

A VIRTUOUS CYCLE?

Reviewing the evidence on women's empowerment and energy access, frameworks, metrics and methods

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EXECUTIVE SUMMARY

This paper is a scoping review of the literature on the energy and women's empowerment nexus, prepared as a background document for the joint workshop by the Sustainable Energy Transitions Initiative (SETI) and Women in Environmental Economics for Development (WinEED) Initiative. The review aims to provide a synthesis of evidence on the links between access to improved energy technology and gender, and evaluate literature that underscores the importance of incorporating gender in examinations of energy poverty. It focuses on lessons from empirical studies, application of various relevant theoretical frameworks and measures of female empowerment, discussion of research designs and methods commonly used in this domain, and identification of gaps in the literature.

The review takes a quasi-systematic approach, combining both peer-reviewed and gray literature identified by members of our research team, supplemented by a non-systematic search in Google Scholar and inclusion of gender-relevant papers from a forthcoming systematic review of studies on the impacts of energy use in low- and middle-income countries (Jeuland et al. 2020). Given the approach used to identify relevant literature, the review does reflect a bias towards quantitative studies, though future iterations will aim to include more qualitative literature. We include studies engaging with issues at the nexus of gender and energy, specifically those examining the role of 1) women's empowerment in driving energy adoption, and/or 2) energy in empowering women.

Among the 130 studies included in our review, we find considerably more that examine the role of energy in empowering women relative to assessment of the role of women's empowerment in driving fuel or technology adoption. A large concentration of studies consider the South Asian context (mostly India), followed by East Africa. Moreover, most studies employ observational, cross-sectional quantitative empirical ap-

proaches. Studies examining the impacts of energy on empowerment are more likely to employ methods for robust causal inference, but such approaches are scarce among studies examining the role of empowerment in driving adoption. Summarizing the major results in the literature, we find that women's empowerment can improve the uptake of cleaner technologies, but that this relationship should not be assumed. Increased bargaining power and social status are correlated with increased adoption of improved cooking technology and clean fuels. In the case of electrical energy services, evidence supports the idea that economic resources (such as access to credit and property rights), as well as access to information and transport are positively related to adoption. However, women can also be more sensitive to price, and are more likely to put the energy needs of the household above their own personal preferences. It is also unclear whether women's employment outside the home spurs the adoption of time-saving technologies or whether the adoption of such technologies facilitates women's employment outside the home.

The benefits of cleaner cooking technologies on women's health are well-studied, but the wider benefits of improved energy technologies are often moderated by social context. Access to improved cookstoves and time-saving appliances can reduce women's drudgery and free up time for other uses. However, how that time is used is highly variable; it may be reinvested in domestic labor, or in leisure activities. Lighting may improve girls' education, women's mobility at night, and allow women to push domestic tasks into the evening, but women are often still responsible for the same tasks and chores. Although more women generally enter the labor force after electrification, and in some contexts, there is a decrease in women in agricultural work, there is also evidence that electrification may increase earnings more for men, possibly because women's industries tend to be less energy-intensive. Finally, telephones, radio and television can spread information that change

social norms, decreasing fertility, lowering rates of domestic violence, and improving awareness of gender equality and human rights.

We explore various theoretical frameworks and measures to assess female empowerment. Most frameworks associate women's empowerment with the ability to choose from different alternatives; and these choices, in turn, determine their quality of life. While choices may be made at individual or collective levels, traditionally, they have been constrained by social norms, cultural beliefs, customs and values which define gender roles. The literature identifies 'process' and 'agency' as being central to achieving women's empowerment, and discusses multiple dimensions of the empowerment concept – economic, socio-cultural, familial/interpersonal, legal, political, cognitive and psychological. Among these, the legal, cognitive and psychological aspects are the least studied.

In terms of measuring women's empowerment and its relationship with the adoption and impacts of energy interventions, most existing measures of the former concept are defined at the country level, despite empowerment being experienced at an individual level. Most measures also tend to capture its economic dimensions. Individual empowerment indices have been developed in some development sectors (e.g. agriculture, livestock, nutrition), but none currently exist in the energy domain. Meanwhile, among quantitative studies in the energy sector, only a small number use the

most rigorous methods of causal inference to study these relationships, mostly regarding the role of empowerment in driving adoption of improved cooking and off-grid technologies. Two experimental studies focused on training women in cookstove projects relate to the theoretical emphasis on the 'process' of female empowerment; the remaining studies focus on 'resources', which are a necessary but not sufficient condition to achieving empowerment.

The paper closes with a description of gender-energy questions and topics that warrant further attention. More evidence is especially needed to understand the 'process' of empowerment in all domains of energy: both how empowerment actually facilitates energy adoption, and the role of energy technology in promoting empowerment processes. Such work should consider variation across contexts and limits to generalizability from particular settings, cultures, and points along the energy and development transition. Importantly, to really understand the two-way relationship between energy and women's empowerment, future research must develop better measures of the latter concept as it relates to energy choices, and more broadly apply mixed methods and intersectional approaches. Such efforts would help clarify women's role in existing institutional structures and the role of complementary interventions that facilitate energy adoption and empowerment of women.

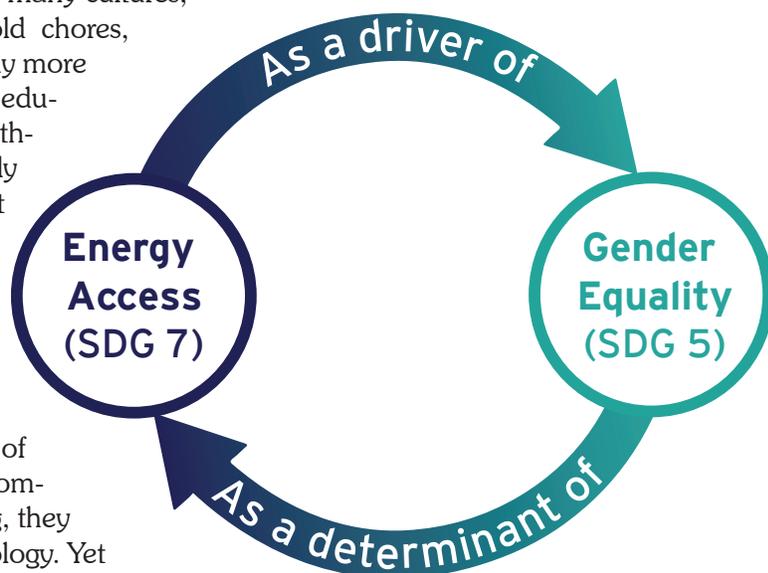
1 INTRODUCTION

Energy is fundamental to achieving several Sustainable Development Goals (SDGs): alleviating poverty, advancing health, improving education and water and sanitation, and addressing climate change (UN Energy 2020). However, nearly 1.2 billion people still lack access to electricity (IEA 2015), and about 3 billion continue to use polluting fuels and inefficient technologies for cooking (WHO 2018). Most of these energy poor individuals reside in low- and middle-income countries (LMICs), and simultaneously face other major development challenges. A key concern in this paper, for example, is the issue of gender inequalities. Women, on average, spend over three times more time on unpaid care and domestic work than men (UN 2019); access to clean and affordable energy can potentially reduce drudgery, and thus also contribute to empowerment of women (SDG5). As gender equality is considered both an outcome and driver of development, the links between energy access and gender run in both directions (Clancy et al 2003). This paper aims to contribute to better understanding of the potential synergies and trade-offs between SDG5 on gender equality and SDG7 on access to sustainable energy (Griggs et al 2017).

The concept of gender is a societal norm where the roles, privileges, attributes and relationships are predefined between men and women (Clancy et al 2012). This norm commonly includes a deeply ingrained division of labor in a household, which in turn leads to gender-moderated and differentiated impacts of household energy interventions (Winther et al 2017). Traditionally, in many cultures, women spend relatively more time on household chores, drudgery and caregiving, while men spend relatively more time on labor market participation. As a result, the education, time use, income generation, health, and other benefits of energy access are generally not evenly distributed between men and women (Johnson et al 2019). It is imperative to understand these varied impacts; energy sector policies or interventions otherwise run the risk of missing opportunities to advance gender equality, or alternatively unintentionally exacerbating gender inequalities.

It is equally important to understand the impacts of female empowerment on energy access. Since women are primarily responsible for household cooking, they may have strong preferences about cooking technology. Yet in studies that rely on household survey data, the influence of female empowerment is typically only proxied by differences between male- and female-headed households, which fails to capture many of the nuances of the intra-household context. Indeed, intra-household bargaining and informal institutions in which households are embedded have been shown to affect the adoption and transition to clean fuels. Furthermore, there is a strong correlation between education and income suggesting that the gender of the person with higher education and income has greater decision-making power regarding energy choices (Permana et al 2015).

The objectives of this paper are two-fold. First, we take stock of the literature on two-way connections between women's empowerment and household energy.



Second, we situate this empirical literature within broader intellectual traditions around (a) the role of female empowerment and gender equality in advancing social development, and (b) the potential mechanisms for improving outcomes for women and girls. The review includes papers that analyze the impact of energy access on women's participation in energy governance and planning, women's and girls' work both inside and outside of the home and their empowerment, among other outcomes. We also consider papers that examine whether and how empowerment, broadly, leads to increased energy access. Recognizing the strong connection between these two concepts, we review energy access as a driver of female empowerment, as well as female empowerment as a driver of energy adoption. We place empirical findings within existing gender analysis and female empowerment frameworks and discuss widely used methods to assess these dimensions of female bargaining and empowerment. Finally, we identify key knowledge gaps in the gender-energy literature and suggest next steps for research.

2 EMPIRICAL EVIDENCE

2.1 *Methods*

For the purposes of preparing a reasonably comprehensive review that is responsive to the needs of the community of energy and gender researchers and practitioners in a timely fashion, this review takes a quasi-systematic approach. A fully systematic review would develop a detailed search syntax, implement that search in a range of scientific and gray literature databases, and finally code articles according to a pre-established protocol. There was insufficient time to implement such a procedure in this case, so ours is more accurately described as a critical review supported by a standardized coding procedure (Grant & Booth 2009). Building on their prior work in this domain, members of the research team contributed papers they knew to be engaging with the gender-energy nexus, drawn from both peer-reviewed and gray literature (33 papers total). These papers were supplemented by literature identified through a non-systematic search implemented in Google Scholar (yielding an additional 16 papers). Lastly, this set was supplemented with gender-relevant papers identified from a forthcoming broader systematic review of studies on the impacts of energy use in LMICs (74 papers total) (Jeuland et al 2020). Given the familiarity of the research team with the quantitative literature, our review reflects a bias towards quantitative studies, though future iterations will aim to include more qualitative studies as well.

Inclusion criteria for studies were that they examined the role of 1) women's empowerment in driving energy adoption, or 2) energy in empowering women. Papers deemed relevant were then coded to extract the following information:

1. Basic study characteristics: study location (country), publication type (e.g. peer-reviewed or gray), main methodologies, type of energy technology studied (e.g. cookstoves, solar home systems, mini-grids, etc.), and a 1-2 sentence summary of the study and how a gender lens was incorporated;
2. Energy services addressed in the study (e.g. cooking, heating, lighting, types of appliances, etc.), following the typology discussed in Jeuland et al (2020);
3. Impacts studied (only relevant for papers on the impacts of energy, rather than on drivers) (e.g. health, attitudes, income, education, etc.);
4. Gender or intra-household related concepts and measures studied and direction of impact (e.g. empowerment, bargaining power, gender norms, etc.)

Our review includes 123 unique articles. More than two-thirds of the articles are peer-reviewed with 21 articles that are gray literature and 5 that are working papers. We identified considerably more studies assessing the role of energy in empowering women (with 79 papers represented) than studies assessing the role of women's empowerment driving the adoption of new fuels or technologies (33 papers represented). A total of 11 studies covered both themes. In our sample, studies examining energy's role in women's empowerment have been published since the 1990s whereas studies on empowerment driving energy adoption are relatively more recent, appearing since the 2010s (Figure 1).

Despite the growing knowledge base at this intersection, there remains substantial geographic homogeneity in where the relationship between energy and empowerment has been studied. There is a large concentration of studies (38) on energy's impacts on women's empowerment (and 18 for empowerment driving adoption) in South Asia, mostly concentrated in India. Elsewhere there are many studies on the impacts of energy in East Africa (15) and West Africa (13) and fewer on the drivers of energy adoption in East Africa (7) and West Africa (2). Lastly, there are some cross-country studies or reviews on the impacts (12) and drivers (11) of energy adoption as these relate to gender or empowerment (Figure 2).

A majority of the literature that we reviewed on empowerment as a driver of energy adoption and the impacts of energy on empowerment use observational, cross-sectional quantitative empirical approaches. Very few studies utilize panel data, model-based, or qualitative approaches. However, there does seem to be a slightly higher prevalence of qualitative review papers compared to mixed method reviews, quantitative reviews and meta-analyses. Quasi-experimental (e.g. instrumental variables and matching) approaches are more common than experimental (e.g. randomized control trial) approaches for the literature on the impacts of energy on empowerment but the reverse is true for the literature on empowerment driving energy adoption (see Appendix for full distribution).

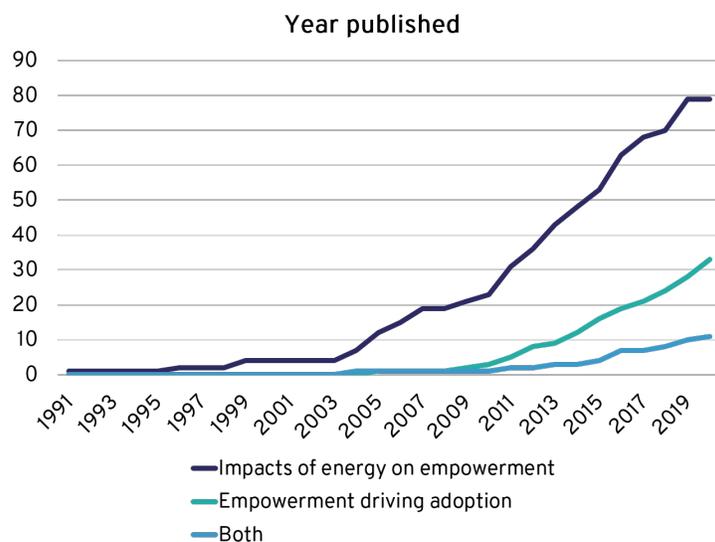


Figure 1: Distribution of studies over time

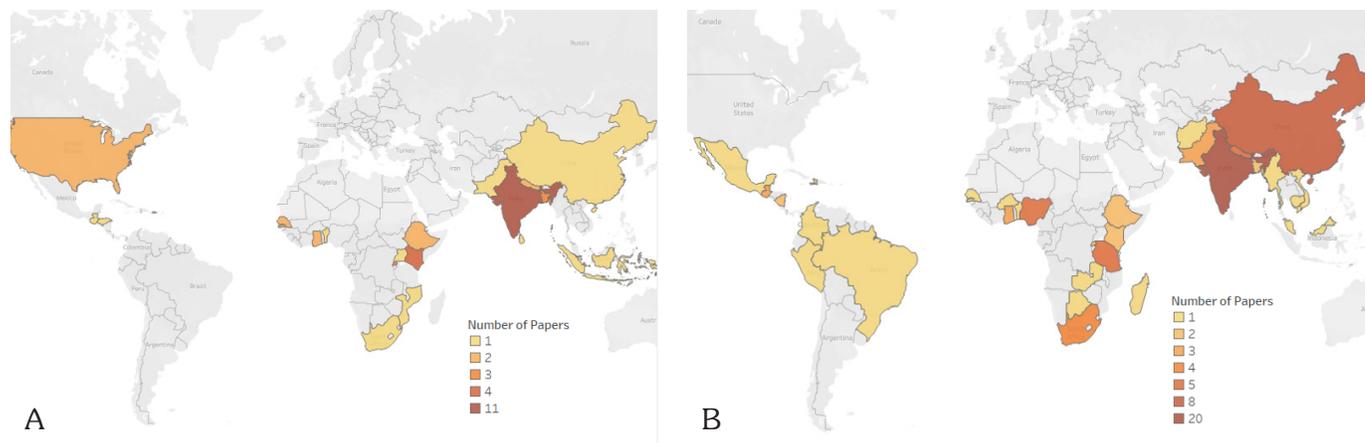


Figure 2: Geographic distribution of women's empowerment as a driver of energy adoption studies (Panel A) and energy access as a driver of women's empowerment studies (Panel B).

2.2 Female empowerment as a driver of energy adoption

The greatest proportion of the literature on empowerment as a driver of energy adoption, among papers included in this review, has focused on cookstoves and fuel use (27 papers). Other energy services have accounted for a smaller selection of papers, including lighting (13), communication and entertainment (8), other household appliances (6), non-agriculture income generation (5), heating (3), and agricultural use (1) (Figure 3). In these studies, female empowerment is occasionally conceptualized as intra-household bargaining power and social status (Pachauri & Rao 2013, Sonne 2016, Kishore & Spears 2014, Austin & Mejia 2017), but more commonly, is not actually defined. The most common operational metrics for these concepts include gender of household head, education, employment, economic status and control of assets. Lesser-studied metrics include fertility, contraceptive use, gender balance within the household, access to information, and access to transport.

Among the papers that focus on cooking and fuel use, the majority examine the relationship between empowerment (loosely defined per the comments above), technology preference and adoption of improved cookstoves (ICS). Others consider the relationship between empowerment and fuel type and usage. Findings from both these categories suggest that increased bargaining power, social status and empowerment of women lead to higher adoption of more efficient cooking technologies and cleaner-burning fuels. For instance, in households where women are more highly educated, there is less solid fuel use and higher uptake of ICS (Austin & Mejia 2017; Lewis & Pattanayak 2012). Greater female employment, earnings and control of assets are also present in households that use clean fuels (Pachauri & Rao 2013). Other evidence suggests that women prefer ICS, but often do not have the authority in the household to make purchasing decisions (Miller & Mobarak 2013). When women are more likely to have that authority – because of higher education, economic status, labor market participation or household ownership – they are more likely to adopt ICS (Mohapatra & Simon 2017).

At the same time, women can be more sensitive to price, less willing to spend money on cooking technologies, and more likely to put the energy needs of the household above their own personal preferences. Evidence from India, Uganda and Bangladesh finds that women have lower willingness to pay for ICS than men (Beltramo et al 2015, Mobarak et al 2012), and are more price-sensitive (Jeuland et al, 2015). Permana et al (2015) find lower household energy consumption in Indonesian households when women are the primary energy decision-makers. Several studies suggest that women's lower economic status and greater prioritization of the good of the household and its finances supersede personal preferences and reduce their demand for clean energy (Beltramo et al 2015; Mobarak et al 2012; Fingleton-Smith 2018).

There also appears to be a disconnect between the notions of purchaser and user of cooking technologies. Women are assumed to be the primary user of cookstoves (Burwen & Levine 2012), and so some programs have made an effort to include women as sales agents, identifying challenges specific to them, and giv-

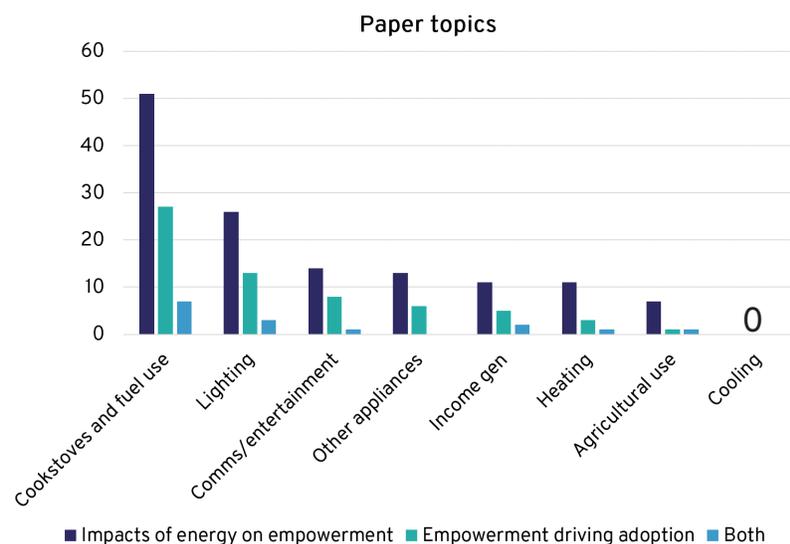


Figure 3: Topical distribution of studies

ing agency-based training, which improves their sales of ICS (Shankar et al 2020; Dutta 2020; Shankar et al 2015). However, as discussed above, male household members are often the ones who ultimately make these purchases (Thompson et al 2018).

After cooking, lighting is the energy service most often considered in the literature, although such studies often overlap with other energy services such as communications and entertainment, heating, household appliances like fans, irons, washing machines, income generation and agricultural services. This section focuses exclusively on electricity, as lighting and heating with other fuels was included in the literature on fuel use reported in the previous section.

As with cooking services, women typically have less power to determine the way in which electricity is used and the appliances that households purchase (Winther et al 2020). As expected, this often results in a mismatch between the users and purchasers of these appliances (Fingleton-Smith 2018). An additional element to consider, which is understudied, is who manages ongoing payments for solar products and who is responsible for their maintenance (Lamb 2019).

In the case of electrical energy services, review papers tend to argue that economic resources (such as access to credit and property rights), as well as access to information and transport have a positive impact on adoption (Wilhite 2017). However, Pachauri and Rao (2013) found that the relationship between female empowerment-related indicators (women's control over assets, employment and earnings, and involvement in enterprises) and adoption was inconclusive. These inconsistencies suggest that more and better evidence is needed that sheds light on why results diverge across studies and settings.

Another branch of the literature considers women's engagement in the energy sector as a determinant of technology adoption. Female energy entrepreneurs have been shown to sell more products than men (Barron et al 2020), and there are significant efforts to remove barriers to women's involvement in enterprises through interventions to increase engagement (Shankar et al 2020; Dutta 2020). Although some studies show no significant effect of female employment in the broader electricity sector on energy technology adoption, there are still calls for involving women in energy governance, with the logic that greater involvement of women in the supply chain will improve women's adoption and use of these technologies (Wilhite 2017, Clancy et al 2019).

Another relevant question is whether women's employment outside the home spurs adoption of time-saving technologies or whether the adoption of such technologies facilitates women's employment outside the home. Leveraging historical data from the United States, research has argued that women's increased employment and income improved their bargaining and purchasing power, and resulted in greater adoption of washing machines (Bose et al 2020). Other evidence suggests that the introduction of such durable goods liberated women to enter the workforce (Greenwood et al 2005). These dual narratives are equally applicable to cooking technologies, which can reduce burdens from domestic tasks that fall disproportionately on women. In the LMIC context, the role of technologies other than cookstoves in such dynamics remains understudied, however, at least among studies reviewed here.

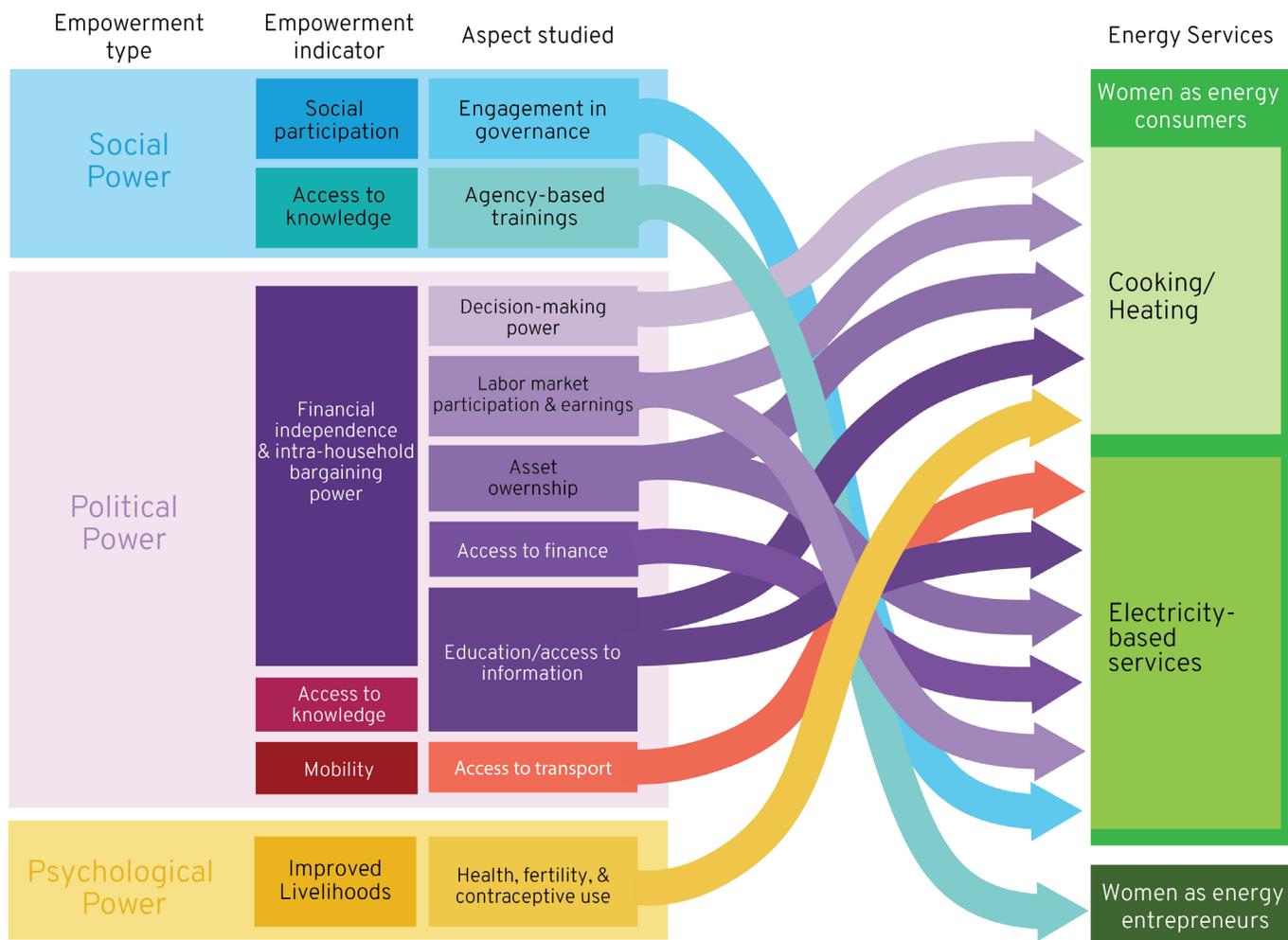


Figure 4: Framework of gender-energy linkages studied for women's empowerment as a driver of energy adoption. Definitions of empowerment adapted from Friedmann, 1992.

2.3 Impacts of energy adoption on female empowerment

Mirroring the trends discussed above, the majority of papers on the impact of energy technology adoption on women's empowerment included in this review also focus on cooking (51 papers). This is followed by lighting (26), communication or entertainment (14), other household appliances (13), heating (11), income generating appliances (11), and agricultural uses (7).

Within the papers on cooking, 36 specifically address the impact of different cooking technologies on household air pollution (HAP) or health. These papers either exclusively sample women, assuming that women are the primary user of cooking technologies, or disaggregate health outcomes by gender. Although there are a few exceptions (e.g. Raspanti et al 2016), almost all studies find that women bear more of the HAP health burden than men.

A second major topic of the cooking energy service studies concerns time use. The act of cooking, and the collection of fuel for cooking, occupy a large portion of women's time in LMICs, although the assumption that women are the main fuel collectors does not hold in all contexts (Sunderland et al 2014). The expectation is that use of improved cooking technologies will reduce this fuel collection burden, and that more efficient combustion can also lower cooking time. There is indeed evidence that traditional cookstoves require significant time for fuel collection, and

that use of ICS can result in time savings. It is also commonly argued that time freed up by improved cooking technologies will be used by women for personal development, namely education or employment (Wickramasinghe 2011), and several studies find a relationship between cleaner cooking and changes in reading, gender roles, women's confidence, asset ownership and control over finances (Ding et al 2014; Gonda et al 2016; Mohlakoana et al 2018; MSSRF and CRT Nepal 2019). However, how women use their freed-up time is highly context-dependent, and that time may be reinvested in domestic labor, or leisure, such as watching television (Mahat et al 2006). Recent findings from Tanzania suggest that how a woman spends her time is strongly related to her socio-economic status, with wealthier women enjoying more leisure time and the use of radio or television appliances for entertainment and information (Lamb et al 2019).

Those papers that focus on electrical appliances – from solar lanterns to sewing machines – offer evidence of a range of improved outcomes for women. It is important to note that many studies focus on the impact of electrification broadly, and do not study how each energy service can play a role in direct and indirect outcomes. That said, access to electric lighting can increase time spent studying in the evening and, by improving safety, facilitate women's nighttime mobility (Daka & Ballet 2011, Dynes et al 2016, Wilhite 2017, Gray et al 2019). Access to electricity, especially lighting, has the capacity to also alter time allocation, as chores can be pushed into the evening, and daylight hours used for other time-sensitive activities. Still, several recent studies suggest that women must often still undertake the same tasks and chores (Barnes & Sen 2004; Lamb 2019; Pueyo & Maestre 2019).

We see some evidence of the emergence of this 'second shift' wherein increased flexibility and decreased time burden in household tasks allows women to work outside the home, but that gendered social expectations continue to mandate that women complete domestic tasks (Hochschild & Machung 1990). Some evidence in LMIC contexts suggests that more hours of lighting allows women to push chores into the evening or early morning, so that they are able to work in paid employment during the day (Lamb 2019). This is mirrored in the experience of high-income countries, where even as women have entered the workforce, the division of labor within households persistently places the burden of unpaid labor on women (OECD 2019; Miller 2020).

Although the expectation is that access to time-saving appliances will allow women to pursue work outside the household and increase the proportion of women working in formal employment, the benefits of women's labor potential is moderated by social expectations (Standal & Winther 2016, Pueyo & Maestre 2019). Likewise, the electrification of income-generating activities may improve incomes generally, but women tend to work in less energy-intensive industries (Pueyo & Maestre 2019). Generally, evidence suggests that electrification increases women's employment and the time that women devote to market work, while decreasing participation in agricultural labor (Grogan 2016, Pueyo & Maestre 2019). However, evidence suggests that electrification may increase employment and earnings more for men than women (Salmon & Tanguay 2016; Pueyo & Maestre 2019).

Where women's income generating activities are electrified, the benefits brought about by improved productivity can impact women's lives more broadly. For instance, in a study where a passive photovoltaic pumping and irrigation system was shared by women's agricultural groups, economic independence and empowerment increased, as measured through the Women's Empowerment in Agriculture Index (WEAI) (Burney et al 2017). It has also been found that engaging women in

selling off-grid solar products increases autonomy, independence and self-esteem (Gray et al 2019).

Access to electricity can also change social expectations to the benefit of women, whether through increased educational opportunities or access to information, or the evolution of social mores. Electrification can lead to lower desire for children and fertility rates (Grogan 2016, Rewald 2017). Evidence also shows a relationship between electricity access and lower acceptance of spousal abuse and reduced rates of domestic violence (Standal, & Winther 2016, Wilhite 2017, Rewald 2017, Sievert 2015). Studies on the impact of television find that exposure to cable television decreases fertility, lowers acceptance of abuse, and improves women's autonomy (Jensen & Oster 2009, Iversen & Palmer-Jones 2015, Sievert 2015, La Ferrara et al 2012). However, in at least one study there is no such effect among women with no education (Iversen & Palmer-Jones 2015).

And yet, the impact of electricity on gender empowerment is also dependent on the socio-cultural context in which women live. For instance, in a study of how the introduction of electricity affected women's lives in India and Afghanistan, patriarchy and dowry practices were reinforced in the former setting, whereas women's status increased in the latter (Standal & Winther 2016). Across a number of contexts, access to electricity has been shown to increase women's awareness and knowledge of their rights, and women's access to information about politics and government, which translates into increased autonomy and self-respect (Cecelski 2006, Wilhite 2017, Rewald 2017). However, there is little evidence that this increase in information and awareness translates into a status change for women in general. Women's roles in the community often do not change, and there is little evidence that electricity access improves women's rights, or alters gender ideologies and power relations (Standal & Winther 2016, Wilhite 2017, Johnson et al 2019). Rather than seeing electricity access as the cause of increased empowerment, energy may act as an enabling factor, and energy projects may serve as an opportunity for gender-sensitive public engagement (de Groot et al 2017, Gippner et al 2013).

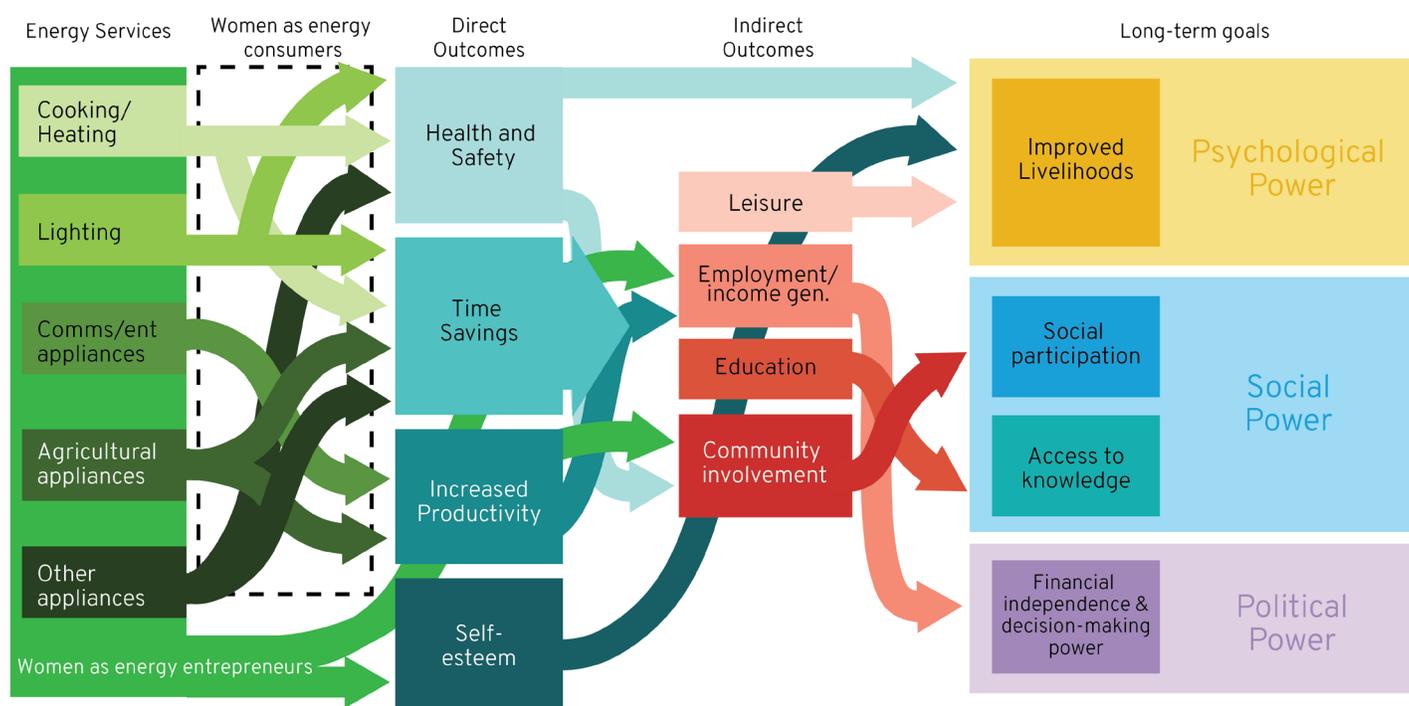


Figure 5: Framework of gender-energy linkages studied for energy as a driver of women's empowerment. Definitions of empowerment adapted from Friedmann, 1992.

3 EXISTING FRAMEWORKS & METRICS TO ASSESS FEMALE EMPOWERMENT

3.1 *Theoretical frameworks*

This section describes some of the commonly used conceptualizations of women's empowerment in the theoretical literature. In doing so, we draw attention to the inherent complexity and resulting measurement challenges of these ideas. As a starting point, the importance of the ability to choose, from different options and alternatives, is repeatedly discussed in the empowerment literature (Kabeer 1999, 2002, Malhotra and Schuler 2005). Kabeer (2002) describes empowerment as “the expansion in people's ability to make strategic life choices in a context where this ability was previously denied to them”. While Kabeer (1999) argues for certain ‘first order’ choices which primarily define the quality of life (such as “choice of livelihood, whether and who to marry, whether to have children, whether and when to have sex in marriage among others”), she acknowledges that these choices are generally constrained by social norms, cultural beliefs, customs and values which define gender roles for men and women within societies (Kabeer 2002). In her seminal work, Kabeer (1999) uses a framework of “resources, agency and achievement” to define the process of decision-making. Resources are the precondition to making choices, including “material, human, and social resources that enhance people's ability to exercise choice”; agency is the process of decision-making that may include “bargaining and negotiation, deception and manipulation, subversion and resistance, and cognitive process of reflection and analysis”; and lastly, well-being and life outcomes comprise achievements (ibid).

Resources and agency in Kabeer's definition (1999) relate to Sen's concept of capabilities (1985). Given choices and constraints, “reflection, analysis and actions” that contribute to the decision-making process may take place on individual or collective levels (Mosedale 2005). Some of the earlier literature on individual empowerment associates empowerment with expanding the choices and increasing productivity of individual women (ibid). Alsop et al (2005) further refer to the individual and collective components of empowerment as “a group's or individual's capacity to make effective choices, that is, to make choices and then to transform those choices into desired actions and outcomes” (2006, p. 10). Highlighting the role of institutions in empowerment, Narayan (2002, p. vi, 2005, p. 5). defines it as “the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affect their lives”. Alkire et al (2013) use this idea to identify four key empowerment elements: access to information, inclusion and participation, accountability, and local organizational capacity. In recent work, Donald et al (2020) argue for considering three dimensions in individual agency: the individual's definition of goals as they align with values, the individual's perception of a sense of control and ability, and the individual's ability to act on goals.

One of the earliest definitions of women's empowerment describes it as a process that enables women to expand their “self-reliance, to assert their independent right to make choices and to control resources which will assist in challenging and eliminating their own subordination” (Keller and Mbewe 1991). Distinguishing women's empowerment from empowerment more generally, Malhotra and Schuler (2005) emphasize that (a) women are not a singular group among other disempowered social groups (e.g. poor, ethnic minorities) but are a collective of individuals that

overlap with these other subsets; (b) household and interfamilial relations are focal to women's disempowerment in ways distinct from other disadvantaged groups. They make two other important arguments: First, that women's empowerment efforts must particularly recognize "the household-level implications of broader policy action", and second, "while empowerment in general requires institutional transformation, women's empowerment requires systemic transformation not just of any institutions, but of those supporting patriarchal structures." Malhotra and Schuler (2005) also define two unique features of women's empowerment relative to other interchangeably used terms such as "gender equality", "female autonomy" or "women's status": process (i.e. processes of change towards greater equality) and agency ("women must be significant actors in the process of change being described or measured"). Process and agency, thus defined, are central to Kabeer (1999) and Alsop et al's definition of empowerment (2006), as described previously. Importantly, as Mosedale (2005) notes, while the onus to claim empowerment must be on women, women's empowerment can be facilitated by external agents or agencies.

Most studies recognize that women's empowerment cannot be measured using uni-dimensional measures. In particular, to realize their full potential, women need to be empowered on multiple fronts: economic, socio-cultural, familial/interpersonal, legal, political, cognitive and psychological (Stromquist 1999, Varghese 2011). These may include variables capturing mobility, economic security, ability to make small purchases, involvement in major household decisions, relative freedom from domination within the family, political and legal awareness, involvement in political campaign and protests (Schuler and Hashemi 1996). Subjective components such as the cognitive and psychological empowerment are difficult to measure and are not sufficiently captured in data. Cognitive empowerment requires women to understand the cause of their disempowerment and the "need to make choices that may go against cultural and social expectations" (Stromquist 1999). Diener and Biswas-Diener (2005) consider the importance of subjective well-being as central to psychological empowerment—the dimension of empowerment that they argue is typically given the least attention. Women are psychologically empowered when they begin to believe that they can improve their condition at personal and social levels; women's psychological empowerment then involves improving their self-esteem and confidence, making them believe that they are not helpless (Stromquist 1999). In addition, studies also indicate the need to include empowerment measures based on health (Pratley 2016). Besides realizing this empowerment, women should be able to use it and it must be sustained and preserved (Pillai 1995 as in Schuler and Hashemi 1996).

3.2 Measures and indices

In this section, we summarize some of the commonly used measures of women's empowerment and their scope in capturing different aspects of the same. Though empowerment is experienced at an individual level, most empowerment indices are measured at the country level (Alkire et al 2013). UNDP's gender-related development index (GDI) and gender empowerment measure (GEM) are examples (UNDP, 1995). While GDI adjusts the Human Development Index (HDI) for gender inequalities across life expectancy, education, and income, GEM measures relative female representation in economic and political power. As a composite index, GEM measures 'gender inequality in three basic dimensions of empowerment: economic participation and decision-making (female employment in industry, agriculture, or services), political participation and decision-making (percentage of female parliamentarians and legislators in a country), and power over economic resources

(female and male earned income (purchasing power parity US\$))' (UNDP, 2004, Syed 2010).

The GEM has garnered much criticism on various aspects. First, that it mainly focuses on women's participation in formal markets, ignoring non-economic dimensions of empowerment. Second, that it is based on absolute income levels instead of relative incomes of men and women. Relatedly, it does not capture women belonging to lower income strata who did not have access to education, or political and economic networks, and are unable to participate in formal labor markets (Syed 2010). Finally, Syed (2010) argues that GEM does not account for the relative agency of males and females vis-à-vis religious choices and commitments. There may be differences in social preferences as well that GEM does not capture. Syed (2010) further advocates the need for a rounded measure which goes beyond economic interpretations, capturing issues in physical, socio-cultural, religious, legal, political and economic domains and their interactions.

The Gender Inequality Index (GII) "measures gender inequalities in three important aspects of human development—reproductive health (measured by maternal mortality ratio and adolescent birth rates), empowerment (measured by proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education), and economic status (expressed as labor market participation and measured by labor force participation rate of female and male populations aged 15 years and older)" (UNDP 2019). Alkire et al (2013) argue that proxy indicators for empowerment, such as those captured in GEM, GDI and GII, neither measure empowerment directly nor at the individual-level.

Seymour and Peterman (2018) construct a relative measure of empowerment called the 'Relative Autonomy Index' which mainly uses psychological tools. This metric compares sole decision-making with joint decision-making by exploring how stronger or weaker feelings of autonomous motivation individuals experience in each case. More recently developed country-level indices include The Women, Business and the Law Measure (World Bank 2020) and Social Institutions and Gender Index (OECD Development Center 2019).

3.3 Women's empowerment indices in the development literature

Overcoming Malhotra and Schuler's four key measurement issues regarding women's empowerment (empowerment multidimensionality, concept operationalization at various aggregation levels and across contexts, infrequency of "strategic life choices" and inherent problems in measuring a process) (2005), some scholars have developed women's empowerment indices in sector-specific domains. Some of these efforts are summarized below.

Alkire et al (2013) in their survey-based Women's Empowerment in Agriculture Index (WEAI) recognize women's and men's achievements in different domains to create an individual multifaceted empowerment profile specific to agriculture, which can then be aggregated. In considering five agricultural and household domains in their index (decisions about agricultural production; access to and decision-making power about productive resources; control of use of income; leadership in the community; and time allocation), they acknowledge the intersectionality of an individual's agency. Specific indicators in each of these five WEAI domains are: production (input in production decisions; autonomy in production), resources (ownership of assets; purchase, sale or transfer of assets; access to and decisions

about credit), income (control over use of income), leadership (group member; speaking up in public), and time (workload and leisure). From these empowerment profiles, they also develop a Gender Parity Index for intra-household inequality between the primary male and female residing in the same household.

Associations between the WEAI and various outcomes have been examined, mainly using cross-sectional surveys and Ordinary Least Squares (OLS) regression, across diverse settings: food security (Sraboni et al 2014), technical efficiency on agricultural plots (Seymour 2017) in Bangladesh, and maize productivity in Kenya (Diirro et al 2018). The WEAI has also been used to explain nutrition-related indicators such as quality of infant and young child feeding practices, women's dietary diversity in Ghana (Malapit and Quisumbing 2015), and child nutritional status in Nepal (Cunningham et al 2015). Some indicators of the WEAI have significant associations with improvements in women's health in Ghana (Ross et al 2015) and maternal nutrition in Nepal (Malapit et al 2015). Using the WEAI framework, in focus group discussions with women in four South-East Asian countries, Akter et al (2017) find that while women seem to have equal access to productive resources (i.e. land and inputs) and higher control over income relative to men, on empowerment at the community-level, there is variation across countries.

Adapting the WEAI for monitoring agriculture-related projects and assessing their impacts, Malapit et al (2019) identify twelve project-level WEAI indicators that pertain to three domains: intrinsic agency (power within), instrumental agency (power to) and collective agency (power with). Intrinsic agency indicators are: autonomy in income, self-efficacy, attitudes about intimate partner violence against women, respect among household members; instrumental agency indicators are: input in productive decisions, ownership of land and other assets, access to and decisions on financial services, control over use of income, work balance, visiting important locations; and collective agency includes group membership and membership in influential groups (ibid).

In fields related to agriculture, methodologies other than the WEAI are being developed to create indices for women's empowerment. Women's Empowerment in Livestock Index (WELI) considers how livestock is linked to and assists women's empowerment, as well as women and children's health and nutrition (Galiè et al 2019). The Women's Empowerment in Nutrition Index (WENI) encapsulates the process that enables individuals to be well-fed and healthy (Narayanan et al 2019). Across themes of knowledge, resource and agency, WENI has detailed indicators in the domains of food, health, institution and fertility.

In their review of experimental and quasi-experimental studies on women's agency across various development domains, Chang et al (2020) not only develop a framework of direct and indirect indicators of women's agency, but also identify mechanisms and moderating factors that increase the same. Direct indicators they identify are power within (aspirations, self-efficacy, attitudes towards gender norms); household decision-making in various spheres; freedom of movement (woman's ability to choose where and when to go); and freedom from violence (particularly freedom from intimate partner violence and violence against adolescent girls). Indirect indicators are in the domains of family (timing of marriage and childbearing), economy (labor force participation and income generation from entrepreneurship) and politics and society (participation in politics and decision-making, voting behavior and participation in groups and community ties).

An example of a large-scale ongoing effort on the subject of female empowerment is The Evidence-based Measures of Empowerment for Research on Gen-

der Equality (EMERGE) Project focused on “gender equality and empowerment measures to monitor and evaluate health programs and track progress on SDG 5-Gender Equality and Empower All Girls” (University of California San Diego 2017). EMERGE considers nine dimensions and their following sub-topics: “(1) social (e.g., social cohesion and social support), (2) psychological (e.g., self-efficacy and resilience), (3) economic (e.g., economic decision-making control), (4) legal (e.g., property rights and inheritance), (5) political (e.g., voting participation), (6) health (e.g., bodily integrity), (7) household and intrafamilial relations (e.g., gender-based violence), (8) environment and sustainability (e.g., water resources), and (9) time-poverty (e.g., time spent on domestic duties)” (ibid).

In the energy literature, however, there exist no similar female empowerment indices as described in this section, and to the best of our knowledge, there appears to be none under development.

3.4 Contextualization of gender-energy empirical evidence within theoretical frameworks

We describe in this section how the empirical evidence (using experimental and quasi-experimental methods) from the energy literature relates to the theoretical literature on female empowerment. In the energy literature, robust experimental designs have been used to examine the influence of intra-household externalities on ICS adoption in Bangladesh (Miller and Mobarak 2013) and Ethiopia (Alem et al 2019); and gender differences in willingness to pay for ICS in Uganda after exposure to marketing messages (Beltramo et al 2015). Klege et al 2019 compare lab experiments with those from the field to examine how gender attitudes and performance under competitive circumstances affect sales and incomes of solar village enterprises in Rwanda.

Recent evidence from Uganda finds that ICS adoption reduces the prevalence of domestic violence (measured by women’s responses to five questions on insults, humiliation, verbal intimidation, threats to her or persons she cares about, and slapping or throwing objects) (Guzman et al 2020). However, the authors could not establish mechanisms through which this relationship was realized.

Two experimental studies speak to Kabeer’s definition of “process” as being central to empowerment: Burwen and Levine’s study design that involved female trainers to teach female primary cooks ICS construction (2012) and Shankar and co-authors’ (2015) study on agency-based empowerment training that significantly increased women’s capacity to sell ICS.

Besides the aforementioned experimental studies, much of the empirical literature on the drivers and impacts of energy access uses publicly available data. To highlight country-specific econometric analyses using household data: Among urban Indian households, Kishore and Spears (2014) use social and cultural son preference over daughters to examine whether women with a male first born have higher status in the household and can influence choice of modern cooking fuel (kerosene, LPG and electricity). They use the National Family Health Survey (NFHS)-3 & instrumental variables approach with fixed effects regression for their analysis. Using cross-sectional survey data from the India Human Development Survey (IHDS), Mohapatra and Simon (2017) assess whether intra-household decision-making affects ICS adoption in rural India. Four proxies for female bargaining power they use include education difference between the most educated male and female in the household, economic status of a woman’s birth or natal family relative to her

husband's at the time of her marriage, percentage of women in the household who participate in the labor market, and whether the woman is a legal owner of the residence. They distinguish between a woman's role in household decision-making and whether she has bargaining power vis-à-vis these decisions. Using the IHDS data, Choudhuri and Desai (2020) find that women's access to salaried work and control over decisions on household expenditures are associated with clean fuel (LPG and kerosene) adoption.

In line with Chang and co-authors' framework (2020), Sonne (2016) is among the few papers that uses direct and indirect measures of bargaining power to examine both intra-household bargaining as a driver of clean fuel adoption, and clean fuel use's association with female bargaining. While this approach of a composite measure may encapsulate some dimensions of female empowerment, contingent on what data were collected, it is incomplete. Most publicly available, nationally representative surveys used in the reviewed literature (e.g. Demographic and Health Surveys, NFHS, IHDS) ask women various questions on household-level decision-making but do not ask men the same questions. Additionally, similar decision-making questions are lacking in the productive and economic domains.

Across countries, in a structural equation modeling framework, Austin and Mejia (2017) use proxy measures (from the WHO Global Health Observatory Database & World Bank data) for women's status, from 91 less-developed nations, to examine whether countries where women have higher social status rely less on solid fuels. Burke and Dundas (2015) examine whether female labor force participation is associated with less household biomass energy use in 175 countries between 1990 and 2010, and test robustness across four sources of biomass energy data.

Our review concurs with that of Narayan-Parker's (2005) of the empowerment in development literature, that data availability often dictates quantitative measurement of empowerment, which leans more towards its economic dimension relative to its social and political dimensions, and least towards its psychological dimension. As described above, most studies we reviewed use disaggregated measures of female empowerment (used interchangeably with 'autonomy', 'status'), while a minority use a composite data-driven measure capturing multiple dimensions.

Researchers have also employed qualitative methods, using case studies, interviews and focus groups to explore the 'how' and 'why' of gender's relationship to energy access. For an overview of the most prominent qualitative empirical findings, see Winther et al 2017. Qualitative research is most useful for exploring perceptions, processes and mechanisms, which makes it an ideal fit for studying gender, itself a concept that is highly contextually-dependent, part of a system of patriarchy, and which is in constant flux as society negotiates and re-negotiates its interpretation.

At a high-level, the study of political economy has generally ignored gender analysis, but it offers an opportunity to explore how gender plays a role in where institutional and organizational power lies and who benefits from public policies (MSSRF and CRT Nepal 2019). MSSRF and CRT Nepal (2019) then use the incorporation of gender in their study to explain how energy access policies in India and Nepal have neglected clean cooking. This type of study usually relies on a mix of quantitative and qualitative data, making use of extensive interviews to extend the analysis of correlations and to suggest causality. Also, at a high level, scholars have synthesized historical studies, using census information, archives and administrative records to illustrate the lessons that developing countries can learn from the sale of appliances to women during periods of electrification in Europe and the USA (Matly 2005).

Several case studies have taken energy interventions as their central subject. Three studies evaluated Mali's Multifunctional Platform program, using a mix of program documents, secondary literature and interviews to identify opportunities and barriers to its success (Denton 2004, Nygaard 2010, Sovacool et al 2013). Similar methods were used to evaluate the effectiveness and role of public participation of micro-hydro projects in Nepal and the effectiveness of a pilot woman-focused business model in Ghana (Upadhyay 2009, Quintero 2006). Few detailed qualitative studies have been conducted on gender-based energy use perceptions (Fingleton-Smith 2018). Thompson et al (2018) used mixed methods to assess knowledge, attitudes and perceptions about LPG stoves among men and women. The use of multiple cases can improve the external validity of these studies (Ilskog & Kjellström 2008). The IEG has also stressed the value of incorporating qualitative analysis in its welfare impact evaluations, especially reviewing Project Performance Audit Reports (IEG 2008). Case studies have also been used by international development organizations to highlight and share information on particular interventions, like the use of women as 'solar warriors' in Bhutan (ADB 2015).

At the level 'closest to the ground' are studies that use ethnographic approaches. These approaches focus on interviews and participant observation in order to understand how technologies are used in practice (Ulsrud 2015, Nygaard 2010, Winther 2008, Sunikka-Blank et al 2019, Matinga 2010). Rich, detailed ethnographic information can also offer insights into how energy use changes women's lives and gender relations (Sunikka-Blank et al 2019, Winther 2014, Matinga & Annegarn 2013, Standal and Winther 2016, Annecke 2005). Some of these studies also look specifically at the impact of a single technology, whether it's lighting or cellphones (Standal 2008, Tenhunen 2014, Daka & Ballet 2011).

4 KEY TAKEAWAYS

A commonality between our review and that of Malhotra and Schuler (2005) is that there is weak evidence on the contribution of empowerment to development outcomes (in our case, female empowerment as a driver of energy choices) and determinants of empowerment (in our review, impacts of energy on female empowerment). Most of the existing literature on the energy and gender nexus focuses on the intersection of use of ICS and clean cooking energy, and female empowerment. This includes how female empowerment can result in greater household adoption of clean cooking energy and ICS, and vice versa. The majority of the research on the impact of women's empowerment on clean cooking technology adoption suggests that although women prefer clean cooking energy and ICS, they seldom have the authority to make purchase-related decisions. In the LMICs context, it is often male household members who are decision-makers (Mohapatra & Simon 2017, Miller & Mobarak 2013). This lack of decision-making power can manifest in women's lower willingness to pay for improved cooking technology (Jeuland et al 2015, Beltramo et al 2015, Mobarak et al 2012).

The impact of traditional cooking technologies – and the positive impacts from improved technologies – is well-studied, and many papers explore the relationship between HAP, gender, and respiratory illness. Research that focuses on clean cooking as a driver of women's empowerment indicates that use of clean cooking

technologies can lead to significant time savings for women (Biran et al 2004, Mahat et al 2006). Further research is needed to determine different pathways through which these time savings then translate into empowering women, however. Access to clean cooking technology may also result in changes in gender roles, women's confidence, asset ownership and control over finances (Ding et al 2014, Gonda et al 2016, Mohlakoana et al 2018, MSSRF and CRT Nepal 2019). Another common topic studied is the impact of improved cooking technologies and lighting on women's time use (Köhlin et al 2011), although there is still work to be done on what women do with additional time and how that is impacted by contextual features.

Research that studies the interaction between access to energy services (besides cooking) and female empowerment is relatively sparse. We summarize available evidence on the two-way connection between access to clean energy and empowerment – pathways through which access to other energy services impact female empowerment, and the converse. Limited evidence suggests that women due to their lower say within households are unable to determine how electricity is used and what electric appliances to purchase (Winther et al 2020). Furthermore, a small, yet emerging, strand of literature suggests that women's engagement in the energy sector may result in increased technology adoption (Barron, et al 2020). Like clean cooking technologies, access to electricity appears to increase women's employment and labor market participation (Grogan 2016, Pueyo & Maestre 2019). Access to electricity may facilitate women's empowerment through increase in awareness, improved knowledge and access to information (Wilhite 2017, Rewald 2017). More evidence is needed, however, to explore whether access to electricity also directly leads to empowerment. It is important to note that the impact of electricity on gender empowerment is dependent on the local socio-cultural contexts (Standal & Winther 2016).

The connection between lighting and education is also oft-cited, but inconclusive. Studies on electricity access often attempt to test the link with employment and income, although the range of approaches taken, and the impact of social and economic context, means that findings are inconclusive. Measuring the full weight of the impact is also stymied by the short time frame of many academic studies. As research in this space has shifted away from the narrative that improved energy access naturally leads to the empowerment of women, there is some more acknowledgement of how women use time that is freed up by lighting in the evening, to work a 'second shift' (Lamb 2019). However, these studies are few and far between, and more work is needed to articulate how socio-economic context changes the use of women's time. Likewise, the complicated causal relationship between time-saving appliances and women working outside the household is poorly studied in LMIC contexts.

Finally, there is a large gap in the literature around productive uses of energy, both in terms of how access to such technologies – e.g. sewing machines, light agricultural processing – might lead to greater empowerment, and on how empowered women may choose to improve the uptake of such income-enhancing energy technologies. There is some recent work on women's use of cooking fuels and technologies in SMEs, but this is an outlier (de Groot et al 2017). A single study of access to electric pumps focuses on women's groups (Burney et al 2017).

Similar to Malhotra and Schuler's (2005) review of female empowerment in the development literature that found much focus on resources, which Kishor (2000) defined as "catalysts for empowerment" or "enabling factors that can foster empowerment", we also find that the energy-gender literature has discussed 'resourc-

es' more than the 'process' and 'agency' elements of women's empowerment. The most frequently used metrics for capturing women's empowerment include economic and demographic measures such as gender of household head, education, employment, increase in wages, engagement in energy enterprises, economic status and control of assets. While resources are critical to empowerment of women, they may not be sufficient (Malhotra and Schuler 2005). There is a need for including measures from political, legal, cognitive, health and psychological concepts in order to measure overall women's empowerment.

The importance of 'process' as being central to achieving women's empowerment has also been repeatedly discussed in the literature. However, the empirical literature is lacking in understanding of this process especially vis-à-vis energy, and how its dynamics can facilitate energy adoption and use in the household and other spheres. Conversely, the role of energy technology in promoting the process of empowerment remains murky. Understanding process questions requires much more thoughtful empirical design, likely using mixed methods approaches or high-frequency data collection that identify gradual changes over time (Taylor & Perezniето 2014). Acknowledging this, studies are incorporating robust quantitative and qualitative methods to study women's empowerment 'processes' (Patalagsa et al 2015). Another lacuna is a lack of intersectional approaches that integrate understanding of women's involvement in groups and within existing institutional structures into energy research. Moreover, women are often treated as a monolithic category, and little research acknowledges where class, race or other socio-economic factors change women's experiences and actions (Austin & Mejia 2017, Lamb 2019). A specific example of this is the assumption that all women represent the interest of the primary cooks in the household, which overlooks the reality that many wealthier, more educated households employ poorer, less educated women as domestic help to do household chores, including cooking, or the fact that among women in a household, there are also particular hierarchies.

5 RESEARCH WAY FORWARD

As described at length in this review, a majority of the literature explores elements of female empowerment – whether measured by social status, education, or employment – in driving energy adoption and use. The clean energy literature often proxies a women's decision-making ability for her empowerment, thereby ignoring the multidimensionality of female empowerment that various scholars across disciplines argue for. Topic-wise, less attention is paid to whether and how women's empowerment might change the electrification of businesses or communities; the types of electrical appliances adopted, or their use, with the exception of the placement of lighting; and the adoption and use of income-generating technologies. Most studies focus on the adoption of transitional or clean energy technologies, much less on the use of and/or decision-making around those technologies.

One strand of research could focus on experimental and quasi-experimental designs exploring intra-household bargaining (between spouses, and women versus other senior household members) and whether that drives energy adoption and use, and mechanisms explaining the same. Well-designed mixed methods studies or high-frequency data collection could also be designed to measure female empowerment processes better in the context of energy provision. Another theme, within these methodological designs, could be to examine which social processes involving women (e.g. participation in social groups, political representation of

women, etc.) facilitate energy outcomes. In each of these broad suggestive designs, less-explored energy services could be the focus, or a bundle of energy services could be examined (e.g. lighting, cooking and productive uses).

Another research theme of importance is assessing the existence of complementary conditions that (a) motivate hypotheses about heterogeneous impacts (depending on cultural context, other development interventions, specific population groups, etc.); (b) examine whether energy is a necessary but not sufficient condition to see long-term development outcomes; and (c) increase populations' choices and opportunities and whose improvement could also accompany energy interventions.

Another strand of research could focus on the development of tools or multidimensional indices for measuring the impact of energy interventions and services on women's empowerment, and vice-versa. The absence of such robust, inclusive measures likely encourages the near singular orientation of current research to the 'resources' dimension of empowerment, which is largely a response to data availability and measurement constraints and challenges. While such limited analyses undoubtedly make a valuable empirical contribution, they do not address the multi-sectoral gap(s) that remain in the literature, and are thus insufficient to move the research-practitioner community towards a holistic understanding of female empowerment. The creation of summary measures (derived from careful testing of relevant gender-energy domains and specific questions under each domain) would be useful not just for comparison across contexts, but for giving practitioners a set of gender-relevant indicators to monitor program impacts.

APPENDIX

	Observational; cross-sectional	Observational; panel	Quasi-experimental	Experimental	Modelling	Meta-analysis	Qualitative	Qualitative review	Mixed methods review	TOTAL
Impacts of energy on empowerment	44	1	15	8	1	3	2	3	2	79
Empowerment driving energy adoption	19	2	1	4	2	1	3	1	0	33
Both	4	0	0	1	0	0	1	4	1	11
TOTAL	67	3	16	13	3	4	6	8	3	123

Figure 6: Distribution of studies by empirical design

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