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## Original research article

## Towards an ethnography of electrification in rural India: Social relations and values in household energy exchanges



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## ABSTRACT

Many energy researchers and practitioners envision householders to have an active role in local energy distribution in emerging energy systems. In the energy literature, the dominant view of local energy distribution, grounded in the rational choice perspective, sees exchanges of energy between households as energy trading. The existing energy literature lacks conceptualization of social and personal exchange of energy between households that is mutually structured and negotiated. This article builds on the theoretical works of an economic anthropologist, Stephen Gudeman, to conceptually discuss such energy exchanges. This article reports from an 'ethnographic intervention' study conducted at an off-grid village in rural India for three months (1 February–30 April 2016). The ethnographic data analysis reveals how social relations and diverse cultural values influence on energy exchanges between households in the village. The article introduces 'circle of mutual energy exchange' as a conceptual, analytical and descriptive unit for understanding such energy exchanges. The article describes two co-existing and dialectically connected modes of energy exchanges: 'mutual energy sharing' and 'mutual energy trading.'

## 1. Introduction

Across the globe, with the increasing adoption of renewable energy technologies, many energy researchers and practitioners envision electrical energy provisioning systems go through a systemic shift towards distributed, decentralized or off-grid energy systems [1–5]. Two key features are central to this shift: first, energy is locally produced, stored, distributed and consumed. In the energy literature, this is also referred to as micro-generation [6,7] or small-scale energy generation [8]. Second, householders are considered as active participants in local energy management [1,9–12]. Many energy scholars envision these energy systems to become more social where householders acquire diverse, active roles not just in energy production and consumption but

also in local energy distribution [1–3,13,14]. They expect that energy distribution scenarios in the near future will enable householders to choose with whom to exchange locally produced energy [1–3,15–17]. This kind of engagement of householders in local energy distribution enables energy exchanges. This article refers to an 'energy exchange' as a transaction or an exchange of energy between an energy-giver and energy-receiver. Technically, there are several ways an energy exchange can take place: one of the means is by use of electricity network and cables. Some upcoming initiatives that are enabling such energy exchange are: Vandebron<sup>1</sup> in The Netherlands, Brooklyn Micro-grid<sup>2</sup> in USA and SOLShare<sup>3</sup> in Bangladesh. Another way for an energy exchange to take place is by use of energy storage devices. Few initiatives that structure such energy exchanges are Ikisaya Energy Centre<sup>4</sup> in

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<sup>1</sup> <http://vandebron.nl/>.

<sup>2</sup> <http://brooklynmicrogrid.com/>.

<sup>3</sup> <http://www.me-solshare.com/>.

<sup>4</sup> <https://vimeo.com/57061330>.

Kenya, Lighting a Billion Lives<sup>5</sup> initiative and Rural Spark<sup>6</sup> in India.

In the emerging body of energy literature, ‘energy trading,’ a particular type of energy exchange, is widely considered to be an innovative approach to incentivize and actively engage householders in energy systems (see for energy trading, [5,9,18–20]). This energy-trading or market-centric approach for energy exchange is discussed under various innovative labels, such as ‘peer-to-peer energy exchange’ [13], ‘peer-to-peer prosuming market’ [2], ‘neighbourhood-level energy trading’ [5,21], ‘virtual net metering’ [22], ‘energy-eBay’ [15], ‘collaborative smart grid’ [9], and ‘consumer-centric smart grid’ [1]. All these labels are mostly based on simulation studies and lab-based prediction models (e.g. [5,13,16,23]), which are built upon a vision of rational choice, rather than based on empirical evidence from people’s everyday social lives. An energy trading is realized when a household sells (or buys) a surplus of locally produced energy either to (or from) the local grid by use of an energy market (see, e.g., [10,24,20]). Here, the term ‘market’ indicates a structure for exchanges of commodities (goods and services) based on neoclassical market principles. Within the dominant rational choice perspective, householders engaging in an energy exchange are viewed as self-interested individuals, motivated by price incentives, aiming to maximize their monetary profit and minimize household expenses [2,4,6,10,24–26]. This prevailing view limits the relationship between energy-giver and energy-receiver to that of a buyer and seller. Furthermore, this rational perspective universally locates the value of energy exchange in ideas of efficiency and optimization of resources, and maximization of financial benefits by balancing of energy surplus and deficit (see, e.g. [1,4,5,9,23]). This rational choice lens heavily dominates the concept of energy exchange and limits its meaning to energy trading. This article describes this dominant notion of an energy trading or a market energy exchange (MaEE) as an impersonal, anonymous, and competitive buying and selling transaction of energy between an energy-giver and energy-receiver where price is determined by self-regulating neoclassical market principles. Such energy trading is formalized, regulated and structured by the mediation of utilities and regulatory bodies. Usually, an energy trading is monetary such that a householder selling energy receives monetary benefits in return. Overall, there appears to be a lack of understanding in energy literature on the influence of social relations between energy-giver and energy-receiver on energy exchanges; and diverse local cultural, moral, and ethical values that shape energy exchanges. This understanding is a needed to comprehend the complex social nature of local energy distribution and to appreciate that there is more to energy exchanges than the dominant rational choice perspective of energy trading.

The existing literature on local energy distribution lacks conceptual understanding of mutual energy exchange (MuEE), which this article describes as a social and personal transaction of energy between an energy-giver and energy-receiver, which is mutually structured and negotiated. The word ‘mutual’ is in reference to the anthropological discourse of ‘mutuality’. Mutuality refers to people’s ability to socially associate with others, form relationships and live life through these social ties [27]. The notion of ‘mutuality’ is crucial in this context as it provides a conceptual lens to transcend the purview of rational choice and to support research on how energy exchanges are socially and culturally embedded, which is one of the key arguments of this article. When two householders configure an energy transaction between them, they structure a mutual energy exchange. An example of mutual energy exchange: a person, bypassing an energy grid, uses his/her solar panels to provide energy to a household of a neighbor. Another trivial but relevant example of a mutual energy exchange: in an off-grid village, a household with solar installation charges mobile phones and batteries of other villagers who do not have access to this energy source. In contrast with energy trading, a mutual energy exchange is informal, unregulated, mutually structured by an energy-giver and energy-receiver, and could include both monetary and non-monetary

benefits. Some empirical evidence on mutual energy exchanges is visible in the academic literature on off-grid solar-lighting projects in ‘developing’ countries (see, e.g., [28–32]). This literature reports on an interesting setup that enables some types of mutual energy exchanges: in an off-grid village where a solar powered centralized charging location charges mobile phones and batteries of other villagers who do not have access to an energy source ([28–32]). This article is based on a similar setup in rural India. Ulsrud et al. [29] note that research on centralized charging systems have been limited to techno-economic perspectives and they have called for greater focus on sociocultural dimensions. In general, such energy systems and rental models have been investigated on a range of issues such as sustainability, energy access, financial viability and scalability, energy poverty alleviation, socio-technical change, development, governance and rural electrification (see, e.g., [28,29,31–36]). All these issues are vital; however, there is another dimension of exchange (of energy) that requires research attention, i.e. how such energy exchanges with the local community are socially and culturally embedded.

This study<sup>7</sup> started with an installation of a small-scale and off-grid energy distribution infrastructure to enable exchanges of solar-lighting in a village in India. The infrastructure was installed at a volunteering household in the village, and the household was given complete control to manage the energy distribution. The installation enabled us to conduct an ethnographic inquiry to address three key research questions: (a) how are social relations at work in energy exchanges between households? (b) what energy exchanges between households emerge with the use of the installation? (c) what values are invoked in the energy exchanges between the households?

Based on a comprehensive survey, Sovacool ([37][37]:26) states, ‘Energy production, distribution, and consumption all have both technical and human components...Energy analysis therefore needs to look beyond the dimensions of technology and economics to include these social and human elements’ and invites energy researchers to engage with anthropology and investigate cultural specific engagement of people with energy systems. The domain of economic anthropology is relevant for studying sociocultural dimensions of energy exchanges as it has highly developed scholarship on a broad range of exchange concepts such as gifting, barter, trading, and sharing (see, e.g., [38–40]). This article builds on theoretical works of an economic anthropologist, Stephen Gudeman, to conceptually discuss the mutual energy exchanges. This article brings attention to energy exchanges as a subject of inquiry. To our knowledge, energy exchanges between households have not yet been investigated from an economic anthropological perspective. The article introduces ‘circle of mutual energy exchange’ as a conceptual, analytical and descriptive unit for understanding the mutual energy exchanges. Based on ethnographic data analysis, the article describes two co-existing and dialectically connected modes of mutual energy exchanges: mutual energy sharing and mutually energy trading.

The remaining part of this article is organized as follows. Section 2 introduces the theoretical background of this article. Section 3 describes the field setting of the study. Section 4 presents the research design and methods utilized. Section 5 showcases the analysis of ethnographic data, and this is followed by an extended discussion and conclusion of the findings in Section 6.

## 2. Theoretical background

### 2.1. Dialectic in economy

Taking support from various ethnographic studies, economic anthropologist, Stephen Gudeman [27,41,42] argues that across cultures, people acquire and distribute goods and services using two dialectically

<sup>5</sup> <http://labl.teriin.org/>.

<sup>6</sup> <http://www.ruralspark.com/>.

<sup>7</sup> This study is part of a wider research where the authors are conducting similar research inquiry on energy exchanges in a Smart Energy System context in a western country.

connected strategies. The first one is described as ‘market realm’ of an economy where self-interest is exalted, in which Gudeman highlights how ‘in part, individuals live from the competitive trade of goods, services, and money that are separated or alienated from enduring relationships. People exchange with others to transform or substitute what they have for something else’ ([42][42]:4). Self-interest refers to an individual’s ability to focus on the personal gain by calculating a means to an end [27]. The second part of the dialectic is described as ‘mutual realm’ of an economy where ‘mutuality’ or social relations are paramount, where Gudeman argues that ‘people also live from goods and services that make, mediate, and maintain social relationships. Through mutuality or community things and services are secured and allocated, by means of continuing ties’ ([42][42]:5). As already mentioned in the Introduction of this article, mutuality refers to people’s ability to socially associate with others, form relationships and live life through these social ties [27]. Gudeman reasons that mutuality takes prominence in the household and community life of people, i.e. in a mutual realm of economy. He adds that mutuality is less visible but has a presence in market engagements of people, i.e. in a market realm of economy. Gudeman ([27][27]:10) indicates relevance of mutuality in a market realm when he writes, ‘economic transactions are contained within larger social commitments that they use and subvert, and are influenced by sociality on the small scale.’ Gudeman states that between the dialectic of mutuality and self-interest exists an innate tension that is fundamental to all economies. People secure their living by employing both the realms, but the significance of each side is dynamic, fluid and varies with time and contexts [27]. The dialectical connection highlights a unique feature of these two realms of an economy: each side depends on the other while at the same time they oppose, overlap and repel each other [27,41,42]. See Fig. 1.

This article builds upon the Gudeman’s conceptualization of dialectic in an economy and focuses on the mutual realm (household and community) of energy exchanges (see Fig. 2 for a classification of energy exchanges). The following sub-sections describe how the dialectic reflects in (a) exchanges (b) social relations, and (c) values.

## 2.2. Exchanges

Gudeman [41,42] informs that exchanges of goods and services in a mutual realm are different from a market realm. The principle mode of exchange in a market realm is trading [41,42]. In contrast, he describes exchanges in a mutual realm as ‘sharing’ [27,41,42]. He delineates sharing as a non-market process of allocation of tangible entities, such as resources and equipment, as well as intangibles, such as knowledge and skills to other ([27,41,42]). The significance of mutuality differentiates sharing from trading. Sharing creates mutuality [42] and is a process of ‘making and maintaining community’ ([41][41]:86). He criticizes market-centric of many economists for overlooking non-market exchanges, such as sharing [27]. Gudeman and other scholars forewarn that sharing should not be confused and conceptually limited to notions of generosity or altruism [27,43,44].

## 2.3. Social relations

Gudeman [27] states that a mutual realm consists of diverse types of social relations that could be based on kinship, ethnicity, religion, nationality or other ideas ([27]). These social relationships are dynamic, vary with time, change in their significance, some can be perpetual (such as kinship bonds), while others can be short-lived associations to tackle a common problem [42]. Gudeman explains differences between social relationships in the market and mutual realm as ‘the market realm revolves about short-term material relationships that are undertaken for the sake of achieving a project or securing a good. In the communal [or mutual] realm, material goods are exchanged through relationships kept for their own sake’ ([41][41]:10). The material life in the mutual realm is established and sustained through enduring social relationships [27].

## 2.4. Values

Gudeman describes mutual and market realms as two distinct ‘value contexts’ [41] or ‘value domains’ [27]. In the market realm, efficiency in distribution and rational choice takes prominence [42]. The exchanges in the market realm are valued for utility maximization and profit generation [41]. Here, the value is commensurable and is often measured against the scale of money [41,45]. A mutual realm comprises of heterogeneous values that are anchored and defined in local cultural contexts and social situations [41,42]. He describes a mutual realm as consisting of diverse values that are not measurable and are incommensurable ([41,42]).

## 3. The field site

This article is based on field research conducted at Rampur<sup>8</sup> (RP) village, an un-electrified village, located in Bodhgaya block, Gaya district of Bihar state in India. Bihar is a federal state located in eastern part of India with a large rural population. For decades, the state struggled with poor public infrastructure, high corruption levels, and violent insurgency by the extreme-left Naxalite movement [46,47]. Since the first decade of the twenty-first century, the state has made noticeable progress on many of these fronts, but still, a lot of ground is yet to be covered. Gaya is the fifth largest district of Bihar with a population of 4.39 million persons [48].

Rampur is around 15 km away from the city center of Gaya and comprises of around 200 households. A joint family group residing within a house is very common in Rampur. Such joint family group consists of patrilineal kin, i.e. membership of the group is based on patrilineal descent. The rule of residence is patrilocal, i.e. after marriage, the wife leaves her family and goes to live with her husband and his patrilineal kin. This prevalence of patrilocality makes her very dependent on acceptance or goodwill of her in-laws. All the inhabitants of Rampur are Hindu by religion. The caste hierarchy is an important aspect of Indian social structure and plays a significant role in everyday life of Rampur. Manjhi, Ravidas, and Yadav caste groups form the majority of the population in Rampur. Manjhi and Ravidas caste groups belong to the lowest caste. As a socio-political unit, they both define themselves as ‘Dalit’ (‘oppressed’) highlighting the social discrimination they have suffered due to untouchability practiced by non-Dalit castes. Recognizing them as a historically disadvantaged group, they are listed in the ‘Scheduled Caste’ (SC) category of the Indian Constitution. Manjhis are the economically poorest group in Rampur. The Manjhi and Ravidas households do not own any agricultural land. In contrast to the Manjhi and Ravidas caste groups, Yadav is a non-Dalit caste and hold a higher caste status as landowners and peasants.

Rampur does not receive any electricity supply from the centralized

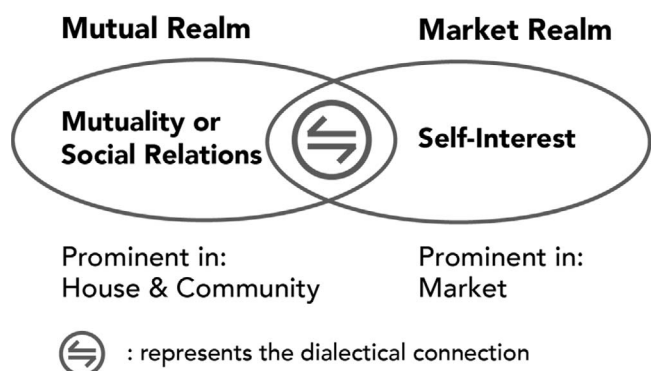


Fig. 1. Dialectic in economy based on Gudeman [27,41,42].

<sup>8</sup> Name of the village and key informants have been changed in this article for the purpose of anonymity.

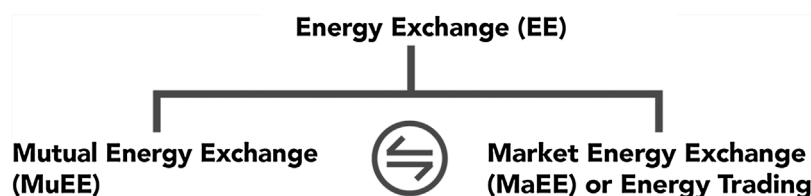


Fig. 2. A classification of energy exchange.

**Table 1**  
Key Components of Off-Grid Energy Distribution Infrastructure for Solar Lighting.

Item	Quantity	Comments
Power Banks	14	These portable power banks provide 5Volts Direct Current (DC) current output to two Universal Serial Bus (USB) ports, which can be used to power a LED light (below) and/or charge a mobile phone. Each power bank was assigned a unique three digits numeric code with the first digit of '1' (e.g., 100, 101, 102...).
LED Bulbs	14	These are bulb shaped 3W LED lights that work only when connected to the power banks as these lights do not have battery components. Each LED Bulb was given a unique three digits numeric code with the first digit of '2' (e.g., 200, 201, 202...).
Solar Lanterns	19	These are rechargeable LED lights. The difference between a LED bulb (above) and the solar lantern is that a solar lantern is fitted with a battery and hence does not require connection with power bank to function. Each Solar Lantern was given a unique three digits numeric code with the first digit of '3' (e.g., 300, 301, 302...).
Solar Panel (75 W)	1	To charge the solar lanterns and the power banks.
Energy Routers	2	An interface between the solar panel and the chargeable items (solar lanterns and power banks).

electricity grid. As per Indian Government's Rural Electrification Corporation's (REC) data<sup>9</sup> of February 2017, in Gaya district, there are only 35.01% of rural households that are electrified with 1707 villages that electrified less than 50%. The villagers rely on Kerosene oil for various purposes: it is used in a traditional lamp (*dhibri*) as a primary source for lighting; it is also utilized for burning woods, cow-dung cakes, and twigs for cooking. Thirty households report having small solar panels (4 W–40 W) installed. Out of this total, fourteen solar panels belong to Ravidas households, four panels to Manjhi households, and ten panels to Yadav households. All of these solar panels are 'privately' owned by the households. These solar panels are used primarily for basic home lighting and are used to power CFL bulbs mounted on walls in households. Other uses of solar panels are charging of mobile phones and to power small music players. Some forms of energy exchanges using the existing solar installations can already be observed in the village. For instance, a person from a household without solar panel charges his/her mobile phone at a neighboring household. On most occasions, this 'informal' service is offered for 'free,' but in some extreme cases householders report to ask for a 'charging fee.' The villagers highly value lighting and cell phone charging practices. Many ubiquitous devices visible in urban Gaya such as television sets and electric fans are absent from the landscape of Rampur. Rampur is close to various retail and wholesale marketplaces. Market-based trading, i.e. buying-selling of goods are part of an everyday experience for the villagers. The village also hosts a few shops that sell small items for daily use.

#### 4. Research design and methods

This inter-disciplinary research combines ethnography with design research activities [49] and is situated in the emerging field of "design anthropology"<sup>10</sup>; [50]. The research approach consists of an 'intervention' where a technical infrastructure is introduced into a social space as a precursor to an ethnographic investigation on people's use of the infrastructure. This technique also appears in literature as 'ethnography by design' [51] and 'research-through-design' [52]. The first author of this article was the ethnographer in the field research. A solar

energy expert, who has been working in the villages of Gaya for past four years, volunteered in the field-study as a research assistant.

##### 4.1. 'Intervention'

The overall aim of the 'intervention' was to enable a research setup for ethnographic investigation. The field engagement started with visits to many un-electrified villages in the Gaya district. Rampur was selected as the field-site as it fulfilled the following pre-identified criteria: (a) RP was un-electrified; (b) the villagers had experience with solar technology and desired better solar lighting solutions; (c) RP had a heterogeneous mix of population belonging to different castes; (d) physical access to RP was not too difficult; (e) it was feasible for the ethnographer to stay in the village for extended period; and (f) a household in the village was willing to volunteer as a 'giver'<sup>11</sup>; for the study and had formed a rapport with the ethnographer that made collecting rich ethnographic data possible. The 'intervention' comprised of an installation of a small-scale energy distribution infrastructure consisting of solar lanterns, power-banks, LED bulbs, solar panel, and energy routers at the household of the giver (see Table 1 and Fig. 3). This infrastructure facilitated exchanges of 'solar items', i.e. solar lanterns, LED bulbs and power banks, in the village. Each solar item was imprinted with a unique numeric code to facilitate tracking of energy exchanges (see Table 1). In total, thirty-three solar items, i.e. fourteen LED bulbs with power banks and nineteen solar lanterns were available for use and exchange. The total cost of the energy distribution infrastructure was 40,000 Indian Rupees (INR) (around 560€). Some of the key criteria for selecting a giver for this study were: (a) skills, experience and comfort with managing solar-based equipment; (b) social relations with different castes at RP; (c) ability to write and maintain records (necessary for self-reporting diary, see 4.2.2); (d) willingness and motivation to become the giver; and (e) possibility and ease of communication with the ethnographer.

A strategic decision for the research setup was to provide the giver ownership and complete control of the energy distribution infrastructure but without asking the giver to make a financial payment for the infrastructure. By setting up the 'intervention' like this, the authors felt it will provide most room for the giver to act according to their

<sup>9</sup> <http://garv.gov.in/garv2/dashboard/main>.

<sup>10</sup> The authors of this article come from diverse backgrounds of design research, economic anthropology, and energy-technology research.

<sup>11</sup> To be concise, the authors use the word 'giver' to refer to 'energy-giver.' Similarly, a household who received a solar item from the 'giver' is referred to as a 'receiver'.

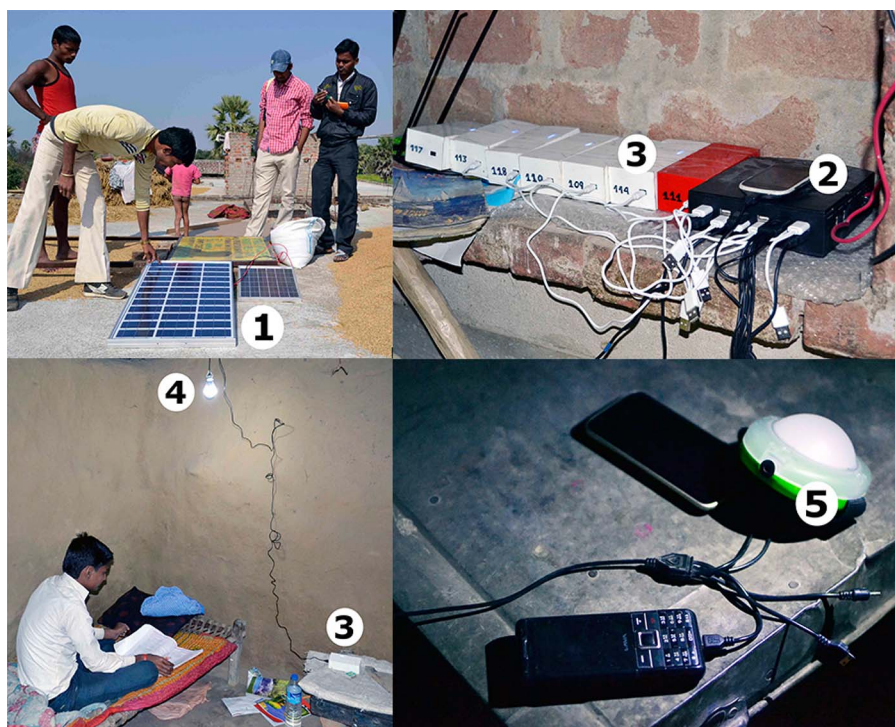


Fig. 3. Energy Distribution Infrastructure. Note the labels: '1': Solar Panel; '2': Energy Router; '3': Power banks; '4': LED Bulb; '5': Solar Lantern.

social, cultural, moral, and ethical values without the pressure of making the setup financially sustainable. As this research focused on investigating the underlying social, cultural and moral logic of energy exchanges that emerged, not asking for payment for the infrastructure was a crucial choice. Even though readers of this article may consider this choice as a bias or limitation of the study, it gave the ethnographer a better understanding of the underlying logic of the energy exchanges. It is typical for village-level centralized charging setups for rural lighting/electrification that the cost of installation is paid by an 'external' agency (NGO, local governments) and the villagers only pay for the cost of operation and maintenance ([28,31,32]).

## 4.2. Ethnography

This research's engagement with ethnography comes close to O'Reilly ([53]:3) description of ethnography as, '*iterative-inductive research (that evolves in design through the study), drawing on a family of methods, involving direct and sustained contact with human agents, within the context of their daily lives (and cultures).*' Similarly, this research followed an iterative, emergent and explorative approach where the field observations shaped the research direction. To investigate social relations in energy exchanges, a research approach of 'personal network research,' which is a type of 'ethnographic network mapping' was adopted [54]. The 'personal network research' centers on 'index' or 'focal' individuals and explores their social network using a range of ethnographic methods.

### 4.2.1. Observations, interviews, and conversations

Following the 'installation,' the first author acquired a role of a participant observer. In this case 'participant observation' [55] consisted of direct and indirect observations by participation in the daily life of the villagers. The interviews and discussions ranged from semi-structured interviews [56], unstructured group discussions, casual chats and conversations [57] with villagers. When given consent by the informants, these interviews and conversations were audio recorded. Field-notes [58] were maintained throughout the field study. The field-study also included discussions with renewable energy officials working in Gaya.

### 4.2.2. Self-reporting diary

A self-reporting diary was provided to the giver to document information about each energy exchange. See Fig. 4 for the various attributes documented. The diaries are considered beneficial for triangulation [59,60]. The diary entries were discussed and cross-checked during interviews with the giver and receiver.

## 4.3. Qualitative data analysis

The ethnographic field study was accompanied by an in-depth qualitative data analysis of the field-notes, diary entries, and interview transcripts. NVivo,<sup>12</sup> a qualitative data analysis software, was used for in-depth exploration of the data. The overall approach for data analysis consisted of iterative cycles of coding, 'memoing' and creating thematic texts<sup>13</sup> [58,61]. Coding is relevant for summarizing, reducing and condensing the data [61]. 'Memoing' captures the analytical reflection, emergent categories, and themes from the data analysis [58,61,62]. The emergent findings were discussed with the co-authors and crosschecked with the villagers.<sup>14</sup>

## 5. Analysis of ethnographic data

### 5.1. Start of ethnography

The ethnography started with two visits to RP to identify and select a potential household to be the giver for this research. This task consisted of the ethnographer visiting eight households in RP belonging to different castes and trying to gauge the suitability of the households to become a giver for the study. The ethnographer's initial approach was to identify a Manjhi household to be the giver as they belong to the

<sup>12</sup> <http://www.qsrinternational.com/what-is-nvivo>.

<sup>13</sup> The coding, 'memoing' and thematic text creation were conducted by the first author.

<sup>14</sup> After leaving the field in March 2016, the first author has maintained telephonic contact with the villagers and the research assistant. Since April, the research assistant visited Rampur once in a month to follow-up on the developments and capture photographs of the diary entries.

नाम	दिनांक	वितरण	आवृत्ति	आवृत्ति	आवृत्ति	आवृत्ति	आवृत्ति	आवृत्ति	आवृत्ति
आमरी देवी	11/2	5:30							
शोनी देवी	11/2	5:30							
कुली देवी	11/2	5:30							
अनला देवी	11/2	5:30							
शोनी देवी	11/2	5:30							
शोनी देवी	11/2	5:30							
शोनी देवी	11/2	5:30							
शोनी देवी	11/2	5:30							
शोनी देवी	11/2	5:30							

Fig. 4. A sample of diary entry documenting exchanges of lights on 19-Feb-2016. Please note the labels for information documented: 1: 'date'; 2: 'distribution'; 3: 'return'; 4: 'name'; 5: 'item-code'; 6: 'time'; 7: 'social use'; 8: 'rent'; 9: 'any comment'; 10: 'signature'.

lowest in caste and class hierarchy. The ethnographer had shortlisted two Manjhi households for the role of giver, but both of the households declined. The ethnographer realized that his identity of an upper caste, educated, male and 'outsider' to the village had created doubts among Manjhi and Ravidas households. Eventually, the ethnographer selected Nita Yadav, and she agreed, to be the giver for this study. Nita, a female in her mid-forties, belongs to Yadav caste. Nita's nuclear family consists of her son (Ranjan), daughter and husband (C-Yadav<sup>15</sup>). Nita was selected to be the giver because of the following key reasons. First, Nita volunteers as a community-mobilizer for a village-level woman Self-Help-Group (SHG). This work requires her to engage with households belonging to all castes regularly. Second, she maintains written records for the SHG. Hence, she was experienced and comfortable with record keeping and documentation required for the use of the self-reporting diary. Third, Nita and her family members were experienced with the solar technology as they have been using a solar home lighting kit. They demonstrated proficiency in performing various simple tasks, such as charging of solar items, for the operation of the energy distribution infrastructure. Fourth, Nita was enthusiastic and willing to be the giver. Fifth, Nita lives near various families of her in-laws (details in Sections 5.4 and 5.5). This situation provided an opportunity for understanding the influence of social relations based on kinship and gender role (of daughter-in-law) on energy exchanges. Sixth, the ethnographer was able to quickly form a rapport with Nita, her son, father-in-law, and brother-in-law. They let the ethnographer participate and observe their everyday life and were comfortable in sharing intricate details of their social relations. This facilitated 'rich' ethnographic data collection for the study.

Other relevant information for this 'intervention' concerns Nita's economic condition: Nita's husband (C-Yadav) works small day jobs in a distant city and returns to Rampur for a couple of months per year. Nita's husband sends back five thousand Indian rupees (around seventy euros) every month for the family's sustenance. The money barely covers the family's expenses, and Nita narrates how her nuclear family struggles to deal with perils of economic poverty on a regular basis. The difficult economic condition of her nuclear family made her serious and sincere towards the use of the energy distribution infrastructure provided. She stated that the installation would fetch her desirable financial benefits to supplement her family's income.

On 1 February 2016, the energy distribution infrastructure was installed at Nita's household. As part of the 'intervention' a formal contract was signed that made Nita the owner of the infrastructure. It was communicated and established that Nita can decide to use the infrastructure in whichever way she feels appropriate. She can decide whom to give or not give a solar item, keep the solar items for herself or her nuclear family, give these items for free or rent, and in any way she

deemed appropriate. It was clarified that there is no right or wrong way to exchange the solar items. A restriction placed as per the contract was that she cannot sell any of the equipment for the next six months. It was also specified that any maintenance or repair of the infrastructure is the responsibility of Nita and the 'intervention' will not cover these costs. Nita and her nuclear family took pride in being selected to be the giver for the entire village. She appreciated that she had been given control and made 'owner' of the infrastructure. It is important to state that Nita and her household did not consider that the infrastructure provided to them as given for free. They considered that operating the setup, maintaining daily records of exchange, and taking responsibility for the maintenance and repair required considerable effort from their end. They considered this effort to be an appropriate 'return' for the infrastructure provided to them. Throughout the study, Nita behaved as the owner of the setup even though she did not make a financial payment or investment to acquire the infrastructure. Nita and her son determined every aspect of the energy exchanges and the ethnographer refrained from any involvement in structuring the energy exchanges.

Immediately after the installation, Nita's house was visited by a large number of villagers enquiring about and requesting the solar items. The villagers were aware of various benefits of solar lights. It is worthwhile to note that the demand for solar items at Rampur was much more than the possible supply, i.e. thirty-three solar-items with Nita. Hence, Nita had to strategize and choose receivers amongst the households asking for the solar-items. Within a couple of days, most of the solar items were already in circulation. A common cycle for this circulation was: a receiver took a charged solar item, used the item for few days in the house, brought back the discharged item for charging, and once the item was re-charged the item was taken back for use. Nita and her son decided to allocate each solar item in circulation to a particular receiver so that they could identify misuse of the solar items. They decided that the receivers would be asked to pay rent based on the number of charging done and hence keeping account of charging became crucial for them. Initially, Nita had decided that the rent for each charging of a solar item would be five rupees. Most of the receivers found this amount to be high and started negotiating with Nita and her family. Finally, Nita and the receivers mutually agreed at three rupees as the rent for each charging. Nita and her son created a 'charging rule,' i.e. the receivers should always charge the discharged solar items at Nita's household. The charging rule was created to stop receivers from charging discharged solar items at other locations in Rampur. Nita's family constructed a social sanction for violation of the charging rule, i.e. the energy exchanges with the violating receiver would be temporarily paused or entirely terminated. Overall, twenty-six unique households became receivers over the period of this study. Five hundred and two energy exchanges were documented in the self-reporting diary during this period.

## 5.2. 'Mutual energy sharing' and 'mutual energy trading'

The ethnographic data analysis reveals two types of mutual energy exchanges: 'mutual energy sharing' and 'mutual energy trading'. The

<sup>15</sup> Three key informants in this research, Nita Yadav, Ranjan Yadav (Nita's son), and Mahesh Yadav (Nita's father-in-law), are referred by full names. These names have been changed for the purpose of anonymity. All the other actors in this research are referred with scheme of 'Initial-Surname' such as, 'C-Yadav'. The surname indicates the caste identity of the person.

Fig. 5. Mutual energy sharing and mutual energy trading as two types of mutual energy exchanges.

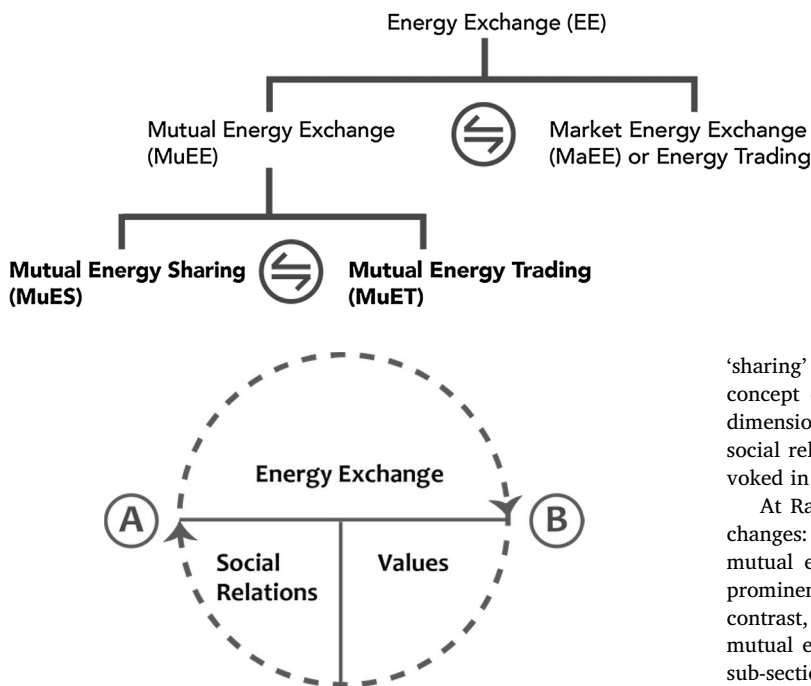


Fig. 6. A visual representation of a circle of mutual energy exchange where 'A' is an 'energy-giver' and 'B' is an 'energy-receiver'.

authors define mutual energy sharing as a social and personal energy exchange where an energy-giver and energy-receiver participate for the sake of social relationship between them. In contrast, mutual energy trading is a social and personal energy exchange where an energy-giver and energy-receiver participate in a calculated exchange for the sake of a commensurate material or monetary gain. The mutual energy trading is distinct from energy trading because it is active in a mutual realm of economy (home and community) in contrast with energy-trading which is operational in a market realm. See Fig. 5.

### 5.3. Circle of mutual energy exchange

The authors define a 'circle of mutual energy exchange' as a conceptual arena for social construction of a mutual energy exchange, which is modeled by social relations between energy-giver and energy-receiver, and is constituted by diverse social and cultural values. See Fig. 6. The word 'circle' is used to highlight the notion of '[circle as] the area within which something acts, exerts influence' (dictionary.com). A giver and a receiver can implicitly or explicitly compose these circles of mutual energy exchange. This concept is a result of the data analysis and connects with Gudeman's theoretical work on the dialectic of

'sharing' and 'trading' as described in Section 2 of this article. The concept of the circle of mutual energy exchange incorporates three dimensions: (a) the energy exchange between a giver and receiver, (b) social relation between the giver and receiver, and (c) and values invoked in these exchanges.

At Rampur, this study identified five circles of mutual energy exchanges: two circles of mutual energy sharing and three circles of mutual energy trading. A circle of mutual energy sharing indicates prominence of mutual energy sharing as a mode of energy exchange. In contrast, a circle of mutual energy trading indicates a preference for mutual energy trading as a mode of energy exchange. The following sub-sections present these five circles of mutual energy exchange. See Table 2 for a summary of these circles.

### 5.4. Circle of mutual energy sharing within the joint family group

#### 5.4.1. Energy exchanges

This case of energy exchanges within Nita's joint family group belongs to a circle of mutual energy sharing. Nita lives in a house comprising of a joint family group made of four nuclear families. These families are bound by patrilineal links with Nita's father-in-law (Mahesh Yadav). The four nuclear families are of Mahesh and his three married sons: C-Yadav (Nita's husband), J-Yadav and M-Yadav (Nita's brothers-in-law). All the adult members, except J-Yadav and J-Yadav's wife, of the joint family group each received a solar item each. Nita explained that she willingly gave solar items to everyone to avoid piquing anyone in the family. When probed further, she answered with a rhetorical question, 'if I had not given these to the family members, would I be able to [happily] stay in the house?' Nita considered it inappropriate and immoral to consider monetary rent for sharing within the joint family group. Nita did not specify or mention any monetary rent for these receivers. Similarly, receivers did not offer or pay any rent. She firmly stated that if someone from her joint family group offered her money for the solar items, she would straight away refuse it. Any benefits, if at all, were in the form of intangible and immeasurable entities, which were neither numerically calculated nor asked for. For

Table 2  
Summary of five different Circles of Mutual Energy Exchanges in the mutual realm at Rampur.

Circles of Mutual Energy Exchanges			
Case	Energy Exchanges	Social Relations	Values
Circle 1: Energy Exchanges with the Joint Family Group	<b>Mutual Energy Sharing</b> , Monetary rent not desired, intangible and immeasurable benefits	<b>Daughter-in-law and Joint Family Group</b>	Maintaining social relations, Cordiality, Moral obligations of a daughter-in-law
Circle 2: Energy Exchanges with Gotiya (Local Patrilineage)	<b>Mutual Energy Sharing</b> , 'In-kind' gestures, Immediate rent payment in cash not desired	<b>Daughter-in-law and gotiya</b>	Maintaining social relations, Avoiding conflicts, Profit inappropriate, Moral obligations of a daughter-in-law
Circle 3: Energy Exchanges with Non-Dalit Households	<b>Mutual Energy Trading</b> , Commensurate monetary rent desired	<b>Co-inhabitants of the village, Non-Kins</b>	Monetary earnings, Embedded in changes in socio-economic life
Circle 4: Energy Exchanges with Ravidas Households	<b>Mutual Energy Trading</b> , Commensurate daily rent desired	<b>Co-dependent patron-client, Yadav (non-Dalit) – Ravidas (Dalit)</b>	Monetary earnings, Consideration for co-dependency and prior social relations
Circle 5: Energy Exchanges with Manjhi Households	<b>Mutual Energy Trading</b> , Commensurate monetary rent desired, 'In-kind' returns (possible)	<b>Yadav (non-Dalit) – Manjhi (Dalit), Cultivator-labour</b>	Monetary earnings, Fear of financial debt embedded in the history of caste relations

instance, Nita spoke of gaining the social support of her joint family group as one benefit of sharing of solar items. This support is useful in case of a dispute with any other household in the village, especially considering the extended periods of absence of her husband from the household.

#### 5.4.2. Social relations

In this case, Nita's obligations as a daughter-in-law of, and social differences within, the joint family group shaped the energy exchanges. Nita's joint family group is dealing with social disputes and tensions between the nuclear families. C-Yadav and J-Yadav have a bitter relationship with each other. Recently, J-Yadav bought the house from Mahesh and had asked Nita's nuclear family to vacate the house. Nita explains that for the time-being she has negotiated her family's stay in the house, but eventually she would have to build a house on a nearby plot of land within RP, which will be a substantial economic investment for her nuclear family. Despite these social differences, Nita has moral obligations as a daughter-in-law within this patrilineal and patrilocal social setup. These obligations include the sharing of things and resources that are also needed or desired by others in the joint family group. A relevant observation was that Nita on few occasions offered to give a solar item to J-Yadav's wife (Nita's sister-in-law), but she refused to accept the light. By offering to share lights, Nita attempted to mend her social relations with her sister-in-law and negotiate more time for her family's stay in the house. By refusing the offer, J-Yadav's wife avoided getting into an energy exchange relationship with Nita and in consequence any resulting social obligation and niceties towards Nita's nuclear family.

#### 5.4.3. Values

In this circle of mutual energy sharing with the joint family group, the values invoked were of maintaining social relations, and cordiality within the joint family group. These energy exchanges were performed for the sake social relations and not for making any monetary benefit. The local cultural values, as seen in Nita's moral obligations for her joint-family group of which she is a member by 'law' (marriage) not by 'blood' (birth), were invoked in these energy exchanges.

### 5.5. Circle of mutual energy sharing with the Gotiya (local patrilineage)

#### 5.5.1. Energy exchanges

This case covers mutual energy sharing exchanges between Nita and six households belonging to Mahesh's (Nita's father-in-law's) *gotiya*. '*Gotiya*,' a Hindi word, refers to a local patrilineage of a person. In this case, the *gotiya* consists of households of Mahesh's four brothers and two cousins. All the households belonging to the *gotiya* received a solar item each from Nita. Some of these families requested her, while others demanded her, to provide the lights. She spoke of the difficulty in ignoring these calls, '*how could I refuse giving lights to them? People will start quarreling with me. After all, they are part of the gotiya. Everyone needs this light.*' She and her family members reasoned that immediate and calculated rent payment in cash resembles '*buying and selling from a shop*' and wish to avoid such exchanges with the *gotiya*. Nita did state the rent of three rupees for each charging of a solar item to the *gotiya* but was reluctant and cautious to enforce it. She later clarified that the *gotiya* supported her with in-kinds gestures and also with monetary returns acknowledging the energy exchanges and her efforts involved in the operation of the installation. Of the six households in this case: one household provided Nita access to their tractor for work on her agricultural land, and another family irrigated her field with the use of their diesel irrigation pump. Three other households paid the rent in-cash at the end of each month, and one of the remaining households did not provide any cash or in-kind return for the exchanges. A subtle yet important observation is that both the giver and receivers did not view and structure these as tit-for-tat exchanges. Any precise monetary calculations and commensurations were avoided.

#### 5.5.2. Social relations

In the patrilocal and patrilineal setup of Rampur, Nita is also considered a daughter-in-law of the *gotiya*. She is dependent on the *gotiya* for various aspects of her social identity and acceptance, as well as for her family's sustenance. Her role as a daughter-in-law and associated (social) power relationship were at the fore in the energy exchanges. She had to sensitively deal with these energy exchanges as they had a potential to impact her social relations with the *gotiya*. In this regard, an unexpected and illustrative event happened at the end of March. Nita facing an urgent economic crisis asked a *gotiya* household, which had not provided any cash or in-kind return, for some financial support. When the household refused her request, she claimed the financial support as a return for the solar item she had been regularly providing them. The household was aggravated by her claim and interpreted this as a culturally inappropriate act to earn a profit from *gotiya*. Ultimately, the household did not make any monetary payment and stopped receiving solar items from Nita. The household's relationship with Nita had been strained since then. She mentioned that her relation with the household before the 'intervention' had also gone through many ups and downs. She and other villagers informed that such tensions with members of *gotiya* are common and were part of the everyday life of an in-marriage female living in a patrilocal setup.

#### 5.5.3. Values

In this circle of mutual energy sharing with the *gotiya*, values of maintaining social relations and avoiding conflicts were of prime emphasis. In the local setting, an exchange with a member of *gotiya* to make a profit is viewed as culturally inappropriate. Nita distributed the solar items neither to maximize monetary profit nor out of altruistic feelings for others but due to obligations as a daughter-in-law in her unequal power relation with the *gotiya*. As in the case of the joint family group, these exchanges were primarily for the sake of social relations and not to make a commensurate material gain.

### 5.6. Circle of mutual energy trading with non-Dalit households

#### 5.6.1. Energy exchanges

This case comprises of mutual energy trading exchanges between Nita and eight households of non-Dalit castes, six Yadav, one Teli and one Brahmin. These eight households are non-kins, i.e. they do not belong to Nita's father-in-law's patrilineage. Nita began giving solar items to most of the households in this group obliging to their repeated requests. She firmly stated that acquiring monetary benefits was the main aim of these exchanges. In contrast to the previous two cases, in this case, Nita was very vocal, precise and calculative about commensurate monetary rent each receiver was required to pay. Nita relentlessly pursued monetary benefits, and the receivers responded with lengthy negotiations in an attempt to avoid rental payment altogether. Eventually, the rent for this group was also established at three rupees for each charging of a solar item. By the end of February 2016, seven of the receivers complied and made the rental payments. However, by the end of April 2016, Nita terminated exchanges with three receivers as they stopped paying rent. Overall, Nita found energy exchanges with these receivers to be inconvenient as the receivers were irregular in making rental payments and she had to put considerable effort to collect the dues.

#### 5.6.2. Social relations

Nita described her social relation with these receivers as of co-inhabitants of the village, and she often referred to them with a phrase such as '*fellow village men.*' This aspect of her social relation with these receivers framed the energy exchanges. She provided the solar items only to those receivers with whom she and her family had a prior social relation. These relationships comprised of cohesive notions of co-operation, cordiality, and co-existence as well as feelings of competition, hostility, and jealousy. They often comparatively and

competitively described each other by referring to accumulated material wealth of households such as land-holdings. In this regard, a fascinating play of social relations was observed. The non-kin Yadavs tried to invoke their caste affinity with Nita (also a Yadav) to get a waiver from rent payment. Nita disregarded her caste affiliation with the non-kin Yadavs and continued to pursue monetary rent.

### 5.6.3. Values

In this circle of mutual energy trading with non-Dalit households, the value of monetary earnings became an overarching purpose. The values invoked are embedded in changes in the socio-economic life of Rampur. The villagers reported that monetary exchange between non-kin and from the same caste have become common and morally acceptable over the past few decades. For instance, it is now a common practice for a villager to rent a tractor or a diesel pump set from a fellow villager of the same caste. In contrast to the previous two cases, here it was not immoral to speak and aim for making a material benefit and profit.

## 5.7. Circle of mutual energy trading with Ravidas households

### 5.7.1. Energy exchanges

This case of energy exchanges between Nita's family and nine Ravidas households belong to a circle of mutual energy trading. Ravidas are Dalits and have the lowest caste status at Rampur. Right from the start of the study, Nita overtly demonstrated her interest in providing solar items to Ravidas households. Her interest also explains the increase in the number of Ravidas receivers from seven at the start to nine receivers by the end of March 2016. She personally invited five of these households to receive the solar items. As in the previous case, she specified that gaining monetary benefits was the main aim of these exchanges. Initially, Nita had decided that the rent for each charging of a solar item would be five rupees. The Ravidas receivers found this amount to be high and started negotiating with Nita and her family. Finally, they mutually agreed at three rupees as the rent for each charging, and all the households regularly made the payments.

### 5.7.2. Social relations

These energy exchanges are embedded in Nita's co-dependent patron-client relation with the Ravidas households and her higher caste status. Nita describes these Ravidas householders are skillful as they demonstrate a range of proficiencies such as masonry, carpentry, and

Surprisingly, she voiced exchanges with Ravidas as more desirable than exchanges with non-kin Yadav indicating her preference to maintain a functional co-dependency with Ravidas over her caste affinity with non-kin Yadav.

### 5.7.3. Values

In this circle of mutual energy trading with Ravidas households, value emphasized was of monetary earnings but with consideration for co-dependency and prior social relations. This value is also signified in Nita's act of reducing the rent even though the local demand for the lights was high. She could have remained firm at the higher rent and found other receivers who were willing to pay the higher rent. As in the previous case, here as well it was morally acceptable to voice and pursue monetary gains.

## 5.8. Circle of mutual energy trading with Manjhi households

### 5.8.1. Energy exchanges

This case of energy exchanges between Nita's family and two Manjhi households belong to a circle of mutual energy trading. Manjhis are Dalit, have the lowest caste status, and are the economically poorest at Rampur. At the start of this study, Nita estimated a high number of Manjhi households would become the receivers. This estimate was far from the reality that followed. Only two households of P-Manjhi and D-Manjhi, whom Nita personally invited, reluctantly became receivers. The rent for this group was three rupees for each charging of a solar item. Nita realized that it is hard for Manjhis to make rental payment in cash due to their poor economic condition. She strategized 'in-kinds' rent payment such as through commensurate amount of work in her agricultural field. D-Manjhi's family appreciated Nita's offer of in-kind payment, but they eventually paid the rent in cash for the duration of this study. In contrast, the exchange with P-Manjhi illustrated tensions in these energy exchanges. After paying monetary rent on a couple of occasions, P-Manjhi stopped bringing the solar lantern for charging to Nita's place fearing accumulation of financial debt. P-Manjhi's family found a way to charge the solar lantern at another Manjhi household. Nita realized that the exchanges with P-Manjhi would not fetch her financial gain unless the 'charging rule' is diligently followed. Eventually, Nita terminated energy exchanges with P-Manjhi. A conversation between Nita's family and wife of P-Manjhi followed:

P-Manjhi's wife [in an angry tone]: '[You] took the light away.'

Nita: 'It is not about the light. You can take the light back right now, but you have to charge here.'

Ranjan: 'You have to give money'

P-Manjhi's wife stated that a rent of three rupees is beyond her means and remained silent on making payment in-kinds. She added:

'You are earning from us. If you add the money due and the interest, then what will we do, give our house to you'

agricultural tool making. At RP, there is a high rate of economic migration of 'working age' Ravidas men to work in the big cities of India. This migration has improved their economic class in the village. Nita's family is dependent on Ravidas for a variety of services where she paid them monetary wages. A co-dependent patron-client relationship between a Yadav (patron) and a Ravidas (client) is typical. These energy exchanges were an extension of this co-dependency and were facilitated by trust between the giver and Ravidas receivers. Nita found Ravidas easy to negotiate with. She reported that Ravidas households usually oblige to her requests. Her higher caste status was at work here.

### 5.8.2. Social relations

These energy exchanges are dominated by the history of social relations with the two Manjhis households and Nita's caste identity of a Yadav. Manjhi men and women work as agricultural laborers who are hired for daily wages by Yadav landowners and cultivators at Rampur. Over the years, the wives of P-Manjhi and D-Manjhi have worked in Nita's fields for various tasks, such as husking of wheat. For their labor, Nita either paid them a wage or a commensurate amount of food grains. She stated that these families agree to her work requests, and this was one of the key reasons for offering them solar items. A startling

observation was that even though Manjhi households desired the solar items, they were unwilling to request for these from Nita. Some Manjhi households added that even if Nita offered a solar item, they would firmly refuse it.

Many Manjhis feared to get into an exchange relationship with Nita's family and were mistrustful of Yadavs in general. Manjhis saw these exchanges as part of the history of caste relations with Yadav, who have held considerable social and economic power over them.

### 5.8.3. Values

In this circle of mutual energy trading with Manjhi households, the value of monetary earning was predominant for Nita but with consideration for their economic conditions. This value was highlighted in Nita's offer of 'in-kinds' rent payment. In contrast, Manjhis valued independence from Yadav. Overall, the fear of financial debt and mistrust embedded in the history of caste relations between Manjhis and Yadavs proved detrimental to mutual energy trading.

### 5.9. Use and status of solar items

The ethnographic account in this article primarily focuses on the energy exchanges between the giver and receiver and little on how the villagers used the solar items. However, a few key points about the use of solar items and how these items are differentiated from other commodities are briefly provided here as it explains their role in energy exchange. A majority of the existing solar home installations in RP consisted of lights mounted on a wall and hence the lights were fixed to a location. The solar items provided as part of the 'intervention' were desired because of their portability, quality and aesthetics of the light emitted. Most common uses of the solar items were: for villagers' work and mobility in the field after sunset; for studying as a replacement of oil-based lamps, which were considered unsafe; and for illuminating cooking places. Some creative uses of solar items were also observed over the course of this study. For instance, some evenings Nita's father-in-law mounted the LED bulb from the terrace of his house to light a public space where he and other seniors of the village gathered to talk. He described this setup as a 'streetlight' and took pride in asserting his house as the only building in RP with a 'streetlight.' Overall, the solar items facilitated these range of practices that in turn shaped the "demand" for these items and hence contributed to the energy exchanges.

The ethnographer also observed exchanges of other everyday items at RP. These observations revealed how the villagers differentiated the solar items from other commodities. Nita and other Yadavs refuse to accept water, milk, any form of cooked food, uncooked food grains (rice, wheat, lentils) and other food items (cooking oil, salt, sugar) from any Dalit (Ravidas and Manjhi) household, although vice-versa is performed. Deeply rooted cultural notions of purity, hygiene, and caste bind exchange decisions of these items. However, there is also a category of commodities that villagers describe as 'machines' such as agricultural tools, bicycles, or mobile phones, which are more liberated from such cultural notions. The villagers placed the solar items and energy in this category. This placement explains why Nita did not have any cultural objection to receiving an 'un-charged' solar item from a Dalit household. Further, these observations clarify the differentiated status of energy as a commodity among other commodities that are exchanged in the village.

## 6. Discussion and conclusion

### 6.1. Energy exchanges

The ethnographic findings and conceptualization of mutual energy sharing are consistent with Gudeman's [27,41,42] description of 'sharing.' The authors suggest mutual energy sharing as a "complex social phenomenon" [63] that should not be construed as a tit-for-tat rational exchange. As demonstrated in cases of mutual energy sharing,

energy exchanges were performed for the sake of social relationships between the giver and receiver. The commensuration in a case of mutual energy sharing was inessential and imprecise. The benefits, if at all, for the giver were based on a tacit acknowledgment of the act of sharing by the receiver. In cases of mutual energy sharing, the giver shunned being a rational, self-interested, and calculative individual.

An interesting finding of this study is that a sharing based mode of energy exchange (mutual energy sharing) does not fill the entire spectrum of exchanges in a mutual realm, as Gudeman's works [27,41,42] seems to suggest. As the ethnographic results described, the mutual realm also contained a self-interested and calculative mode of exchange, which this article defines as mutual energy trading. The description of mutual energy trading is an extension of Gudeman's conceptualization of trading. Gudeman sees trading as a competitive, anonymous, and impersonal exchange limited to the market realm of an economy and governed by market principles. Whereas the findings of this study indicate a presence of a mutual energy trading, which is calculative, personal, social and mutually structured by an energy-giver and energy-receiver in the mutual realm. One of the key dimensions that distinguish mutual energy trading from mutual energy sharing is that while former is performed and strategized for the sake of material gain, the later is practiced for the sake of social relations. In cases of mutual energy trading, a negotiation with argumentation for the personal and material benefit was not problematic. The commensuration was essential and precise. An important point to note is that although the desire for material and monetary benefits dominates mutual energy trading, it conceals the mutuality that makes such exchanges possible. For instance, in all the cases of mutual energy trading reported in the ethnography, prior existing social relations such as co-dependency, work engagement, and associated trust formed a base for the mutual energy trading to take place.

As demonstrated by the ethnography, the two modes of mutual energy exchanges, i.e. mutual energy sharing and mutual energy trading, can be co-present. The authors view these two modes as conceptually distinct and dialectically conjoined to each other. It indicates a manifestation of a dialectical tension between mutuality and self-interest in the mutual realm. The dialectic of mutual energy sharing and mutual energy trading also implies that a householder can be self-interested and focus on mutuality simultaneously. Both sides of the dialectic were relevant and important for the giver. As demonstrated in cases of mutual energy sharing, mutuality or importance of social relations was at the foreground emphasizing morality, sociability, and sociality. On the other hand, mutual energy trading has self-interest at the forefront and accentuates calculations, strategizing for material benefits, profit, economic and rational thinking. The social gestures and other benefits of mutual energy sharing are incommensurable to the material returns from mutual energy trading. One may argue that the mutuality side of the dialectic is nothing more than another instance of self-interest. For long, similar arguments have been the cornerstones for debates between economics and economic anthropology [27,42]. Such an argument would rob mutual energy sharing of the critical and conceptual attention that it requires. Both of these modes of mutual energy exchanges are conceptually discrete and worthy of further research inquiries. Many studies fail to make a conceptual distinction between 'sharing' and 'trading' of energy and these either use these concepts interchangeably (see [9,18]) or at times 'sharing' is used when conceptually the authors imply 'trading' (see [11,12,16,19,20,64,65]). The authors encourage energy researchers to investigate mutual energy sharing and mutual energy trading in emerging contexts of local energy distribution initiatives across diverse social settings and contexts.

### 6.2. Social relations

The ethnographic findings described how different types of social relations influenced mutual energy exchanges at RP. In the case of Nita, the energy exchanges were embedded in varying dimensions of her

social relational identity of a daughter-in-law, a female and a Yadav. Kinship and caste defined types of social relations which had a strong influence on mutual energy exchanges at Rampur. The existing energy literature lacks attention to the role of kinship in energy exchanges. These results on the role of kinship and associated obligations seem to be consistent with that of Mehlwana [66] who reported kinship as a significant factor in inter-household exchanges of lighting fuel (kerosene) in low-income urban settings in South Africa. Some previous studies (e.g., [67–69]) have briefly suggested the relevance of kinship in a context of energy consumption in households, but these do not provide any ethnographic evidence for a role of kinship in energy exchanges.

Similarly, the role of caste in energy exchanges is left unexplored in the energy literature. The historic nature of caste relations and its potential impact on mutual energy exchanges had been particularly visible in case of energy exchanges with Manjhi receivers. In this case, the historicity explained the breakdown of mutual energy exchange as well as the unwillingness of Manjhis to get into an exchange relationship with the giver despite their desire and the need for the solar items. At the same instance, it is significant to note that this historic structural element such as caste is not static. Instead, this aspect of social relation is dynamic. This dynamic aspect of caste relations and its impact on mutual energy exchanges was visible in the case of energy exchanges with Ravidas receivers where historical caste barrier was transcended due to the emerging dynamics of co-dependency between the giver and Ravidas receivers. Hence, the authors' recommendation for energy researchers and practitioners is to understand mutual energy exchanges in connection with relational identities of people involved as well as to the dynamics of structural elements that shape these social relations.

### 6.3. Values

The ethnographic findings of this study demonstrate that the mutual energy exchanges at Rampur invoked diverse values. On the one hand, in the case of mutual energy sharing, values were beyond financial benefits or maximization of economic value; price calculations were not desired and even refused by the giver. Both the giver and receiver in the cases of mutual energy sharing considered it immoral, unethical and culturally inappropriate to use the measuring scale of money or aim to earn a profit. On the other hand, in the reported cases of mutual energy trading, financial benefits were sought for, a scale of money was utilized, and earning profit from others was considered morally appropriate and ethical. Hence, it appears, first, that the mutual energy exchanges are encapsulated in diverse moral, ethical, social and cultural values. The values invoked in the mutual energy exchanges are plural, varied in nature and emerges in the exchange. The values observed in these mutual energy exchanges transcend the dominant notions of economic rationality as suggested by the rational choice approach. It seems worthwhile to consider that when energy becomes a contender for a mutual energy exchange, it flows through 'regimes of value' [70].

Second, the mutual energy sharing and mutual energy trading seem to be rooted in different moralities and ethical judgments, which are complex, diverse, sometimes conflicting and at other times converging. This suggestion is consistent with Widlok's [43] and Gudeman's [41] argument that 'sharing' and 'trading' embrace distinct moralities. The ethnography indicates that there is a lack of a unified, uniform and normative frame for moral and ethical valuation that is used by the giver and receivers engaging in a mutual energy exchange. As noted in the Introduction to this Special Issue, ([71]:3), '*great diversity exists in how people make ethical judgments about the role of energy in the types of "good societies" they imagine for themselves... there is no singular set of values that are shared equally at all times by all actors.*' The ethnography suggests that instead of taking a homogenizing and universal viewpoint of locating the value of energy exchanges in ideas of efficiency, optimization of resources and maximization of financial benefits; one needs to be sensitive to people's notion of moral obligations and ethical

judgments. Energy practitioners and researchers attempting to enable energy exchanges should be responsive to this diversity of values as these have potential to explain emergence or disappearance; adoption or rejection; and success or failure of particular types of energy exchanges between a giver and receiver. The recommendation here is that energy practitioners and researchers rise above the limited view of the rational choice approach and embrace a culturally sensitive approach to understanding values invoked in energy exchanges. Further research and discussion by energy researchers and practitioners are required on a different type of rationality, one that is embedded in social relations and local cultural values.

The authors speculate that if the infrastructure used for this study was given to a shopkeeper at RP, then the energy exchanges may have been entirely cash-based. In contrast to the case of Nita, the shopkeeper may not have encouraged negotiation on rent or accepted in-kind payments but may have provided a discount on rent to some of his/her personal connections in the village. The authors also postulate that in case Nita had made a financial investment to acquire the infrastructure provided the energy exchanges with all the groups, except the *gotiya*, would have remained the same. As already mentioned in Section 5.1, Nita did not consider that the infrastructure has been given to her for free, and she had established her ownership since the start of the study. Even in this scenario, her decisions would be shaped by her relational identity and values. She would still have given the solar items to members of her joint family group without asking for a monetary rent. In the case of energy exchanges with the *gotiya*, she may have been more forthright in asking for a return, but she would still have preferred in-kind gestures.

### 6.4. Circle of mutual energy exchange

This article presented circle of mutual energy exchange as a descriptive, conceptual, and analytical unit for understanding mutual energy exchanges. As a descriptive unit, a circle helps to focus on characteristics of social relations and cultural values, and how these shape mutual energy exchanges. As a conceptual unit, a circle provides a space to understand structuring and negotiations that carve different types of mutual energy exchanges influenced by the elements of social relations and cultural values. From an analytical perspective, a circle acts as a tool to explain why certain mutual energy exchanges can and cannot happen in a particular sociocultural environment. During the time-frame of this study, five circles of mutual energy exchanges were observed at Rampur. The study also demonstrates that multiple circles of mutual energy exchange can co-exist in a mutual realm.

The concept of 'circle of mutual energy exchange' takes a relational and cultural view of energy exchanges. Each circle of mutual energy exchange defines a mutually constituted relational and cultural boundary for energy exchanges. The concept is relational as it centers on and acknowledges the influence of social relations in shaping energy exchanges. For instance, Nita's social relation as a daughter-in-law of the joint family group and the *gotiya* shaped the energy exchanges that ensued. The concept of the circle of mutual energy exchange is cultural as it incorporates and is sensitive to diverse local cultural values that contour energy exchanges. A circle outlines what types of exchanges within the circle can be considered culturally appropriate or inappropriate. For instance, Nita considered monetary rent collection as culturally inapt in the circle of mutual energy sharing within the joint family group, but it was culturally acceptable in the circle of mutual energy trading with the Ravidas households. Overall the concept illustrates a social and cultural embeddedness of mutual energy exchanges. Different social environments and contexts would produce other types of circles of mutual energy exchange based on the three dimensions that describe a circle of mutual energy exchange. This conceptualization of a circle of mutual energy exchange supports Sovacool's [37] emphasis on cultural values in people's engagement with aspects of energy.

At the level of ethnography the case reported in this article is specific to rural India but the authors consider the conceptual output of circle of mutual energy exchange of this article to be relevant for other 'developing' countries where similar infrastructure to the one used in the ethnography can be found. The authors consider the concept of the circle of mutual energy exchange to be relevant for rental or 'fee-for-service' models of off-grid rural electrification initiatives in 'developing' countries. Some of these models are operational at 'Ikisaya Energy Centre' in Kenya [28,29], Mini-Grid project in rural Uganda [36], 'Millennium Villages Project' in Malawi [72], as well as in various locations in South Asia [30,33]. An instance of mutuality influencing some aspects of rental exchange can be seen in Eder et al.'s [36] writing on Mini-Grid project in Malawi: *'three interviewees [villagers] believed that the secretary charged different connection fees and prioritised certain households depending on their personal relationships'* ([36][36]:52), and *'it should also be noted that households were connected to the grid not only because they could afford the investment costs but also because of social complications. For example, it was revealed that some villagers were connected to the grid earlier because of their personal relationship with the secretary'* ([36][36]:51). We suggest that by utilizing the concepts proposed in this article, energy researchers and practitioners would be able to develop a holistic understanding that involves the role of diverse social relations and cultural values in shaping the rental exchanges at these sites.

We consider the concept of the circle of mutual energy exchange to be relevant for some emerging and envisioned contexts in the 'developed' world. Gudeman's cross-cultural approach systematically and convincingly contends, that the dialectic of mutuality and self-interest in exchanges is not limited to 'small-scale economies' in developing countries but is also present in 'developed market economies' in western countries [27]. Take for example visionary energy systems such as 'Smart MicroGrids' [73] or 'Decentralized Energy Systems' [74,75], where householders are imagined to get a certain degree of control, choice and an active role in local energy distribution. Such systems allow mutuality to gain prominence in local energy distribution and therefore mutual energy exchanges could emerge. In such scenarios, the concept of circles of mutual energy exchange may help researchers and practitioners to develop a realistic understanding of people's choices and decision-making in energy exchange. Vandebroun, in the Netherlands, also described as *'Airbnb for green power'* [76] in popular media, is an example where emergent traces of mutuality in a context of energy exchanges in a western country can be seen. These aspects can be noticed in Vandebroun's Facebook web page where stories of social interactions, social gatherings and face-to-face encounters of energy-givers and energy-receivers are presented. An important topic for future research is to investigate what forms of mutuality emerge in upcoming energy initiatives in the western world such as Vandebroun, where digital platforms seem to be playing a vital role in energy exchanges.

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## References

- [1] W. Saad, A.L. Glass, N.B. Mandayam, H.V. Poor, Toward a consumer-centric grid: a behavioral perspective, *Proc. IEEE* 104 (2016) 865–882, <http://dx.doi.org/10.1109/JPROC.2016.2520760>.
- [2] Y. Parag, B.K. Sovacool, Electricity market design for the prosumer era, *Nat. Energy* 1–6 (2016), <http://dx.doi.org/10.1038/nenergy.2016.32>.
- [3] T. van der Schoor, H. van Lente, B. Scholtens, A. Peine, Challenging obduracy: how local communities transform the energy system, *Energy Res. Soc. Sci.* 13 (2016) 94–105, <http://dx.doi.org/10.1016/j.erss.2015.12.009>.
- [4] I.F. Ballo, Imagining energy futures: sociotechnical imaginaries of the future Smart Grid in Norway, *Energy Res. Soc. Sci.* 9 (2015) 9–20, <http://dx.doi.org/10.1016/j.erss.2015.08.015>.
- [5] D. Ilic, P.G. Da Silva, S. Karnouskos, M. Griesemer, An energy market for trading electricity in smart grid neighbourhoods, 2012 6th IEEE Int. Conf. Digit. Ecosyst. Technol. IEEE, 2016, pp. 1–6, <http://dx.doi.org/10.1109/DEST.2012.6227918>.
- [6] Y. Strengers, *Smart Energy Technologies in Everyday Life: Smart Utopia?* Palgrave Macmillan, Basingstoke, Hampshire, UK, 2013.
- [7] J. Watson, R. Sauter, B. Bahaj, P. James, L. Myers, R. Wing, Domestic micro-generation: economic, regulatory and policy issues for the UK, *Energy Policy* 36 (2008) 3095–3106, <http://dx.doi.org/10.1016/j.enpol.2008.04.028>.
- [8] S. Mandelli, J. Barbieri, R. Mereu, E. Colombo, Off-grid systems for rural electrification in developing countries: definitions, classification and a comprehensive literature review, *Renew. Sustain. Energy Rev.* 58 (2016) 1621–1646, <http://dx.doi.org/10.1016/j.rser.2015.12.338>.
- [9] L.M. Camarinha-Matos, Collaborative smart grids—a survey on trends, *Renew. Sustain. Energy Rev.* 65 (2016) 283–294, <http://dx.doi.org/10.1016/j.rser.2016.06.093>.
- [10] N. Yaagoubi, H.T. Mouftah, Energy Trading in the smart grid: a game theoretic approach, *Int. Conf. Smart Energy Grid Eng. SEGE 2015* (2015), <http://dx.doi.org/10.1109/sege.2015.7324593>.
- [11] R. Carli, M. Dotoli, A decentralized resource allocation approach for sharing renewable energy among interconnected smart homes, *Proc. IEEE Conf. Decis. Control* (2015) 5903–5908, <http://dx.doi.org/10.1109/CDC.2015.7403147>.
- [12] A.Q. Huang, M.L. Crow, G.T. Heydt, J.P. Zheng, S.J.N. items selected dale, the future renewable electric energy delivery and management (FREEDM) system: the energy internet, *Proc. IEEE* 99 (2011) 133–148, <http://dx.doi.org/10.1109/JPROC.2010.2081330>.
- [13] S. Bellekom, M. Arentsen, K. van Gorkum, Prosumption and the distribution and supply of electricity, *Energy Sustain. Soc.* 6 (2016) 22, <http://dx.doi.org/10.1186/s13705-016-0087-7>.
- [14] K. Zhou, S. Yang, Z. Shao, Energy internet: the business perspective, *Appl. Energy* 178 (2016) 212–222, <http://dx.doi.org/10.1016/j.apenergy.2016.06.052>.
- [15] C. Rosen, R. Madlener, *Regulatory Options for Local Reserve Energy Markets: Implications for Prosumers, Utilities, and Other Stakeholders*, Aachen, Germany, 2014.
- [16] F. Skopik, The social smart grid: dealing with constrained energy resources through social coordination, *J. Syst. Softw.* 89 (2014) 3–18, <http://dx.doi.org/10.1016/j.jss.2013.04.052>.
- [17] P.G. Da Silva, S. Karnouskos, D. Ilic, A survey towards understanding residential prosumers in smart grid neighbourhoods, *IEEE PES Innov. Smart Grid Technol. Conf. Eur.* (2012) 1–8, <http://dx.doi.org/10.1109/ISGTEurope.2012.6465864>.
- [18] Y. Luo, S. Itaya, S. Nakamura, P. Davis, Autonomous cooperative energy trading between prosumers for microgrid systems, *Local Comput. Networks Work. (LCN Work)*. 2014 IEEE 39th Conf. (2014) 693–696, <http://dx.doi.org/10.1109/LCNW.2014.6927722>.
- [19] N. Yaagoubi, H.T. Mouftah, A distributed game theoretic approach to energy trading in the smart grid, 2015 IEEE Electr. Power Energy Conf. (2015) 203–208, <http://dx.doi.org/10.1109/EPEC.2015.7379950>.
- [20] A.J.D. Rathnayaka, V.M. Potdar, O. Hussain, T. Dillon, Identifying prosumer's energy sharing behaviours for forming optimal prosumer-communities, *Proc. – 2011 Int. Conf. Cloud Serv. Comput. CSC 2011* (2011) 199–206, <http://dx.doi.org/10.1109/CSC.2011.6138520>.
- [21] R. Velik, East-west orientation of PV systems and neighbourhood energy exchange to maximize local photovoltaics energy consumption, *Int. J. Renew. Energy Res.* 4 (2014) 566–570.
- [22] F. Mey, M. Diesendorf, I. MacGill, Can local government play a greater role for community renewable energy? A case study from Australia, *Energy Res. Soc. Sci.* 21 (2016) 33–43, <http://dx.doi.org/10.1016/j.erss.2016.06.019>.
- [23] T. Cui, Y. Wang, S. Nazarian, M. Pedram, An electricity trade model for multiple power distribution networks in smart energy systems, 2014 IEEE PES Innov. Smart Grid Technol. Conf. ISGT 2014 (2014), <http://dx.doi.org/10.1109/ISGT.2014.6816496>.
- [24] A.J.D. Rathnayaka, V.M. Potdar, T. Dillon, S. Kuruppu, Framework to manage multiple goals in community-based energy sharing network in smart grid, *Int. J. Electr. Power Energy Syst.* 73 (2015) 615–624, <http://dx.doi.org/10.1016/j.jepes.2015.05.008>.
- [25] M. Ampatzis, P. Nguyen, W. Kling, Local electricity market design for the co-ordination of distributed energy resources at district level, *Innov. Smart Grid Technol. Eur. ISGT Eur. Oct. 12–15, Istanbul, IEEE*, 2014, pp. 1–6 [http://ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=7028888](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7028888).
- [26] P.G. Da Silva, D. Ilic, S. Karnouskos, The impact of smart grid prosumer grouping on forecasting accuracy and its benefits for local electricity market trading, *IEEE Trans. Smart Grid* 5 (2014) 402–410, <http://dx.doi.org/10.1109/TSG.2013.2278868>.
- [27] S. Gudeman, *Anthropology and Economy*, Cambridge University Press, Cambridge,

- U.K. 2016.
- [28] K. Ulsrud, T. Winther, D. Palit, H. Rohrer, Village-level solar power in Africa: accelerating access to electricity services through a socio-technical design in Kenya, *Energy Res. Soc. Sci.* 5 (2015) 34–44, <http://dx.doi.org/10.1016/j.erss.2014.12.009>.
- [29] C. Muchunku, K. Ulsrud, The energy centre model: an approach to village scale energy supply, in: S. Groh, J. van der Straeten, B.E. Lasch, D. Gershenson, W.L. Filho, D.M. Kammen (Eds.), *Decentralized Solut. Dev. Econ.—Addressing Energy Poverty Through Innov.* Springer International Publishing, Switzerland, New York, 2015.
- [30] D. Palit, Solar energy programs for rural electrification: experiences and lessons from South Asia, *Energy Sustain. Dev.* 17 (2013) 270–279, <http://dx.doi.org/10.1016/j.esd.2013.01.002>.
- [31] A. Chaurey, T.C. Kandpal, Assessment and evaluation of PV based decentralized rural electrification: an overview, *Renew. Sustain. Energy Rev.* 14 (2010) 2266–2278, <http://dx.doi.org/10.1016/j.rser.2010.04.005>.
- [32] A. Chaurey, P.R. Krithika, D. Palit, S. Rakesh, B.K. Sovacool, New partnerships and business models for facilitating energy access, *Energy Policy* 47 (2012) 48–55, <http://dx.doi.org/10.1016/j.enpol.2012.03.031>.
- [33] D. Palit, K.R. Bandyopadhyay, Rural electricity access in South Asia: is grid extension the remedy? A critical review, *Renew. Sustain. Energy Rev.* 60 (2016) 1505–1515, <http://dx.doi.org/10.1016/j.rser.2016.03.034>.
- [34] B.K. Sovacool, I.M. Drupady, *Energy Access, Poverty, and Development*, Ashgate Publishing Limited, Farnham, England, 2012.
- [35] M. Bazilian, S. Nakhoda, T. Van de Graaf, Energy governance and poverty, *Energy Res. Soc. Sci.* 1 (2014) 217–225, <http://dx.doi.org/10.1016/j.erss.2014.03.006>.
- [36] J.M. Eder, C.F. Mutsaerts, P. Sriwawit, Mini-grids and renewable energy in rural Africa: how diffusion theory explains adoption of electricity in Uganda, *Energy Res. Soc. Sci.* 5 (2015) 45–54, <http://dx.doi.org/10.1016/j.erss.2014.12.014>.
- [37] B.K. Sovacool, What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda, *Energy Res. Soc. Sci.* 1 (2014) 1–29, <http://dx.doi.org/10.1016/j.erss.2014.02.003>.
- [38] J. David, *Exchange*, Open University Press, Ballmoor, Buckingham, 1992.
- [39] R.R. Wilk, L.C. Cliggett, *Economics and Cultures—Foundation of Economic Anthropology*, second, Westview Press, Boulder, Colorado, 2007.
- [40] A Handbook of Economic Anthropology, in: J.G. Carrier (Ed.), Edward Elgar Publishing Limited, Cheltenham, UK, 2005, <http://dx.doi.org/10.1017/CBO9781107415324.004>.
- [41] S. Gudeman, *The Anthropology of Economy – Community, Market, and Culture*, Blackwell Publishers Ltd, Oxford, UK, 2001.
- [42] S. Gudeman, *Economy's Tension – The Dialectics of Community and Market*, Berghahn Books, New York, 2008.
- [43] T. Widlok, Sharing by default?: outline of an anthropology of virtue, *Anthropol. Theory* 4 (2004) 53–70, <http://dx.doi.org/10.1177/1463499604040847>.
- [44] R.C. Hunt, Forager food sharing economy: transfers and exchanges, *Senri Ethnol. Stud.* 53 (2000) 7–26 <http://ci.nii.ac.jp/naid/110004448971/en/> (Accessed 16 May 2015).
- [45] S. Narotzky, N. Besnier, Crisis, value, and hope rethinking the economy, *Curr. Anthropol.* 55 (2014) 4–16, <http://dx.doi.org/10.1086/676327>.
- [46] G. Rasul, E. Sharma, Understanding the poor economic performance of Bihar and Uttar Pradesh, India: a macro-perspective, *Reg. Stud. Reg. Sci.* 1 (2014) 221–239, <http://dx.doi.org/10.1080/21681376.2014.943804>.
- [47] A.N. Sharma, Political economy of poverty in Bihar, *Econ. Polit. Wkly.* 30 (1995).
- [48] District Census Handbook – Gaya, CENSUS OF INDIA 2011, 2011.
- [49] I. Koskinen, J. Zimmerman, T. Binder, J. Redstrom, S. Weensveen, *Design Research Through Practice- From the Lab, Field, and Showroom*, Morgan Kaufmann, Waltham, USA, 2011.
- [50] Design Anthropology – Theory and Practice, in: W. Gunn, T. Otto, R.C. Smith (Eds.), Bloomsbury, London, UK, 2013, <http://dx.doi.org/10.1017/CBO9781107415324.004>.
- [51] K.M. Murphy, G.E. Marcus, Ethnography and design, ethnography in design. ethnography by design, in: W. Gunn, T. Otto, R.C. Smith (Eds.), *Des. Anthropol.—Theory Pract.* 2013 London.
- [52] P.J. Stappers, F.S. Visser, A.I. Keller, *The Role of Prototypes and Frameworks for Structuring Explorations by Research through Design*, Routledge Companion to Des. Res. (2015), pp. 163–174.
- [53] K. O'Reilly, *Ethnographic Methods*, Taylor & Francis, Abingdon, UK, 2005, <http://dx.doi.org/10.4324/9780203320068>.
- [54] J.J. Schensul, M.D. LeCompte, R.T.I. Trotter, E.K. Cromley, M. Singer, *Mapping Social Networks, Spatial Data, & Hidden Populations*, AltaMira Press, Plymouth, United Kingdom, 1999.
- [55] K.M. DeWalt, B.R. DeWalt, *Participant Observation: A Guide for Fieldworkers*, second, AltaMira Press, Plymouth, United Kingdom, 2011.
- [56] H.R. Bernard, *Research Methods In Anthropology: Qualitative and Quantitative Approaches*, fifth, AltaMira Press, Plymouth, United Kingdom, 2011.
- [57] K. O'Reilly, *Key Concepts in Ethnography*, fifth, SAGE Publications Ltd, London, 2009.
- [58] R.M. Emerson, R.I. Fretz, L.L. Shaw, *Writing Ethnographic Field Notes*, second, The University of Chicago Press, Chicago & London, 2011, <http://dx.doi.org/10.1007/s13398-014-0173-7.2>.
- [59] J. Lazar, J.H. Feng, H. Hochheiser, *Research Methods in Human-Computer Interaction*, first, Wiley, Chichester, United Kingdom, 2010.
- [60] A. Alaszewski, *Using Diaries for Social Research*, Sage Publications, New Delhi, India, 2006, <http://dx.doi.org/10.1111/j.1467-9566.2007.1077.6.x>.
- [61] J. Saldana, *The Coding Manual for Qualitative Researchers*, SAGE, 2016.
- [62] P. Bazerley, K. Jackson, *Qualitative Data Analysis with Nvivo*, (2013).
- [63] T. Widlok, Sharing—allowing others to take what is valued, *J. Ethnogr. Theory* 3 (2013) 11–31.
- [64] M.M. He, E.M. Reutzel, X.J.X. Jiang, R.H. Katz, S.R. Sanders, D.E. Culler, K. Lutz, An Architecture for Local Energy Generation, Distribution, and Sharing, *IEEE Energy 2030 Conf.* (2008) 1–6, <http://dx.doi.org/10.1109/ENERGY.2008.4781028>.
- [65] W. Zhong, Z. Huang, T. Zhu, Y. Gu, Q. Zhang, P. Yi, D. Jiang, S. Xiao, IDES: Incentive-driven distributed energy sharing in sustainable microgrids, *2014 Int. Green Comput. Conf. IGCC 2014* (2014), <http://dx.doi.org/10.1109/IGCC.2014.7039166>.
- [66] A.M. Mehlwana, The anthropology of fuels: situational analysis and energy use in urban low-income townships of South Africa, *Energy Sustain. Dev.* 3 (1997) 5–15, [http://dx.doi.org/10.1016/S0973-0826\(08\)60208-2](http://dx.doi.org/10.1016/S0973-0826(08)60208-2).
- [67] C. Wilson, H. Dowlatabadi, Models of decision making and residential energy use, *Annu. Rev. Environ. Resour.* 32 (2007) 169–203, <http://dx.doi.org/10.1146/annurev.energy.32.053006.141137>.
- [68] T. Winther, H. Wilhite, Tentacles of modernity: why electricity needs anthropology, *Cult. Anthropol.* 30 (2015) 569–577, <http://dx.doi.org/10.14506/ca30.4.05>.
- [69] S. Bell, E. Judson, H. Bulkeley, G. Powells, K.A. Capova, D. Lynch, Sociality and electricity in the United Kingdom: the influence of household dynamics on everyday consumption, *Energy Res. Soc. Sci.* 9 (2015) 98–106, <http://dx.doi.org/10.1016/j.erss.2015.08.027>.
- [70] A. Appadurai, Introduction: commodities and the politics of value, *Soc. Life Things Commod. Cult. Perspect.* Cambridge, Cambridge University Press, 1986, pp. 3–63.
- [71] J. Smith, M. High, Exploring the anthropology of energy: ethnography, energy and ethics, *Energy Res. Soc. Sci.* (2017).
- [72] E. Adkins, S. Eapen, F. Kaluwile, G. Nair, V. Modi, Off-grid energy services for the poor: introducing LED lighting in the Millennium Villages Project in Malawi, *Energy Policy* 38 (2010) 1087–1097, <http://dx.doi.org/10.1016/j.enpol.2009.10.061>.
- [73] A.M. Adil, Y. Ko, Socio-technical evolution of decentralized energy systems: a critical review and implications for urban planning and policy, *Renew. Sustain. Energy Rev.* 57 (2016) 1025–1037, <http://dx.doi.org/10.1016/j.rser.2015.12.079>.
- [74] G. Fuchs, N. Hinderer, Towards a low carbon future: a phenomenology of local electricity experiments in Germany, *J. Clean. Prod.* 128 (2016) 97–104, <http://dx.doi.org/10.1016/j.jclepro.2016.03.078>.
- [75] M. Boucher, Decentralized energy: prospects, justice, and transition, *Energy Res. Soc. Sci.* 11 (2016) 288–293, <http://dx.doi.org/10.1016/j.erss.2015.10.006>.
- [76] R. Postma, Airbnb voor groene stroom, NRC Read, 2014 <https://www.nrc.nl/nieuws/2014/04/11/airbnb-voor-groene-stroom-1365020-a739010> (Accessed 30 July 2016).