Glossary

Acronym	Definition
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
DAO	Distributed Autonomous Organization
DER	Distributed Energy Resource
DOD	Department of Defense
DSO	Distribution System Operator
EV	Electric Vehicle
EVM	Ethereum Virtual Machine
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
HE	Homomorphic Encryption
ML	Machine Learning
NFT	Non-Fungible Token
NILM	Non-Intrusive Load Monitoring
NIST	National Institute of Standards and Technology
PNNL	Pacific Northwest National Labs
PSN	Proof-of-Stake on Numbers
zk- SNARK	Zero-Knowledge Succinct Non-interactive Arguments of Knowledge
SWEET™	Smart Wrangling Engine for Extraction and Transformation™
TAC™	Trusted Analytics Chain™
ZTA	Zero Trust Architecture
ZKP	Zero-Knowledge Proofs

Executive Summary

- Consumer energy data is highly valuable but legally a challenge for third parties to access.
- In aggregate, consumer actions that reduce energy consumption can reduce power outages but consumers are difficult to coordinate and motivate.
- There is an urgent need for consumer energy data and consumer actions due to compounding macro factors such as the Russo-Ukraine war, increasing extreme weather, and aging and failing power infrastructure.
- VIA's Skylight solution enables third parties to compensate consumer energy participants in real-time for their energy data and actions.
- A variety of Web3 technologies including blockchain smart contracts, zero-knowledge proofs, and privacy-preserving encryption enable Skylight.
    - Consumers maintain provable and anonymous ownership of their data at all times.
    - Consumers can be compensated for insights aggregated from their data and for energy efficiency actions validated through their data.
    - Utilities and other data custodians earn a fee for their data custodial services.
- The underlying technology is in daily use at the U.S. Department of Defense (the only blockchain with Top Secret level cybersecurity accreditation) and granted 8 patents.

Introduction and Acknowledgements

Analysts, planners, and decision makers in every sector know that access to data is a challenge. In energy, rapid decentralization of both power generation and consumption (e.g., electric vehicles (EVs), rooftop solar, battery storage) is making data access even harder. As described in a highly cited 2019[1] academic study, a major barrier to analysis of energy data has been data privacy.

It's not an overstatement to say that the consequences of scarce energy data are existential. The transition to clean energy to reduce greenhouse gas (GHG) emissions requires decentralized energy data. On an everyday level, blackouts occur when local grid operators can't coordinate among prosumers, EV charging station providers, and independent generation companies. Energy prices surge and energy retailers fold when data to market and manage their pricing is incomplete. Energy traders can lose a whole year of profits from a single misjudgment of day-ahead or week-ahead energy forecasts. See Appendix G for a summary of energy data use cases and economic impact.

VIA's mission has always been to leverage data privacy technologies to make communities cleaner, safer, and more equitable (see Appendix I). In fact, since 2017, VIA has been developing and deploying what we believe are the best technologies (see Appendix L for summary of Web3 stack) to address the data decentralization problem across utilities. In August 2022, VIA will launch Skylight, a blockchain-based energy insights platform, to enable access to consumer energy data. Skylight uses smart contracts, Zero-Knowledge Proofs (ZKPs), and other Web3 technologies to provide energy analysts answers (insights) to queries about power data while maintaining strict privacy compliance for data owners.

The foundational technology is based on VIA's privacy-preserving, computational blockchain platform, Trusted Analytics Chain™ (TAC™)[2]. VIA holds eight issued patents with over 10 additional patents pending (see Appendix K) related to homomorphic encryption (HE) and the use of smart contracts to guarantee data privacy. In addition, VIA's blockchain is used daily by the U.S. Department of Defense (DOD) and is the only blockchain that has a DOD-wide cybersecurity accreditation for top secret level and above applications[3].

[1] Review of Smart Meter Data Analytics: Applications, Methodologies, and Challenges | IEEE Journals & Magazine
[2] A more detailed description of TAC™ is available in VIA's February 2018 white paper, *Trusted Analytics Chain: On-Premise Learning for AI Models on Highly Sensitive, Distributed Data*
[3] VIA Receives US Department of Defense Platform One Accreditation for Blockchain Core of Base Operations and Infrastructure Application

With Skylight, analysts, planners, and decision makers will obtain valuable insights from consumer data and sponsor consumers to take actions that improve grid flexibility. Consumers become data owners and will earn tokens for their participation.

Multiple technical elements, already proven in the market, make Skylight consumer ready today:

- Smart contracts provide a guarantee of programmable permissions.
- Zero-Knowledge Proofs (ZKPs), homomorphic encryption (HE), and patented verified templates provide security on computations[4].
- Cryptocurrencies and Non-Fungible Tokens (NFTs) provide an ecosystem for monetization and trading of digital assets such as energy data.

A first community Skylight demonstration will be live as of September 1, 2022 in Zurich, Switzerland. As energy markets are under increasing pressure (see Appendix H), more utilities across the globe are expressing interest.

Skylight will accelerate the transition to clean energy through:

(1) *Insights:* improve energy planning and forecasting by governments and businesses, and
(2) *Actions:* incentivize grid flexibility and real-time operational efficiency.

Communities will benefit from a “no trade-off” solution that reduces power outages, reduces costs, and reduces emissions. In addition, each participating consumer will benefit from increased data privacy and compensation for their energy data with real-time settlement.

VIA greatly appreciates the support of the more than 30 utilities, regulators, government agencies, academics, and other industry experts that have tested our technology and provided detailed input to this white paper.

Skylight: A Market to Incentivize Energy Consumers

In most jurisdictions (e.g., U.S. and Europe) the data generated by consumers legally belongs to those consumers. So, while power companies install hardware (i.e., meters) to collect and transmit data, and are also custodians of consumer energy data, they cannot use it without their customers’ consent (except for billing and maintenance purposes). Large scale studies[5] have demonstrated that given real-time feedback, consumer action can impact aggregate peak demand. More recently, energy emergencies have shown that consumer action is a requirement to avoid widespread power outages (e.g., New York[6], Texas[7]).

To unlock consumer energy data, we propose an insights platform, Skylight, to give the explicit control of data back to consumers who are the rightful data owners and to reward them for their active participation in energy related activities (“Opportunities”).

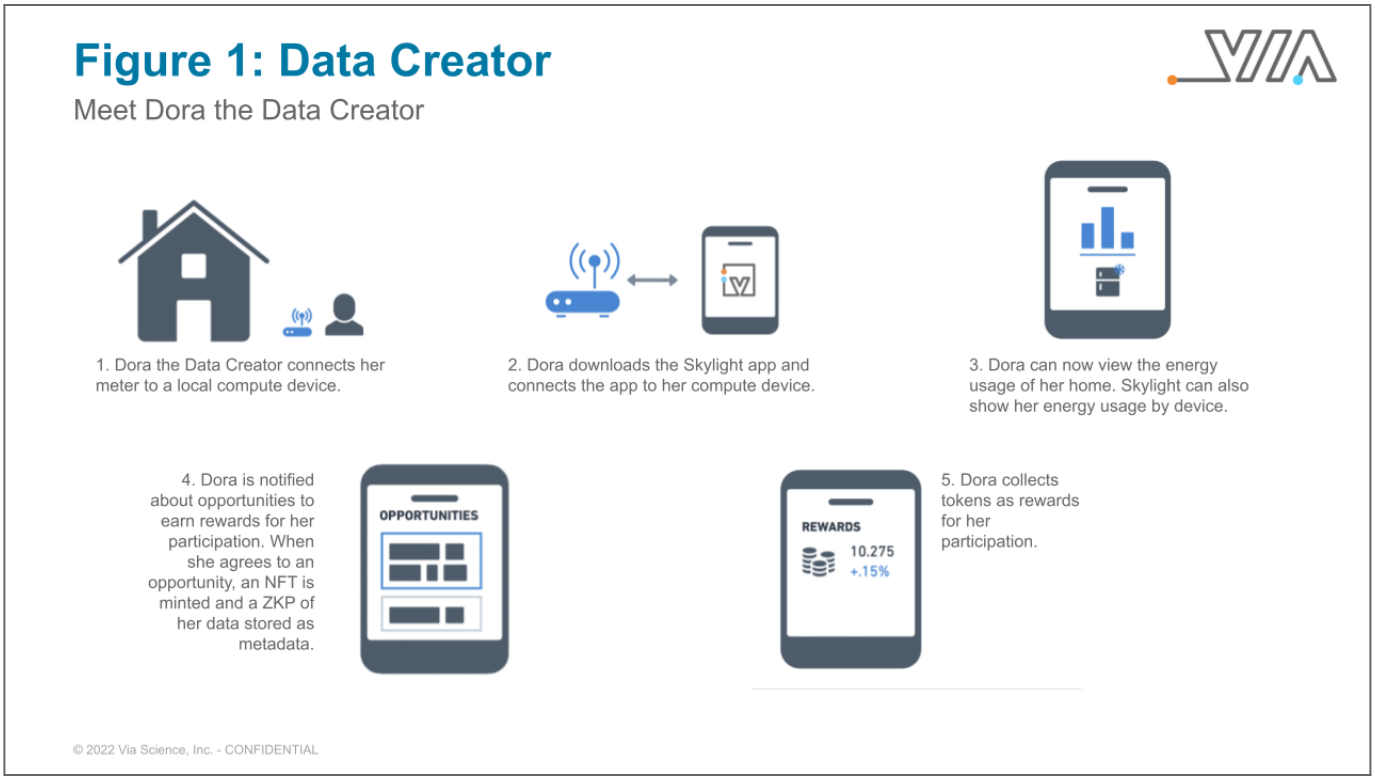
In the first phase of our launch, data owners with smart meters and distributed energy resources (DERs) will use Skylight to mint NFTs of their own energy data. NFTs, particularly the ERC-1155 Multi-Token Standard, is a standardized protocol to uniquely identify and validate the ownership of a digital asset, in this case the consumer’s energy data. A growing, public ecosystem exists to mint, store, publish, and search for NFTs.

These NFTs contain ZKPs of the data so that analysts can verify that the data exists without having to upload the data to the blockchain or otherwise observe the data directly. ZKPs are used in Bitcoin and other cryptocurrencies

[4] A more detailed description is available in VIA’s December 2021 white paper: *Trusted Analytics Chain™ (TAC™): Balancing Continuous Data Protection and Query Flexibility*

[5] Distribution System Operation with Transactive (DSO+T) Study | PNNL
[6] New York City outage averted
[7] Customer reduction during Texas storm

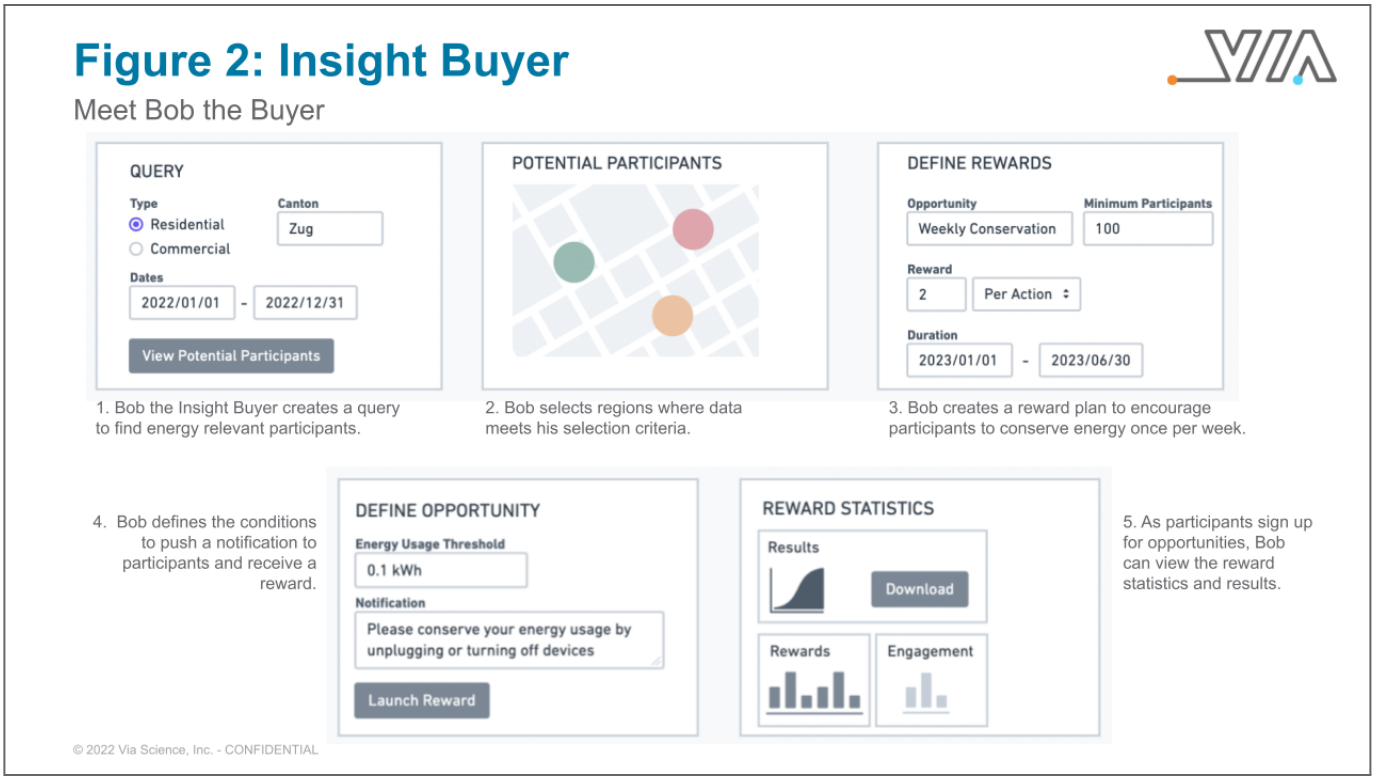
to automate the settlement of disputed transactions between two anonymous parties without the need for an intermediary and while maintaining the privacy of each party. For Skylight, VIA has developed a ZKP that enables data owners to prove that their energy data is valid. The ZKP can also be used to verify that an action taken by an energy consumer (e.g., curtailing energy consumption) was taken at the expected time. Each party's anonymity is maintained during any verification process. See Appendix C for more details on VIA's ZKP, Proof of Stake on Numbers.



In a second phase, data custodians such as utilities will use Skylight to mint NFTs of their customers' data and associated ZKP, and airdrop the NFTs to the data owners for them to claim.

Data owners can approve the use of their NFTed data in a Privacy Pool. Privacy Pools are collections of NFTs that comply with a common set of smart contract-controlled, privacy-preserving rules on a specific topic (e.g., solar, EVs, load forecasting). Data owners may participate in one or more Privacy Pools.

Insight Buyers can purchase insights through Privacy Pools. These insights include historical insights on a one-off basis or a subscription for a fixed period to receive insights going forward (e.g., the next 12 months) on a real-time basis. Insight Buyers can also reward participants for energy savings actions that they take. Zero-Knowledge Proofs are used to verify data and actions.



Skylight Market Roles

Skylight facilitates data analysis and verification among four main user types:

- *Data Creators* are energy consumers whose daily activities generate data that can be used by Insight Buyers. Data can include historical use of energy and also actions taken by request to reduce or increase energy consumption. Data Creators decide how their data is used and what compensation is fair to them in exchange.
- *Custodians* are utilities, EV charging station companies, and other organizations that collect and store data on behalf of Data Creators. For example, most utilities collect and store energy usage (load) data at 15-min intervals from smart meters and store the data on premise or on the cloud.
- *Insight Buyers* are organizations, such as utilities, that have specific operational challenges, or sustainability goals, that can be solved by gaining access to data held by Data Creators or Custodians.
- *Verifiers* are individuals who receive compensation for their compute power to cryptographically verify data and system integrity. Verifiers are only required in the scenario where a Data Creator and an Insight Buyer disagree on a transaction.
- *Skylight* is the Web3 application that provides the smart contracts, ZKPs, and infrastructure for Data Creators, Custodians, and Insight Buyers to transact with each other anonymously.

System Components

The VIA Skylight platform consists of the following components:

- *Smart Contracts and Privacy Pools:* An Ethereum Virtual Machine (EVM)-compatible smart contract template to create NFT staking pools. Skylight contracts include built-in mechanisms to protect data owners (consumers and custodians).
- *Trusted Analytics Chain™ (TAC™)*: A Zero Trust Architecture (ZTA) network for Insight Buyers to schedule and execute privacy-preserving computations on data that is decentralized on premise at consumer homes or their designated Custodians (e.g., utility).
- *NFTs:* Data and computation NFTs to have publicly available proofs (see Appendix B).

- *Proof-of-Stake on Numbers:* A new, VIA-invented, cryptographic proof mechanism to verify data owner participation (see Appendix C).
- *Smart Wrangling Engine for Extraction and Transformation (SWEET™):* A VIA-proprietary artificial intelligence (AI) module to standardize energy data from multiple formats into a single "universal," AI-ready format (see Appendix E).
- *Non-Intrusive Load Monitoring (NILM):* A non-proprietary AI algorithm to identify detailed user behavior patterns from an aggregated load data source (see Appendix F).
- *Distributed Autonomous Organization (DAO):* Governance to update reward allocations, prioritize analytical insights, and enhance privacy rules.

Smart Contracts to Enforce Data Privacy and Compensate Data Creators

Skylight uses smart contracts to reward Data Creators for their participation in Opportunities.

Each smart contract controls:

- Data privacy constraints (e.g., data must be in a group of greater than 100 participants) - Initially, these constraints are pre-programmed[8] by VIA. A DAO or other peer-reviewed method may be used to introduce and enforce future data privacy constraints.
- An analytics function (e.g., calculate peak power consumption from the last 12 months) - Initially, analytics functions are pre-built by VIA. Functions may be extended by other actors in the system. Data Creators can "opt-in by default" to one or more categories of analytics functions. Initial analytics functions provided by VIA include a calibration function to improve labeling "on" and "off" of specific residential devices, peak load calculations, and power curves.
- The workflow required to execute the analysis within the data privacy constraints
- The allocation of rewards to Data Creators - The Insight Buyers must stake enough tokens to compensate all parties in the system to achieve the Opportunity (e.g., Data Creators for their data, Custodian for managing the data).
- Electronic signatures of participants - An Opportunity becomes active only once enough participants have digitally signed.

As part of the workflow, each completed Opportunity is validated to ensure that the results meet all contracted privacy criteria. Once the validation is complete, the result of the analytics function is returned to the Insight Buyer. This triggers the transfer of tokens that were staked by the Insight Buyers to each participating Data Creator.

Privacy Pools to Enable Analysis of Data While Complying with Privacy Restrictions

A Privacy Pool is a collective of Data Creators who sign up for the same smart contract. The smart contract for each privacy pool enforces a privacy-preserving workflow that can be used to achieve an Opportunity to extract information (e.g., a statistic or machine learning (ML) model result) that does not reveal any detail about the individuals who contributed data to achieve the Opportunity.

Privacy Pools help Data Creators, Insight Buyers, and Custodians gain trust in the market. This is done by providing two main types of assurances:

- Insight Buyers cannot execute workflows that reduce Data Creator privacy
- Results from achieving an Opportunity are honest

The template executes on each participating Data Creator's data. The results are aggregated and / or otherwise post-processed to protect data privacy before any information is returned to the Insight Buyer. Data Creators opt in to a Privacy Pool by wrapping their NFT and staking it into the available token Privacy Pools.

[8] VIA has worked with leading data privacy regulators in Switzerland to identify the world's leading data privacy standards.

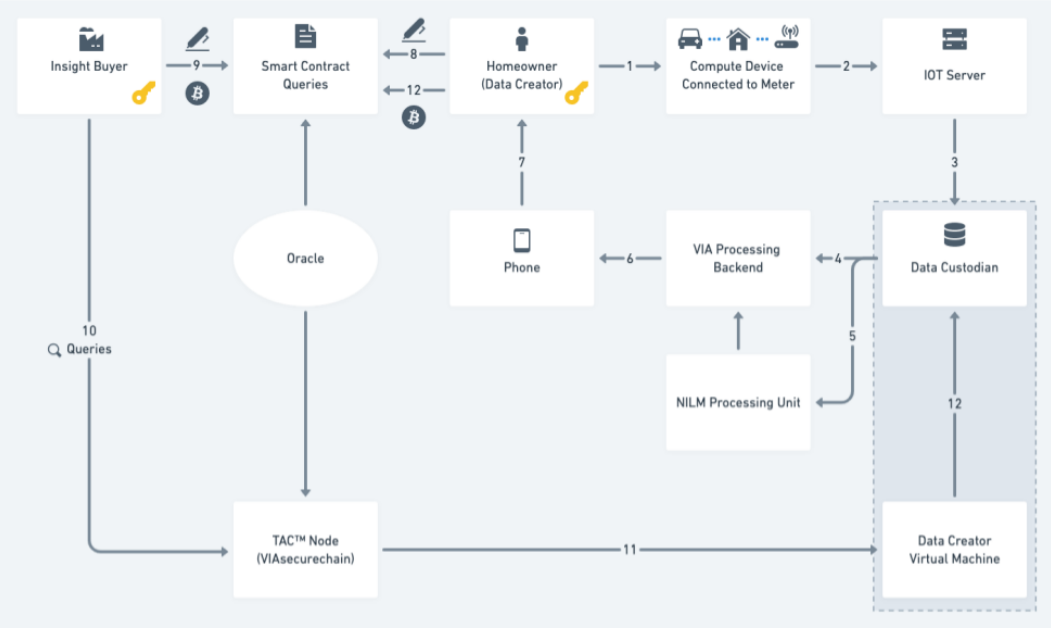
Insight Buyers can make use of the market by renting access to the data in a Privacy Pool. When an Insight Buyer subscribes to a Privacy Pool, a data query will be built to select data from all Data Creators who have opted into the Privacy Pool and a workflow that loads the queried data will be run either locally on a device private to the Data Creator or at a data center managed by the Custodian. Upon completion of the workflow execution, Data Creators are rewarded for the subscription to the analysis of their data. The private workflow result is returned to the Insight Buyer.

With the permission of the original Data Creators, Privacy Pools also enable a secondary market for refined datasets that are the results of achieving Opportunities.

Skylight Network Structure

The Skylight network structure consists of a TAC™ system configured to interact with an EVM compatible public ledger.

Figure 3: Skylight Initial Design



As illustrated in Figure 3, the Skylight network is a combination of three existing and proven networks:

1. *Public Blockchain* is an EVM-compatible ledger that hosts NFT smart contracts and Privacy Pools
2. *TAC*™ is a consortium blockchain (VIAsecurechain) and analytics workflow platform for private data that provides a decentralized privacy-preserving computational platform, so that Opportunities can be achieved at Custodian data centers or on devices owned by Data Creators. This means that Data Creator data is only temporarily used to achieve an Opportunity and is never copied or transferred outside the Data Creator's device or a Custodian's premises.
3. *Oracle Network* is in charge of bridging the information between the public and consortium layer. Data Creators rent an NFT representing a subscription to their data in Skylight. Oracle servers constantly monitor the smart contracts to translate the rental agreement into privacy-preserving smart contracts for execution using the TAC™ decentralized computing platform.

Protecting Data Creator Privacy using Trusted Analytics Chain™

In 2018, VIA developed its Trusted Analytics Chain™ (TAC™) platform for privacy-preserving data analytics in the power sector. TAC™ is built according to the principles of "Privacy by Design[9]." With eight issued patents and ten patents pending, TAC™ is in use and accredited today at the largest power companies in the U.S., Europe, and Asia around the world as well as the U.S. DOD .

Privacy and Security features of TAC™ include:

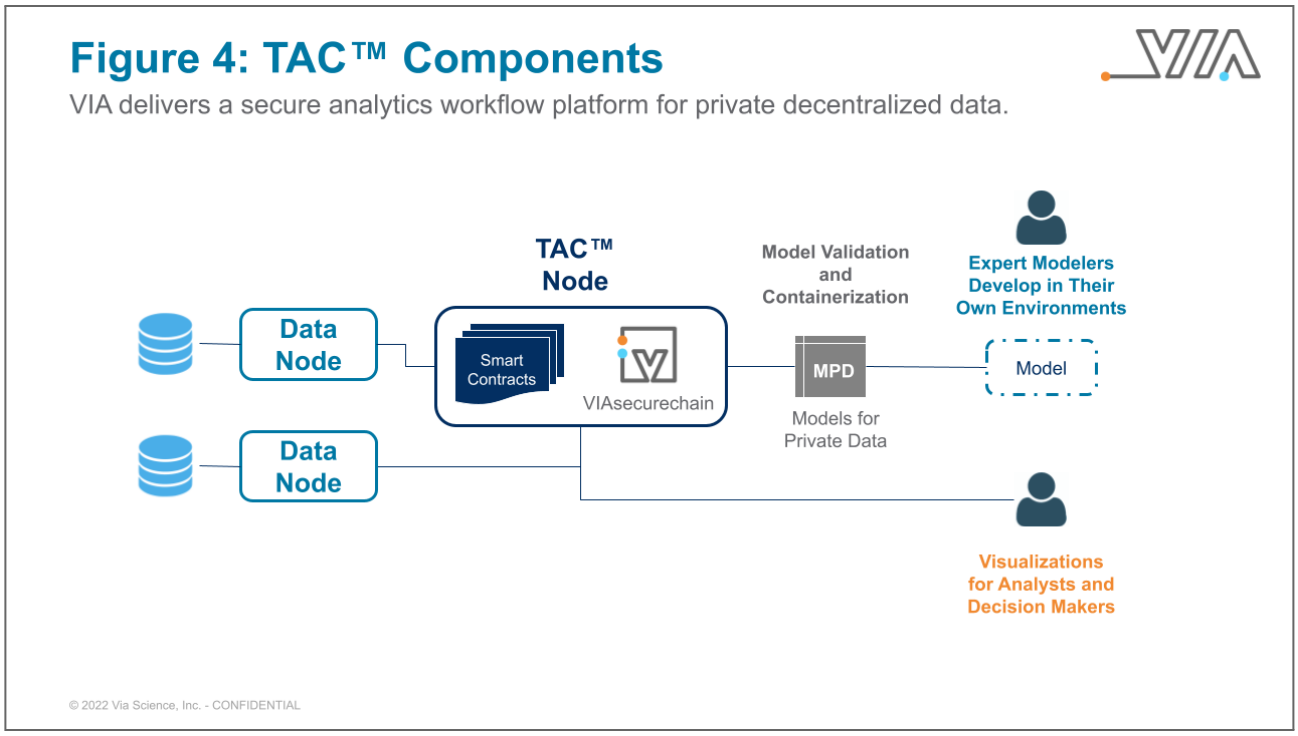
- *Zero Trust Architecture (ZTA):* In addition to perimeter network security, all containers in TAC™ communicate through mutual TLS and only accept communications from containers that have been authorized in the ZTA configuration.
- *Tamper-Proof Workflow Control and Permission Management using VIAsecurechain:* VIAsecurechain is a consortium (based on Tendermint) that includes a set of containers that are hardened with a U.S. DOD cybersecurity accreditation to control classified, top secret level, workflows. TAC™ uses this blockchain to record contracts that grant users the right to execute privacy-preserving workflows on data. VIA's patented templating technology is used to describe analytics workflow rights that can be granted to users in the system.
- *Practical Privacy-Enhancing Technologies:* TAC™ enables computations on encrypted data using NIST-certified and well-trusted cryptographic technology (HE), as well as tools for dataset anonymization.

Skylight is an application leveraging TAC™ infrastructure. Skylight uses TAC™ so that data owners (e.g., Data Creators) can publish datasets for analysis, and analysts (e.g., Insight Buyers) can request access to datasets for analysis. Both data owners and analytsts can exchange contracts to create smart contracts on VIAsecurechain.

TAC™ has two main types of components:

1. *Data Nodes* are hosted by data owners or their proxies (e.g., Custodians). Power companies are already Custodians for millions of energy Data Creators around the world. Data Nodes enable the creation of virtualized datasets for local or federated computation without transferring or copying data. Data Nodes are already run by organizations other than VIA around the world. They can be installed on AWS, Azure, on-premise, or any combination thereof. VIA provides security and other upgrades to Data Nodes quarterly.
2. *TAC™ Nodes* are decentralized nodes in charge of monitoring and controlling workflows through smart contracts. TAC™ nodes can also be used as trusted subjects for outsourced computations including aggregation and verification.

[9] https://iapp.org/media/pdf/resource_center/pbd_implement_7found_principles.pdf



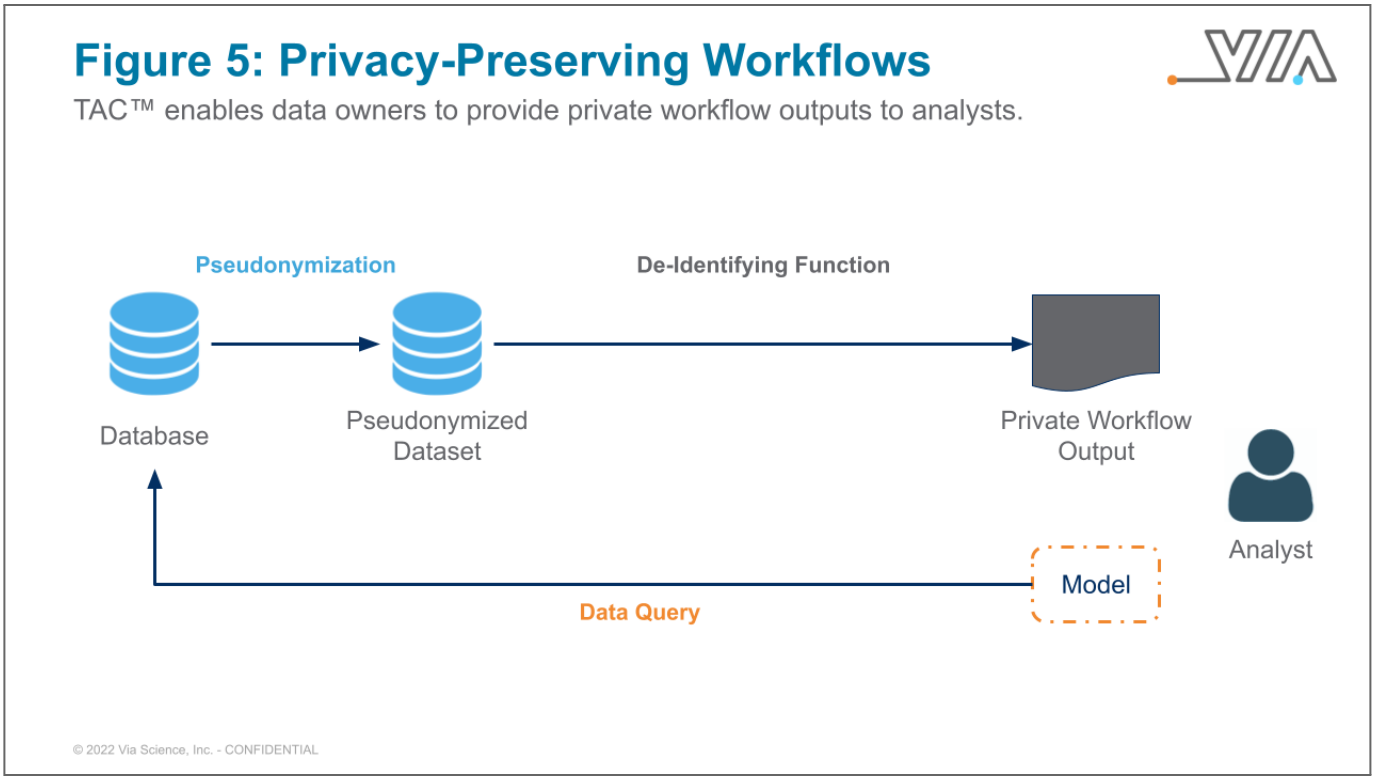
Analysts submit workflows that are then validated against the VIAsecurechain. If the workflow has been explicitly allowed by VIAsecurechain, it is forwarded from TAC™ nodes to Data Nodes for execution.

Privacy-Preserving Workflows

A privacy-preserving workflow is a computational process that starts with raw data and is transformed to an output from which it is difficult to identify any individual whose data was used to produce the result. In general, there are four main components to a privacy preserving workflow:

1. *Database:* containing raw data
2. *Data Query:* a parameter used to select a subset of the database
3. *Pseudonymization:* A preprocessing step that replaces personal identifiers with pseudo-random cryptographic hashes. This step may include other preprocessing steps such as *K*-anonymity[10]. If desired, the pseudonymization step may return true anonymous data, with no identifiers, so that data cannot be linked.
4. *De-Identifying Function:* Given a dataset, a de-identifying function transforms the data by computing some statistic (e.g., mean) or, in machine learning cases, a gradient of a loss function averaged over each element in the dataset.

[10] https://www.solvewithvia.com/lets-tac-k-anonymity/



The process can be represented as directed acyclic graph, as shown in Figure 5, with two nodes, and two outputs:

- *Pseudonymized Dataset:* Given a raw database, a data query, running the pseudonymization step, returns the pseudonymized dataset.
- *Private Workflow Output:* Given the pseudonymized dataset, calling the de-identifying function returns the workflow output.

TAC™ enables data owners to provide private workflow outputs to analysts that do not violate the privacy of any individual because individuals cannot be identified from workflow outputs. The process works as follows:

1. A workflow consisting of a tuple (Data Query, Pseudonymization, De-Identifying Function) must be specified to create a smart contract for execution.
2. An analyst selects a Data Node where the execution should run.
3. The workflow request is sent to a TAC™ node. The TAC™ node queries VIAsecurechain to verify that the analyst is authorized to run the workflow on the specified Data Node. If the workflow is authorized, the TAC™ node then submits the workflow to the Data Node.
4. The Data Node verifies with VIAsecurechain that the workflow is authorized. If the workflow is authorized, the query is executed and the private workflow output is returned to a TAC™ node that forwards it to the analyst.

Verifying the Custodian as Trusted Compute Provider

While each Data Creator can act as a trusted compute provider to generate insights from their data, Custodians can provide outsourced computational resources as well. That is, in exchange for cryptocurrency rewards, Custodians can lend comput to the Insight Buyers on behalf of the Data Creators. Each Custodian runs a Data Node that listens for requests sent by a TAC™ node to rent access to Privacy Pool data.

Each Custodian is required to provide Proof-of-Stake to participate in the system. The system can also send random challenges to the Custodian's Data Node to ensure that the Custodian can be trusted as a compute

provider. When a Custodian fails a random challenge, a fine is withdrawn from the Custodian's stake account. Challenges include:

1. *Proof-of-Responsiveness:* Random cryptographic puzzles of known strength are generated and sent to the Custodian's Data Node. The Data Node must respond with a correct answer and computation time within a prespecified time period. This ensures that the Data Node is responding.
2. *Proof-of-Non-Tampering:* When a Data Creator joins a Privacy Pool, the Custodian generates a detailed Merkel Tree summary of the Data Creator's energy consumption data. This is stored as a ZKP on VIAsecurechain. The Custodian is periodically challenged to provide proof of knowledge of energy consumption details for specific Data Creators in the Privacy Pool.
3. *Proof-of-Stake-on-Numbers:* To prove the validity of the energy usage data, an independent verification of energy usage data can be taken at random intervals and published as ZKPs on VIAsecurechain. The system can challenge the Custodian to provide energy usage data for a Data Creator or set of Data Creators over a prescribed period. The protocol is detailed in Appendix C.
4. *Proof-of-Computation:* TAC™ nodes are used as trusted subjects to repeat computations on pseudonymized data. For a random fraction of subsets of the pseudonymized data, the dataset is sent to a TAC™ node for recomputation.

These challenges and proofs establish the Custodian as a trustworthy outsourced computation provider, which is key to earning trust of Insight Buyers who wish to rent access to Privacy Pools.

Real-World Use Cases

Insights: Solar Installer Example

As an example, imagine two companies in a city: Power Inc and Acme Solar.

- Power Inc has a regional monopoly and has deployed advanced metering infrastructure (AMI) to collect energy usage data at all homes and businesses across the city.
- Acme Solar is a solar energy installer and has an Opportunity it would like to achieve:
    - Identify which customers are the highest priority for sales and marketing efforts.

In many regions, Acme Solar invests in a door-to-door sales force to find potential customers. Those potential customers can only receive a quote from Acme Solar if they give written permission to Acme to gather details from Power Inc.

Instead, Acme Solar could use data from the Data Creators of Power Inc to solve its problem. The Data Creators in the system are the energy customers of Power Inc and Power Inc is the Custodian.

In this example, Power Inc:

- Stakes tokens to encourage Data Creators to participate in the program
- Installs a Data Node on premise at Power Inc
- Sends Data Creators an invitation for them to join Skylight in exchange for a token reward
- Mints an NFT and either places it in an already existing customer wallet, or creates a new VIA Wallet[11] (see Appendix A), when a Data Creator agrees to participate in Skylight. Customers then receive instructions on how to claim their NFT and their token reward
- Creates a Privacy Pool for Insight Buyers such as Acme Solar who will be the Opportunity owners

Once a Privacy Pool is created, Acme Solar can publish its Opportunity and request participation from Data Creators in the city. When the threshold set by Acme Solar for a minimum number of participating Data Creators is reached, Acme Solar stakes tokens and submits its query (e.g., computes the average energy consumption profile

[11] VIA's Wallet is in alpha and due to launch in late August, 2022. VIA Wallet will leverage Gasless transactions https://docs.openzeppelin.com/learn/sending-gasless-transactions

per city block in the neighborhoods of interest). Providing all validations pass, Acme Solar receives the result of its query and its tokens are transferred to other actors in the system (Data Creators and Custodian).

The example above can be expanded. In addition to Power Inc, New Energy Ltd could join the system and provide data from its customers by installing a Data Node. New Energy Ltd and Power Inc are competitors but can cooperate here without exchanging any data with each other or centralizing data with a third party. Both Power Inc and New Energy could make the Privacy Pool available to others beyond Acme Solar including Acme Solar's competitors or companies in adjacent markets such as EV charging.

Actions: Grid Flexibility Example

As another example, imagine a utility concerned with meeting the power demand of its customers as it faces fuel supply shortages. An increasing number of global events are making this a more common challenge for utilities. Extreme weather events in the U.S. and Europe[12], nuclear plant maintenance issues in France[13], and a conflict with Russia are simultaneously severely constraining supply and increasing consumer demand.

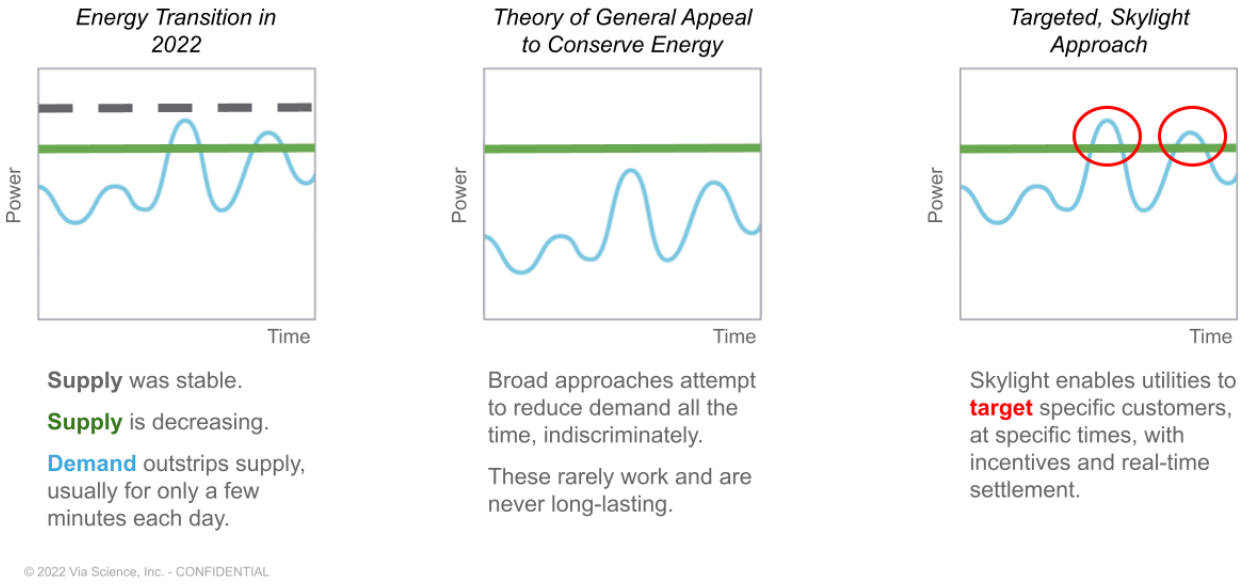
The general wisdom is to broadcast to consumers to reduce their consumption. This is highly dissatisifying for consumers, and frankly ineffective for utilities. By contrast, with Skylight:

- The utility defines its compensation program to incentivize consumers to reduce their consumption.
- The utility uses a VIA smart contract template to codify its incentive program.
- The utility stakes tokens to the contract.
- Consumers are notified through the Skylight app and have the option to participate in the program.
- Participants are notified to take an action at specific times.
- When participants take an action, they are immediately compensated through a token reward.
- Skylight creates a ZKP of each participant's action. These ZKPs are published to resolve disputes that may arise later.

[12] Storms batter aging power grid as climate disasters spread | AP News
[13] French Nuclear Outages Risk Making Europe's Gas Crisis Worse

Figure 6: Skylight Enables Grid Flexibility

Before Skylight, utilities had only broad approaches to engage residential energy consumers.



The real-time and programmable element of smart contracts enable utilities to define incentives that they believe best match their customer base and their grid needs. This enables personalization at scale. For example:

- One utility may decide to provide a high reward to the first participants and declare that rewards will decrease over time and stop once supply and demand are balanced.
- Another utility may decide to offer a small reward to the first 100 participants, and if supply and demand are not balanced, then the reward will increase for the next 100 participants.

In addition, with the rise of smart devices, consumer actions can be even more targeted and automated. For example:

- *Targeted:* A small number of appliances account for the majority of a residential consumers' power consumption. Actions could be limited to a subset of devices registered with Skylight such as cooling and heating systems, hot water heaters, and lighting.
- *Automated:* Smart contracts can ensure actions are taken only when all contractual conditions have been met, even when a residential consumer is not home. Actions when a participant is not at home may provide the best "no trade off" option to reduce consumption with no noticeable impact on the consumer.

The combination of targeted, automated control through smart contracts enables energy providers to provide hyper-personalized offers to consumers to address significant and immediate needs.

More use cases are referenced in Appendix G.

Initial Capture of Energy Data

VIA is working today to:

- Enlist Custodians who collect and steward data
- Provide Custodians and Data Creators with tools to mint NFTs tied to energy usage data

- Work with Custodians to offer starter incentives to Data Creators to participate in Skylight. As Data Creators opt in:
    - A VIA Wallet is created (optional if the user already has a compatible wallet)
    - The NFT token is minted and placed inside the VIA Wallet
    - Consumers receive an email with a link to install the VIA Wallet application on their mobile device or use another wallet of their preference
- Attract Insight Buyers who will stake tokens to gain access to Privacy Pools to solve achieve analytical Opportunities
- Provide Challenge Owners with a client to submit analytic workflows to run at a Custodian data center.
- Provide data privacy tools to Data Creators and Custodians so that:
    - Analytic workflows that run on Data Creator devices or at Custodian data centers are built on top of Privacy Pools
    - All workflows submitted by Insight Buyers run on Privacy Pools. These pools protect the privacy of Data Creators and ensure that Custodians are in compliance with all relevant privacy regulations in their jurisdiction

DAO Governance

In a future phase, Skylight will use a DAO to provide guidance on privacy risk, reward allocation, and infrastructure health measures such as compute, scalability, and storage capacity. The DAO can also play the role of privacy auditors, ensuring that Opportunity results comply with privacy agreements, and that the results cannot be reverse engineered to reveal details of an individual Data Creator. The DAO will ultimately govern itself. See Appendix D for more details.

Tokenomics: Rewards to Motivate Data Owner Participation

Tokenomics are a fundamental part of Skylight to motivate Data Creators to take action and to promote positive behavior changes. Incentive mechanisms in Skylight could include:

- Tokens, a cryptocurrency launched by VIA, used as the main legal tender for actors to participate in Opportunities and Dapps powered by Skylight.
- System actors are rewarded with tokens in exchange for allowing their data to be used in an Opportunity. Reward tokens will be locked for the duration of the Privacy Pool to prevent users from negatively affecting renters / subscribers.
- To address the cold start challenge, Data Creators who claim their NFTs early could see their rewards boosted until adoption of the privacy pool reaches critical mass[14].
- Custodians of the data are rewarded for their investment in data collection, management infrastructure, and to compensate for the cost of compute.
- Verifiers receive tokens for active attestation of the data by running cryptographic computations.

The construction of Privacy Pools in carefully designed segments and analytic functions can itself be incentivized by tokens. This creates a role for privacy experts, analytics experts and system experts on Skylight. This expertise is in high demand. This fosters a secondary market in tokens to reward expertise for their participation in the market.

A major advantage of tokens is real-time settlement. In most regions, the time to reconcile and then reimburse participants for their energy curtailment or other actions is between 45 and 90 days. As many behavioral studies have shown, the shorter the interval between reinforcement and an action, the stronger the effect. Real-time settlement, therefore, should have the strongest impact on incentivizing actions.

[14] The Web3 Playbook: Using Token Incentives to Bootstrap New Networks | Future

Future Work

In a second phase, utilities will use Skylight to mint NFTs of their customers' data and associated ZKP, and airdrop the NFTs to the data owners for them to claim. The current pilot in Switzerland provides an end-to-end demonstration of Skylight. VIA is in discussions with utilities observing the pilot to leverage Skylight as a foundational platform for their own markets using this approach.

In addition, energy data provides significantly more insights than solely for the transition to clean energy and grid reliability. Analysis of high frequency power data can provide inferences regarding how many people live in a house, their ages, their schedules, and how old their appliances are. These insights come from advances in AI (see Appendix F) to analyze smart meter data. VIA's third phase will focus on unlocking this data and compensating Data Creators for insights that they are willing to sell to Insight Buyers outside of the energy industry. As an example, logistics companies (e.g., home delivery) are interested in the use of energy data to predict and confirm attendance at home to sign for a package delivery.

We also see consumers' comfort and appetite evolving to where other types of data (e.g., location of their EV or preferred work location) may become part of the market. This kind of data is valuable to employers, campus and building facility managers, and public transportation coordinators. As an example, a large European bank recently asked about how to return from COVID more effectively and work with the surrounding community (e.g., bakers, bars, dry cleaners) to create compelling offers that encourage employees to be in the office. Skylight is ideal to enable rewards for participation in a broad range of community actions while meeting data privacy agreements.

In the near-term, VIA has already had interest in its Web3 stack (e.g., ZKPs). The market for CO_2 trading, for example, was $851 billion[15] last year and growing rapidly. As blockchain applications emerge for applications like carbon trading, VIA's Web3 stack is well positioned to provide a much needed, secure, energy-specific infrastructure layer.

As energy markets and the blockchain sector are evolving rapidly, the latest details on VIA's strategy to commercialize Skylight are available upon request.

[15] Global carbon markets value surged to record $851 bln last year-Refinitiv | Reuters

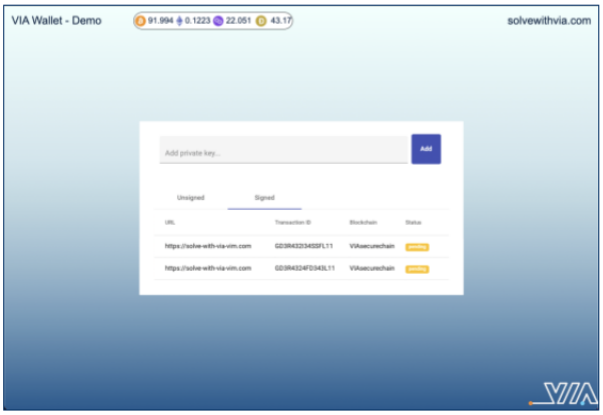
Appendix A: VIA Wallet

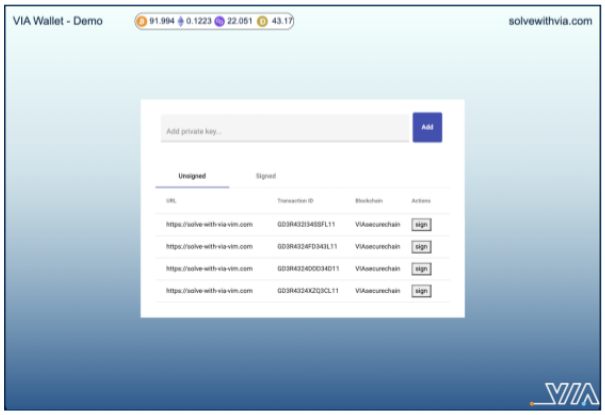
Non-native crypto users and enterprise customers will benefit from a secure and easier way to digitally sign transactions. In addition to a user interface focused on simplifying transactions, VIA's wallet has multiple other advantages:

- Multiple approaches to prevent common phishing and password exfiltration attacks
- Single-Sign On compatibility for consumers and enterprise users
- Dual factor authentication
- Ability to sign multiple blockchain transactions simultaneously
- Reduction in gas fees

Figure 7: VIA Wallet

VIA Wallet is a consumer-friendly and enterprise-compatible means to authorize transactions.





Appendix B: NFT Allocation

Skylight supports two types of NFTs:

1. Data NFTs: Represent a proof of the data
2. Computation NFTs: Represent the allowed computations with the data

Data NFTs

This type of NFT represents a ZKP of the data. It is owned by the Data Creator and generated by the Custodian of the data. The data NFT can be minted under these circumstances:

- At the time that a Data Creator decides to offer their batch data in a privacy-preserving pool for Insight Buyers to analyze in exchange for a reward
- After an Insight Buyer has offered a Data Creator a reward for taking an action and the Data Creator has agreed and completed the action. In this case, an NFT with the data proof is minted for the period of time starting when the customer accepted to the moment they flagged the action as concluded. This NFT serves as verifiable proof of the data that the customer is claiming.

Custodians may generate NFTs and airdrop them to their rightful owners, the Data Creators. ZKPs can be used to airdrop NFTs while preserving the on and off chain information confidentiality[16].

Computation NFTs

Skylight also uses NFTs to represent the computations permitted by a Data Creator on their data. These NFTs represent the privacy preserving pool restrictions and they are a link between the public blockchain and TAC™.

Computation NFTs are minted by the originator of the privacy preserving pools.

[16] Privacy-Protecting Crypto Airdrops with Zero Knowledge Proofs

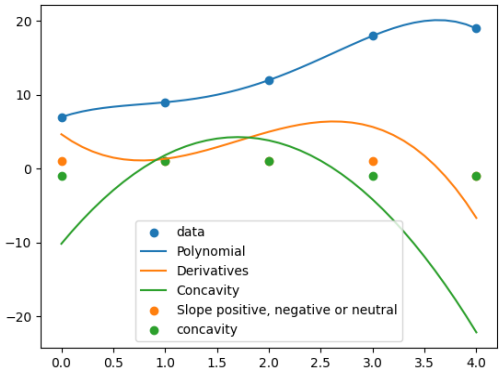
Appendix C: Proof-of-Stake-on-Numbers

Proof-of-Stake on Numbers (PSN) is a combination of data validations and ZKPs that provide Skylight the ability to publicly release proofs created by Data Creators or Custodians while maintaining individual anonymity. With data, PSN proves that the data and / or consumer is valid. With ZKPs, PSN proves the Data Creator ownership without revealing the identity or details of the data.

At a high level, the process involves taking readings from a consumer's smart meter (e.g., 1.0 kWh, 1.1 kWh, 0.9 kWh). These readings can be plotted as a curve. The curve can be described by a polynomial function. Certain mathematical functions (the polynomial function, derivatives, concavity) related to the curve make up the key proof points. Importantly, these proof points do not reveal any private or personally identifiable information.

More specifically, the process involves:

- Publicly verifying individual reading sequences by specific verifiers with knowledge of the partial information while not releasing the data[17]
- Obtaining the polynomial given a sequence of readings by:
    - Using Lagrange interpolation to obtain the polynomial
    - Calculating the first and second derivatives, f(x)' and f(x)''
    - Taking samples on a specific range of interest of the meter readings and calculating a vector for the slope f(x)' and the concavity f(x)'' as positive sample 1, neutral 0 and negative -1. This provides us enough information to assess the direction of the readings without revealing the data.
- Data validations can also be performed by randomly requesting samples by an escrow that has an understanding of the underlying meter readings. The escrow can be assured that the data received is not fake using ZKPs.



The ZKP can be applied using HE and publicly releasing the encrypted sum over random samples requested by verifiers. A trusted oracle would validate the result of the sum compared to the expectation by the verifier.

Uniquely, VIA has its own patented, NIST-compliant, additive HE algorithms[18]. VIA is also researching the application of zk-SNARKs over sequences to encrypt the polynomial rather than specific data points.

In summary, VIA's PSN approach combines data validations and ZKPs to verify that:

- A series of meter readings are what a Data Creator claims.
- The meter readings are valid against some given expectations without publicly revealing the data.

While smart meter readings are used in this example, this same approach can be extrapolated to other data types in other industries.

[17] Open Source Monday: Zero-Knowledge Proofs - VIA
[18] Let's TAC™ About It: Homomorphic Encryption Algorithms on TAC™ (HEAT) - VIA

Appendix D: Nash Equilibrium

The reward allocation to Data Creators will vary based on the Nash equilibrium. New Data Creators will join the pool as long as the reward matches their optimal strategy.

An infinitely repeated transactional system, like Skylight, may contain one or many Nash equilibria per game. Therefore, the optimum selection for participants could be different per application and evolve with transactions. Communication between members of the DAO and restriction of options will provide support to direct the outcome of the market and update the market as equilibrium is reached at different stages. As an example, we can define the system as a repeated game where we would like participants to adhere to a privacy pool as long as needed to perform an analysis (multiple queries).

Join option by user versus reward allocation on privacy pool:

	No reward pool	Fixed reward in pool
Not join pool	(0, 0)	(0, -1)
Join single game pool	(0, 1)	(1, 1)
Join repeated game pool	(0, 1*stage)	(1, 1*stage)

Join option versus data risk:

	No privacy mechanism	Privacy mechanism
Not join pool	(0, 0)	(0, 0)
Join single game pool	(-∞, 1)	(0, 1)
Join repeated game pool	(-∞, 1*stage)	(stage > 0 ? -1*stage : 0, 1*stage)

In this case, for the DAO to engage customers in a repeated game, the reward allocation will have to be updated with the number of iterations performed on the game. Otherwise the risk to customers will outweigh their interest to stay in the game.

Appendix E: AI to Automate Standardizing Data from Multiple Formats Into a Single Format

The data from electricity smart meters can come in multiple formats. Power companies may transform their data into different formats and may extract the data for analysis differently over time. Power companies told VIA that it could take a data scientist 4 to 8 hours per meter file to transform into a standardized format. This is a very high transaction cost and barrier to standardized analysis, particularly AI.

VIA has solved this issue at scale for commercial energy companies such Enel X[19], the world's largest energy storage, demand response, and eMobility company.

The AI module behind VIA's meter data ingestion process is called the Smart Wrangling Engine for Extraction and Transformation™ (SWEET™). Separate from data quality, VIA's system has been designed to handle common file and data format issues such as:

- Unclear schemas
- Missing column names
- Irregular headers and footers
- Multiple tables in one file
- Irregular date stamps
- Ambiguous time zones
- Daylight savings changes
- Duplicate columns due to backup meters

VIA's AI approach has multiple benefits:

- Speed - In comparison to one power company's manual processes, VIA's approach is at least 100x times faster than traditional software coding approaches.
- Accuracy - To identify issues, VIA leverages recent advances in computer vision models to "look at" each dataset. This approach yields results that are significantly better than humans. An AI-driven approach is at least twice as accurate as a manual data science approach.
- Flexibility - VIA's approach improves over time as the system sees a greater variety of data and formats. This is the opposite of most traditional systems that struggle to create rules to capture the increasing complexity and variety of data over time.

This AI function works similarly to the AI in your smartphone for photos. For example, when you point your phone's camera at a person, a small rectangle appears over the individual's face. Even though every individual is unique, every photo's context is widely varying, and you did not train your camera on specific people, the AI in your phone is able to identify what is a face and what isn't. The SWEET™ engine performs a similar function to identify data irrespective of the context (file format) and whether it has seen that data before.

[19] VIA and Enel X: Bridging power company data and AI solutions

Appendix F: AI to Identify Detailed Household Insights from Aggregate Smart Meter Data

Data from electricity meters can provide detailed demographic and behavioral insights. The industry term for the AI technique that provides these analytical insights is called Non-Intrusive Load Monitoring (NILM). NILM is a deep learning, neural network model.

For example, studies[20] have shown that household income and age of occupants can be estimated from the type of data that NILM systems analyze. As AI has evolved, NILM accuracy has increased and processing power requirements have decreased[21]. In parallel, VIA has demonstrated[22] that it can replicate NILM analysis accurately using a federated AI learning approach[23]. A federated approach leaves the data in multiple, decentralized locations. There is no requirement to centralize and physically aggregate the electric meter to build models or analyze it.

In addition, VIA has been working closely with the Swiss national energy ministry and one of the largest utilities in Switzerland to develop a federated approach that applies an algorithm or model (and specifically NILM) to multiple datasets without combining them, while yielding results equivalent to applying the same algorithm or model to a centralized database.

The ongoing project investigates how algorithms work in conjunction with smart meters at the grid edge. The project considers the practical integration of AI algorithms and federated analytics approaches into residential, industrial, and commercial settings through field-based trials.

[20] Feature extraction and filtering for household classification based on smart electricity meter data | SpringerLink
[21] Real-time non-intrusive load monitoring: A light-weight and scalable approach - ScienceDirect
[22] A more detailed description is available in VIA's March 2019 white paper *Privacy Preserving Analysis of Smart Meter Data to Improve Demand Response Programs for Building Energy Usage*
[23] VIA Wins Swiss National Energy Project

Appendix G: 25+ Smart Meter Data Use Cases and Economic Value

Over the past decade, a number of studies have identified and demonstrated the value of meter data. One academic study[24] from 2017 summarized 26 use cases (see excerpt below).

Category	Code	Use Case	Data Required	Maximum Sampling Time	Maximum Latency	Interested Stakeholders		
						Customer	DSO	Retailer
Awareness	A1	Dashboard for consumption and production awareness	energy data withdrawn and injected (only prosumers)	15 min	15 min	X	-	-
	A2	Ex-post analysis of an electric event (e.g., defrost cycle)	Active power withdrawn, injected, produced	1 min	1 h	X	-	-
	A3	Consumption awareness and cost estimation (revenue estimation for prosumers)	Instant active power withdrawn (injected and produced for prosumers)	15 min	1 h	X	-	X
	A4	Contractual information	All data regarding contractual information	-	15 min	X	X	X
	A5	warning for exceeding available power thresholds	event type, instant active power, timestamp	30 s	5 s	X	-	-
	A6	Warning for exceeding power thresholds (chosen by the customer)	event type, instant active power, timestamp	-	30 s	X	-	-
	A7	Information about a scheduled outage	event type, date, time, duration	-	1 h	X	X	-
	A8	information about a possible blackout	event type, date, time	-	1 h	X	X	-
	A9	information about a recently occurred blackout	event type, date, time	-	1 h	X	X	-
	A10	realtime power curve visualization	Instant active power withdrawn (injected and produced for prosumers)	1 s	1 s	X	-	-
Market	M1	Dynamic pricing contracts (ToU, RTP)	energy withdrawn	15 min	1 min	X	-	X
	M2	Prepaid contracts	energy totalizers grouped according to timebands	15 min	15 min	X	-	X
	M3	multi-contract customer	energy data withdrawn (injected/produced for prosumers)	15 min	15 min	X	-	X
	M4	contract change awareness	Contractual information	-	15 min	X	-	X
Scheduling & control	SC1	Scheduling for appliances	Instant active power withdrawn (injected/produced for prosumers)	5 s	5 s	X	-	-
	SC2	PV self-consumption with appliances and storage systems	Instant active power withdrawn (injected/produced for prosumers)	1 s	30 s	X	-	-
	SC3	Peak shaving with appliances and storage systems	Instant active power withdrawn (injected/produced for prosumers)	1 s	2 min	X	X	-
	SC4	Load shifting with storage systems	Active power withdrawn (interval average)	1 min	1 min	X	X	-
	SC5	Load shifting with appliances	Active power withdrawn (interval average)	1 min	1 min	X	X	-
	SC6	Monitoring for elderly people	Instant active power withdrawn (injected for prosumers)	15 min	15 min	X	-	-
Network services	N1	Active demand for network issues	Active power set point (withdrawn/injected) active power (interval average)	1 min	10 s	X	X	-
	N2	tertiary reserves	Active power set point (withdrawn/injected) reactive set point, active power (interval average), reactive power (interval average)	3 min	1 min	X	X	-
	N3	secondary reserves	Active power set point (withdrawn/injected) reactive set point, active/reactive power	3 min	1 min	X	X	-
	N4	reactive power exchange	active/reactive power set points	-	1 min	X	X	X
	N5	Demand Response	Max active power withdrawn/injected set point	-	1 min	X	X	-
Diagnostics	D1	Supply service anomalies monitoring	rms voltage, outages registers	30 s	1 min	X	X	-

More recently, industrial companies, software companies, and even bitcoin miners[25] have identified and deployed their own applications of meter data to support energy efficiency and cost savings.

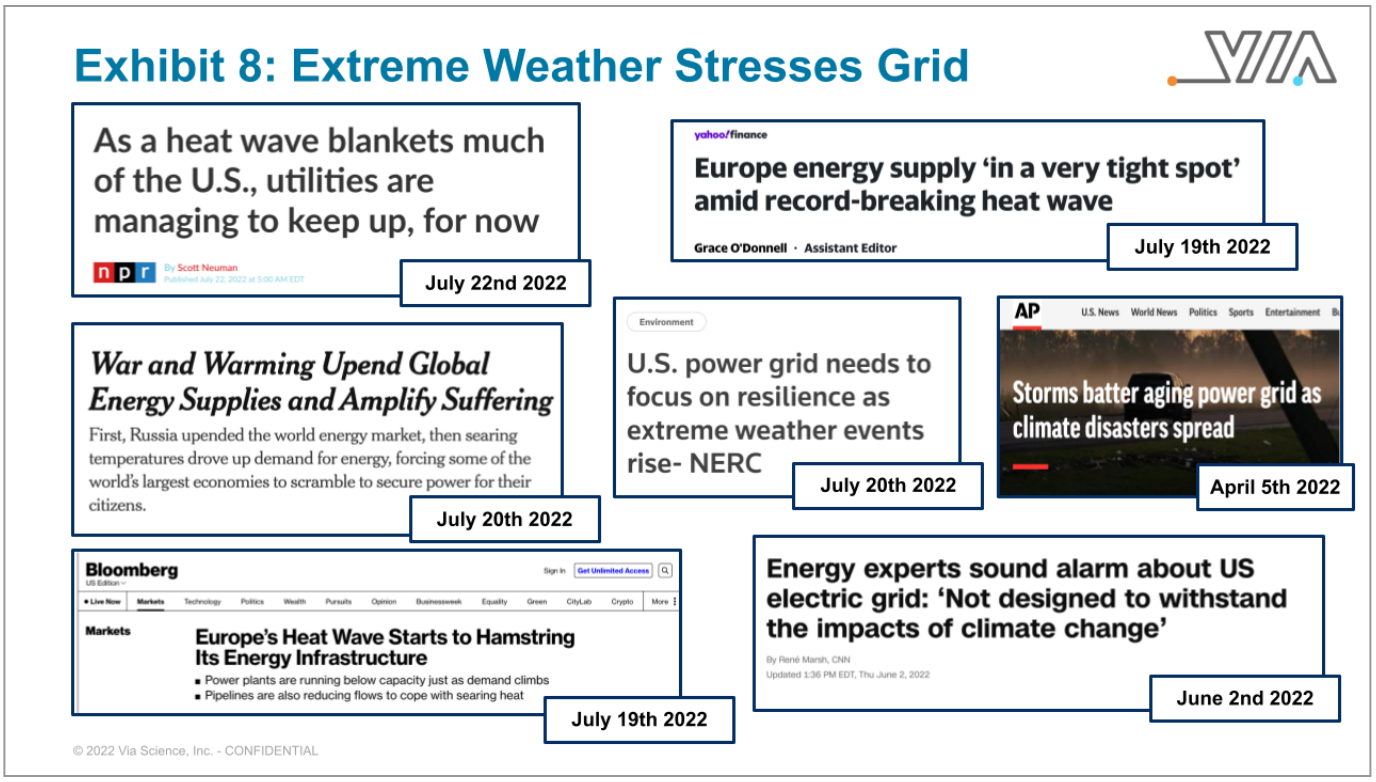
The value of energy meter data continues to grow. A study published in 2022[26] by PNNL (Pacific Northwest National Labs, the U.S. Department of Energy's lab leading smart grid research) that used data from 60,000 simulated homes and businesses showed that transactive energy would reduce daily load swings by 20% to 44%. The economic benefits were estimated at $5 billion annually for Texas and $50 billion for the U.S. as a whole. The study commented that this impact will grow as EV penetration increases.

See Appendix J for details of VIA's pilot and expected outcomes in Switzerland.

[24] The Role of Smart Meters in Enabling Real-Time Energy Services for Households: The Italian Case
[25] Why My Energy Company Pays Me For Running A Bitcoin Miner At Home
[26] How a Smart Electric Grid Will Power Our Future | PNNL

Appendix H: Urgent Need for Community-Led Energy Efficiency

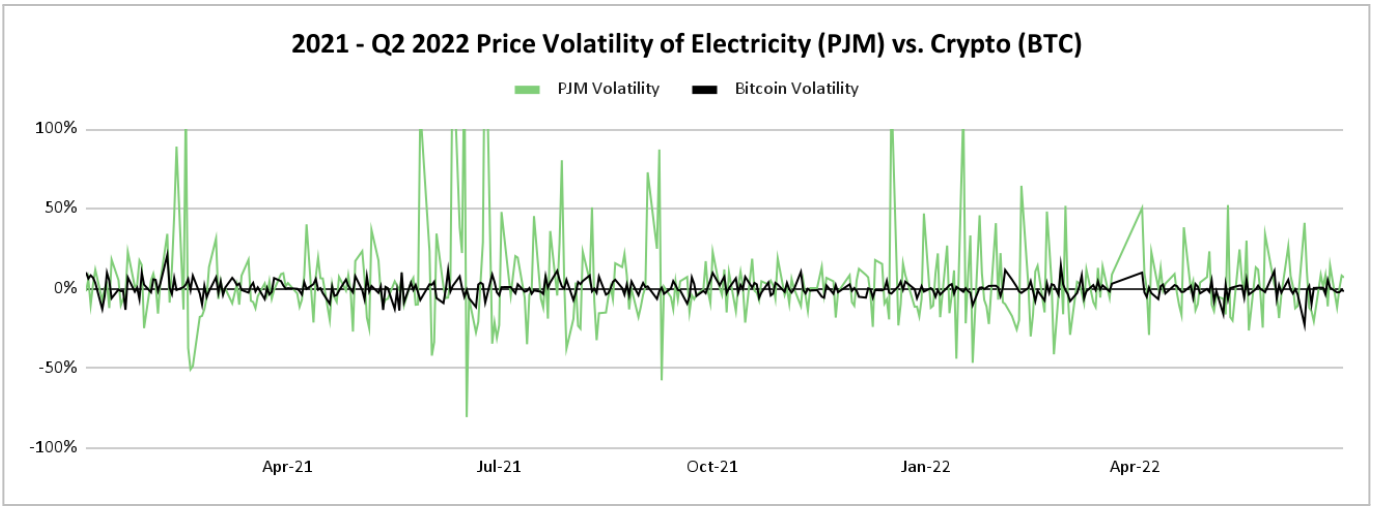
High energy prices, extreme weather events[27], and consumer demand for cleaner air and water are a few of the key factors driving the transition to clean energy.



The energy transition is further accelerating due to spikes in fossil fuel prices and a growing interest in national energy independence. The European Union and the U.S. spent more than $2 trillion on energy in 2020. Analysts believe that energy bills will increase more than 50% in 2022 over 2020 levels[28].

[27] U.S. power grid needs to focus on resilience as extreme weather events rise- NERC | Reuters
War and Warming Upend Global Energy Supplies and Amplify Suffering
Energy experts sound alarm about US electric grid: 'Not designed to withstand the impacts of climate change'
Storms batter aging power grid as climate disasters spread | AP News
Europe Heatwave Temperature Starts to Hamstring Its Energy Infrastructure - Bloomberg
Europe energy supply 'in a very tight spot' amid record-breaking heat wave
Blackouts possible this summer due to heat and extreme weather, officials warn - CNN

[28] European Energy Bills to Rise 54% From 2020 Level, BofA Says - Bloomberg



	2021			2022		
	PJM	BTC	PJM vs BTC	PJM	BTC	PJM vs BTC
Daily volatility	30%	5%	6.07	23%	5%	4.85
Monthly volatility	137%	27%	5.04	105%	26%	4.03
Quarterly volatility	237%	47%	5.04	183%	45%	4.03
Annual volatility	473%	94%	5.04	365%	91%	4.03

Figure 9: Wholesale energy prices are significantly more volatile than bitcoin prices.

The clean energy transition is a decentralization of energy generation and consumption. Energy is now generated everywhere from offshore wind farms to rooftop solar panels. Energy consumption patterns, accelerated by COVID-19, have shifted to homes. EVs and battery storage technologies are introducing flexibility options to balance renewable energy supply and demand.

As energy decentralizes, the need for decentralized energy data increases.

Data from home smart meters, EVs, and rooftop solar provide necessary insights to ensure grid reliability at a cost effective rate. In Europe and the U.S., however, consumer energy data must be kept completely private for data processing activities other than invoicing or maintenance[29]. The legal standard in many jurisdictions is that valuable energy data can only be analyzed with the permission of the consumer who generates that data. As an example, the European Commission has recently proposed a new Data Act[30] to cover data from Internet of Things devices. In particular, the new act:

"*Firstly, it wants to avoid the sensor-laden Internet of Things (IoT) further concentrating market power in the digital sphere by empowering consumers who own so-called 'smart' devices to gain access to data generated by their own usage; and be able to order a manufacturer to provide their data in real-time to third parties of their choosing whose (non-competing) services they wish to take up.*"[31]

[29] In Switzerland, StromVV, Art 8d, in New York state M-0082, GDPR in the EU and new forthcoming stricter European Commission laws

[30] Data Act: Proposal for a Regulation on harmonised rules on fair access to and use of data | Shaping Europe's digital future

[31] Europe proposes rules for fair access to connected device data | TechCrunch

In addition, recent, highly public breaches of trust by traditional Web 2.0 companies have heightened consumer awareness about the value of their personal data and the dangers of sharing it.

Power companies that have provided compensation (e.g., gift cards) in return for energy data have seen strong, positive consumer responses. In some instances, utilities have paid as much as $50 per consumer for a single insight such as does the resident own an EV. Power companies that failed to provide an incentive saw less than 1% opt in from consumers.

To address this issue, VIA proposes a decentralized market, Skylight, where consumers take ownership of their individual and confidential data.

Skylight provides consumers the ability to rent the insights from their data while adhering to different levels of privacy-preserving mechanisms. Given the growing general awareness of tokens, increased consumer adoption in telecom of decentralized data models (e.g., Helium and Pollen), and the recent White House executive order regarding cryptocurrencies[32], we believe that the timing is right for a token to enable decentralized clean energy data analysis and to directly incentivize grid flexibility behavior of end customers at the same time. In fact, a September 2021 Pew Research study[33] of 10,371 Americans across demographic groups found that:

- 86% have heard about cryptocurrencies
- 43% of men ages 18 to 29 say they have invested in, traded or used a cryptocurrency

In addition, VIA's blockchain platform, developed and tested in mission-critical U.S. DOD applications, provides the foundation for a cybersecure, decentralized data analysis platform.

[32] Executive Order on Ensuring Responsible Development of Digital Assets | The White House
[33] 16% of Americans say they have ever invested in, traded or used cryptocurrency

Appendix I: VIA Mission to Enable Cleaner, Safer, and Equitable Communities

The following is verbatim text from VIA's mission document circulated internally to employees and advisors.

VIA's mission is to make communities cleaner, safer, and more equitable.

As a starting point, AI and analytics will help improve the reliability and cost effectiveness of clean energy.

Mission Challenge

Clean energy is a non-trivial challenge.

The primary responsibility of power companies is to deliver reliable electricity at a fair and reasonable cost to their customers. Without careful planning, however, clean energy can be at odds with this responsibility.

A few current anecdotes of the grid reliability barriers to clean energy adoption include:

- *In some Californian municipalities, the high concentration of EVs) is causing transformers to remain hot overnight, never getting a chance to cool down. This leads to fires and explosions.*
- *In Hawaii, behind-the-meter solar is changing power flow from one-way (central generation) to two-way power flow (surplus solar being sold back to utilities). A sudden increase in two-way power flow is hypothesized to lead to premature equipment failure and unexpected power outages.*
- *In some U.S. wind farms, wind generation is going unused. Intermittent generation from wind causes fast changes in load. This is a challenge for traditional generators and dispatchers to synchronize and maintain reliable electricity supply.*
- *Recent studies have shown that deployment of energy storage can actually increase carbon emissions when the batteries are charged by conventional fuels.*

The list of issues is much longer and continues to grow as electrification and renewable technologies increase in prevalence.

We believe that AI and other advanced analytics is the key to modeling how clean technology impacts grid reliability. More importantly, AI can increase the speed to develop and test strategies that mitigate power disruption.

For all the reasons we are familiar with as data scientists, data for AI can be hard to gather at the best of times. The energy world is rapidly changing, making it even harder. Data, formerly hosted only by a utility, is now fragmented, as deregulation and distributed generation increases. To adopt clean energy and maintain reliability in a cost effective way, utilities need careful planning. In today's world, careful planning requires input and coordination among regulators, communities, EV charging stations, distributed generation companies, and a long list of other third parties that utilities may not even be aware of and likely to change in the very near future.

The Additional Analytical Wrinkle

The primary reason we developed our blockchain platform was to make data sharing and analysis easy. As General Data Protection Regulation (GDPR) regulations point out, sometimes, however, AI and other analytical techniques can inadvertently impact disadvantaged groups, even if the intentions were honorable. To paraphrase, a favorite Marvel movie: with great analytics, comes great responsibility.

This turns out to be true in energy as well. In 2019, David Kolata, Executive Director of the Illinois Citizens Utility Board commented that "Potentially, lower-income consumers are subsidizing higher-income consumers." Clustering of actual load curves showed that "Because these [low income] customers use less electricity and contribute less to the grid's peak load than others, and because peak load drives overall system costs higher, low-income customers could be paying more than their fair share for electricity."

It's intuitive that clean energy adoption is going to be earliest and highest among wealthier communities. Without thoughtful planning, it would be easy for grid reliability and infrastructure to favor already high-income communities at the expense of low and moderate income communities. In the Illinois example, because asset infrastructure costs are amortized across all customers regardless of consumption, lower income households were at risk for paying for upgrades largely targeted at higher income neighborhoods.

This means that as part of how we achieve our mission, we must also ensure that we provide responsible analytics. We should be vigilant to understand where data and analysis (or lack thereof) may lead to negative consequences for certain groups. Responsibility also means that we need to voice our understanding directly to our customers and publicly, for example through our blog posts[34].

Why Not X?

A question new hires often ask is "why power and not x," where x is another worthwhile mission.

For sure, we agree that eliminating famine, poverty, increasing education levels, health, and general equality and equity are incredibly worthy causes.

There are three main reasons we haven't expanded beyond power:

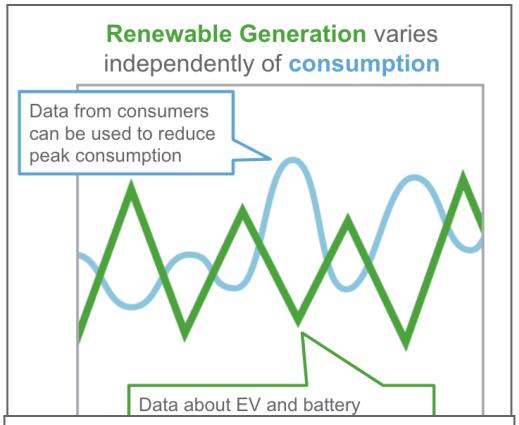
1. *Power has a broad impact. A few examples include:*
    a. *Education: Cheaper distributed generation helps remote communities power schools and have night time lighting for students to complete homework.*
    b. *Food: Cleaner air and water improve crop yields.*
    c. *Health: Electric power reduces the reliance of dangerous cooking fuels, a source of carcinogens and frequent household fires in villages without electricity.*
    d. *Water: Energy is the number one cost (after labor) to purify and access potable water.*
2. *It's hard to do it all. Any individual challenge is, to put it mildly, "crazy big." To have an impact, we believe focus has a higher chance of success than breadth.*
3. *Power was overlooked. When we began, the power sector was largely ignored by startup companies. Even today, financial services and healthcare have a much larger ecosystem for innovation. We can have a disproportionate impact here.*

We're proud of our mission. And, when you love what you do, it shows in the quality of your work.

[34] Let's TAC™ About It: 15/15 - VIA

Appendix J: Summary of Skylight Pilot in Swiss Residences

Problems

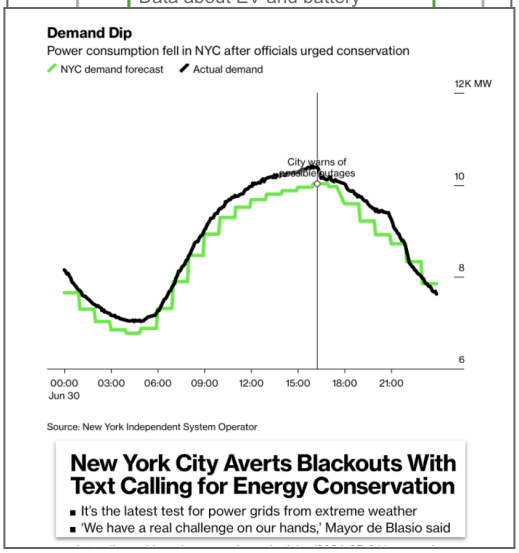


- Mismatch of consumer demand and renewable energy supply can lead to significant economic and environmental consequences.
- Data privacy concerns and regulations limit the use of real-time, individual consumer energy data by Distribution System Operators (DSOs) and third parties.
- Consumers have low engagement with energy data and the consumption of their devices.
- High risk of power outages in winter 2022/2023 due to fuel supply shortages
- Inefficient and slow communication between DSOs and consumers

Economic and Environmental Consequences

The problems above result in:

- Power outages due to lack of total generation capacity (e.g., during extreme weather events)
- High network electricity costs
- Curtailment or underutilization of generation assets
- Reliance on foreign energy sources



Solution: Consumer-Driven Energy Efficiency

- Given real-time feedback, consumer action can impact aggregate peak demand (e.g., Ticino[35]. New York[36], Texas[37]).
- Incentives can drive consumer engagement and grid-friendly behavior through real-time energy visualization and compensation.
- Self-sovereign data sharing provides the basis for community-led, energy efficiency improvements while ensuring privacy protection of sensitive data.
- Feedback and incentives can be improved through a combination of load data and sensitive individual (location) and building-level data through distributed analytics / federated learning

Solution Components

- Device for real-time data accessibility
  - Substantially cheaper than alternatives
  - Simple for consumers to install
- Intuitive mobile app
  - Swipe right to opt-in or swipe left to opt-out
  - Gives individuals choice and control
  - Provide direct, real-time, bi-directional communication between utilities and consumers
- Open, auditable blockchain-based smart contracts to enable data privacy
- Token-based compensation for participation and/or data use
- Energy consumption insights of "behind-the-meter" appliances through AI (non-intrusive load monitoring)
- Data access to third parties through an Application Programming Interface (API) for third party access (e.g., federated learning) while maintaining data privacy

[35] Hive Power enables utility company to offer dynamic energy prices to households
[36] New York City outage averted
[37] Customer reduction during Texas storm

- Real-time monitoring and energy optimization tool for building facility managers

Pilot and Demonstration: Community Engagement

- Easy-to-use app for consumers to participate in blockchain-based smart contracts
- Consumers opt-in to participate in clean energy companies' community-based energy efficiency programs
- Consumers' energy-saving actions are rewarded with tokens
- Data privacy maintained for all consumers
- Real-time feedback and incentive settlement
- DSOs and facility managers request energy efficiency actions such as delayed energy consumption
- Facility managers optimize energy interaction with distribution network in coordination with EV charging companies and solar installers
- Target 1000 participants across two building complexes

Benefits to Consumers

- Compensation
    - Financial compensation using tokens for participation
    - Opportunity for compensation to grow through tokenomics
    - Real-time settlement of compensation (more effective positive reinforcement)
- Choice: Complete control, opt-in or opt-out at will
- Contribution to community benefits (reduced GHG, outages, costs, foreign reliance)

Benefits to DSOs and Building Facility Managers

- Real-time data with potential to influence consumer energy behavior to improve grid resiliency and reduce energy consumption
- Direct communication channel to end-customers to influence behavior and to directly incentivise desired actions

Target Outcome

- Automate access to consumption data by third-parties
- Demonstrate that data privacy is protected under current and planned Swiss law
- Demonstrate the impact of real-time energy data feedback on energy reduction and clean energy adoption to communities
- Demonstrate that Skylight aids the direct communication between utilities and end-customers
- Publication of all results

Appendix K: Summary of VIA Patent Portfolio

The cornerstone of TAC™ is a set of eight issued and multiple pending patents for VIA-developed techniques in the fields of privacy-protected federated analysis (i.e., simultaneous, secure analysis of decentralized datasets), secure search, homomorphic encryption, and permissioned AI/ML workflows.

All VIA patents were developed in house. No intellectual property is licensed from a third party.

U.S. Patent / Application No.	Status	Summary
17/348,164	Granted	“Verified Templates” -- ensuring data analysis complies with permissions set by data owners
16/361,966	Granted	“Additive HE” -- aggregating / performing addition on encrypted values without decrypting them
17/329,677 (006)	Granted	“Model release on quality threshold” -- ensures that federated model builders are improving AI models and not spoofing the AI training system
10,972,261 B1	Granted	“Encrypted Comparison Oracle” -- comparing encrypted values without decrypting them
17/329,270	Granted	“Secure Multiplication Using TAC™” -- multiplying encrypted values without decrypting them
11,038,683 B1	Granted	“Fast Encrypted Anomaly Detection” -- identifying the presence of outliers or anomalies in encrypted values without decrypting them
16/361,982	Granted	"Neural-Network Training Using Secure Data Processing" ensures that federated model builders are improving AI models and not spooking the system.
17/083,789	Granted	“Secure Data Processing” - predictions using homomorphic inputs
63/192,811	Pending	“Encrypted Search” -- anonymity for data queries
63/193,859	Pending	“Decentralized Secure Aggregation” -- additive homomorphic encryption without a centralized server capable of decrypting data
63/241,602	Pending	“Dataflow Interpreter” -- ensuring only legitimate code is used to analyze data
63/131621	Pending	“Privacy Analysis From Cryptographically Verified Dataflows” -- enduring data analysis complies with data privacy requirements
16/362,057	Pending	“Additive HE With Noise” -- enhanced cybersecurity protection for aggregating and analyzing encrypted data
16/362,051	Pending	“Market For Models And Escrow” -- permissioning system that governs AI model training
17/329,447	Pending	“Tripartite Federated Learning” -- training AI models on data without ingesting or centralizing the data first

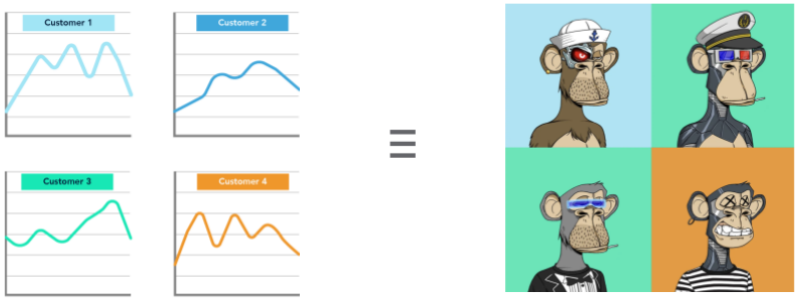
Appendix L: Which Web3 Technologies Apply to Skylight and Why

Since 2017, VIA has been developing and deploying Web3 technologies to make communities cleaner, safer, and more equitable.

Web3 Tech	Energy Application	Web3 Advantages
Blockchain	Blockchain for decentralized energy AI workflow	- Auditable, immutable record of digital assets - Fastest evolving tech stack
Smart Contracts	Contracts for privacy-preserving data analytics	Increased data privacy through code-based workflows
Zero-Knowledge Proofs	ZKPs to ensure off chain data is valid	Non-interactive proof of data validity without revealing data
NFTs	Minting of data and proofs as digital assets	Fast growing market and toolset to manage digital assets
Tokens	Dedicated token to compensate consumers for their data, data validation, and energy flexibility	- Real-time settlement - Potential for more motivating returns to participants than cash
Crypto Wallet	Browser plug-in based wallet	Secure, easier-to-use wallet for non-native crypto users and enterprise customers

Figure 9: Why Web3

Consumer power data are decentralized digital assets. Web3 technologies are the best match to govern the analysis of data, and incentivize action, while maintaining data privacy.



Power datasets are valuable digital assets that can be managed, marketed, and monetized through Web3 technology.