Energy for Sustainable Development 24 (2015) 44–49

Contents lists available at ScienceDirect

Energy for Sustainable Development

Energy poverty among urban street vendors in India: Evidence from Patna, Bihar☆

David Szakonyi, Johannes Urpelainen *

Columbia University, USA

ARTICLE INFO

Article history:
Received 8 May 2014
Revised 11 November 2014
Accepted 19 November 2014
Available online xxxx

Keywords:
Energy poverty
Energy access
Urbanization
Informal economy
Street vendors
India

ABSTRACT

Rapid urbanization in the developing world underscores the policy challenge of urban energy poverty. This article investigates patterns of energy poverty in Patna, the capital of the state of Bihar in India. Informed by the field research, our emphasis is on inadequate lighting among street vendors. A survey of 1000 street vendors in the metropolitan area reveals high levels of energy poverty, with vendors being forced to choose between inadequate lighting and expensive power from diesel generators operated by local entrepreneurs. The survey also shows that vendors consider improved lighting a top priority and believe that improved lighting could expand their business and attract customers. While vendors are generally aware of solar panels, a few are using this technology in the marketplaces. The results reveal the need for new policy interventions that either promote grid access for the informal economy or seek new alternatives, such as solar lighting, to diesel generators.

Introduction

Since most studies of energy poverty focus on rural areas (Cabraal et al., 2005; Barnes, 2007; Zerriffi, 2011; Sehjpal et al., 2014; Akpan et al., 2013) the problem of energy access in urban areas is frequently overlooked. At a time of rapid urbanization across the developing world (Montgomery, 2008), this omission presents a problem for policy formulation. Marginalized slum dwellers and people employed in the informal sector also suffer from energy poverty (Hosier and Kipondya, 1993; Mwampamba, 2007; Baruah, 2010; Parikh et al., 2012), and the high population densities of urban centers make them potential targets for policy interventions. Together with rapid urban growth and the exponential growth of slums, the opportunities available for cost-effective policy interventions call for new empirical evidence on energy poverty among the urban poor.

This article contributes to this effort by providing detailed survey evidence on energy poverty and priorities among street vendors in Patna, the capital of the state of Bihar in India. The city's metropolitan area comprises a population of about two million people and suffers from high levels of energy poverty. According to the 66th round of the National Sample Survey of India in 2010, only 73% of the interviewed urban households in the Patna district had electricity at home. Although Patna's electricity access levels are much higher than in the surrounding rural areas of Bihar (Oda and Tsujita, 2011), inequities within Patna are significant. Few people participating in the informal economy have access to grid electricity, whereas wealthier shop owners can rely on electric power for their lighting, electronic, charging and cooling needs. The lack of reliable electricity supply prevents the urban poor from improving their livelihoods and saving money.

To understand energy poverty among street vendors, in early 2014 we conducted a baseline survey of 1000 vendors in 24 marketplaces in Patna and the neighboring satellite town of Hajipur. The 45-minute survey was based on a comprehensive canvassing of the marketplaces for vendors who participate in the informal economy regularly, and it contained detailed questions on the energy situation, with a particular emphasis on lighting. The survey was conducted in January–February 2014 among a random sample of vendors who were present at the marketplaces at daytime. The survey contained detailed questions on the livelihood, business, community, and energy access of the vendors.

Adding to a growing body of literature on electrification and microenterprises (Neelsen and Peters, 2011; Peters et al., 2011; Akpan et al., 2013; Grimm et al., 2013), the survey highlights the high degree of energy poverty among street vendors. Based on our fieldwork, we found that the lack of adequate lighting was by far the most common energy problem that the vendors faced. If vendors are to sell their products at night, they need a reliable and bright light. Customers avoid vendor carts that are in the dark, both because they are worried about their own security and because they cannot easily evaluate the quality of the products sold. This problem is critical for vendors that sell fruit,

☆ We thank Nidan for their efforts to ensure the success of this project and MORSEL for the excellent data collection. The survey was funded by the Bihar office of the International Growth Centre (35115). We are grateful to Michaël Aklin, Patrick Bayer, and S.P. Harish for their excellent comments on a previous draft.

* Corresponding author at: 420 West 118th Street, 712 International Affairs Building, New York, NY 10027, USA. Tel.: +1 734 757 0161; fax: +1 212 854 5670.
E-mail address: ju2178@columbia.edu (J. Urpelainen).

http://dx.doi.org/10.1016/j.esd.2014.11.002
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sweets, and means. Vendors that sell services, such as tailoring, also need a bright light to be productive in their line of business.

The vendors lack access to grid electricity for reliable and affordable lighting, pay a high cost for inferior alternatives, are dissatisfied with their current lighting solutions, and consider improved lighting a top priority for improving their business. At the same time, there was considerable variation among vendors in their situation. More experienced and profitable vendors chose to pay a high cost for access to a diesel generator as a stopgap measure, while female vendors seemed to suffer more from the lack of inadequate lighting than their male counterparts. The gender effect is particularly important insofar as it supports the interpretation that female vendors are generally worse off than male vendors. In the case of lighting, an additional explanation could be that female vendors have more reason to be concerned about safety problems that weak lighting creates.

These results have both academic and policy significance. For academic researchers, they identify an understudied area in the growing field of energy poverty, that of the urban informal economy. The interest in urban energy poverty has grown in recent years (Baruah, 2010; Parikh et al., 2012), but there are few recent efforts to capture systematically the extent of energy poverty among participants in the informal economy. Earlier efforts, such as Barnes et al. (2005) have focused on households and are, in any case, by now largely outdated.

In recent years, a few important studies have investigated the lighting issue for street vendors in particular. Yaqoot et al. (2014) conduct a survey of street vendors and centralized solar charging stations in the city of Dehrarun in India. Based on data from 150 survey respondents, they find that vendors are willing to pay a sufficiently high daily fee to cover the operating costs of a centralized solar charging station. We conduct our survey in a different area, use a much larger sample of vendors, and analyze energy poverty in a more comprehensive fashion. Rao et al. (2009) discuss a pilot project on the implementation of a centralized charging station in the city of Mysore in India. They argue that the pilot was largely successful because of careful coordination between a local bank, a non-governmental organization, a technology provider, and the street vendor community. Our survey provides descriptive results on the problem of energy poverty in a large metropolitan area and characterizes the demand for further solar interventions. Singh (2009) conducts a survey of three marketplaces in the city of Kanpur in India, finding that financial access is a key impediment to greater adoption of solar technology. We analyze a much larger sample of vendors and study energy poverty for various subgroups of the population, such as males and females. In a departure from all three studies mentioned in this paragraph, we also document and evaluate the widespread use of diesel generators in the marketplaces, along with vendor perspectives on why and how improved lighting would contribute to their business.

For policymakers, our findings underscore the need for urban energy interventions. Simple measures, such as the provision of adequate electricity infrastructure in busy marketplaces, could encourage small businesses to grow and become more profitable. For example, 87% of the vendors that we surveyed reported that they expect more customers with better lighting. Given the importance of street vendors in the economies of many developing countries, and certainly India, such small business growth could be a significant engine of growth and poverty alleviation. Our findings show that lighting solutions are a major impediment to improved profitability and livelihoods. The municipal corporation could offer electricity connections to street vendors against a small lease. In densely populated marketplaces, bright street lighting could also provide a collective solution to the problem. One additional benefit of street lighting is that it provides a collective solution to the problem of security, which turns out to be a major concern among vendors in our sample.

Another approach would be a government program to promote the use of decentralized off-grid alternatives, such as solar power. Most policy interventions and academic studies of solar technology have focused on their potential in rural areas (McEachern and Hanson, 2008; Chaurey and Kandpal, 2009; Wong, 2012; Palit, 2013; Smith and Urpelainen, 2014; Urpelainen, 2014), but our findings show that the urban solar market is also worth further investigation and pilot policy interventions. In addition to individual solar lights, there is potential for solutions such as centralized charging stations that provide lighting for a group of street vendors within a marketplace.

Energy poverty among street vendors in the Patna metropolitan area

This section describes patterns of energy poverty among urban street vendors in Patna, India. We describe both the high levels of energy poverty and the variation in the solutions that the vendors have developed to deal with their lack of energy access. Patna is a city with a population of approximately two million in the metropolitan area. While there are no comprehensive formal surveys of street vending in the city, our canvassing exercise suggests that tens of thousands of people participate in street vending in the metropolitan area. To study energy poverty, we conducted a random survey of 1000 vendors, asking them an extensive array of questions about their business and their energy profile. In the next two sections, we discuss the methodology used to conduct the survey as well as present basic descriptive statistics.

Methodology

The data for our study were collected in January–February 2014 in Patna, India, by the survey company MORSEL India. In collaboration with the NGO Nidan, we mapped all marketplaces in the city and the neighboring small town of Hajipur. We found a total of 51 marketplaces. Of these, we selected 24 for the purposes of the study based on three requirements. First, the marketplace should not be under the threat of immediate eviction by the municipal corporation. Second, the marketplace should have at least 30 regular vendors for the survey. Third, the marketplace should not pose a risk of violence to the enumerators. We also excluded one marketplace because we did a pilot study there and wanted to avoid contamination effects.

The vendors chosen to participate in this study sell vegetables, fruit, grain, sweets, garments, and street food. Many vendors also provide services such as tailoring, barbering, or repairs. In practice, the key form of energy poverty for street vendors is the lack of adequate lighting. We did not interview people who owned actual shops, since these shopkeepers are part of the formal economy and have access to basic infrastructure. The low quality of lighting reduces customers, causes safety problems, and prevents vendors from selling after sunset.

In the 24 marketplaces chosen, a comprehensive mapping exercise located a total of 1916 street vendors. Of the street vendors on this list, we interviewed a random sample of 1000 vendors. The survey lasted approximately 45 min and was conducted in Hindi, a language that all vendors spoke, by experienced enumerators who were fluent in the language. Exact question wordings for all results reported are included in the Appendix. In exchange, we paid a modest compensation of INR 10 (~USD 0.16) for their participation.[1] The response rate was above 95%, as is typical in the Indian context. To the extent possible, the surveys were conducted during the slow business hours between 11 AM and 5 PM. The Nidan staff accompanied the survey enumerators to the marketplaces to ensure the collaboration of the local leaders.

Data analysis

Basic descriptive statistics underscore the marginalized nature of the community. Although a street vendor runs a business, only 64% of them could read and write Hindi. Median household income per month was INR 7000. With a median household size of six people, this is less than INR 1200 (~USD 19) per person. The comparison to the urban median

[1] Exchange rate of 61.9 INR for 1 USD on January 1, 2014, at the beginning of the survey.

per capita in Bihar, INR 1507, is clearly unfavorable (Financial Express, 2014), despite the fact that Patna is generally wealthier than the other urban areas of Bihar. The median age was 36 years, and 40% of all vendors in the sample were in debt. Perhaps most tellingly, 67% of the vendors reported being in the profession because they did not have a choice. The vendors were also mostly stationary; 8.4% said that they had not needed to move over the last three months. On the whole, vendors appear to stay within their chosen locations for considerable periods of time. 66% of the vendors reported being at the marketplace seven days a week and the median vendor had been in the business for 12 years.

The data show a clear problem of energy poverty. Overall, the lack of adequate lighting is a serious concern among street vendors. As many as 13% of the vendors had no lighting solution of their own, and fuel expenditures among the remaining vendors were high. The average daily cost of lighting was 10.6 rupees among those who paid for their lighting, with some vendors paying as much as 50 rupees per day. By far the most common reported value is ten rupees per day. This significant variation, as illustrated in Fig. 1, highlights the diversity of lighting solutions and needs among vendors.

On average, the vendors had only 3.6 h of artificial lighting every day. Given that the sun usually sets in Patna already around 6 PM, it is clear that the lack of lighting is an obstacle to evening business. 62 vendors reported having no artificial lighting at all, while another 326 vendors reported having less or equal to 3 h of lighting. Overall, levels of lighting in the marketplaces were well below what one would expect, given that many customers with regular employment – and the high income that comes with such employment – can only do their shopping after business hours.

The lighting sources varied. Of the vendors, 11% reported relying on candles while another 13% reported having no lighting solution at all, depending on the street light, or exploiting a neighboring shop's light. 27% used a chargeable light, and only 11% reported using a kerosene, LPG, or emergency light. Only two vendors had a solar lighting solution, and the remaining vendors reported using grid electricity, a generator, or some combination of the two. This variety of lighting solutions suggests a lack of a proper infrastructural solution, such as reliable grid electricity.

In general, the vendors are trying to deal with the problem of lighting in different ways. Only 10% of the vendors reported having a grid electricity connection. Of every ten such vendors, only four had a legal connection. Even among this small group, there are good reasons to believe that the grid electricity connection is not a reliable source of power. Patna suffers from an acute power shortage and outages occur many times every week. Over the past five years, the state of Bihar has been rocked by several severe electricity crises, with millions of people adversely affected. A recent report by the data journalism initiative IndiaSpend (Bhowmick, 2013) identified Bihar as one of two states, along with Punjab, most at risk for serious electricity supply problems in the future. As of 2013, Bihar was already one of the five most power deficient states in India.

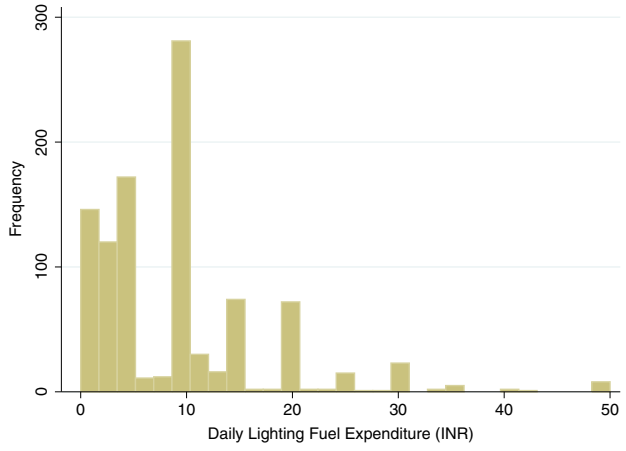

Fig. 1. Lighting expenditures among street vendors ($N = 1000$). Exchange rate: 61.9 INR for 1 USD.

Among the vendors, as many as 26% depended on a diesel generator. Of the 24 marketplaces under study, nine had no generator whatsoever, while the others had vendors that did and did not rely on a generator. None of the vendors owned their own generator. They were all paying a daily fee for their lighting solution provided by a prominent local businessman. Diesel generators are widely recognized as an inefficient and expensive "stopgap" source of power (Shah, 2009; Szakonyi and Urpelainen, 2013), and vendors would pay much less if they had access to grid electricity.

According to the survey, generator use doubled the daily lighting expenditure of the vendors, as illustrated in Table 1. While the mean daily lighting expense among non-users was 7.39 rupees per day, the corresponding expense among generator users was 14.6 rupees, that is, almost exactly double. The difference is statistically significant at the $p < 0.001$ level. At the same time, access to a generator does result in more lighting hours and a higher level of satisfaction with the current lighting solution. Generator users had almost 1 h more lighting than non-users, and their lighting satisfaction was 0.55 units higher on a 1–4 scale, with a value of 4 signifying them being 'very satisfied' with their current lighting. These differences are also statistically significant at the $p < 0.001$ level. Generator users pay a high price for their improved electricity access.

We also examined any potential differences in lighting expenditures, hours, and satisfaction between other types of vendors. As shown in Table 1, females appear to pay more money in daily fuel expenditures but do not receive in turn a larger number of hours of lighting or increased satisfaction from these payments. However, these differences are not statistically significant at the $p < 0.1$ level and we should be careful in drawing conclusions. Larger stands, as measured by superior income (higher than the mean of the sample) also spend more on fuel every day and experience an additional half hour of light every day. Subsequently, they appear to be more satisfied with their energy supplies. The same is true of stands that enjoy a connection to the electricity grid: they spend more money, but experience longer hours and greater satisfaction. All of these differences are statistically significant at the $p < 0.001$ level.

Among the vendors, levels of lighting satisfaction were on the whole quite low, as shown in Table 2 which reports answers to the question "How satisfied are you with your lighting?" on a 4-point scale. Almost 50% of the vendors are either very or somewhat unsatisfied with their current lighting solution, and only 16% are very satisfied. This is understandable, given that much of the street vendor business occurs at night. Without adequate lighting, street vendors cannot fully profit from the lucrative business hours after dusk, as customers eschew vendors whose carts are not adequately lit.

Table 1
Daily fuel expenditures, hours of lighting, and lighting satisfaction for vendors subset by: having a generator, gender, the size of stand, and having a grid connection.

	Daily fuel expenditure (INR)			Daily lighting hours (number)			Lighting satisfaction (1–4 scale)		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Generator no	7.39	7.69	743	3.32	1.68	743	2.44	1.06	743
Generator yes	14.6	7.66	257	4.34	0.98	257	2.99	0.76	257
Male	9.22	8.44	849	3.59	1.63	849	2.63	1.00	849
Female	9.36	7.49	151	3.54	1.41	151	2.34	1.08	151
Small stand	8.29	7.27	716	3.43	1.66	716	2.51	1.02	716
Large stand	11.6	10.1	284	3.96	1.35	284	2.77	1.00	284
Grid Connection no	8.97	8.43	818	3.41	1.52	818	2.44	1.00	818
Grid Connection yes	10.5	7.61	182	4.37	1.70	182	3.24	0.82	182

Higher values on the 'Lighting satisfaction' question denote increasing satisfaction. Stands are coded as 'Large' if they have income that is larger than the mean income of the vendor sample. Exchange rate: 61.9 INR for 1 USD.

Table 2
Levels of lighting satisfaction among the surveyed vendors ($N = 1000$).

	Lighting satisfaction	
	Count of vendors	Percent (%)
Very unsatisfied	239	23.9
Somewhat unsatisfied	97	9.70
Somewhat satisfied	505	50.5
Very satisfied	159	15.9
Total	1000	100

To summarize, the evidence underscores the challenges of energy poverty among street vendors. Only a small minority of vendors have access to grid electricity, and even they cannot rely on it completely due to frequent outages and voltage fluctuation. Among the rest, vendors decide between the expensive stopgap measure of paying for access to a diesel generator, if one is available in the marketplace, and continued use of less expensive but inadequate lighting solutions. Many choose to have no lighting at all. Levels of satisfaction about lighting are low.

The potential effects of improved lighting: vendor perspectives

A key goal of the survey was to identify any potential benefits that vendors might accrue from increasing their access to lighting solutions. To that end, we asked respondents to speculate about how their business operations might change if their lighting situation improved. The results offer new insights into the extraordinary gains that small business owners can receive from attention paid to their infrastructure needs.

In general, improved lighting is unequivocally in demand by shop owners. As Fig. 2 shows, nearly 80% of vendors considered improved lighting a top priority for their business. The survey question requested that the vendors evaluate the importance of lighting as a problem. This is a striking result, given how many problems vendors face in conducting their daily business.[2] Virtually every vendor considered improved lighting relevant for their business. These observations suggest that the low levels of lighting satisfaction reported in the previous section correspond to concerns about the profitability of the business and the difficulty of making a livelihood.

Generator users consider improved lighting less of a priority than non-users. On a 1–5 scale, with higher values indicating vendors seeing improving lighting as holding more priority, the mean is 3.57 for generator users and 3.73 for non-users. The difference is statistically significant at the $p < 0.001$ level. At the same time, it is also notable that the mean level is closer to top priority than to somewhat important even for generator users. This, again, suggests that generators are not a robust, sustainable solution to energy poverty among street vendors.

For example, the vast majority of surveyed vendors (87.5%) believed that improved lighting would help them increase the number of customers visiting their shop. Two possible explanations exist for this optimism. On the one hand, with more effective lighting solutions, vendors can stay open longer to hit the after-work consumer rush. Currently, many small shops are forced to shut down at sunset, with negative consequences for their overall revenue.

Vendors attested to the importance of lighting for extending their hours of operation, with 86% answering that improved lighting would allow them to work longer hours. Although longer hours carry an opportunity cost, it is important to remember that most vendors are in this business because they were unable to find alternative opportunities. Their household incomes are also so low that their families live in poverty. Therefore, the ability to work longer hours would be a major improvement for their livelihoods and the future of their families.

[2] However, we do not have extensive data on other problems that these vendors face with which to compare the results from this question.

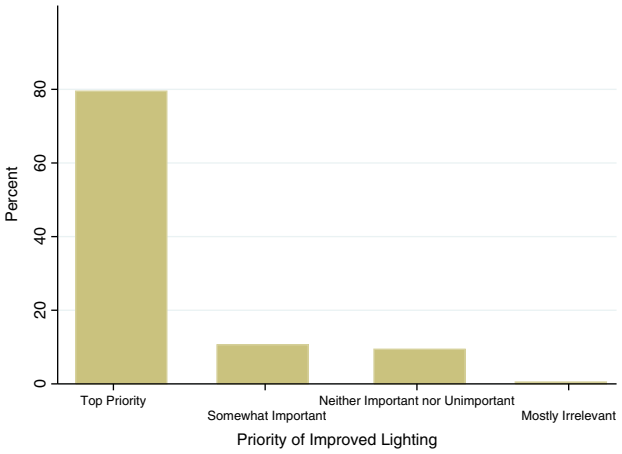

Fig. 2. Importance of lighting priority for vendors ($N = 1000$).

In addition to staying open at night, improved lighting may also result in a better sense of security in the marketplace. Many shoppers, especially women, may feel insecure in outdoor markets after-dark. More concretely, 42% of vendors attested to having witnessed violence near their shops. Similarly, 20% of vendors said that their customers had complained about a lack of security in their marketplace. Much of that feeling of vulnerability can be linked to lighting, to the degree that 78% of vendors stated that a lack of lighting is a real security concern for them. While adequate street lighting would be the ideal solution to this problem, individual vendors can also improve their lot by installing bright lights that illuminate the immediate vicinity of their cart.

Improving access to lighting will also have a marked effect on the composition of the vendors' customer base. As of now, women make up only 30% of the total number of the customers to the surveyed shops. Similarly, the average amount of money that women spend in the markets is significantly lower than that which men do; men spend on average 93 rupees versus roughly 60 rupees spent by women. This disparity may be partly caused by worries about their physical vulnerability in the marketplaces. Vendors agree: 76% agreed that they would get more female customers if the markets were safer, while 80% answered that improved lighting would help increase the number of women shoppers as well.

Lighting may also benefit vendors' bottom line beyond just increasing their customer base. Improved and consistent lighting solutions allow shopkeepers to better display their products and attract potentially wealthier customers. In fact, 31% of vendors agreed with the statement that improved lighting would allow them to increase their prices with the opportunity for more of that revenue stream to be used on further investments in their business.

We dug further into the data in order to explore which vendors were most encouraged by the possibilities offered by improved lighting. We ran regressions using each of the above questions as dependent variables: the effect of improved lighting on (i) attracting additional customers, (ii) working longer hours, (iii) increasing product prices, and (iv) attracting female customers. Predictors included a vendor's gender, age, and literacy, as well as a wide range of other business-related characteristics. The full results are presented in the Appendix.

Several findings especially stand out. First, female vendors, who make up 15% of the total sample, are among those most optimistic about the benefits of improved lighting for their business. They consistently answered that lighting would help them attract more customers – especially female ones – and work longer hours. We interpret these statistically significant findings of evidence that female business owners are apprehensive about working late into the night and taking advantage of the evening rush, most likely because of security concerns. Improving their lighting situation could thus have a notable effect on their business income.

Table 3
The effect of improved lighting on various business outcomes.

	More customers (%)			Longer hours (%)			Higher prices (%)		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
Male	0.87	0.34	849	0.85	0.35	849	0.30	0.46	849
Female	0.91	0.28	151	0.92	0.27	151	0.38	0.49	151

Each outcome is a binary measure: 1 denotes that a vendor believed that improved lighting would result in each of the outcomes, 0 denotes disagreement. The mean values are proportions in the relevant population. All quantities are statistically distinguishable between the two groups at least at the $p < 0.1$ level according to a two-tailed t-test. The differences in longer hours and higher prices are significant at the $p < 0.05$ level.

To illustrate this key finding, consider Table 3. It contrasts the beliefs of male and female vendors on the effects of improved lighting on their business. Female vendors believe that improved lighting will help them attract more customers, work longer hours, and charge higher prices. All differences are statistically significant at conventional levels. While the difference in the expected increase in customers is small, with both groups reporting high levels of optimism, the differences in the ability to work longer hours and charge higher prices are larger. This is important since female vendors tend to run much less profitable businesses than their male counterparts. The median male vendor reports a monthly profit of INR 6000 from the business, while the median female vendor only reports a profit of INR 5000. The difference in favor of the male vendor is 20%.

Next, we find that on average, those vendors who have already experimented with or are aware of various advanced lighting solutions are more likely to expect positive returns from lighting. For example, those vendors who already pay for generator access agreed that lighting improvements would help them increase prices – they are paying high prices for generator access now – and help attract female customers. Similarly, vendors with an awareness of the workings of solar panels are also more likely to see potential benefits if their own lighting situation was improved. These results suggest that increasing awareness among vendors about the effects of lighting on their business will increase interest in such solutions and potential technology uptake down the road.

Encouragingly, a majority of vendors are aware of solar lighting systems; 67% of respondents had heard of solar power. Over a third of vendors (34%) also knew someone who had used it. Even though information about this technology has diffused quite widely across this population, adopters are still extremely few in number. In all, only two of the thousand vendors surveyed stated that they used solar lamps themselves to provide light for their stands. Two possible explanations exist for these patterns: vendors either are aware of solar but refuse to adopt the lights for their business or vendors simply do not have the opportunity to use solar in their stands. Our survey currently does not allow us to distinguish between the two, but work on this type of technology adoption is forthcoming.

Men and women also have very differing awareness of solar power. As presented in Table 4, men are much more likely to be aware of solar lighting. Almost 3/4 of men had heard of solar, while less than half of females knew anything about this technology. This gender gap is important for policymakers wishing to market the systems to vendors, as females may have less access to information about the technology and require different marketing techniques. However, we do not observe similar differences in awareness between vendors who use generators and those who do not. Roughly the same percentage of vendors from the two groups attested to knowing about solar power.

Table 4
Differences in awareness of solar panels, subset by vendor characteristics.

	Solar awareness		
	Mean	SD	N
Male	0.73	0.44	849
Female	0.42	0.49	151
Generator no	0.67	0.47	743
Generator yes	0.71	0.46	257

Solar awareness is a binary variable: 1 if a vendor had heard of solar power, 0 otherwise. The mean values are proportions in the relevant population. The difference in awareness between males and females is statistically distinguishable at the $p < 0.1$ level according to a two-tailed t-test, while the difference between generator users and non-users is not.

Diesel generators as a stopgap measure

Effective, affordable lighting solutions are not readily available to most vendors. Some business owners have acted assertively to solve their energy problems. As discussed above, access to generators is available in some marketplaces; vendors can plug into nearby machines and pay relatively high prices for electricity. Generators are thus an effective 'stop-gap measure' to energy shortages for vendors, but come with an additional set of substantial costs (environmental, economic, and so on) for both individual and public welfare (Alby et al., 2013; Szakonyi and Urpelainen, 2013).

We investigated which street vendors were more likely to turn to generators as a solution to their energy problems by running a set of regressions. The full results are presented in the Appendix. Unsurprisingly, vendors with larger business income are more likely to use generators; their higher revenues allow them to spend greater amounts of money on securing electricity than smaller stands. In addition, vendors with more years working in street trade are more likely to use generators, even when controlling for business size. We interpret this as evidence that greater experience with vending translates into more understanding of the importance of lighting for growing one's business.

These results come from models that use fixed effects specifications in an attempt to control for the fact that generator access may not be uniformly available to street vendors. For example, some marketplaces may be too small, remote, or fragmented to make running a generator business profitable for a motivated entrepreneur. Our data confirms this claim: larger marketplaces with higher revenue among their vendors are more likely to see generator access available. Generator operating businesses have simply not penetrated smaller marketplaces, though we suspect that if they would offer this type of electricity, the same type of vendors (wealthier and more experienced) within these locations would pay for access.

Significant potential exists to facilitate a move by vendors from using generators for electricity provision to other more efficient and less costly forms of power production. Vendors using generators in general understand the benefits of having consistent power for their stands, but currently are being held back by the high prices of paying for this type of electricity (not to mention the pollution or noise caused by these machines' operation). Our survey suggests that the introduction of advanced lighting technology, such as solar panels, into the marketplace would be met warmly by many vendors, especially those larger stands who are currently paying too much for their power. Given the potential for solar lighting systems to lower business owners' costs and provide reliable energy, we see ample opportunities for a variety of providers to enter the market and immediately win over customers.

Conclusion

Urbanization a significant trend in the developing world, and the rapid growth of urban areas is creating a host of new policy challenges for governments. One such challenge is urban energy poverty. This article has sought to shed light on the severity of the situation by focusing on a marginalized community, street vendors, in Patna, the capital of the state of Bihar, India. In collaboration with the NGO Nidan, we surveyed 1000 street vendors in 24 marketplaces in the metropolitan area. The survey focused on both objective indicators and subjective

perceptions of energy poverty, along with ideas for improvement. Based on conversation with vendors and the NGO, we chose to emphasize lighting as a key issue that was common to vendors of all stripes.

The survey revealed high levels of energy poverty with regard to lighting. Among the vendors, only 10% reported having access to grid electricity, in spite of working in a metropolitan rural area. Diesel generators were more common, with 26% of vendors relying on them. While this offered access to a brighter light and more lighting hours at night, generator users paid more than 14 rupees per day for their lighting solution. Given the low levels of income among the vendors, this is a significant expense that prevents vendors from investing in their business or, say, the education of their children. We also found that four out of every five vendors considered lighting a top priority to expand their customer base. In particular, the perception that improved lighting would attract female customers was widespread among the vendors.

To our understanding, this is the first comprehensive and detailed survey of energy poverty among street vendors anywhere in the world. The survey revealed several research needs that scholars of energy poverty and access should strive to meet. In our view, the most important research gap pertains to successful strategies to eradicate energy poverty among informal vendors. For example, the lack of urban electrification is a puzzle that should be addressed. Given Patna's high population densities, why has the municipal government not found a way to offer grid electricity to street vendors? Alternatively, why have private entrepreneurs not sold more solar lighting systems to street vendors? There is a lot of research on strategies and business models for rural electrification (Wamukonya, 2007; Chaurey and Kandpal, 2009; Kirubi et al., 2009; Zerriffi, 2011; Chaurey et al., 2012; Palit, 2013), but studies that focus on the urban informal economy are lacking.

In regard to potential policy interventions, the need to offer grid electricity to street vendors stands out. Despite occasional outages and voltage fluctuation, access to the grid can offer street vendors an inexpensive source of power and reduce the need to rely on inferior or expensive technologies. Our findings indicate that municipal corporations in cities such as Patna should develop innovative institutional and legal strategies to formalize street vendors and give them access to electricity for lighting. Street vendors run businesses that can contribute to a vibrant urban economy, but their ability to invest and grow is limited without adequate infrastructure. The municipal corporation plays a critical role in the development of such interventions, and it cannot solve the problem without recognizing street vending as a legitimate enterprise in an economy that offers few employment opportunities to the majority of the people. In our sample, two-thirds of all street vendors were in this business simply because they did not see an alternative to it.

For the private sector and non-governmental organizations, distributed power generation through solar devices offers a potential avenue. Under today's high oil prices, diesel generators are not only polluting and noisy, but also expensive. As the cost of solar electricity generation decreases (Bazilian et al., 2013), economic opportunities for alternatives to diesel generators become more and more attractive. And yet, many challenges remain. If diesel generators are already being used by more than one in four vendors, it can be difficult to induce a technological change in the urban marketplaces. The owners of diesel generators may not welcome solar technology as a competitor, and our experience indicates that said generators are often operated by powerful street gangs who maintain order in the marketplaces. To the extent that the lack of grid electricity access remains an issue, solar entrepreneurs and non-governmental organizations play an important role in introducing alternative technologies to the urban marketplace.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.esd.2014.11.002.

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