Blockchain Applications to Solar Panel Energy: Landscape Analysis

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Our Model

Our model addresses the energy needs of developing countries, such as India and Barbados, through a blockchain-enabled, collateralized solar micro-grid solution that consists of the following components:

1. *Blockchain technology* to record data, transfer energy, and regulate digital-currency payments within a village-based decentralized solar power microgrid. A blockchain -- essentially a digital, incorruptible, distributed ledger that's independently validated by multiple computers -- can facilitate software-managed "smart contracts" that coordinate automatic payments and transfers between different entities when pre-specified conditions are met. When used within a self-contained microgrid of shared generation capacity, these contracts will allow participants in that system -- consumers, producers, and "prosumers" -- to buy and sell solar energy from each other, using digital tokens that can be redeemed for rupees. Prices, which reflect the respective surpluses and deficits of energy supply and demand, can fluctuate to create a market-based clearing mechanism. The blockchain's immutable, highly secured distributed infrastructure ensures that this process is completely automated and cannot be hacked or corrupted by an individual or institution.

2. *A digital registry* of solar equipment assets (PV cells and panels, batteries, transmission lines,etc.) that is imbedded into a blockchain ledger to give the data trusted immutability and create a precise, automatable record of time-stamped changes of title and encumbrances. With that secure registry as the underlying record of property rights, outside investors can be issued with special solar-backed "crypto-securities" that can be structured either as negotiable loans bearing a right to a fixed stream of payments, as equity claims on the assets and the revenue streams they generate, or as hybrid certificates that dilute over time as new local investors buy in.

3. *A mini corporation/cooperative.* At its simplest iteration, one local owner of the microgrid would issue the solar crypto-securities to attract outside fixed income or equity investors who will help finance his or her project. The owner would install the power lines and other equipment linking homes within the village into a microgrid and then charge households for the right to use that power under a pay-to-use model. Using an Internet of Things-enabled "kill switch" chip and an automated smart contract arrangement, delivery of power to those households will be contingent on digital payments being kept current. M-Kopa in Kenya has successfully applied this technology but, without securitization of the equipment, it does not have capacity to scale the current business-to-customer relationship into a microgrid.[i]
    a) An alternative structure would appoint various households as prospective shareholders in the grid, their equity stakes accumulating over time as their payments for power constitute installments to repay a de facto hire-purchase loan. We envisage the governance being that of a cooperative, ideally with a set of simplified, codified responsibilities and obligations that can itself be regulated with smart contracts and the blockchain. Outside investors in the cooperative's project could be invited in under a "B corp" and/or DAO structure, where dividends are paid if and only if pre-set community priorities are met by the grid infrastructure.

4. *Digital currency/tokens.* Payments through this system -- whether for power consumption or to repay loans -- will be made with cryptocurrencies and/or digital tokens that can be converted into rupees. Users will make periodic payments to the owner in bitcoin -- or, if the technology has

arrived by then, in rupee tokens issued over the blockchain -- drawing on the bitcoin protocol's secure prevention of double-spending fraud to create a fully verifiable and securitizable flow of revenues. Smart contracts will then ensure that those digital currency inflows are distributed among equity and/or fixed income investors according to the rights attached to their claims.

A NOTE ABOUT ELECTRICITY THEFT: We envision that the ability to closely monitor power usage in a digital/blockchain environment will greatly aid in enforcement against electricity theft. Constructive carrot-and-stick rules -- for example, withholding access to certain communal services that the local grid operator could provide on the side (such as WiFi or currency exchange) to those who do not have a proven record of payments -- can also be applied to entice honest usage. Moreover, we believe that the communal, local structure of this microgrid system will help inculcate a culture of compliance with the rules.

A NOTE ABOUT ON-GRID APPLICATIONS: While we have deliberately focused on providing power to off-grid communities, those who need it most for development opportunities, we believe the model we have laid out could easily be adjusted to finance the creation of community-managed microgrids in regions that are connected to the public grid (e.g. Barbados). In those cases, part of the profits to the co-op could be derived by selling power back to the grid and the savings to the government could come from extracting gains from reductions in the urban-to-consumer cross-subsidy of power.

Existing Blockchain Solar Energy Models

L03

The energy team has met with the CEO and CFO of LO3 to discuss synergies and partnership potential. A blockchain energy solutions company that engages in projects and tool development to proliferate the use of distributed energy. L03 has three primary projects:

- *Project Exergy.* An effort to turn computers into heat in order to recapture wasted resources. LO3 offers "cryptographically-secured grid services" in order to monetize underutilized computational capacity and store thermal energy.
- *Brooklyn Microgrid.* Creates a distributed energy infrastructure that can be utilized during emergency needs of the local community. An additional intent is to boost the local economy through the creation of new community energy job opportunities.
- *Transactive Grid.* A joint venture with Consensus Systems to deliver real-time metering of local energy generation and other relevant data over the Ethereum blockchain. This platform is open source, transparent, and peer-to-peer. The first pilot installation will be in Brooklyn.

Ideo

Ideo's Co-Lab is working on an interesting project with NASDAQ and Filament around renewable energy certificates. Essentially, they are patenting a system that uses the NASDAQ platform to issue the assets and using Filament's technology to track the solar panel data. A live demo is scheduled to be released in the near future that will shed more light to the technology and overall model.

SolarCoin

SolarCoin is a Digital Asset rewarding solar energy producers. Launched in January, each MWh of solar electricity produced by a photovoltaic installation awards one SolarCoin to the solar producer. SolarCoin in itself, is a currency that has a value assigned to it by a community of users, a social group, as a means of payment and value circulation. Additionally, the SolarCoin Asset has a social utility for its community: by rewarding the owner of a solar photovoltaic system, SolarCoin acts as an effective incentive, thereby stimulating the implementation of solar power worldwide. With a forward value, SolarCoin may thus reduce the payback time for the solar installation as well as increase its returns. SolarCoin currently operates in 19 countries.

Other Relevant Solar Energy Startups

Wundor Capital

Wunder Capital develops and manages solar investment funds by leveraging its national partnership network, tested processes, proprietary underwriting framework, and best-in-class online investment portal. Wunder actively manages everything, from the sourcing of commercial solar opportunities, to the underwriting, contracting, and construction of each project. Once a system is live, Wunder manages the ongoing operation and maintenance of the array, bills the energy customer, and distributes proceeds to investors. This financial model is of interest to our project given that it has securitized solar energy. We have not connected with the team yet but plan on doing so in the near future.

M-Kopa

One of the more well-known financial inclusion and workforce development models utilizing solar microgrid systems. Based in Kenya, M-Kopa has a pay-to-own model in which it leases small (8 to 20W) solar panel systems to off-grid communities. Operating in Kenya, Uganda, and Tanzania, M-Kopa has connected 330,000 homes to solar power and employed 757 full time staff and 1,251 field agents.

Governance Structure Analysis

The analysis below defines and outlines the characteristics of three types of governance structures: Benefit Corps, B Corps, and Decentralized Autonomous Organizations.

Benefit Corp

A legal tool to create a solid foundation for long term mission alignment and value creation. It protects mission through capital raises and leadership changes, creates more flexibility when evaluating potential sale and liquidity options, and prepares businesses to lead a mission-driven life post-IPO. The corporation voluntarily meets different standards of corporate purpose, accountability, and transparency.

B Corp Definition: B Corps are for-profit companies certified by the nonprofit B Lab to meet rigorous standards of social and environmental performance, accountability, and transparency. Currently, more than 1,600 Certified B Corps exists in 42 countries and representing over 120 industries.

Benefit Corp & B Corp

Both were created by B Lab (nonprofit)

Issue	Benefit Corporations	Certified B Corporations
Accountability	Directors required to consider impact on all stakeholders	Same
Transparency	Must publish public report of overall social and environmental performance assessed against a third party standard*	Same
Performance	Self-reported	Must achieve minimum verified score on B Impact Assessment
		Recertification required every two years against evolving standard
Availability	Available for corporations only in 30 U.S. states and D.C	Available to every business regardless of corporate structure, state, or country of incorporation
Cost	State filing fees from $70-$200	B Lab certification fees from $500 to $50,000/year, based on revenues

Benefit Corp Requirements:

1. Have a corporate purpose to create a material positive impact on society and the environment
2. Required to consider the impact of their decisions not only on shareholders but also on workers, community, and the environment
3. Required to publicize, except in Delaware, an annual benefit report that assesses their overall social and environmental performance against a third party standard (not a formal audit, just meet the standard: comprehensive, credible, independent, and transparent)

Shareholders Traditional vs Benefit Corp

Shareholders have same protections as traditional shareholders, only differences are:

- Mission Alteration High Vote (so a type of reassurance that entity will abide by mission in long-term)
- Annual Benefit Report
- Structure empowers shareholders to enforce mission

International Presence

Only formally recognized outside U.S. in Puerto Rico and Italy

Benefit Corp Pros and Cons

Pros	Cons
Provides social impact language and governance practices to be included in articles of incorporation	No enforcement agency, essentially up to Board to uphold standards and requirements
Socially conscious marketing and brand which may be attractive to investors and employees	Need to ensure investors educated around common misconceptions (e.g. Benefit corps can make money and generate returns)
Less expensive alternative to B Corp certification	Incorporation limited to participating 30 states

Examples of Existing Benefit Corps

Alter Eco, AltSchool, APDS, Cotopaxi, Ello, Ethical Electric, Farmigo, Kickstarter,Schoolzilla, and yerdle have successfully raised investor funding.

Examples of Benefit Corps Investors

Andreessen Horowitz, Founders Fund, First Round Capital, Forerunner Ventures, Foundry Group, Baseline Ventures to name a few.

Decentralized Autonomous Organizations (DAO)

Definitions vary but in essence a DAO is a self-governing organization under the control of the rules and restrictions set in place by publicly auditable open-source software distributed across the computers of their stakeholders.

How it works (using Ethereum)

Anyone interested in being part of DAO sends ether to the address of the DAOs smart contract during a time period of initial funding. The fundraising time period and the funding goal are set ahead of time and integrated into the contract (think Kickstart campaign). These funds buy tokens which represent membership as well as ownership of a DAO (tokens given proportionate to amount funded, the price per token changes over time, similar to how equity gets more expensive over the lifetime of a company). Membership can be transferred.

A DAO purely manages funds. Members of the DAO set forth proposals which represent action items or "projects". Members propose a project (e.g. how to use the DAO's profits) by depositing a minimum amount of ether (limits proposal spamming). Projects are approved through quorum, members cast votes weighted by the amount of tokens they control, and the member who proposed an approved projects gets his/her initial ether deposit back. When a project is not approved, the deposit amount is given back to the DAO (so the member loses that deposit amount).

A Decentralized Autonomous Corporation is a type of DAO in which excess funds are paid out to members as a type of dividend.

Risks

Because votes are weighted, a majority (51%+) token holder could propose a project that is in his or her own interest (e.g. send all of DAO's funds to him/herself).

According to Slock.it, this risk can be mitigated by allowing the minority shareholders to create a special type of project proposal to take out their funds and create a separate DAO.

Legal Considerations

Pending Questions

Generally, my questions focus on the ability to adjust restrictions. I assume this is something we can tweak to our own preferences:

- Can the initial funding time period be adjusted and, if so, how is the decided?
- Can token transfers be limited or restricted?
- Can quorum rules be changed? Again, does the DAO decide this and how?
- How would this actually play out in a rural setting? What happens if members are disengaged thereby allowing only engaged members to make proposals vote, etc.
- If the governance of a DAO is mismanaged, what legal backing does a DAO have?

Pros and Cons

Pros	Cons
Transparent and automated way to direct an entity's funds	Automation could open doors for corruption if DAO members apathetic or misinformed (especially in rural setting where social capital such an integral part of the culture)
	Governance of an organization, though, is not completed by a DAO. The DAO is simply a complex and interactive smart contract that transfers funds
	DAOs are not a legal entity. Regardless, a co-op or corporation would still have to go through a legal incorporations process.

General Take

I can certainly see the benefit of having this automated entity in specific settings but I don't think this is the best governance option for a pilot in rural India. Perhaps the project as a whole can be set up as a DAO as an umbrella management tool (e.g. each microgrid is a member of a bigger DAO or DAC and they receive dividends that are distributed equally). The individual microgrids themselves that are run by the community would need something a bit more robust, at least to start.

Energy Landscape in Barbados

According to the World Bank, the average cost of electricity in the Caribbean region is four times higher than in developed nations such as the U.S.[ii] Barbados' energy sector is dominated by a sole provider, Barbados Light and Power Company (BL&P) and relies heavily on imported fossil fuels given the land limitations of the island. Barbados' residential electricity rates average at $0.28 per kWh (stands below the Caribbean average of $0.33/kWh).[iii] On the regulatory side, the government introduced an Electric Light and Power Act (ELPA) which will facilitate independent power producers (IPPs) to supply energy to the grid.[iv]

The table below summarizes the energy use in Barbados as of 2012.

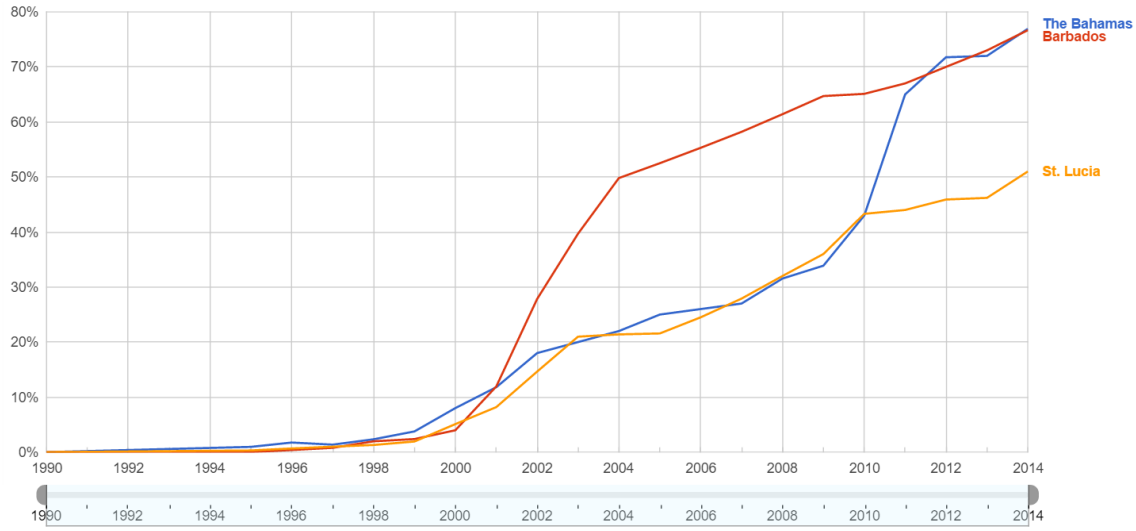
Total Installed Capacity	239.1 megawatts (MW)
Peak Demand	167.5 MW
Total Generation	1,024.3 gigawatt-hours
Transmission & Distribution Losses	6.2%
Electrification Rate	98%

Solar

Since 1974, Barbados has passed legislation that promotes renewable energy sources starting with the Fiscal Incentive Act that granted tax exemptions for solar water heater producers. Today, one in two homes in Barbados use solar water heaters.[i] BL&P and the government continue to work in tandem to pass and carryout legislation that favors renewable energy production and, in 2014, BL&P introduced an energy rider pilot program which allows customers to sell their renewable energy back to the grid (given eligibility). As of February 2015, the Fair Trading Commission increased the Renewable Energy Rider (RER) limit which now permits up to 20 MW of power to be sold back to the grid. All kWh sold to the grid are credited at 1.8 times the Fuel Clause Adjustment or 31.5 cents/kWh, whichever is greater.[v] The intent behind this program is to incentivize decentralized renewable grid connections.

According to the BL&P 2014 Annual Report, the cost of solar PV panels decreased which increased interest in solar energy investments. Despite this cost reduction, renewable energy still cannot compete with fossil-fuel energy.[v] This dynamic reinforces the need for creative financing solutions to make solar more affordable and accessible.

Barbados - Internet Users as Percent of Population



Data from World Bank Last updated: Mar 30, 2016

Energy Landscape in India

An estimated 300 million Indians lack access to electricity[vi] -- approximately two-thirds of those in rural areas.[vii] Studies show access to electricity increases education, health, and labor productivity outcomes. Accordingly, Prime Minister Modi has ambitiously pledged to provide electricity to all villages in India and aims to bolster energy production by 118 GW by 2017. But the challenges are daunting: to deliver sustained GDP growth of 8% until 2031-2032, primary energy supply must grow up to four times faster than current consumption, with a necessary six- or seven-fold increase in generating capacity, according to BMI.

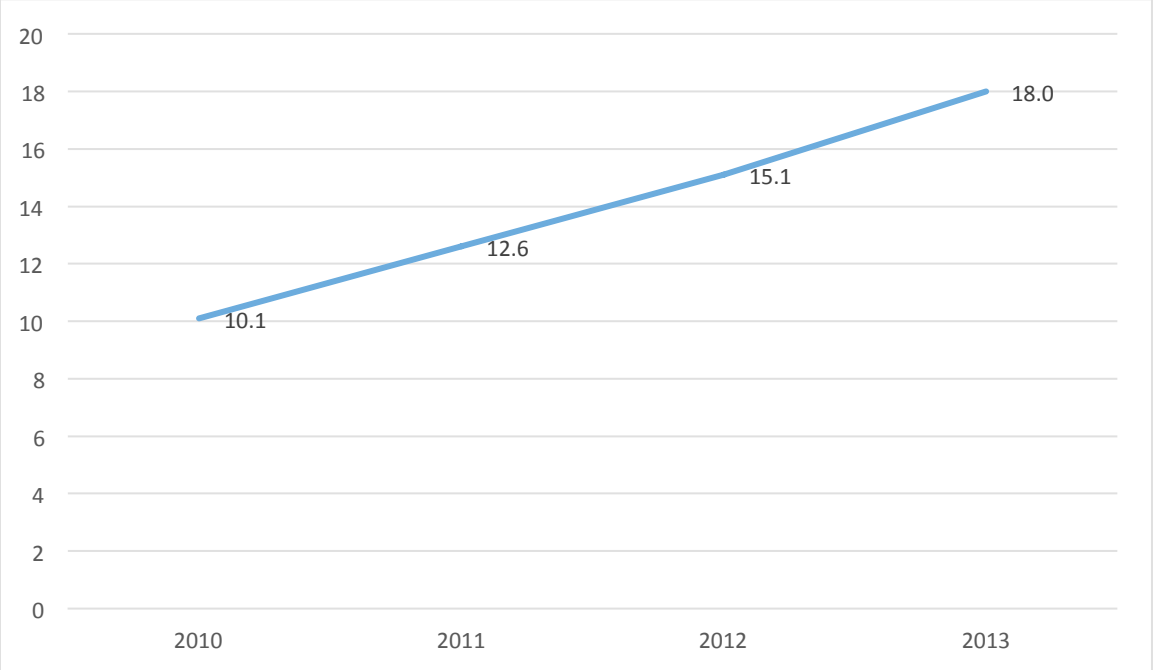
The World Bank estimates that 17% of India's total generated power is lost in the transmission and distribution process.[viii] Already, India faces a bottleneck in grid infrastructure, with investment in transmission and distribution trailing power plant projects, representing just 10% of all projects in the pipeline. Although CEA data show a recent reduction in peak power shortages across India as a whole, the deficit between installed capacity and peak demand still runs as high as 12% in poorer regions such as Uttar Pradesh and up to 18% in Kashmir. These conditions will spur ongoing stop-gap demand for local, decentralized power generation and distribution. But without an alternative, that implies dependence on expensive, inefficient, polluting fossil fuel sources such as diesel generators.

Another threat India faces is its level of carbon emissions. If India were to use its current mix of fuel sources to achieve its energy needs, the global environmental impact would be devastating. (India is currently at over 67% reliance on coal, making the country the third largest emitter of greenhouse gasses.[ix] Recognizing this, PM Modi boldly committed at the 2015 COP21 conference to a renewable energy solution, pledging to install 175 GW of additional renewable capacity by 2022, of which 100 GW would be solar.[x] The government has estimated that goal will require USD $120 billion in capital investment and USD $40 billion in equity.[xi]

The current approach of building and subsidizing large solar farms cannot be efficiently scaled to include off-grid, power-deprived communities

- There are insufficient incentives for rural communities to cover the high cost of solar installation and power generation through electricity charges, given the existing urban-to-rural subsidy for power distribution.
- Solar farms depend on the ability to resell power to the public grid to maintain profitability -- a benefit that's not possible in off-grid settings.
- Land acquisition costs are high.
- Household-only solar solutions are prohibitively expensive: A small solar system that can run three lights and a television costs over USD $500, far beyond the budget of the average rural Indian family.

India – Internet Users per 100



[i] M-Kopa's web site.
[ii] http://www.worldbank.org/en/news/opinion/2015/01/31/unlocking-the-caribbeans-energy-potential
[iii] http://www.nrel.gov/docs/fy15osti/64118.pdf
[iv] http://www.emeracaribbean.com/site-emera/media/EmeraCaribbean/2015%20Emera%20Caribbean%20Inc.pdf
[v] http://www.ftc.gov.bb/index.php?option=com_content&task=view&id=212&Itemid=26
[vi] World Bank Electrification Statistics by Country
[vii] DW article
[viii] World Bank T&D loss estimates
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[x] Ministry of New and Renewable Energy
[xi] India MNRE RE-Invest 2016 document