



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

30 October 2018

Presentation for *Transportation Supercluster Monthly Review*

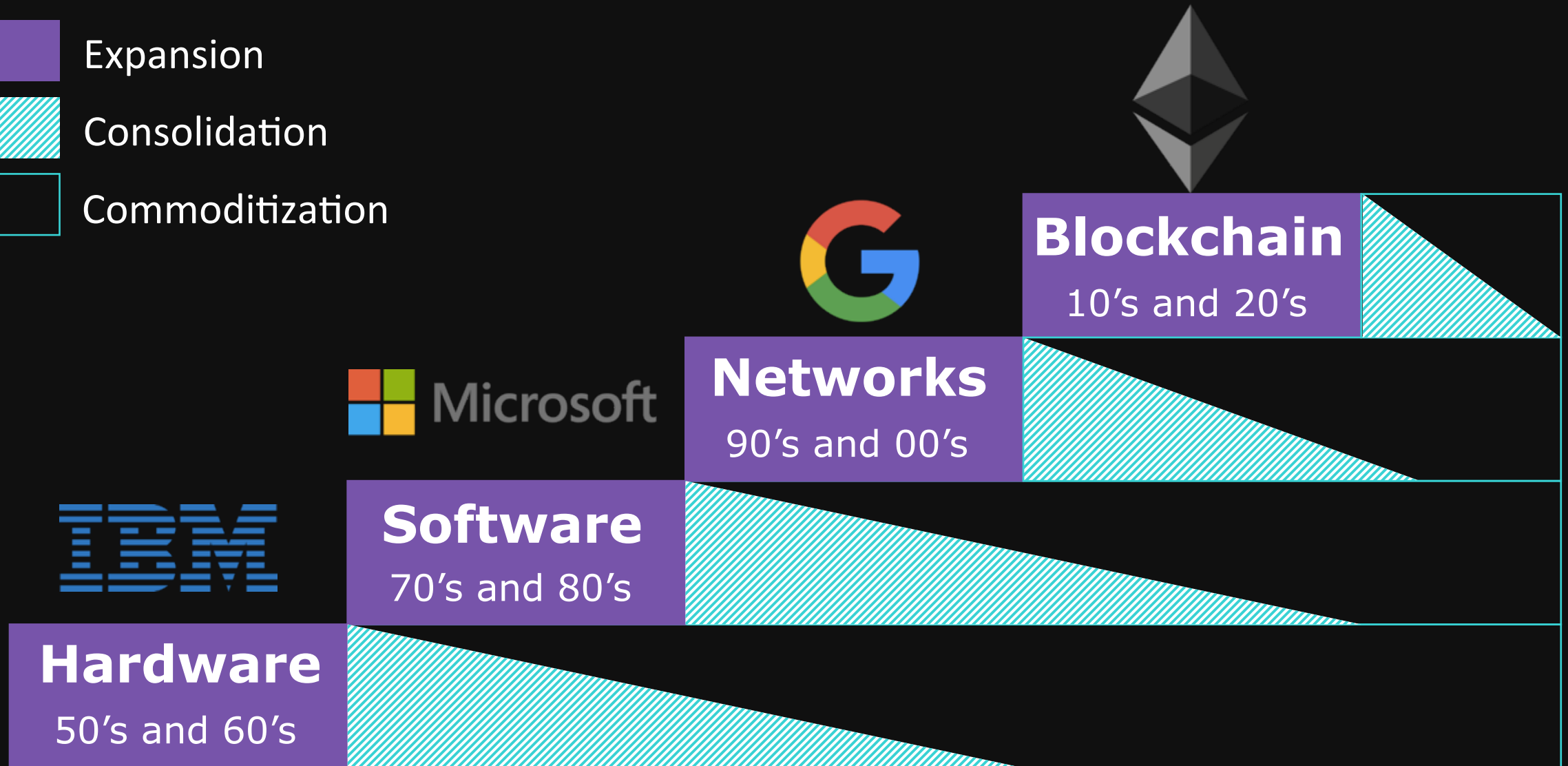
Doug Miller



A history of computers



- Expansion
- Consolidation
- Commoditization



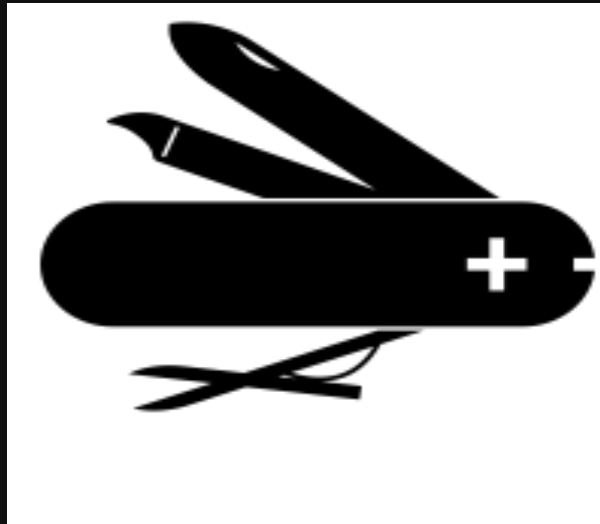
Blockchains are decentralized networks



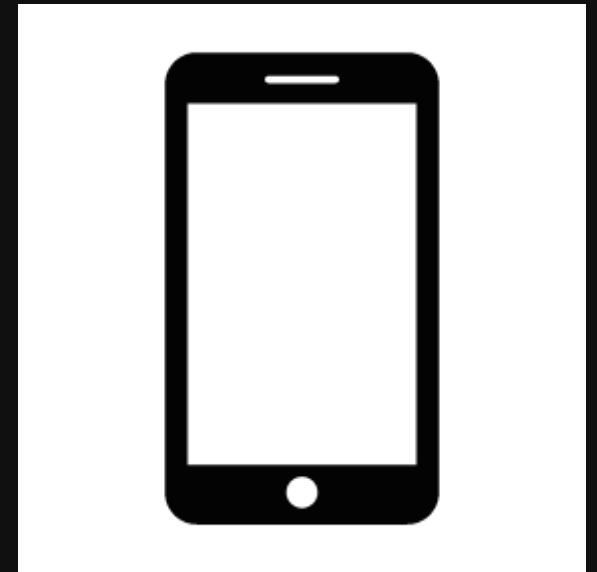
Time



Single Purpose



Multi-Purpose



ANY purpose

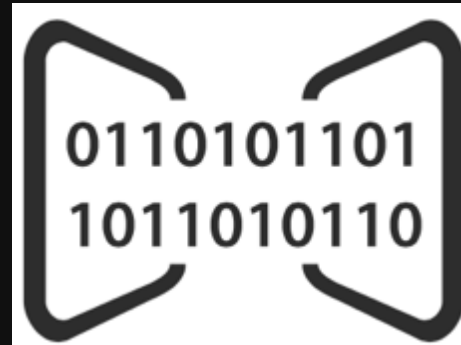
Blockchains are decentralized ~~networks~~ *computers*



Interactions



Create user
accounts



Read and write
data securely



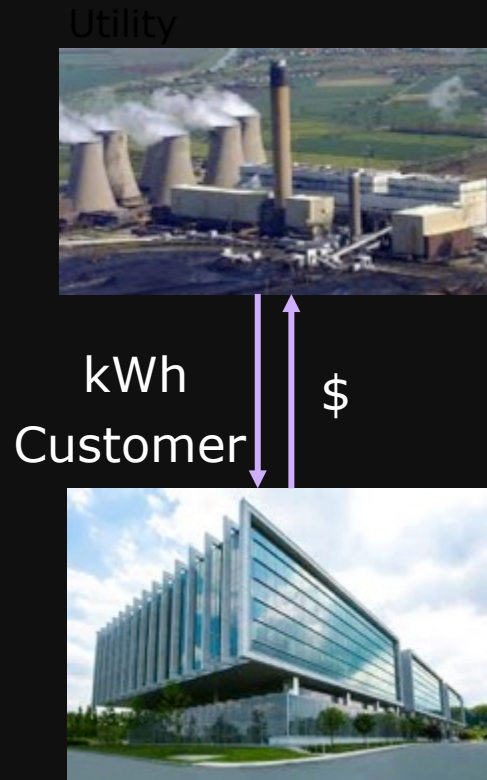
Write and run
programs

The Energy Transition



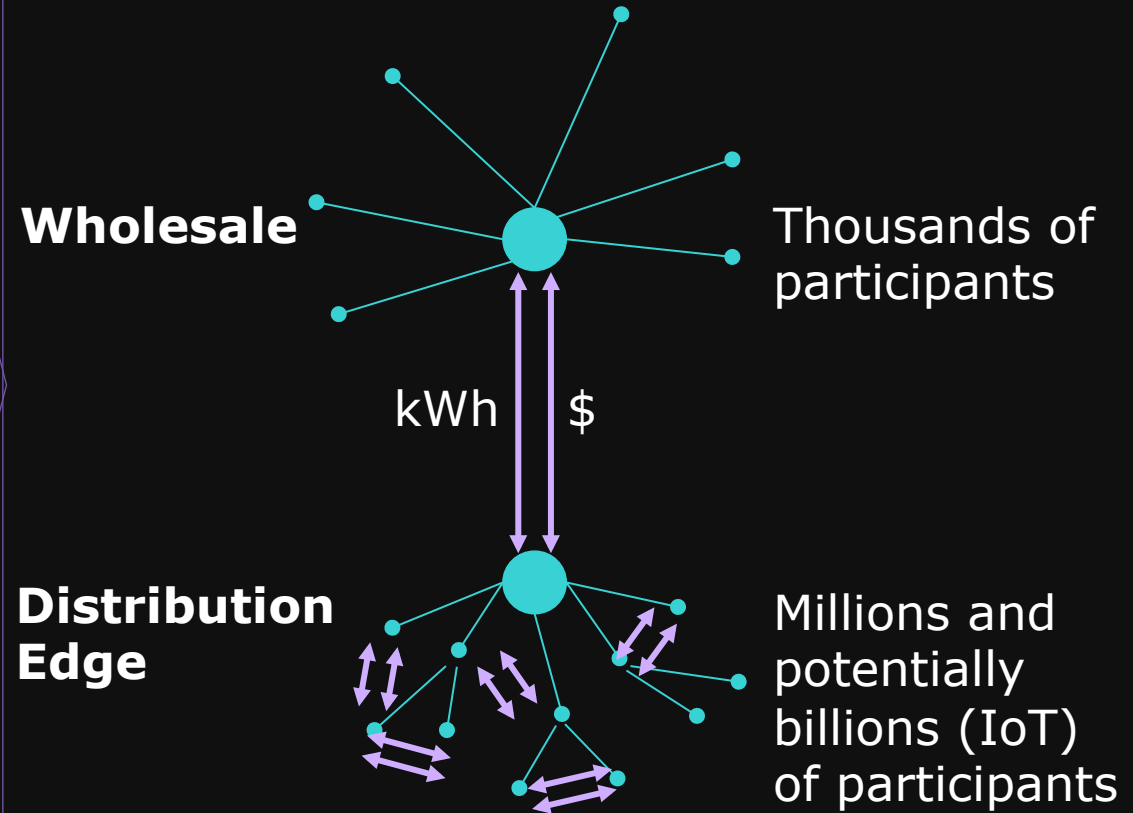
20th-century models clashing with 21st century technologies

Legacy system architecture



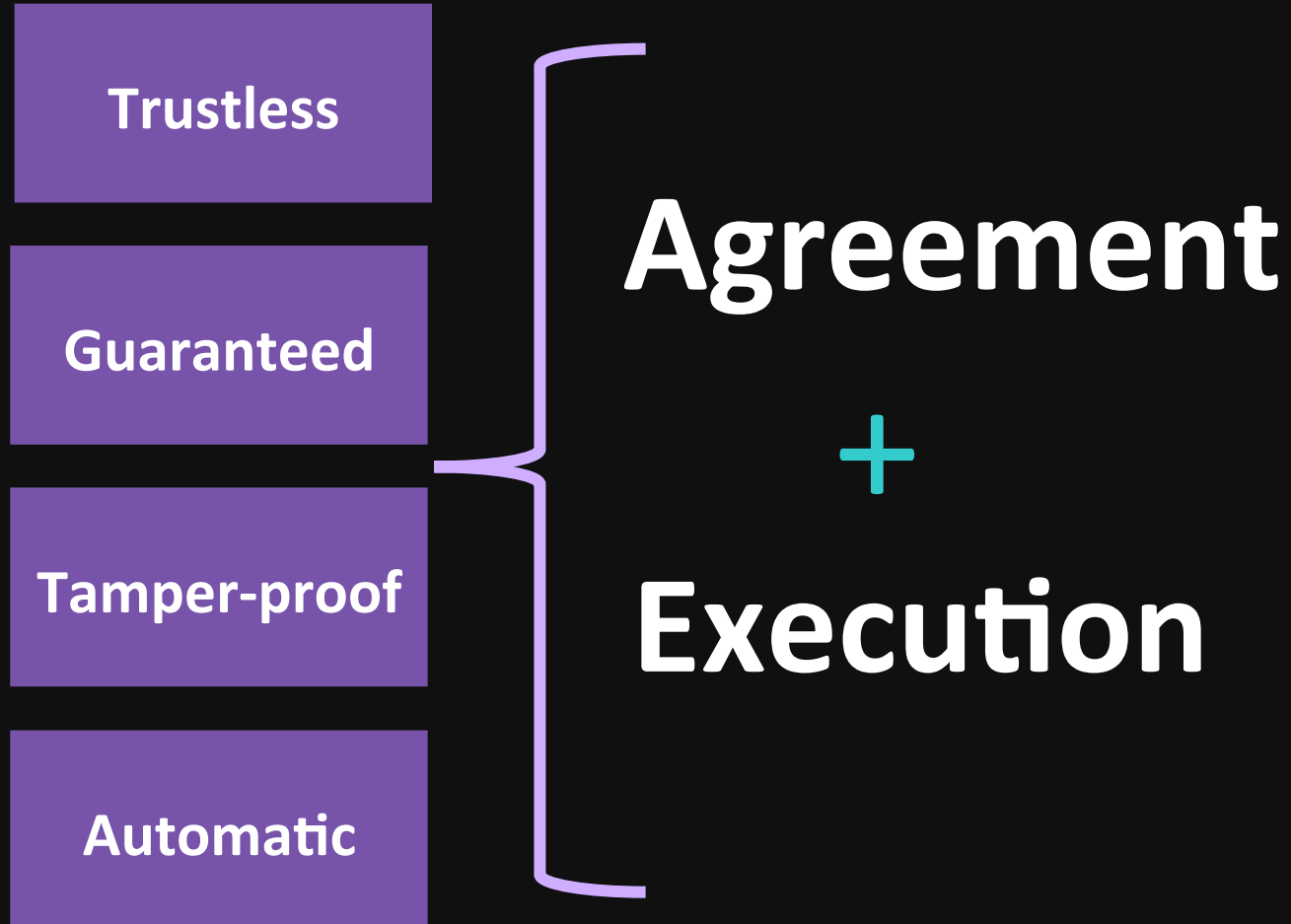
*Unidirectional flows of
electricity and money*

Emerging system architecture

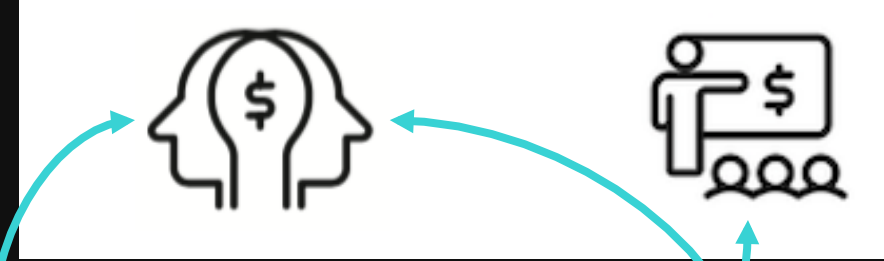


*Multidirectional, complex flows
of electricity and money*

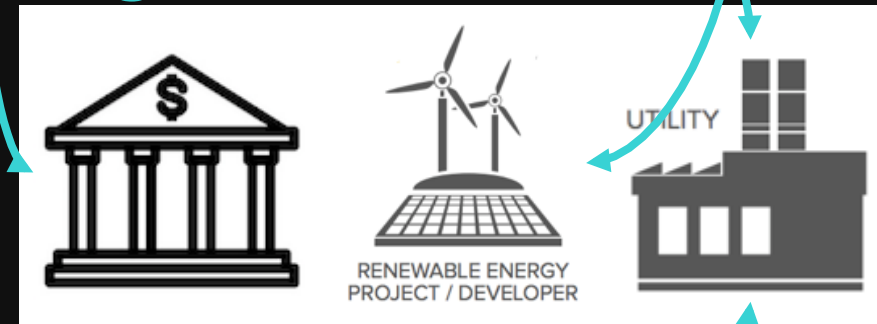
Blockchain's value proposition: digital DNA for the energy sector



People



Organizations



Machines

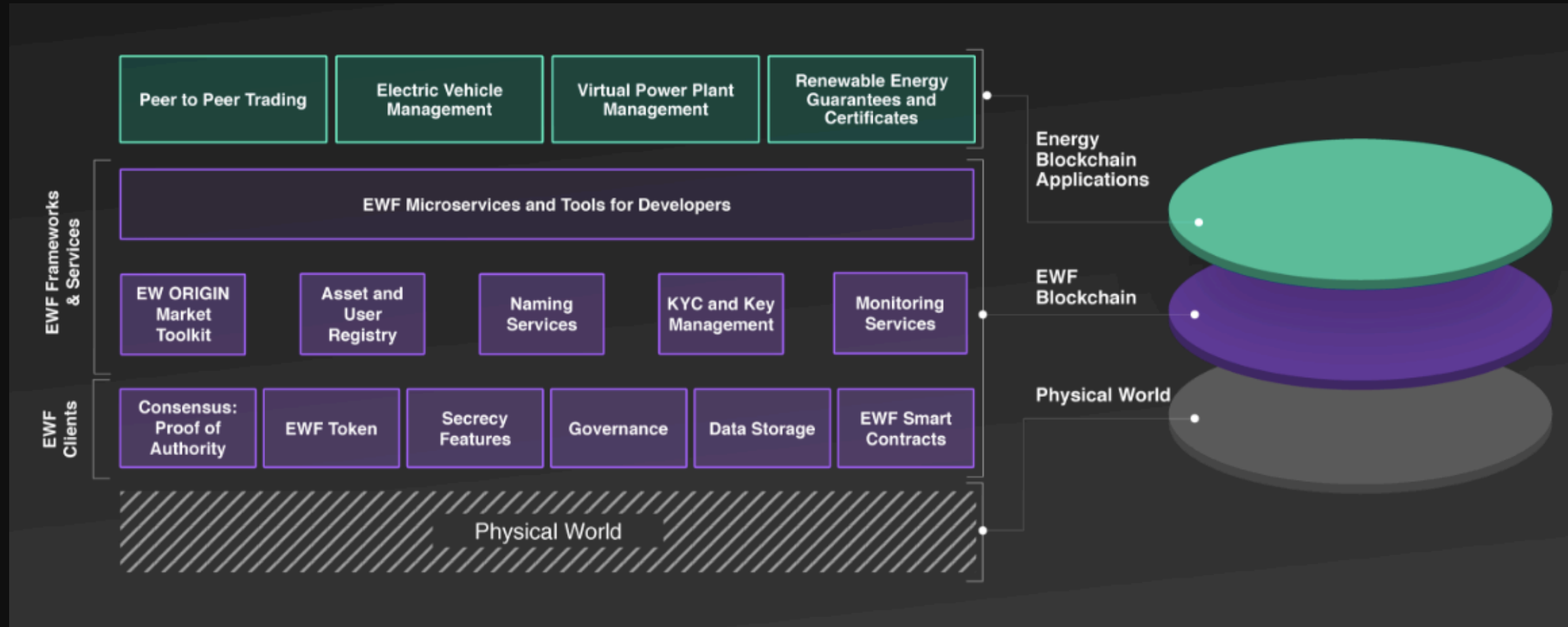




Energy Web Foundation (EWF) is leveraging blockchain to enable and accelerate the global clean energy transition

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

Corporates



Start-Ups



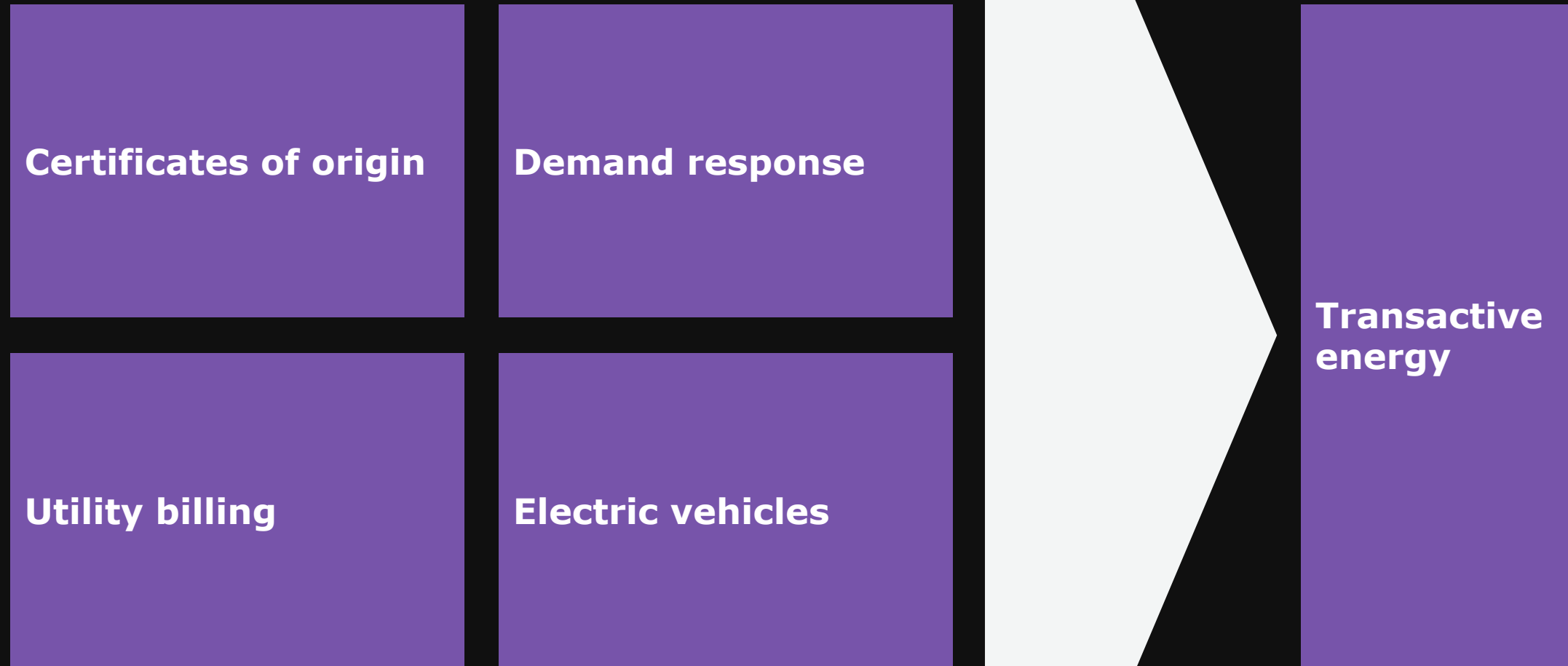
Funds








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		<ul style="list-style-type: none">• 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		<ul style="list-style-type: none">• Automate contractual relationship management, measurement & verification, and financial settlement• Reduce time from 2 months to minutes
Utility Billing		<ul style="list-style-type: none">• Decentralized meter registry with digital ID to track relationships between consumers, meters, and buildings
Electric Vehicles		<ul style="list-style-type: none">• Inter-network charging settlement; creating certified "green product" at charge points; enabling peer-to-peer charge sharing to increase asset utilization
Transactive Energy		<ul style="list-style-type: none">• 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

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 CO₂ emissions info

Lower transaction costs

Reduced barriers to entry

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



Certificate Id 0	Current Owner Microsoft Corporation	Claimed no	Producing Asset Id 0	Co2 saved (kg) 0.001	Certified Energy (kwh) 10.000	Creation Date 12 Apr 18
Asset Owner Engle AS	Certified by Registry none	Kind Production	Geo Location 50.654188, 3.65156			
Asset Type Wind	Other Green Attributes N.A	Commissioning Date 01 Jan 70				
	Public Support N.A	Nameplate Capacity 6000.000 kW				
12.4.2018, 13:16:00 - 0xf45f139a6f871bb919edab254e2f3fc91fcdd5b232beec00b6098225df61cee1 Certificate Created - Initially owned by Microsoft Corporation						
12.4.2018, 13:15:00 - 0x27ba3923c448135aa696986bfe1ea721b646daafdae2161a8f75d5f9a90d7b28 Initial Logging - Logging by Asset #0						

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



General

Start Date:

Pick a date

End Date:

Pick a date

Buyers output share:

Location

Country:

All

Only this Country:

Region:

All

Only this Region:

Type

Asset Type:

All

Only this Asset Type:

Choose Asset Type

Arbitrage rules

Target asset type:

Choose Target asset type

Asset ratio:

Range

Only fixed ratio:

Country:

All

Only this Country:

Region:

All

Only this Region:

CREATE PPA

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

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

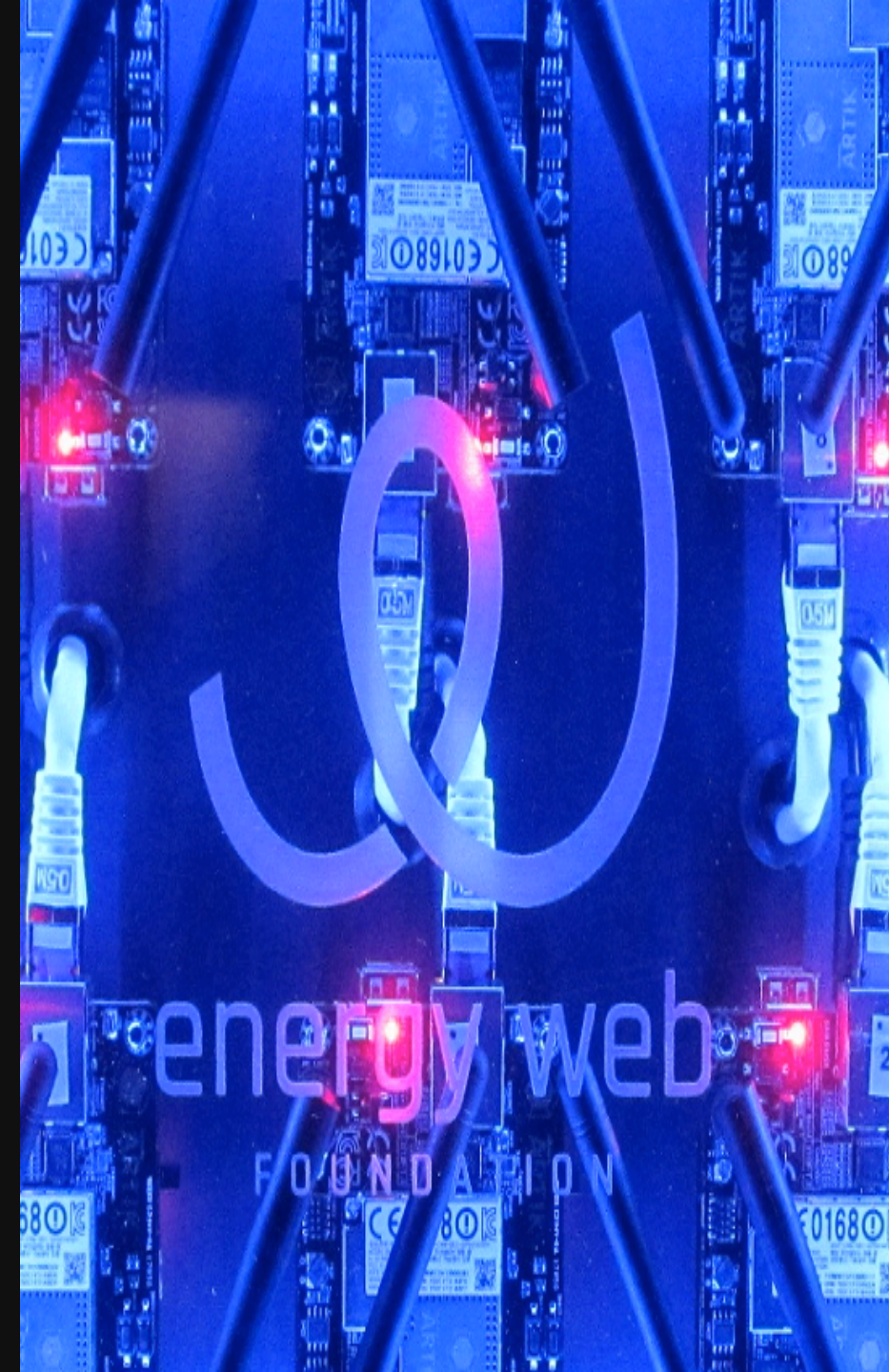


- **What questions do you have about EWF or EW Origin?**

Thank you!

Doug Miller

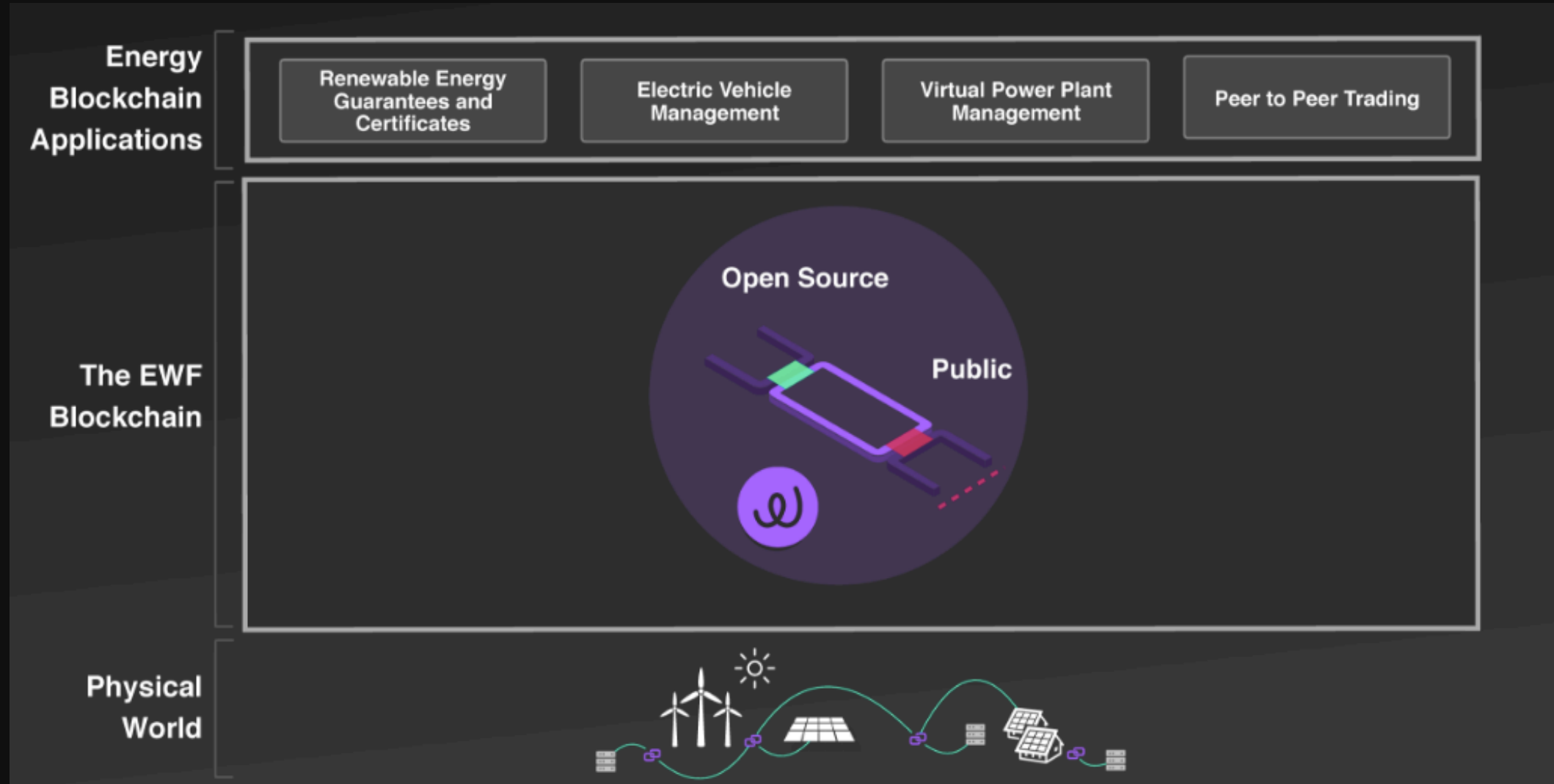
e: doug.miller@energyweb.org



An aerial night photograph of the Chicago skyline. The Willis Tower is the most prominent building, with its two antennas glowing against the dark sky. The city lights are visible throughout the lower half of the image, and the Lake Michigan is visible on the right. A large, dark, semi-transparent rectangular box is centered over the image, containing the word "Appendix" in a light purple font.

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...



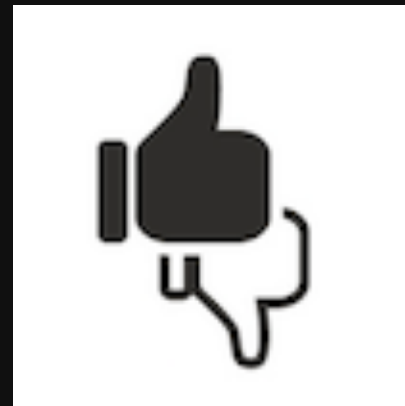
**Performing
M&V**



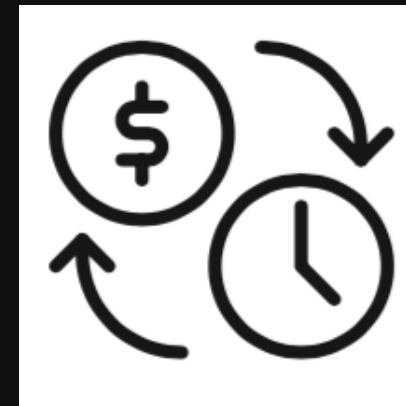
**Verifying &
enforcing
contracts**



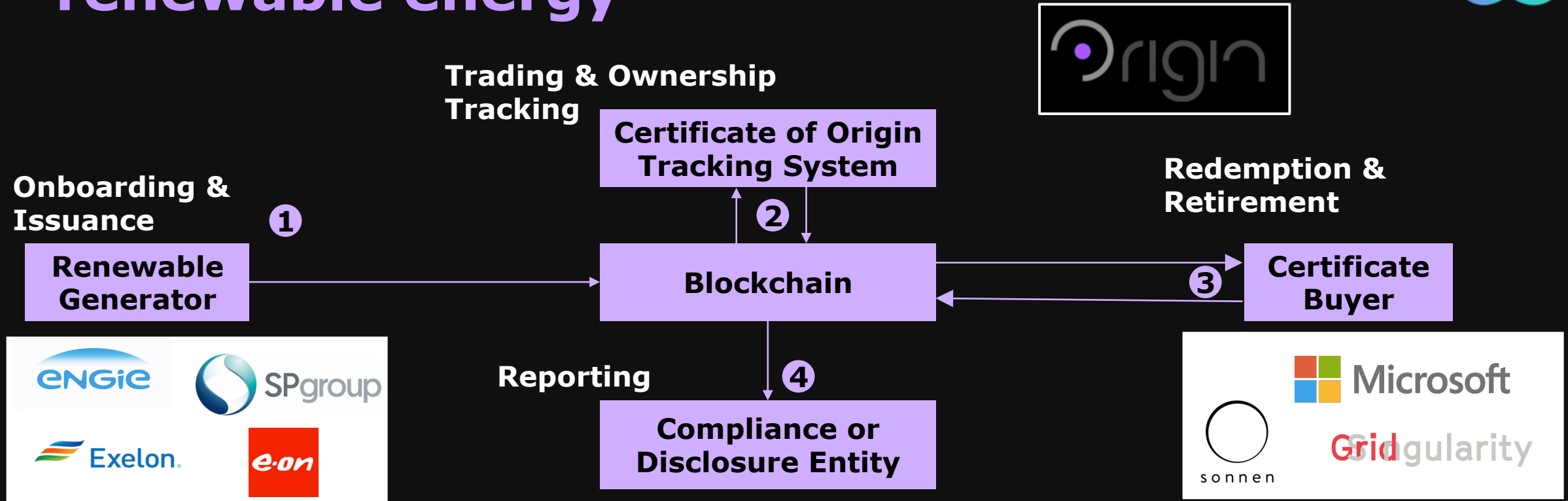
**Reconciling
data between
parties**



**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

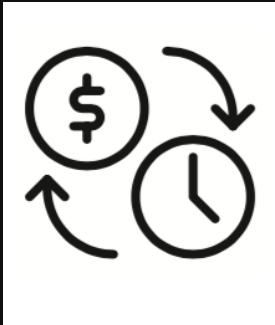
- **Expand market participation on both buyer and seller side**
- **Incentivize development of RE with particular attributes**
- **Improve auditing of CO2 emissions and RE generation – without NEM**

Supporting new EV products and services



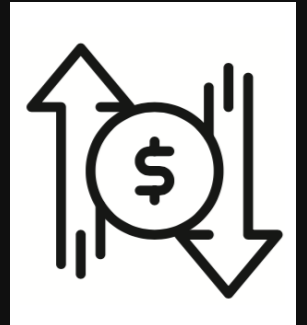
Open-source settlement engine for inter-network charging

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

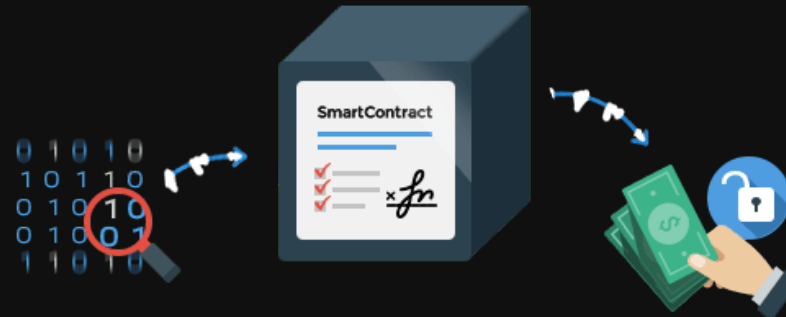


- Reconcile contractual, M&V, and performance data between flexibility resources, aggregators, DSO, and balancing parties
- Reduce settlement time from 2+ months to < 1 day
- **Lower overhead costs → expand market participation to larger number of smaller resources**

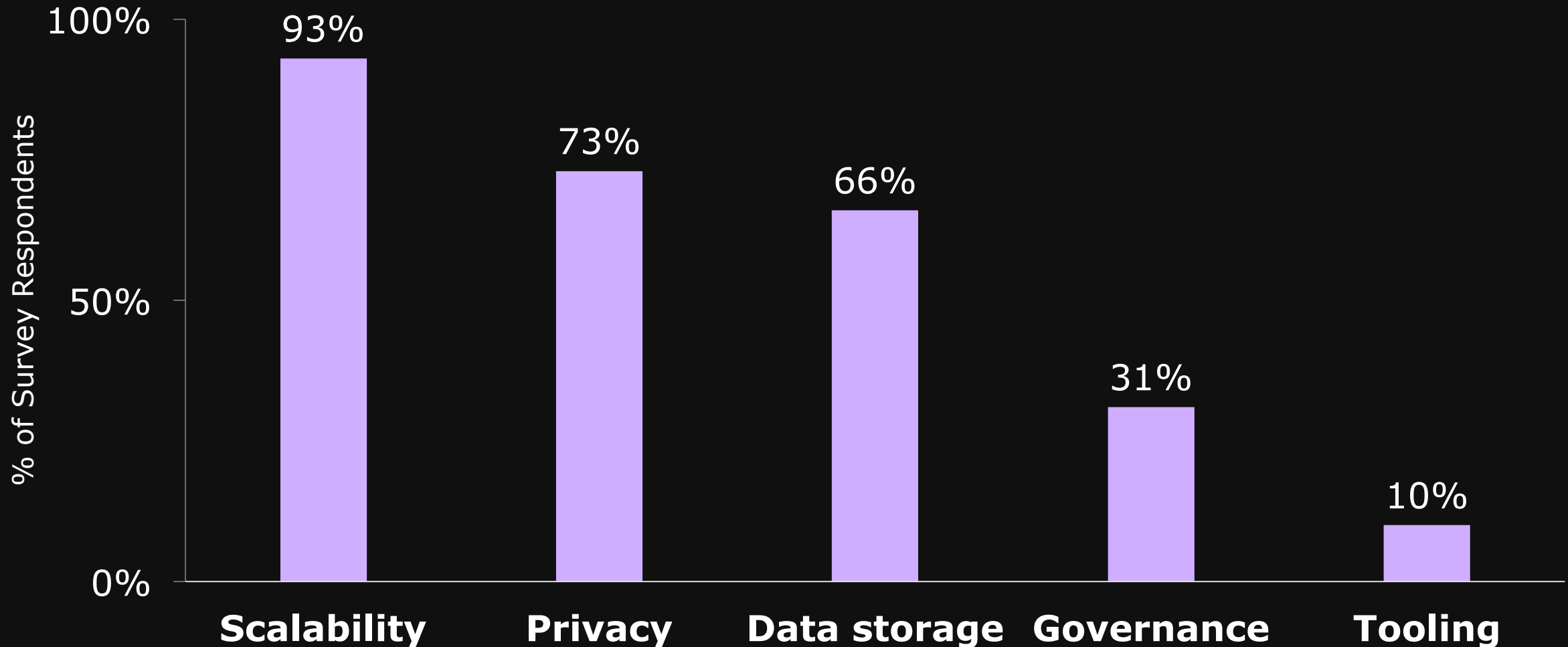
Distribution Networks



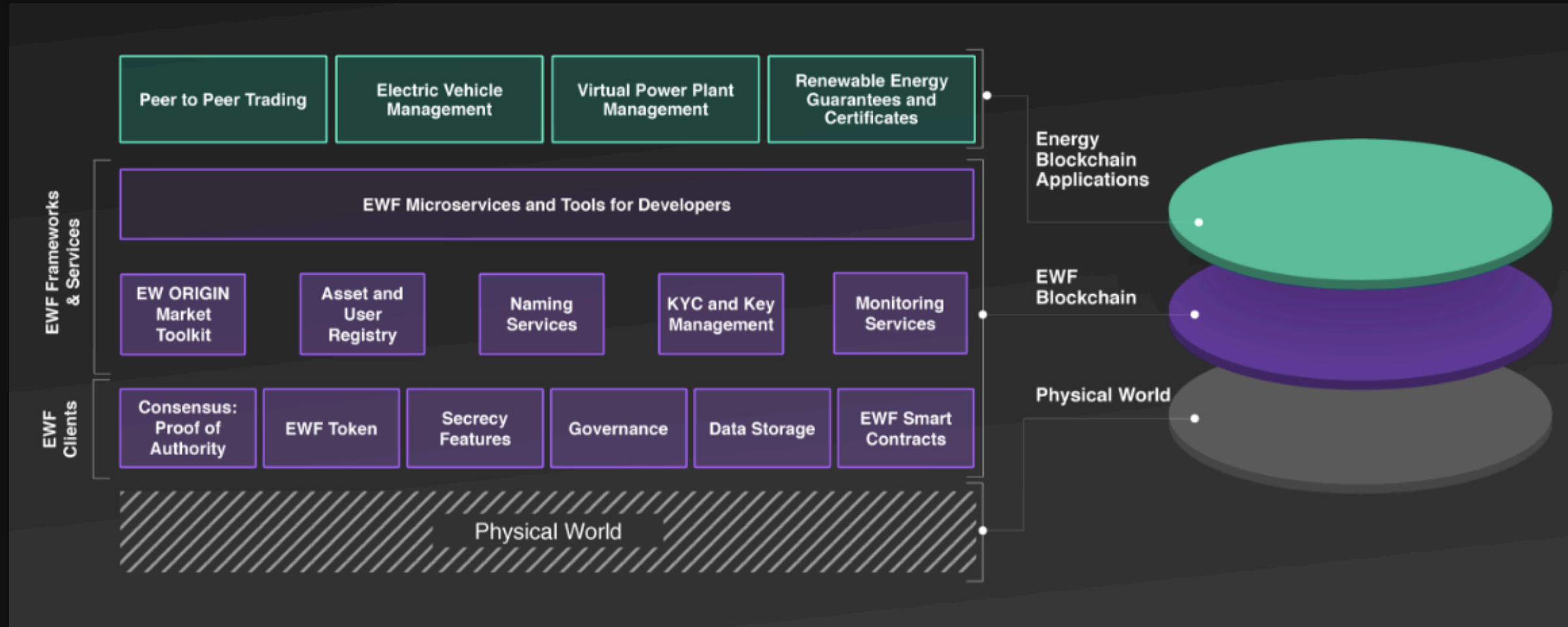
- Localized peer-to-peer day-ahead market model enabling customers to monetize at two campus facilities
- Using data from wifi connected home devices (Battery, PV, Dishwasher etc.)
- Match bids and execute settlement between peers and DSO



Technical challenges currently inhibit mass adoption of blockchain applications



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)

The screenshot shows a web form titled 'General' for creating a demand. It includes several sections with input fields and toggle switches:

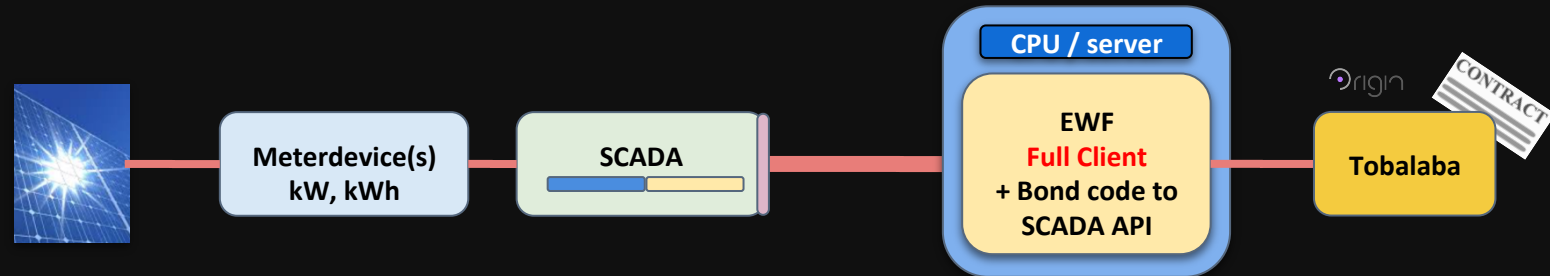
- General:** Fields for 'Cap per Timeframe (kWh)', 'Timeframe' (dropdown), 'Start Date' and 'End Date' (date pickers), 'Total Demand (kWh)' (set to 0), and 'Buyer's Address'.
- Criteria:** Two rows with toggle switches. The first row has 'Originator' set to 'All' and 'Only this originating address' (disabled). The second row has 'Min CO2 Offset' set to 'All' and 'Only if the CO2 saved is above' (disabled).
- Location:** Two rows with toggle switches. The first row has 'Country' set to 'All' and 'Only this Country' (disabled). The second row has 'Region' set to 'All' and 'Only this Region' (disabled).
- Type:** Two identical rows. Each has 'Asset Type' set to 'All' and 'Only this Asset Type' (disabled), and 'Compliance' set to 'All' and 'Only if compliant to' (disabled). Each row also has dropdowns for 'Choose Asset Type' and 'Choose Compliance'.
- Consumption:** Two rows with toggle switches. The first row has 'Coupled to Production Asset' set to 'No' and 'Yes, coupled to this producing Asset' (disabled). The second row has 'Coupled to Consumption' set to 'No' and 'Yes, coupled to this consumption address' (disabled).

A 'CREATE DEMAND' button is located at the bottom right of the form.

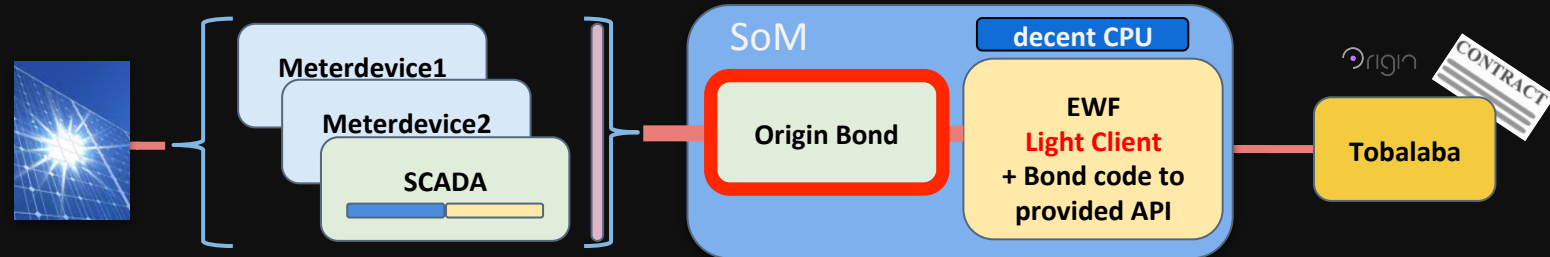
EWF developed reference implementations for different device connection scenarios



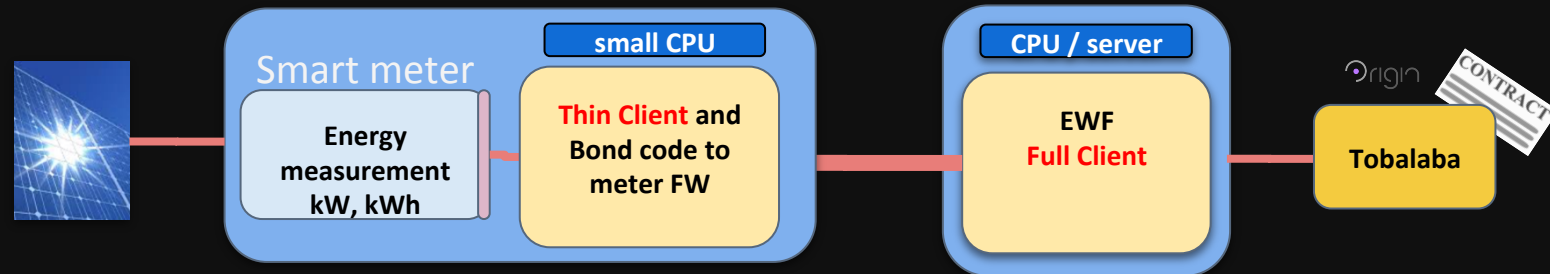
SCADA / Server



Origin on a SoM



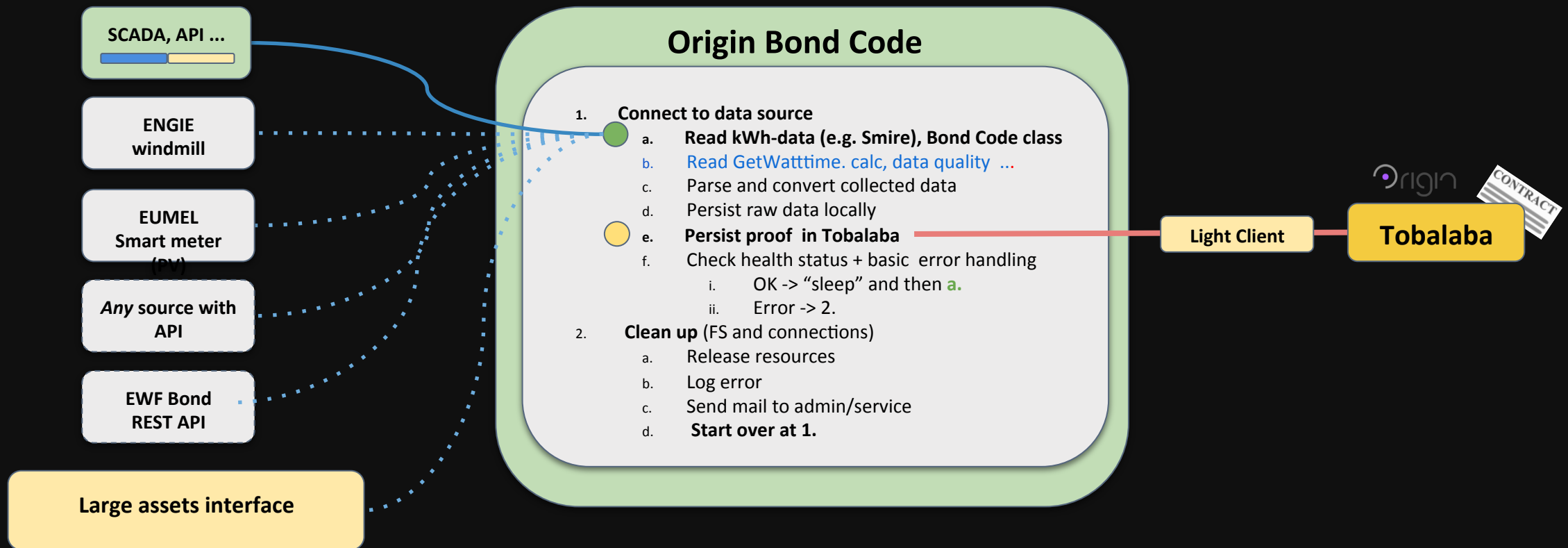
In a smart meter



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

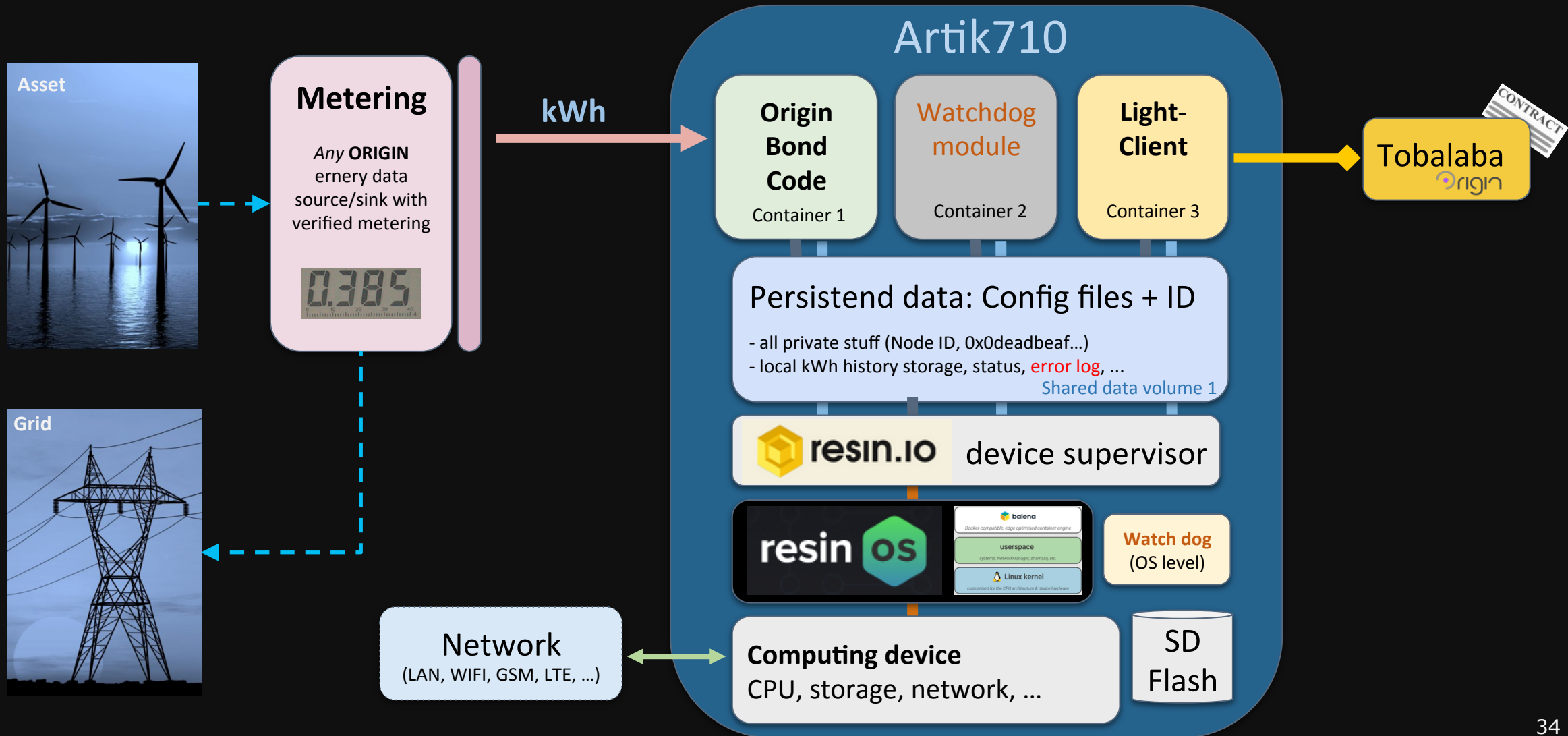


EWF is using the Artik 710 device as a powerful SoM to securely host the EW Origin bond code and EWF light client

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	I ² S 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, I ² C, SPI, UART, SDIO, USB 2.0, JTAG, Analog Input



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

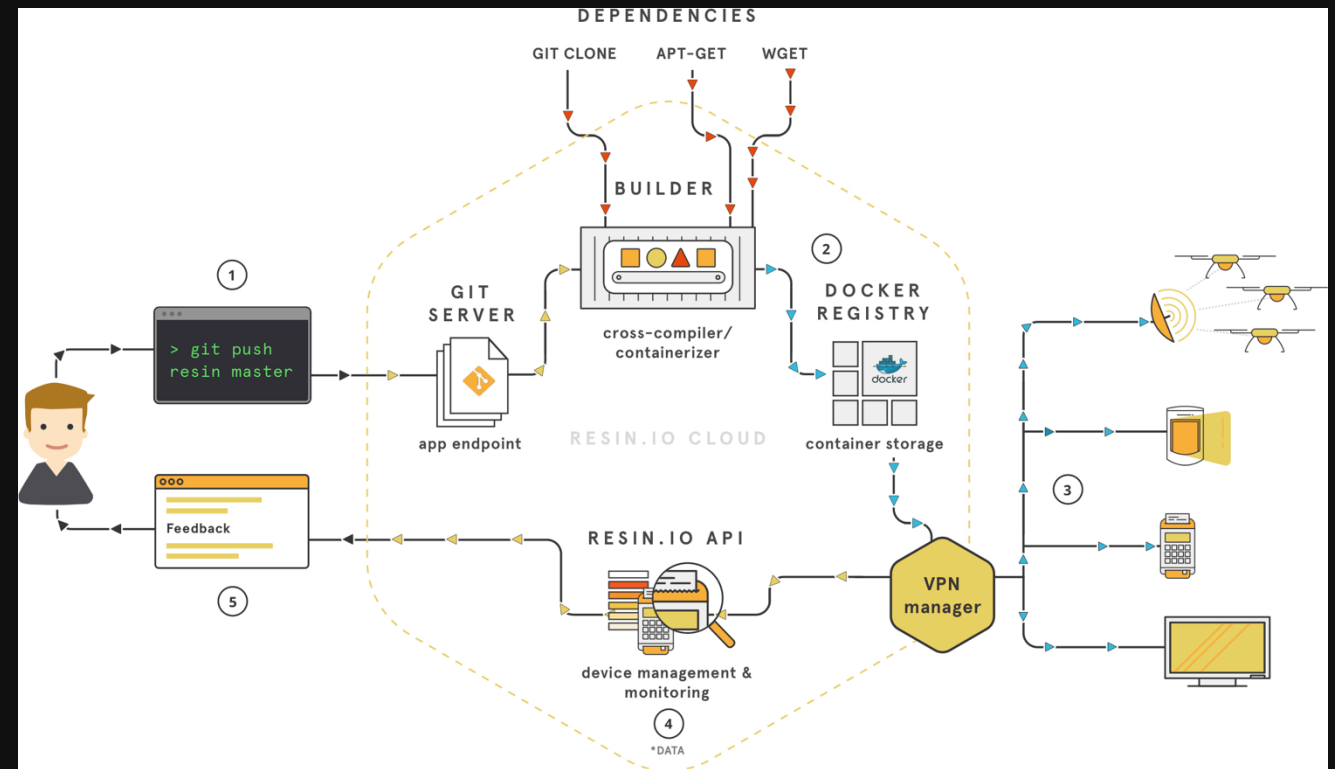


More details on ResinOS and Resin.Io



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



resin.io ⚡ Getting Started 📄 Docs 🟢 Status

Applications > **origin** Microservices

git remote add resi

Search entries...

Views

Application commit: 63.2% 9ca7f41

Group actions Tags

Status	Name	Last Seen	UUID	OS Version	IP Address	Commit
Online	EWF_01 dyn MAC	Currently online (for 8 hours)	63c3c9b	Resin OS 2.12.5+rev1 (prod)	192.168.178.32	9ca7f41
Offline	smoking-field	15 hours ago	130d446	Resin OS 2.12.5+rev1 (prod)	192.168.178.32	9ca7f41

DEVICE

EWF_01 dyn MAC

Reboot Restart

STATUS Online

UUID 63c3c9b

LAST ONLINE Currently online (for 8 hours)

HOST OS VERSION Resin OS 2.12.5+rev1 (prod)

SUPERVISOR VERSION 7.1.18

COMMIT 9ca7f41

IP ADDRESS 192.168.178.32

PUBLIC DEVICE URL

NOTES

Boot log after last flash:

SERVICES

Service	Status	Commit
bond	Running	9ca7f41

Logs

UTC Timestamps

Search entries...

Views

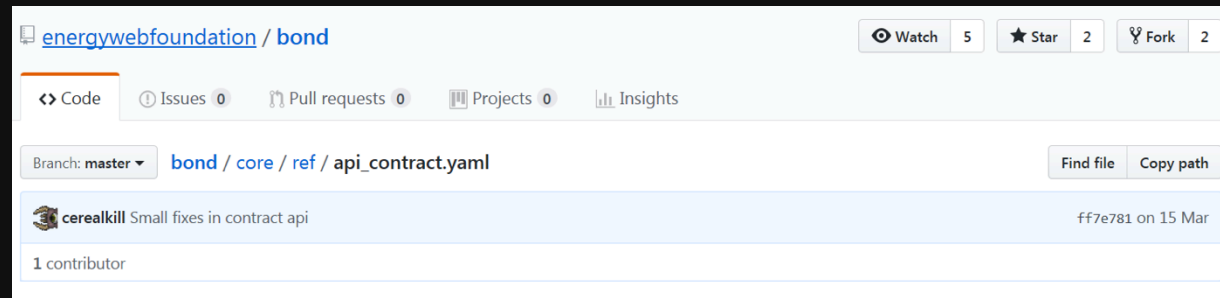
```
14.04.18 12:20:45 (+0200) bond b'Qm41c7ak1GZ4pPhvomwFkLNA2RzW\x00\x00\x00'
14.04.18 12:20:45 (+0200) bond -----
14.04.18 12:20:52 (+0200) bond Receipt Block Number: 3950B16
14.04.18 12:20:52 (+0200) bond -----
14.04.18 12:20:52 (+0200) bond New Remote Hash:
14.04.18 12:20:52 (+0200) bond b'Qm2cCEyGnDjnzVLqxyKgb7Y5xocTrW\x00\x00'
14.04.18 12:20:52 (+0200) bond -----
14.04.18 12:20:52 (+0200) bond New Local Hash:
14.04.18 12:20:52 (+0200) bond Qn4RDh9wR7Lb5GhRwyfQlsgZsGBAf
14.04.18 12:20:52 (+0200) bond -----
14.04.18 12:20:52 (+0200) bond New Local File:
14.04.18 12:20:52 (+0200) bond ./tobalaba/production/2018-04-14-10:20:45.json
14.04.18 12:20:52 (+0200) bond -----
14.04.18 12:20:52 (+0200) bond
```

Terminal

Origin
Bond
Code

... in action

Onboarding via Origin REST API



Swagger.io: api_contract.yaml



230 lines (226 sloc) | 7.2 KB

```
1 # This is an example. Please use it as such. For more info read swagger documentation and wikipedia article
2 # Please mind that the generators for servers and clients can be outdated and are open source contributions.
3
4 # Don't change swagger: "2.0".
5 swagger: '2.0'
6 info:
7   title: Energy Measurement API
```

Swagger Editor

```
1 # This is an example. Please use it as such. For more info read swagger documentation and wikipedia article
2 # Please mind that the generators for servers and clients can be outdated and are open source contributions.
3
4 # Don't change swagger: "2.0".
5 swagger: '2.0'
6 info:
7   title: Energy Measurement API
8   description: Company name, project name, purpose of the api creation, date of last update, sometimes code
9   author name:
10 # Always change the version of the API endpoints and contracts, keeping compatibility in the major version.
11 # I.E. Client versions 1.*.* are able to access the /v1/* endpoints without changing any code. Minor
12 # versions only fix typos and unpredicted behavior, adding endpoints is possible but not removing previous
13 # ones.
14 # When version 2.0.0 is release under /v2/* endpoint, /v1 is kept for keeping version 1.*.* working.
15 version: "1.0.0"
16 # the domain of the service, site can be added like api.site_name.your_company.com, keeping site_name
17 # your_company.com for dashboards or any other webapp based on api.site_name.your_company.com.
18 host: api.yourcompany.com
19 # array of all schemes that your API supports
20 # note: DO NOT use http with authentication enabled.
21 # Either use http only with no authentication OR https + auth.
22 schemes:
23   - https
```

Energy Producer

GET /produced Produced energy

Energy produced measured in Mega Watts during a certain period.

Parameters

Name	Description
limit	How many items to return at one time (max 10)
integer (query)	Default value : 5
start	Date in RFC 3339 format ie. 2018-03-14T17:11:19+00:00
string	Default value: last hour

Try it out

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/#/>