Powering a Transactive Energy System
Driven by the urgent need to improve the sustainability and efficiency of energy systems, the modern power grid is required to be flexible, low-carbon, and resilient in the face of power outages. However, power systems continue to remain centralized and unidirectional, utilizing high-carbon emitting fuel for power generation and, as a result, are susceptible to climate change-driven extreme weather events that lead to power outages. It should be noted that 78% of the total US power outages are related to extreme weather events, causing an annual economic loss of $20 billion\(^1\).

Furthermore, the increasing demand for energy places additional stress on an already jaded system that is seriously in need of upgrades to communication and control infrastructure.

Greenhouse gas emissions rose by 1.4% in 2017, the first such rise since 2014.\(^2\)
The last decade has seen a shift towards decentralization and the increased usage of distributed energy resources (DERs). Distributed generation in the form of photovoltaic panels and wind turbines are coupled with energy storage systems to reduce demand at peak times and provide backup power in times of need. The uptake of electric vehicles offsets GHG emissions caused by petroleum-powered vehicles, while flexible loads such as smart thermostats seek to lower overall energy consumption using artificial intelligence techniques. However, these DERs are most often not owned by power system operators, and are instead owned by the end consumer. As such, the role of the end consumer has now changed into that of a prosumer, capable of deciding when to purchase energy from the grid and when to sell it back.

Two significant challenges face power system operators as the grid continues to decentralize. The first relates to the management and coordination of the DERs connected to the grid-edge, which clearly cannot be handled by legacy control room software that is centralized and outdated. The second relates to direct control, where unilateral control is not possible because the DERs are prosumer-owned and will be strategically operated to satisfy prosumer objectives, not necessarily those of the power system. It is apparent that if the modern power system is to embrace the positive uptake of DERs, a decentralized, non-discriminatory, and incentive-based system needs to be implemented.

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It is important to note that as energy systems continue towards decentralization, the responsibility of ensuring the safe, reliable, and efficient delivery of energy to all consumers does not fall on the power system operators alone. Rather, the vision is geared towards a decentralized, service-oriented system that optimizes the flow of energy according to the cheapest, cleanest sources available. While decentralized, the system should also be highly coordinated, such that aggregated DERs (known as virtual power plants) can trade both energy and services with the grid and other virtual power plants. This would result in an ultra-modern power system that could organize local energy trading markets to correct power mismatches, as well as strategically dispatch stored energy to reduce demand in a congested portion of the grid. This vision requires a great deal of trust and automation, features that are challenging due to the fact that present stakeholders are disparate and will continue to pursue the most economically attractive course of action.
To this end, the revolutionary concept of transactive energy has been much talked about post-2015, with the aim of combining economic objectives of all stakeholders together with distributed control techniques to improve overall grid reliability and efficiency.4

Transactive energy focuses on attaching economic value, or incentives, to strategically coordinate disparate groups of DERs into making decisions that are collectively better for system health. The guiding principles of transactive energy focuses on auditability, accountability, improvement of the penetration of renewable energy, and self-optimization.

Blockchain has emerged as a suitable candidate for the overall implementation of transactive energy systems, given its propensity to establish trustless transactions amongst distributed, disparate peers. Blockchain utilizes a shared, distributed ledger that requires consensus to ensure that all peers accessing the ledger have a single, consistent version of the truth. Smart contracts, which are logic-based software modules that act based on ledger data, can be used to automate the aforementioned grid services and/or energy trading, obviating the need for a centralized service provider.

Herein lies the alignment of blockchain and transactive energy system ethos, where blockchain can trustlessly create a service-oriented power system that is fundamentally auditable, accountable, and automated.

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Problems in modern energy systems (particularly power transmission and distribution systems)

1. Power systems of today do not have common control infrastructure at the “grid-edge”.

2. With the grid decentralizing, the responsibility of improving grid reliability is no longer the power system operator’s completely. Rather, it is the shared responsibility of all stakeholders in the energy sector, whether they are electric utilities, owners of distributed energy resources such as photovoltaic (PV) panels, energy storage systems, and flexible loads.
The Insolar Transactive Energy System (TES) is designed to align the economic objectives of distributed stakeholders with the overall objective of maintaining grid resiliency. It seamlessly connects all stakeholders within the energy sector to realize smarter, and more sustainable energy systems. The TES seeks to create resilient and sustainable microgrids to serve self-sufficient communities due to the local production and consumption of renewable energy. In addition, these microgrids may trade energy and supply ancillary services to each other, creating a more cohesive and secure grid that is not dependent on a single source of energy and is also price-competitive.
Benefits of Insolar TES

**P2P**
Increases the uptake of renewable energy by administering peer to peer electricity markets where green energy can be both produced and consumed locally.

**Unified**
Enables disparate prosumers to aggregate together and virtual power plants to provide ancillary services to the grid, thereby deferring the need for power system operators to build/invest in new infrastructure.

**Auditable**
Increases prosumer and consumer engagement by providing auditable information on the source of electricity and unlocking new revenue streams for them.

**Resilient**
Increases energy security and resiliency by providing multiple sources of backup power in times of need.

**Interoperable**
Improves interoperability of electric vehicle charging stations by acting as the transactive layer that all service providers can use to provide charging services to electric vehicle owners.
Large, industrial/commercial, multi-unit buildings that are often mission-critical in nature would use the Enterprise Microgrid service to conduct local energy marketplaces to trade energy from building to building. Examples would be army bases, government buildings, school campuses, and hospitals. The Insolar platform would also provide advanced authentication and verification measures to correctly identify system operators before critical control decisions are made.

**Smart Demand Response**

Allowing power system operators to surgically zoom into a congested area within the grid, locate disparate resources within the area, and issue smart contracts to incentivize control actions of these resources to alleviate the congestion. This would typically involve in flexible loads reducing their energy consumption, or energy storage systems discharging energy into the grid. Other examples of this service allow DERs to contribute towards power factor correction and voltage regulation by modulating their active/reactive power in real-time.

**Smart EV Charging**

Incentivizing EV owners to reduce the rate of charge during peak times, or use vehicle to grid charging stations to supply energy at critical times. This is also particularly useful when sudden peaks of renewable generation need to be consumed in real-time, such as peak irradiance in the mid-afternoon and gusts of wind at night-time. Smart EV Charging effectively creates a smart mobility network that allows power system operators greater visibility and control, while unlocking new revenue streams for EV owners.
About

Insolar is building an open source blockchain platform for enterprise to enable seamless interactions between companies and unlock new growth opportunities powered by distributed trust.

The platform is rapidly deployable and solves the scalability, ease of use, and interoperability challenges of current blockchains. In addition to the platform, Insolar provides blockchain services and ecosystem support for companies that are looking to develop and deploy blockchain solutions.

Insolar has a team of 70 people across Europe and North America, including a 35-person-strong engineering team with blockchain and systems engineering know-how, and 10 academic blockchain researchers from top-tier academic institutions.

References


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