Access to modern energy: a review of barriers, drivers and impacts

JACOPO BONAN, Corresponding author
Fondazione Eni Enrico Mattei (FEEM), C.so Magenta, 63 - 20123 Milan, Italy. Email: jacopo.bonan@feem.it

STEFANO PAREGLIO
Department of Mathematics and Physics, Università Cattolica del Sacro Cuore; and Fondazione Eni Enrico Mattei (FEEM), Italy. Email: Stefano.Pareglio@unicatt.it

MASSIMO TAVONI
Fondazione Eni Enrico Mattei (FEEM); and Politecnico di Milano, Italy. Email: massimo.tavoni@feem.it

ONLINE APPENDIX

Table A1. *Summary of included studies*

	Barriers to adoption		Impacts	
	Electricity	ICS	Electricity	ICS
Total number of studies	3	8	24	10
Experimental	3	7	6	5
Non Experimental	0	1	18	5
DD-FE		1	4	
IV			9	1
PSM-Heckaman			4	4
RDD			1	

Table A2. *Barriers to and enablers of access to energy*

Outcome	Study, geographical region	Main results	Method	Sample size (level)	Period (n. of time obs)	Risk of bias
Electrification						
	Bernard and Torero (2015), Ethiopia	20% reduction of fixed connection cost leads to 15% increase in connection	RCT	565 (household)	(2)	Low
Liquidy constraints	Lee *et al*. (2016), Kenya	100, 57, 29% reduction in fixed connection cost leads to 95, 23,6% take-up	RCT	2289 (household)	2014 (1)	Low
	Hanna and Oliva (2015), India	Asset transfer program leads to increase in electricity use for lighting	RCT	812 (household)	2007-2011 (3)	Low
Social networks	Bernard and Torero (2015), Ethiopia	Evidence of bandwagon effects in the decision of connecting to the grid in rural areas: having more people connected in the neighbourhood increases individual propensity to be connected	RCT	565 (household)	(2)	Low
Cookstoves						
Prices, Adoption rate, use and maintenance	Hanna *et al*. (2016); India	60% adoption rate with a 94% subsidy. Only 3 more meals on the improved stove per weeks. 36% more hh maintained the improved cookstove	RCT	2651 (household)	2005-2010 (2)	Low
	Miller and Mobarak (2013); Bangladesh	97% orders and 69,5% purchases for free stove; 70% orders and 27.5% for subsidized at 80% average subsidy	RCT	800 (household)	2008 (1)	Low
	Miller and Mobarak (2014); Bangladesh	25% orders and 4% actual purchases at full price; 40% orders and 11% purchases at half price	RCT	2100 (household)	2008-2009 (2)	Low
	Mobarak *et al*. (2012); Bangladesh	50% discount implies an increase of 25% in intentions to buy; 5-12% increase in actual purchase. Small actual purchases at full price (2-5%).	RCT	2280 (household)	2008 (1)	Low
	Alem *et al*. (2014); Ethiopia	Household economic status, access to credit, price of electricity and price of firewood are significant determinants of ICS	Panel data	2934 (household)	200-2009 (3)	Medium
Information	Bonan *et al*. (2017); Mali	Large positive effects (+25pp) of a training session with cooking show and 12% discount offer	RCT	1077 (households	2014 (2)	Low-Medium

Marketing	Levine, Beltramo, Blalock and Cotterman (2016); Uganda	4% uptake with traditional cash and carry offer and 46% uptake with a novel offer with free trial and time payments. Individually time payments generate 22% uptake and right to return 33%. Cookstoves were offered at full price (6-10$)	RCT	1690 (household)	2010 (1)	Low
Intra-household decision making	Miller and Mobarak (2013); Bangladesh	When offered for free, women take-up more than men, particularly the health-improving stoves. When small prices are charged, no difference between men and women	RCT	800 (household)	2008 (1)	Low
Social networks	Miller and Mobarak (2014); Bangladesh	Positive (negative) effect of unanimous acceptance (rejection) of purchase by opinion leaders on efficiency stove orders. No positive effect on chimney stove, only significant negative effect from unanimous rejection. Info from opinion leaders is more salient at lower prices. No effect of opinion leader on actual purchase. Only unanimous rejection significantly decreases actual purchase	RCT	2100 (household)	2008-2009 (2)	Low
	Miller and Mobarak (2014); Bangladesh	Negative effect of social network on purchase: more network members purchased in first round, less likelihood of buying in the second round for members of the same network: overly optimistic opinions about benefits of cookstoves	RCT	2100 (household)	2008-2009 (2)	Low
	Bonan *et al.* (2017); Mali	Women are more likely to buy if they receive info about peer's purchasing behaviour	RCT	1077 (households)	2014 (2)	Low

Table A3. *Causal effects of access to electricity on time allocation and labour market*

Outcome	Study, geographical region	Source of electricity	Results	Method	Sample size (level)	Period (n. of time obs)	Risk of bias
Allocation of time	Grimm *et al*. forthcoming, Rwanda	Solar Pico PV	No effect on time allocation of hh members	RCT	300 (households)	2011-2012 (2)	Low
	Arraiz and Calero (2015); Peru	Solar PV	More time awake; women spend less time in agriculture, more time in household activities; more people spend time on home business; children spend more time studying at home	PSM	1329 (households)	2013 (1)	Medium
	Bernard and Torero (2015), Ethiopia	On-grid	No short run effect on children study time	RCT	563 (household)	(2)	Low
	Barron and Torero (2016), El Salvador	On-grid	Strong positive effect on children participation in educational activities and more time spent on household chores	RCT	500 (households)	2007-2012 (4)	Low
	Lenz *et al*. (2017), Rwanda	On-grid	More time awake and study time at night for children but no effect on overall study time. No effect on adults' time allocation	DD-PSM	974 (houshlds)	2011-2013 (2)	Mediu-Low
	Furukawa (2014), Uganda	Pico-PV lamp	Increase in study time	RCT	155 (students)	2011 (2)	Medium
	Bensch *et al*. (2011), Rwanda	Micro-hydro mini-grids	Small positive effects on the children studying at home	PSM	531 (household)	2005 (1)	Medium
	Khandker *et al*. (2012), India	On-grid	Large significant decrease in time collecting biofuel for women and men. Small slightly significant for boys. No effect on girls Significant increase in time spent studying for both boys and girls	IV	~24000 (households)	2005 (1)	Medium-High
	Aguirre (2014), Peru	On-grid	Positive and significant effect on time studying home by children	IV	987 (households)	2013 (1)	Medium-High
	Samad *et al*. (2013), Bangladesh	Solar PV	Increase in study time for children and in time for fuel collection for women	PSM	4000 (households)	2012 (1)	High
Employment and labour supply	Barron and Torero (2016), El Salvador	On-grid	Increase in non-farm employment and in home business, particularly for women	RCT	500 (households)	2007-2012 (4)	Low

	Burlig and Preonas (2016), India	On-grid	Small decrease in share of men working in agriculture and small increase in non-agriculture activities. No effect on female employment	RDD	30.000 (villages)	2001-2011 (2)	Low
	Bernard and Torero (2015), Ethiopia	On-grid	No short-run effect of rural electrification on time spent on income generating activities	RCT	563 (household)	(2)	Low-Medium
	Libscomb *et al*. (2013); Brazil	On-grid	Strong effect on activity rate and employment in the formal sector, both in rural and urban areas	FE - IV	2184 (county)	1960-2000 (5)	Low-Medium
	Grogan and Sadanand (2013); Nicaragua	On-grid	Significant increase in the propensity to work outside the home for women. No effect for men	FE-IV	6882 (household)	1971-2005 (3)	Medium
	Squires (2015), Honduras	On-grid	Increase in children employment rate; increase in female employment	FE-IV	~19.000 (houeholds)		Medium
	Dinkelman (2011), South Africa	On-grid	Increase in employment for women and no significant effect for men	D-D - IV	1816 (community)	1996-2001 (2)	Medium
	Dinkelman (2011), South Africa	On-grid	Increase in labour supply for both women and men (only OLS)	pooled OLS & FE	1816 (community)	1996-2001 (2)	Medium
	van de Walle *et al*. (2015); India	On-grid	Significant substitution of days of work from causal wage works to regular wage and agriculture self-employment for men. Small significant reduction of female causal wage work.	Panel data & IV	~3000 (household)	1981-1999 (2)	Medium
	Dasso and Fernandez (2015); Peru	On-grid	Increase in male working hours, no effect on women. Decrease in the likelihood of having more than one job among males Women: higher employent, lower probability of working in agricultural sector	FE	3980 (individuals)	2006-2012 (6)	Medium
	Alcazar *et al*. (2007), Peru	On-grid / better supply	Significant reduction in hours worked in agriculture and increase in non-farm activities	PSM	6690 (households)	2005	Medium
Wages, Earnings, Income	Dinkelman (2011), South Africa	On-grid	No significant effect on wages. Higher earnings for men, no significant impacts for women	pooled OLS & FE	1816 (community)	1996-2001 (2)	Medium
	Barron and Torero (2016), El Salvador	On-grid	Positive effect on household profit from small business and household income	RCT	500 (households)	2007-2012 (4)	Low
	Libscomb *et al*. (2013); Brazil	On-grid	Strong effect on household income	FE - IV	2184 (county)	1960-2000 (5)	Low-Medium
	Chakravorty *et al*. (2016); Philippines	On-grid	Significant increase in household income	FE-IV	~12.000 (households)	2003, 2012 (4)	Low-Medium

	Lenz *et al*. (2017), Rwanda	On-grid	No effect on income generation or productive take-up	DD-PSM	974 (houshol ds)	2011-2013 (2)	Mediu-Low
	Chakravorty *et al*. (2014); India	On-grid / better supply	Strong effect on household non-agricultural income. Also the quality of electricity (frequency of outages) matters for hh income	FE - IV	9790 (househ old)	1994-2005 (2)	Medim
	Bensch *et al*. (2011), Rwanda	Micro-hydro mini-grids	Inconclusive evidence of increase in income	PSM	531 (househ old)	2005 (1)	Medium
	Dasso and Fernandez (2015); Peru	On-grid	Higher wages for women	FE	3980 (individ uals)	2006-2012 (6)	Medium
	Arraiz and Calero (2015); Peru	Solar PV	No effect on income	PSM	1329 (househ olds)	2013 (1)	Medium
	Khandker *et al*. (2013); Vietnam	On-grid	Significant increase in total hh income, due to the increase in non-agricultural income. No effect on wages	Panel data &FE	1120 (househ old)	2002-2005 (2)	Medium -High

Table A4. Causal effects of access to electricity on consumption, schooling and health

Outcome	Study, geographical region	Source of electricity	Results	Method	Sample size	Period (n. of time obs)	Risk of bias
Consumption and expenditure	Burlig and Preonas (2016), India	On-grid	No impact on asset ownership and housing stock	RDD	30.000 (villages)	2001-2011 (2)	Low
	Grimm *et al*. (forthcoming), Rwanda	Solar Pico PV	Significant decrease in fuel expenditure	RCT	300 (households)	2011-2012 (2)	Low
	Lenz *et al*. (2017), Rwanda	On-grid	Significant decrease in energy expenditure	DD-PSM	974 (houshold s)	2011-2013 (2)	Medium-Low
	Chakravorty *et al*. (2016); Philippines	On-grid	Large significant increase in total expenditure and energy expenditure increases	FE-IV	~12.000 (households)	2003, 2012 (4)	Medium-Low
	Arraiz and Calero (2015); Peru	Solar PV	Significant decrease in expenditure for candles, batteries and firewood	PSM	1329 (households)	2013 (1)	Medium
	van de Walle *et al*. (2015); India	On-grid	Significant increases in total expenditure, particluarly for food and fuel. Significant increase in the purchase of kerosene stove	Panel data & IV	~3000 (households)	1981-1999 (2)	Medium
	Bensch *et al*. (2011), Rwanda	Micro-hydro mini-grids	Increase in energy expenditure	DD-PSM	272 (housheolds)	2007 (1)	Medium
	Khandker *et al*. (2013); Vietnam	On-grid	Significant increase in household expenditure	Panel data & FE	1120 (household)	2002-2005 (2)	Medium-High
	Samad *et al*. (2013), Bangladesh	Solar PV	Significant higher total expenditure, decrease in expenditure for kerosene	PSM	4000 (households)	2012 (1)	High
Schooling	Burlig and Preonas (2016), India	On-grid	No significant effect on enrollment	RDD	30.000 (villages)	2001-2011 (2)	Low
	Libscomb *et al*. (2013); Brazil	On-grid	Strong effect on literacy and enrolment: increase in years of schooling (+2 years)	FE - IV	2184 (county)	1960-2000 (5)	Low-Medium
	Hassan and Lucchino (2016), Kenya	Pico-PV lamps	Significant direct and spillover effect on school performance	RCT	300 (students)	2013-2014 (2)	Low/Medium
	van de Walle *et al*. (2015); India	On-grid	Significant positive effects o on enrollment and the average years of schooling as a share of the maximum possible for a given age, only for girls.	Panel data & IV	~3000 (households)	1981-1999 (2)	Medium
	Arraiz and Calero (2015); Peru	Solar PV	Positive effect on years of schooling for children at elementary school, higher enrollement rate for children at secondary school	PSM	1329 (households)	2013 (1)	Medium

	Furukawa (2014), Uganda	Pico-PV lamp	Decrease in school performance	RCT	155 (students)	2011 (2)	Medium
	Squires (2015), Honduras	On-grid	Reduction in attendance (-4pp), attainment and higher drop-out rate	FE-IV	~19.000 (houehold s)		Medium
	Kudo *et al*. (2016), Bangladesh	Pico-PV lamps	Significant effect on home study hours, no effect on performance	RCT	882 (students)	2013-2014 (2)	Medium
	Khandker *et al*. (2013, EDCC); Vietnam	On-grid	Significant increase in school enrolment and years of completed schooling for both boys and girls	Panel data & FE	1120 (household)	2002-2005 (2)	Medium-High
	Khandker *et al*. (2012), India	On-grid	Significant increase in school enrolmen and years of completed schooling for both boys and girls	IV	~24000 (households)	2005 (1)	Medium-High
Health	Barron and Torero (2016), El Salvador	On-grid	Large significant reduction of PM2.5 concentration, due to less kerosene consumption for lighting Large significant reduction of acute respiratory infections among children under 6 (self-reported)	RCT	486 (household)	2009-2012 (4)	Low
	Gonzalez and Rossi (2007), Argentina	On-grid / better supply	Inconclusive evidence of reduction of low birth weight and lower child mortality rates caused by food poisoning	DD	264 (households)	(2)	Medium-High
	Samad *et al*. (2013), Bangladesh	Solar PV	Reduction in respiratory deseases for women	PSM	4000 (households)	2012 (1)	High

Table A5. *Causal effects of improved cookstove adoption on health and household welfare*

Outcome	Study, geographical region	ICS main feature (fuel and imprved features)	Results	Method	Sample size (level)	Period (n. of time obs)	Risk of bias
IAP exposure and health	Smith *et al*. (2011); Guatemala	Fuelwood, reduced IAP	Significant decrease in carbon monoxide concentration Significant carbon monoxide exposure reduction for children and women. No effect on physician-diagnosed pneumonia. Positive effect of fieldworker assessed severe pneumonia	RCT	534 (household)	2002-2004 (weekly)	Low
	Hanna *et al*. (2016); India	Fuelwood, reduced IAP	Significan carbon monoxide exposure reduction in the first year. No effect in the longer run . No effect on lung functioning (measured with spirometry) and self-reported measures	RCT	2651 (household)	2005-2010 (2)	Low
	Bensch and Peters (2015); Senegal	Charcoal/fuelwood, efficiency	Significant effect on self-reported symptoms of respiratory diseases and eye problems	RCT	253 (household)	2009-2010 (2)	Low
	Beltramo and Levine (2013); Senegal	Solar, efficiency, reduced IAP	No effect on carbon monoxide exposure (measured on a small sub sample). No effect on self-reported symptoms associated with cooking	RCT	790 (household)	2008 (2)	Low-Medium
	Bruwen and Levine (2012); Ghana	Fuelwood, reduced IAP, efficiency	No effect on carbon monoxide exposure. Significant decline in self-reported symptoms associated with cooking	RCT	488 (household)	2009 (2)	Medium
	Yu (2011), China		Significant effects on acute respiratory infections	PSM-DD	5500 (households)	2003-2005 (2)	High
Time allocation, fuel use and expenditure	Hanna , *et al*. (2016); India	Fuelwood, reduced IAP	No effect on time for cooking No effect on wood use and expenditure	RCT	2651 (household)	2005-2010 (2)	Low

Bensch and Peters (2015); Senegal	Charcoal/fuelwood, efficiency	Significant reduction in daily cooking time. No significant effect on time spent collecting wood Significant reduction in wood consumption	RCT	253 (household)	2009-2010 (2)	Low
Beltramo and Levine (2013); Senegal	Solar, efficiency, reduced IAP	No effect on time spent for wood collection and time of cooking Slight decline in wood use only for large households	RCT	790 (household)	2008 (2)	Low-Medium
Burwen and Levine (2012); Ghana	Fuelwood, reduced IAP, efficiency	No effect on wood consumption	RCT	488 (household)	2009 (2)	Medium
Adrianzen Agurto (2013), Peru	Fuelwood, efficiency, reduced IAP	Significant decrease in firewood consumption	IV	194 (households)	2008 (1)	Medium-high
Brooks *et al*. (2016), India		Significant decrease in time spent collecting biomass fuels and cooking on traditional stoves Significant decrease in biomass fuel consumption	Two-steps Heckman	1234	2012 (1)	Medium-High
Bensch *et al*. (2015); Burkina Faso	Charcoal/fuelwood, efficiency	Significant decrease in firewood consumption	PSM	1166 (household)	2011 (1)	High
Bensch and Peters (2013); Senegal	Charcoal/fuelwood, efficiency	Significant decrease in firewood consumption	PSM	624 (household)	2009 (1)	High

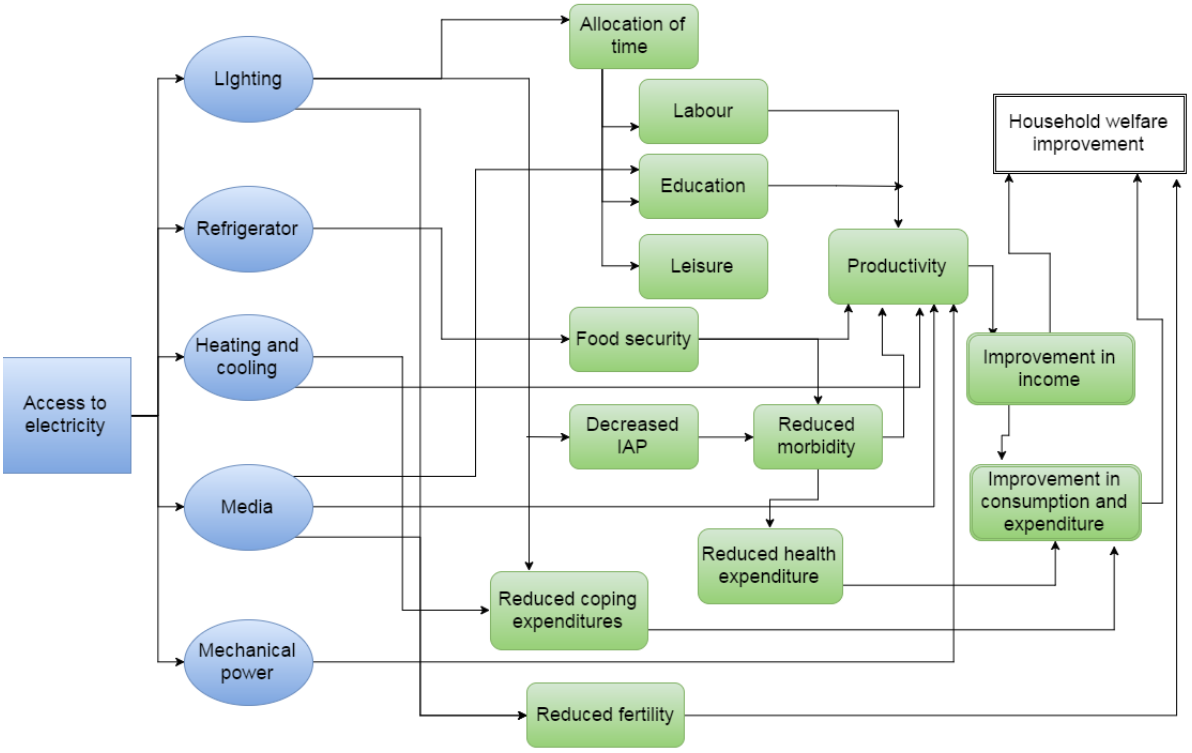

Figure A1. *Causal chain of impacts of access to electricity*

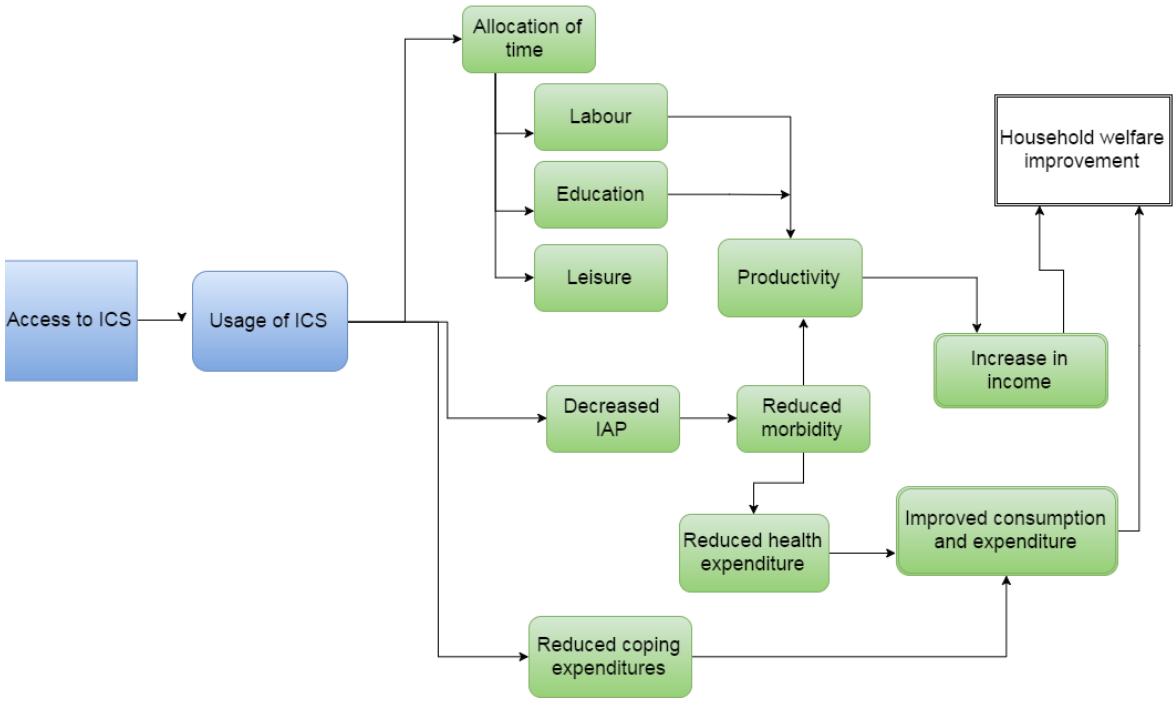

Figure A2. *Causal chain of impacts of access to ICS*

Risk of bias tool, from Baird *et al*. (2013)

Risk of bias is determined across five categories: selection bias and confounding, spillovers, cross-overs and contamination, outcome reporting, analysis reporting, and other risk of bias. For each of the five categories listed below we code the paper as 'Yes' if it addresses the issue, 'No' if it does not, and 'Unclear' if it is unclear. We then aggregate to an overall risk of bias as Low, Medium or High based on an aggregation across the five categories as follows:

a. Low Risk of Bias: 'Yes' for four or five categories

b. Medium Risk of Bias: 'Yes' for three categories

c. High Risk of Bias: 'Yes' for two or less categories

The five categories are now discussed in detail:

1. Selection bias and confounding

Experimental approaches (random allocation of the treatment): was the allocation free from any sources of bias or were sources of bias adequately corrected for with an appropriate method of analysis?

i. Score "yes" if[1]:

a. A random component in the sequence generation process is described (e.g. Referring to a random number table) and if the unit of allocation is based on a sufficiently large sample size.

b. The unit of allocation was by geographical/social unit, institution, team or professional and allocation was performed on all units at the start of the study; or if the unit of allocation was by beneficiary or group or episode of treatment and there was some form of centralised

c. Randomisation scheme, an on-site computer system or sealed opaque envelopes were used.

d. If the outcomes are objectively measurable.

e. Baseline characteristics of the study and control/comparisons are reported and overall similar based on t-test or anova for equality of means across groups.

f. if relevant (e.g. Cluster-rcts), authors control for external factors that might confound the impact of the programme (rain, infrastructure, community fixed effects, etc) through regression analysis or other techniques.

g. The attrition and noncompliance rate is below 15%, or the study assesses whether drop-outs are random draws from the sample (e.g. By examining correlation with determinants of outcomes, in both treatment and comparison groups)?

ii. Score "unclear" if a) or b) not specified in the paper, c) scores "no" or if d) scores "no" but the authors controlled for the relevant differences through regression analysis.

[1] Please note that when a) b) or f) score no or large differences in baseline characteristics, we assess risk of bias considering other study designs (Diff-in-Diff, cross-sectional regression, Instrumental variables). If the study presents high rate of non-compliance and combines an effective random design with IV, the report is assessed using the IV checklist and assuming a perfect instrument

iii. Score “no” otherwise.

Quasi-experimental approaches (non-random allocation of the treatment): was the identification method free from any sources of bias or were sources of bias adequately corrected for with an appropriate method of analysis?

I. Propensity score matching and combination of psm with panel models:

i. Score “unclear” if :

a. The study matched on either (1) baseline characteristics, (2) time-invariant characteristics or (3) endline variables not affected by participation in the programme.

b. The variables used to match are relevant (e.g. Demographic and socio-economic factors) to explain a) participation and b) the outcome and thus there are not evident differences across groups in variables that explain outcomes.

c. Except for kernel matching, the means of the individual covariates are equal for both the treatment and the control group after matching based on t-test for equality of means or anova.

ii. score “no” otherwise.

II. Regression discontinuity design[2]:

i. Score “yes” if:

a. Allocation is made based on a pre-determined discontinuity blinded to participants or if not blinded, individuals cannot amend the assignment variable. The sample size immediately at both sides of the cut-off point is sufficiently large.

b. The interval for selection of treatment and control group is reasonably small, or authors have weighted the matches on their distance to the cut-off point.

c. the mean of the covariates of the individuals immediately at both sides of the cut-off point (selected sample of participants and non-participants) are overall not statistically different based on t test or anova for equality of means..

d. If relevant (e.g. Clustered studies) and although covariates are balanced, the authors include control for external factors through a regression analysis.

ii. Score “unclear” if a) or b is) not specified in the paper or d) scores “no” but authors control for covariate differences across participants and control individuals.

iii. Score “no” otherwise.

III. Cross sectional regression studies using instrumental variables and Heckman procedures:

i. Score “Yes” if all the following are true:

a. the instrumenting equation is significant at the level of $F \geq 10$; if an F test is not reported, the author reports and assesses whether the R-squared (goodness of fit) of the participation equation is sufficient for appropriate identification

[2] Please note that when a) or b) scores “No” or there are large differences in baseline characteristics across groups, we assess risk of bias considering non-experimental assignment of the treatment (Diff-in-Diff, cross-sectional regression, Instrumental variables)

b. for instrumental variables, the identifying instruments are individually significant ($p \leq 0.01$); for Heckman models, the identifiers are reported and significant ($p \leq 0.05$)

c. for generalised IV estimation, if at least two instruments are used, the study includes and reports an overidentifying test ($p \leq 0.05$ is required to reject the null hypothesis)

d. the study qualitatively assesses the exogeneity of the instrument/ identifier (both externally as well as why the variable should not enter by itself in the outcome equation); only score yes when the instrument is exogenously generated: e.g. natural experiment or random assignment of participants to the control and treatment groups. If instrument is the random assignment of the treatment, the systematic reviewer should assess the quality and success of the randomisation (e.g. see section on RCTs).

e. the study includes relevant control for confounding, and none of the controls is likely affected by participation.

ii. Score "Unclear" if d) scores "no" and c) scores "yes".

iii. Score "No" otherwise

IV. Cross sectional regression studies using OLS or maximum likelihood models including logit and probit models.

i. Score "Unclear" if all the following are true:

a. The covariates distribution are balanced across groups

b. The authors control for a comprehensive set of confounders that may be correlated with both participation and explain outcomes (e.g. demographic and socio-economic factors at individual and community level) and thus, it is not evident the existence of unobservable characteristics that could be correlated with participation and affect the outcome.

c. The authors use proxies to control for the presence of unobservable confounders driving both participation and outcomes.

d. Participation does not have a causal impact in any of the controls.

ii. Score "No" otherwise

V. Panel data models (controlled before-after, difference in difference multivariate regressions):

i. Score "unclear" if the following are true:

a. the authors use a difference in difference multivariate estimation method or fixed effects models.

b. the author control for a comprehensive set of time-variant characteristics (e.g. the study includes adequate controls for confounding and thus, it is not evident the existence of time-variant unobservable characteristic that could be correlated with participation and affect the outcome)

c. the attrition and noncompliance rate is below 10%, or the study assesses whether drop-outs are random draws from the sample (e.g. by examining correlation with determinants of outcomes, in both treatment comparison group)?

ii. Score “No” otherwise.

2. Spillovers, cross-overs and contamination: was the study adequately protected against spillovers, cross-overs and contamination?

I. Score “yes” if the intervention is unlikely to spillover to comparisons (e.g. Participants and non-participants are geographically and/or socially separated from one another and general equilibrium effects are not likely) and that the treatment and comparisons are isolated from other interventions which might explain changes in outcomes.

II. Score “no” if allocation was at the individual level and there are likely spillovers within households and communities which are not controlled for, or other interventions likely to affect outcomes operating at the same time in either group.

III. Score “unclear” if spillovers and contamination are not addressed clearly.

3. Outcome reporting: was the study free from selective outcome reporting?

I. Score “yes” if there is no evidence that outcomes were selectively reported (e.g. All relevant outcomes in the methods section are reported in the results section).

II. Score “no” if some important outcomes are subsequently omitted from the results or the significance and magnitude of important outcomes was not assessed.

III. Score “unclear” if not specified in the paper.

4. Analysis reporting: was the study free from selective analysis reporting?

I. Score “yes” if authors use ‘common’ methods of estimation (i.e. Credible analysis method to deal with attribution given the data available). Additionally, specific methods of analysis should answer positively the following questions:

a. For rcts, score yes if randomisation clearly described and achieved, e.g. Comparison of treatment and control on all appropriate observables prior to selection.

b. For psm, score “yes” if (a) for failure to match over 10% of participants, sensitivity analysis is used to re-estimate results using different matching methods (kernel matching techniques); (b) for matching with replacement, there is not any observation in the control group that is matched with a large number of observations in the treatment group; (c) authors report the results of rosenbaum test for hidden bias which suggest that the results are not sensitive to the existence of hidden bias.

c. For iv and heckman models, score “yes” if (a) the author tests and reports the results of a hausman test for exogeneity ($p \leq 0.05$ is required to reject the null hypothesis of exogeneity); (b) the study describes clearly and justifies the exogeneity of the instrumental variable(s)/identifier used (iv and heckman); (c) the value of the selectivity correction term (rho) is significantly different from 0 ($p<0.05$) (heckman approach).

d. For regression analysis, score “yes” if authors carried out a hausmann test with a valid instrument and the authors cannot reject the null of exogeneity of the treatment variable at the 90% confidence.

II. Score “no” if authors use uncommon or less rigorous estimation methods such as failure to conduct multivariate analysis for outcomes equations.

5. Other risks of bias

I. Score “yes” if the reported results do not suggest any other sources of bias

II. Score “no” if other potential threats to validity are present, and note these below (e.g. Coherence of results, data on the baseline collected retrospectively, information is collected using an inappropriate instrument or a different instrument/at different time/after different follow up period in the control and in the treatment group).

References

Adrianzén Agurto, M. (2013), 'Improved cooking stoves and firewood consumption: quasi-experimental evidence from the Northern Peruvian Andes', *Ecological Economics* **89:** 135–143.

Aguirre, J. (2014), 'Impact of rural electrification on education: a case study from Peru', [Available at] http://udep.edu.pe/cceeee/files/2014/07/1B_3_Aguirre.pdf.

Alem, Y., S. Hassen, and G. Kohlin (2014), 'Adoption and disadoption of electric cookstoves in urban Ethiopia: evidence from panel data', *Resource and Energy Economics* **38:** 110–124.

Arraiz, I. and C. Calero (2015), 'From candles to light: the impact of rural electrification', IADB Working Paper Series No IDB-WP-599.

Baird, S., F.H.G. Ferreira, B. Özler, and M. Woolcock (2013), 'Relative effectiveness of conditional and unconditional cash transfers for schooling outcomes in developing countries: a systematic review', *Campbell Systematic Reviews* **9**.

Barron M. and M. Torero (2016), 'Household electrification and indoor air pollution', [Available at] https://www.ocf.berkeley.edu/~manuelb/Research/IAP/IAP-Jan2016.pdf.

Beltramo, T. and D.I. Levine (2013), 'The effect of solar ovens on fuel use, emissions and health: results from a randomised controlled trial'. *Journal of Development Effectiveness* **5:** 178–207.

Bensch, G., M. Grimm, and J. Peters (2015), 'Why do households forego high returns from technology adoption? Evidence from improved cooking stoves in Burkina Faso', *Journal of Economic Behavior & Organization* **116**: 187–205.

Bensch, G., J. Kluve, and J. Peters (2011), 'Impacts of rural electrification in Rwanda', *Journal of Development Effectiveness* **3**: 567–588.

Bensch, G. and J. Peters (2013), 'Alleviating deforestation pressure? Impacts of improved stove dissemination on charcoal consumption in urban Senegal', *Land Economics* **89**(4): 676–698.

Bensch, G. and J. Peters (2015), 'The intensive margin of technology adoption – experimental evidence on improved cooking stoves in rural Senegal', *Journal of Health Economics* **42**: 44–63.

Bernard, T. and M. Torero (2015), 'Social interaction effects and connection to electricity: experimental evidence from rural Ethiopia', *Economic Development and Cultural Change* **63**(3): 459–484.

Bonan J., P. Battiston, J. Bleck, P. LeMay-Boucher, S. Pareglio, B. Sarr, and M. Tavoni (2017), 'Social interaction and technology adoption: experimental evidence from improved cookstoves in Mali', Unpublished manuscript.

Brooks, N., V. Bhojvaid, M.A. Jeuland, J.J. Lewis, O. Patange, and S.K. Pattanayak (2016), 'How much do alternative cookstoves reduce biomass fuel use? Evidence from North India', *Resource and Energy Economics* **43:** 153–171.

Burlig, F. and L. Preonas (2016), 'Out of the darkness and into the light? Development effects of electrification in India', Energy Institute at Haas WP 268.

Burwen, J. and D.I. Levine (2012), 'A rapid assessment randomized-controlled trial of improved cookstoves in rural Ghana', *Energy for Sustainable Development* **16:** 328–338.

Chakravorty, U., K. Emerick, and M.-L Ravago (2016), 'Lighting up the last mile: the benefits and costs of extending electricity to the rural poor', RFF Discussion Paper 16–22.

Chakravorty, U., M. Pelli, and B. Ural Marchand (2014), 'Does the quality of electricity matter? Evidence from rural India', *Journal of Economic Behavior and Organization* **107:** 228–247.

Dasso, R. and F. Fernandez (2015), 'The effects of electrification on employment in rural Peru', *IZA Journal of Labor & Development,* **DOI:** 10.1186/s40175-015-0028-4.

Dinkelman, T. (2011), 'The effects of rural electrification on employment: new evidence from South Africa', *American Economic Review* **101**(7): 3078–3108.

Furukawa, C. (2014), 'Do solar lamps help children study? Contrary evidence from a pilot study in Uganda', *Journal of Development Studies* **50**(2): 319–341.

Gonzalez, M. and M.A. Rossi (2007), 'The impact of electricity sector privatization on public health', IADB Research Network Working Paper #R-524.

Grimm, M., A. Munyehirwe, J. Peters, and M. Sievert (forthcoming), 'A first step up the energy ladder? Low cost solar kits and household's welfare in rural Rwanda', *World Bank Economic Review*.

Grogan, L. and A. Sadanand (2013), 'Rural electrification and employment in poor countries: evidence from Nicaragua', *World Development* **43:** 252–265.

Hanna, R., E. Duflo, and M. Greenstone (2016), 'Up in smoke: the influence of household behavior on the long-run impact of improved cooking stoves', *American Economic Journal: Economic Policy* **8**(1): 80–114.

Hassan, F. and P. Lucchino (2016) 'Powering education', CEP Discussion Paper No 1438.

Khandker, S.R., D.F Barnes, and H.A. Samad (2013), 'Welfare impacts of rural electrification: a panel data analysis from Vietnam', *Economic Development and Cultural Change* **61:** 659 – 692.

Khandker, S.R., D.F Barnes, H.A. Samad, and A. Rubaba (2012), 'Who benefits most from rural electrification? Evidence in India', Policy Research Working Paper Series 6095, The World Bank.

Kudo, Y., S.A. Shonchoy, and K. Takahashi (2016), 'Can solar lanterns improve youth academic performance? Experimental evidence from Bangladesh', Unpublished manuscript.

Lee, K., E. Miguel, and C. Wolfram (2016), 'Experimental evidence on the demand for and costs of rural electrification', National Bureau of Economic Research.

Lenz, L., A. Munyehirwe, J. Peters, and M. Sievert (2017), 'Does large-scale infrastructure investment alleviate poverty? Impacts of Rwanda's electricity access roll-out program', *World Development* **89**: 88–110.

Levine, D.I., T. Beltramo, G. Blalock, and C. Cotterman (2016), 'What impedes efficient adoption of products? Evidence from randomized sales offers for fuel-efficient cookstoves in Uganda', CEGA Working Papers.

Lipscomb, M., A.M. Mobarak, and T. Barham (2013), 'Development effects of electrification: evidence from the topographic placement of hydropower plants in Brazil', *American Economic Journal: Applied Economics* **5:** 200–231.

Miller, G. and A.M. Mobarak (2013), 'Gender differences in preferences, intra-household externalities, and low demand for improved cookstoves', NBER Working Paper No. 18964.

Miller, G. and A.M. Mobarak (2014), 'Learning about technologies through opinion leaders and social network: experimental evidence on non-traditional stoves in rural Bangladesh', *Marketing Science* **34**(4): 480–499.

Mobarak, A.M., P. Dwivedi, R. Bailis, L. Hildemann, and G. Miller (2012), 'Low demand for nontraditional cookstove technologies', *PNAS* **109**: 10815–10820.

Samad, H.A., S.R. Khandker, M. Asaduzzaman, and M. Yunus (2013), 'The benefits of solar home systems: an analysis from Bangladesh', Policy Research Working Papers, The World Bank.

Smith, K.R., J.P. McCracken, M.W. Weber, A. Hubbard, A. Jenny, L.M. Thompson, J. Balmes, A. Diaz, B. Arana, and N. Bruce (2011), 'Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial', *The Lancet* **378**: 1717–26.

Squires, T. (2015), 'The impact of access to electricity on education: evidence from Honduras', [Available at] https://economics.ucr.edu/seminars_colloquia/2014-15/applied_economics/Squires_JMP_Electricity.pdf.

van de Walle, D., M. Ravallion, V. Mendiratta, and G. Koolwal (2015), 'Long-term gains from electrification in rural India', *World Bank Economic Review* lhv057.

Yu, F. (2011), 'Indoor air pollution and children's health: net benefits from stove and behavioral interventions in rural China', *Environmental and Resource Economics* **50:** 495–514.