
Solar PV Array at Night (Source: http://atverdebrasil.com.br/energia-solar-ainda-e-pouco-explorada-no-brasil/)

Blockchain Technology – A Key Enabler for Renewable Energy

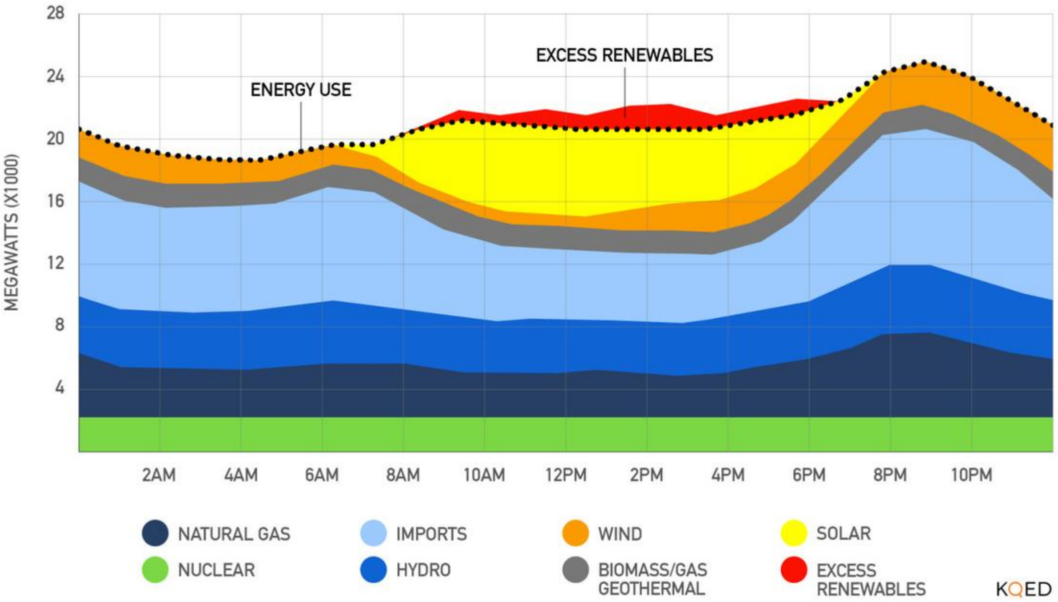
By Pat Sonti and Steven Slome

SUNRISE TO SUNSET: THE VARIABILITY OF RENEWABLE SUPPLY

Solar photovoltaics (PV) and wind are economically attractive and financially viable options to produce clean energy with no carbon emissions. Since solar PV and wind are intermittent energy sources, they inherently cannot be dispatched on a baseload basis, nor be counted on to supply peak demand. The sun shines as and when it shines. The wind blows as and when it blows. These renewable energy supply sources are not always well matched to meet grid demand loads. At night, when the lighting demand load is highest, the sun is not shining and no electric power is generated. Variability in wind patterns can also lead to difficulty in balancing energy supply and demand. While levelized cost of energy (LCOE) for solar PV and wind has decreased substantially and are now competitive with natural gas-based generation (peaking facilities), there are still impediments to completely decarbonizing and greening the grid.

This mismatch of energy supply and demand has led to instances where there are excesses of renewable power. In some cases, generation facilities are temporarily taken off-line. In California, renewable solar PV power has been sold to other states (Arizona and Nevada) at a negative price;[1] they pay customers to consume this power, in order to still obtain the subsidy credit for its production. In the UK, a similar situation has occurred, where wind power has to be taken off line, and producers are paid "constraint payments;" these facilities are actually more profitable offline than online.[2]

FIGURE 1 - PROFILE OF ENERGY SUPPLY VERSUS DEMAND IN CALIFORNIA



STAY POSITIVE: WASTE NOT, WANT NOT

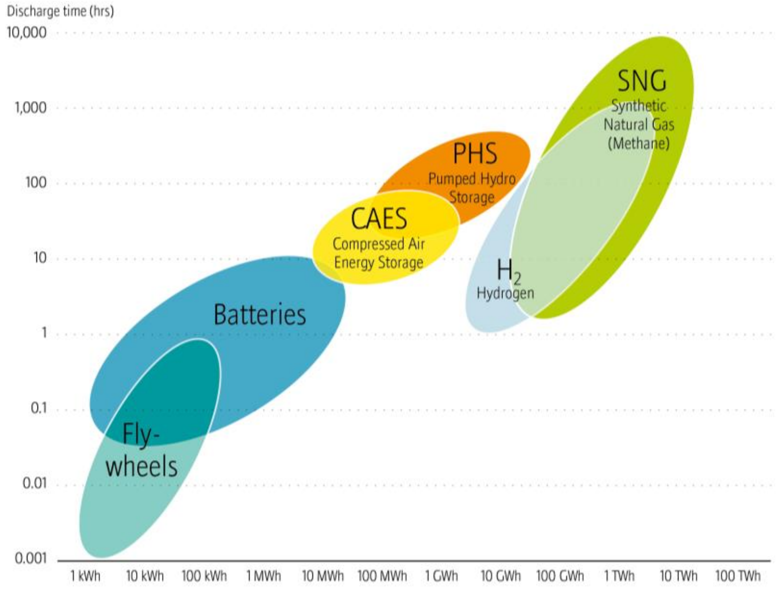
Several technically feasible and economically viable options have emerged as a means to store unutilized renewable energy.

- Batteries
- Solid State Batteries
- Flow Batteries
- Capacitor
- Electrofuels (e.g., hydrogen)
- Flywheels
- Compressed Air Energy Storage (CAES)
- Thermal
- Pumped Hydropower and other gravitational potential energy storage

When peak electric power demand is high, these technologies can deploy the stored energy -- albeit at a reduced efficiency.

[1] http://www.latimes.com/projects/la-fi-electricity-solar/
[2] https://www.telegraph.co.uk/news/2018/01/08/wind-farms-paid-100m-switch-power/

FIGURE 2 – COMPARISON OF ENERGY STORAGE SOLUTIONS[3]

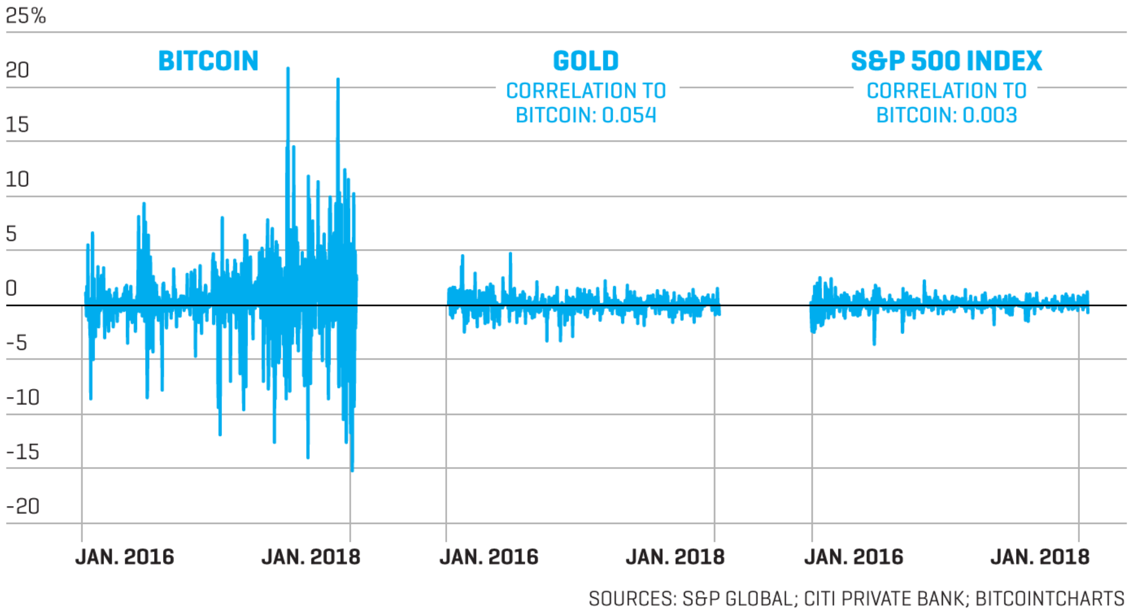


RENEWABLE ENERGY FOR CRYPTOCURRENCY MINING: THE POWER IS YOURS

During periods of excess generation, instead of selling at a loss or using costly storage, renewable energy generators can use blockchain technology to sell to users off the grid. One set of power-hungry users is cryptocurrency mining operations. Some are already building peak-shaving plants and renewable energy facilities into their operations. Excess electrons could be used by generators to mine for currency, or to sell power to miners. That could provide a cryptorevenue stream to generators and thereby bring the levelized cost of wind and solar even lower than natural gas. The risk is that less renewable power might be available, and less fossil fuel displaced. Displacing fossil fuel is the whole point. And those crypto earnings – the value is volatile.

[3] http://fortune.com/2018/02/06/bitcoin-stock-volatility-vix-sec/

FIGURE 3 – VOLATILITY IN TYPICAL CRYPTOCURRENCIES COMPARED TO OTHER INDICIES - DAILY PERCENT CHANGE IN PRICE[4]



DRIVING THE FUTURE OF THE ENERGY VALUE CHAIN: BLOCKCHAIN IS A TRANSFORMATIVE TECHNOLOGY

Blockchain technology is a key underlying driver for "digital transformation" of the global energy and utilities sectors and chemicals industries with respect to all value chains for generation/production, processing, transmission, storage and distribution. This includes supply chains from wellhead-to-burner tip-to end customers and/or renewable resources-to-end customers. Blockchain technology will enable the global energy and chemicals markets to use big data and analytics, artificial intelligence (AI), machine learning and robotics. Blockchain's "bankable" and transparent multiple ledger system may become increasingly important (especially when coupled with smart meters) for the mass deployment of renewable energy. It might minimize the role of speculators and middle men, allowing renewable energy producers to sell directly to end-customers. Blockchain can enable the cleantech sector in three ways.

1. Buying/selling/transaction support
   a. Transition from past power purchase agreement (PPAs) to "bankable" transactional funding/financing mechanisms and payment plans like offshore wind renewable energy certificates (ORECs)
   b. Monetize renewable energy as a cryptocurrency (e.g., Solarcoin), and manage "smart" transactional contracts with creditworthy offtakers
   c. Allow retail customers to engage in peer-to-peer transactions, essentially sharing solar PV arrays and battery usage, thereby propagating "captive community energy" or "captive energy collectives"
   d. Allow instantaneous payment mechanisms and plays, thereby increasing availability of capital
   e. Increasing decarbonization - Monetize and catalog GHG emission reductions as a cryptocurrency (as Noriton is doing), coupled with federal investment tax credits (ITCs), state-level solar PV or wind RECs, and carbon credits (if any)

[4] http://fortune.com/2018/02/06/bitcoin-stock-volatility-vix-sec/

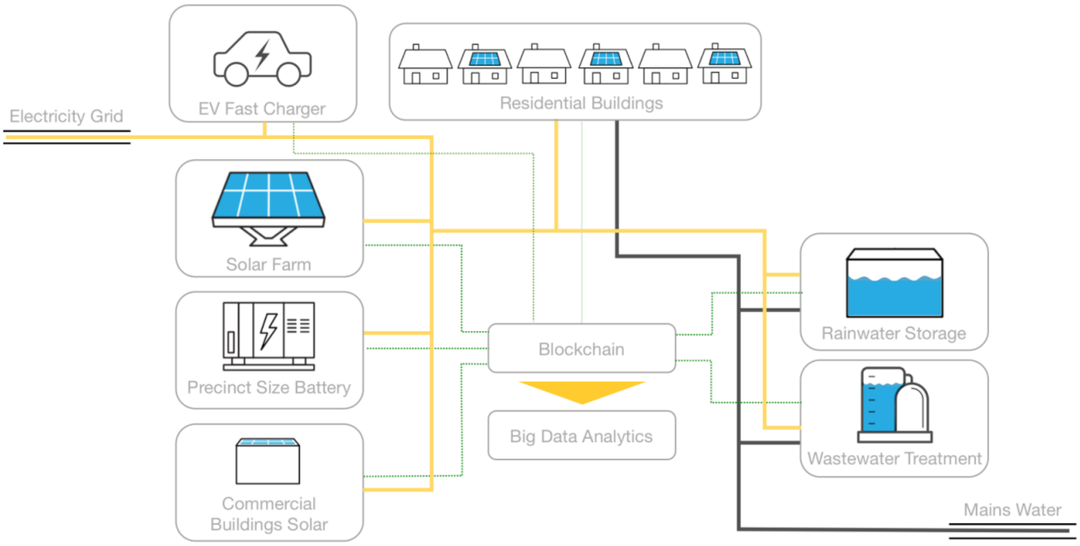
f. Capital formation - Initial coin offerings (ICOs) have paved the way for critically required investment capital via the global capital markets, where ICOs currently make up approximately 75 percent of funding in the blockchain energy industry. (This equates almost a quarter of a billion dollars, but this is only a small fraction of the total for the blockchain sector, with over $3 billion raised this past march alone.)

It should be noted that blockchain transactions support and implementation will appeal beyond the renewable energy sector. Definitive mechanisms of instantaneous payment plans will be of great interest to the global energy, utilities and chemicals sectors regardless of their fuels, feedstocks, and byproduct streams. Further, blockchain can enhance sustainability of the energy and chemicals sector by increasing emphasis on energy efficiency; demand side management (DSM); distributed energy resources (DER); demand response (DR); health, safety and environmental (HSE) compliance; functional and operational excellence; improving key performance indicators (KPIs); and business process transformation.

Blockchain is already enabling peer-to-peer energy transactions. Recently, Brussels-based SolarPowerEurope developed a digitalization tool for energy trading in the solar industry. It is used for energy billing and exchanging.

Accounting for renewable inputs into the power grid is arcane. When a renewable energy facility generates a unit or kilowatt-hour (kWh) of electricity, a meter logs the data in a spreadsheet. The spreadsheet is then sent to a registry provider, where the data gets entered into a new system and a REC is created. A second set of market intermediary(s) brokers deals between buyers and sellers of these RECs, and yet another party verifies the RECs after they are purchased. This leads to an increased transaction costs and the potential for financial and accounting errors along with a complete lack of transparency. The viable solution is to utilize smart meters which record the data directly into a blockchain.

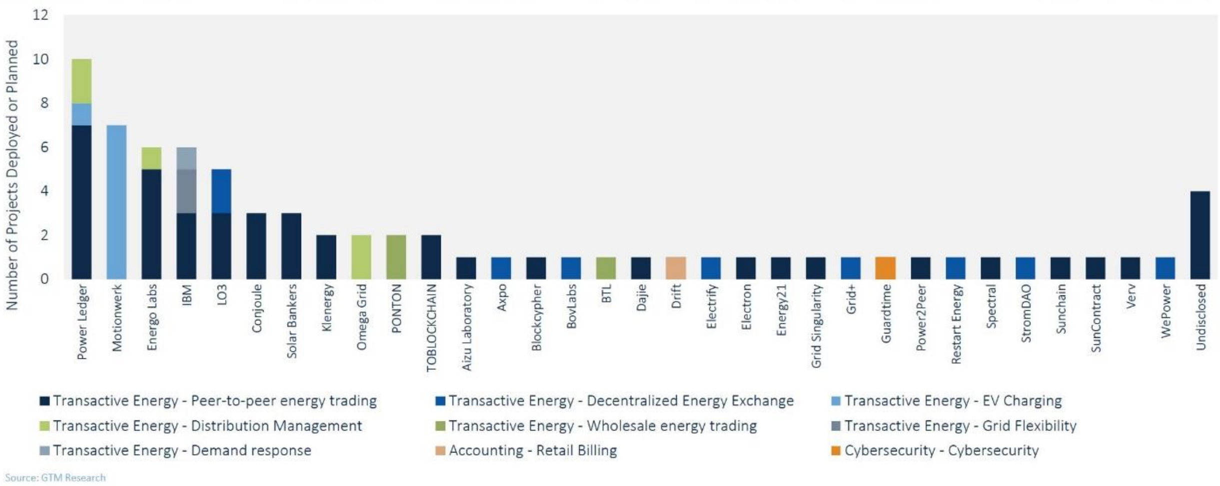
FIGURE 4 - A VIABILITY OF BLOCKCHAIN DEPLOYMENT IN LOCAL MICROGRID



Blockchain for Energy: Future Is Now

Blockchain is permeating the entire global energy sector at a rapid pace by providing innovative, practical and real solutions for energy producers and their customers. As an example, one company known as Power Ledger has demonstrated a product that can turn an apartment building into a microgrid based on a shared solar PV array and battery storage. Another company known as LO3 Energy set-up a neighborhood microgrid in Brooklyn, New York. Major energy utilities such as Pacific Gas & Electric (PG&E), Ameren, Tepco, Innogy, Centrica, and Engie have all been investing in blockchain technologies - and many are actively piloting the technology for mass deployment. There has been a flurry of activity since 2016 in this sector with over 30 projects/pilots, as shown in the chart below.

FIGURE 5 - A BLOCKCHAIN-IN-ENERGY PROJECTS/PILOTS, 2016-2018[4]



There are some naysayers who wonder whether cryptocurrencies are in a bubble. Still, the underlying blockchain technology offers to all industries technically feasible, economically viable and financially profitable solutions for:

- Security / authentication
- Transaction support
- Certificate generation / authentication
- Big data and analytics
- Potential for integration with AI, machine learning, and robotics

In summary, blockchain technology is rapidly growing leaps and bounds and is being integrated into every facet of global investment, trade, markets, value/supply chains, manufacturing processes, corporate operations, wholesale and retail distribution – all of which are focusing on the highest value addition to the end-customer. Key now is for energy and chemicals sector stakeholders to embrace the benefits of blockchain, and for lawmakers to enact a non-burdensome legal and regulatory framework to accelerate its deployment.

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Pat Sonti *is a Senior Consultant with Nexant's Energy & Chemicals Advisory division. He has three decades of experience in natural resources, energy and infrastructure sectors for global sponsors and lenders on existing assets and development of brownfield and greenfield projects. His experience includes technical and commercial due diligence, market advisory, lenders technical advisory, independent expert and litigation witness. His skillset includes project feasibility, technology evaluation and assessment, estimation of capital costs (CAPEX) and operating costs (OPEX), economic modeling and financial analysis, regulatory policy and framework analysis, and project development-execution-operations. His transactional expertise includes structured/project finance, mergers and acquisitions (M&A), acquisitions and divestiture (A&D), restructuring, strategic sale and initial public offerings (IPOs). His sector experience includes, power generation facilities (natural gas, solar PV, wind, hydro and biomass), captive cogeneration plants (process and chemicals plants and commercial/industrial facilities), natural gas infrastructure (from wellhead to local distribution companies), LNG (liquefaction/shipping/receiving terminals), enhanced oil recovery (secondary and CO2), atmospheric gases and air separation facilities, energy efficiency and distributed energy resources. He received his Bachelor of Science in Chemical Engineering at the University of Southern California (USC) in Los Angeles, California. He is a member of American Institute of Chemical Engineers (AIChE), American Society of Mechanical Engineers (ASME), and American Council on Renewable Energy.*

Steven R. Slome *is a Project Manager working in Nexant's Energy and Chemicals Consulting group. He is the program manager and director for the Biorenewable Insights program, in which reports are published in various areas of biorenewable chemicals, fuels and feedstocks, with quarterly updates to economics and capacity. He is a specialist in renewable energy and chemicals. During his time at Nexant, Steven has been involved in multiple areas of market and technical research, participated in the evaluation of bio-based fuels and polymers, been involved in many single client projects as well as written several multiclient reports, including reports on algae technology, first and second generation biobased carbohydrate feedstocks (e.g., corn, sugarcane, and cellulosic biomass), first and second generation biobased oleaginous feedstocks (e.g., soy, palm, and advanced feedstocks such as algae and jatropha), biobased chemicals, as well as biofuels (first generation and next generation). Single client work has included in depth analyses of technologies and markets for first and second generation biofuels and chemicals, feasibility studies, siting studies, market research, as well as technoeconomic due diligence. Steven has also been involved in a number of due diligence engagements in the, many in the biotech area, and frequently in advance of IPOs and private investment. These due diligence engagements have included algae technologies (both photosynthetic and heterotrophic), multiple different types of fermentation technologies, several different thermochemical technologies, as well as some purely chemical/catalytic technologies. Steven has been with Nexant since he graduated from SUNY Purchase with a degree in Biochemistry in 2007.*

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