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Supplementary Materials for

Does basic energy access generate socioeconomic benefits? A field experiment with off-grid solar power in India

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This PDF file includes:

section S1. A comprehensive literature review of the effects of electricity access

This section offers a comprehensive literature review of the effects of electricity access on socio-economic outcomes and social change. As the literature is vast, we separately discuss arguments related to grid extension and off-grid technologies. Among the former, we distinguish between low-quality and high-quality grid power, while we distinguish between microgrids, home systems, and solar lanterns among the latter. We also assess claims about solar microgrids and socio-economic effects which are made by microgrid providers and international organizations.

S1.1 Summary of Key Findings

The literature cited below offers a few key insights. First, studies of grid extension show that there is a substantial difference in socio-economic effects between low-quality and high-quality supply of power. Second, many studies on off-grid solar power indicate positive socio-economic effects even from minimal electricity supply, though many of these studies are not based on causal inference. Finally, many practitioners are enthusiastic about socio-economic effects from off-grid solar power.

S1.2 Socio-Economic Effects and Grid Access

Low-quality grid access:

While most studies conceive of electricity access as either present or absent, a recent paper demonstrates that quality of supply is equally important (*17*). Building on a cross-sectional survey of 8,568 households in 714 villages from the six energy poor states of Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal in India, reported satisfaction with power access is heavily correlated with hours of electricity access. These results suggest that electricity access alone is insufficient to increase household satisfaction with power supply, but they are also at least indicative that socio-economic effects from electricity access may be smaller in size when power supply is intermittent and unreliable.

High-quality grid access:

Leveraging South Africa's end to apartheid and the ensuing commitment to electrify two million households from 1993 to 2001, a paper by (*4*) shows the effects of grid electrification on employment markets. Using both an instrument variable and a fixed effects approach for identification, Dinkelman finds that female employment increases over the next five year. This finding is supported with evidence that strongly suggests this effect comes from releasing women from work at home and allowing them to work in micro-enterprises.

Well known research (*5*) assesses the development effects of electrification in Brazil, 1960-2000. The authors use a county and time fixed effects IV estimator to account for endogenous targeting of electrification. Specifically, they construct a forecasting model to predict grid expansion as if it was based on cost considerations alone, ignoring demand-side effects. This estimate captures variation in grid expansion that is driven by cost and can then be used as an instrument to identify welfare effects from grid electrification. Based on this empirical strategy, which works as most of Brazil's power supply comes from large hydro-power dam projects, there is robust evidence for strong effects on human development and housing values, with an expected increase in total land value per county of about USD 61 million (*5, p.228*). Effects are comparable across urban and rural areas and are strongest in terms of employment, salaries, and investment in education.

An evaluation study of Bangladesh's Rural Electrification Program (*29*) comes to a fairly positive assessment of the effects of electricity access, in particular for female empowerment. Based on a quantitative survey of 3,718 respondents, where customers using rural electrification were assumed 'treated' (while not controlling for selection into treatment) and those without electricity as the 'control' group, and 27 focus groups, the study not only shows positive income and employment effects – households with electricity earn 65% more than households in unelectrified villages and more than 15,000 jobs were created in the 67 member-owned electric cooperatives, called *Palli Bidyut Samities* (PBS) – but also demonstrates "positive development on women's socio-economic status" (*29, p. xi*). This specifically relates to women mobility, female village participation, women rights, and women's control over household decisions and finances.

Following the work by (*29*), work by (*7*) also offers insights on the welfare effects of Bangladesh's Rural Electrification program. They are especially worried about reverse causality in earlier empirical assessments and thus offer empirical results based on IV estimation to alleviate concerns about endogeneity, both at village and household levels. The analyzed data come from a survey conducted in all of Bangladesh, covering 45 out of all 70 PBS in 2005. The survey was stratified by electrification status to ensure that there are equal shares of electrified and unelectrified respondents. The reported findings suggest that rural electrification has strong effects on consumption expenditure and income at household level as well as school years and study hours at the individual level. The effects are sizable with income gains of up to 21.2% (*7, p.199*) and increases of up to 1/4 and 1/6 of a grade in completed school years, for both boys and girls respectively. Overall, “the rural electrification program in Bangladesh has a strong and robust impact on both economic and educational outcomes” (*7, p.204*).

In a more recent 2013 study then (*30*), the authors estimate effects of rural electrification in Vietnam. Using a panel data design, World Bank-financed rural electrification was happening at the same time as Vietnam’s general rural electrification program. In 2002, when the initial survey for the World Bank’s Vietnam Rural Energy Project was conducted, households scheduled (‘treatment’ group) and not scheduled (‘control’ group) to participate in the Bank’s program were interviewed. Welfare effects were analyzed from a sample of 42 communes, stratified for electrification status, which did however change during the time of implementation due to the Vietnamese government’s rural electrification efforts, resulting in a final sample size of 1,120 households from 41 communes (*30, p.665*). The authors are clear that grid access has many welfare effects, among them “intermediate outcomes as extended study time, longer hours of operating home business, greater exposure to business knowledge and information, better health, and more efficient business operations” (*30, p.669*). For identification, a household-level fixed effects estimator is used to address concerns of endogeneity. The findings are consistent with general trends in the literature: total income rises by up to 28%, expenditures are up by more than 20%, and school enrollment rates increase by 9% and 6%-points for girls and boys, once households are connected to the grid (*30, p.681ff*). These effects persist over time, albeit with limited implications for rural industry creation.

S1.3 Socio-Economic Effects and Off-Grid Technologies

Mini-/Microgrids:

Positive development effects of community-based microgrids in rural Kenya are documented in (*16*). Using a case study approach of the Mpeketoni Electricity Project over a time period of 13 years, 1994-2007, microgrids are shown to have both effects for productive use and micro-enterprises but also for more effective delivery of social and business services. The diesel powered mini-grid, which cost about USD 40,000 at the time of installation in 1994 can produce electricity for about 19 hours a day, produced from three generators. After installation of this system worker productivities at least doubled and income levels rose by 20-70%. Socio-economic effects did also materialize because of the electricity's positive effects on how village-level services such as schools, public spaces, and health can be provided. High loads are however determined as key factor for cost recovery.

A recent paper (*21, 31*) looks into the comparison of benefits from microgrids, solar home systems, and (low quality) grid connections in three districts in Bihar and Nepal. Based on results from 859 household surveys and 75 interviews with small businesses, the results are preliminary, but the study itself is remarkable for its comparative nature. The design is also clever as the close proximity of study sites is to minimize con-founding in benefits of electricity and uptake of technology; propensity score matching is used to compare across fairly comparable units. While electricity services are highly differentiated across the three systems, microgrids are typically used during nights around between 7pm-11pm, whereas grid availability is better but much more erratic. Interestingly, the use of kerosene as a lighting fuel is comparable for households with grid and microgrid power (80%), but much lower for solar home system households (25%). Aside from these direct effects, electrified offgrid households perceived lighting for children's study time at night more beneficial than grid customers. Small scale businesses are reported to suffer great, albeit unquantifiable losses, from unreliable grid access, and female leisure increases significantly through electricity access.

Pushing the importance of socio-economic effects further, another study (*18*) finds sizeable effects on study time and female empowerment. Drawing on a sample of 158 respondents from eleven villages in the Indian state of Chhattisgarh (Bilaspur and Bastar areas), the authors only interviewed women and selected an equal mix of villages with solar home systems (four villages with 48 respondents) and solar microgrids (three villages with 56 respondents), as both technologies are used in the Indian Remote Village Electrifi-cation program. Their main findings are that, after two years, in villages in which solar power electricity became available (i) children studied on average 41 minutes more in the evenings, a twofold increase to pre-electrification levels, (ii) dinner cooking started on average 36 minutes later, which was interpreted as "a sign of higher flexibility of time use and thus of women's empowerment" (*18, p.486*), and (iii) monthly kerosene use decreased by about two thirds. Finally, electricity access, likely because of small loads from these technology, did not affect commercial productive activities.

Socio-economic effects are not limited to microgrids powered by the sun, but socio-economic impacts of hydroelectric microgrids in Nepal's Rural Energy Development Program (REDP) have also been researched (*19*). As part of semi-structured interviews, the authors collected data on three microhydro plants at the rivers Malekhola (26 kW), Daunne Khola (12 kW), and Bom Khola (100 kW). Variation in size, location, and duration of operation allows the authors to cross-validate their findings in different contexts. Overall more than 60 community members, households, and other stakeholders from government, civil society, business, academia, and local communities were interviewed in this field research. Aside from direct effects on employment for maintenance and manufacturing of microhdyro plants, indirect employment effects, even for small systems, which provide power to run light bulbs or minimal mechanical tasks, are sizeable, especially in agroprocessing services. There is however also evidence to suggest that microhydro plants help power lights that can be used to improve breeding conditions for livestock, such as chicken, which would only eat when exposed to lighting. Apart from this evidence that microgrids can have positive entrepreneurial effects, effects on female empowerment particularly in the context of Nepal's REDP have been key. The authors (*19, p.417*) note that "the majority of agroprocessing facilities connected to the microhydro plants are operated by women per program guidelines. The same is true for poultry farming. Finally, the electricity and light provided, as well as the reduction of time spent on collecting fuelwood, have allowed women to pursue their own studies (taking classes during evenings) or engage in income-generating activities." Microgrids hence can have transformative societal impacts.

Solar lanterns:

There is not only variation in how off-grid technologies are powered, but there are also differences in size (*20*). A randomized control trial (RCT) in rural Rwanda uses pico-PV kits. These kits consist of a 1 watt solar panel, a solar lamp with 4 LED lights, a mobile phone charger, a radio with charger, and a battery set; the kit is similar to the ones used by the World Bank as part of their *Lighting Africa* program, for which these kits are also certified. Grimm et al use randomized assignment of these PV kits where treatment and control groups are balanced across a stratified baseline sample of 300 households in 15 remote village in rural Rwanda. The study was carried out from November 2011 to July 2012, and intent-to-treat (ITT) estimates are reported. From this small-scale RCT, the authors find that the use of traditional lamps decreases substantively relative to the control group and 47% of households even used the PV kits as their exclusive lighting source (*20, p.24*). Energy expenditures are also reported to have decreased and indoor air quality has improved according to household responses. The kit lamps are primarily used by females for housework, but despite this use, only a minor increase in spouses' time spent on labor is detected. Children seem to adjust their study patterns, too. There is no effect for total study time, but the share of children studying at night is much higher in the treatment than control group. In sum, the authors conclude that they "find significant effects on households' budget, productivity and convenience" (*20, p.1*) from the introduction of pico-PV lanterns.

Kerosene is not only an inefficient lighting fuel, but it also comes with considerable, negative health impacts. With capital constraints as the primary obstacle to a much wider dissemination of solar lanterns, (*33*) examine an alternative dissemination model of solar lanterns in India. They find that a fee-for-service/rental type model, where customers could either recharge their own lantern at a central location or even rent already charged lanterns from this location, offer only limited opportunities to replace lantern ownership. In a very similar study (*32*), the suitability of solar powered LED lanterns in rural Ghana is assessed – with an eye towards positive health effects. The authors establish that investments in solar lanterns are recouped after two years, and the annual emissions saved amount up to more than 250kg CO2 per household. In conclusion, solar lanterns are a "cost effective off-grid lighting alternative for fuel-based lighting systems in rural Ghana" (*32, p.282*), with corresponding health benefits from reduced indoor air pollution, particularly for women and children.

S1.4 Non-Academic Claims about Socio-Economic Effects

Claims by Microgrid Providers:

In a recent Point of View piece in The Proceedings of IEEE (*34*), a PV storage and distribution system by SunEdison is described that comes with its own battery block. Installed in Meerwada, a remote village in the Indian state of Madya Pradesh, this 14kW system is large enough to power the village of 70 households, which are all connected through a circuit. In speaking about this system, the author (*34, p. 864*) highlights that " (w)ith electric lights, children could study at night without depending on kerosene lamps and candles at about the same cost that they were spending on it without the harmful effects of the resulting smoke from kerosene lamps and candles," hence emphasizing the beneficial aspects for children's education at night.

A newspaper article published in *The Guardian* in 2012 about Mera Gao Power (MGP) specifically

mentions villagers in Uttar Pradesh speaking about the benefits from solar lighting ("Indian villagers' lives transformed by new energy delivery system." *The Guardian*, January 16, 2012. https://www.theguardian.com/global-development/poverty-matters/2012/jan/16/india-solar-power-system accessed on December 8, 2016). The main benefits mentioned are the possibility to work at night, additional time for income generating activities, children's study time in the evenings, and public safety after dark. MGP is no exception here. Husk Power Systems, another rural empowerment entreprise out of Bihar, India, provide information about the socio-economic impact of their operations on their website. See http://www.huskpowersystems.com/innerPage.php?pageT=Community%20Impact&page_id=81 (accessed on December 8, 2016). Having installed 84 mini-power plants that provide electricity to more than 200,000 people in 300 villages, each plant saves about 42,000 liters of kerosene and 18,000 liters of diesel a year, for a village of 400. The website also mentiones that "[b]y extending village life beyond daylight hours, HPS [Husk Power Systems] promotes economic development by enabling businesses to stay open after dark and allowing children to study at night. HPS creates an ecosystem around each plant by providing income generation opportunities to local farmers and entrpreneurs."
Grameen Shakti, currently one of the largest and fastest growing rural based renewable energy companies in the world, has installed one million solar home systems in Bangladesh over the last 16 years. See http://www.gshakti.org/index.php?option=com_content&view=article&id=57&Itemid=77 (accessed on December 13, 2016). The organization documents the positive effects of the installation of solar home systems by stating that: "This has brought significant improvements in the standard of liv- ings of the people better light for children education and household activities for women, reduced in-door air pollution, more security and income generation opportunities including reduced work load for women etc." See http://www.gshakti.org/index.php?option=com_content&view=article& id=72&Itemid=62 (accessed on December 13, 2016). Their website also offers several case studies with rural villagers' testimonials on welfare effects from SHS systems, especially in the context of business promotion, including increased business turnover due to longer opening hours, increased efficiency in an electronics repair shop, and new business creation in the form of handicrafts and solar lamp rental services.

Claims by International Organizations

Claims about beneficial welfare effects from solar microgrids are not limited to the academic literature or microgrid businesses, but are also supported by governmental and international organizations. US- AID, for instance, runs a program together with Power Africa, aiming to make 60 million new electricity connections by 2030 in sub-Saharan Africa. Part of this program is the "Beyond the Grid" initiative in Ethopia, which prioritizes off-grid solutions and targets households unlikely to get connected to the grid by 2030. Katrina Pielli of the U.S. Department of Energy makes clear that "[b]y providing reliable and affordable electricity to communities, microgrids also enable entrepreneurship and help existing businesses grow." ("Your Voice: When a Microgrid is More Powerful Than the National Grid." *Frontlines Online Edition*, November/December 2016 Online Edition. https://www.usaid.gov/news-information/frontlines/november-december-2016/your-voice-when-microgrid-more-powerful; accessed on December 8, 2016).

An influential report by the World Bank published in 2008 also strongly speaks to the positive welfare effects of rural electrification as a whole and better lighting, too (*2*). The report's executive summary, for instance, states that "[l]ighting alone brings benefits such as increased study time and improved study environment for school children, extended hours for small businesses, and greater security" (*2, p.xiii*). With off-grid technologies becoming more prevalent in the Bank's lending portfolio, many off-grid technologies suffer admittedly from lower capacity, but the for unelectrified households "the choice [...] is not between grid and off-grid, but among grid, kerosene, and car batteries." (*2, p.51*).

The UN Sustainable Energy For All (SE4ALL) initiative's ambition is no less than to end energy poverty around the world by scaling up energy access. In its latest 2016 Strategic Framework for Re- sults, there is a clear emphasis on off-grid and mini-grid technologies and the needed financing options, with "a particular cross-cutting focus on energy and women" (*35, p.42*). Mini/microgrids re playing an important role in realizing this outcome, as evidenced by the Clean Energy Mini-Grids High Impact Op- portunities group, which runs under the SE4ALL umbrella. See http://www.se4all.org/hio_ clean-energy-mini-grids (accessed on December 13, 2016).

section S2. Summary statistics

This section provides summary statistics.

- Table S1 shows summary statistics for key variables across all survey waves.
- Table S2 shows summary statistics, separately by treatment group and survey wave.

table S1. Summary statistics for outcome and other key variables across all three survey waves.

Summary Statistics

	Mean	S.D.	Min.	Max.	Obs.
Total Kerosene Spending (INR/Month)	89.95	60.60	0	520	3825
Kerosene Spending (Private) (INR/Month)	54.41	63.98	0	520	3825
Kerosene Spending (PDS) (INR/Month)	35.54	25.91	0	400	3825
Hours of Electricity/Day	1.34	3.20	0	24	3824
Sufficient Lighting for Cooking	2.26	1.18	1	5	3529
Hours of Lighting/Day	5.42	2.34	0	24	3825
Household Electrification (=1)	0.24	0.43	0	1	3825
Satisfaction with Lighting	3.12	1.12	1	5	3825
Business Ownership (=1)	0.07	0.25	0	1	3825
HH Expenditures (INR/Month)	3885.50	2318.22	100	25000	3825
HH Savings (INR/Month)	571.12	1227.39	0	30000	3825
Girls/Boys Sent to School Equally	3.59	0.71	1	4	3529
Equal Job Opportunities for Women	3.32	0.94	1	4	3529
Domestic Violence Against Women	1.42	0.84	1	4	3529
Eve-Teasing of Women	1.17	0.54	1	4	3529
Feel Safer with More Light	1.08	0.28	1	3	3529
Sufficient Lighting for Going Outside	1.79	1.02	1	5	3529
Age of HH head	40.01	13.58	16	87	3825
# Children	1.49	1.61	0	17	3825
Hindu	0.84	0.36	0	1	3825
Scheduled Caste	0.23	0.42	0	1	3825
Scheduled Tribe	0.00	0.04	0	1	3825

table S2. Summary statistics for outcome and other key variables, separate for treatment, control, and remote control group and by wave.

Summary Statistics, by Treatment Group and by Wave

	1st Wave	2nd Wave	3rd Wave
Control Group			
HH Expenditures (INR/Month)	4454.83	3553.65	3546.09
HH Savings (INR/Month)	912.11	391.75	379.01
Age of HH head	39.67	40.81	41.63
# Children	1.56	1.40	1.31
Hindu	0.84	0.85	0.85
Scheduled Caste	0.21	0.20	0.22
Scheduled Tribe	0.00	0.01	0.00
Kerosene Spending (INR/Month)	107.01	85.19	88.77
Kerosene Spending (Private Market) (INR/Month)	72.05	54.40	53.48
Business Ownership (=1)	0.06	0.06	0.06
Treatment Group			
HH Expenditures (INR/Month)	4383.27	3730.83	3599.37
HH Savings (INR/Month)	876.76	413.44	438.04
Age of HH head	38.62	39.50	40.67
# Children	1.63	1.57	1.38
Hindu	0.84	0.84	0.84
Scheduled Caste	0.25	0.25	0.25
Scheduled Tribe	0.00	0.00	0.00
Kerosene Spending (INR/Month)	110.09	79.24	73.50
Kerosene Spending (Private Market) (INR/Month)	72.94	47.63	32.32
Business Ownership (=1)	0.08	0.06	0.07
Remote Control Group			
HH Expenditures (INR/Month)	4331.96	3603.82	3553.59
HH Savings (INR/Month)	743.35	200.64	259.48
Age of HH head	38.84	39.77	40.51
# Children	1.76	1.87	1.75
Hindu	0.91	0.90	0.91
Scheduled Caste	0.30	0.30	0.30
Scheduled Tribe	0.00	0.01	0.00
Kerosene Spending (INR/Month)	116.07	83.63	67.39
Kerosene Spending (Private Market) (INR/Month)	76.31	45.20	25.16
Business Ownership (=1)	0.03	0.02	0.06

section S3. Study setting

This section provides detailed information on the setting of our study.

S3.1 General Information

An overview of the Barabanki district is shown in fig. S1. There are 81 habitations in Suratganj block, the primary study area. The remaining 20 habitations (not included in primary analysis) are located in Fatehpur and Ramnagar blocks. As the map shows, installation failed in five ITT habitations because of flooding. If these habitations are excluded, the results do not change (Section S17). Conservatively, these habitations are considered part of the ITT group. In four habitations, a microgrid was installed accidentally because the team had not received instructions on the treatment assignment on time. Despite the accidental installation, these habitations are considered part of the control group: even though the attempts to install were accidental, the ability to install could reflect the characteristics of these villages. Because our instrumental variable approach can account for accidental installations, keeping the accidental installations in the control group ensures our estimates are unbiased. See Section S18 for robustness tests that demonstrate that the results are not sensitive to this decision.

A solar microgrid was accidentally installed in the remote control habitation marked by a star during the last round of surveys in June 2015, and the households that subscribed are excluded from the analysis. As shown in Section S19, dropping the entire habitation from the study does not change any of the results.

S3.2 Sampling Strategy

The habitations were located as follows. Operating from Suratganj town, field researchers from the survey company, MORSEL India, explored the area with motorcycles in expanding circles. Any habitation that had an electricity connection was excluded from the study, and all unelectrified habitations were included. The target was to find 80 habitations, and the team came up with a list of 81 habitations. Next, the team went to the neighboring blocks of Fatehpur and Ramnagar to find 20 habitations for the remote control group. Within each habitation, the field researchers found a central *pucca* house that met the guidelines provided by MGP for solar microgrid installation. The house also had to be in the center of the habitation to ensure that the MGP installation would be done there. A random sample of 16 households was chosen within 100

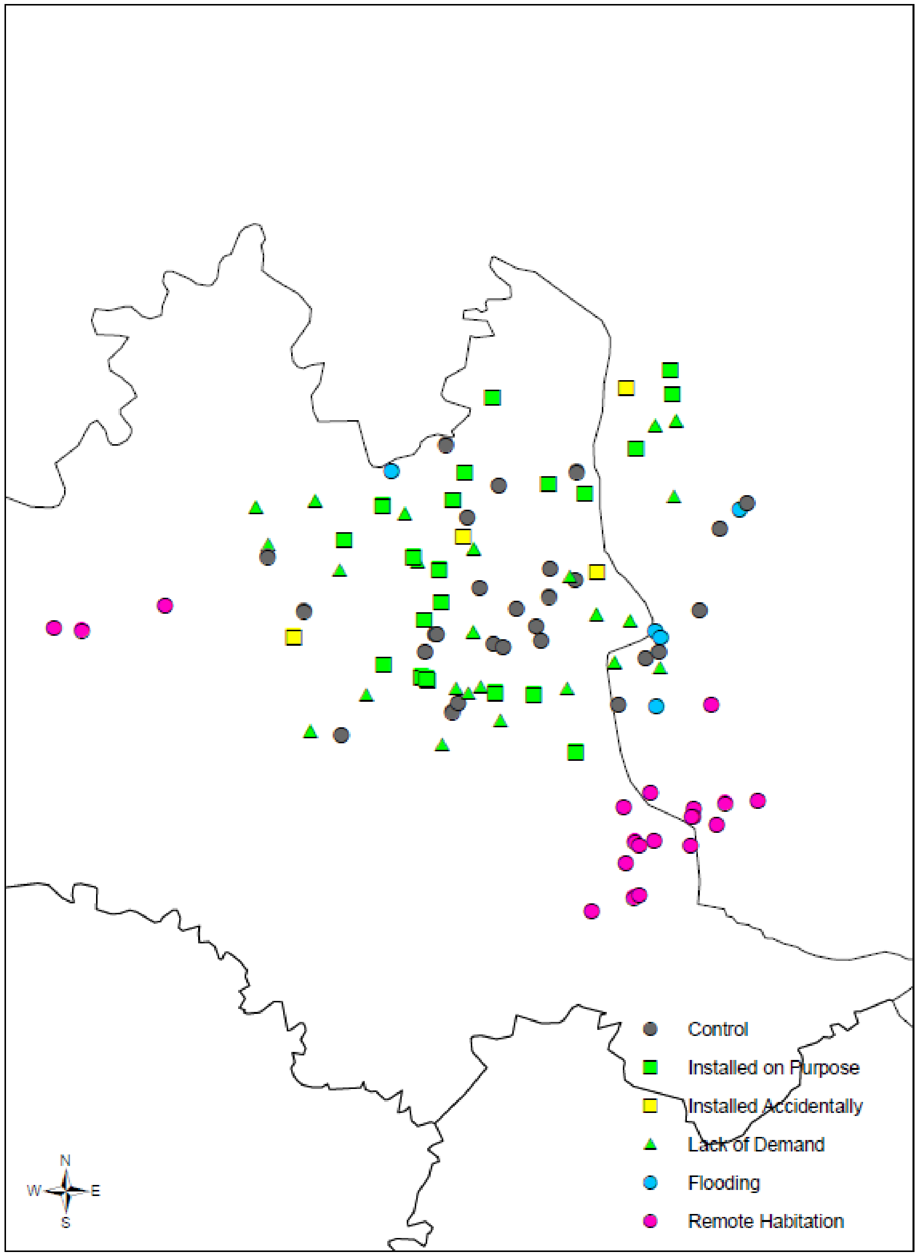


fig. S1. Locations of study habitations in the Barabanki district. The pink habitations are in the remote control group in Fatehpur and Ramnagar blocks. The asterisk indicates the habitation contaminated by an accidental MGP installation in June 2015, at the end of the study.

meters of the central *pucca* house. Households farther than 100 meters were excluded because they could not be electrified due to the distance. Notably non-sample households were allowed to subscribe to the MGP service.

S3.3 Data Collection

The primary data were collected in three rounds. The baseline survey was done in February-March 2014. The survey lasted approximately 45 minutes and was conducted in the local language, Hindi, by experienced enumerators from Uttar Pradesh or Bihar. The two-day training and pilot was conducted by one of the researchers.

The midline survey was conducted in September-October 2014. The main component lasted approximately 45 minutes and was almost identical to the baseline survey, but additional survey questions about electricity use were included in a module that lasted approximately 15 minutes. Again, the survey was conducted in Hindi, and by the same enumerators. The two-day training and pilot was conducted by one of the researchers.

The endline survey was conducted in May-June 2015. Again, the length of the survey was approximately 45 minutes. Additionally, 400 respondents were selected for an open-ended survey that lasted less than ten minutes. As before, the survey was conducted in Hindi, and by the same enumerators. The two-day training and pilot was conducted by one of the researchers.

In all surveys, the household head was interviewed whenever possible. If the household head was not at home and was not expected to return on the same day, another adult member of the household was interviewed. For questions related to female empowerment, an adult female member – typically the spouse of the male household head – was interviewed separately. Throughout, detailed notes were kept on the identity of the respondent.

S3.4 Randomization and Treatment Assignment

The randomization was done using a spreadsheet program. For each element of the list of 81 habitations, a random number between 0 and 1 was drawn. The habitations were then ranked such that higher numbers meant inclusion in the treatment group and lower numbers in the control group. Specifically, the randomization was conducted during the baseline survey as follows:

- Of the 81 habitations in the main study area, 40 were assigned to the initial treatment group.
- The remaining 41 habitations were ranked for a wait list in case not enough habitations would be electrified for statistical analysis.

Based on the progress of solar microgrid installation during the first four months, the research team decided that the first 10 habitations on the wait list would be moved to the treatment group, for a treatment group of 50. Although equally sized treatment and control groups are generally optimal for statistical power, the surprisingly slow installation rate at the habitation level warranted a randomly assigned expansion of the treatment group. Our concern was that if a small number of households in the initial treatment group would subscribe to the MGP service, then we would not have enough adopters to estimate local average treatment effects because of wide confidence intervals. When the number of installations is relative small, adding habitations to the treatment group improves the precision of the estimates without inducing bias because the wait list is randomized and does not change depending on treatment assignment. In any case, Section S20 shows that even if we exclude the habitations on the wait list completely, the results remain unchanged.

At this time, however, it also became clear that the MGP team had accidentally installed microgrids in four habitations in the control group. These were verified to be accidental because the MGP affiliates were not aware of the treatment assignment. They were still included in the control group because installations could be non-random despite the accidental nature of targeting: even if MGP did not go to these habitations intentionally, it is possible that the installations occurred because households in these habitations had a keen interest in solar power. In the LATE estimations, the use of the randomized treatment/ITT group membership as an instrumental variable for installation ensures the MGP accidents do not bias our estimates. Overall, then, 50 habitations were included in the treatment group. Of these, 21 saw the installation of a solar microgrid. Within these habitations and in our survey, 117 households adopted MGP service at some point in time (outside our survey of 16 randomly chosen households, the number of adopters was much higher, given MGP's goal of having 20 households per system).

Between the endline and midline surveys, a full-time field researcher ensured that MGP did not accidentally install microgrids in any of the control habitations. During the endline survey, however, an MGP team from another branch office, located in Baddosarai, installed a solar microgrid in the Moti Purwa hamlet of village Lohatijai in Ramnagar block (remote control group; not included in main analysis). When conducting the spatial spillovers analysis, these ten subscribers were excluded from the analysis.

section S4. Site selection and external validity

We chose to work in Barabanki district because (i) it has, according to the 2011 Census of India, a very low rural electrification rate (15%) and (ii) MGP has a branch office in the area. Thus, the district is an area that could benefit from lighting interventions and the presence of a branch office makes the intervention feasible. To establish external validity of our results, we compiled data on all villages in India from the 2011 national census. We also distinguished between the non-electrified subsample (i.e., villages where no household used electricity as their lighting source) and the entire village population. We use the village as the unit of comparison since the census numbers are available at this level. Using the census has the obvious advantage of comparing our sample against the population. However, it is important to note that comparisons at the village level involve some aggregation since our treatment was administered to habitations, a unit smaller than villages.

Table S3 compares our baseline sample with the India and Uttar Pradesh (UP) censuses along 10 differ- ent dimensions: scheduled caste population, having a bank account, use of kerosene for lighting, literacy, ownership of a television, radio, mobile phone, bicycle, motorbike, and using solar as the primary source of lighting. Overall, we find the results of the comparison encouraging. The proportion of a village's scheduled caste population from our sample (0.23) is similar to that in unelectrified villages as well as to the whole of UP (0.24). Similarly, the proportion of people who have a bank account in our sample (0.70) is comparable to unelectrified (0.77) and the whole of UP (0.75). Given that kerosene is the main source of lighting, we expect our sample to match with that observed in unelectrified villages. That turns out to indeed be the case: 95% of our sample use kerosene for lighting and this matches the proportions seen in unelectrified villages of UP (98%) and whole of India (93%). The proportion of the literate population in our sample (0.35) is slightly lower than the two censuses (0.45-0.57). That is likely because we measure literacy in our sample depending on whether respondents were able to read/write Hindi, whereas the literacy rate in the census is more general.

As with kerosene use, we expect television ownership to match unelectrified villages because of the lack of electricity access. Just 5% of our sample said that they owned a television and this is the same exact proportion for the whole country (5%) and similar to that of UP (13%). Mobile ownership is comparable between our sample (0.67) and all of UP (0.61) as is ownership of a bicycle (0.85 and 0.74 respectively). The

table S3. Mean values of different variables at the village level across different samples, all on a scale of 0 to 1 of population shares. The survey means are from the baseline round. The unelectrified sample represents villages where no household used electricity as their lighting source. The source for the Uttar Pradesh and India means is the 2011 census.

External Validity

	Survey (All)	Uttar Pradesh (All)	Uttar Pradesh (Unelectrified)	India (All)	India (Unelectrified)
Scheduled Caste	0.23	0.24	0.24	0.18	0.13
Have Bank Account	0.70	0.77	0.75	0.56	0.41
Kerosene for Lighting	0.95	0.75	0.98	0.48	0.93
Literacy	0.35	0.56	0.51	0.57	0.45
Own Radio	0.08	0.26	0.25	0.18	0.19
Own TV	0.05	0.23	0.13	0.28	0.05
Own Mobile	0.67	0.61	0.55	0.45	0.29
Own Bicycle	0.85	0.74	0.74	0.46	0.46
Own Motorbike	0.11	0.16	0.12	0.13	0.05
Solar Installation	0.00	0.01	0.01	0.01	0.04

proportion of households owning a motorbike is also similar between our sample (0.11), all of UP (0.16), the unelectrified villages of UP (0.12) and all of India (0.13). The slightly higher numbers in the census for motorbike ownership can be attributed to the fact that it includes both scooters and motorbikes for the UP census and additionally mopeds for the all India census. Radio ownership in our sample (8%) is lower than the average levels in UP and India more generally; this drop might be due to the fact that our study took place 3-4 years after the census. The levels of solar installation in our sample (non-existent) is in line with trivial adoption in UP and elsewhere in India.

section S5. Preanalysis plan

The full text of the pre-analysis plan is available at goo.gl/mgDOYm. The relevant section is 3.2; the other sections (technology adoption, social/political effects) will be analyzed separately. In the pre-analysis plan, we listed the variables analyzed for energy access (electricity access, lighting availability/quality, and fuel expenditures). The only deviation from the pre-analysis is that we analyzed PDS and private market kerosene expenditures separately, because we noticed that the two components follow different patterns. Next, we listed variables for socio-economic effects (savings per month, expenditure per month, home business creation, time spent working in productive activity, children's study time, mobile phone charging expenditures).

section S6. Additional estimates based on the preanalysis plan

Our pre-analysis plan contained two additional hypotheses, both of which relate to gender dynamics (see Section S5 for details on the pre-analysis plan). The first one stated that the adoption of solar microgrids would increase support for girls' education. The second one conjectured that women would have more work opportunities after the introduction of electrification. These hypotheses rely on the work on gender-specific consequences of electrification (*4, 36, 29, 31, 19*). The questions in our survey from the female module were as follows:

- *Do families in your hamlet send girls to school equally as boys?*: An ordinal variable (1-4 scale) that measures perceptions of schooling equality between boys and girls. *Respondent is adult female from the household*.
- *Do women have the opportunity to work in the fields or do business in your hamlet equally as men?*: An ordinal variable (1-4 scale) that measures perceptions of job opportunity equality between men and women. *Respondent is adult female from the household*.

The tables are as follows:

- Table S4 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on beliefs about equal schooling opportunities for boys and girls (Panel A). In Panel B, we report the same results but using a dichotomous outcome instead (=1 if the respondents believes that girls have the some or as many opportunities as boys).
- Table S5 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on beliefs about equal job opportunities for men and women (Panel A). In Panel B, we report the same results but using a dichotomous outcome instead (=1 if the respondents believes that women have the some or as many opportunities as men).

table S4. Effect of MGP solar microgrids on gender schooling equality. Effect of MGP solar microgrids on beliefs about equal schooling opportunities for boys and girls, with higher values on a 1-4 scale indicating greater equality (Panel A), or with a dichotomous version of this variable (Panel B; =1 if the respondents believes that girls have the some or as many opportunities as boys). The standard errors are clustered by habitation.

Explaining Gender Schooling Equality

	Panel A: Original Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.00	-0.01	0.00	-0.04
	(0.08)	(0.08)	(0.28)	(0.27)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

	Panel B: Dichotomous Outcome			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.02	0.01	0.08	0.03
	(0.03)	(0.03)	(0.10)	(0.10)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

table S5. Effect of MGP solar microgrids on gender job equality. Effect of MGP solar microgrids on beliefs about equal job opportunities for men and women, with higher values on a 1-4 scale indicating greater equality (Panel A), or with a dichotomous version of this variable (Panel B; =1 if the respondents believes that women have the some or as many opportunities as men). The standard errors are clustered by habitation.

Explaining Gender Job Equality

	Panel A: Original Outcome			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.03	-0.01	-0.10	-0.04
	(0.09)	(0.12)	(0.32)	(0.39)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

	Panel B: Dichotomous Outcome			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.01	-0.00	-0.03	-0.01
	(0.04)	(0.05)	(0.12)	(0.15)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

section S7. Balance statistics

This section provides balance statistics.

- Table S6 shows balance statistics for key variables at the habitation level.
- Table S7 shows balance statistics for key variables at the household level.

table S6. Balance statistics at habitation level (pretreatment). Columns (1)-(3) show the means for each variable, separately for treatment, control, and remote control groups. Treatment habitations are defined as those in which MGP offered to install a microgrid (50 habitations). In this treatment group a microgrid was actually installed in 21 habitations. Columns (4)-(6) show p-values for difference-in-means tests at the habitation level for treatment versus control group, treatment versus remote control group, and control versus remote control group. The last line shows that there are 50 habitations in the treatment group, 31 in the control group, and 20 in the remote control group, for a total of 101 habitations.

Balance Statistics (Habitation level)

	Treatment	Control	Remote	(1) vs. (2)	(1) vs. (3)	(2) vs. (3)
Kerosene Spending (INR/Month)	110.122	106.956	115.699	0.533	0.284	0.196
Kerosene Spending (Private Market) (INR/Month)	72.970	72.104	75.981	0.875	0.607	0.577
Kerosene Spending (PDS) (INR/Month)	37.151	34.852	39.718	0.396	0.403	0.062*
Hours of Electricity (per Day)	0.242	0.113	0.000	0.472	0.238	0.334
Sufficient Lighting for Cooking	1.697	1.683	1.622	0.806	0.217	0.422
Hours of Lighting (per Day)	5.239	5.563	4.913	0.160	0.106	0.023**
Household Electrification (=1)	0.035	0.014	0.000	0.343	0.179	0.260
Satisfaction with lighting	4.043	4.039	4.008	0.956	0.670	0.735
Business Ownership (=1)	0.080	0.063	0.035	0.397	0.054*	0.096*
HH Expenditures (INR/Month)	4384.093	4445.536	4323.266	0.710	0.743	0.574
HH Savings (INR/Month)	875.513	906.469	741.376	0.741	0.174	0.203
Age of HH head	38.658	39.621	38.861	0.218	0.837	0.400
# Children	1.630	1.565	1.755	0.574	0.401	0.240
Hindu	0.845	0.842	0.906	0.963	0.419	0.419
Scheduled Caste	0.247	0.217	0.299	0.705	0.575	0.411
Observations (#)	50	31	20			

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

table S7. Balance statistics at household level (pretreatment). Columns (1)-(3) show the means for each variable, separately for treatment, control, and remote control groups. Treatment habitations are defined as those in which MGP offered to install a microgrid (50 habitations). In this treatment group a microgrid was actually installed in 21 habitations. Columns (4)-(6) show p-values for difference-in-means tests at the household level for treatment versus control group, treatment versus remote control group, and control versus remote control group. As the treatment was administered at the habitation level, standard errors are clustered at the habitation level. The last line shows that there are 794 households in the treatment group, 487 in the control group, and 316 in the remote control group, for a total of 1,597 households.

Balance Statistics (Household level)

	Treatment	Control	Remote	(1) vs. (2)	(1) vs. (3)	(2) vs. (3)
Kerosene Spending (INR/Month)	110.089	107.013	116.066	0.569	0.227	0.147
Kerosene Spending (Private Market) (INR/Month)	72.938	72.048	76.310	0.877	0.527	0.506
Kerosene Spending (PDS) (INR/Month)	37.151	34.965	39.756	0.387	0.279	0.045**
Hours of Electricity (per Day)	0.237	0.115	0.000	0.443	0.068*	0.226
Sufficient Lighting for Cooking	1.695	1.669	1.619	0.672	0.179	0.454
Hours of Lighting (per Day)	5.242	5.569	4.915	0.180	0.030**	0.006***
Household Electrification (=1)	0.034	0.014	0.000	0.301	0.037 **	0.158
Satisfaction with lighting	4.045	4.041	4.009	0.952	0.656	0.722
Business Ownership (=1)	0.081	0.064	0.035	0.361	0.007***	0.054**
HH Expenditures (INR/Month)	4383.275	4454.825	4331.962	0.671	0.783	0.561
HH Savings (INR/Month)	876.763	912.115	743.354	0.723	0.189	0.174
Age of HH head	38.616	39.669	38.839	0.141	0.816	0.380
# Children	1.627	1.565	1.756	0.585	0.428	0.264
Hindu	0.844	0.842	0.905	0.978	0.368	0.404
Scheduled Caste	0.247	0.214	0.301	0.670	0.562	0.383
Observations (#)	794	487	316			

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

section S8. Additional descriptive data

This section provides additional descriptive data on aspects of our study.

- Table S8 reports the primary source of lighting for each household, by wave.
- Table S9 reports the primary source of lighting for each household, by treatment status and by wave.
- Table S10 shows the number of households in treatment, control, and remote control groups, as well as the number of subscribers to MGP.
- Table S11 reports the reasons given by households that discontinued their MGP service between the second and third wave.
- Figures S2 and S3 report the distribution of spending on kerosene on the private market and the public distribution system, respectively, in the baseline survey.
- Figure S4 reports the distribution of hours of electricity per day in the baseline survey.

table S8. Primary lighting sources by survey wave. The category "other" includes candles, batteries, and other less common sources of lighting. Households with multiple lighting sources list their primary choice.

Lighting Source		
	Frequency	Percentage
1st Wave		
Kerosene	1218	95.08
Other	63	4.92
Total	1281	100.00
	Frequency	Percentage
2nd Wave		
Kerosene	917	72.55
MGP	117	9.26
Other Solar	77	6.09
Grid	17	1.34
Other	136	10.76
Total	1264	100.00
	Frequency	Percentage
3rd Wave		
Kerosene	932	72.81
MGP	89	6.95
Other Solar	83	6.48
Grid	13	1.02
Other	163	12.73
Total	1280	100.00

table S9. Primary lighting sources by survey wave and treatment status. The category "other" includes candles, batteries, and other less common sources of lighting. Households with multiple lighting sources list their primary choice.

Lighting Source

Treatment Group

1st Wave	Frequency	Percentage
Kerosene	770	96.98
Other	24	3.02
Total	794	100.00

2nd Wave	Frequency	Percentage
Kerosene	540	68.79
MGP	100	12.74
Other Solar	50	6.37
Grid	12	1.53
Other	83	10.57
Total	785	100.00

3rd Wave	Frequency	Percentage
Kerosene	572	72.04
MGP	79	9.95
Other Solar	46	5.79
Grid	10	1.26
Other	87	10.96
Total	794	100.00

Control Group

1st Wave	Frequency	Percentage
Kerosene	448	91.99
Other	39	8.01
Total	487	100.00

2nd Wave	Frequency	Percentage
Kerosene	377	78.71
MGP	17	3.55
Other Solar	27	5.64
Grid	5	1.04
Other	53	11.06
Total	479	100.00

3rd Wave	Frequency	Percentage
Kerosene	360	74.07
MGP	10	2.06
Other Solar	37	7.61
Grid	3	0.62
Other	76	15.64
Total	486	100.00

Remote Control Group

1st Wave	Frequency	Percentage
Kerosene	312	98.73
Other	4	1.27
Total	316	100.00

2nd Wave	Frequency	Percentage
Kerosene	260	82.80
Other Solar	11	3.50
Other	43	13.69
Total	314	100.00

3rd Wave	Frequency	Percentage
Kerosene	244	79.74
Other Solar	23	7.52
Grid	5	1.63
Other	34	11.11
Total	306	100.00

table S10. Number of households by subgroup and wave. The *MGP* column indicates the number of households that are subscribers to MGP's system in a given wave. This is a subset of the *Treatment* group. *Control* are households that are in the control habitations. *Remote Control* are the control households from the Ramnagar and Fatehpur blocks.

Households by Subgroup-Wave

	MGP	Treatment	Control	Total HH	Remote Control	Total HH (all)
Wave 1	0	794	487	1,281	316	1,597
Wave 2	112	785	479	1,264	314	1,578
Wave 3	81	794	486	1,280	306	1,586

table S11. Reasons for discontinuation of MGP services. In total, households that discontinued MGP service at some point gave 52 responses to a question about reasons for discontinuation. This table lists the reasons provided for this.

MGP Discontinuation of Service

Reason	Count	%
Lighting quality	30	57
Service quality	13	25
Payment problem	6	12
Other	3	6
Total	52	100

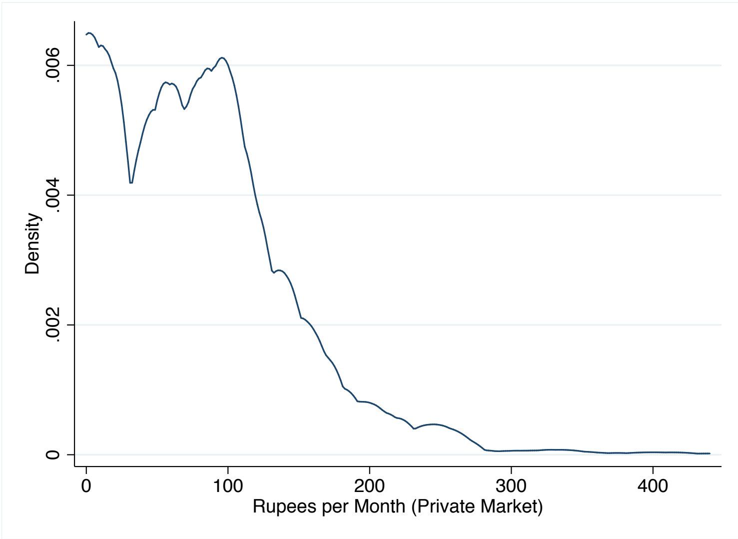


fig. S2. Spending on kerosene on the private (black) market in the pretreatment period (baseline survey).

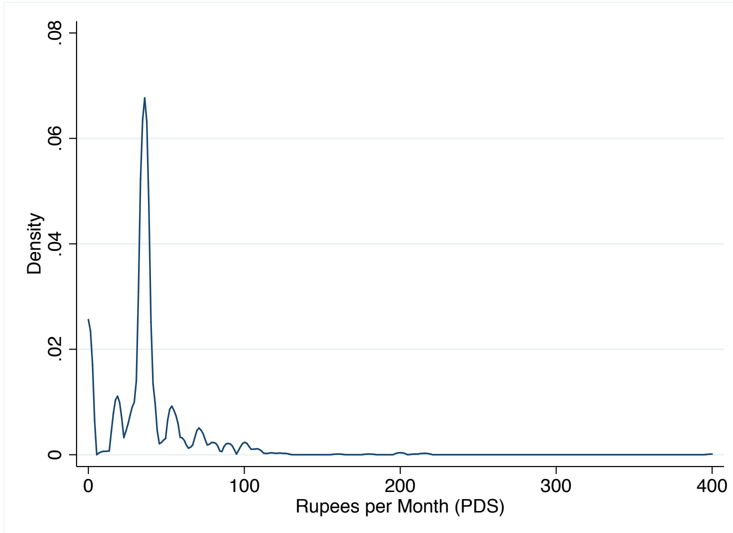


fig. S3. Spending on kerosene through the PDS in the pretreatment period (baseline survey).

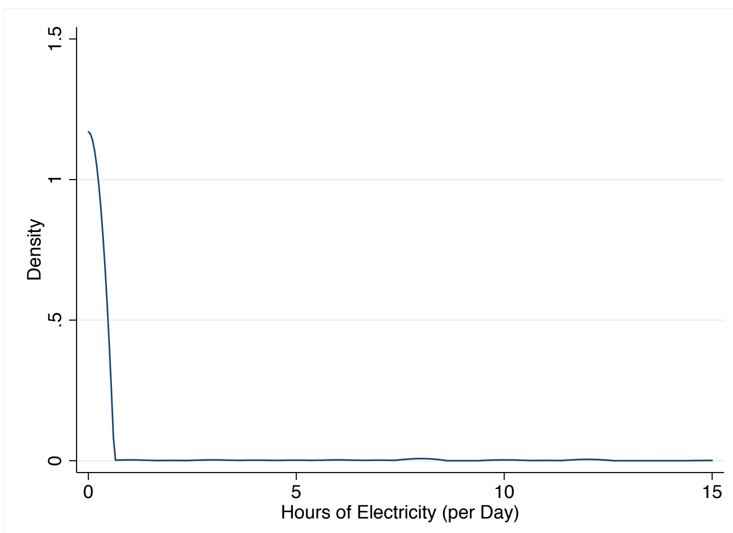


fig. S4. Hours of electricity per day in the pretreatment period (baseline survey).

section S9. Different LATE

This section presents the estimates of the local average treatment effects (LATE) where the instrumented variable is the household-level decision to subscribe to MGP service.

- Table S12 replicates the LATE results of Table 2.
- Table S13 replicates the LATE results of Table 1.
- Table S14 replicates the LATE results of Table 3.

table S12. Effect of MGP solar microgrids with a different LATE (see text) on household spending on kerosene in the private market and on kerosene through the PDS. The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure (Different LATE)

	Private Kerosene		PDS		Total	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-155.50′′	-161.12′	37.37	13.66	-118.14′′	-147.46′
	(75.36)	(89.57)	(34.30)	(29.79)	(58.10)	(77.37)
Household FE		✓		✓		✓
Wave FE	✓	✓	✓	✓	✓	✓
Observations	3825	3825	3825	3825	3825	3825

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

table S13. Effect of MGP solar microgrids with a different LATE (see text) on household electrification and hours of electricity per day. The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity (Different LATE)

	Electricity		Hours of Elec.	
	(1)	(2)	(3)	(4)
Treatment	1.17′′′	0.94′′	4.66	3.24
	(0.43)	(0.41)	(3.03)	(3.06)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3824	3824

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

table S14. Effect of MGP solar microgrids with a different LATE (see text) on household electrification and hours of electricity per day. The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Socio-Economic Outcomes (Different LATE)

	(1) Savings	(2) Exp.	(3) Business	(4) Work Time	(5) Study	(6) Phone
Treatment	731.74	2143.57	-0.11	-0.57	-0.08	9.25
	(1044.85)	(2204.76)	(0.20)	(2.25)	(0.32)	(16.74)
Household FE	✓	✓	✓	✓	✓	✓
Wave FE	✓	✓	✓	✓	✓	✓
Observations	3825	3825	3825	3529	3825	2532

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

section S10. Testing for geographic spillovers

This section provides the main results when the sample includes households in the remote control group. These households were located in 20 habitations in the two districts of Fatehpur and Ramnagar. All of these were far enough from Suratganj to reduce concerns of potential spillovers between treatment and control habitations. Because of the geographic distance between these habitations and the treatment/control groups, any spillover effects that could violate the stable unit treatment value assumption are not a major concern. Based on our fieldwork, the most likely source of spillovers in our case is changes in behavior in response to treatment in neighboring habitations. If households in a control habitation see that treatment habitations gain access to MGP service, these households may choose to purchase solar technology from the market in Suratganj town. In this case, the spillovers would induce a downward bias in our coefficients, as households in the control group would mimic the behavior of the treatment group. In contrast, it is very unlikely that the MGP treatment would have effects through changes in kerosene prices, as the number of treated habitations is very small relative to the thousands of habitations in the Barabanki district.

We conduct the analysis by including an indicator for remote control villages in the midline or endline survey. This indicator runs parallel to the MGP program for the ITT group, and thus allows us to compare the remote control trajectory to the trajectory of the treatment and control groups. Specifically, the three groups are coded as follows:

1. In the baseline, both indicators (IIT, remote control) score zero for all households.
2. In the midline, the ITT indicator scores 1 for households in the ITT group; the remote control indicator scores 1 for households in the remote control group.
3. In the endline, the ITT indicator scores 1 for households in the ITT group; the remote control indicator scores 1 for households in the remote control group.

With this specification, we can conduct three simultaneous comparisons in one regression. First, the ITT/LATE coefficient shows the intent-to-treat effect or LATE relative to the close control. Second, the remote control coefficient shows the differential trend between the remote control and the close control. Finally, subtracting the remote control coefficient from the ITT/LATE coefficient provides the differential trend between the intent-to-treat group and the remote control.

With these comparisons, we can shed light on spillovers. Because theory predicts that spillovers are *pos- itive* the ITT/LATE coefficient (relative to the close control) should be downward biased. If these spillovers are large, then the remote control group should show very different patterns from the ITT and close control groups, whereas the ITT/LATE and close control groups should show very similar trends over time.
We can now test this hypothesis by seeing whether the remote control coefficient is large relative to the ITT/LATE coefficient. If it is, then one possible interpretation is that spillovers between the treatment and close control group are mitigating the treatment effect. If it is not, then such an interpretation is less likely (though, without randomization, uncertainty naturally remains).

The results are reported in tables S15-S16:

- Table S15 shows the results for kerosene spending including all households and a time varying control variable for remote controls (replication of Table 2 from the main text). The control variable is coded 1 for remote control habitations in the post-treatment (midline, endline) surveys and 0 for all other observations.

- Table S16 shows the results for access to electricity including all households and a time varying control variable for remote controls (replication of Table 1 from the main text). The control variable is coded 1 for remote control habitations in the post-treatment (midline, endline) surveys and 0 for all other observations.

The key takeaways from the spillover analysis are the following. First, the ITT coefficients in Panel A of table S15 and both panels of table S16 are approximately of the same size as the remote control coefficients. These coefficients compare the ITT and remote control, respectively, to the close control. This result thus means that it cannot be said that the treatment and close control groups are very similar but the remote control is very different.
Second, the LATE estimates are even more telling. Because the ITT coefficient is an extreme low bound for the treatment effect in the absence of 100% adoption rates, the LATE estimates are even more mean- ingful. The LATE coefficients for the treatment effect are much larger than the remote control coefficients. This result also goes against spillovers, as substantial spillovers would mean that the control group baseline is biased close to the average outcome value of the treatment group. In the data, we instead see a large estimated LATE, as compared to differences between the close and remote control group.

Third, consider the differences between the ITT group and the remote control. While these differences are unidentified, they are still meaningful from the perspective of testing spillover hypotheses. This difference can be obtained by subtracting the remote coefficient from the treatment coefficient. In Panel A of table S15 and both panels of table S16, the LATE estimates suggest that when we compare the treated outcomes to the remote control outcomes, the sign always remains to the expected direction. The ***t***-tests shown in the tables also show that the differences are statistically significant in 3 out of 6 LATE models (models 3-4 in Panel A of table S16; model 3 in Panel B of table S16). These results show that even if we compare the ITT group outcomes via LATE to the remote control, the results are consistent with the main comparison. This, again, suggests that spillovers between the ITT and close control groups are not driving our main results.

table S15. Effect of MGP solar microgrids on household kerosene spending including remote control habitations. The standard errors are clustered by habitation. Dependent variables are measured in rupees per month. The sample includes households from the remote control group and a time-varying con- trol for these households. P-values are for t-tests of difference between the effect of the treatment and the time-varying control for remote households.

Explaining Electrification and Hours of Electricity (incl. Remote Control Habitations)

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-14.01***	-14.50**	-47.50**	-49.37**
	(5.27)	(6.90)	(19.83)	(24.60)
Remote (Time-Varying)	-18.74***	-22.86***	-24.80***	-29.21***
	(6.06)	(7.75)	(7.58)	(10.21)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
P value for t-test	0.33	0.17	0.13	0.24
Observations	4761	4761	4761	4761

	Panel B: Kerosene Spending on PDS			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	3.37	1.23	11.41	4.18
	(2.70)	(2.62)	(9.81)	(8.78)
Remote (Time-Varying)	7.32**	2.51	8.77**	3.05
	(2.84)	(2.75)	(3.65)	(3.47)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
P value for t-test	0.10	0.60	0.72	0.86
Observations	4761	4761	4761	4761

	Panel C: Total Kerosene Spending			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-10.64**	-13.27**	-36.09**	-45.19**
	(4.56)	(6.00)	(15.93)	(22.19)
Remote (Time-Varying)	-11.43**	-20.35***	-16.03**	-26.16***
	(5.73)	(6.90)	(6.90)	(9.19)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	4761	4761	4761	4761

Standard errors in parentheses
* $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$

table S16. Effect of MGP solar microgrids on household electrification and hours of electricity including remote control habitations. The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day. The sample includes households from the remote control group and a time-varying control for these households. P-values are for t-tests of difference between the effect of the treatment and the time-varying control for remote households.

Explaining Electrification and Hours of Electricity (incl. Remote Control Habitations)

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.11**	0.08*	0.36**	0.29**
	(0.04)	(0.04)	(0.14)	(0.14)
Remote (Time-Varying)	-0.01	0.01	0.04	0.04
	(0.04)	(0.04)	(0.05)	(0.05)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
P value for t-test	0.01	0.07	<0.01	0.02
Observations	4761	4761	4761	4761

	Panel B: Hours of Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.42	0.29	1.42	0.99
	(0.26)	(0.27)	(0.91)	(0.92)
Remote (Time-Varying)	-0.15	-0.04	0.03	0.09
	(0.28)	(0.28)	(0.35)	(0.34)
Constant	1.96***	1.40***	1.77***	1.87***
	(0.22)	(0.21)	(0.31)	(0.29)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
P value for t-test	0.02	0.22	0.04	0.20
Observations	4760	4760	4760	4760

Standard errors in parentheses
* $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$

section S11. Additional regression output for energy access effects

This section provides regression results for kerosene spending, quality of lighting, and lighting hours.

- Table S17 shows the ITT treatment effect separately for each wave, distinguishing between private (Models 1-3), public (Models 4-6), and total kerosene expenditures (Models 7-9).
- Table S18 shows ITT (Models 1-2) and LATE (Models 2-4) estimates for the effect on lighting satisfaction (Panel A) and hours of lighting (Panel B).
- Table S19 shows ITT (Models 1-2) and LATE (Models 2-4) estimates for the effect on kerosene as the main source of lighting.

table S17. Effect of MGP solar microgrids on household spending on kerosene by wave, separate for private, public, and total kerosene expenditures. Estimated effects are ITTs and standard errors are clustered by habitation. All dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, by Wave

	Private Kerosene			Public Kerosene			Total Kerosene		
	(1) Wave 1	(2) Wave 2	(3) Wave 3	(4) Wave 1	(5) Wave 2	(6) Wave 3	(7) Wave 1	(8) Wave 2	(9) Wave 3
Treatment (ITT)	0.89	-6.76	-21.16′′′	2.19	0.81	5.89′′	3.08	-5.95	-15.27′′
	(5.72)	(5.53)	(6.91)	(2.51)	(3.05)	(2.79)	(5.38)	(5.10)	(6.11)
Constant	72.05′′′	54.40′′′	53.48′′′	34.97′′′	30.80′′′	35.29′′′	107.01′′′	85.19′′′	88.77′′′
	(4.73)	(4.28)	(6.38)	(1.74)	(2.40)	(2.26)	(4.60)	(3.82)	(5.46)
Observations	1281	1264	1280	1281	1264	1280	1281	1264	1280

Standard errors in parentheses

′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

table S18. Effect of MGP solar microgrids on household lighting satisfaction and hours of lighting. Satisfaction is measured on a scale from 0 (very unsatisfied) to 4 (very satisfied). The standard errors are clustered by habitation.

Explaining Lighting Satisfaction and Hours of Lighting

	Panel A: Lighting Satisfaction			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.02	0.02	0.06	0.07
	(0.07)	(0.09)	(0.22)	(0.31)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

	Panel B: Hours of Lighting			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.08	0.23	-0.28	0.79
	(0.16)	(0.27)	(0.60)	(0.86)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S19. Effect of MGP solar microgrids on the use of kerosene as the main source of lighting (=1 if the household uses kerosene for lighting). Standard errors are clustered by habitation.

Kerosene as Main Source of Lighting

	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.06	-0.11**	-0.20*	-0.37**
	(0.04)	(0.04)	(0.12)	(0.15)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

section S12. Multiple comparisons

For the energy access outcomes, we now report *p*-values corrected for the family-wise false discovery rate using the procedure recommended by (*27*). We do not conduct these tests for the socio-economic outcomes because they are statistically significant even without the correction. We focus on the LATE estimates based on Model 4 in the main tables, for a total of five comparisons (electricity access, hours of electricity, total kerosene, private kerosene, PDS kerosene). Using this procedure, we adjust the *p*-values for those obtained from the estimates. The results are reported in table S20. As the table shows, the *p*-value for the three statistically significant variables increases slightly to 0.075.

table S20. Benjamini and Hochberg (*27*) corrections of *P* values for the energy access family of outcomes. All estimates are based on the LATE estimations in the main results with household and wave fixed effects.

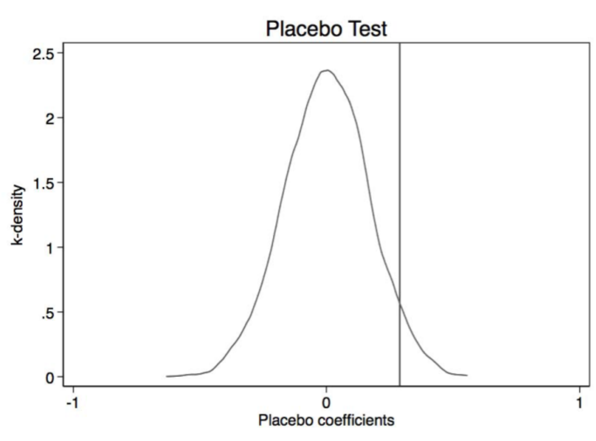
Variable	*p*-value	Benjamini-Hochberg correction
Access to electricity	0.038	0.075
Total Kerosene Spending	0.042	0.075
Private Kerosene Spending	0.045	0.075
Hours of electricity	0.281	0.351
PDS Kerosene Spending	0.634	0.634

section S13. Placebo tests from randomization inference

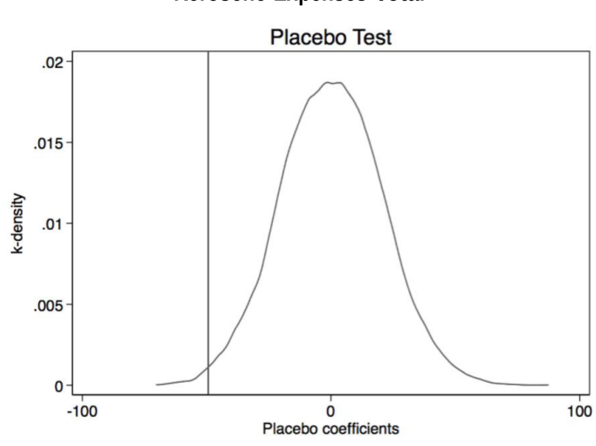
We implemented a series of randomization tests of experimental significance to further establish the robustness of our results. Specifically, we used the approach outlined in (*37*) and (*38*), and conducted randomization tests for each statistically significant outcome. In our sample of 81 non-remote habitations, we had a total of 50 treated habitations. So we generated a series of placebo treatments where a random 50 habitations would be considered to have received the treatment (while retaining all other co-variate and outcome information). Given the number of treatment habitations, every placebo randomization would include some of the habitations that were treated in our sample. So we 'purged' the outcome variable using the estimate from our main model (i.e. using the LATE estimates based on Model 4 in the main tables), allowing us to randomize across all 81 habitations in the placebo estimations. We repeated this procedure 10,000 times and then generated the probability density function of the treatment coefficient.

Figure S5 represent the probability density functions for each of the three statistically significant outcomes (electricity access, private kerosene expenses and total kerosene expenses) with the vertical line indicating the LATE estimates based on Model 4 in the main tables. As we would expect with random allocation of treatment, the distribution of the placebo estimates is centered around zero for all three outcomes. For electricity access, only 4.31% of the placebo estimates are higher than our main model, a number that goes down to 0.9% when we take the statistical significance of these estimates (at the 5% level) into account. Similarly, for private kerosene expenses, only 0.61% of the placebo estimates are lower than our main model, going down to 0.45% when we count only statistically significant placebo estimates. The results for total kerosene expenses are similar: about 1.06% of the placebo estimates are lower than our main model with the number declining to just 0.71% with statistical significance. Taken together, they provide robust support for our main findings and that they are not a result of a small number of treated habitations.

Electricity Access Private



Kerosene Expenses Total



Kerosene Expenses

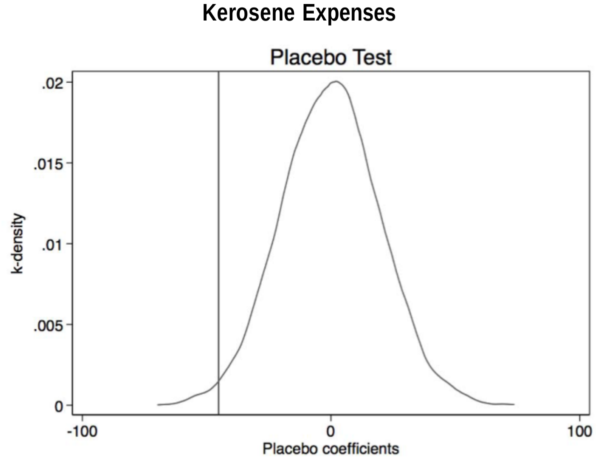


fig. S5. Placebo estimates for electricity access, private kerosene expenses, and total kerosene expenses. The vertical line indicates the LATE estimates based on Model 4 in the main tables.

section S14. Additional regression output for socioeconomic effects

- Table S21 and S22 show ITT estimates by wave for the socio-economic outcomes.

table S21. Effect of MGP solar microgrids on socioeconomic outcomes by wave. Estimated effects are ITTs and standard errors are clustered by habitation.

Socio-Economic Outcomes, by Wave (First Part)

	Savings			Expenses			Business		
	(1) Wave 1	(2) Wave 2	(3) Wave 3	(4) Wave 1	(5) Wave 2	(6) Wave 3	(7) Wave 1	(8) Wave 2	(9) Wave 3
Treatment (ITT)	-35.35	21.69	59.02	-71.55	177.17	53.28	0.02	0.01	0.01
	(99.48)	(89.10)	(99.90)	(167.96)	(159.70)	(148.14)	(0.02)	(0.02)	(0.02)
Constant	912.11′′′	391.75′′′	379.01′′′	4454.83′′′	3553.65′′′	3546.09′′′	0.06′′′	0.06′′′	0.06′′′
	(85.53)	(75.17)	(81.28)	(136.93)	(122.10)	(105.35)	(0.01)	(0.01)	(0.01)
Observations	1281	1264	1280	1281	1264	1280	1281	1264	1280

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

table S22. Effect of MGP solar microgrids on socioeconomic outcomes by wave. Estimated effects are ITTs and standard errors are clustered by habitation.

Socio-Economic Outcomes, by Wave (Second Part)

	Work Time			Study			Phone Charging		
	(1) Wave 1	(2) Wave 2	(3) Wave 3	(4) Wave 1	(5) Wave 2	(6) Wave 3	(7) Wave 1	(8) Wave 2	(9) Wave 3
Treatment (ITT)	-0.01	-0.07	-0.07	0.02	0.04	-0.01	-1.53	-0.33	-0.96
	(0.16)	(0.21)	(0.20)	(0.04)	(0.04)	(0.04)	(0.94)	(1.37)	(0.73)
Constant	4.07′′′	4.77′′′	5.52′′′	0.61′′′	0.55′′′	0.52′′′	8.84′′′	8.37′′′	4.63′′′
	(0.13)	(0.16)	(0.17)	(0.03)	(0.04)	(0.03)	(0.72)	(0.98)	(0.56)
Observations	1132	1213	1184	1281	1264	1280	866	798	868

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

section S15. Socioeconomic effects: Full results

This section shows the full results tables for socio-economic effects.

- Table S23 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on household savings (INR/month).
- Table S24 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on household expenditures (INR/month).
- Table S25 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on ownership of a business.
- Table S26 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on work hours per day.
- Table S27 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on whether lighting is used for studying.
- Table S28 and S29 show ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on the money spent for mobile phone charging (INR/week). The second model controls for electrification.
- Table S30 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on the use of domestic violence from the female module (Panel A), or with a dichotomous version of this variable (Panel B; = 1 if there was any violence against women).
- Table S31 shows ITT(Models 1-2) and LATE (Models 3-4) estimates for the effect on views on eve-teasing from the female module (Panel A), or with a dichotomous version of this variable (Panel B; = 1 if there was any harassment against women).
- Table S32 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on safety feelings from the female module (Panel A), or with a dichotomous version of this variable (Panel B; = 1 if lighting would be much safer).

- Table S33 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on willingness to go outside after dark from the female module (Panel A), or with a dichotomous version of this variable (Panel B; = 1 if lighting is sufficient or very sufficient).
- Table S34 shows ITT (Models 1-2) and LATE (Models 3-4) estimates for the effect on time spent cooking from the female module.

table S23. Socioeconomic effects of MGP solar microgrids on household savings in rupees per month. The standard errors are clustered by habitation.

Explaining Household Savings (INR/Month)				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	40.48	65.82	137.24	224.17
	(76.80)	(88.96)	(261.82)	(316.67)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S24. Socioeconomic effects of MGP solar microgrids on household expenditures in rupees per month. The standard errors are clustered by habitation.

Explaining Household Expenditures (INR/Month)				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	114.81	192.81	389.26	656.69
	(115.24)	(174.24)	(420.16)	(638.43)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S25. Socioeconomic effects of MGP solar microgrids on household business ownership, measured as a dichotomous indicator that takes a value of 1 if the household head owns a business. The standard errors are clustered by habitation.

Business Ownership				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.01	-0.01	0.03	-0.03
	(0.01)	(0.02)	(0.05)	(0.06)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S26. Socioeconomic effects of MGP solar microgrids on the amount of work hours per day (female module). The standard errors are clustered by habitation.

Explaining Time Women Spent Working (Hours/Day)				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.07	-0.05	-0.24	-0.18
	(0.15)	(0.21)	(0.52)	(0.71)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S27. Socioeconomic effects of MGP solar microgrids on household use of lighting for studying, measured as a dichotomous indicator that takes a value of 1 if the respondent or the children use lighting to study at night. The standard errors are clustered by habitation.

Explaining Whether Lighting Used for Studying				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.01	-0.01	0.04	-0.02
	(0.04)	(0.03)	(0.13)	(0.10)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S28. Socioeconomic effects of MGP solar microgrids on household expenditures to charge mobile phones, measured in rupees per week. The standard errors are clustered by habitation.

Explaining Money Spent on Phone Charging (INR/Week)				
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.66	0.66	-2.45	2.55
	(0.79)	(1.11)	(3.08)	(4.34)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	2532	2532	2532	2532

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S29. Socioeconomic effects of MGP solar microgrids on household expenditures to charge mobile phones, measured in rupees per week, controlling for electrification status of the household. The standard errors are clustered by habitation.

Explaining Money Spent on Phone Charging (INR/Week)

	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.19	0.93	-0.76	3.65
	(0.76)	(1.09)	(3.02)	(4.28)
Household Electrification (=1)	-4.92‴	-5.95‴	-4.83‴	-6.25‴
	(0.62)	(1.07)	(0.73)	(1.19)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	2532	2532	2532	2532

Standard errors in parentheses
′ $p < 0.10$, ″ $p < 0.05$, ‴ $p < 0.01$

table S30. Effect of MGP solar microgrids on prevalence of domestic violence against women in the habitation (female module). Results are shown on a 1-4 scale with higher values indicating more violence (A) and a dichotomous version (B; =1 if there was any violence against women). The standard errors are clustered by habitation.

Explaining Domestic Violence (Female Module)

	Panel A: Original Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.04	-0.14	-0.14	-0.46
	(0.05)	(0.11)	(0.17)	(0.39)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529
	Panel B: Dichotomous Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.01	-0.06	-0.03	-0.19
	(0.03)	(0.05)	(0.10)	(0.19)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses
′ $p < 0.10$, ″ $p < 0.05$, ‴ $p < 0.01$

table S31. Effect of MGP solar microgrids on prevalence of eve teasing of women in the habitation (female module). Results are shown on a 1-4 scale with higher values indicating more harassment (A) and a dichotomous version (B; =1 if there was any harassment against women). The standard errors are clustered by habitation.

Explaining Eve-Teasing (Female Module)

	Panel A: Original Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.01	0.02	0.03	0.06
	(0.03)	(0.07)	(0.11)	(0.24)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

	Panel B: Dichotomous Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.00	0.02	0.01	0.05
	(0.02)	(0.04)	(0.06)	(0.14)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S32. Effect of MGP solar microgrids on perceived safety in habitation because of better lighting (female module). Results are shown on a 1-3 scale with higher values indicating weaker beliefs that lighting would improve safety (A) and a dichotomous version (B; =1 if lighting would make respondent feel much safer). The standard errors are clustered by habitation.

Explaining Whether Respondents Would Feel Safer with Better Lighting (Female Module)

	Panel A: Original Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.00	0.00	-0.01	0.01
	(0.02)	(0.02)	(0.06)	(0.08)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

	Panel B: Dichotomous Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.00	-0.01	0.01	-0.02
	(0.02)	(0.02)	(0.06)	(0.08)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S33. Effect of MGP solar microgrids on belief there is enough light to go outside in habitation (female module). Results are shown on a 1-5 scale with higher values indicating stronger beliefs that there is enough light to go outside (A) and a dichotomous version (B; =1 if lighting is consider sufficient or very sufficient). The standard errors are clustered by habitation.

Explaining Whether Respondent Believes that there is Enough Light to Go Out (Female Module)

	Panel A: Original Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.12	-0.04	0.41	-0.13
	(0.08)	(0.11)	(0.30)	(0.37)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529
	Panel B: Dichotomous Outcome Variable			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.01	-0.03	0.02	-0.11
	(0.02)	(0.03)	(0.06)	(0.10)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S34. Effect of MGP solar microgrids on women's time spent cooking per day (female module). The standard errors are clustered by habitation.

Explaining Time Spent Cooking (Female Module)

	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-0.03	-0.00	-0.10	-0.02
	(0.07)	(0.11)	(0.24)	(0.38)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3529	3529	3529	3529

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

section S16. MGP

In our setting, the Indian solar service provider MGP provides households in non-electrified habitations with minimal electricity access in exchange for a monthly fee of 100 rupees (~USD 1.67). See http://www.meragaopower.com/ for more information provided by the company (accessed November 30, 2016). In exchange for this fee, MGP offers two LED lights and a mobile charger, provided that at least ten households within the habitation subscribe to the service. The 100-rupee charge contrasts to a 112-rupee monthly kerosene expenditure (PDS and private, combined) on average in the baseline for 5.3 hours of light per day. These households may or may not be in our random sample, as we did not try to restrict offers to surveyed households. Thus, some subscribers are not in our sample.

While MGP cannot share their revenue numbers with us for standard business reasons, these numbers offer a rough sense of payback times. A typical MGP system has on average 20 subscribers at any given time, so the monthly revenue is 33.33 dollars per system. Thus, the capital cost is recovered in 30 months, that is, 2.5 years. In reality, of course, the payback time is longer because payment collection and maintenance are costly. Still, the fact remains that the low capital cost of the MGP system implies that the payback time is not prohibitive. For example, even if collections and maintenance together form 50% of the total cost, each system would still pay itself back within 5 years. If the totality of the soft costs is higher, then the payback time would be longer. MGP also faces considerable systemic risk, as grid extension in India is rapid under the country's flagship rural electrification program.

Households can only use electricity at night, beginning at sunset and ending by 11 p.m. or, if insolation is insufficient, when the battery discharges so much that further power consumption would be detrimental. Thus, the maximum hours of lighting available to a household per day is five. MGP does not allow households to choose their own electricity consumption: the lights are switched on/off at the same time in all households; mobile phone charging is only available at that time.

The MGP solar microgrid is powered by a 200-watt (or more, depending on the number of customers) panel and includes a battery and wiring for subscribers within a radius of approximately 100 meters. MGP installs systems of varying size and can expand the system if the number of subscribers increases; for example, MGP can increase from ten to 15 or 20 households as necessary. Payments are typically collected on a weekly or monthly basis by the local MGP team. The system can be constructed within one day after subscribers have been found and the equipment is delivered to the nearest branch office.

A major advantage of the MGP system is that it is designed to minimize power theft. Because MGP only offers power for restricted hours during the day and households have no control over their consumption of power, overdrawing is very difficult. The power supply to each household is controlled by a device under lock and key; if power consumption exceeds what the MGP-provided equipment requires, the device cuts off the household. Compared to systems that allow households to choose their own consumption, perhaps based on pre-paid devices, the MGP system makes power theft much more difficult. The only practical way to steal power would be to connect a wire to the connection between the central batter and the household, and in this case the MGP customer would notice immediately.

section S17. Robustness: Energy access effects without flooded villages

This section demonstrates the robustness of our energy access effects when excluding flooded villages.

- Table S35 replicates the estimation results (Table 2 from the main text) for private (Panel A), public (Panel B), and total (Panel C) kerosene expenditures when excluding flooded villages.
- Table S36 replicates the estimation results (Table 1 from the main text) for electricity access (Panel A) and hours of electricity per day (Panel B) when excluding flooded villages.

table S35. Effect of MGP solar microgrids on household kerosene spending, without flooded villages. Effects are shown for spending in the private market (A), the PDS (B), and overall (C). The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, w/o Flooded Villages

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-15.57***	-15.44**	-45.44***	-45.27**
	(5.20)	(7.01)	(17.16)	(21.14)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3585	3585	3585	3585

	Panel B: Kerosene Spending on PDS			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	4.53	1.84	13.21	5.38
	(2.73)	(2.71)	(8.99)	(7.88)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3585	3585	3585	3585

	Panel C: Total Kerosene Spending			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-11.04**	-13.60**	-32.22**	-39.89**
	(4.56)	(6.14)	(13.32)	(18.83)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3585	3585	3585	3585

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S36. Effect of MGP solar microgrids on household electrification and hours of electricity, without flooded villages. Results are shown for household electrification (A) and hours of electricity per day (B). The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity, w/o Flooded Villages

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV) (1)	
		(2)	(3)	(4)
Treatment	0.11′′	0.09′′	0.33′′′	0.26′′
	(0.04)	(0.04)	(0.13)	(0.12)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3585	3585	3585	3585
	Panel B: Hours of Electricity per Day			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.36	0.21	1.06	0.61
	(0.26)	(0.27)	(0.74)	(0.77)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3584	3584	3584	3584

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

section S18. Robustness: Energy access effects without contaminated villages

This section demonstrates the robustness of our energy access effects when excluding contaminated villages that were electrified accidentally.

- Table S37 replicates the estimation results (Table 2 from the main text) for private (Panel A), public (Panel B), and total (Panel C) kerosene expenditures when excluding contaminated villages.
- Table S38 replicates the estimation results (Table 1 from the main text) for electricity access (Panel A) and hours of electricity per day (Panel B) when excluding contaminated villages.

table S37. Effect of MGP solar microgrids on household kerosene spending, without contaminated villages. Effects are shown for spending in the private market (A), the PDS (B), and overall (C). The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, w/o Contaminated Villages

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-17.75‴	-17.18″	-42.03‴	-40.69″
	(5.36)	(7.36)	(13.91)	(17.55)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3638	3638	3638	3638

	Panel B: Kerosene Spending on PDS			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	4.44	2.41	10.50	5.71
	(2.81)	(2.68)	(7.09)	(6.39)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3638	3638	3638	3638

	Panel C: Total Kerosene Spending			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-13.32‴	-14.77″	-31.53‴	-34.98″
	(4.73)	(6.47)	(11.38)	(15.35)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3638	3638	3638	3638

Standard errors in parentheses
′ $p < 0.10$, ″ $p < 0.05$, ‴ $p < 0.01$

table S38. Effect of MGP solar microgrids on household electrification and hours of electricity, without contaminated villages. Results are shown for household electrification (A) and hours of electricity per day (B). The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports hav- ing electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity, w/o Contaminated Villages

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV) (1)	
		(2)	(3)	(4)
Treatment	$0.13^{\prime\prime\prime}$	$0.11^{\prime\prime}$	$0.31^{\prime\prime\prime}$	$0.26^{\prime\prime\prime}$
	(0.04)	(0.04)	(0.10)	(0.10)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3638	3638	3638	3638

	Hours of Electricity per Day			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	$0.55^{\prime\prime}$	0.44	$1.31^{\prime\prime}$	1.04
	(0.26)	(0.27)	(0.64)	(0.65)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3637	3637	3637	3637

Standard errors in parentheses
$^{\prime}$ $p < 0.10$, $^{\prime\prime}$ $p < 0.05$, $^{\prime\prime\prime}$ $p < 0.01$

section S19. Robustness: Energy access effects without suspicious case

This section demonstrates the robustness of our energy access effects when excluding a household that reports having adopted MGP while being in the control group.

- Table S39 replicates the estimation results (Table 2 from the main text) for private (Panel A), public (Panel B), and total (Panel C) kerosene expenditures when excluding the one suspicious household.
- Table S40 replicates the estimation results (Table 1 from the main text) for electricity access (Panel A) and hours of electricity per day (Panel B) when excluding the one suspicious household.

table S39. Effect of MGP solar microgrids on household kerosene spending, without suspicious household. Effects are shown for spending in the private market (A), the PDS (B), and overall (C). The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, w/o Suspicious Observation

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV) (1)	
		(2)	(3)	(4)
Treatment	-14.01′′′	-14.49′′	-47.49′′	-49.36′′
	(5.28)	(6.91)	(19.83)	(24.62)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

	Panel B: Kerosene Spending on PDS			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	3.37	1.23	11.41	4.18
	(2.71)	(2.62)	(9.81)	(8.79)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

	Panel C: Total Kerosene Spending			
	ITT (OLS)		LATE (IV) (1)	
		(2)	(3)	(4)
Treatment	-10.64′′	-13.26′′	-36.08′′	-45.18′′
	(4.56)	(6.01)	(15.93)	(22.21)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

table S40. Effect of MGP solar microgrids on household electrification and hours of electricity, without suspicious household. Results are shown for household electrification (A) and hours of electricity per day (B). The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity, w/o Suspicious Observation

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.10′′	0.08′	0.36′′	0.29′′
	(0.04)	(0.04)	(0.14)	(0.14)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3825	3825	3825	3825
	Panel B: Hours of Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.42	0.29	1.42	0.99
	(0.26)	(0.27)	(0.91)	(0.92)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3824	3824	3824	3824

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$

section S20. Robustness: Energy access effects without treatment from wait list

This section demonstrates the robustness of our energy access effects when excluding contaminated treatment habitations from the waiting list.

- Table S41 replicates the estimation results (Table 2 from the main text) for private (Panel A), public (Panel B), and total (Panel C) kerosene expenditures when excluding treatment habitations from the waiting list.
- Table S42 replicates the estimation results (Table 1 from the main text) for electricity access (Panel A) and hours of electricity per day (Panel B) when excluding treatment habitations from the waiting list.

table S41. Effect of MGP solar microgrids on household kerosene spending, without treatment habitations from wait list. Effects are shown for spending in the private market (A), the PDS (B), and overall (C). The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, w/o Treatment Hab from Waiting List

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-14.83***	-16.51**	-38.70***	-43.17**
	(5.41)	(7.19)	(14.95)	(19.21)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓

	Panel B: Kerosene Spending on PDS			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	2.79	1.90	7.28	4.97
	(2.88)	(2.75)	(7.73)	(7.12)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓

	Panel C: Total Kerosene Spending			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	-12.04**	-14.61**	-31.42**	-38.20**
	(4.74)	(6.35)	(12.40)	(17.24)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3413	3413	3413	3413

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

table S42. Effect of MGP solar microgrids on household electrification and hours of electricity, without treatment habitations from the wait list. Results are shown for household electrification (A) and hours of electricity per day (B). The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports hav- ing electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity, w/o Treatment Hab from Waiting List

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.12′′	0.11′′	0.31′′′	0.30′′
	(0.05)	(0.05)	(0.12)	(0.12)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
	Panel B: Hours of Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.47	0.45	1.21′	1.16
	(0.28)	(0.28)	(0.73)	(0.76)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓

section S21. Robustness: Energy access effects without households with 24 hours of electricity

This section demonstrates the robustness of our results when we remove households that have 24 hours per day of electricity. There are 16 such observations in the treatment group, five in the control group, and four in the remote control group. All of these were observed in the midline; one was observed in the endline.

- Table S43 replicates the estimation results (Table 2 from the main text) for private (Panel A), public (Panel B), and total (Panel C) kerosene expenditures when excluding households with 24 hours of electricity.

- Table S44 replicates the estimation results (Table 1 from the main text) for electricity access (Panel A) and hours of electricity per day (Panel B) when excluding households with 24 hours of electricity.

table S43. Effect of MGP solar microgrids on household kerosene spending, without households with 24 hours of electricity per day. Effects are shown for spending in the private market (A), the PDS (B), and overall (C). The standard errors are clustered by habitation. Dependent variables are measured in rupees per month.

Explaining Monthly Kerosene Expenditure, w/o HH With 24h/Day of Electricity

	Panel A: Kerosene Spending on Private Market			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	$-13.76^{\prime\prime}$	$-14.04^{\prime\prime}$	$-45.93^{\prime\prime}$	$-47.44^{\prime\prime}$
	(5.28)	(6.90)	(19.14)	(24.06)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3804	3804	3804	3804
	Panel B: Kerosene Spending on Public Distribution System			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	3.31	1.20	11.06	4.05
	(2.71)	(2.63)	(9.59)	(8.74)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3804	3804	3804	3804
	Panel C: Total Kerosene			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	$-10.45^{\prime\prime}$	$-12.84^{\prime\prime}$	$-34.87^{\prime\prime}$	$-43.38^{\prime\prime}$
	(4.59)	(6.01)	(15.54)	(21.68)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3804	3804	3804	3804

Standard errors in parentheses

$^{\prime}$ $p < 0.10$, $^{\prime\prime}$ $p < 0.05$, $^{\prime\prime\prime}$ $p < 0.01$

table S44. Effect of MGP solar microgrids on household electrification and hours of electricity, without households with 24 hours of electricity per day. Results are shown for household electrification (A) and hours of electricity per day (B). The standard errors are clustered by habitation. The dependent variable in Panel A is a dichotomous variable that takes value 1 if the household reports having electricity, and zero otherwise. The dependent variable in Panel B is the number of hours of electricity available per day.

Explaining Electrification and Hours of Electricity, w/o HH With 24h/Day of Electricity

	Panel A: Access to Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.10′′	0.08′	0.34′′	0.28′′
	(0.04)	(0.04)	(0.14)	(0.14)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3804	3804	3804	3804
	Panel B: Hours of Electricity			
	ITT (OLS)		LATE (IV)	
	(1)	(2)	(3)	(4)
Treatment	0.31	0.18	1.03	0.61
	(0.23)	(0.24)	(0.79)	(0.80)
Household FE		✓		✓
Wave FE	✓	✓	✓	✓
Observations	3803	3803	3803	3803

Standard errors in parentheses
′ $p < 0.10$, ′′ $p < 0.05$, ′′′ $p < 0.01$