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Lessons from Dharnai, "India's First Fully Solar Powered Village": A Case Study

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Lessons from Dharnai, "India's First Fully Solar Powered Village": A Case Study

Manu V. Mathai[1]

Abstract: *This case study is of "India's First Fully Solar Powered Village"[2] —Dharnai. It is a case of the promises of and challenges facing the realization of "energy democracy"—the idea that distributed renewable energy systems have the potential to democratize the economy and society. This case study offers the reader three takeaways. First, it locates the project at Dharnai in relation to the theoretical framework of energy democracy and the national and global renewable energy policy regimes. This is based on the academic literature on energy-society studies, documentation and outreach material about the project and interviews with individuals involved in the life of the project. Second, the case study details how the project was conceived and implemented in Dharnai. Third, it records how citizens of Dharnai experienced the microgrid, as well as their interpretation of what it means for them. The latter two takeaways are based on interviews with the villagers of Dharnai conducted in December 2017 and March 2020 as well as interviews with individuals associated with the project as representatives of its external proponents. This case study ends with some considerations about the realization of energy democracy; specifically, the proposal of devolving sovereignty to the grassroots through participatory governance enabled by the ability to devolve ownership of energy infrastructure. The challenge illustrated by this case study, to the idea of energy democracy as an alternative path to energy transition, is two-fold. First, the relatively low capacity of solar photovoltaic systems to convert energy, i.e., "power density," was perceived to be at odds with the aspired to levels of energy availability. The citizens of Dharnai tended to associate the more expansive availability of electricity from the grid, as "real electricity," that was more closely matched to meeting their aspirations. Low power density limits the possible economically productive applications, which further undermines the financial viability of the project. Second, somewhat surprisingly, some of the citizens' of Dharnai tended to disavow their capacity for participatory governance, presumed in the energy democracy literature, insisting instead that an external, powerful actor, whom they "feared," was better suited to manage the affairs of the microgrid. This could be understood as suggesting that prior to, or at least in parallel with investments in decentralized energy technology, significant commitment is needed to understand and foster the social and cultural infrastructures for participatory democracy and local governance. Such an engagement may have to grapple with deep-seated caste divisions and the resulting undermining of civic community.*

Keywords: *Decentralized renewable energy; energy autonomy; energy democracy; local governance; participatory planning; sustainable energy.*

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2 As it is referred to widely in the media. For example, see, https://www.ibtimes.co.in/bihars-dharnai-becomes-first-fully-solar-powered-village-india-606094. Accessed on 30th October 2020.

Lessons from Dharnai, "India's First Fully Solar Powered Village": A Case Study

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It is time we brought decision making back into the hands of the people. It is time for decision makers to feel the direct impact of their decisions on their own daily lives, whether they are good or bad. Change, to be real, has to come from the people; it cannot be trickled down, it cannot be imported, and it cannot be imposed. It is only when people and communities organize their own structures that decentralize production and distribution, promote assets formation and ownership, build capacities, provide social security, encourage text full participation and give voice, that our world will become a dynamic and nurturing place.

– Ela Bhatt, in *Anubandh*.

"Hame aslee bijilee chahiye, nakli nahi" (We want real electricity, not fake).
Some residents of Dharnai addressing Chief Minister Nitish Kumar.

1. Introduction

In 2014, Dharnai, a village in Bihar, that sits astride the Gaya-Patna highway and railway line, about 80 km south of Patna, at a railway station called Barabar Halt, became famous as "India's First Solar Powered Village".[3] Dharnai's transformation from "darkness to light" was reported widely in news outlets in India and internationally. The village, comprised of three main *tolas* – Bishunpur, Dharnai (which also contained a secluded *"dalit basti"*) and Jhitkoria – achieved this transformation by setting up four microgrid clusters powered by solar photovoltaic panels and accompanying battery storage. The four systems together add up to 70kW and generate, on average, 350kWh per day. The project was conceived and installed through a collaboration between Greenpeace India, the Centre for Environment Energy and Development (CEED) and BASIX.

3 In government schemes like the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) and its successor under the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) an electrified village is one where the public buildings like the Panchayat office, the schools, primary health centre, etc. and 10% of homes were connected to the grid. In contrast a solar powered village, such as Dharnai, is one where electricity is supplied for streetlights, and to all homes who desire to and can afford to be connected.

Greenpeace India provided the concept and mobilised the required investment in the form of a grant of about Rs. 3.5 crores to purchase and install the system's hardware components; CEED was responsible to scale up the model through institutional networking and policy advocacy in Bihar. BASIX took on the responsibility of the operator of the microgrid (collecting user charges; overseeing technical aspects; providing supervisors and engineers to build the system; and training for maintenance) and to handover to the community at a later date.

In energy policy discussions, microgrids like Dharnai's, fall under the label of energy technology architectures known as Distributed or Decentralised Renewable Energy (DRE) systems. Solar microgrids are comprised of, as in the case of Dharnai, of a series of solar photovoltaic panels fitted often on rooftops or other locally available spaces where adequate sunshine is available, batteries to store the electricity, local distribution lines, power conditioning devices, control switches, meters and finally domestic or small commercial, agricultural or small industrial (often motors) loads. Such a microgrid can be designed to operate independently of the larger state or national grid. In that sense, all aspects of the system can potentially be determined and controlled by the community of the citizens it serves. In energy studies, such systems represent the "soft path" – an early term used in energy sector reform proposals to advance peace and sustainability by distributing and devolving *power* (pun intended) (see, Lovins 1977, Goldemberg et al., 1988; Reddy et al., 1995; Mathai 2012).

In contrast, standard electricity generation is centralised, dominated by generators of high capacity (often 1000 million watts, i.e., 1000 Megawatts or 1 Gigawatt, and sometimes even higher) and serves hundreds of thousands and even millions of customers. Such systems depend predominantly on fossil fuels and hydropower, and nuclear energy to a smaller extent – all of which have unsustainable social and environmental impacts. Such systems are planned, financed, operated and maintained by techno-bureaucratic organizations that are largely hidden from and inaccessible to the average citizen. In this energy architecture, citizens are pared down to customers who simply "benefit" from and pay for the electricity they consume, at a rate determined and prescribed by the regulators. The technological know-how, power to make decisions about electricity generation and fuels, are not under the control of citizens. Being large and centralized, such electricity generators are enabled only by either state or big private capital investment and ownership. The technology involved, i.e., the hardware, software, skills are not recognized as commons to be directed by and for the common good, instead, they are configured as proprietary assets under state or private investors' control. This tendency toward centralization of power was referred to earlier in the energy studies literature as the "hard path" (Lovins, 1977).

Beyond presenting a different way of organizing energy-society relations, DRE systems have technical benefits such as the quick provisioning of electricity at locations that have remained un- or underserved by state and national grids due to their inaccessibility or due to unreliability. Even in jurisdictions where electricity provisioning is mature, adequate and reliable, DRE systems can provide valuable services like peak shaving that positively impact the economics of electricity services overall. DRE systems can contribute robustness to the electricity supply system by being

less likely to suffer debilitating damage during natural disasters and being able to bounce back faster after such disasters. This, due to the dispersed nature of the infrastructure and the fact that the fuel supply – sun, wind or water – is not hampered by long supply chains. Long before ports, roads, railway lines and long distance transmission cables are restored after a hurricane or earthquake, the sun will shine and the wind will blow. Such systems also have the benefit of not contributing to GHG emissions while provisioning electricity to underserved citizens.

Finally, in India, where thousands of villages lacked any or adequate access to electricity a decade ago, the potential of DRE systems was obvious (Greenpeace, 2014). Many academics and renewable energy advocates agreed on these merits. But how were the politicians to be brought onboard? How to make the promise of DRE systems manifest? How was the concept to be proven for rural India? The DRE system that materialised in Dharnai was conceived by Greenpeace India to answer these questions.

Dharnai village when it was identified as the location was ideal for these purposes. The DRE system would demonstrate a clean renewable energy based technology that could in a matter of months provide electricity for a village that was left in the dark for over three decades by bureaucratic apathy. In addition, Dharnai was accessible by road and rail, and thus well-suited to tell the world that this idea works. And work it did! The microgrid was up and running in a matter of months. Electricity arrived in the village, again, for many of the elders, but the first time for those younger than thirty years. The nights were transformed on the streets, while indoors, people breathed more easily in kitchens and homes. The DRE system in Dharnai manifestly was an "alternative" to bureaucratic apathy,[4] to a creaking, lethargic large centralised electric grid that failed too often in its promise of bringing electricity, even carbon loaded electricity, to millions of people in remote villages across India. Dharnai ticked all the boxes – fast, responsive, renewable and decentralised. There was in this project an alternative, a zero-carbon one at that, it seemed, to the daily inconveniences and indignity faced by millions of predominantly rural Indians of living in the dark against their choice.

2. Contextualising Renewable Energy and Rural Electrification in India

a) Early Days: The 1970s' Oil Shock and Renewable Energy

The Government of India has a long-standing interest and engagement in utilising renewable energy. The oil crises of the 1970s introduced the language of energy scarcity into energy policy discussions, particularly, vis-a-vis conventional fuels (Fuel Policy Committee, 1975; Working Group on Energy Policy, 1979). Starting with its Sixth Five Year Plan (1980-85), India brought renewable energy into its economic planning process. The budget outlays in this plan introduced "New and Renewable Sources of Energy" as a new line. In 1981 renewable energy found a place in the "Prime Minister's 20-point Development Program." This plan period also saw the emergence of a dedicated renewable energy bureaucracy tasked with promoting "non-conventional energy" sources. The first

4 Dharnai was supplied with grid electricity until about 1984, at which point the creation of separate Gaya and Jahanabad districts, and presumably the administrative rearrangement, resulted in the loss of grid electricity.

such body was the Commission of Additional Sources of Energy in 1981 housed in the Department of Science and Technology. This was followed by the Department of Non-conventional Energy Sources housed in the Ministry of Energy in 1982. This department was upgraded in 1992 into the full-fledged Ministry of Non-conventional Energy Sources. In 2006 the ministry was renamed as the Ministry for New and Renewable Energy. In 1987, the Indian Renewable Energy Development Agency (IREDA) was established to finance renewable energy projects (Mathai, 2013; Bhattacharya and Chinmoy, 2009).

Beginning in the 1970s, this bureaucracy created programmes to promote renewable energy technologies. A historical review of such programmes, achievements and performance comparisons with other countries, is available in Bhattacharya and Chinmoy (2009)[5]. Overall, until the late 2000s, India was doing and had done a lot in disseminating renewable energy technologies. However, achievements, when considered in terms of installed and operational capacity, or dynamism and vitality of the renewable energy ecosystem (i.e., research and development, financing, production, installation and operations and maintenance), or in terms of the proportion of the fuel mix of energy supply in the country, the renewable energy sector remained unremarkable. Since the late 2000s this marginal status of renewable energy seems to be changing.

India initiated a national Solar Phototvoltaic (SPV) program in the mid-1970s. The IREDA launched its effort to commercialise SPV in 1993 and the evolution of the sector since has followed two trajectories. The country's production of solar panels grew from about 9.5 MW in 1998 to 40 MW in 2004. For perspective, global production grew from 288 MW to 1760 MW in this period (Bhattacharya and Chinmoy, 2009). On the application side, about 120 MW was installed by 2008, of which 110 MW were as standalone applications like street lighting, home lighting, solar lanterns and pumps. Only about 10 MW of SPV were installed in grid-interactive arrangements like solar power plants (Byrne et al., 2010). For perspective, the installed capacity of the national grid in 2008 was about 200 GW and in 2020 it was about 368 GW.

Worldwide the interest in renewable energy as a measure to address energy scarcity concerns quickly dissipated during the 1980s and 1990s. In India as well, renewable energy did not change the country's dependence on scarce oil or domestic coal. If anything, this dependence increased significantly. Rural electrification remained a challenge even as the discourse of climate change introduced a new vocabulary and rationale for renewable energy.[6]

5 Illustratively some of the earliest programmes addressed the fuel wood depletion problem in the country, where over 70% of the household used biomass for cooking. So, the National Programme on Improved Stoves was launched in 1983. Other significant programmes from this period also focused on the better utilisation of biomass fuels. These included biomass gasifiers (early 1980s), industrial biomass combustion for power generation and cogeneration (early 1990s). Predating these efforts by decades were efforts to produce biogas from cow dung that date back to the 1920s. The All India Coordinated Biogas Programme was launched in 1975. See Bhattacharya and Chinmoy (2009) for more details.

6 It is important to note here that the material impact on greenhouse gas emission from rural electrification is negligible; see Pachauri (2014).

b) Access to Electricity and Renewable Energy

According to the Census of India (2011), about 55% of rural and 93% of urban households had access[7] to electricity. For 2001 the corresponding numbers are 43.5% and 87.6% (Ahmed et al., 2014). The scale of the household electrification challenge in India is important to acknowledge. Table 1 below, tells the story of this transformation.

Table 1: Household Electrification in India (in %)

Year	Total	Urban	Rural
1973	16.3	53.5	6.6
1981	26.2	62.5	14.7
1987	39.8	56.1	30.5
1993	54.6	59.9	52.7
1999	59.4	85.3	49.9
2004	67.9	89.6	59.7
2009	79.3	93.5	73.2

Source: Data compiled by the Global Electrification Database (Alkin et al., 2018)

The gains in electrification over four decades are apparent and need to be credited to ambitious policy objectives. In April 2018, Prime Minister Narendra Modi announced that the country's last village without electricity has been electrified. Government programmes like the Rajiv Gandhi Grameen Vidhyuthikaran Yojana (RGGVY) launched by Prime Minister Manmohan Singh and renamed by Prime Minister Modi, as the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) (Government of India, 2017a) were crucial to this transformation.

These programmes counted a village as electrified if the Gram Panchayat certified that, a) that infrastructure such as distribution transformer and distribution lines are provided in the inhabited locality, b) electricity is provided to public places like schools, the Panchayat office, health centre, dispensaries, community centre, etc. and c) the number of households electrified is at least 10% of the total number of households in the village. The obvious problem being that even a 100% electrification of villages in a state, could mean that 90% of the households remain without access to electricity. The RGGVY, DDUGJY and other initiatives by state governments targeted Below Poverty Line (BPL) households (Dugoua et al., 2017).

Bihar, Jharkhand and Uttar Pradesh stand out in this regard. For example, only about 5.5 million of over 12 million rural households in Bihar were electrified. To connect all remaining un-electrified homes and address the problem of last-mile connectivity the Government of India launched the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (a.k.a *Saubhagya* scheme) in October 2017. This scheme also provides for the use of Solar Photovoltaic (SPV) systems for "un-electrified households located in remote and inaccessible villages/habitations, where grid extension is not feasible or

7 Access is different from availability, which is often compromised by blackouts and low voltage supply.

cost effective" (Government of India, 2017a). The *Saubhagya Dashboard*, a website operated by the Government of India, notes that in April 2020 only about 18,700 out of over 214 million households in India, remain to be electrified (Saubhagya Dashboard, 2020; also see Agarwal et al., 2020).

c) Climate Change and Renewable Energy

India is now the third largest emitter of carbon dioxide emissions at 2.48 Gigatonnes (Gt), behind the USA (5.15Gt) and China (9.43Gt). On a per capita basis primary energy consumption in India in 2018 was 25GJ, compared to China's 97GJ, the USA's 295GJ and a global average of 76GJ (BP 2019). This situation informs energy policy priorities. Key among them is increasing per capita energy consumption constrained by concerns about GHG emissions.

The National Solar Mission was launched in January 2010 by Prime Minister Manmohan Singh and contributed to the expansion of SPV over the past decade. This mission was one of eight missions formulated as part of the National Action Plan on Climate Change released in 2008. It radically altered the policy ambition guiding solar energy in the country. The Government of India targeted 20GW of installed SPV capacity by 2022. In 2015, this target was increased to 100 GW[8] by Prime Minister Narendra Modi's government. An important turn in the policy regime for solar energy in India was the December 2014 announcement of the government scheme to support the development of Solar Parks and Ultra Mega Solar Power Projects. Such parks are conceived as projects of 500MW and above. The initial ambition was 25 such parks with a total capacity of 20GW within five years. This ambition was revised in 2017 to 40GW out of 50 such parks by 2020-21. By the 2019-20 financial year proposals for 39 such parks and an installed capacity of 22.89 GW have been approved by the Government of India (Ministry of New and Renewable Energy, 2020).

Out of India's 368.28 GW of installed capacity at the beginning of 2020, coal accounted for ~204GW. The other fossil fuels included natural gas (~25GW) and diesel (~0.5 GW). The remainder was made up of hydropower (~45GW), nuclear power (~7GW) and renewable energy sources at ~86GW[9] (National Power Portal 2020a). This represents a sea change from a decade ago. However, fossil fuel sources continue to dominate in terms of actual electricity generation. For example, the average monthly electricity generation for the 2019-20 financial year from conventional sources (thermal, nuclear and hydro) was 1,01,171 MU[10]. A comparable monthly average is not yet reported for renewable energy. However, in February 2020, a month that is reported, generation from renewable energy sources (wind, solar, biomass, bagasse, small hydro, others) was ~ 11,245 MU[11] or about 11%. In addition, about 212 MW of standalone solar power plants were installed by the end of 2019. In

8 The National Institute of Solar Energy estimates that the solar energy potential in India is about 750 Gwp. (Ministry of New and Renewable Energy, 2020)

9 According to National Power Portal (2020a) this includes: Small Hydro Power (4,677 MW); Wind (37,608 MW); Biomass Power and Cogeneration (9861 MW); Waste-to-Energy (140 MW); and Solar Power (34,036 MW).

10 Central Electricity Authority. National Power Portal. All India / Region-wise Power Generation Overview 18-Mar-2020, Sub-Report 1.https://npp.gov.in/public-reports/cea/daily/dgr/18-03-2020/dgr1-2020-03-18.pdf (accessed April 27, 2020).

11 Central Electricity Authority. Renewable Energy Generation Report. February 2020. http://cea.nic.in/reports/monthly/renewable/2020/renewable-02.pdf (accessed April 27, 2020).

Bihar alone, projects like the solar microgrid in Dharnai added up to about 6.7 MW. In addition to such standalone power plants, lakhs of solar lanterns, solar home lighting systems, streetlights and water pumps are in place (Ministry of New and Renewable Energy, 2020).

The energy supply scenarios for 2031-32 reported in Integrated Energy Policy (2006) modelled with a GDP growth rate of 8% p.a. arrive at an 85.3% share of fossil fuels for a coal dominated scenario; and at the other end, where alternatives are "forced", fossil fuels contribute 73.7%. Comparable outcomes are projected by more scenarios modelled for the Draft National Energy Policy (2017). It concludes: "In 2040, with renewable comprising 7%-10% of India's energy mix, the overall import of primary energy is expected to rise substantially" (Government of India, 2017b: 86). While the country's import dependence on oil and gas is expected to grow to 81%-88% and 35%-51%, respectively. For coal, the supply growth is expected to be largely domestic, with production reaching nearly 1,400 Million Tonnes (MT) under the ambitious scenario, from the present production of around 600 MT (ibid.). The expansion is projected to more than double per-capita GHG emissions to between 2.7 and 3.5 tons/capita of CO2 equivalent per year in 2040, from about 1.2 tons presently.

This means more than a doubling of India's present cumulative emissions of 2.48Gt. However, through the particular lens of climate negotiations, this figure still remains vastly below where the USA and China are today. Nevertheless, within the country land conflicts and pollution related to energy infrastructure development will expand. The government is becoming more aggressive in making coal blocks available for mining (e.g., The New Indian Express, 2019), even as pollution from coal fired power plants is already significant (e.g., Guttikunda and Jawahar, 2014). What is particularly noteworthy is that the expansion of solar photovoltaic generation as large utility-scale installations has also already generated significant land conflicts (e.g., Yenneti et al., 2016).

The story of Dharnai – solar photovoltaic technology conceived as an off-grid, decentralized system – resides in this evolving context and its notable tensions. The project embodies one proposal in the debate around how to address access to electricity and expand renewable energy technologies. It also embodies a long-standing dialogue in energy policy to rethink energy-society relations and the challenges posed to local governance therein (e.g., Lovins, 1977; Goldemberg et al., 1988; Byrne and Toly, 2006; Mathai, 2013; Szulecki, 2018).

3. The Making of "India's First Solar Powered Village"[12]

a) Urja Kranti Yatra

On October 2nd, 2009 Greenpeace India's Energy Access campaign launched the *Urja Kranti Yatra* (Energy Revolution Journey). Symbolism was central to the launch. The *yatra* was flagged off from

12 The names of all the residents of Dharnai have been anonymised. However, the names of those occupying public office, such as the gram panchayat mukhya, and staff of the project proponents have been retained. This latter specially to acknowledge their contributions in terms of details about the project as well as possible ways of interpreting the events described in this case.

the location of the Gandhi Ashram at Bhitiharwa in Bihar's West Champaran[13] district on Mahatma Gandhi's birth anniversary. The *yatra* aimed at mobilising "village panchayats, youth leaders and local collectives to demand quick, quality access to sustainable power that can be delivered through local renewable energy solutions" (Greenpeace Press Release, 2010). The *yatra* travelled across 10 districts of the state with the intent of making electricity access using renewable energy a politically salient issue in the 2010 elections to the state legislature. A prominent supporter of the campaign exhorted: "With more than half of the state of Bihar lacking basic energy access, it is the duty of political parties to address the issue of energy and to do so in a manner that ensures that people living in villages are not ignored. This campaign will inform and galvanise support for energy solutions that can change lives now, not five or 10 years down the line. Use your power in the election to demand renewable energy" (ibid.).

b) "Sustainable Energy for All"

At the same time internationally, renewable energy was having its moment in the sun. The possibility of enhancing energy access enabled by renewable energy technologies was integrated within key discursive turns in the global development discourse. In December 2010, the United Nations General Assembly declared 2012 as the International Year of Sustainable Energy for All. The motivation for the resolution included the fact that "...that over three billion people in developing countries rely on traditional biomass for cooking and heating, that one and a half billion people are without electricity and that, even when energy services are available, millions of poor people are unable to pay for them" (UNGRA, 2011).

This concern was integrated into the development discourse by "[r]ecognizing that access to modern affordable energy services in developing countries is essential for the achievement of the internationally agreed development goals, including the Millennium Development Goals, and sustainable development, which would help to reduce poverty and to improve the conditions and standard of living for the majority of the world's population" (ibid.). With regard to the provisioning of modern affordable energy services, the resolution emphasised: "investing in access to cleaner energy technology options and a climate-resilient future for all and the need to improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources for sustainable development, and taking into consideration the diversity of situations, national policies and specific needs of countries, in particular developing countries" (ibid.).

13 In 1917 Mahatma Gandhi launched the Champaran Satyagraha from this district, against a British Raj policy forcing tenant farmers to growth indigo as a precondition for leasing agricultural land.

c) The Chief Minister's Challenge

It was in this wider context that in 2012 Greenpeace India organized a conclave in Patna with a number of multilateral organizations in attendance. The Chief Minister in his remarks noted that money is available for expanding renewable energy, there is clearly a need for electricity provisioning, but where is the model that the government can run with? He posed this challenge to those in attendance. Utilising this moment, Greenpeace India launched a report titled *"E[r] cluster" for a smart energy access: The role of microgrids in promoting the integration of renewable energy in India,* in 2012 (Greenpeace, 2012). The question the report asked was how to alleviate the energy starvation in contexts like Bihar, a largely rural state (88% of the population) where, in 2012, less than 20% of the population had access to electricity. Rather than wait for electricity services through the rural electrification programmes, Greenpeace India advanced a concept they called "E[r]clusters" - "a system which functions as a "bottom-up" grid expansion" (ibid. p. 7). The concept refers to starting by building microgrids at the village level and working up the scale, as demand for electricity grows, by networking these stand-alone systems with the central grid. This is the bottom-up route, rather than waiting for the central grid to arrive at the village and then percolate from the top, down to all users.

This political campaign for DRE systems succeeded in catching the attention of Bihar's Chief Minister Mr. Nitish Kumar. He invited the Greenpeace team with a challenge. He pointed out that people in Bihar (and not just Bihar, he could have said) think of renewable energy as useful only for basic loads like minimal lighting, charging phones, etc. The minister proposed that if Greenpeace could demonstrate a model for 24×7 electricity supply for multiple uses, then his government will commit to replicating it. In the early months of 2013, Greenpeace took up this challenge, and along with CEED and BASIX, set about identifying an ideal village to *pilot* and *demonstrate* the concept. The campaign also embarked on a period of research and outreach to figure out how to meet this challenge. It engaged with decision makers at various levels including the Principal Secretary of the State Energy Department, the leadership of the Bihar Renewable Energy Development Agency (BREDA), the administrative leadership at the District Level, as well as the informal markets and users, to understand perceptions about solar energy and solar powered water pumps for agriculture.

d) Identifying Dharnai

A number of villages across four districts were considered as potential sites to locate the project, against the following criteria: a) the village had to be relatively easily accessible, but without electricity; b) there had to be evidence of commercial demand; c) that the village had agricultural lands of certain dimensions to demonstrate agricultural applicability, and d) that a certain size and scope of domestic demand was available. In response to the Chief Minister's challenge, these criteria were derived from the intended role of this project as piloting and *demonstrating* the viability of this approach to supply various rural electricity demands. It was not just the provisioning of electricity that was a measure of the project's success. It was important that this proof of concept was seen by the outside world. Thus, accessibility to the media and journalists was important.

Dharnai, with about 450 households, across the three *tolas*, was found satisfactory against these criteria. The revenue village of Dharnai is located in the Makhdumpur block of Jehanabad district of Bihar.[14] The three separate, largely caste configured *tolas* include, Dharnai, the "upper caste" (Brahmin and Bhumihar) *tola*, which also contained a separate mahadalit *basti* comprised of families settled there as workers by the dominant groups. Bhishunpur, located a stone's throw from Dharnai is the Other Backward Caste (OBC) *tola*, and adjoins the state highway that passes alongside the revenue village. This *tola* has a significant presence of commercial establishments facing the highway. Jitkoria, located on the other side of the Gaya – Patna railway line from Dharnai, is the Schedule Caste (SC) *tola*. The proportion of families in government employment is higher in Bhishunpur and Jitkoria as compared to Dharnai. Landholdings and their size follow the opposite pattern, with Dharnai on top and Bhishunpur and Jitkoria on the lower end. It is also noteworthy that the few government jobs held by members of families from Dharnai are at higher levels than those by residents of the other two *tolas*.

e) Creating a Microgrid

After Dharnai was identified, an energy audit through door-to-door household surveys was conducted to understand the level of electricity demanded. This exercise was intended not just to assess demand in a limited sense. It also served to understand people's perceptions as well as to educate them about and create a perception about a DRE system. Similarly, farmers were surveyed to understand water demand, existing diesel agriculture pump sets were mapped, their consumption of fuel was queried, and willingness to pay for electricity was assessed. Assessment of demand in the commercial sector was also done. Members of a Village Electricity Committee (VEC) participated in this survey. Women were not part of the surveying team, but were respondents whose perceptions were sought. At this very early stage this proto VEC, was essentially an informal group of villagers from across the *tolas* who befriended the project proponents and informally and voluntarily helped them in their interactions with other residents of the village. This group's work was mainly about making people understand the microgrid, what it was, what it was able to do, and how it had to be used.

The energy audit revealed that the main demand from the households, were bulbs at home and mobile chargers; while some wanted fans to tide through the hot summer months. Greenpeace and its partners agreed to the fans, but with the caveat that they should be energy efficient fans. In some cases, electricity supply for televisions was also identified as an important demand. The total land holding of the village was about 1500 bighas[15], of which 1200 bighas are used for agriculture. The initial surveys estimated that more than four lakh cubic meters of water were required annually for irrigation, incurring an expense on diesel of Rs. 12.5 lakhs every year. The commercial demand was spread across about 100 bighas in the village and included various shops (e.g., agricultural

14 Jehanabad is among the districts of Bihar that have seen extreme violence (murders and massacres) along caste lines.

15 In North Bihar and Patna it is understood that one bigha is approximately 1.7 acres. The local conventions around land areas varies greatly across the country.

supplies, medical shops and eateries as well as a bank and ATM) along the highway (Greenpeace 2014; personal observations).

In addition to interactions and conversations during the door-to-door surveys, meetings with villagers took the form of "many, many, many"[16] informal, small and large group conversations, as well as a couple of Gram Sabhas[17] and *aam sabhas*[18]. These interactions were used for a variety of purposes. They included explaining and promoting the model as well as figuring out the micro-details like location and alignment of the distribution poles, wiring and other system components.

Following the energy audit, the tariff structure was developed. Initially, this did not identify a unit cost of supplying electricity. Instead, based on the audit, three "packages" were designed. A package referred to the number of watts that a household wanted to sign up for. Thus, packages 1, 2 and 3 corresponded to 18W, 30W and 50W, respectively. The package was developed through consultations with the Gram Sabah (a general assembly of all adult villagers) over at least ten such meetings. Households were charged a fixed amount based on the number of watts they signed up for. No meters were installed initially (until 2015) to measure the actual number of units consumed and to be billed accordingly. The wiring and bulbs were provided free of cost to the households initially.

For meeting agricultural demand, solar irrigation pumps were incorporated into the project. Solar pumps are simply water pumps powered by electricity from a solar photovoltaic system. The project initially planned for 10 pumps to be installed across all *tolas*, at a cost Rs. 5 lakhs per set (solar panel, inverter and pump). The pumps were to be operated on a commercial basis by franchisees. They were to be installed by BASIX in phases. So far, only two of these 10 pumps have been installed in Bishunpur. The others reportedly were installed elsewhere, even in other districts (Gaya and Purnia). These systems have now been identified and are in working order. The villagers now want these systems back, but there is no resolution yet on this issue. While the exact details of the experiences of agriculture pump sets is not fully clear (for example, how did the two that were installed in Bishunpur perform financially) there is a view that the solar pumps pilot did not succeed since they were unable to meet the high water demand of crops.

16 Personal communication in April 2020, from Mr. Naveen Kumar ex-Greenpeace Renewable Energy campaigner who worked in the implementation team.

17 Statutorily recognized meeting attended by people from the revenue village. Formal proposals can be made and decisions taken. The *mukhiya* of the Gram Panchayat participates in these meetings in his official capacity.

18 These are non-statutory meetings where people of revenue village and even neighbouring villages can participate. The involvement of neighbouring villages not part of the administrative unit, may be a curious phenomenon. One possible explanation is that their involvement is part of a conflict resolution mechanism. It appears that this has to do with the pattern of kin relationships beyond one's own revenue village. In cases where a party to a local conflict, within a given administrative unit is proving to be intransigent, other parties to the conflict from that administrative unit appeal for the presence of the intransigent party's extended family and community who tend to live in the surrounding villages. This is done purportedly to show the intransigent villager to his kinsmen in poor light, as a threat of losing face (*"naak kaatna"*); or it could be to appeal to the outsiders to press upon their kinsman to be more accommodating to his fellow villagers (Author's interpretation, based on a narration by the ex-President of the Dharnai VEC, of events around an ongoing unresolved conflict about the siting of solar panels; 14th March 2020).

f) Constituting the Village Electricity Committee (VEC)

The formal Village Electricity Committee (VEC) was constituted with the aim of ultimately overseeing daily operations and management of the microgrid. This was a critical initiative by the proponents intended to build the capacity of the community to manage its energy infrastructure. According to the project proponents: "we wanted them to learn and run the project themselves."[19] This aspect of community engagement and oversight is a fundamental differentiator of DRE systems – their promise of "energy democracy" (Szulecki 2018) as a means of transforming social and political relationships – compared to the conventional, centralised energy infrastructure. The project proponents put forward two conditions for the constitution of the VECs. First, it should not be dominated by any caste, and second, 33% representation of women was mandated. As alluded to above, Jahanabad district falls in the region of Bihar that is infamous for brutal inter-caste violence (e.g., Human Rights Watch 1999). The project proponents hoped to address this in their small way through this intervention; "we will sit together" is what they required of the villagers, to plan and build the microgrid.

The "proto VEC" comprised of volunteers from all tolas who joined the early activities of the proponents in Dharnai. However, the formal constitution of the VEC entailed the creation of three separate VECs, one for each caste constituted tola. The ambition of addressing the predominance of caste in public affairs, by "sitting together" was set aside in the face of the entrenched realities they confronted. The microgrid itself, as alluded to above, was physically built as four separate clusters, one for each caste constituted tola and the "dalit basti." The members of the VEC were nominated through tola wise nomination meetings. Each VEC was comprised of seven ordinary members, plus three office bearers, viz. a president, a secretary and a treasurer. The VEC had a five-year term. The requirement of women's representation was also effectively set aside. There were no women members in the initial VECs. The VECs were reconstituted in 2019 after their first five-year term. This time, on the insistence of Greenpeace, one woman was nominated to each VEC.

g) Operating the Microgrid

After nearly a year of outreach by the project proponents in Dharnai, which included an energy audit, and then installation of the system, electricity arrived on 1st January 2014. All the tolas had street lighting. Lighting in the homes followed in a fortnight. The microgrid was running and about 350 households had signed up as customers, out of 450 households. The grid was formally inaugurated by Mr. Nitish Kumar, the Chief Minister of Bihar, on 21st July 2014 – who declared Dharnai as "India's first solar village". This purported distinction, as we will see later, was a critical value associated with the microgrid by the residents of the village.

19 Personal communication from Mr. Munna Jha of CEED (formerly with Greenpeace) on 7th December 2017.

After the provisioning of electricity under the "package" system, it was noticed that customers were using more than their allotted load! They were charged a flat rate depending on the package. The amount of electricity consumed did not matter. This created the conditions for a classic free-rider problem—some members of a collective in a shared arrangement managing a limited resource (the solar electricity stored in the batteries, in this case) use more than what is collectively agreed upon. In doing so they deplete the common resource to benefit themselves, while the costs arising out of the depleted quality and quantity of the resource is placed on everybody. While a majority of customers did not do this in Dharnai, the number of those who did was significant enough to undermine the technology in place. The storage batteries drained faster than expected and a high frequency of line outages due to burnt out fuses also ensued.[20]

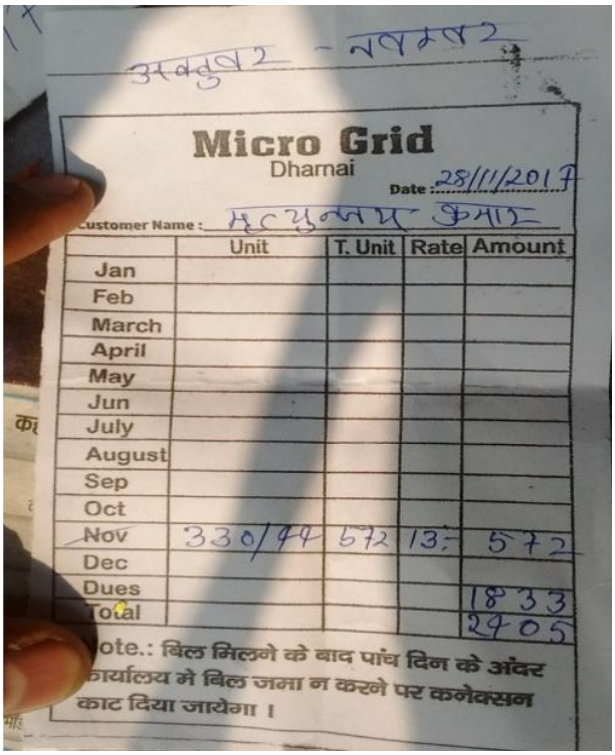

Image 1: Bill generated for a microgrid customer

The problem, however, was resolved by instituting a pay-as-you-go model. Rather than a flat-rate package, the decision was made to charge customers based on the actual amount of electricity they consumed. This decision to install electricity meters was taken by the VECs and the rate of Rs. 9.50 per kWh was decided. The microgrid is said to have functioned smoothly after the meters were installed. As a member of the Dharnai VEC noted, "automatically everyone came to their correct path". The member earlier complained, using an exaggeration, that on a "50kW system, when people were provided power for free, people wanted to use 5000kW!"

20 To make matters more difficult, one of Dharnai's lineman noted, "there was no way initially to say where the line was not working – you had to pick each fuse!" A fix to this problem was arrived at through indicator bulbs that would identify the specific fuse which caused the problem.

The procedure for dealing with operations and maintenance issues is for connection requests and complaints from the customers to be lodged at the relevant VEC, which then assigned a lineman to address the request. The routine tasks involved in operating and maintaining the system were refilling the lead-acid batteries with distilled water, dealing with system outages and replacing damaged equipment. The bills (Image 1) are generated based on meters installed for each customer, and the lineman collects the money from each *tola* and maintains tola wise account. Non-payments of dues were referred to the VEC.

h) Operations

New connections were approved by the VEC after a letter and proof of identity were submitted along with a security deposit. The VEC then assigned a technician to connect the house. BASIX was responsible for the collection of the security deposit and managed the collections of dues as well until 2015, when India Grameen Services (IGS) replaced BASIX and performed this function until 2016. The salaries (Rs. 8,000 per month) of the two linemen and rent for the one-room project office maintained in Dharnai, were paid from the organizational budgets. After BASIX and IGS exited the project in 2016, CEED performed these functions for about a year during 2017. Greenpeace paid BASIX and CEED for maintenance (repairs, replacement). Table 2 captures the operations of the system discerned through the total number of connections and the number of connections that remained in good standing through payment of dues. Between May 2015 and August 2018, the total collection of dues from Dharnai was Rs. 94,975/-. The collection from Bishunpur between May 2015 to November 2018 was Rs 72,156/-, and the collection from Jhitkoria between May 2015 and September 2018 was Rs 1,40,161/-. A total of Rs. 3,07,292. The calculated outstanding dues yet to be paid are Rs. 17,037, but unbilled dues are likely to be more than this.

Table 2: Operational status of the microgrid across three periods

Time period	***Tola***	**No. of registered connections**	**No. of non-paying connections**	**Comment**
May '15 – April '16	Dharnai	36	0	None
	Jitkoria	68	0	None
	Bishunpur	41	0	None
May '16 – April '17	Dharnai	44	~22	VEC did not take punitive action against non-paying households) connections.
	Jitkoria	68	~4	Lot of zero readings because houses were locked. People migrated for work. Also, when the grid arrived, they tended not use the microgrid because they didn't have the same ability to pay as the Dharnai families.
	Bishunpur	14	0	Many commercial connections and readily switched to the grid when it came. But billing was almost 100%.

Time period	*Tola*	No. of registered connections	No. of non-paying connections	Comment
May '17 – April '18	Dharnai	43	24	Storage starts falling. Availability and consumption fell. Payments reduced and became irregular. The VEC started to ban collection of dues if problems arose with the system.
	Jitkoria	68	15	By October 2018 the VEC directed the technician to disconnect households that were not paying. About 12 such houses were disconnected in this manner.
	Bishunpur	16	~3	Similar dynamics as Dharnai. The VEC started to ban collections if problems arose with the system.

Source: Data on payment of dues shared by Greenpeace, India. Data collected in March 2020.

With regard to the solar pumps, BASIX and then IGS was in charge of collecting the money for the pumps. They collected the security deposits and dues from the franchisee. The amount that has accrued is to be returned to the VECs, after they are registered as a co-operative society, or three separate Societies, as discussed below in Section 4(c).

3. The Experience and Interpretation of the Microgrid

What did the microgrid mean to the people of Dharnai? This section records their reactions to the microgrid gathered through open-ended conversations with individuals and small groups on the street sides, forecourts and within homes, in Dharnai. These reactions are organized into three broad groups: a) the material experience of the microgrid; b) what the microgrid symbolises in Dharnai; and c) issues needing redressal in the near future.

The arrival of the microgrid in Dharnai was marked by sudden attention and fame for the village—most notably the privilege of welcoming the Chief Minister of Bihar in July 2014 to inaugurate the project. This visit and what transpired on that occasion became a definitive moment in this story, in unexpected ways. When Mr. Kumar came to Dharnai that July, he was also met with placards and some of the villagers *"gheraoed"* him demanding *"nakli bijlee nahi, asli bijlee chahiye"* (we don't want fake electricity, give us real electricity). The Chief Minister, who trained early in his life as a mechanical engineer and even worked briefly at the Bihar State Electricity Board, tried to explain to the villagers that electricity from solar energy is the real electricity and *nakli* electricity is what the fossil fuelled state grid provides.[21] However, the politician in him, had to soon concede. He said, be that as it may, "if you want the state grid electricity, I will request the Principal Secretary to provide the grid here". In eight days, Dharnai was reconnected to the state grid, after a gap of thirty years in the dark of bureaucratic apathy.

21 This according to Mr. Munna Jha is a unique and strong endorsement of DRE. Mr. Jha has considerable experience in political advocacy over the years and this endorsement was new to him. Interviewed on 7th December 2017.

This sudden turn of events was unexpected for the proponents. As noted above, the eventual inter-connection with the state grid is part of the conceptualisation of ER Clusters. And this plan affirms that the project proponents did not expect the villagers to continue to live in a "subsistence mode" as some authors have suggested (Sharma, 2020). Yet, the arrival of the state grid at such short notice, as a parallel electricity supply, without interconnection with the microgrid was a surprise. The immediate finances of the project were thrown into disarray. The financial viability of the project was contingent on cash flow and projections based on 350 households. Soon that changed. The microgrid retained about 140 households once the main grid arrived. Until this time the proponents considered such matters as Return on Investment (RoI) of the microgrid in their decision making. But that soon changed. In practical terms, the proponents had to sort out the financial viability of the microgrid in this new reality. Strategically, for Greenpeace's advocacy on DRE, RoI was a secondary issue. The main focus was keeping the counter-narrative in check.

Riding on those practical considerations were other valuable learning opportunities. It is evident that the microgrid lost many customers. This is not surprising given that the cost of microgrid electricity was Rs. 9.5 per kWh[22], as compared to about Rs. 3.5 per kWh for grid electricity. Further, for BPL households, electricity was available at a flat rate from the state grid. What is remarkable though is that the microgrid did retain 140 households, spread across the tolas (see Table 2). In addition, the microgrid continued to enjoy certain popularity, affection even, among residents of Dharnai. This social acceptance of the project is revealed in the fact that not a single panel or related equipment of the solar microgrid has been vandalised or stolen. This is a remarkable feat for any public infrastructure in India, where it is all too common to see public property being misused. Consider the state of public roads, public trains, buses and buildings across the country and in Bihar as well. It is within such a cultural milieu that this microgrid survived without being vandalised or its many distributed parts (e.g., panels, wires, poles and batteries) being stolen. A number of interesting questions arise. Why did 140 households stay on? What accounts for the general sense of ownership toward the microgrid, even when a majority of the villagers, are not its customers? What value, other than electricity provisioning for the majority, does this microgrid bring to the village?

a) Living with the Microgrid[23]

For Mr. Gaurishankar from Jitkoria, the main grid's electricity is unpredictable. It could be a transformer that needs repairs and remains unattended or a monthly bill that is incomprehensible or a bill payment process that takes the better part of the day with expenses incurred on travel to the electricity department office in town. He recounted instances where two or three houses even sought to give up the main grid electricity connection because of these issues. In marked contrast, "the Greenpeace bill" – as the villagers refer to it – is predictable, easy to understand and is settled

22 When Greenpeace arrived at Rs. 9.50 per unit in 2015, the cost of electricity for other solar microgrids was higher than this.

23 All names in this section have been anonymised with common names from Bihar. The interviews were conducted in December 2017 and March 2020 at Dharnai. Respondents included members and office bearers of the VECs as well as ordinary residents.

with the lineman in the village. While the *sarkari* meters are complicated to read (see Image2) with multiple metrics of electricity and a button to find the measure of interest, the Greenpeace meters (see Image 3) are simple. They directly display the cumulative unit count that "even a kid can read," as some respondents said to me.

Image 2: The state electricity grid meter with variable readout of metrics that are difficult to understand.

Mr. Gaurishankar noted that now "nearly all homes" have TVs and watch sports. But reminded me of the problem when the *sarkari* grid is off and the village has to depend on the solar electricity stored in the batteries. Calling upon an impressive analogy, he said, if you have a fixed amount of water and your consumption is high, the water is going to run out fast. Similarly, there is a problem with the prevalence of cheap 100W incandescent bulbs—locally referred to as the "yellow bulb"—that drain storage batteries faster than would have been the case if lower wattage CFL or LED bulbs producing the same light intensity were used. Anecdotally, the provisions store inside Dharnai tola, appeared to stock only incandescent bulbs. The lineman too complained about "back up running out within two hours on one of the lines in Dharnai," because the loads on that line were in excess of what the system and its storage capacity were designed for.

While talking about microgrid, many respondents offered analogies that evoke ideas like "energy autonomy" and collective ownership. Mr. Gaurishankar, for instance, observed, "we get it [solar electricity] whenever we want – it's like our switch with a finger on it – until the sun shines". It was interesting to note this reference to a concept like energy autonomy that has now been formally written about and discussed for many decades by progressive writers (e.g., Scheer, 2007) in energy policy.

Image 3: The microgrid meter with a straightforward readout of cumulative units consumed.

Integral to living with the microgrid, is the question of governance of the microgrid, and the primary governance structures for this purpose are the VECs. Mr. Gaurishankar noted that the VEC meets once in four to six months – but now (i.e., December 2017) has not met for over a year. According to him, this was because office bearers were busy with their jobs and not able to host meetings. The background to Mr. Gaurishankar's observation is that reportedly 85% of the household heads in Jitkoria work in government jobs, albeit mostly in lower levels positions – perhaps reflecting India's affirmative action policies playing out in this largely OBC *tola* – and are thus unavailable or otherwise do not have the time to convene meetings of the VEC.

Since July 2017 – the maintenance, operations and accounts have been decentralised to the *tolas*. Primarily, therefore, funds accrued in one *tola* cannot be used for microgrid expenses incurred in another *tola*. This was likely a response to a controversy that erupted in 2016, when Bishunpur *tola* witnessed a protest disconnection because one of the *tolas* (Jitkoria) was given relief from some of its dues, by drawing from the common fund. The separation of the management of funds and accounts to each *tola* was to alleviate the potential for the recurrence of this problem.

While routine maintenance and management of accounts were devolved to the VEC, Greenpeace remained involved after CEED and BASIX exited the project – and the villagers even referred to electricity from the microgrid as "Greenpeace *ka*" (i.e., Greenpeace's) as opposed to *sarkari*, for the electricity from the state grid. In addition to oversight of financial accounts and for dealing with technical issues that could not be resolved locally, the respondents nearly unanimously expressed reliance on Greenpeace for two further aspects: a) to secure the investment needed to

replace the system's lead-acid storage batteries; and b) for conflict resolution on issues ranging from non-payment of bills to siting of electricity distribution poles to managing the local staff. Conflict resolution in any collective endeavour is a critical capacity for effective self-governance arrangements. It is worth noting that the confidence among the members of the microgrid community in themselves, in this regard, was less than reassuring. Mr. Gaurishankar, plainly stated that "we need a higher authority to resolve such problems...the Superintendent of Police (SP) or the Deputy SP needs to be involved to resolve problems".

Ms. Ramadevi, a young woman who works in Delhi and was visiting during my visit is from Dharnai *tola*. Echoing Mr. Gaurishankar's view (we talked to them separately), Ms. Ramadevi stated that there is "no single opinion in the village – people don't share the same thinking – therefore cannot run the system without Greenpeace or an outside agency." Explaining why outside intervention was needed for them to govern the microgrid, she elaborated that the villagers have "fear for people from the outside and hence willing to listen to them. Even the *mukhiya* cannot run the system," she declared. Such statements problematize an issue that has evaded other studies of the microgrid that sought to ascertain their "drivers and barriers". For instance, Jawaid (2018) makes many interesting observations that correspond to the once documented in this case study as well. However, while discussing barriers, the villagers' confidence and capacity to self-govern, without reliance on a higher authority from outside the village, is not identified as a barrier.

Separately, Ms. Ramadevi noted that there is a demand for a 24-hour electricity supply. The "food has been served, we will eat," she stated. While the need for electricity has increased, the scope for expanding the microgrid is limited because, a) money is limited to expand the system, 2) and more importantly, the village is now connected to the state grid. But the problem is that while electricity is available from the state grid – food has indeed been served – the supply is irregular, unpredictable and inadequate. The state grid's supply needs to be supplemented by the microgrid, but to do so the microgrid has to expand in terms of generation capacity as well as storage – both of which are investment intensive and not feasible based on existing cash flow trends (see Section 3(h)). Reflecting a sentiment that does little to resolve this problem, Ms. Ramadevi also expressed her hope that the VEC would allow a waiver of her electricity bill.

Echoing the experience of energy autonomy and a sense of ownership, Mr. Lalitnarayan, observed that "this [microgrid] can be our own project. We can use it according to need. This is our energy, and we must be thoughtful when we use it". Underscoring the problem of acquiring land for infrastructure projects – as also seen in the case of utility-scale solar energy projects – he noted that the "biggest advantage is that we don't use land from anywhere. Rooftop is enough". He went on to outline some of the other attributes, by noting that "this is a clean, new source of energy... non-polluting". Some problems when it rains. Good for South India (perhaps due to the fact that I was a visitor from the South!). He also went on to note, echoing government policy on this matter for many decades, that the solar micro-grid is a good energy technology for *"durgam ilaka"*- remote/ inaccessible areas.

Being a teacher, Mr. Lalitnarayan was quick to note that while the availability of electricity was a boon, he felt that "students were not studying" - an observation that creates an important wrinkle in the common association of renewable electricity availability and "productivity enhancements" - be it students being able to do homework or cottage industry manufacture. There may indeed be such a relationship, but it's worth working through the mechanisms and their social and cultural nuances.

The self-governance of the microgrid is a recurring theme. Mr. Lalitnarayan too, observed, "we gave electricity within boundaries – but people became selfish. Once you get the *adat* (habit) of electricity you cannot give it up. A very small percentage do not listen to the others. Majority are willing to live within the VEC prescribed limits." He then also pointed out that in the Jitkoria VEC (Mr. Lalitnarayan is from Dharnai *tola*) *sanghatan* (unity) is a problem and that the promise to change VEC has not materialised yet.

Ms. Veenadevi, a homemaker. whose house did not have a state grid connection due to denial of access for the electricity pole. She has had a microgrid connection since the beginning. She said it was "better than *sarkari* line". In the access to electricity that the local microgrid offers and personal familiarity with the operators of the system, the "Greenpeace line" is indeed accessible. Accessing the *sarkari* grid requires wading through layers of an often apathetic bureaucracy, that is further removed from the village by being physically located in the town far away.

Mr. Jagdish recounted the history of the project and how Dharnai did not have electricity for 30 years. The streets are well-lit now, it's "good for studies" he offered and there is no need for a torch anymore at night. He also noted that the microgrid was "safer than the grid". But the new insight that Mr. Jagdish offered was to outline the symbolic value of the microgrid, even if its electricity provisioning ability is limited. He said, "see the Chief Minister has visited twice. If there was no solar microgrid, then *sarkari* line would not have come either." He went on to note that we are now "famous world over." He had spoken to many visitors and was "still enthusiastic to talk about it". There are many visitors and there are "videos online" as well, he added.

His appreciation of these benefits, notwithstanding, Mr. Jagdish, felt that the "future looks dark – collections will not be able to pay for the upcoming replacement of batteries." He was quick to add that "collection...was working well in Jitkoria." Mr. Jagdish, who is economically well-placed, as evidenced by his house as well as "permanent" government job, runs three electricity lines at his home, the *sarkari* electricity, "Greenpeace" and an Uninterrupted Power Supply (UPS) as a backup.

Delving into the functioning of the VEC, he mentioned that two of the members work faraway, one in distant Pune. Still, the VEC meets "three-four-five" times a year, he offered. The main problems he felt were non-payment of bills and billing issues – referring to the situation of the two solar irrigation pumps installed in Bishunpur that are reportedly not being billed. In terms of sanctioning mechanisms that Jitkoria VEC has instituted, he pointed to the 15-days punishment for shorting a line, by overloading it. For a new connection, prospective customers had to get approval from the VEC and make a security deposit of Rs. 1000. Disconnecting a customer requires a letter from VEC.

My respondents from Bishunpur *tola* appeared to be disaffected toward the microgrid and its operations. Mr. Ranjanprasad said that the "main issue is money. After the *sarkari* electricity arrived there have been many disconnections". Elaborating further he said, "Money for batteries is a big problem. Estimated at Rs. 16 lakhs to replace batteries for 20kW, the microgrid is proving to be financially non-viable. Cheap electricity has displaced it". Bishunpur did not look very optimistic and it appeared that there wasn't a clear idea about how the microgrid will go forward here.

There were "some problems when it gets cloudy" he noted, echoing a commonly recognised aspect of the technology. But he recounted a slightly different local distinction between solar electricity supplied by the microgrid and conventional electricity from the state grid – as *asthayiee aur sthayee bijlee* (temporary and permanent electricity). In Mr. Ranjanprasad's rendering of the story, the people "asked [the Chief Minister] for original electricity – who corrected them saying that this [solar microgrid] is original".

Mr. Ranjanprasad ventured to observe that the NGOs are "not clear – NGOs used to meet everyone". It appears that now things have changed - "One or two people can meet with one or two people – people have no information about what to do going forward. It has now become a picnic". His view is that employees of the three NGOs don't meet everyone. He compared the present situation to earlier times – perhaps, I think, the multiple Gram Sabhas and other meetings held when the project was being conceived and energy audits conducted – and observed that they "used to have meetings in the beginning – almost on a monthly basis – now there are no meetings. The consumers are not unhappy. It's going on as it is". Mr. Ranjanprasad, noted that the "VEC does not meet," and Mr. Hari (also from Bishunpur) explained, "the problem is with the VEC". The "VEC is not organising meetings", he protested. Some of the tensions in the VEC in Bishunpur, seem to be attributable to questions around the solar irrigation pumps that remain unresolved.

The disaffection with the microgrid and its running was also expressed in an unexpected manner. This complaint was related to the Viswakarma[24] Puja, a festival that is widely celebrated in this region. It was alleged that Greenpeace refused to contribute to or enable this particular puja. Further, and touching on delicate issues of religious identity, that remain unresolved as much in Dharnai, as elsewhere in India, alleged that this lack of participation in the puja was due to the religious affiliations of Greenpeace staff. On the one hand, it reflects the elementary issues of identity that complicate the realization of ideas such as "commons", "devolution of power" and "local self-government". On the other hand, it points to an immediate and delicate people management hurdle that Greenpeace staff had to handle with skill.

Mr. Hari pointed to the need for making the microgrid "more established," but pointed out that it is "very costly and we can't use other instruments – only bulbs and fans". When the Chief Minister visited, we *gheraoed* him with the demand "that we're not getting electricity in sufficient quantity".

24 Viswakarma is a god of machinery, tools and technology, and is known as the engineer of the heaven! He is worshipped on 17th September in factories, workshops, garages, hotels, restaurants etc. in parts of eastern India.

Mr. Hari observed that the "PV systems are not available for pumps" and there are "no schemes to support farmers. Groundwater is available but can't pump it". The conversation ended up as a recital of a litany of complaints about the government's ineffectiveness. However, even at this moment, he conceded that the "streetlight system is very successful". But, echoing others, said that the "collection system is not working – finances are not clear." And repeated again, as have others, that the solar pump situation is not clear. They apparently don't know what is happening to the money. At one point in the interaction, Mr. Hari and the people in his company had a hearty laugh at the expense of "tourists" who came to Dharnai to see the microgrid; and some of whom proceeded to take photographs and even ended up kneeling in cow dung while doing so!

b) Significance of the Microgrid

Mr. Ajay Singh Yadav[25] is the mukhiya of Dharnai Gram Panchayat, which was declared an Adarsh (Exemplary) Gram Panchayat by the Government of Bihar. Such recognition has the very important advantage of access to and bureaucratic responsiveness under various government development schemes. Mr. Yadav came across as an ambitious politician who seemed able to get things done for his constituency. His interaction with me was hurried, in between appointments elsewhere in the panchayat. He seemed to be well-rehearsed in talking about himself, his panchayat and listing of the accomplishments during his tenure. After a few perfunctory niceties and explaining the purpose of my visit, he proceeded to list the *vikas* (development) accomplishments during his tenure and asked that I make note of them. I did so, stenographically, and postponed my questions for later. The list below is reflective of what Development means to him, and it is also a testament to his energy and evident ability to work the government bureaucracy and political class to direct government funds to his constituency:

Panchayat Sarkar Bhavan; MNREGA Bhavan; model *aanganwadi*; cold storage for milk; piped water supply to the *"mahadalit"* tola; a godown for grain in Bishunpur; eight cremation grounds; *the solar microgrid worth Rs. 3 crores;* a primary health centre in Dharnai; deepening of the village pond and creation of a park around it; resources have been committed for construction of a sports stadium, and construction was to commence soon; the proposal to locate a police outpost in Dharnai has been accepted; he has managed to get a commitment for Rs. 22 lakhs for the construction of a *"mahadalit"* community hall.

"We will keep it permanently," he said about the microgrid. "It can be 24-hour electricity. State line can be cut. *Apna hi hai. Greenpeace ki bijili hai.* (It is our own. It is Greenpeace's electricity)". Mr. Yadav attributed the fact that Dharnai is the first *adarsh* gram panchayat in Bihar to the microgrid and other development due to Greenpeace. This symbolic value of the microgrid needs to be understood within the larger narrative of Dharnai and the values at play (e.g., see Image 4).

25 Mr. Yadav is an elected public official holding a public office, and this is his real name.

Image 4: The two yellow boards announce in Hindi that this is Dharnai, an Adarsh Gram Panchayat, and in the biggest font size on these boards, states the name of its mukhiya, Ajay Sing Yadav, to those passing by on trains plying this fully electric double-track Patna-Gaya railway line. The smaller white board, placed there by Greenpeace, states "Solar Microgrid Village" with the Greenpeace, CEED and BASIX logos.

In Munna Jha's recounting of the story, Dharnai was a dry nondescript village, just like any other village when the project proponents started to empower the *mukhiya*. The heightened visibility and branding of Dharnai that followed pushed the local administration to be supportive across development sectors in the village. This is important while reading the significance of the microgrid. While the project's conceptualisation was energy centric, its social acceptance has come to be associated with its association with all the other "good things" that have also come about. The many multiplier effects due to the solar DRE include Dharnai's fame in Bihar (this is true and anecdotally too, random passengers I spoke with on my train from Gaya to Patna were aware of Dharnai and its solar microgrid) but across the country and abroad as well. In addition to fame, the attention also allowed it to benefit from various government funding schemes that have helped build significant physical infrastructure in the village (i.e., Mr. Singh's list of achievements). The microgrid may have helped transformed the village's confidence and investments that followed under government schemes are regarded highly.

c) The Status of the Microgrid in 2020

Since this microgrid is a system with battery back-up, designed at a time when the grid electricity supply to the village was absent, the replacement of the batteries was a concern, voiced even in 2017. The project proponents committed to replacing the batteries and handing over the system in 2017. Quotations were solicited for this purpose from three vendors and ranged from nearly Rs 53 lakhs on the higher end to a little over Rs. 37 lakhs at the lower end. To place these numbers in context, the dues collected and pending from the domestic connections added up to under Rs. 4 lakhs. The accrued security deposits and accounts pertaining to the agricultural pumps are not available with this author. But it is unlikely that they will add up to the difference between the approximately Rs. 4 lakhs in hand, and the Rs. 37 lakhs, needed to replace the batteries. This difference, should the batteries be replaced, will have to be secured externally.

The project proponents' plan was to replace the batteries, register the VECs as a cooperative society and hand over the system to their care. Outside of the basic economics of the system recounted above, two other problems have challenged this plan. First, the state of Bihar allows only one cooperative society per village; so, the three VECs had to agree on registering as a single cooperative. The criteria to do so also included requirements in terms of SC/ST and women as members. While Bishunpur and Jitkoria were reasonably favourable to this idea, Dharnai dismissed it. The proposal was shelved. The second problem was the Enforcement Directorate investigation of Greenpeace launched around October 2018. The investigation froze the organization's bank accounts resulting in severe disruptions to its staffing arrangements and ongoing work. While the discussion about the cooperative society stalled, staff continued to be greeted with requests for replacing the batteries. Such requests were tempered slightly once news of the Enforcement Directorate's clampdown and its implication for Greenpeace's ability to operate normally, became public.

The storage capacity of the system started declining during 2018 and by early 2019 the batteries were no longer working. A technical review of the microgrid in July 2019 confirmed this. It found all the solar panels to be in good operational condition, but nearly all the 224 batteries needed replacement. As the batteries died, so did the back-up electricity supply role of the microgrid. By the beginning of 2020, Jitkoria had 69 connections, Bishunpur had 15 and Dharnai 38. But since no electricity is being supplied, bill collections have also stopped. At the time of this writing, in March 2020, only one lineman was employed by the project. There was little work to be done by way of attending to repairs and maintaining the batteries and panels. The VECs have little work to do as well. The general opinion of VEC members interviewed was that the VECs "need to meet". The question of the agricultural solar pumps remains unresolved as well.

As discussed in Section 3(h), about Rs. 4 lakhs have been collected from customers as dues for electricity supplied. Customers who owe money say they will pay their dues once the system comes online again. Other monies were collected as well. For example, all customers paid a security deposit. This amount is now held in an account operated by BASIX and is to be returned into the bank account of the entity/entities that replace(s) the VECs, once the latter is/are registered.

In March 2020, during discussions with the joint District Magistrate-District Commissioner of Jehanabad district Mr. Naveen Kumar, he reiterated that the district administration's recommendation is that the microgrid, through the registered cooperative, enters into a net-metering[26] arrangement with the electricity supply company, facilitated by the Bihar Renewable Energy Development Agency. He went on to note, that since the grid has now arrived at the village such an arrangement can avoid the need for laying out a huge sum for replacing the batteries. He

26 Net-metering is an arrangement where the owner of a decentralized renewable energy (DRE) generator enters into a contract with the electricity distribution company (backed by a government mandate) to buy the electricity generated by the DRE generator. Metering in this arrangement is the 'net' of the electricity that the owner of the DRE generator buys from the grid for use on her property and the electricity this owner sells to the grid. This arrangement has two advantages. First, the expense incurred by the owner on electricity is considerably reduced and can even be a net savings, if the property is able to manage within the electricity generated by the DRE generator and spare some for sale to the grid. Second, it eliminates the need for storing electricity and the significant capital outlay needed for batteries. The grid in effect, is the storage system as far as the individual DRE generator is concerned.

stated that renewable energy systems with storage were the "old concept" and the government does not endorse this anymore. Interestingly, this proposal resonates with the path imagined for ER Clusters in Greenpeace's eponymous report published in 2012. This appears to be one option available to Greenpeace India, the sole remaining proponent, to hand over the project to the village.

As discussed above, registering a cooperative society—a key step to making the net-metering arrangement possible—requires all three VECs to come together and submit to the SC/ST and women's participation conditions. Dharnai remains disinterested in this route. Another alternative is to register the VECs separately as three separate societies under the Societies Registration Act. Each of the societies can then enter into a net-metering arrangement with the power supply company. The complication here is that the rules allow two options for entities seeking interconnection—either as individuals (e.g., a family home) or as a commercial venture. While the first is not applicable for a *tola*, a commercial venture seeking interconnection has to have a minimum capacity of 1 MW, whereas the total system in Dharnai (across all the tolas) is only 70 kW. As of October 2020, discussions are underway to explore how this situation might be favourably resolved.

5. In Conclusion: Lessons from Dharnai

One insight that emerges with some clarity in the story of Dharnai so far is that it is a case of differing values ascribed to and associated with a technological infrastructure—in this case the solar microgrid. For the project proponents, the project is valuable as a proof of concept demonstrating a sustainable strategy for rural electrification. This project shows the world a short gestation infrastructure to supply electricity to an under/unserved population, accomplished using a decentralized renewable energy technology configured in a way that creates the potential for energy democracy. These are crucial values for those grappling with the challenge of reconciling human development priorities with environmental goals.

For the residents of Dharnai village, the solar microgrid is a welcome option, but for a somewhat different set of values that are not necessarily those prioritised by the project proponents. No doubt a chance to reduce indoor air pollution from the dim lights of kerosene lamps and candles made available by the project is welcome. But it was particularly welcome as a source of electricity when the state grid supply was absent in the village. It allowed for advances in lighting inside and outside homes, as well as the ability to use fans, mobile phone chargers and even music stereos on special occasions like weddings. It was a step from darkness to light. It fulfilled a sense of catching up with the times for a village that was literally left in the dark by decades of administrative apathy. And the project remains a desired option today when the state grid underperforms on a number of criteria[27], which it continues to do.

27 These include attributes like access to the grid, availability of electricity from the grid, quality of the electricity, the lack of predictability of supply, the speed of recovery from disruptions. In addition, two other attributes were mentioned. One was the distance and time needed to visit the office of the electricity supply company if any matter had to be redressed. Second, was the incomprehensibility of the electricity bill and meter supplied by the state grid electricity supply company. Both of these factors as well led some respondents to the feeling that it's better to disconnect their state grid supply entirely!

There is a value ascribed to the state grid supply that the microgrid finds difficult to match. This is simply the quantum of electric loads (the "energy density") that the state grid can supply (when it works!). An illustration of this value was when the villagers picketed the Chief Minister saying that "we don't want fake electricity, give us real electricity". What the slogan captured is the value attached to using electricity outside the bounds of constraints of community norms necessitated by a small "finite" supply of electricity stored in batteries. Such a demand must be recognized against the background of Bihar recording the lowest per capita electricity consumption in India,[28] a country where per capita electricity use is lower than the world average. The demand for "real electricity" reflects the existence of significant unmet demand. Alternative energy can have very different values attached to it. While an environmental group might associate alternative lifestyles and economies with it, it appears that the residents of Dharnai make somewhat different associations. For them, it appears to fulfil instrumental, aspirational and symbolic roles.

In early 2020, the microgrid supplied zero electricity, having lost its battery storage capacity. Even in its early days, when the microgrid was newly installed, its practical value was dented when the village was connected to the state grid soon after. However, its value as a backup when the state grid fails remained and many respondents mentioned this. But the continuation of this role for the microgrid needs the batteries to be replaced. If the proposal made by the administration to enter into a net-metering arrangement with the electricity distribution company is taken forward, the ability of the microgrid to be a back-up will be lost. Overall, however, the instrumental value of the microgrid as a supply of electricity was undermined by the arrival of the state grid. The integration through a possible net-metering arrangement with the state grid will further this transformation.

Nevertheless, many of the respondents felt strongly about keeping the microgrid functional in Dharnai and a large part of their reported reasoning was symbolic. As recounted above (see Section 4(b)), the presence of the microgrid has put the village on the "development map" of the country. There is pride associated with it. But more importantly, it created a pretext for recognition by the state and national bureaucracies, and through that for opportunities and investments through various state and central government development funding streams. A recent example of this status enjoyed by the village was when Mr. Yadav, the *mukhiya* of Dharnai, was identified among a handful of *mukhiyas* from across India, to address the Prime Minister on Panchayati Raj Divas in 2020.

The reasons associated with the demand for "real electricity" are not singular. There are multiple, even contradictory drivers existing at the same time. Many homes in the village have televisions and when running on electricity supplied by the state grid, this is not a problem. Adherence to collectively agreed on norms of electricity usage and accountability to the local community on this matter become irrelevant. However, when this supply is interrupted and the village turns to its solar electricity saved in batteries, the norms of usage have to suddenly transition to locally and

28 In the year 2018-19, the national average per capita electricity consumption was 1181 kWh. In comparison Bihar stood at 311 kWh (Press Information Bureau, 2019).

collectively determined ones geared to maximising the life of the battery supply for goals such as lighting, which have priority. As one of the respondents explained: "we gave electricity within boundaries, but people became selfish. Once you get the *aadat* (habit) of electricity you cannot give it up". This respondent further clarified that "a very small percentage do not listen to the others". But this is precisely the challenge for organizing a common resource to allow shared well-being: a minority is likely to be free-riders. Dealing with this requires processes and institutional mechanisms with the necessary legitimacy within the community so that collectively developed rules and norms are voluntarily followed, and if needed, can be enforced under the threat of sanctions.

The late German thinker and advocate for renewable energy Herman Scheer, among others, long associated the idea of *energy autonomy* with renewable energy technologies that are arranged in small-scale, modular, decentralized installations. Such configurations are theorized as being able to liberate individuals and communities by empowering them to pursue goals for social change that are different from the power centralising dynamics and interests represented in the larger national grids. There are limited echoes of this sentiment among the respondents at Dharnai as well, one of whom said: "we get it [solar electricity] whenever we want—it's like our switch with a finger on it—till the sun shines". Similarly, another respondent noted "this [microgrid] can be our own project. We can use it according to need. This is our energy and we must be thoughtful when we use it". But, as noted above, this limited appreciation of energy autonomy exists with skepticism about solar energy as *nakli* (false) electricity—electricity from a source that is lower in energy density compared to that from the state electricity grid.

These observations culminate in a lesson about local democracy and capacities for local governance required for the community to arrive at priorities and norms, and to enforce them. In discussions of energy democracy, researchers and advocates often tend to assume a community's ability to do so. For example, in the project proponents' view, the microgrid promotes norms and values associated with "commons", "devolution of power" and "local self-government". However, a comment made by one of the respondents while discussing Greenpeace's eventual exit from the project and its overall operation and maintenance needs to be considered attentively. The observation from Mr. Gourishankar documented above, was that "we need a higher authority to resolve the problems... the Superintendent of Police (SP) or the Deputy SP needs to be involved to resolve problems". This view reflects the distance between the promise of local democracy and the willingness for local self-government and its enabling social conditions, as it obtains in Dharnai. Explaining his view, Ms. Ramadevi clarified that we villagers "fear for people from the outside and hence willing to listen to them...we don't listen to each other". This reality is a challenge that projects seeking to advance energy democracy, and local democracy more generally, need to acknowledge. This point is often missed however by studies that point to consumers' lack of awareness about the benefits of solar microgrids (e.g., Jawaid, 2018), presuming, that just the creation of awareness will be instrumental in realizing the desired outcome. As it turns out, and as captured in sections three and four above, the community appeared to be reasonably aware about the advantages and disadvantages of the microgrid. What they lacked, it appears, was an ability to govern the grid

collectively and effectively. This tells us that perhaps the challenge of creating and organizing a *community* must precede or at least parallel that of choosing, installing and operating decentralized energy infrastructure.

This question is particularly pertinent in India given the society's ethos of graded inequality and identity based cleavages that can and do preempt ready imaginaries of a polity comprised of citizens equal in human dignity before the Constitution and the State. This situation is essentially what Harris (2006) called "specific trust" at the expense of "generalized trust". The former derives from closed social networks, such as caste groups, and/or personalized transactions. The latter tends to trust in impersonal relations and reflects a high level of faith in institutions (e.g., the law) to mediate affairs, if and when needed. While Harris's (2006) proposal was in the context of discussing institutions and the functioning of the market economy, the distinction is useful in our context as well. It is against this rather unfavourable background, that Dharnai illustrates for development practitioners and the funding agencies supporting them, the need to commit long-term investments of money and time to nurture civic community, capable of local democracy and local-governance that may eventually enable *Anubandh*. This possibility of a Gandhian democratic socialism, as a means for building a sustainable nature-society relationship, is the yet to be redeemed promise of energy democracy.

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Azim Premji University was established in Karnataka by the Azim Premji University Act 2010 as a not-for-profit University and is recognized by The University Grants Commission (UGC) under Section 22F. The University has a clearly stated social purpose. As an institution, it exists to make significant contributions through education towards the building of a just, equitable, humane and sustainable society. This is an explicit commitment to the idea that education contributes to social change. The beginnings of the University are in the learning and experience of a decade of work in school education by the Azim Premji Foundation. The University is a part of the Foundation and integral to its vision. The University currently offers Postgraduate Programmes in Education, Development and Public Policy and Governance, Undergraduate Programmes in Sciences, Social Sciences and Humanities, and a range of Continuing Education Programmes.

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