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An anthropological perspective on local energy sharing and trading

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Original research article

Exploring peer-to-peer returns in off-grid renewable energy systems in rural India: An anthropological perspective on local energy sharing and trading

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ABSTRACT

Within the areas of distributed, off-grid, and decentralized energy, there is a growing interest in local energy exchanges. A crucial component of an energy exchange is a return provided by an energy-receiver to an energy-giver for the energy provided. The existing energy literature on such returns is primarily limited to monetary returns and lacks a critical discussion on the different types of monetary and non-monetary returns possible and variation in people' preferences for these. Based on an ethnographic 'research intervention' study conducted at two off-grid villages in rural India for 11 months, this article presents a sociocultural understanding of returns. The article presents a classification of returns consisting of three types, i.e., in-cash, in-kind and intangible, and proposes a conceptual model of 'returns-continuum.' The article showcases how people's preference for a type of return varies with the nature of their social relationships with each other and suggests that configuring a return is not merely an economic act but a complex sociocultural process. Finally, the article recommends to energy researchers and practitioners to enable diversity in returns, to acknowledge dynamics of social relations in returns, to interconnect energy economy with the local in-kind economy, and to engage with ethnographic approaches.

1. Introduction

The theme of local or inter-household energy exchanges is increasingly gaining attention in the academic as well as in the business world. Within the realm of distributed, off-grid and decentralized energy, the topic of energy exchange appears under the guise of various labels, such as peer-to-peer energy [1–3], transactive energy [4–6], energy trading [7–9], energy sharing [10–12], and mutual energy exchange [13]. Some off-grid pilots in the global south are utilizing local energy exchanges to provide access to clean energy to underprivileged population of the world (see, for instance, Lighting a Billion Lives[1] and Rural Spark[2] in India, SOLShare[3] and Grameen Shakti[4] in Bangladesh, Ikisaya Energy Centre[5] in Kenya). In many of the off-grid initiatives, energy exchanges are structured in the form of a rental service, where a central location in a village is set as a charging station for solar products such as solar lanterns and battery packs, and villagers access these products by paying a rent [14–17]. Such a setup has been described in energy literature as 'Energy Centre Model' [18,19], 'Centralized Charging Station Model' [15,20–22], 'Energy Kiosk Model' [21] and 'Energy Hub Model' [23]. These models are hailed as innovative ways to address energy poverty and lauded for increasing local community's participation by giving members of the community a central role in the

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[1] http://labl.teriin.org/.
[2] http://www.ruralspark.com/.
[3] https://www.me-solshare.com/.
[4] http://www.gshakti.org/.
[5] https://vimeo.com/57061330.

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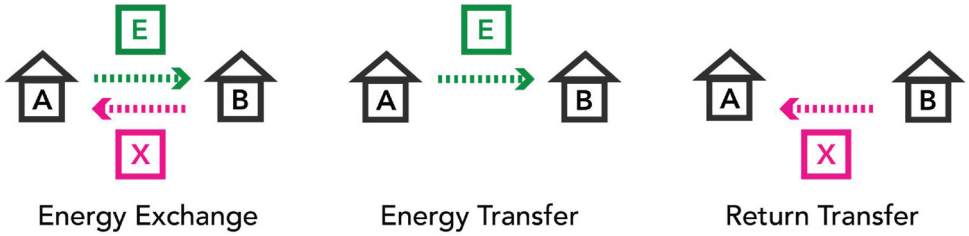

Fig. 1. Conceptual diagrams of energy exchange, energy transfer, and return transfer.

management of a local energy system [16,18,24–27]. Often external agencies (NGOs, utilities, governments) initiate an energy exchange pilot in an off-grid setting by creating a local energy market, where a return structure is constructed based on a socioeconomic evaluation of a local community gauged by willingness-to-pay metric and the local community is engaged in the payment collection (see [17,28]). In such settings, returns are discussed as 'rent,' 'payment,' 'fee-for-service,' and 'pay-as-you-go' (see [14–17,23,27,29–32]).

Conceptually, from an anthropological perspective, an energy exchange in such a system could be viewed as consisting of two types of 'transfers': 'energy transfer' and 'return transfer' (see Fig. 1). In this article, we extend Robert C. Hunt's [33], an economic anthropologist, conceptual distinction between a 'transfer' and 'exchange.' An 'energy transfer' is *a physical or figurative movement of energy units (E) either through cables or storage devices such as batteries from an energy-giver (A) to an energy-receiver (B)*. In contrast, a 'return transfer' or 'peer-to-peer return' or for brevity a 'return' is *a counter-movement of an entity X from the energy-receiver (B) to the energy-giver (A)*.[6] An energy exchange is complete when both A and B recognize X as a return for the energy units provided by A. In this article; we prefer to use the word 'return' rather than more commonly used money oriented terms in energy literature, such as rent, tariff, fee, and payment. A 'return' provides a larger conceptual canvas that allows us to include a variety of non-monetary and intangible entities observed in our analysis. Moreover, the concept of 'return' has an established discourse in anthropology (see [34–37]). We prefix 'peer-to-peer' (p2p) to 'return' to indicate specific structural elements of the returns discussed in this article, i.e., these are mutually structured, negotiated, and organized by energy-givers and energy-receivers.

In the existing energy literature on off-grid energy systems, there are two main knowledge gaps about peer-to-peer returns that this article attempts to address. First, an emerging body of energy literature sees a local, social, and cultural understanding of various aspects of off-grid systems as crucial for their success and adoption by people [16,17,38–41]. However, the existing discussion on returns in such energy systems is mostly rooted in a techno-economic analysis [14,20,23,42–44] and lacks an understanding of the sociocultural embedding of the returns, i.e. how these returns are grounded in the social and cultural reality of people's life. Second, the existing energy literature on such returns in off-grid settings is primarily limited to discussion on monetary returns (fiat money) and lacks an understanding of different types of monetary and non-monetary returns possible and people's preferences for these. Moreover, the contemporary understanding of p2p returns in limited to a 'rational market' paradigm that presumes universal and exclusive preference for fiat money and primacy of logic of market where the householders engage in competitive buying and selling of energy in return for fiat money. Such an understanding does not take social and cultural variations and particularities, and diversity in logics into account. To respond to these above-mentioned knowledge gaps, in this article, we bring a perspective from the discipline of anthropology to develop a sociocultural understanding of p2p returns. To the best of our knowledge, p2p returns in off-grid energy systems have not yet been explored from an anthropological perspective. In a broad sense, an anthropological perspective focuses on two types of understandings. First, a holistic, bottom-up, and embedded understanding of a (sociocultural) phenomenon which starts by building and analyzing 'emic' (insider's or internal) viewpoints, i.e., people's multiple realities, perceptions, and logics. Second, translating the 'emic' understanding to 'etic' (external) concepts, i.e., an analytical and conceptual description of the phenomenon (for more on 'etic' and 'emic perspectives see [45,46]). Hence, this anthropological perspective attempts to ground the understanding of a phenomenon in everyday realities of peoples' social life.

This article is based on an ethnographic 'research intervention' study conducted at two off-grid villages Rampur and Manpur in rural India for 11 months (1 February 2016–31 December 2016).[7] The study started with the installation of an off-grid energy distribution infrastructure to enable exchanges of solar-lighting in the villages. The 'research intervention' allowed one household in each of the villages to be a giver for their respective village. The householders had complete control of the energy infrastructure installed and freedom to structure returns, as they desired without any involvement of the ethnographer. This setup facilitated the ethnographic inquiry to address the following broad research questions: What types of returns givers and receivers invoke when they are given control of an off-grid energy distribution? How are these returns embedded in the social, cultural, and economic life of the villagers?

The ethnographic data analysis reveals the existence of three types of peer-to-peer returns: in-cash, in-kind and intangible returns. The article presents four ethnographic vignettes that showcase variations in preference of the three types of returns and demonstrate various issues with in-cash returns. Based on learning from the ethnography, the article presents 'returns-continuum,' a conceptual model that proposes the following.

a) The three types of returns can be viewed as a coexisting, overlapping, dynamic, and continuous spectrum of returns.
b) The people's preference for a type of return varies with the nature of their social relationships with each other.
c) A diversity of returns is a better fit for the social, cultural, economic and moral life of people engaged in off-grid energy system than solitary money-centric return;
d) Configuring a return is not merely an economic act but an intricate sociocultural process.

Before moving ahead, we would like to clarify that some references to in-kind and intangible entities appear in energy literature in two broad contexts in which an external agency (non-governmental organization, utility, or state) is either a receiver (see [24,25,47–50]) or a giver (see [17,51–54]) of in-kind or intangible entities as payments. See Table 1 for more details on these two contexts. However, these have not

[6] To be concise, we use the word 'giver' to refer to an 'energy-giver.' Similarly, a household who received a solar-item from the 'giver' is referred to as a 'receiver' in this article. For the p.

[7] Please note that the real names of villages and all the participants have been changed in this article for the purpose of anonymity.

Table 1
Two broad contexts where in-kind and intangible entities are discussed in the energy literature.

Types of payment	Reason	References
Context 1: In-kind payment by a householder or a local community to an external agency for an energy infrastructure installed by the external agency	Land and labor for the capital cost of the energy infrastructure	Baldwin et al. [45], Emili et al. [25]
	In-kind contributions in the form of material and labor as a way to increase local ownership and engagement of people in rural electrification projects.	Hirmer et al. [48]
	In-kind contributions in the form of land and labor are utilized to achieve community participation, ownership and engagement in renewable energy initiatives.	Sovacool and Drupady [24]
	In-kind payment scheme where the poorer population are allowed to pay by use of cattle dung and fertilizers.	Sovacool and Drupady [24]
	In-kind payment for the dissemination of Solar Home Lighting kits amongst householders who are unable to pay by cash.	Mainali and Silveria [49]
	In-kind payments as a financing mechanism for off-grid renewable energy access to the poor in Nepal.	Glemarec [50]
Context 2: In-kind and intangible entities as compensation, benefits, or subsidies provided by an external agency to a householder or local community for participation in and acceptance of energy infrastructure	In-kind payments such as constructing a visitor center as a 'benefit payment' or 'compensation scheme.'	Kerr et al. [51]
	In-kind payments in the form of infrastructure and assets as 'community compensation' to a local wind farm community.	Delicado et al. [52], and Upham and García Pérez [53]
	In-kind benefits for fisherman communities in the form of local infrastructure for community acceptance of marine renewable energy.	Reilly et al. [54]
	'In-kind donation' of solar lanterns to a local cooperative in rural Malawi.	Adkins et al. [17]
	'In-kind transfers' to poor citizens as support for rising energy prices.	Freund and Wallich [65]
	'In-kind gifts' as rewards for energy behavior of householders.	Camara et al. [66]
	Intangible rewards such as praise, recognition as 'intrinsic rewards' for energy behavior of householders.	Camara et al. [66]
	Prestige, an intangible entity, in a village level energy project in rural India.	Malhotra [67]
	Intangible benefits of rural electrification to a local community.	Zerriffi [27]
	Non-monetary benefits in the adoption of a decentralized renewable energy system.	Yaqoot et al. [68]

been discussed in reference to peer-to-peer energy exchanges.

Apart from the others, this article addresses the following key themes relevant for energy research and social science:

(a) Beyond techno-economic understanding: Various energy studies' scholars emphasize the need for energy research to investigate the sociocultural dimensions of energy [19,55–59]. More specifically on peer-to-peer renewable energy systems, Ruotsalainen et al. [1] have argued for approaching such energy systems within broader social and cultural contexts filled with diverse values.
(b) Study from the global south: Many researchers have reported cases from the global south that attend to people' s everyday life as underrepresented in energy studies [55,59–61].
(c) Anthropological viewpoint and ethnographic approach: Several energy studies have invited researchers to embrace anthropological [55,56,62] and ethnographic [60,63,64] research on studying energy systems and society.
(d) Extension of our previous publication: The ethnographic observations from Rampur during the initial phase (Feb.–April 2016) of this research were presented in an earlier publication (see [13]). It reported on a classification of energy exchanges and significance of mutuality in energy exchanges. In contrast, here we focus and go deeper into a discussion of types of returns based on long-term ethnographic data from two villages.

The remainder of this article is organized as follows. Section 2 describes field setting of the study. Section 3 provides details of the research approach and methods used. Sections 4–6 present the ethnographic results by respectively providing an overview of energy exchanges, showcasing the classification of returns, and presenting four ethnographic vignettes and a coda to the study. Section 7 presents the conceptual model of returns-continuum. Finally, Section 8 provides recommendations, conclusions and future work.

2. Field sites

This article is based on field research conducted at two villages, Rampur and Manpur, located in Bodhgaya block, Gaya district of Bihar state in India (see Figs. 2 and 3). India is home to around 1.21 billion people with 68.85% of this population living in rural areas [69]. It is estimated that approximately 300 million people in India lack access to electricity [70]. Bihar is a federal state of India with 88.7% of its total population of 104 million living in villages [71]. Gaya district, with a population of 4.39 million, is the fifth largest district of Bihar [71].

Bihar is one of the least 'developed' states of India [72] and performs poorly on various socio-economic indicators as compared to other states in India [73,74]. According to the 2011 Census of India [75], only 10.4% of the rural households in Bihar were electrified. However, in the past few years, India and Bihar have made rapid strides in the area of village electrification, which many attributes to a successful implementation of Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) policy [76,77].[8] Latest data on village electrification (as of 7 May 2018), report 96% of the villages [78] and 75% of the households in Bihar to be electrified [79]. Many scholars while laud the government's efforts also point to the rudimentary definition of 'village electrification' used by DDUGJY where a village is considered to be 'electrified' even if only 10% of the households are electrified [70,77,80]. Moreover, the current approach to electrification does not take quality and reliability of electric connectivity into account, which remains barriers in rural electrification [77,80]. Hence, large swaths of

[8] Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) policy was earlier known as Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme.

Fig. 2. Map of India with Bihar state and Gaya district highlighted.

households still remain without access to electricity in Bihar [70].

The field engagement started with visits to many un-electrified villages in the Gaya district. Manpur and Rampur were selected as field-sites as they fulfilled some pre-identified criteria (See Table 2). Rampur and Manpur are around fifteen kilometers away from the center of Gaya and are four kilometers apart from each other. The route to the villages consists of passage through half-made roads, agricultural fields, and driving on a long, dried and stone-filled riverbed.

Manpur and Rampur comprise of 350 and 200 households respectively. All the inhabitants of the villages are Hindu by religion. Both the villages were off-grid as the villages did not receive any electricity supply from the electricity grid. The villagers rely on Kerosene oil as a primary source for lighting. Twenty-three households at Manpur and thirty households at Rampur report having small solar panels (4 W–40 W). The existing solar panels are used primarily for basic home lighting, to power small music players and to charge mobile phones. Mobile phones are ubiquitous, and persons without solar panels charge their mobile phones at the households with solar panels. Often this informal charging service is offered for free, but in some cases, householders ask for a charging fee. The villagers report that agricultural outputs are not anymore sufficient for the economic sustenance of a household. They report it to be the main reason for a large-scale migration of working age men from the village to big cities in India.

3. Research approach

This interdisciplinary research is based on a multi-method ethnographic study [13]. The research approach consists of a 'research intervention' where a material infrastructure is introduced into a social space as a precursor to an ethnographic investigation of people's engagement with the infrastructure. This research technique is situated in the emerging field of 'design anthropology' [81] and 'research-through-design' [82].

3.1. 'Research intervention'

The aim of the 'research intervention' was to enable a research setup that facilitates inter-household energy exchanges for an ethnographic investigation. The 'research intervention' is not intended as a pilot to demonstrate how to structure off-grid energy systems. 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 givers' households (see Table 3 and Fig. 4). This infrastructure facilitated the exchange of 'solar-items,' i.e., solar lanterns, LED bulbs and power banks, between households in the villages. In total, thirty-three solar-items, i.e., fourteen LED bulbs with power banks and nineteen solar lanterns were available for use and exchange in both the villages. The total cost of installation of energy distribution infrastructure was 40,000 Indian Rupees (INR) (around 560€).

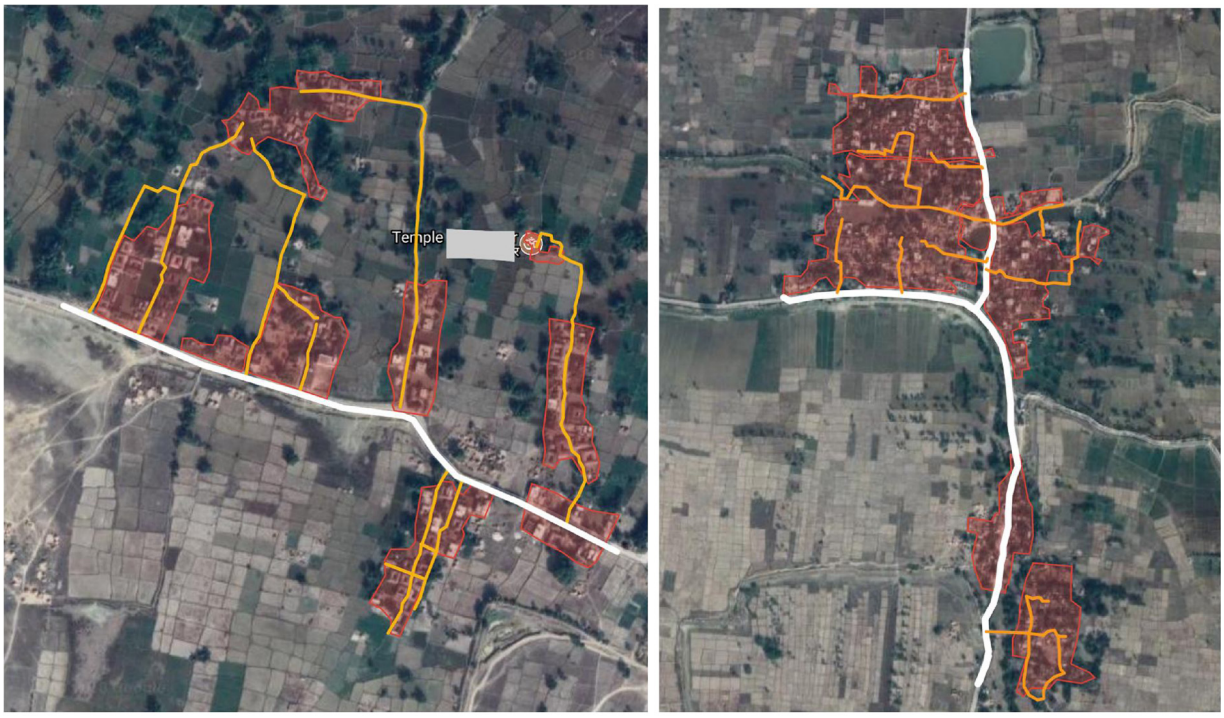

Fig. 3. Google Map images of (a) Rampur and (b) Manpur. Please note red polygon highlights the inhabited land, the white lines represents roads, and orange lines represent streets within the villages. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

Table 2
Pre-identified criteria for selecting field-sites.

	Pre-identified criteria for selecting a field-site	Status of Manpur and Rampur
1	Un-electrified Villages	Both the villages were un-electrified. The villages did not receive any electric supply from the centralized grid and did not have any community based off-grid energy provisioning system
2	Heterogeneous Population	Both the villages had a heterogeneous mix of the population belonging to different castes
3	Physical Access	Physical access to both the villages was not too difficult
4	Experience with solar technology	The villagers had experience of solar technology
5	Feasibility for extended field-research	It was feasible for the ethnographer and the research assistant to stay in the village for an extended period
6	Rapport and Volunteering Households	In each of the villages, a household was willing to participate as a giver for the study. The ethnographer managed to form a rapport with the givers that made collecting rich ethnographic data possible.

3.2. Research methods

The details of ethnographic methods used in this research were published in an earlier publication [13]. Hence, here, we provide only a brief overview of the methods. To investigate energy exchanges, a research approach of 'personal network research,' which is a type of 'ethnographic network mapping' was adopted [83]. The 'personal network research' centers on 'focal' individuals and explores their social network using a range of ethnographic methods. The givers were the focal individuals, and we investigated energy exchanges between the givers and each receiver invoked through a family of ethnographic methods, such as participant observation [84], interviews and conversations [85], and field-notes [86]. 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 the past four years, volunteered in the field-study as a research assistant.

A self-reporting diary was provided to the givers to document information about energy exchange. See Fig. 5 for the various attributes documented. Such diary-based approaches are beneficial for triangulation [87]. The diary entries were discussed and crosschecked during interviews with the givers and receivers.

A hand-drawn exchange mapping approach was utilized to (a) to create a spatial map of the energy exchanges, (b) utilize the map to inquire about social relationships between the givers and receivers, and (c) to cross-check preliminary findings from other ethnographic methods and analysis of self-reporting diary entries. The hand-drawn exchange mapping technique used in this research draws inspiration from various visual methods proposed by the Participatory Rural Appraisal (PRA) approach. PRA is a participatory research methodology that utilizes various visual methods to build an understanding of participants' social world [88–91]. PRA encourages adoption of the mapping methods according to the research context and has been used in combination with ethnographic methods [88–91]. Overall, three mapping sessions, one each in February, March and December 2016, were held in both the villages. The energy givers and their family members collaboratively constructed the map.

Table 3
Key Components of Off-Grid Energy Distribution Infrastructure for Solar Lighting.

Item	Quantity	Comments
Power Banks	14	These portable power banks provide 5 V Direct Current (DC) current output to two Universal Serial Bus (USB) ports, which can be used to power a LED light (below) and 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 3 W LED lights that work when connected to the power banks as these lights do not have battery components. Each LED Bulb was given a unique three-digit 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-digit 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).

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

NVivo,[9] a qualitative data analysis software, was used for in-depth qualitative data analysis. The ethnographer crosschecked the emergent findings with the givers and concerned receivers by telephonic and face-to-face interviews.[10] See [13] for more details on data analysis procedure followed in this research.

3.3. Recruitment and protocol

The ethnography at Rampur and Manpur started with two visits to identify and select potential households to be givers for their respective villages. This task consisted of the ethnographer visiting eight households in Rampur and meeting five different householders in MP to gauge the suitability of the households to become a giver for the study. Eventually, the ethnographer selected Nita Devi at Rampur and Aarti Devi at Manpur to be the givers for this study. Nita and Aarti are married females, and while the former is in her mid-forties, the latter is in her late-twenties. Nita's nuclear family consists of her husband (Chandan Yadav), fifteen years old son (Ranjan), and nine years old daughter. Aarti's nuclear family consists of her husband (Ramesh Singh) and her eight months old daughter. Nita and Aarti were selected to be the givers because of the following principal reasons:

(1) Both Nita and Aarti volunteer as community-mobilizers for a village-level woman Self-Help-Group (SHG) in their villages. Their work requires them to engage with households belonging to all castes.
(2) They were experienced and comfortable with record keeping and documentation required for the use of the self-reporting diary.

[9] http://www.qsrinternational.com/what-is-nvivo.

[10] 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 the field once in a month to follow-up on the developments and capture photographs of the diary entries. The first author revisited the field for a week in December 2016 and utilized the visit to get feedback from the villagers on the emerging themes and categories.

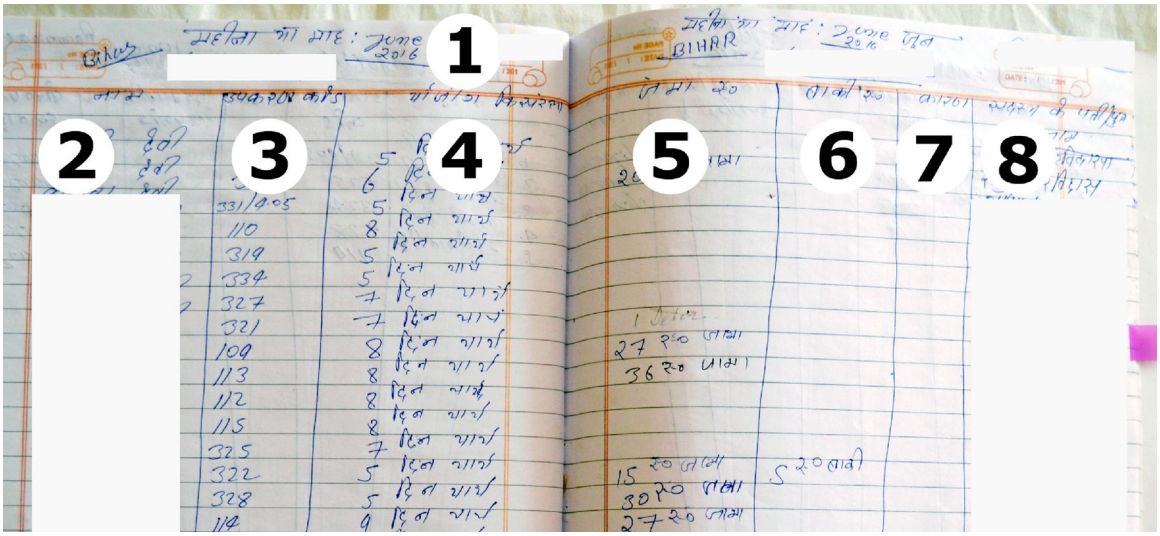

Fig. 5. A sample of diary entry documenting energy exchanges for June 2016. Please note the labels: 1: 'month'; 2: 'receiver name'; 3: 'item code'; 4: 'number of charging'; 5: 'return provided'; 6: 'return due (if any)'; 7: 'any reason/comment'; 8: 'head of the receiver's household'. (We have concealed the names mentioned in the figure to anonymize research participants).

(3) They demonstrated proficiency in performing various tasks, such as charging of solar items for the operation of energy distribution infrastructure.
(4) Both of them were enthusiastic and willing to be the giver for their village.
(5) The ethnographer was able to form a rapport with them and their family members. They let the ethnographer participate in their everyday life and were comfortable in sharing intricate details, which facilitated 'rich' ethnographic data collection.

Additionally, Nita and Aarti were selected to be the givers as females in the villages have a constant presence in the village while 'working-age' men migrate to big cities in India to work and therefore are less regularly present in the villages.

As part of the 'intervention,' a textual contract was made with both Nita and Aarti. The contract formally established them as the owners of the infrastructure installed in their respective villages. The contract catered to a strategic research design decision: to provide the givers with complete control and ownership of the energy distribution infrastructure without asking them to make any financial payment for the infrastructure. The research team sensed that such a setup would allow the givers to act according to their social, cultural, moral, and ethical values without the pressure of making the setup financially sustainable. Moreover, such a setup is typical for village-level centralized charging models where 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 [15,16,18,27,61,92,93]. The contract underlined that the energy-giver would get to keep, use and maintain all the components of the infrastructure even after the study has been completed. It was communicated and established that the givers can decide to use the infrastructure in whichever way they feel appropriate. They can decide whom to give or not give a solar item, give these items for free or for rent, or in any way they deemed appropriate.

4. Ethnographic overview of energy exchanges

4.1. Start of energy exchanges

The installation and the contracts were signed in the presence of some other villagers and the news of the installation spread through the village. A large number of villagers visited the givers to inquire about the installation and conditions for procuring solar-items. These visits were followed by discussions within the villages about various aspects of the infrastructure. Concurrently, the givers started discussing with their family members on ways to institute energy exchanges. Overall, in both the villages, the solar-items generated considerable enthusiasm amongst the villagers. The givers appreciated that they had been given control, and behaved as owners of the infrastructure. They were aware of the total cost of the infrastructure, deemed it to be expensive, considered it to be a crucial way to add to financial earnings of their households, and therefore as an entity that they to be cautious in using it.

Within a couple of days since the installation, the givers started assigning the solar-items to receivers. A general way for the exchange was: a receiver visited the giver's home, obtained the assigned and charged solar-item, judiciously used the solar-item in their household for few days, once the solar-item was drained of the charge, the receiver brought the item back to the giver's place for charging.

4.2. Rental negotiations

The givers decided to ask for rent for providing the solar-item to the receivers. However, the villagers were cognizant that the setups had been provided to the givers without requiring them to make any financial investment. Hence, some villagers questioned the appropriateness of being asked to pay rent. The givers responded by establishing the legitimacy of rent collection. First, the givers reasoned that operating and maintaining the infrastructure, and participating in the research that included keeping daily records required considerable effort from their end. They argued that this effort was an appropriate 'payment' for the infrastructure. Second, the givers established that repair of the solar-items would incur a cost that has to be recovered by rental collection. Third, on many occasions, the givers cited the contract with the ethnographer that made them the rightful and exclusive owner of the infrastructure and empowered them to create their own rules. Finally, the givers were able to socially establish their ownership of the infrastructure and need for a rental collection. Some villagers were still not convinced by the arguments and decided not to take any solar-item from the givers.

Fig. 6. Various benefits of the solar-items. Please note the labels. '1': lighting interiors of a house; '2' cooking after sunset; '3' mobile phone charging; '4': mobility after sunset.

Each giver developed the rental strategy independently of the other, i.e., without any consultation with each other. The ethnographer did not inform the villagers about the existence of similar research setup in the other village.[11] This situation also explains the variation in rental strategies developed in both the villages. At MP, Aarti and Ramesh structured a monthly rental scheme where a power-bank and a solar-lantern had a flat rent of 60 rupees (0.79 euro) and 40 rupees (0.53 euro) per month respectively independent of a number of charging. In contrast, at Rampur, Nita started with a rent-per-charging scheme where rent would be charged based on the number of charging performed. She initially stated the rent to be 5 rupees per charging with an assumption that the receivers would charge a solar-item five to eight times per month. However, the receivers considered the rent to be high and started negotiating with Nita, and eventually reached an agreement for 3 rupees as the rent for each charging. Soon, the villagers found ways to charge the solar-items with small solar panels and batteries in the village and avoided making rental payment to Nita. Nita sensing this issue of her scheme revised the rental scheme at the end of April 2016 to a flat monthly rate of 30 rupees, which was independent of the number of charging. She continued with this scheme throughout the study.

Interestingly in both the villages the givers and receivers invoked the price of kerosene oil, the primary source of lighting, as a reference to determine the rent and capacity for the receivers to pay. The receivers estimated the household consumption of oil for lighting to vary between 1–2.5 L per month, i.e., between 21–105 rupees (0.25–1.3 euros) concerning monetary worth. The givers and receivers attempted to keep the rent for a solar-item to be comparable to a household's monthly expenses of kerosene used for lighting.

[11] The givers eventually became aware of the setup in the other village but they did not communicate with each other.

4.3. Use and benefits

The receivers were highly pleased with the solar-items and reported on many benefits of these. The solar-items were portable, and hence the villagers were effortlessly able to carry these around. The solar-items facilitated work in the field after the sunset. Similarly, people reported an enhanced sense of safety in movement in the village and cooking after dark. The children used the solar-items for studying as a replacement of '*dhibri*' (oil-based lamp) that are unhealthy and unsafe. They also remarked on better range and aesthetics of the light emanating from the solar lanterns and the LED bulbs as compared to '*dhibri*.' The villagers utilized the power-bank (a solar-item) charging mobile phones, which in turn were used for accessing digital video and songs. See Fig. 6. The infrastructure was successful in providing access to solar-lighting to many households. In total 63 distinct households became receivers during the study (see Section 5 for more details).

5. Classifications of returns and quantitative overview

The ethnographic data reveals three types of returns, i.e., in-cash, in-kind and intangibles, used by the villagers as part of the rental structure developed in both the villages. This section presents a classification and quantitative overview of these returns. See Table 4.

5.1. Defining in-cash return

In-cash return is *a payment made by an energy-receiver to energy-giver for the energy provided in the form of currency notes and coins*. Here, we use the term 'cash' to denote what anthropologists define as 'fiat money' [35,94] or 'general-purpose money' [95], which is a legal tender issued by the state assuring its value. In-cash returns are monetary. In-cash returns are an integral part of mutual energy trading, a type of energy exchange. Mutual energy trading (MuET) is '*a social and personal energy*

Table 4
A classification of returns.

Dimension	In-Cash Return	In-Kind Return	Intangible Return
Monetary/Non-Monetary	Monetary	Monetary (calculating monetary worth)	Non-Monetary
Quantitative measurement of return	Yes	Yes	No
Scale of measurement of return	Money	Diverse scales but a translation to monetary worth for commensuration	Not Used
Commensuration	Important	Important	Not Important
Social Relation (between giver and receiver)	Usually with 'Socially distant'	With both 'socially distant' and 'socially close'	With 'Socially intimate'
'Profit'	'Profit' desired	'Profit' desired from 'socially distant'; 'profit' avoided from 'socially close'	'Profit' absent
Type of Energy Exchange	Predominantly in Mutual Energy Trading (MuET)	Can be part of both Mutual Energy Trading (MuET) and Mutual Energy Sharing (MuES)	Predominantly in Mutual Energy Sharing (MuES)
Entities of return	Currency Notes and Coins	Work such as service of irrigation pump-set, tractor; Food items such as potatoes, lentils, corn; Non-food items such as oil, cow-dung cakes	Goodwill, Labor, Social Support, Favor, Friendship

exchange where an energy-giver and energy-receiver participate in a calculated exchange for the sake of a commensurate material or monetary gain' ([13]:109) Commensuration or *'to compare by use of a common measure'* ([35]:51) is important. It is achieved by use of rental schemes and quantitative measurement of the return using the scale of money. In both the villages, the givers usually pursued in-cash returns from receivers who were 'socially distant' or less connected to them. The givers described 'socially distant' receivers with the phrase such as *gaon ke aadmi* ('village men') and explained that the relationship between them is of a village acquaintance, where they are familiar with each other but do not have any social bonding or connection with each other. The givers explicitly stated that in the cases of energy exchanges with the village acquaintances making some 'profit' was their primary motive. Here, the notion of 'profit' indicates a value of making some monetary or material gain. The villagers interchangeably referred to a discourse of 'profit' with various Hindi words such as *munafa*, *faida*, or *laabh* and sometimes also with the English word *profit*. The villagers spoke of *munafa* exclusively in the context of financial 'profit,' whereas they used the words *faida* and *laabh* to refer to having a financial 'profit' and also to indicate getting some (non-financial) advantage or benefit from something.

5.2. Defining in-kind return

We define in-kind returns as *a payment made by an energy-receiver to energy-giver for the energy provided in the form of a thing or work of economic value*. In-kind returns involve four strategic calculations. (A) A giver identifies the monetary dues for a particular receiver based on the rental scheme mutually agreed by the giver and receiver. (B) The giver measures the quantity of the in-kind return provided by a receiver. This measurement is done using different scales of measurements. For instance, access to diesel-powered irrigation pump-set is measured with the scale of time (per hour basis) whereas medical consultations are measured with the number of consultations provided. (C) The giver and the receiver mutually calculate and agree upon the monetary worth of the quantity of in-kind return provided. Various local and market references are used for this calculation. For instance, an hour of access to an irrigation pump is translated to a monetary worth based on a mutually agreed price, whereas monetary worth of food-grain provided as an in-kind return is calculated based on the ongoing market rate of the grain. This step of translating the quantity of an in-kind return to a monetary worth is essential for a giver's and receiver's satisfaction on commensuration and equivalence in an energy exchange. This act of monetary translation of an in-kind return is a salient feature of in-kind returns observed during the field-study. (D) Finally, the giver and the receiver determine the overall credit/debit balance. Hence, these in-kind returns are non-cash but still are monetary. It is in contrast to a discussion on in-kind payments in energy literature, where it is referred as 'non-monetary' when essentially researchers indicate its non-cash nature (for instance, see [53,96]).

In-kind returns were observed in energy exchanges of the givers with both a 'socially distant' as well as a 'socially close' receiver. 'Socially close' refers to a type of social relationship between a giver and receiver where they are closely connected and bonded with each other, such as between members of an extended family ('*gotiya*' or '*gotiya parivar*') or neighbors ('*padosi*'). A subtle distinction observed between in-kind returns invoked in energy exchanges with 'socially distant' and 'socially close' is in the discourse of 'profit'. In case of energy exchanges with 'socially distant' receivers, the givers emphasized their ambition to obtain a 'profit,' whereas in case of 'socially close' receivers the givers avoided and abstained from a 'profit.' In-kind returns can be part of both mutual energy trading and mutual energy sharing. Mutual energy sharing (MuES) is another type of energy exchange and it is '*a social and personal energy exchange where an energy-giver and energy-receiver participate for the sake of social relationship between them*' ([13]: 109).

During the field research, the ethnographer also enquired about local exchanges of other everyday items such as food grains, vegetables, agricultural tools, and utensils. This line of inquiry revealed how the villagers differentiate between the materiality of a solar-item from other entities when considered as a commodity for exchange. In both the villages, people describe a category of entities as 'machine' that includes various types of technological tools such as agricultural instruments, motorbike, diesel generator, mobile phone, and solar-items. They view a 'machine' as expensive and damageable and consider it as an entity that one acquires with considerable investment. Hence, they rationally associate with a 'machine' specifically when making them part of an exchange with other villagers. This view of solar-item as 'machine' also explains the givers' rationale for calculating the monetary worth of in-kind returns provided by the receivers. It was typically observed that a giver allocates a solar-item to a receiver on a financial basis, while simultaneously gives other non-machine items to the receiver on a non-monetary basis.

5.3. Defining intangible return

We define intangible returns as a return in the form of unmeasured and unquantified social gestures and actions, such as goodwill or social support, made by an energy-receiver in favor of energy-giver for the energy provided. The critical factor that differentiates intangible returns from in-cash and in-kind returns is that the giver and receiver neither quantitatively nor monetarily measure intangible returns. Thus, intangible returns are non-monetary. Commensuration is not essential and a notion of 'profit' is absent in case of intangible returns. Intangible

returns are constituent of mutual energy sharing. In both the villages, intangible returns were observed in energy exchanges with 'socially intimate' receivers. The givers described their relationship with 'socially intimate' persons by use of Hindi words kareebi (close), mohabbati (love), dosti (friendship) and parivar (family). 'Socially intimate' refers to a type of social relationship between a giver and receiver where they feel a strong sense of social connection and solidarity with each other, such as between proximate friends. We consider 'socially intimate,' 'socially distant,' and 'socially close' to be different states of 'social connectedness,' which is a character of social relations between people. We define 'social connectedness' as a feeling of togetherness, solidarity, and closeness experienced and performed by a person for another.

5.4. Quantitative overview of returns

During this study, 36 households at Manpur and 27 households Rampur received solar-items from the giver for varying durations.[12] At Rampur, one particular household had three unique receivers; therefore the total number of receivers at Rampur was twenty-nine persons. Fig. 7 provides an overview of the type of returns utilized by the receivers at Manpur and Rampur. In-cash return was the most common type of returns used: 39% (14 receivers) at Manpur and 52% (15 receivers) at Rampur used in-cash returns without combining those with any other type of returns. 25% (9 receivers) and 28% (8 receivers) at Manpur and Rampur respectively used in-kind returns either solitarily or in combination with in-cash returns. 14% of the receivers in both the village used intangible returns. 22% and 7% of the receivers at Manpur and Rampur respectively did not provide any return during the period of the study. However, at Manpur, Aarti estimated that some of the non-paying receivers might eventually provide an in-kind return to clear the dues. It is crucial that an intangible return is not confused with no-payment. In case of no-payment, a giver expects a return while the receiver provides none, whereas in case of an intangible return a giver qualifies an un-quantified and unmeasured social gesture as a valid return. Figs. 8–10 show distributions of receivers who provided in-cash, in-kind and intangible returns respectively by the types of their social relations with the givers. Fig. 8 shows that in-cash returns were more common in energy exchanges with 'socially distant.' Fig. 9 highlights that in-kind returns were utilized with both 'socially distant' as well as 'socially close.' Fig. 10 indicates that all the receivers who used provided intangible returns were 'socially intimate' to the givers. In the following section, with use of ethnographic vignettes from the field, we demonstrate the differences between the three types of returns.

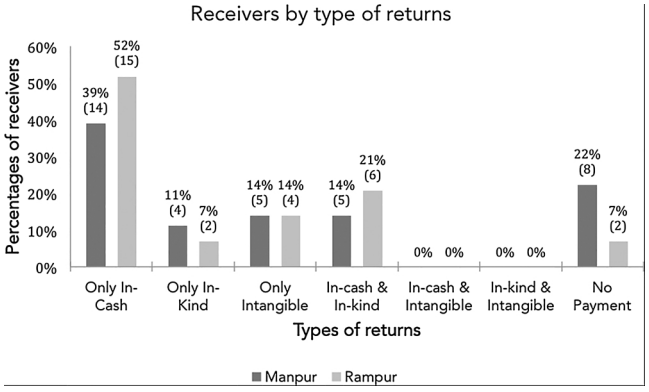

Fig. 7. Distribution of receivers by types of returns (1 February–31 December 2016).

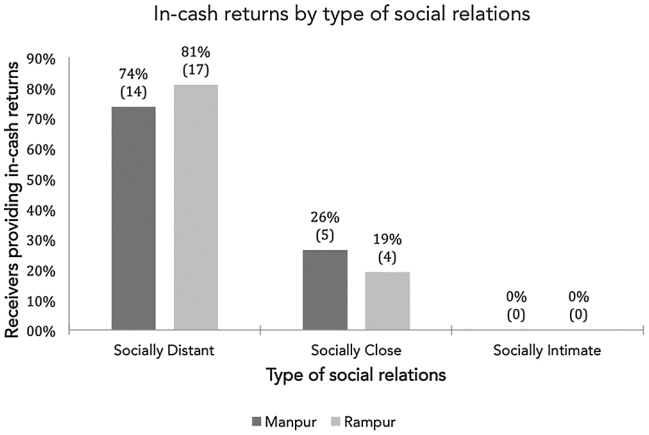

Fig. 8. Distribution of receivers who provided in-cash returns by the type of their social relations with the givers. (Please note that the distribution combines receivers who provided only in-cash returns with those who provided both in-cash and in-kind returns).

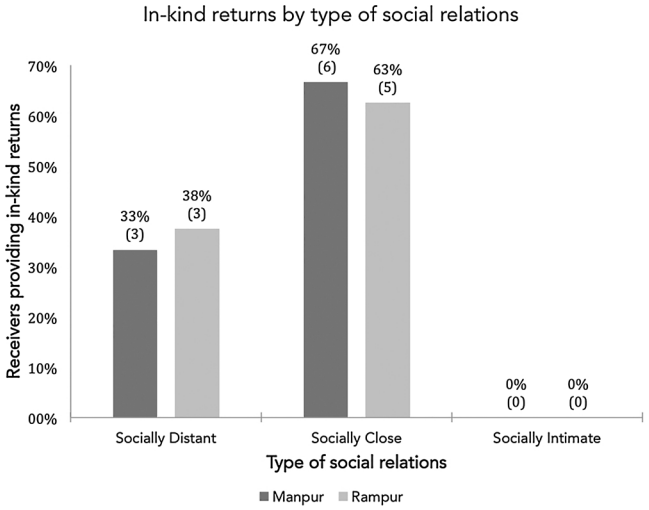

Fig. 9. Distribution of receivers who provided in-kind returns by the type of their social relations with the givers. (Please note that the distribution combines receivers who provided only in-kind returns with those who provided both in-cash and in-kind returns).

6. Ethnographic vignettes

6.1. Vignette: a desire for and problems with in-cash returns

This vignette describes characteristics of in-cash returns, which the givers usually pursued from 'socially distant' receivers while engaging in a mutual energy trading. Cash (fiat money) is a scarce and highly desired entity in the economic life of the Rampur and Manpur. There is a noticeable variation in the economic class of the villagers with few households economically well-off while a large number of villagers struggle to cope with perpetual poverty. Therefore, it was not surprising that the givers in both the village valued in-cash return, while the receivers, in general, attempted to avoid it. When asked about the relevance of in-cash returns in her life, Nita responded, '*with money we get [to pay for] grinding [to make wheat flour], salt, cooking oil, turmeric. With all this, at least some of my [financial] troubles are resolved…when I get 20-30 rupees then only I get to buy spices for cooking*'. Ranjan added, '*if we get regular payments, my study fees could easily be covered by the [cash] collection.*' Aarti on many occasions spoke of lack of cash as one of the

[12] There were solar-items used by the Nita, Ranjan, Aarti and Ramesh, i.e. the givers and their nuclear family members. But we have excluded these from the calculations of the number of receivers at both the villages as the focus of the research is on inter-household exchanges.

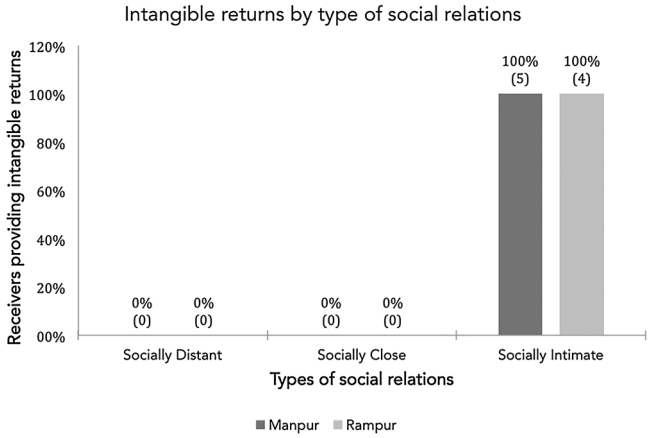

Fig. 10. Distribution of receivers who provided intangible returns by the type of their social relationswith the givers.

starved. Moreover, cash availability in the households varies across the year as agricultural production is seasonal and does not result in regular monthly income for the households. Both the givers reported the in-cash collection to be strenuous, and heavily contested as compared to the cases of in-kind and intangible returns. Nita and Aarti stated that the situation where all the receivers provide in-cash returns at the end of every month could create some problems for them. They fear large quantity of cash in their household would bring unwanted attention to the monetary accumulation, which could lead to demands for small monetary borrowing by other villagers, needless purchasing requests by their family members, and can also make their household vulnerable to theft.

An introduction of in-cash return has potential to strain a social relationship between a giver and a 'socially close' or 'socially intimate' receiver and can turn other ongoing exchanges of goods and services between them to be cash based. The villagers fear such a situation and wish to avoid it. It is common to hear people making statements like, '*when he/she takes money from me so would I*' in an attempt to justify and

Fig. 11. Some examples of returns. Please note the labels: '1' shows Aarti calculating in-cash return provided by a receiver seen in the background; '2' shows Vasu Yadav's tractor (Section 6.1); '3' displays some two spades made by a receiver (RP-R22 in Table 5) to be a return; '4' shows Shiv Yadav's diesel-powered pump-set (Section 6.3).

reasons for economic troubles of her household and hence her interest in obtaining in-cash returns. See Fig. 11. In the cases of energy exchange with 'socially distant,' the givers desired in-cash returns as well as making some 'profit.' In such energy exchanges, the givers categorically specified monetary rent to the receivers, numerically calculated the in-cash returns and registered the amount of the return provided in respective self-reporting diaries. Commensuration was important for the givers.

Even though at Rampur and Manpur in-cash returns were the most common type of return, these have many limitations, and the givers had to deal with many issues in administrating, operationalizing, and procuring them. A large section of the population reported being cash-caution others when asked for any cash payment. It is visible in case of energy exchanges of Nita with Vasu Yadav. Vasu Yadav belongs to local patrilineage (*gotiya*) of Nita's husband. Vasu Yadav's family on a past number of occasions has helped Nita without asking for any monetary benefits. Whenever Nita requested them for little access to their tractor, Vasu's family member agreed to plow Nita's field without stressing for money. They asked for a monetary return only when the tractor was needed for a considerable amount of time (see Fig. 11). Similarly, both the families exchanged small quantities of goods on need basis without any monetary translation. Nita started providing them a solar-item and initially stated that she would not ask for in-cash returns from Vasu Yadav due to close social relations between the families. However,

when Nita faced a severe economic crisis in life, she asked for in-cash returns.[13] She cautiously but firmly emphasized 30 rupees as monthly rent for providing solar-item. Vasu Yadav's family reacted strongly to Nita's demand and Vasu said, '*we help her family a lot, she should not ask for money from us.'* Vasu's family was also bitter that Nita had made the monetary calculation. Nita persisted with her demand, and Vasu's family provided her with in-cash payments to clear some of the dues and made a cautionary statement, '*you have taken money from us. Fine, but when you will need something from us, we will also do the same*'. A few months later, Nita requested them for brief access to the tractor. Vasu responded by asking for a precise cash payment for the tractor and Nita had to agree reluctantly. Since then, both families have started calculating the monetary worth of other goods as well, which were often provided without any monetary translation and this forces them to use cash, a limited resource, as a mode of payment. The bitterness with the use of cash has trickled in their social relations.

6.2. Vignette: combining in-cash with in-kind returns

This vignette describes characteristics of in-kind returns that the givers pursued from 'socially distant' receivers while engaging in a mutual energy trading. Further, this vignette showcases how in-kind returns were utilized as the receiver did not have sufficient cash for payment.

Nandan Singh is a middle-aged farmer at Manpur whom Aarti describes as their village acquaintance. He became a receiver at the end of February 2016 and continued to be one since then. Nandan started taking a charged solar-item on a regular basis but did not pay any rent for four months. On a few occasions, Aarti and Ramesh reminded him to pay the monthly rent of 60 rupees. As in the previous vignette, here as well making a 'profit' or a material gain was necessary for the givers. Nandan apologized for the delay due to lack of sufficient cash to pay the rent but assured them to clear all the accumulated dues eventually. Aarti and Ramesh demonstrated their trust and empathy for his economic condition and continued to provide him the solar-item. A fascinating event happened in September 2016 when Nandan provided two kilograms of garlic pods to Ramesh as a return for the solar-item. In the following extract, Ramesh indicated his view on accepting garlic:

> Ethnographer: *Why did he give you garlic instead of cash? Did you need it?*
>
> Ramesh: *Yes. I have sown garlic in my field. You will see it outside [pointing to his field]. Garlic was needed for it. He [Nandan] said he was going to sell garlic and then will give me cash [to clear the dues]. I told him as I am in need of garlic, give me garlic instead of cash. He said okay, take it.*

It is a common practice that the villagers sell any surplus of their harvest to the wholesale market in Gaya. When Nandan brought the garlic pods to Ramesh's house, Ramesh measured them using his weighing scale. At that moment, the market rate of one kilogram of garlic was 120 rupees. Nandan and Ramesh mutually agreed to use the market rate as a reference to calculate the monetary worth of two kilograms of garlic to be 240 rupees. Hence a commensuration in return was achieved. This measurement and agreement were crucial for the satisfaction of both the giver and the receiver as indicated in the following comment:

> Aarti: *both parties [giver and receiver] are satisfied if it is measured.*

[13] In March 2016, Nita's cow died due to an illness. She had bought the cow a few months earlier with a large loan from a bank. This situation was a massive economic crisis for her household. This situation also marked a shift in her approach towards energy exchanges. Monetary returns became even more significant for her. She started speaking of energy returns as a way to reduce her financial stress.

Table 5
Various in-kind returns utilized at Rampur and Manpur between 1 February–31 December 2016.

S. No.	Receiver-ID	Village	Relation with the giver	Type of Return Provided	Description of In-Kind Returns
1	RP-R5	Rampur	'Socially-Close' (*gotiya*)	In-kind (work)	Service of diesel-powered irrigation pump-set for 20 h and 30 min.
2	RP-R6	Rampur	'Socially-Close' (*gotiya*)	In-kind (work) combined with in-cash	Service of diesel-powered irrigation pump-set for 4 h, access to buffalo and plow, and 150 rupees.
3	RP-R8	Rampur	'Socially-Close' (*gotiya*)	In-kind (work) combined with in-cash	Provided service of his tractor and ploughed Nita's field twice in 2016, and 90 rupees.
4	RP-R9	Rampur	'Socially-Close' (*gotiya*)	In-kind (work) combined with in-cash	Service of diesel-powered irrigation pump-set for 3 h, and 105 rupees.
5	RP-R10	Rampur	'Socially-Close' (*gotiya*)	In-kind (work) combined with in-cash	Service of diesel-powered irrigation pump-set for 4 h, and 227 rupees.
6	RP-R21	Rampur	'Socially-Distant'	In-kind (work)	Access to 'jharni,' a tool for husking of grains on three occasions, and 227 rupees.
7	RP-R22	Rampur	'Socially-Distant'	In-kind (work)	Made a wooden ladder and two spades (agricultural tools).
8	RP-R27	Rampur	'Socially-Distant'	In-kind (non-food) combined with in-cash	8 L of Kerosene oil and 103 rupees.
9	MP-R12	Manpur	'Socially-Close'	In-kind (work) combined with in-cash	Medical consultations and 60 rupees.
10	MP-R8	Manpur	'Socially-Close'	In-kind (food) combined with in-cash	Provided few liters of milk and 100 rupees.
11	MP-R19	Manpur	'Socially-Close'	In-kind (food) combined with in-cash	250 g of clarified butter ('ghee') worth 200 rupees, milk, and 120 rupees.
12	MP-R20	Manpur	'Socially-Close'	In-kind (food)	Milk for two months (worth 80 rupees).
13	MP-R23	Manpur	'Socially-Distant'	In-kind (food) combined with in-cash	7 kg of potatoes (worth 120 rupees) and 240 rupees.
14	MP-R31	Manpur	'Socially-Distant'	In-kind (food) combined with in-cash	2 kg of garlic, 1 kg of corn, and 280 rupees.
15	MP-R27	Manpur	'Socially-Close'	In-kind (non-food)	Cow-dung cakes (worth 180 rupees) and milk (worth 70 rupees).
16	MP-R29	Manpur	'Socially-Close'	In-kind (food)	Green lentils (worth 150 rupees), cow-dung cakes (worth 100 rupees), 1-kg vegetable (worth 20 rupees), and few liters of milk
17	MP-R16	Manpur	'Socially-Distant'	In-kind (non-food)	Cow-dung cakes (worth 200 rupees).

Both will be assured that the amount returned is fair and balanced. If it [return] is unmeasured, then they [receiver] may feel whether they have given more than what was an appropriate amount. Similarly, we [giver] will be assured they have not given less than what it should be.

Similarly, Nandan also provided Ramesh with one kilogram of corn worth twenty rupees as a return for the solar-item. Over the period of eleven months, Nandan provided 260 rupees through in-kind return and 280 rupees in cash. At the end of 2016, he still owed 120 rupees to Aarti but assured her to clear all the dues using a combination of both in-cash and in-kind returns. See Table 5 for details of other 'socially distant' receivers at Rampur and Manpur who used a combination of in-kind and in-cash returns.

A noteworthy finding was that when the giver had a choice between accepting in-kind return in the form of an item they need or an equivalent amount of cash, they preferred the former. Ramesh in the following conversation eloquently put forth his rationale behind the choice.

Ethnographer: *If someone asks you to choose between taking cash as rent or an item you need, such as garlic. What will you choose?*

Ramesh: *As such both are fine. However, if I accept cash eventually, it will be a lesser amount. If he is already selling the item, so I will take the item. Like, I choose to take garlic instead of cash.*

Ethnographer [indicating obscurity]: *Why will you prefer the item [over cash]?*

Ramesh: *To get an item, I would have to go to the market. So if someone [any receiver] is going to sell the item by himself, so I will tell him that as you have dues to clear then why don't you give this thing to me as I have to buy it in any case.*

In general, the villagers' value peer-to-peer exchange of locally produced goods, such as food items, over trading in the market. The transaction cost of market-mediated trading of goods is high due to the remote location of these villages and inadequate public infrastructure such as roads and means of transports. Moreover, the villagers wish to circumvent a need for involving a middleman to trade in the market. A common perception amongst the villagers is that the middlemen financially benefit at their expense and trading an item in the market often introduces various intermediaries in the process. Furthermore, it is a common practice for villagers to compensate each other for providing a service by use of an in-kind mechanism. For instance, at Rampur, Nita regularly hires some (landless) villagers to work in her field and commensurate them with rice grains.

At Manpur, six other receivers provided food items as returns (see Table 5). An important caveat many receivers explicitly state is that they will use a food item for a return only when they have a surplus of the food item beyond the requirements of their households. Preference for food item over cash is further indicated in Aarti's strategy to not ask for any in-cash returns from a lentil farmer, also a receiver (MP-R28), with whom she has reached an agreement for taking five kilograms of *moong daal* (green lentils) in late 2017.

6.3. Vignette: in-kind return to avoid in-cash

This vignette describes characteristics of in-kind returns that the givers pursued from 'socially close' receivers while engaging in a mutual energy sharing. This vignette presents a case where a giver and her 'socially close' relation used in-kind returns as they were unwilling to use in-cash returns due to the nature of their social relationship.

Shiv Yadav is a farmer at Rampur and belongs to local patrilineage (*gotiya*) of Nita's husband. Shiv requested Nita for a solar item for her frail and elderly mother, who has failing eyesight that severely restricts her mobility after the sunset, and for his school going children to study after the sunset. Nita readily agreed to the request and assigned a solar-item. However, Nita was hesitant to ask for any in-cash return due to the nature of her social relationship with Shiv and his family. In the local sociocultural setting, taking cash-based payment from *gotiya* is a contentious issue as they can construe it as an act of pursuing 'profit.' The villagers consider profiting from *gotiya* as immoral. However, it is not objectionable for someone to get his/her monetary due but without making any 'profit.' Nita feared Shiv and other members of the *gotiya* would view her as greedy and making monetary 'profit' if she asked for cash-based payment at the end of every month. This situation is in contrast with the previous two vignettes where the value of 'profit' was justified and desired by the giver. This situation was precarious for her as it could socially isolate her from the *gotiya*.

For the first few weeks since the start, Nita continued to provide Shiv with a solar-item without mentioning any rental payment. She started to implicitly convey to Shiv's family and her other members of the *gotiya* through casual talks about the amount of labor that goes into managing the setup. She attempted to first establish a moral and social legitimacy for a rental collection from them. Most of the *gotiya* households acknowledged her efforts and an opinion developed amongst the *gotiya* that her efforts deserved monetary compensation either by providing in-kind returns or a combination of in-cash and in-kind returns. A notable exception was the reaction of Ravi Yadav, who was unsatisfied with Nita's rationale rental collection and raised moral questions by stating, '*You would take money from us? You are making a profit from us (humse faida kamati hai).*' They refused to provide any in-cash or in-kind rent, returned the solar-item and the energy exchanges stopped. In contrast, Shiv's family considered the rent as fair and not 'profit', however, they revealed their unwillingness to part with hard-earned cash for the rental payment. In mid-March, Nita cautiously made an offer to Shiv's family to which they agreed. Nita agreed to regularly provide Shiv's family with a solar-item for the rent of 30 rupees per month. Instead of providing rent in-cash, Shiv would irrigate Nita's field using his diesel-powered irrigation pump-set.

Shiv owns a diesel-powered irrigation pump-set for past many years. As Rampur does not has access to any form of running water, villagers rely on monsoon rains and groundwater extracted by these irrigation pump-sets as the primary means for irrigation. It is a common practice for the villagers to provide service of the pump-sets to other villagers for a locally agreed rate of 30 rupees per hour. In the past, Nita had requested and negotiated with Shiv and other villagers for irrigation and had paid them 30 per hour in cash and in-kind for accessing their irrigation pump-sets. Hence, Nita and Shiv had an ongoing monetary exchange relationship. Shiv irrigated Nita's field for a total of 20.5 h as a return for the solar-item (see Fig. 11). At the end of 2016, Nita owed Shiv 285 rupees, which she intended to balance with solar-items in 2017.

In this case, Nita and Shiv quantitatively measured the return by keeping account of the number of hours of access to the irrigation pump. The giver and the receiver achieved commensuration by figurative translation of these hours of use to a monetary worth as indicated by Nita in the following statement, *'rent for one month [of solar-item] is 30 rupees. One hour of irrigation pump is also 30 rupees. So, when I used the pump for six hours, I makeup [sic] for 6 months of [providing] light within the day'*. A vital aspect of these calculations is that the giver performed these as a way to get fair compensation and excluded the notion of 'profit.' See Table 5 for details of other 'socially close' receivers at Rampur and Manpur who either provided a combination of in-kind and in-cash returns or used solitary in-kind returns.

An important observation was that whenever Nita had an option to choose between in-cash return and in-kind return she selected the later. This observation corresponds with the preference for in-kind returns at Manpur as reported in the previous section. In many instances, Nita refused to accept an instant in-cash return from a receiver and negotiated for a delayed in-kind return. In such a situation, Nita could have accepted in-cash return whenever it was offered and used the money collected to pay for the entity (work, service, or commodity) whenever she needed it. In such a way, she could have lowered any risk of non-

payment, but the following conversation provides an alternative explanation:

Ethnographer: *What is better for you if a receiver offers you payment in cash or in-kind, such as by providing work?*

Nita: *Work is better*

Ethnographer: *Why is work better?*

Nita: *Isn't work always better? If one gives me 30 rupees, it will not be of much benefit [to the household's economic condition]. That is why I said to them [receivers], why do you give me 30 rupees [in cash]? Add all the dues and later do some work for me. So this [work] is better. If someone gives us 30 rupees, then it will be spent somewhere but if someone works then some vital work will get done. That is why I prefer work [over cash].*

In the above extract, the reasoning for Nita's choice to prefer for in-kind returns over cash lies in the value of such work and services in these villages. Nita and other villagers narrated difficulty in securing such essential services and resources. Acquiring such service requires a lot of social negotiations, and one has to deal with the risk of disagreement and other crisis. Villagers reported various instances of disputes and arguments over access to such services. Hence, Nita preferred in-kind returns as it secures a need in the future.

6.4. Vignette: cases of intangible returns

This vignette describes characteristics of intangible returns, which the givers pursued from 'socially intimate' receivers while engaging in a mutual energy sharing. This section exhibits the conceptual distinction of intangible returns from the monetary returns (in-cash and in-kind) by describing the cases of Ram Manjhi at Manpur and Nita's joint family group at Rampur.

Soon after the installation, Aarti and Ramesh invited Ram Manjhi to take a solar-item from them. Both of them were eager to provide a solar-item to Ram's family. Ramesh informed that his grandfather and Ram's grandfather were close friends. He proudly stated that close bonding between the families have continued since then and the families have firmly stood by each other. Ram accepted Ramesh's offer and continued to use the solar-item till it was broken-down in November 2016. For the lights provided for ten months (Feb.-Nov.), Aarti and Ramesh did not ask for any rent. Ram did not provide any in-cash or in-kind return, and yet Aarti and Ramesh were satisfied with the exchanges. This behavior was in contrast with energy exchanges with 'socially distant' receivers with whom Aarti and Ramesh were found demonstrating their anguish for non-payment and demanding rental payment either in-cash or in-kind. The ethnographer probed this situation further:

Ethnographer: *Did you ever ask them [Ram Manjhi] for rent?*

Aarti: *No. We have not asked them to give us rent. They will give [rent] on their own*

Ethnographer: *So, why have you not asked them for any payment?*

Aarti: *Well, our families are very close to each other. Our families have a history of being and dining together. We have worked together [indicating their closeness]*

Ethnographer: *For what do you work together?*

Aarti: *We work together in the field. For instance, sometimes they [Ram Manjhi's family members] help us with agricultural tasks. On some other occasions, we help them.*

Ethnographer: For the work in the field do you pay each other?

Aarti: *No! It is 'adla-badli' [reciprocating/swapping], meaning I do something for you and you do the same for me.*

Ramesh and Aarti gave similar responses for four other receivers consisting of three of his friends and a *gotiya* (Surya Singh). Aarti informed of a noteworthy interaction with Surya. Months after the start of energy exchanges with Surya, he visited Aarti and gave her 200 rupees. Aarti refused to accept the money, but Surya insisted that the amount was not a rent payment but a contribution to repair and maintenance of the setup. She eventually relented to Surya's insistence. She emphasized that he gave the cash by himself ('*apse se de gaye*') and mentioned that this was without any expectation from her end. She did not count this cash transaction as an in-cash return but as a token of social support. Ramesh later added, '*we will not ask for a monetary return from any family members. They will say that he is giving amongst his own and still asking for money.*' Ramesh and Aarti considered various social gestures and acts such as help in the field, and assistance during the time of need to be appropriate returns from the 'socially intimate' receivers. Similarly, at Rampur, Nita provided a solar-item each to her father-in-law, mother-in-law, brother-in-law and sister-in-law throughout the study. All of these receivers are part of her joint family group. Nita did not ask for any rent, and these receivers offered none. It also reflected in the self-reporting diary where there is not a single instance during the eleven months where Nita and Ranjan mentioned any monetary dues. It is a significant observation in light of financial trouble Nita was dealing with and desperate measures she was taking to increase her financial earnings. As in the case of Ram Manjhi at Manpur, Nita made similar arguments for not asking for any rent from these receivers:

Ethnographer: *Do you take any rent from these receivers [pointing to names written on a self-reporting dairy entry]?*

Nita: *We do not take any rent from Madhav [Nita's brother-in-law]*

Ethnographer: *From Rachna [Nita's sister-in-law]?*

Nita (attempting to clarify): *She is my sister-in-law, [similarly my] mother-in-law and father-in-law, how can they pay rent?*

Ethnographer: *But do you tell them to provide rent?*

Nita: *I do not ask. What will I tell them? From them, rent is not necessary. I do not ask them for anything.*

Ranjan: *If you feel like it, then only give, if you do not feel like it then does not give anything*

Nita's choice (and also of Aarti and Ramesh at Manpur) to not ask for any monetary rent from her 'socially intimate' receivers is grounded in a sociocultural milieu, where engaging in a monetary exchange with such persons is considered to be morally inappropriate. Elaborating on this issue, she and other villagers mention, '*this is how we live.*' Nita further added that by offering solar-items to her in-laws she was able to maintain her social relationships, demonstrate her goodwill and preserve their social support. She viewed these intangible entities as sufficient return for the solar-items provided. In the absence of her husband, Nita relies on her in-laws for various tasks. They play a crucial role in mediating in resolving any crisis she faces. Brewing property dispute between her husband and one of her brother-in-law had made the situation of her nuclear family precarious. For the time being, with the mediation and support from other members of her joint family group, a temporary truce has been established. The disputes within the joint family group have made her realize that she cannot take the social support and goodwill of members of her joint family group for granted.[14]

Overall, in these cases of mutual energy sharing with the 'socially intimate' receivers, the givers deemed intangible returns as more valuable than any monetary (in-kind or in-cash) return. The ethnography demonstrates that people repelled quantification and measurement of the intangible returns. Similarly, they do not translate intangible

[14] See [13] for more details on disputes within Nita's family and its influence on energy exchanges.

returns into any monetary value. The notion of 'profit' is absent in these cases. These returns are qualitatively felt and experienced. Likewise, an idea of commensuration and translation concerning money can destroy the essence of these returns. A receiver provides an intangible return on his or her own without being asked for it. The act of asking, calculating and measuring are a risk and counter for purposes of intangible returns such as maintaining an enduring social relationship.

There are two unique methodological problems with intangible returns. First, these intangible returns are often latent and well concealed within ongoing social interactions that the givers and receivers usually do not perceive or state them as 'give and take.' For instance, a giver does not view a specific act of kindness by a receiver as a return for energy transfers. Second, in-cash and in-kind returns can also lead to some intangible benefits. For instance, Nita and Ranjan reported getting small favors and help, such as borrowing an agricultural instrument or getting a free ride to the city, from the receivers. They stated with confidence that the energy exchanges have contributed to various small and mundane favors they received in their everyday life, but they struggled to specify which one to those gestures were returns linked with energy transfers.

6.5. Coda to the study

The infrastructure remained with the givers after the end of the study on 31 December 2016. The givers continued to provide the solar-items to the receivers. During the study many solar-items were damaged; nevertheless, the givers were able to repair some of these and put them back in circulation. At the time of preparation of this manuscript, i.e., in early 2018 and two years since the 'installation,' the infrastructure was still being used. However, only a small number (< 10) of the solar-items have remained functional. The longevity of the infrastructure can be attributed to the value the givers attached to the infrastructure and also to the maintenance and care they had provided. The givers have repeatedly communicated their sense of satisfaction with the overall compensations provided by the receivers.

Towards the end of the study, the ethnographer asked the givers about how the choices they made were similar and different from a situation where they had to invest in the infrastructure to procure it financially. As also highlighted in Section 4.2, the givers firmly stated that even though they did not financially invest in the infrastructure, they 'paid' for it with their efforts. They considered the infrastructure as privately owned by them and mentioned that their choices and decisions would have been mostly the same.

However, the givers state specific subtle differences. The givers felt had they financially invested in the setup the energy exchanges would have started with lesser rental negotiations. The villagers would not have questioned the legitimacy of their decision to ask for rent. They clarified that even then the negotiations on the amount of rent would have happened. They pointed out that such negotiations are typical in the villages and are part of everyday access to goods and services from each other. The givers stated that with the 'socially intimate' persons they would have dealt with in the similar way as observed in this study. The givers reiterated that the villagers avoid monetary and calculative exchanges with 'socially intimate.' In support of their argument, they indicated that their 'socially intimate' relations regularly share various 'machines,' such as motorcycles and mobile phones, with them without asking for any payment or monetary calculations. In case of 'socially close,' the givers stated that they still would have offered the solar-items, however, a difference would have been in the directness in asking for the rent from these receivers. For instance, at Rampur, Nita felt that had she purchased the setup she had been more forthright in asking for in-kind returns from gotiya ('socially close') households, yet she would have preferred in-kind returns in dealing with them. The givers added that the infrastructure had made them and the villagers aware of how energy exchanges can work in their social world. However, without this understanding, the givers and the villagers are less likely to buy the infrastructure.

7. Returns-continuum: a conceptual model

Based on the ethnographic findings, we propose that the three types of returns, i.e., in-cash, in-kind and intangible, can be viewed as a co-existing, overlapping, dynamic, and continuous spectrum, i.e., a returns-continuum, in the social sphere of economy. See Fig. 12. Here, we utilize formulation of spheres of an economy by Arjo Klamer, a cultural economist, to support the proposition of returns-continuum.

Klamer proposed the notion of spheres of an economy as a way to bring together perspectives from anthropology and economics (see [97] for more details). He proposed three distinct spheres of economy, namely, market sphere, social sphere, and home sphere. The social sphere of the economy consists of everyday social interactions that are outside of the home and the market [97]. Hence, it is also considered to be a non-market space where local communities strive. Economic Anthropologist, Stephen Gudeman, describes it as 'community realm' of an economy [98]. A social sphere is where mutual energy exchanges emerge (see [13]). Our conceptualization of returns-continuum views the social sphere of energy economy to overlap with the market sphere at one end and with the home sphere at the other end. The market sphere comprises of people's everyday participation in acts of buying and selling mediated by a market structure [97]. Whereas the home sphere encompasses processes of transfer and allocation of things based on a strong sense of kinship, or a feeling of social bonding and connectedness [97].

The returns-continuum proposes that at the market end of the social sphere, in-cash returns are preferred whereas towards the home sphere intangible returns are valued, and in between these two ends in-kind returns acquire prominence for people. Further, the returns-continuum suggests that people's preference for a type of return varies with the dynamics of their social relationship, i.e. 'social connectedness' between a giver and receiver. In general, the returns-continuum, conceptually suggests that structuring and procuring a return is not only an economic event but also a complex sociocultural process.

7.1. Preference for in-cash return

The givers usually pursued in-cash returns when participating in mutual energy trading with the 'socially distant' receivers. In-cash returns are important for the givers as it helps them to acquire fiat money, an entity that is an important means to address various necessities of people's life. As is the case of a large number of villages in the world, these villages are not entirely self-sufficient. The villagers have to obtain a variety of necessary goods and services from the market for their survival. Therefore, a social sphere and home sphere of an economy are connected to and dependent on a market sphere for certain necessities. This reliance and need to engage with the market contribute to the value of fiat money in the village, as it is an essential means of payment for procuring goods and services from the market. It seems that fiat money is one of the necessary tools for connecting a home, community, and village economy to the market sphere of an economy.

From a utilitarian perspective, use of in-cash return seems to make an energy exchange simpler and efficient. As compared to in-kind and intangible returns, the in-cash return seems easier for the villagers to document, memorize, and calculate credit/debit balance. However, the ethnography also reports various issues with in-cash returns (Section 6.1) such as (a) scarcity of cash; (b) procuring these is a strenuous exercise; (c) theft and unnecessary spending risks; and (d) potential to strain social relationships. The ethnography provided rich accounts of situations where the givers refrained from pursuing in-cash returns from 'socially close' and 'socially intimate' receivers. All these issues also indicate that people do not view and invoke returns using only utilitarian economistic logic. Instead, people structure returns by employing a range of social, cultural, moral and economic notions, which

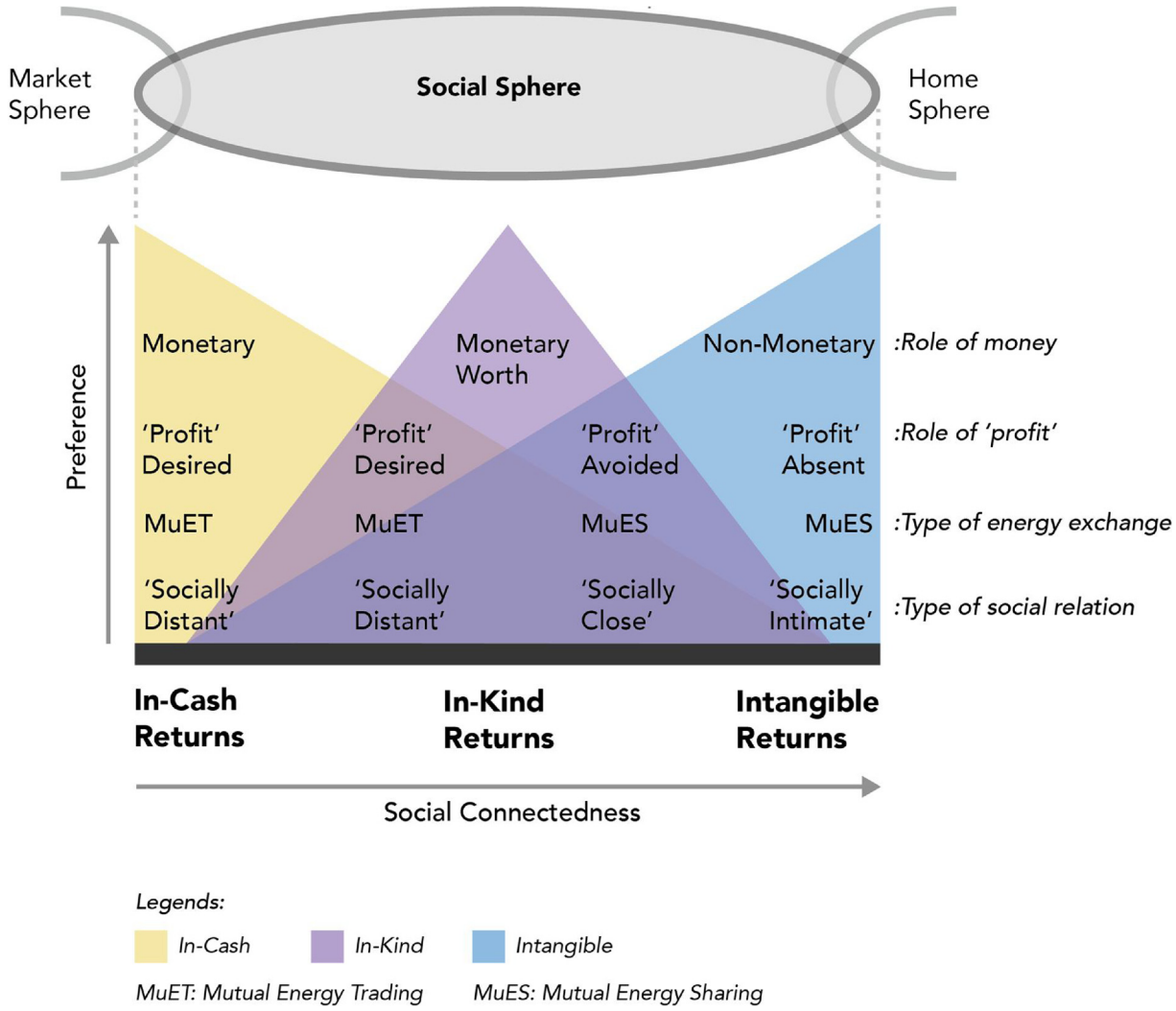

Fig. 12. A visual representation of a returns-continuum.

explain why people prefer a particular type of return in a context while renouncing the same in another context.

7.2. Preference for in-kind return

The returns-continuum proposes the in-kind return as conceptually between in-cash and intangible returns. The givers pursued these in-kind returns when participating in mutual energy trading with the 'socially distant' as well as in mutual energy sharing with the 'socially close' receivers. The ethnographic findings (Sections 6.2 and 6.3) denote that the givers at Rampur and Manpur when they have to choose between in-cash and an in-kind return of equal monetary worth, they hold the following preference order:

In-Kind Return > = In-Cash Return

An important caveat for this preference order is that the giver needs and values the in-kind entity offered by a receiver. With the use of in-kind returns, Nita and Shiv avoided any in-cash transactions and yet managed to access a needed item (solar light) and work (irrigation) for their respective households. Similarly, in-kind returns were a useful alternative in the situation of cash scarcity and poverty, where without the use of in-kind return energy exchanges would have stopped and many households would have been deprived of the solar lighting. With creative use of in-kind return, people were able to transact using items they needed and make the return mutually beneficial. This also signifies that even though both in-kind and in-cash returns are monetary, they cater to different social and moral values. The ethnography demonstrated and gave a more nuanced understanding of how monetary logic can govern in-kind return. In total, the ethnography showcases that in-kind returns are desired in a number of contexts: (a) to address scarcity of cash (Section 6.2); (b) to utilize locally produced goods and services for accessing energy (Section 6.2); (c) as a way to avoid moral issues with in-cash returns and to enable circumvention of cash in energy exchanges (Section 6.3); and (d) to secure a service in near future (Section 6.3).

7.3. Preference for intangible return

The ethnography (Section 6.4) indicates that the givers restricted themselves to intangible returns when participating in mutual energy sharing with the 'socially intimate' receivers. The intangible returns are built upon the notion of togetherness, friendship, love, solidarity, and different ways of bonding with others. In such cases, people seem to value their enduring social relationships more than making any monetary or material gain. The study indicates that in such a condition the givers at Rampur and Manpur seems to have the following preference order:

Non-Monetary Return (Intangible) > Monetary Return (In-Kind or In-Cash)

The giver and receiver structure an intangible return not through a rational economic framework but by using a moral, social, and cultural

compass where various intangible entities are aspired for and override the search for any tangible monetary benefit. The case of Surya Singh (Section 6.4) also hints at a way fiat money can acquire a different sociocultural meaning within the returns-continuum and can appear as an intangible return between 'socially intimate'. In cases of in-cash and in-kind returns, if a receiver does not provide a return, then the receiver has a monetary debt, whereas in case of intangible returns a receiver does not incur any monetary debt when not providing a return. However, a receiver can destroy the relationship and the exchange by only taking and not giving back, for instance by not contributing to the sense of togetherness, failing an expectation of the giver, or by not offering support when a giver needs it.

7.4. Variations in the meaning of 'profit'

The ethnography indicates variations in the sociocultural logic of 'profit' as invoked in the energy exchanges with different receivers. It showcases that the local notion of 'profit' is a relative concept rather than an absolute or fixed idea. A relational stance on 'profit' was visible in the breakdown of energy exchange with Ravi Yadav (Section 6.3), Nita's *gotiya*, while energy exchanges with Shiv Yadav and other *gotiya* households continued. Ravi Yadav interpreted the rent to be 'profit' while other *gotiya* considered the same amount of monetary rent to be not 'profit' but a fair compensation. A 'profit' seems to be relative to the various dimensions such as the nature of social relations, socio-economic statuses, and context of the exchange. We consider that the distinction between mutual energy trading and mutual energy sharing hinges upon this variation in the notion of the 'profit' as emphasized in the returns-continuum. The ethnography suggests that a giver and receiver mutually construct the notion of 'profit.' Hence, the valuation of 'profit' seems to be constantly negotiated within the locally emerging social, cultural and moral values of appropriateness, fairness, propriety, friendship, kinship, and family ties. These negotiations can be explicit and visible in conversations for a 'profit' desired from 'socially distant,' can be muted and avoided in case of 'socially close,' and can be absent in case of exchanges with 'socially intimate.'

8. Recommendations, conclusions, and future work

8.1. Acknowledging dynamics of social relations in returns

The concept of returns-continuum describes the complexity of social relationships in peer-to-peer returns. It emphasizes that the types of returns desired by a giver differ with the nature of his or her social relationship (social connectedness) with receivers. The concept views the social connectedness between people as dynamic, which changes with the passage of time, alters with shifts in life situations, and can be reconfigured during various social events. For instance, a 'socially close' person can become 'socially distant' and vice versa. Such changes in social connectedness between a giver and receiver could lead to a shift in the type of returns that they utilize in energy exchanges. Analogously, a variation in the type of return between people can also influence their social connectedness. A trace of it was observed in case of energy exchanges with Vasu Yadav (Section 6.1).

The concept of returns-continuum implies that practice of structuring, administering, and provisioning of a return is a sociocultural process that has potential consequences for a social relationship between a giver and receiver. Some energy researchers suggest the use of 'peer pressure' and making local community responsible for the payment collection from other villagers (for instance, see [14,23]). We recommend to energy researchers and practitioners that passing the entire responsibility of payment collection to a local community should be sensitively structured. A possible way forward is to take into account the social connectedness of local community members who are tasked with payment collection from other villagers. Potential future research in this regard can be in developing methods that can support energy practitioners to gain quick insights into social connectedness of people who are entrusted with payment collection in off-grid energy setting.

8.2. Enabling diversity in returns

Based on the ethnographic findings, the returns-continuum underscores that the three types of returns can co-exist and overlap with each other in the social sphere of an energy economy. Hence, these returns should preferably be understood as neither disjoint nor static. The proposal of returns-continuum recognizes that all the three types of returns have different values for people in different contexts of energy exchanges. Moreover, the returns-continuum acknowledges people's ability to use different types of returns simultaneously.

As already discussed, cash (or fiat money) is not the only type of return that people value. Even though in-kind and intangible returns, from the utilitarian point of view, may seem inefficient and laden with social negotiations. However, these allow people to cater to their social relationships and demonstrate sensitivity to the socioeconomic conditions of others. In-kind and intangible returns enable givers to creatively and empathically address their social dependencies on receivers, who are not merely their 'customers' but are an essential part of their life world. Hence, in-kind and intangible returns benefit local energy exchanges by creating space for sociality to emerge through social negotiations and maneuvers in the process of identifying an appropriate return. Moreover, these returns facilitate such off-grid setups to become more embedded in the social life of people rather than being a tool of lone rational economic benefit. Therefore, the concept of returns-continuum advocates for in-kind and intangible returns as meaningful in their own right and not as mere fillers in the absence of cash.

We recommend to energy researchers and practitioners to move beyond the fiat money-centric thinking by enabling diversity in peer-to-peer returns in off-grid energy systems. We advocate for an off-grid setup where all the three types of returns are facilitated, and people are provided with the control to structure and choose from these returns depending on the varying contexts of energy exchanges.

We consider that enabling diversity in returns can bring the following three benefits. First, it can help in making an off-grid setup to be more people-centered. This approach will allow people to adapt returns to the multiplicity of their life contexts. Moreover, it will make energy exchanges to be more responsive to the social, cultural, economic and moral values of people. Second, enabling diversity in returns can also help in addressing rural householders' limited ability to pay in cash, which is stressed as one of the major impediments to the growth of off-grid energy systems (see [16,23,32,99]), as the householders can legitimately use the other types of returns in case of cash scarcity. Third, relatedly, it has the potential to improve the rental collection, which is documented in energy literature to be a pressing issue for rural electrification [14,19,23,31,42]. For instance, in the case of energy exchanges with Nandan Singh (Section 6.2) rental collection could happen by combining in-cash and in-kind returns. Further research is needed to study technical, financial, infrastructural, and business challenges an external agency would have to address to enable diversity in returns. For instance, in a project where an external agency (NGO, utility, state) has to collect payment from people to cover the capital cost of the energy infrastructure (for instance [21]), in-kind and intangible may not be directly useful for them.

8.3. Interconnecting energy economy with the local in-kind economy

Building upon the formulation of spheres of economy by Klamer [97] and taking support from ethnographic findings, the concept of returns-continuum suggests that inter-household energy exchanges within a village to be considered as part of social sphere of energy economy, which is distinct and different from market sphere (and home sphere) of an energy economy. The ethnography demonstrated how the three types of return that populate the social sphere of energy economy

vary in types of calculation performed, scales of measurements used, notions of commensuration, logics, and values.

The study reported that the villagers' tend to prefer a localized, peer-to-peer, and in-kind exchange of goods and services within the village. Some of the reasons for this as documented in the ethnography (Sections 6.2 and 6.3) are: (a) to reduce transaction costs; (b) to avoid market trading that often involves various middlemen, whom villagers wish to evade; and (c) to escape use of fiat money for procuring goods and services for their households. Moreover, the villagers demonstrated their ease, creativity, and capabilities in exchanging various in-kind entities with each other. Hence, we recommend interconnecting local village economy of in-kind things, such as of agricultural yields, dairy production, skills, labor, and other everyday things with the economy of energy exchange. This recommendation suggests moving beyond '*energy for fiat money*' model of off-grid energy economy towards '*energy for in-kind things*' economic structures. Such an approach could assist in the development of new energy exchange models that can function without the need for fiat money and utilize locally available goods and services for the provisioning of energy.

A further study with more focus on investigating the potential of local economies for such system is suggested. Correspondingly, more research is needed to design and develop novel mechanisms that facilitate payments using different types of returns, incorporate a range of quantitative and qualitative calculations, various scales of commensuration, and importantly are not limited to the market-logic by enabling people to use diverse logics of their social spheres. Similarly, we recommend development of scalable solutions to interconnect such energy economies across villages. In this regard, ongoing developments in blockchain technology could have some potential. Blockchain technology could be utilized to track and translate various types of returns into scalable and meaningful measures. However, more interdisciplinary research is needed for making blockchain technology usable and relevant for energy exchanges in such low-resource settings in the global south. Similarly, further research is required to understand how with the mediation of digital technology the dynamics of social relations between a giver and receiver engaged in peer-to-peer energy exchange changes.

8.4. Relevance of ethnographic approach

On the methodological front, we recommend energy researchers to include ethnographic approaches to study the use of 'rents,' 'tariff,' 'fee-for-service,' 'payments,' and 'fees' in any off-grid setting across the globe. An ethnographic research endeavor, as demonstrated in this study, has potential to bring a holistic, layered, and embedded understanding of such returns. This ethnography showcased that the village level decision-making is complex, negotiated, convoluted, emergent, and filled with competing values and logics.

In this section, we also reflect on the generalizability of findings of this study. The emic details as presented in the descriptive ethnographic vignettes may be particular to rural India. We do not claim that the preferences for the three types of returns to be universal, rather these are locally embedded and can be ethnographically studied and uncovered. Similarly, moral issues with 'profit,' and determinants of social connectedness maybe particular to rural India. However, the etic understanding as presented with the concepts of returns-continuum, and conceptual categories of returns, and the social connectedness are more general than the ethnographic particularities. Similarly, the lens of social relationships, as emphasized by returns-continuum, in understanding various aspects of returns is generally applicable.

8.5. Significance of findings beyond rural India

We consider these conceptual outputs of this study to be relevant for off-grid rural electrification initiatives in the global south, such as [14,17–20,100]. For instance, instances of social connectedness influencing returns can be seen in the following text reporting on a 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*' ([100]: 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*' ([100]: 51). These empirical pieces of evidence are reflective of the underlying logic of social relations, which the returns-continuum brings to the forefront.

We also consider the concept of returns-continuum to be relevant for some emerging and envisioned contexts in the global north. The first author's ongoing user research on scenarios of energy sharing using bi-directional electric cars in a vehicle-to-grid system in a western European country indicates the relevance of in-kind and intangible returns in such contexts as well. Preliminary findings document various limitations of individual in-cash returns in such a setup and also indicate people's preference for in-kind and intangible returns when they consider energy exchange with their 'socially close' and 'socially intimate.' Once this ongoing research is completed, it will be published in a separate article. Another example from the global north is the Jouliette pilot [101] in The Netherlands where a local community manages a dedicated renewable energy-based smart-grid and the corresponding local energy economy. The website of the project mentions their plan to include some in-kind returns: *'Beyond just enabling energy exchange, the community will be exploring further applications for the Jouliette, such as using it to trade for goods at the De Ceuvel Café [site of the pilot], to facilitate a local time-banking system, and to integrate other intra-community services, such as a car-sharing program.'* [102]. We suggest further research on the relevance and preference of in-kind and intangible returns in correspondence with different factors of social connectedness in off-grid and smart decentralized grids located in the global north and global south [103,104]. Such an understanding can potentially provide useful insights for the energy practitioners and governments. Another challenging yet fruitful line of inquiry could be on how findings from off-grid setting in the global south can provide insights to off-grid pilots in the global north and vice versa.

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