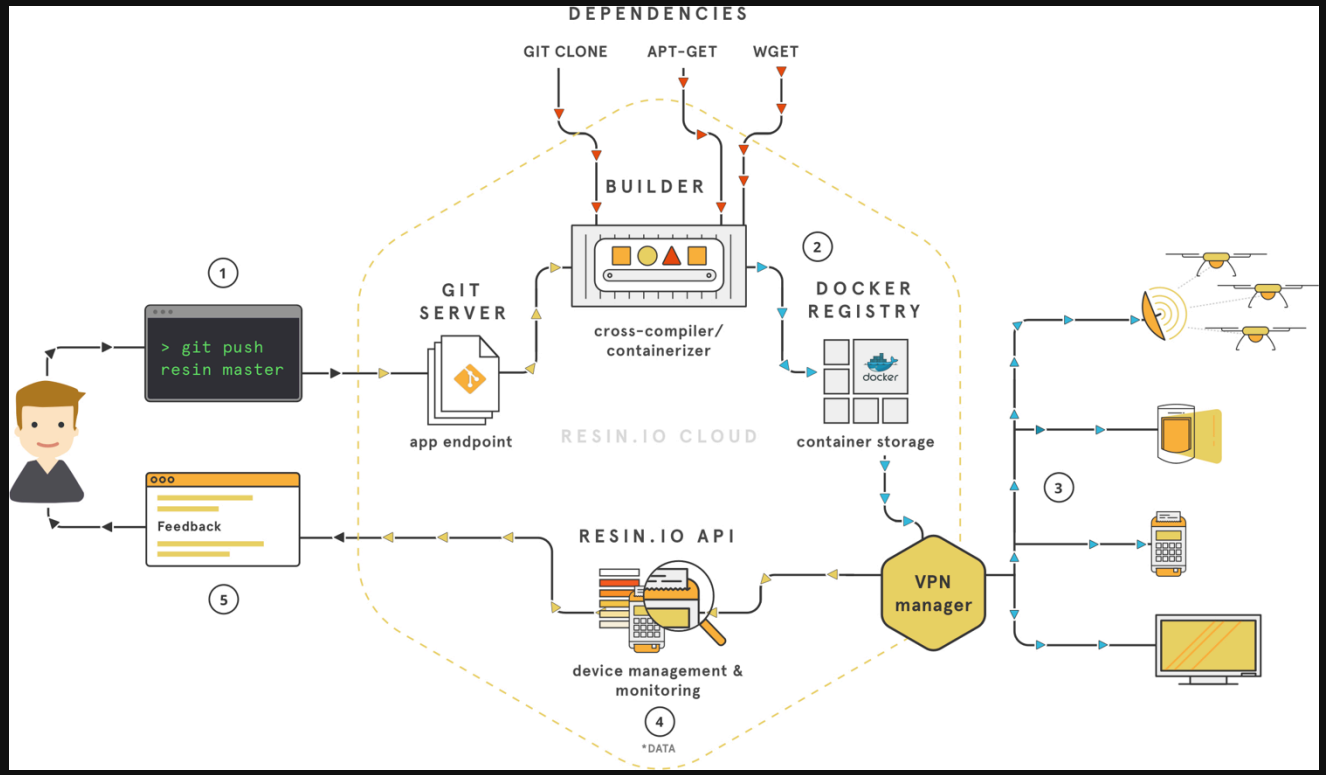
Computing device
CPU, storage, network, …

SD Flash

More details on ResinOS and Resin.Io

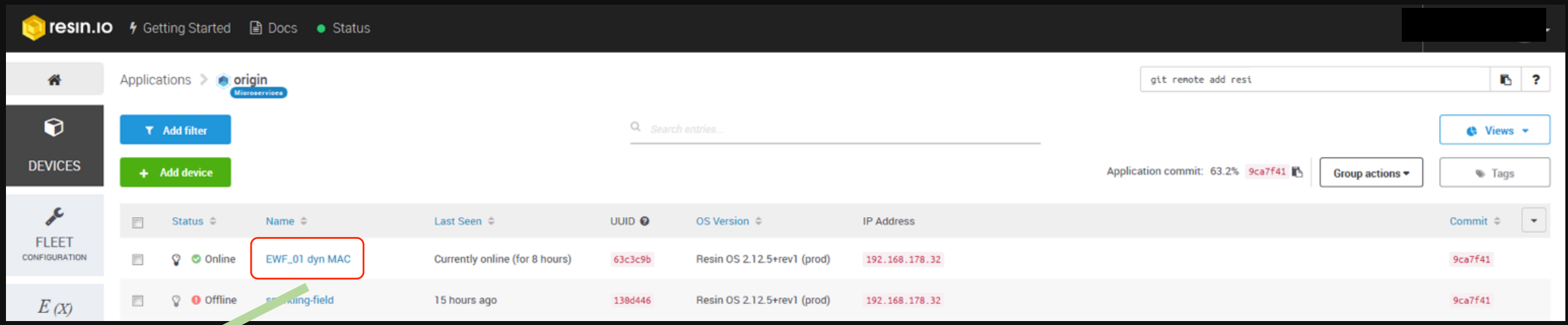
OS focused on IoT security and secure fleet management

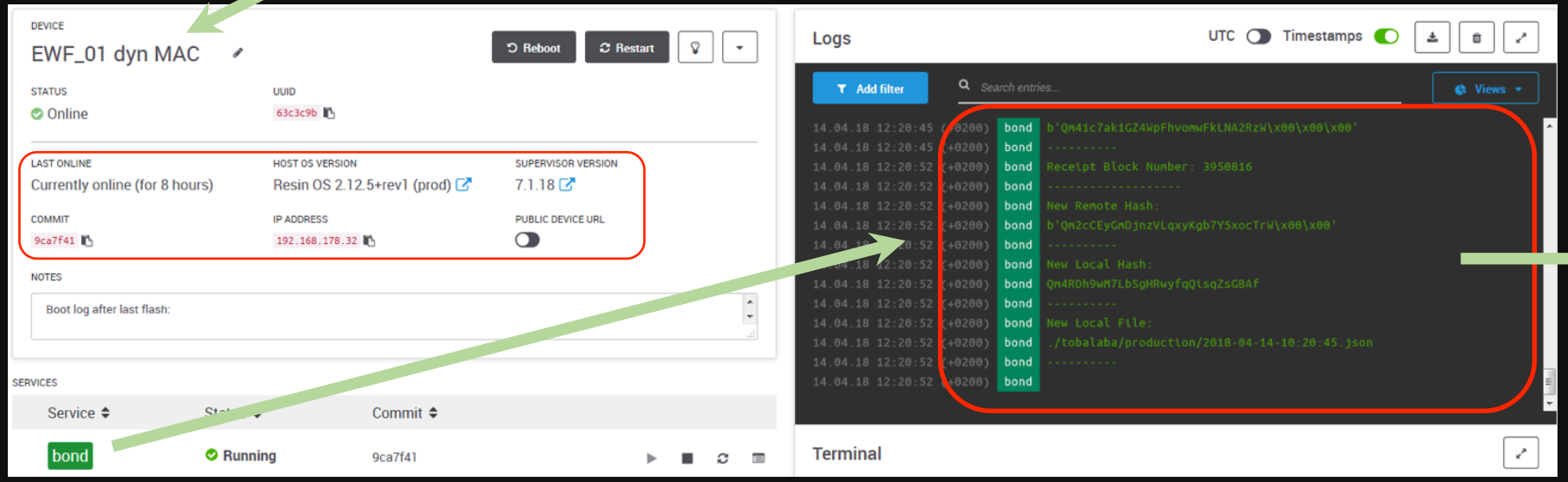
- **ResinOS:** Open source Linux based on Yocto
- **Resin.io:** Secure tool chain from *git push* to device provisioning
- Trusted CI/CD to the fleet via VPN manager
- Supports Artik platform



Source: Resin.io

The Resin.io dashboard

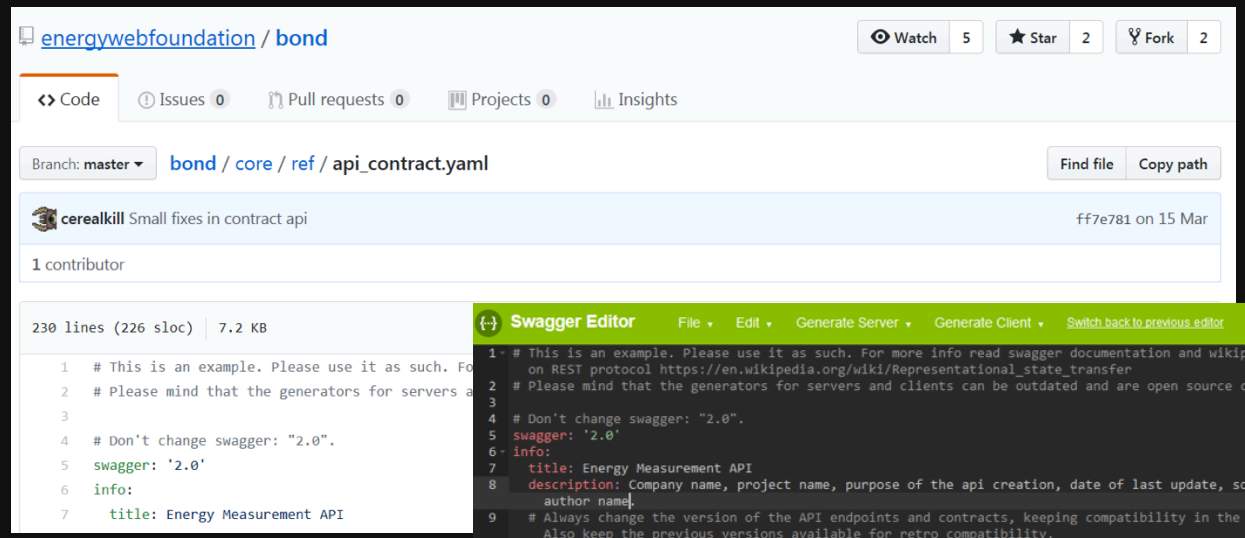




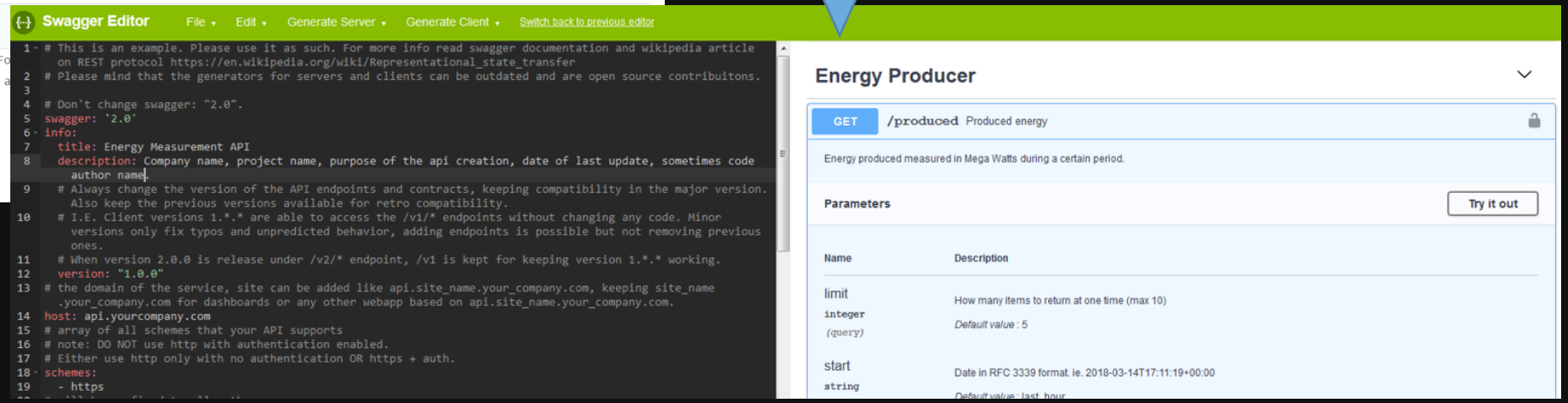
Origin Bond Code

… in action

Onboarding via Origin REST API



Swagger.io: api_contract.yaml



Create your server stub and integrate your production/consumption data with Origin easily https://github.com/energywebfoundation/bond/blob/master/core/ref/api_contract.yaml, https://editor.swagger.io/#!/