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A background paper for the World Development Report 2012 on Gender Equality and Development
Paper No. 125 / August 2011

Energy, Gender and Development What are the Linkages? Where is the Evidence?

Gunnar Köhlin

Erin O. Sills

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Executive Summary

The objective of the report is to review the literature on the links between energy access, welfare, and gender in order to provide evidence on where gender considerations in the energy sector matter and how they might be addressed. Prepared as a background document for the 2012 World Development Report on Gender Equality and Development, as well as a part of the Social Development Department's ongoing work on gender and infrastructure, the report describes and evaluates the evidence on the links between gender and energy focusing on the following areas: increased access to woodfuel through planting of trees and forest management; improved cooking technologies; and access to electricity and motive energy.

The report is intended to complement ongoing efforts to formulate a gender business plan for the Sustainable Development Network of the World Bank. It focuses on reviewing the academic evidence and does not aim to offer specific operational recommendations which are better left for the gender business plan and other documents that follow up on the 2012 World Development Report.

Focusing on the academic peer-reviewed literature, fairly inclusive screening criteria are applied when selecting the evidence to consider. Thus, much of this review is based on quantitative studies with samples that are relatively small, yet sufficient to support multivariate regressions to control for confounding effects. Thus, we include studies even if they were not experimental or quasi-experimental; used cross-section measures instead of a before and after; and relied on proxy indicators of welfare outcomes.

The main finding of this review is that energy interventions can have significant gender benefits which can be realized via careful design and targeting of interventions based on a context-specific understanding of energy scarcity and household decision-making. The Bank may also want to consider a program of rigorous impact evaluations and participatory monitoring of household energy projects.

While Sub-Saharan Africa has particularly low electrification rates, rural electrification is a policy goal in many countries and 68 developing countries have set explicit targets for electricity access. In most countries, electricity is not used for cooking, and therefore does not directly substitute for polluting and time-consuming traditional cooking technologies and fuel sources. Thus, there are very significant potential health gains, particular for women and children, from effective dissemination of improved cookstoves or other modern energy technology for cooking in rural South Asia and Sub-Saharan Africa, and of less polluting cooking and heating technology in China.

The impact of interventions designed to promote energy access depends on household decision-making, and, in particular, how women's preferences, opportunity cost of time, and welfare are reflected in those decisions. Studies show that both women and men are involved in fuelwood collection but to varying degrees, with women often doing most of the collection labor. Studies also show that the labor allocation between men and women, and between sources of fuel, is responsive to relative shadow wages as well as to cultural norms. Realizing the full potential of these interventions therefore requires that project design is based on a context-specific understanding of energy scarcity and how household energy decisions are made.

There are several reasons to expect that the determinants and rates of adoption of new cooking technology and electricity may be different for female-headed vs. male-headed households: in some places, female-headed households are more likely to be poor and thus less able to afford the up-front cost of new stoves or electricity connections. And, in many places, the legal and cultural constraints on

women may also place households that they head at a disadvantage, limiting their opportunities even conditional on household income. Finally, one would expect decisions by female heads of households to more closely reflect women's preferences, welfare, and opportunity cost of time. All of this raises the possibility that female-headed households may be more responsive to interventions to improve access to new cooking technology and electricity. In the Lao PDR Rural Electrification Project, for example, it was found that female headed households made up 43% of poor households, who would not be able to afford fees for connecting to the electricity grid. This circumstance led to a pilot component, known as Power to the Poor, which set up a revolving loan fund to enable the poor to finance the upfront connection costs. However, it is also possible that the legal, cultural, or institutional constraints faced by women may adversely affect the ability of female-headed households to switch fuels, adopt technology, or establish an electricity connection regardless of income.

Access to woodfuel through tree plantation and forest management

The need for woodfuel in low-income countries will remain large for the foreseeable future. Since the 1970s, many interventions have aimed to increase access to woodfuel and decrease women's collection efforts. At first, the focus was on the establishment of plantations of fast-growing species such as eucalyptus under various management regimes. Later on, the emphasis has gradually shifted toward community-based woodfuel management (as in Bank-supported projects in Niger, Mali and Senegal) in line with the global trend towards devolution of forest management to communities.

The potential for positive project impacts depends on the economic scarcity of woodfuel and households' capacity to adapt to that scarcity. The academic case study literature indicates that households, particularly women, tend to spend more time collecting fuelwood as it becomes scarcer. However, access to woodfuel is not only an issue of physical and labor scarcities, but also reflects cultural norms and intra-household bargaining strengths. Thus, the potential welfare gain for women from increased woodfuel access is great, but needs careful targeting and design that considers the many margins on which households adapt when fuelwood grows scarcer.

The consensus of the 1980s was that fuelwood supply interventions at the time showed little potential for positive impacts. However, this finding may have changed for women facing a high degree of economic scarcity of woodfuel due to few assets, exclusion from previous open access sources, and reduced natural vegetation. This being said, the impact on women depends on their participation in collection as well as their relationship to the management structure put in place by interventions. Since management of wood resources often involves exclusion, there is a risk that women and other less powerful groups may be negatively affected in the short run.

Resource scarcity can lead to lower school enrolment for girls if they are more involved than boys in fuelwood and dung collection. A negative relationship between natural resource-collection and schooling was found for Malawi and Kenya, but it affected girls and boys equally. However, Koolwal and van de Walle (2010) found that investments in water infrastructure led to a statistically significant increase in the share of rural girls enrolled in school in four out of nine countries considered. Something similar may apply to energy interventions.

Given the large amount of time spent by women collecting fuel, there is potentially scope for increasing women's employment in income generating activities by making woodfuel more accessible, but we have been unable to identify studies analyzing this potential, and a recent review of impacts in the water sector does not support this hypothesis.

Project experience suggests positive but varying impacts of community plantations with large variations in impacts between genders, households, and villages, pointing to the need for careful design and targeting of interventions if welfare improvements of women is to be realized. Woodfuel is increasingly grown and collected on private land. Policy reforms, such as increased security in private tenure and reduced access to state-owned forests, are important in further inducing private tree planting, but the gender implications of such reforms need to be carefully considered.

Devolution of forest management to communities has become a major global trend. In West Africa, for example, such programs have been implemented to secure a sustainable source of fuelwood and charcoal. As with any resource of value, there is a risk of institutional capture in the devolution of forest resources, and it is therefore a challenge for interventions to secure local participation while not marginalizing women. The goal should be to move women beyond token participation to real influence. Quotas for women's representation in management institutions should be considered, for example via a threshold requiring one-third of positions of voting power to be held by women. However, sustainable change would probably require a combination of more profound improvements in democratic institutions and empowerment of women to enable them to represent themselves in these institutions, far beyond the scope of individual energy interventions.

Improved cookstoves

Improved cookstoves have the potential to reduce indoor air pollution, improve the health of women and children, and cut time spent collecting fuelwood. However, penetration remains very low everywhere except in China, and few studies exist that identify the barriers to greater uptake. The Bank Group should facilitate tapping into carbon finance and technical assistance to promote improved cooking options.

Our review of cooking interventions covers a broad spectrum of improved fuels and stoves designed to improve energy efficiency, remove smoke from the indoor living space, and raise the productivity of cooking. We include studies that examine cheap stoves as well as advanced and more expensive stoves. The literature on the health impacts of household energy interventions is reasonably robust and shows that cooking interventions improve respiratory health of both women and men. For example, a recent meta-analysis of 25 studies shows that, compared to cooking with clean fuels or improved stoves, cooking with biomass increases the risk of pneumonia by 80% (Dherani et al., 2008). In addition, there is some evidence that improved stoves lead to decreased fuelwood collection.

None of the major ongoing cookstove initiatives have been evaluated rigorously, but at least three recent attempts by the Bank to assess household energy, access, and gender issues offer directions for the Bank in this area. These directions seek to avoid direct consumption subsidies and instead promote uptake and supply, and focus on combining supply-side, demand-side, and capacity building to promote, regulate, monitor, evaluate, and finance cookstoves. Further, they seek to promote demand via awareness and microfinance (while avoiding direct subsidies) and to involve NGOs, stove manufacturers, governments, and women in policy making and in setting up infrastructure to design and test stoves to satisfy performance standards. These directions may help the Bank mainstream household energy access interventions in lending operations.

Access to electricity and motive power

The literature on gender and energy suggests that providing electricity to communities and homes and motive power for tasks considered women's work can promote gender equality, women's empowerment, and women's and girls' access to education, health care, and employment. Rural electrification projects often seek to promote gender goals through benefits such as lighting, television, and appliances powered by electricity.

Most gender benefits of providing electricity and motive power occur because women tend to spend more time at home, are responsible for household chores that can be carried out more productively with electricity, and because certain tasks that are culturally defined as women's work can benefit from motive power. There is an ample case study literature documenting how many of these benefits accrue to women in communities that receive electricity or motive power. However, there are also numerous cautionary tales about the difficulties of sustaining and scaling up interventions, and the need for complementary investments in order for women to fully realize the potential benefits of electricity.

In general, lighting and TV are the first common uses of electricity, accounting for at least 80% of rural electricity consumption. The first and strongest impacts of electricity therefore also occur via lighting and TV. Electricity displaces more expensive candles and kerosene lamps, thereby reducing indoor air pollution and fire and burn risk, and providing higher quality light. Lighting and television help improve access to information, the ability to study, and extend the effective working day. Lighting also improves the productivity of many household activities, and has potential benefits for public safety and expanded income-generating opportunities.

Considering the significant resources invested in electrification projects, there are surprisingly few robust studies of their impacts, and even less is known about gender-differentiated impacts. Therefore, while a long list of potential benefits of electrification to women has been posited, not all claims have been backed up by evidence. However, rural electrification has been demonstrated in a few studies to increase women's work outside the home, especially for younger cohorts of women, most likely by increasing the supply of women's time and boosting the demand for labor in small enterprises.

Dinkelman (forthcoming) finds that electrification of rural communities in South Africa results in a 9 percentage-point increase in female employment, but no comparable increase in male employment. Grogan and Sadanand (2009) obtain a similar estimate of a 9 percentage-point increase in female employment, versus no impact on male employment, from rural electrification in Guatemala. Both studies attribute this largely to the fact that electricity frees up women's time by increasing the efficiency of domestic chores, especially cooking. These results are broadly consistent with other studies that draw on large samples of electrified and non-electrified households and control for numerous potential confounders. For example, ADB (2010), Barkat (2002), and Chowdhury (2010) find that electrification reduces the time that women spend collecting fuelwood (in Bhutan) and increases the evening time they allocate to income generating activities and the probability of employment (in Bangladesh).

These findings support the conclusion that electrification has greater positive impacts on women when accompanied by effective social marketing and financing schemes for appliances that reduce the time required for domestic chores or enterprise services for women to take advantage of electricity services.

Electrification has been shown to have clear positive impacts on the education of boys and girls, and the evidence is mixed on whether boys or girls benefit the most. The health benefits of electricity stem from cleaner air, reduced risk of burns, fires, and accidents, better nutrition and food safety from refrigeration, and improved health knowledge from access to mass media. A number of studies have found that electricity is associated with reduced use of fuelwood, whether measured as time collecting fuelwood or choice of cooking technology.

There is also evidence from a range of studies that electrification reduces fertility rates in rural areas, with positive impacts for women. For example, census data from across Latin America suggests a systematic negative association between birth propensities and household electrification status in rural areas. One probable channel for the impact of electrification on fertility is through television.

There is a small but important body of evidence on the impacts of television on gender roles and women's empowerment, substantiating the frequent references to this in the case study literature and identifying a potential causal mechanisms. For example, Jensen and Oster (2009) find that access to cable television results in lower acceptance of spousal abuse, lower son preference, more autonomy, and greater likelihood of sending young girls to school in rural India. Chong and La Ferrara (2009) find that access to the television network that carries *telenovelas* in Brazil resulted in higher divorce rates, which may be related to empowerment of women. The impact of TV may stem from imitation of role models of emancipated women in fictional TV dramas.

It would appear that the social benefits of electricity can be enhanced in situations where mass media present an image of empowered women and gender equity. There may also be important complementarities between investments in electricity and in new cooking technologies, with resulting benefits for family health and income.

Supplying electricity to community facilities can have positive effects on women and girls, for example through improving school quality; health care (e.g., refrigeration to maintain cold chain); security and street lighting; social capital from lighting community spaces; and improved economic options for small enterprises.

Engaging women in the supply of electricity and motive energy can also increase their welfare but the evidence is scarce. There is a clear need for rigorous studies to identify key design elements to obtaining benefits for women in energy supply.

1 Motivation for Gender Analysis of Household Energy Interventions

1.1 Introduction

The objective of this report is to review the academic literature to identify well-established links between energy access and welfare and gender implications. We consider three major areas of intervention: (i) increased access to woodfuels through planting of trees and forest management, (ii) increased access to improved cooking technologies and (iii) increased access to electricity and motive energy, in order to provide a basis for gender sensitized analyses and identify opportunities to generate positive impacts for women in interventions sponsored by the World Bank Group (WBG) and others.

That nearly three billion people still rely on solid fuels and that women and children are disproportionately affected by the resulting indoor air pollution¹ is clearly spelled out in recent World Bank reports (e.g. World Bank 2011 and 2010a). This establishes the potential importance of the gender dimension for energy interventions. In this report, we describe and evaluate the nature of the evidence for gender implications of energy poverty and of energy interventions and then comment on opportunities for energy interventions that will empower women and improve their livelihoods.

We focus on whether interventions achieve their intended impacts and whether these are differentiated by gender (e.g., women's health improves more than men's health as a result of subsidies for new cooking technology), but we also note other benefits with differential impact on women, e.g. improved health, nutrition, or education of girls, as well as unintended consequences of interventions in the energy sector. As caveats, we note that first, the quantitative evidence base on causal impacts is thin. Second, the interventions that have a *greater* impact on women than on men are not necessarily the interventions with the *greatest* positive impact on women. And third, the impacts of past interventions under *ceteris paribus* conditions may not identify the impacts that would be possible to achieve with complementary interventions that address various aspects of women's condition. Our discussion of options reflects these caveats and the reality that promoting gender equality and improving women's lives requires complementary interventions in the energy and in many other sectors (e.g., land tenure, forest management, education, and health).

The bulk of this report is a review of the academic literature on the links between energy access and welfare, with gender implications. The focus is on three major areas of intervention: (i) increased access to woodfuels through planting of trees and forest management, (ii) increased access to improved cooking technologies and (iii) increased access to electricity and motive power. After reviewing the evidence, we offer concluding reflections and discuss potential implications. But first we establish a basis for the reviews by introducing some basic facts about household energy access, examining whether and when female-headed households may respond differently to interventions, and discuss methodological challenges.

1.2 Household energy choices and expenditures

1.2.1 Household energy use patterns in developing countries

Rural electrification is particularly lacking in Sub-Saharan Africa, but it is a widely acknowledged policy goal, with 68 developing countries having explicit targets for electricity access. In most countries, electricity is not used for cooking, and therefore does not directly substitute for polluting

¹ Also WHO/UNDP (2009) notes that 44% of deaths due to indoor air pollution from solid fuels are children, and 60% of adult deaths are women.

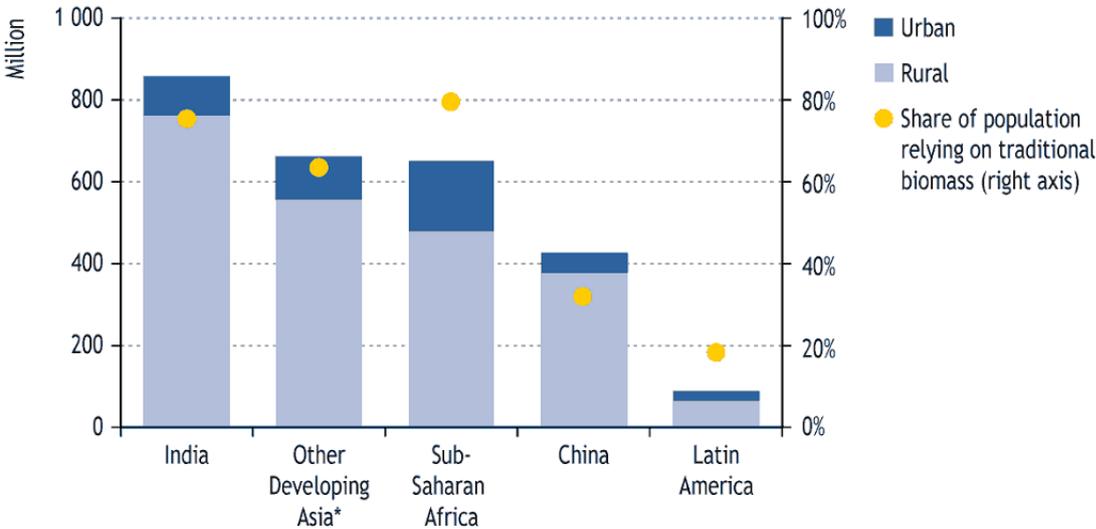
and time-consuming traditional cooking technologies and fuel sources. In terms of sheer numbers of women, there are huge potential health gains from effective dissemination of improved cookstoves or other modern energy technology for cooking in rural South Asia and Sub-Saharan Africa, and of less polluting cooking and heating technology in China.

According to the latest World Energy Outlook, 40% of the global population relies on “traditional use of biomass for cooking” (i.e., 3 stone fires and unimproved stoves), and 20% of the global population (1.4 billion people) do not have access to electricity. The greatest number of people without access to electricity are in SSA (585 million), followed by India (404 million). There are 855 million people in India and 653 million people in SSA who cook with biomass using traditional methods (see figure 9 from WEO). In China, there are another 423 million, plus 400 million who rely on coal, in many cases for both cooking and heating; the need for heating in cold climates presents significant additional challenges both to households and to those seeking to promote new technology (Baris and Ezzati 2007; Lucas et al. 2003; Pokhrel et al. 2010). In all countries, the majority of people who rely on biomass for thermal energy and who lack access to electricity are in rural areas

There are clear patterns in household energy use between rich and poor and rural and urban areas and households. Nevertheless, the “energy ladder” hypothesis, which expected a sequential change of fuels as income rises, has been replaced by a “fuel stacking” hypothesis given a number of studies that show that many households use multiple fuels and that the choice of fuel is affected by many more factors than income (see e.g. Masera et al. 2000; Heltberg 2004, 2005; Gupta and Köhlin 2006; Gundimeda and Köhlin 2008). The availability of multiple fuels enables policies encouraging fuel switching, e.g. from charcoal to electricity in urban areas. However, only few studies estimate the cross-price elasticities of demand for various fuels for larger samples that could shed light on the potential for policies to promote fuel switching. One example is Gundimeda and Köhlin (2008), using Indian NSSO data (110000 households). It reported for rural areas: cross price elasticity of wood with respect to kerosene ranging from 0.49 to 0.71²; of wood with respect to electricity ranging from 0.38 to 0.45; and of wood to LPG ranging from 0.56 to 0.84. In urban areas: cross price elasticity of wood with respect to kerosene ranging from 0.43 to 0.54; of wood with respect to electricity ranging from 0.32 to 0.47; and of wood with respect to LPG ranges from 0.38 to 0.65. The cross-price elasticities are thus quite low, reducing the potential for sizable impact of tax and subsidy schemes.

² Thanks to the large number of observations, the elasticities were calculated for low, medium and high income groups.

Figure 1: Number and share of population relying on the traditional use of biomass as their primary cooking fuel by region, 2009



*Includes developing Asian countries except India and China.

Source: OECD/IEA 2010 (World Energy Outlook).

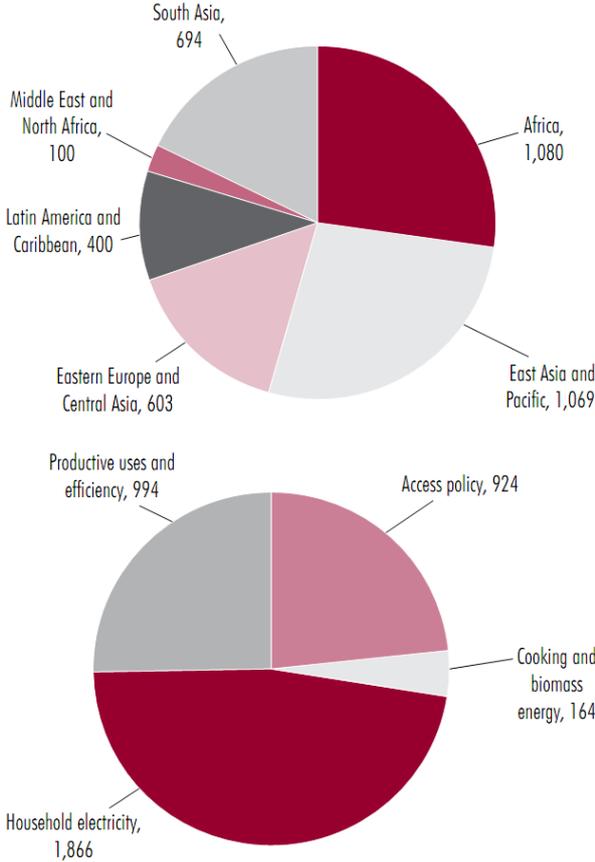
According to WHO/UNDP, 2 million deaths annually in the developing world are attributable to solid fuel use for cooking. Among the 56% adult deaths, 60% are women. The largest number of these (665,000) occurs in East Asia and the Pacific, where COPD and lung cancer are particularly important results of solid fuel use in China. Another 662,000 of the estimated deaths occur in South Asia, and 551,000 in SSA, where pneumonia is the primary cause. Considered in terms of DALYs, SSA carries the largest burden. Likewise, SSA has by far the smallest number of households using improved cookstoves as a proportion of all households using solid fuel, and the largest proportion of urban households still relying on solid fuel (particularly charcoal). While lack of access to electricity and use of traditional unimproved cooking methods are predominantly rural phenomena, there are also many urban households who cannot obtain reliable electricity and who spend large fractions of their budgets on cooking fuel. In an urbanizing world (UNFPA 2007), these somewhat different energy access issues in urban areas clearly also merit attention, although the evidence on the gender differentiated impacts of possible interventions is very thin.³

While the World Bank makes substantial investments in the energy sector, a relatively small proportion is dedicated to projects that promote adoption of improved and advanced biomass stoves (which are often more efficient and generate less indoor air pollution), and fuel switching to cleaner fuels such as LPG. For example, from 2000 to 2008, \$164 million, or 4% of the World Bank’s total investment in energy access projects, was applied to cooking and biomass energy (see figure from Barnes et al. 2010). A much larger proportion of the portfolio is for household electricity. With some exceptions (such as Bhutan, Namibia, and South Africa), only a small proportion of households in developing countries cooks with electricity or natural gas. Another set of donor-funded interventions

³Grogan and Sadanand (2011) point out one practical reason that efforts to estimate causal impacts have focused on rural electrification: “there is much more likely to be truly exogenous variation in electricity access in rural than in urban areas. The grid extends to virtually all urban areas, so that urban people without electricity tend to be relatively poor. Since so few houses in urban areas do not have electricity, the unobserved characteristics of those without electricity in the city likely differ more substantially from those that have electricity than they do in rural areas.” One exception is Peters et al. (forthcoming), who compare impacts in rural vs. urban Cote d’Ivoire.

are designed to increase, decrease, or improve technology for use of 'intermediate fuels' such as charcoal and kerosene. And finally, there are what REN (2010) calls "niche cooking technologies" such as biogas systems, especially in China.

Figure 2: World Bank Energy Access Investment by Region and Type, FY2000-08 (US\$ millions)
 Source: Barnes et al. 2010



In addition to large donor investments to expand the electricity grid and improve access for urban and rural households, there is also long-standing donor interest in micro-grids and household systems, including systems based on renewable energy. As REN (2010) notes, no international organizations are collecting consistent statistics on renewable energy across developing countries. However, evidence on particular countries and technologies shows that there has been significant uptake in some cases, such as solar power for lighting and TV in China, South Asia, South Africa and Kenya.

According to WHO/UNDP (2009), 68 governments (out of 140 developing countries) have set targets for electricity access. Building and maintaining the electricity grid are priorities for governments. However, only 17 governments have set targets for access to modern stoves, and only 11 have set goals for improved stoves. According to the 2010 World Energy Outlook, projections suggest that energy access problems will persist and even deepen in the longer term: in their New Policies Scenario, 1.2 billion people still lack access to electricity in 2030, 87% of them living in rural areas (Figure 1). Most of these people will be in Sub-Saharan Africa, India and other developing Asian

countries (excluding China). In the same scenario, the number of people relying on the traditional use of biomass for cooking rises to 2.8 billion in 2030, 82% of them in rural areas (OECD/IEA 2010 - WEO).

1.2.2 Do women spend more time than men on fuel collection and cooking?

Studies show that both women and men are involved in fuelwood collection but to varying degrees, with women often doing most of the collection labor. The labor allocation between men and women, and between sources of fuel, is responsive to relative shadow wages as well as cultural norms.

Ever since the seminal paper by Eckholm (1975) on the "Other energy crisis" there has been a concern with the increasing time needed for collection of fuels. Over the decades there have been numerous studies that have attempted to record time allocated to fuel collection and cooking. In the following, we concentrate on evidence of (i) gender differences in fuel collection and cooking, and (ii) implications on time allocation (particularly for women) from changes in energy access.

There is a received wisdom that women and girls do all or most of fuel collection and cooking, as well as water collection. Such a situation could emanate from a rational allocation of labor in the household

or cultural norms slanting the intra-household bargaining, or both. Let us briefly look at some empirical evidence:

Charmes (in Blackden, 2006) reviews empirical evidence from time use surveys in four Sub-Saharan African countries (Benin, Madagascar, Mauritius and South Africa) along with data from the Ghana Living Standards Survey. These surveys are interesting since they (i) are large scale (ranging from 7743 individuals in Madagascar to 25664 individuals in Ghana), (ii) have nationally representative samples, and (iii) collect information about many different kinds of time uses, both “formal” (i.e. included in the System of National Accounts, or SNA) and “informal” (i.e. non-SNA work). The overall results confirm that women spend 3-5 times as much time as men on domestic activities. Specifically for firewood collection the picture is less clear, as can be seen in table 1.1, with women spending four times as much time as men in Benin (16 vs. 4 minutes per day) while in Madagascar men spend almost twice as much time as women (13 vs. 7 minutes per day). The picture is similar, although less extreme, if we look at only those collecting. This implies that both participation and intensity in participation show the same gender pattern in a country, that participation seems to be the dominating factor and, most importantly, that we can refute the received wisdom that it is *always* mostly women and girls that are involved in fuelwood collection⁴. However, as can be seen in table 1.2, when it comes to time spent preparing meals, women completely dominate the men – and this is consistent across all five countries. A direct implication of this could be to focus on energy solutions for cooking, rather than on the availability of fuels, if the time use of women is a high priority. Charmes also looks at time spent fetching water. Here the pattern of time use is more clearly dominated by female collection. This is relevant to energy policy to the extent that the time required can be reduced by electrical pumps or other forms of motive power for pumping water.

Table 1. Time spent collecting firewood by women and men (in hours and minutes)

		Benin (1998)			South Africa (2000)			Madagascar (2001)			Ghana (1998-99)		
		Women	Men	Women/ Men	Women	Men	Women/ Men	Women	Men	Women/ Men	Women	Men	Women/ Men
Full Population	Urban	3	1	300%				3	6	50%	44	51	86%
	Rural	23	5	460%				8	27	30%	37	28	132%
	Urban & Rural	16	4	400%	6	3	200%	7	12	54%	37	30	123%
Only those Collecting	Urban	1h 5	1h 11	92%				1h 6	1h 13	90%			
	Rural	1h 50	1h 30	122%				1h 14	1h 31	81%			
	Urban & Rural	1h 14	1h 23	89%	2h 17	2h 14	102%	1h 12	1h 26	84%			

Charmes in Blackden, 2006.

Table 2. Time spent preparing meals (minutes per day)

Benin (1998)			South Africa (2000)			Madagascar (2001)			Mauritius (2003)			Ghana (1998-99)		
Women	Men	Women/ Men	Women	Men	Women/ Men	Women	Men	Women/ Men	Women	Men	Women/ Men	Women	Men	Women/ Men
75	6	1250%	84	19	442%	94	7	1343%	116	12	967%	107	55	195%

Charmes in Blackden, 2006, presented in World Bank 2010b.

Another large scale time use study was carried out by ESMAP in India in 1996 (ESMAP, 2004). Detailed time use was collected from 5000 households in 180 villages in six states. The 33% women that collected fuel spent an average of 2 hours per day on this activity.

⁴ Although the review evidence given here is from Africa, similar evidence is also available from India, where Köhlin (1998) e.g. found men to collect more fuelwood than women in rural Orissa.

The general findings from the national time use surveys are also confirmed in smaller case studies: both women and men are involved in fuelwood collection but to varying degrees (Cooke et al, 2008). One of these studies, Köhlin (1998) shows that the labor allocation between men and women, and between sources of fuel, is responsive to the relative shadow wages. Although cultural norms are important for intra-household labor allocation, as indicated by e.g. significant caste dummies in choice of fuel source, it is apparent that the opportunity cost of women's time is also important.

Below, we take up the more interesting question of how the relative, and absolute, burden for women changes with changing circumstances, and especially donor-funded interventions.

1.2.3 Technology uptake and electricity connections

The impact of interventions designed to promote the use of new cooking technology and electricity in homes depends on household decision-making, and in particular, how women's preferences, opportunity cost of time, and welfare are reflected in those decisions. Good project design requires context-specific understanding of how these household decisions are made.

The ultimate impact of many interventions in the energy sector are mediated by household decisions about (i) the type of cooking fuel and technology to employ, and (ii) whether and how to use electricity in the home.⁵ This raises the question of whether and how women's preferences and welfare are reflected in these household level decisions. It is commonly argued that because women have lower status and lower perceived opportunity cost of time, their preferences and their welfare carry less weight in these household decisions. For example, male household heads who control cash accounts may decide which appliances to buy, without considering the preferences or well-being of the women in the household. Social norms that place a low value on women are often internalized so that, even if women are the decision makers, they afford low priority to new cooking technologies that might benefit them. In addition, cultural constraints on women's paid work may deter households from switching from energy that requires female labor (e.g., fuelwood) to purchased energy (e.g., LPG); this is essentially a labor market imperfection that constrains welfare maximization. Such cultural constraints could also lead to vicious cycles where girls are expected to contribute to collection of fuel and water, thus spending less time in school, becoming less attractive to the labor market and with the resulting lower opportunity cost of time having to resort to collection activities.

1.2.4 Technology uptake and female headship

There are several reasons to expect that the determinants and rates of adoption of new cooking technology and electricity may be different for female-headed vs. male headed households: (i) in some places, female-headed households are more likely to be poor and thus less able to afford the up-front cost of new stoves or electricity connections, (ii) in many places, the legal and cultural constraints on women may also place households that they head at a disadvantage (limiting their opportunities even conditional on household income), and (iii) in general, we would expect decisions by female heads of households to more closely reflect women's preferences, welfare, and opportunity cost of time, raising the possibility that female-headed households may be more responsive to interventions to improve access or reduce barriers to new cooking technology and electricity.

⁵ We note that there are energy interventions whose welfare impacts depend on individual decisions, although these are also often constrained by intra-household decision-making dynamics and compounded by institutional constraints operating at the community level or higher. For example, the welfare impact of providing electricity to communities depends not only on household decisions to connect to the grid but also on individual use of public services (health clinics, schools, street lighting), which may be affected by cultural expectations of women and other institutional factors. And some interventions, such as multi-function platforms, are designed to involve individuals (rather than households) via associations, sometimes targeted towards women.

Although in most contexts, only a small fraction of the poorest women are part of female-headed households, this segment of the population has nonetheless been the subject of significant interest and concern from a gender perspective. The question is whether female-headed households face different constraints or have different preferences for adoption of new fuels, technology, and electricity. In this case, we might expect household decisions to more strongly reflect women's preferences, but also to be subject to the legal and cultural constraints on the women who head those households.

There is a substantial literature and mixed evidence on whether female-headed households tend to be poorer (Buvinic and Gupta 1997; Quisumbing et al. 1995; Fuwa 2006). There are both countries and categories of female-headed households (e.g., widows vs. married, urban vs. rural) for which this is the case, and others for which it is not. One reason to expect that female-headed households may be poorer, controlling for household size, is that their heads are more likely to be responsible both for generating income and for child care and domestic chores. However, the causal impact of having a female head on socio-economic status is difficult to establish, because of potential endogeneity (with the possible exception of widows, whose status could be considered due to random bad luck).

Where female-headed households are more likely to be poor, targeting either female-headed households or poor households can also have implications for the other category. For example, in Kenya, "female heads of households constitute a higher proportion of the poor both in the rural (54.1% female vis-à-vis 52.5% for male heads) and urban areas (63.0% female vis-à-vis 45.9% for male heads). Also, female headed households rely more on the fuelwood than the male headed households. For instance, 81 percent of all female headed households used firewood compared to 68.1 percent for males," according to the Population and Housing Census the Popular Report Aug 2002 as reported in Muchiri (2008). As a result, targeting an intervention to fuelwood users would also effectively target that intervention to female-headed households. Another implication of higher poverty rates among female-headed households is that when uptake of new technologies is income-elastic, female headed households will be less likely to adopt if (and because) they generally have lower incomes (e.g., kerosene and LPG in Andhra Pradesh, ESMAP 2004).

In the Lao PDR Rural Electrification Project, it was found that female headed households made up 43% of poor households, who would not be able to afford fees for connecting to the electricity grid. According to World Bank (2010c), "this led the project team to design a pilot component, known as *Power to the Poor*, which targeted the poorest, especially the women-headed households. With initial support from the Global Environment Facility (GEF), Aus-AID, and Gender Action Plan funds, the national electricity company, EDL, set up a revolving loan fund to provide these households interest-free loans to cover 80 percent of their connection and wiring costs. All women-headed households were eligible for support. Within a few years, electrification rates in pilot areas increased by about half (from 63 to 90 percent) and more than a quarter for women-headed households (from 75 to 96 percent) (Boatman, J. et al. 2009)."

Perhaps more relevant to program design is that the legal, cultural, or other institutional constraints faced by women may also affect the ability of female-headed households to switch fuels, adopt technology, or establish an electricity connection, even conditional on a given household income level (cf. Meinzen-Dick et al. 2010 conclusion that there is widespread empirical evidence of "gender-based disparities in adoption of improved technologies including improved seed, inorganic fertilizer, chemical insecticide"). For example, in countries where women cannot legally own land, this may limit access to credit and hence ability to make up-front investments (see examples in first issue of "Gender Equality as Smart Economics" newsletter, World Bank 2008). FAO (2008) also notes that this lack of land ownership may prevent women and female-headed households from benefiting from new opportunities in the energy sector such as cultivation of biofuel (cf. evidence on productivity

differential (Goldstein and Dry 2005) and lower probability of adoption of agro-forestry (Fortmann et al. 1997)). In countries or regions where women do not have equal access to education or where they are not allowed to interact with male extension agents or civil servants, this may also constrain female-headed households from learning about new technologies or understanding the process of obtaining a connection to the grid. In many cases, programs could be designed to reduce these barriers to female-headed households, either by tackling them directly through complementary investments (e.g., land titling programs that specifically include women as landowners) or by providing culturally adapted means of accessing new technology, fuels, or electricity (e.g., financing designed for women to obtain new household appliances).

On the other hand, women in female-headed households may have more decision-making power and therefore household energy decisions may be more likely to reflect women's preferences and needs.⁶ For example, in a different policy domain, Chudgar (2010) finds that female-headed households, and in particular widow-headed households, invest more in their children's education and discriminate less against female children, all else equal. Madon (2003) presents suggestive evidence for Indonesia (by simple cross-tabs that do not rule out rival explanations) that female-headed households own different types of appliances (sewing machines, water pumps, refrigerators) than male-headed households (televisions, radios). Likewise, Dithale and Wright (2003) find "some support for the hypothesis that female decision makers are more likely to opt for modern energy," but note that better data and more research are needed to confirm these findings. With further evidence, this could be an argument for targeting female-headed households (possibly by geographic targeting akin to poverty mapping), because to the extent that women do prefer improved stoves and electricity connections, investing in removing barriers and constraints on female-headed households may result in greater marginal impact on uptake than equivalent investments in male-headed households.

1.3 Methodological challenges in linking energy interventions and gender

In this study, we apply inclusive screening criteria for selecting the evidence on energy and gender. Most of the evidence considered in this review comes from small sample studies with sufficiently large samples to support multivariate regression to control for potential confounders. Thus, we include studies even if they had limitations with design (not experimental or quasi-experimental); used cross-section measures instead of a before and after; and relied on proxy indicators of welfare outcome (e.g., quantity of fuelwood collected, instead of time spent on fuelwood collection).

There is increasing demand for "evidence-based" practice in the design of environment and development interventions. There has also emerged a new and higher standard for what counts as "evidence" and a new emphasis on careful causal inference in order to assess which set of projects, programs, and policies deliver environmental and development outcomes or the conditions under which the impacts can be scaled up and sustained (Banerjee, 2006; Ferraro and Pattanayak, 2006; Ravallion, 2009; Savedoff et al. 2006). This new standard is not met by most studies on the benefits of electrification, biomass, and cookstove programs for women. This is because they do not effectively account for heterogeneous treatments and endogenous program placements, in addition to other basic

⁶ This is subject to the caveat that there may be other systematic differences in male and female preferences, which could change the probability of participation (Croson and Gneezy 2009; Eckel and Grossman 2010). For example, there is some evidence that women have lower discount rates or are more patient, which could increase the probability of making an upfront investment with long-term benefits (see Rubalcava et al. (2007) for Mexico for differences, and for counter-evidence, Tanaka et al. (2010) in Vietnam, Bauer and Chytilová (2010) in Uganda, and Kirby et al. (2002) in Bolivia). There is more consistent evidence that women are more risk averse than men (Croson and Gneezy 2009), although the bulk of the experimental literature is based on student populations in developed countries (see Fletschner et al. 2010 for an exception). Risk aversion could make women, and consequently female-headed households, less likely to adopt new technology but more likely to respond to interventions that help mitigate risk.

problems with measurement and missing variables (Pattanayak and Pfaff, 2009). This makes it virtually impossible to attribute causality to the interventions.⁷

So what are the key elements of today's standard for causal impact analysis required to assess the gender implications of interventions in the energy sector? First, the outcomes of interest – health, livelihoods, drudgery, time, employment, indoor air pollutants – would be measured for at least 4 sub-groups corresponding to women and men (separately) who are exposed to the policy and their control counterparts who are not exposed to the policy (program, project, intervention). Ideally, these measures would be before and after the intervention – i.e., before the sub-group used an improved cookstove or cleaner fuel. Second, each sub-group estimate would be derived from a relatively large sample of households and individuals so that we would have some degree of confidence in that estimate (i.e., the standard deviation would not be larger than the means).⁸ Third, an experimental or quasi-experimental approach or rich multivariate regression would be used to address the likely endogeneity of the intervention.⁹ Finally, in addition to being of sufficient size, the sample would have sufficient variation over policy-amenable variables (e.g., access to roads, quality of local institutions, mother's education) to support identification of why the program works under some conditions (or for some portion of the population) and not under others. Without the ability to identify the moderating influence of these factors that introduce heterogeneity, we cannot derive meaningful policy advice for scaling up and sustaining the impacts.

While all of the above elements are critical, we actually apply relatively inclusive screening criteria for purposes of this report. Specifically, the preponderance of the evidence considered in this review comes from small sample studies, as long as they were large enough samples to support at least multivariate regression to control for key potential confounders. Thus, we include studies even if they had limitations with (a) design – not experimental or quasi-experimental, (b) single cross-section measures, instead of a before and after, and (c) proxy indicators of the direct welfare outcome – e.g., quantity of fuelwood collected, instead of time spent on fuelwood collection. Despite this approach and as presaged by the TOR, the empirical literature on the rigorous “causal impacts” of household energy policies and programs is scattered, shallow, and patchy. The highest methodological standards are found in one-off academic ventures that may not be generalizable across all developing countries. There are very few studies with the ambition of the prospective RESPIRE trials in Guatemala (Smith et al.) or the careful retrospective quasi-experimental approaches to examine the household welfare impacts (Dinkelman, forthcoming; Edmonds, 2002; Mueller et al. 2011). Especially

⁷ The fields of environment and development, which is where household energy and gender concerns reside, are particularly lagging in the use of experimental and quasi-experimental designs, large samples and careful consideration of covariates to address the thorny but critical issue of causal impacts (Dinkelman, forthcoming; Duflo et al. 2008; Pattanayak et al., 2009; Peters 2009, Estache 2010, Bernard 2010). Ferraro and Pattanayak (2006) conjecture about attributes of resources, energy and environment that might cause this laggardness, but these arguments are no more compelling than in the field of disease control, education, poverty alleviation, and other sectors with “soft” or amorphous outcomes, long ambiguous causal chains and impatient donors. Ravallion (2009) presents some alternative claims about political economy concerns and market failures in the supply of evaluations.

⁸ Most studies summarized in this review (except potentially those examining the impacts of electrification) are underpowered to detect gender differences; we have included these studies otherwise our empirical base would be virtually a null set. Future research should consider working with the large scale household surveys such as DHS and LSMS with several thousand observations, some of which measure gender differentiated outcomes, in pursuing the kinds of impacts – health, time spent, forest products extracted – examined in this report.

⁹ Experiments use the power of randomization to ensure that potential confounders are balanced across intervention and control units and therefore any differences in the outcomes between the two can be attributed to the intervention. The quasi-experimental designs that use econometrics to compare intervention to “controls” include: (a) matching—finding a control group that “matches” important observable characteristics of the program group; (b) instrumental variables—using variables that are uncorrelated with the outcome but correlated with program participation to identify a control group; (c) difference-in-difference—using repeated measures of the same individuals (units) to account for time-invariant differences between control and program groups; and (d) Heckman two-stage models—using covariates to predict who participates and using the predicted probabilities to correct bias when comparing controls to program groups (Ravallion 2007).

limiting is that none of the large-scale government policies or donor funded interventions for household energy (e.g., China's NISP, GTZ's HERA program, India's NCI and efforts in Guatemala, Tanzania, and Thailand) planned any careful evaluation of impacts to begin with. Thus, attempts to hastily and retrospectively *attribute effect* to the *cause* seem at best to fall short or at worst have no empirical basis. We are not claiming that these policies, programs, projects and practices have no impacts; just that, there is very little evidence that satisfies the new standards for causal inference and evidence-based policy and practice.

2 Access to Woodfuels through Tree Plantation and Forest Management

2.1 Brief description of interventions and intended impacts

Since the 1970s, many interventions have aimed to increase access to woodfuels and decrease women's collection efforts. At first, the focus was on the establishment of plantations (primarily fast growing exotics such as eucalyptus) with variations in the management. Later on, the emphasis has gradually shifted toward community-based woodfuel management (as in Bank-supported projects in Niger, Mali and Senegal) in line with the global trend towards devolution of forest management to communities. The impact on women depends on their participation in collection, as well as their relationship to the management structure put in place by interventions. Since management often implies exclusion, there is a risk that women, and other less powerful groups in society, are negatively affected, at least in the short run.

Arnold et al (2006) describe the changing perspectives on woodfuel¹⁰ interventions since the mid-1970's¹¹. It started with the recognition that huge and growing numbers of people depended on fuelwood as their principal domestic fuel (Eckholm, 1975; Agarwal, 1986). This led to predictions of potentially devastating depletion of forest resources, with serious negative livelihood consequences for the rural poor, unless action was taken to address this "fuelwood crisis". Fueled by "gap models", large scale plantation projects were implemented with the expectation that they would provide easily accessible fuel, reduce time spent collecting fuelwood, improve nutrition and reduce deforestation and environmental degradation. Already by the mid-1980s, both the underlying analysis and the efficiency of the interventions were seriously criticized. For example, it was pointed out that gap models did not account for the price elasticities of demand and supply of fuelwood. Dewees (1989) argued that the gap models grossly underestimated actual supply, because the models were based on stock and yield figures relating to forest resources, whereas most fuelwood in practice comes from woody plant resources other than forests - scrub, bush fallow, farm trees etc - and much of this can and does regenerate. Leach and Mearns (1988) noted that "By ignoring these flaws, gap methods have done much to exaggerate the scale of the woodfuel problem and foster inappropriate, large-scale, energy-focused remedies at the expense of other actions which could have done more to improve welfare, reduce deforestation, and generally support sustainable development".

As a consequence, during the 1990s, most of the fuelwood-oriented forestry programs that had been put in place in the 1970s and 1980s were terminated or scaled back (Arnold et al. 2006). The focus shifted to devolution of forest management such as Joint Forest Management in India, Forest User Groups in Nepal, Participatory Forest Management in Tanzania and World Bank funded Community-Based Woodfuel Resources Management in Niger, Mali and Senegal.

World Bank (2010a) reviews Bank projects dealing with household access to woodfuels and stoves over the last 20 years. The review shows that the Bank projects follow the general trends described above. Over the last 20 years, 19 projects have been implemented with a total budget of 1.25 billion USD out of which 161 million USD have supported various household energy access components dealing with woodfuel and stoves. All projects, except one, were implemented in SSA and as many as half (10 projects) in West Africa. There has thus also been a change in geographical focus from South Asia towards Africa.

¹⁰ We will use the same terminology as Arnold et al. and in woodfuel include fuelwood and charcoal but not the use of biomass as feedstock for other sources of energy such as biogas.

¹¹ The paper was the outcome of a CIFOR project called "*Fuelwood: Crisis or Balance?*" that investigated in some depth the arguments of a fuelwood crisis in the 1970's and its antithesis of balance in terms of fuelwood supply of the 1980's.

The gender perspective has always been present since one of the rationales of these projects has been to alleviate the time burden on women for collecting fuel and cooking. However, this perspective has been more pronounced since 2003 as part of the growing gender-energy portfolio under ESMAP's "Increased Access to Modern Energy Services" and even more so under the "Energy and Poverty" theme that included access to modern cooking fuels for poor and rural households and efficient use of biomass in its agenda (World Bank 2010a, pp.12-13). It has also led to specific gender sensitized energy programs such as the Africa Renewable Energy Access program (AFREA) and gender-energy tools such as "Making energy work for Women and Men" (World Bank 2010f).

In practice, the projects include a range of activities with varying potential for improving the welfare of women. A recurrent activity ever since the 1970s has been planting of trees, primarily fast growing exotics such as eucalyptus, with variations in management ranging from subsidies for private planting of trees, community plantations, peri-urban plantations, to large-scale commercial plantations (often under government ownership). The primary objective has been to increase the availability of fuelwood and decrease collection time. The impact on women therefore depends on their participation in collection, as well as their relationship to the management structure put in place by interventions. As mentioned, emphasis has gradually shifted toward community-based woodfuel management (as in Bank-supported projects in Niger, Mali and Senegal), echoing the global trend of devolution of forest management to communities, spearheaded by Joint Forest Management in India but now seen in many countries also in Africa, Latin America and South East Asia. While there is often an environmental aspect in plantation projects, this is typically more pronounced in forest management projects. In either case, since exclusion is often an important component of management, there is a risk that women, and other less powerful groups in society, are negatively affected, at least in the short run. A related activity concerns charcoal production, and in particular securing supplies and increasing efficiency in the production, as in projects in Senegal, Tanzania and Mozambique.

2.2 Welfare implications

The potential for positive project impacts depends on the economic scarcity of woodfuel and households' capacity to adapt to that scarcity. The consensus of the 1980s was that fuelwood supply interventions at the time showed little potential for positive impacts. However, this finding may have changed for women facing a high degree of economic scarcity of woodfuel due to few assets, exclusion from previous open access sources, and reduced natural vegetation.

When planting of trees and forest management have been designed primarily to relieve woodfuel scarcity¹², the potential for positive project implications depends on the economic scarcity of woodfuel faced by households. How utility is affected by scarcity (and subsequently by an intervention addressing the scarcity) varies from household to household depending on household labor, assets, preferences, income, and the availability of feasible substitutes. To the extent that female-headed households have less land and labor, they can be more vulnerable. The more substitution options available to a household, such as alternative sources of fuel, improved efficiency in fuel use, use of idle labor e.g. in agricultural off-peak seasons, the better it will be able to cope with increased energy scarcity in a way that minimizes welfare loss. These substitution possibilities are also the reason for the common assumption that the welfare loss of such adaptation is rather low (Arnold et al., 2003). However, there can be great variation in adaptation possibilities over space and time. The conditions that limited the impact of plantation projects in the 1980s might not hold now in regions where population density has increased, natural vegetation has been degraded, and land tenure rights have

¹² There are also other rationales for these projects, such as economic development and environmental concerns.

been clarified, thus reducing access. Given the vast potential for fuel substitution, the welfare implications of interventions will vary over time, space, and according to household characteristics.

In the following sections, we review the literature on welfare implications of fuelwood scarcity and associated interventions. Most households have very few assets beyond their own labor. Although the monetary value of female labor expended in household chores is seldom estimated it is nevertheless essential for the survival of the household. Since energy collection and use is labor intensive, it is expected that energy interventions primarily affects household welfare through the intra-household labor allocation. Here we will focus on four aspects of this labor allocation: first of all any evidence of a (i) direct impact of woodfuel access on women's time use, then whether access has any (ii) impact on agricultural production, or (iii) off-farm income and finally on (iv) education.

We start by noting that, despite the many potential substitution mechanism ameliorating woodfuel scarcity, households in many cases respond to increasing scarcity of fuelwood by using less. Many household studies indicate that fuelwood consumption decreases as market or shadow prices increase, although typically not by a large amount (Cooke et al., 2008; Hyde and Köhlin, 2000; Heltberg et al., 2000, Linde-Rahr, 2003; Pattanayak et al., 2004; Van't Veld et al., 2006).

2.2.1 *The implications of woodfuel access on women's time use*

The academic case study literature indicates that households in general and women specifically, tend to spend more time collecting fuelwood as it becomes scarcer. However, the intra-household labor allocation to collection is affected both by cultural norms and relative productivity and opportunity costs. Thus, the potential welfare gain for women from increased woodfuel access is great, but needs careful targeting and design that considers the many margins on which households adapt when fuelwood grows scarcer.

The fuelwood collection literature generally does not examine specific interventions but rather general indicators of scarcity. Most empirical results from Nepal and India indicate that households tend to spend more time collecting fuelwood as it becomes more costly as measured by either market price (Amacher et al., 1999), by a shadow price (Cooke, 1998a), or by a physical measurement such as decreases in forest stock or decreases in forest accessibility (Amacher et al., 1993a; Köhlin, 1998; Heltberg et al., 2000). There is also evidence that women spend more time collecting when availability decreases¹³ (Kumar and Hotchkiss, 1988; Cooke, 1998a). Van't Veld et al. (2006), on the other hand, find that households do not spend more time searching for fuelwood when biomass availability from common areas decreases¹⁴. Rather, fewer women choose to collect fuelwood from the village forest commons in villages where these are degraded. Instead, they use fuelwood from private trees or agricultural waste as fuel. Cooke 1998a and Van't Veld 2006 also find clear seasonality in collection, with more collection, particularly by men, in the dry season which is also the agricultural slack season. This highlights the many margins on which households may adapt when fuelwood becomes scarcer. Still, there is much to learn about how interventions can relieve energy poverty triggered by various constraints.

¹³ A reviewer pointed out the potential contradiction in that women do not always collect a majority of the fuel with the findings that they spend more time collecting when availability decreases. Interestingly enough, in the studies reported here, collection by women seems to be more sensitive to changes in availability than male collection.

¹⁴ Van't Veld et al (p.4) also point out that in most studies that estimate the relationship between time spent collecting and forest degradation, the measures of fuelwood availability are indirect (eg time spent to collect 20 kg) and likely endogenous. Since unobservable, household-level characteristics that affect the total time spent in collection are likely to affect the time spent collecting a fixed quantity of firewood in the same direction, these measures of scarcity are likely endogenous, and possibly biased towards finding the result that these studies report (i.e., that time spent collecting increases with scarcity). In contrast, Van't Veld et al uses a direct physical measure of firewood availability, namely, the volume of biomass available per household in the village. Köhlin and Amacher (2005) use distance to forest measured in a GIS from village to a certain quality of forest (NDVI based).

One potential intervention is to relieve the time constraint for women involved in fuel collection, taking into consideration that fuel collection often is carried out jointly with other activities. The potential for time savings for women from the establishment of community plantations is exemplified in an evaluation of the Sida-funded Orissa Social Forestry Program in India. Köhlin (1998)¹⁵ finds for a random sample of villages with and without plantations that the introduction of community plantations reduced the collection time for households who collect by almost 10 hours a week. The main beneficiaries of this change were the women that reduced their collection time by more than 10 hours a week. In the case of Orissa, men participated more than women in collection and participation by men and children increased further with the introduction of easily accessible community plantations, to the benefit of the women. The collection also became more efficient. The marginal product was significantly higher for collection in community plantations than in natural forests both for men and women. And men had a significantly higher marginal product in collection – in the case of collection in natural forests, more than twice that of women. The value of the time saved through the introduction of community plantations differed greatly, from zero to 455 USD per hectare per year¹⁶, primarily depending on the availability of readily available substitutes (Köhlin and Amacher, 2005). Similarly, Van't Veld et al. (2006) found that in villages with JFM projects, women were more likely to collect fuelwood from the village forests, and spend less time collecting essentially the same quantity of fuelwood.

The conclusion is that there are significant potential welfare gains from tree planting and forest management interventions for resource-constrained women. The good news for targeting is that there is self-selection: as long as collection is time-consuming the poorer women with lower opportunity cost of time utilize the resource more. Still, projects could be targeted based on indicators such as time spent collecting, availability of close substitutes, and household capacity to adapt to scarcity.

2.2.2 Implications for agricultural production

Another potential motivation for interventions supporting tree planting and forest management is declining agricultural productivity as inputs are diverted from agriculture to fuels in response to woodfuel scarcity. Limited evidence from Ethiopia indicates that improved stoves are more important than planting of trees in increasing the use of dung as manure instead of as fuel. However, the evidence on this is not gender specific, and does not suggest immediate agricultural impacts.

A commonly cited concern is that in places where fuelwood is scarce and dung is used as fuel instead of as manure, agricultural production may be negatively affected. Consequently, community plantations as well as private tree planting are expected to increase application of manure as fertilizer. However, Van't Veld et al. (2006) find that households avoid using dung as fuel at times of the year when it is useful as fertilizer. Cooke et al. 2008 find that the cross-price evidence between fuelwood and dung, and fuelwood and crop residues is mixed as to whether the fuels are substitutes or complements. Mekonnen and Köhlin (2008) specifically study the use of dung as fuel or manure in a panel of more than 1300 households in the Ethiopian highlands in 2000, 2002 and 2005. They find only weak evidence that more trees increase the probability of applying dung as manure. A much stronger effect comes from the use of improved stoves, which significantly increases the probability that dung is used only as manure. Households with more women, on the other hand, are more likely to use the dung as fuel, rather than as manure. As long as dung use as fuel has strong cultural and taste

¹⁵ We will use this evaluation of welfare implications of a Social Forestry project to exemplify more general points. Although the implementation of community plantations was not randomized by design, it was evidently not designed to meet the fuelwood needs of the villages since the utilization ranged from zero to meeting 80% of fuel needs.

¹⁶ 13,670 Indian rupees in 1995. Exchange rate at the time was Rs. 30 per USD. The average value of time saved was USD 135 per hectare community plantation. This was estimated using the time savings, a time based consumer surplus measure and one of two estimates of opportunity cost of time.

connotations, interventions to decrease its use as fuel and increase its use as manure are likely to be inefficient.

Fuelwood scarcity could also affect agriculture through labor and land allocation. The evidence suggests that households avoid reducing agricultural labor input even as they spend more time in fuelwood collection (Cooke, 1998b; Amacher et al., 2004), and often plant trees in such a way as to provide erosion control, thus also providing some benefit to agricultural production (Anderson, 1988; Yin and Hyde, 2000), although Saxena (1994) finds a negative effect of eucalyptus trees planted on the borders of fields on crop production on these fields.

2.2.3 Implications for off-farm income

Given the large amount of time spent by women collecting fuel, there is potentially scope for increasing income by making woodfuels more accessible, but we have been unable to identify studies analyzing this potential, and a recent review of impacts in the water sector does not support this hypothesis.

Increased access to woodfuels has the potential to increase labor allocated to off-farm income generating activities. Economic development implies, in large part, a transition involving more and more of the population entering the labor market and increasing their productivity. Koolwal and van de Valle (2010) cite a number of sources that argue that infrastructure development could play an important role in increasing women's off-farm labor participation and thus improve women's situation by enhancing their control over resources, financial independence, bargaining power within the household, etc. Collection of fuel and water are very time consuming. Koolwal and van de Valle (2010) carry out an ambitious attempt to identify the impact of improved water infrastructure in nine developing countries, controlling for the inherent geographical endogeneity in water infrastructure decisions and labor market participation. The study concludes that there is no evidence that water infrastructure affects women's labor participation. They also point out (p.5) "given that water (unlike fuel) has few alternatives, and that access to water in rural areas is often limited to wells, public standpipes or natural sources, substantial time can be spent collecting water." Greater substitution possibilities among fuels and sources of fuels, would suggest that woodfuel interventions are even less likely to have an impact on off-farm wage participation. This is of course, ultimately, an empirical issue. Koolwal and van de Walle motivate their study with the claim that "there appears to be little rigorous empirical evidence to address these questions." Our review of the literature confirms the lack of empirical evidence.

2.2.4 Implications for education

Resource scarcity can lead to lower school enrolment for girls, if they are more involved than boys in fuelwood and dung collection. Although a negative relationship between natural resource-collection and schooling was found for Malawi and Kenya, it affected girls and boys equally. However, Koolwal and van de Walle (2010) found that investments in water infrastructure led to a statistically significant increase in the share of rural girls enrolled in school in four out of nine countries, which may also apply to energy interventions

Children might be looked upon as an investment in household production (See e.g. Dasgupta 1993: 12.6). The investment could be short-term, for collection of water and fuelwood and agricultural production, or more long-term, through education. When energy is scarce, children, in particular girls, are often involved in collection of leaves, twigs and dung for fuel. This leads to the expectation that projects that increase the availability of biomass would have a positive impact on education, particularly of girls. A negative relationship between participation in natural resource-collection and schooling has been found for Malawi (Nankhuni and Findeis, 2004) and Kenya (Ndiritu and

Nyangena, 2010). Although girls in these cases are not discriminated against in school enrolment, they are more involved in resource collection, and collection depends on resource scarcity. Once again, we have not found many rigorous studies linking plantation projects with schooling. However, the potential for impact seems greater than for off farm income. Koolwal and van de Walle (2010) found that water infrastructure investments led to a statistically significant increase in share of rural girls enrolled in school in four out of nine countries. Not surprisingly, these were the countries where enrollments were low overall, and where the gender gap between girls and boys was particularly pronounced. The same can be expected to hold for improved energy access.

2.3 Discussion and lessons from project implementation

Access to woodfuels is not only an issue of physical and labor scarcities, but also reflects cultural norms and intra-household bargaining strengths. These are some of the factors that interventions aiming to increase woodfuel availability need to consider.

2.3.1 *The potential for community plantation projects*

The need for woodfuel in low-income countries will remain large for the foreseeable future. Past interventions to address such needs have shown mixed results. Empirical findings point to positive but varying impacts of community plantations with large variations in impacts between genders, households, and villages. Careful targeting of interventions is needed if the potential for welfare improvements of women is to be realized.

At least 2.5 billion people depend on traditional biomass fuels (wood, charcoal, agricultural waste, and animal dung). In Sub-Saharan Africa, more than 80% of the population relies on solid fuels for cooking (UNDP and WHO, 2009). Therefore large- (and small-) scale interventions have been made to increase the access of woodfuels for decades. During this period verdicts have been given on what works, and what does not, a number of times. In the era of criticism of the large scale interventions of the 1980s Chambers, Saxena and Shah summarized the situation as follows: *“There exists a vast potential for helping the poor through forest and village lands. The major lesson of experience is that any attempt to realize this potential must start with the priorities not of officials and other professionals. But of the rural people, and especially the poorer, themselves”* (Chambers et al. 1989: 169).

Such a “bottom-up” perspective, and careful targeting of interventions is also supported by our review of welfare implications. The fact that there are so many substitution possibilities on both the supply side (different sources of biomass, varying opportunity cost of labor within the household and over the seasons) and demand side (different kinds of stoves, fuels, food-stuffs) was one of the reasons that led to the conclusion *“in the late 1980s that there is not a 'fuelwood crisis' of such a magnitude and with such potentially dire consequences, as to often require major interventions devoted just to provision of fuelwood.”* (Arnold et al., 2006). But Arnold et al. (2006) also conclude that *“[t]he decline in attention to fuelwood as a co-product of farm and agro forestry systems that occurred as a result of the arguments that prevailed in the 1980s now seems in need of review.”*

The substitution possibilities necessitate careful targeting to geographic areas and groups that are particularly constrained. Let us again exemplify this by the Social Forestry project in Orissa in India. In the 1980s the various Indian states were divided between donors for implementation of large scale Social Forestry programs. Sida chose to support Tamil Nadu, Bihar and Orissa with an annual budget in the order of 20 million USD in order to increase supply of various wood products (including fuelwood) and decrease the pressure on the natural forest. By 1995, Social Forestry was declared a “dead concept” based on the common knowledge, at the time, that fuelwood was not a high priority.

A closer analysis was then made of the community plantation component of the Orissa Social Forestry Project using a random sample of villages (with and without plantations) around a natural forest. In brief, the findings of this closer look revealed that (i) while the original intention had been to use the eucalyptus trees as fuelwood, they were instead sold as poles and for pulp which had a much higher market value. The demand for fuel was instead to a large extent met by leaves that were swept regularly and constituted from zero to 80% of fuel consumption in villages with plantations; (ii) the increased accessibility of leaves from the plantations led to higher energy consumption, but also, as reported above, significant time savings, particularly for women. Across communities, the value of this time saving ranged from zero to 455 USD per ha and year (Köhlin and Amacher, 2005); (iii) access to readily available plantations decreased the collection pressure on natural forests, but this impact also ranged from zero to 1.5 tons per household and year, particularly depending on the distance to the natural forest (Köhlin and Parks, 2001); (iv) the willingness to pay for a new plantation, revealed in a contingent valuation study¹⁷, indicated benefit-cost ratios ranging from 0.2 to 4.3, once again stressing the wide variation in the value of plantations for villages not very far from each other (Köhlin, 2001). These results point to the great variation in welfare impact of plantations – and that there is variation both between households and between villages. There is thus great potential for interventions that increase access to woodfuels, but in order to realize this potential, particularly for women, careful design and targeting is needed taking local conditions into account (Mearns, 1995).

There is no generally agreed upon design and targeting mechanisms for realizing the potential of these interventions. However, the literature review offers some pointers. Various measures of energy scarcity (e.g. time spent collecting fuelwood) can be applied. It is important that the resource is made available to households that are labor constrained for some reason. There might also be great variations in access to land for fuel collection (e.g. due to landlessness, tenure reform, imposed forest management, biofuel plantations, carbon sequestration or conservation).

2.3.2 The potential for policies to induce private tree plantation

Woodfuels are increasingly coming from private land. Policy reforms, such as increased security in private tenure and reduced access to state-owned forests, are important in further inducing private tree planting, but their gender implications need to be carefully considered.

Institutional changes and interventions have also affected private incentives. One of the key findings of the literature debunking the fuelwood crisis was that woodfuels were often not collected from forests but rather from what came to be called “trees outside forests.” While this included open access and commons, there were also reports of up to 70% coming from private land (Bhattarai, 2001). In a Nepali sample 86% collected fuelwood from private sources (Webb and Dhakal, 2011). This trend has been accentuated through the reduced access that comes with devolution of forest management as has been found in India (Van’t Veld et al, 2006), Bolivia (Bluffstone et al., 2008) and Ethiopia (Mekonnen and Bluffstone, 2008). Heltberg et al. (2000) also show that private fuel consumption is affected by availability (scarcity) and management institutions.

Although trees often have multiple uses, a received wisdom from the 1980s was that trees were seldom planted on private land for fuelwood purposes. There are indications that this situation is changing with increased demand for, and reduced access to, woodfuels. Arnold et al. (2006) report on evidence, primarily from East Africa, that tree management by farmers is on the rise resulting in increasing reliance on private fuelwood supplies. In a survey in the Ethiopian highlands, 72% of trees were planted primarily (37%) or partly (35%) to produce fuelwood. In a more recent survey from Ethiopia on the use of trees and forest (EEPFE, 2008), 50% of a sample of 600 households said that they

¹⁷ Households with fewer men and with more women had greater WTP for a new plantation, indicating that more accessible fuelwood sources are especially important when less male labor is available.

got their fuelwood from their own property. Fuelwood was also the most important (19%) or second most important (24%) purpose of planting the most dominant tree.

In an agricultural household survey carried out in Tanzania in 2002-2003 with more than 9000 households, 48% answered that timber/planks were the main use of trees planted on their own land, but this was followed by fuelwood with 22% reporting it as the main use (United Republic of Tanzania, 2003). Similarly, in a smaller household survey (1000 households from 50 villages) 18% ranked fuelwood as the most important benefit coming from trees planted on their own land, 31% as the second most important and 10% as the third most important (Lokina et al, 2011)¹⁸.

Planting of trees can also be affected by tenure reforms. Deininger and Jin (2006) and Mekonnen (2009) report that trees are planted to increase tenure security. Both Deininger and Jin (2006) and Ayalew et al. (2011) find for the case of Ethiopia that insecure tenure decreases plantation. Shively (1998) shows how investments in trees can be sensitive to both price fluctuations and risk preferences with an application to the Philippines. Policies that both increase woodfuel prices (such as reduced open access for charcoal production) and reduce tenure insecurity can therefore be important for increasing the supply of woodfuels from private sources. In doing so, past experience, and the studies cited above, point to the importance of considering the multiple uses of trees, where fuel is only one, and seldom the most important.

A key question is how such reforms affect women's right and access to trees. For example, Chambers and Leach (1989) show the important role of planted trees in meeting contingencies, which benefit women mostly if they have rights to those trees. Reforms can be designed to improve the rights of women to land (Place, 2009). However, Mearns (1995) points out that in some areas in Western Kenya, such as Kakamega, women are seriously constrained both from planting and utilizing planted trees. In a related study by Ngugi (1988), Kakamega district is compared with Murang'a, where women were found to participate more freely and frequently in both tree planting and cutting. Access to woodfuels is thus clearly not only an issue of physical and labor scarcities, but also reflects cultural norms and intra-household bargaining strengths. And the case of Murang'a shows that such norms can change (Ngugi, 1988). Rocheleau and Edmunds (1997) highlight the gendered domains in tree tenure and emphasize that these not only can change but are negotiable. This negotiability of tenure rights provides policy makers, and project interventions, with a lever to promote more equitable distribution of rights and resources. Meinzen-Dick et al (1997) also encourage such a gender perspective in tenure policy analysis and design but caution that it needs to be based not only on an understanding of physical and socio-economic characteristics of the resource use but also the bargaining power of men and women of different classes. They also stress that projects need to ensure that there is appropriate infrastructure for women to exercise their rights.

2.3.3 Lessons from charcoal and forest management projects

Devolution of forest management to communities has become a major global trend. In West Africa, for example, such programs have been implemented to secure a sustainable source of fuelwood and charcoal. But local forest management has in some cases decreased access to woodfuels and marginalized women from access and control of forest resources. As with any resource of value, there is a risk of institutional capture in the devolution of forest resources. It is therefore a challenge for interventions to secure local participation while not marginalizing women and potentially worsening their situation. The goal should be to move women beyond token participation to real influence. Quotas for women's representation in management institutions are an option to consider, for example via a threshold requiring one-third of positions of voting power

¹⁸ This is one example of papers now being drafted to analyze the implications of forest management on private tree plantation.

be held by women. However, real sustainable change would require a combination of more profound improvements in democratic institutions and empowerment of women to enable them to represent themselves in these institutions.

Although fuelwood is still the dominant source of domestic fuel in Africa, the use of charcoal is increasing rapidly particularly in urban areas (Arnold et al. 2006) and specifically in Tanzania (World Bank 2009; World Bank 2010c). The increasing consumption and perceived and verified implications on forest degradation (Wurster 2010; Ahrends et al. 2010) have led to an increased focus in interventions on charcoal production, marketing and use (World Bank 2009). In the case of Tanzania proposed interventions in production and marketing include increased local taxes and fees, education of producers regarding their rights and responsibilities, community based and participatory forest management, as well as dissemination of improved kilns. Positive impacts on women are expected primarily from interventions regarding use, including promotion of improved stoves and alternative energy sources such as LPG and biomass briquettes (World Bank 2010c).

A major challenge with charcoal is that the lower transportation cost (relative to fuelwood) makes illegal harvesting and production of charcoal profitable far away from the market, including across national borders. Improved protection of forest land, for example through forest tenure reform, is therefore an essential component of a more sustainable supply (World Bank, 2009). Community-Based Woodfuel Resources Management projects have therefore covered large areas and affected many people in Senegal, Mali, Niger, Benin and Burkina Faso. According to World Bank (2010a) village forest management plans were effectively implemented in 200 villages in Mali, covering 320,000 ha of forest land. The first phase in Senegal covered 317 villages and 378,000 ha for sustainable charcoal production. It is important to remember that the design of these projects go beyond their energy objective. For example, *"the developmental objectives of "Sustainable and Participatory Energy Management Project (PROGEDE)" were to meet an important part of the rapidly growing urban demand for household fuels, without the further loss of forest cover and the ecosystem's carbon sequestration potential and biodiversity, and to generate opportunities for employment and income generation in the participating communities"* (World Bank 2005).

In its Implementation Completion Report (World Bank 2005) the PROGEDE was rated highly satisfactory. It more than achieved its energy outcomes in terms of sustainability of woodfuel supply, end-use efficiency and fuel switching. It also led to significant and quantifiable positive outcomes in terms of poverty alleviation (rural community empowerment and social change, generation of rural employment and incomes, creation of new economic activities, etc.), environmental sustainability (promotion of sustainable forest and natural resource management principles and practices, ecosystem conservation, deforestation reduction, CO₂ abatement, reduction of forest fires, biodiversity conservation, etc.) and institutional development. Given the positive reviews, and strong public and government support, a second phase was approved in 2010. It gave further focus on eco-friendly income generating activities associated with community forest management the project design included a gender assessment.

Despite such high ratings in the review, academics question the benefits accruing to local people from the PROGEDE project (see e.g. Post and Snel, 2003). Similar controversy surrounds the gender impact. According to the completion report *"PROGEDE recognized and promoted the role of women within the village structures, and provided substantive capacity development and revitalized all women's groups and associations. PROGEDE's gender activities in fact resulted in some of the project's most important social development impacts."*(World Bank 2005) This is in stark contrast to the findings made by Bandiakya (2008:67) of the same project: *"Generally, the women that one finds in the village committees hold positions that are secondary or marginal in importance. They tend to be leaders of women's associations confined to work*

*in the sub-committees rather than the more powerful decision-making board. Furthermore, the positions that women occupy on the committees are frequently only on paper. Personal interviews with female committee members suggest that women are often unaware of their supposed memberships on village committees. These fictional positions are often created to satisfy donor requirements with respect to gender equality, and do little to substantively improve women's involvement in key decision-making processes at local level." But according to Bandiaky the project led to even more active interventions in local political life (2008:71): "government and donor interventions provided alternative sources of power and authority to those deprived of legitimacy in the context of electoral politics. Resources that came with such authority as presidency of the newly created reserve and chairmanships of various committees by far surpassed those of newly elected, but effectively powerless with regard to conservation, rural councils. The new resources were used to channel patronage and punish political opponents. Not only did these dynamics fail to rectify extant inequalities between and among women, but they served to deepen them generating resistance among women."*¹⁹

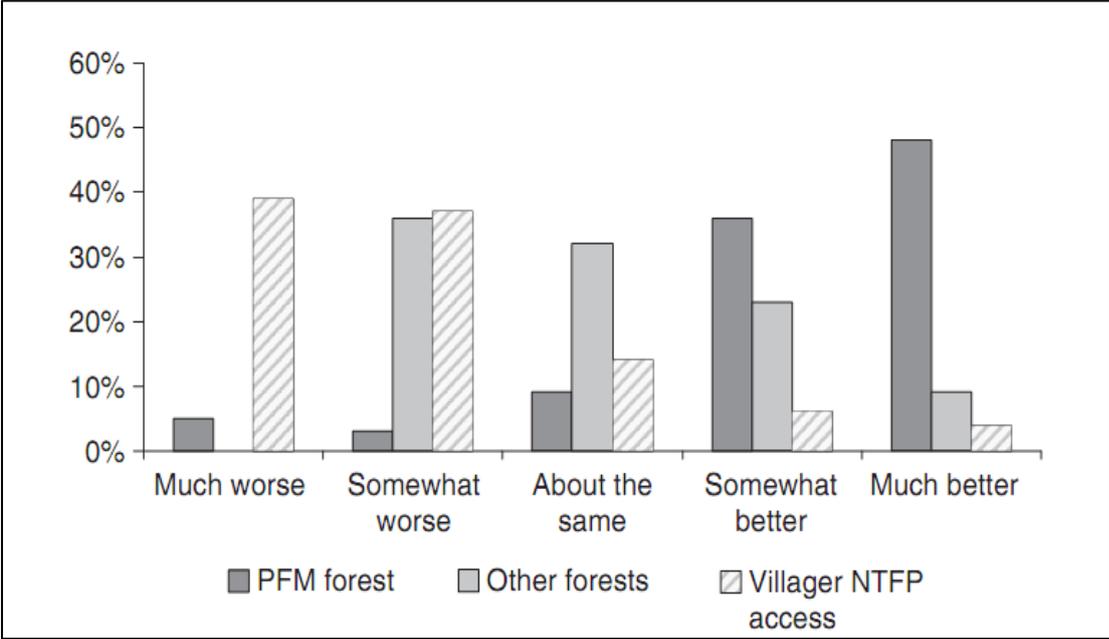
One might argue that Bandiaky is referring to a special case of 10 villages in only one, albeit important, project. Unfortunately, there is a wider body of literature that points out that devolution of forest management does not necessarily lead to effective involvement of women and increased access to woodfuels.²⁰ Increased fuelwood availability is far from the only rationale for devolution of forest management to local institutions. In many countries, state-controlled natural forests turned into *de facto* open access resulting in general mismanagement and over-utilization, including for woodfuels. Such forests have substantial potential as sources of timber, pulpwood and other commercial products. There is thus an obvious risk that improved management practices, particularly of natural forests, may decrease the availability of fuelwood as the management is likely to target higher value products. This would affect all those who previously used the forest for fuelwood collection, but especially those who are also marginalized from forest management. Cooke et al. (2008) review the effect of community forest management on household fuelwood collection and find a pattern of decreasing collection in the managed areas, displacement of collection to other areas and increased collection from private sources. The trade-off between the quality of the managed forest and the availability of NTFP's (primarily fuelwood) is evident from the perceptions expressed in a sample of people involved in Participatory Forest Management (PFM) in Tanzania (see Figure 3). Almost 90% of respondents perceive the forest under PFM to be somewhat better or much better quality while almost 80% perceive the availability of NTFP's (to a large extent fuelwood) to have become somewhat or much worse (Robinson and Lokina 2011). The pattern is clear: participatory forest management can decrease fuelwood access, at least initially.²¹

¹⁹ See also the film "The plucking of local democracy in Senegal" (Ribot 2007) which gives a fictionalized account of the gendered political economy of these forest interventions, focusing particularly on the misuse of quotas for forest exploitation.

²⁰ There is also a smaller body of evidence such as Van't Veld et al. (2006) and Bandyopadhyay and Shyamsundar (2004) that indicate that JFM can increase access to woodfuels.

²¹ One can expect changes in access over time. When forest management leads to increased quality of the forest, access can once again increase. A reviewer points out that communities targeted by the PROGEDE project in Senegal experienced increased fuelwood access.

Figure 3: Villagers’ perceptions of impact of PFM on the PFM forest, other forests, and NTFP access.



Source: Robinson and Lokina, 2011.

A more in-depth analysis of the forest sector reform in Uganda shows that decentralization to local governance had minimal impact on the contribution of forests to household income portfolios (Jagger, 2009). Similarly, Chhatre and Agrawal (2009) find that community management (as compared to government ownership) lead to reduced livelihood contributions in an analysis of 80 forest commons in 10 tropical countries. In a related article (Chhatre and Agrawal, 2008) using the same IFRI data, they show that not only is local enforcement important in reducing the proportion of fuelwood for household consumption, but this more strict enforcement also significantly reduces the probability of degradation and increases the probability of regeneration of the forest. However, access is related to user group composition. In a sub-sample of the IFRI data, covering 290 user groups in Kenya, Uganda, Mexico, and Bolivia, Sun et al (2011) analyze the correlation between gender composition of the user groups and rights to harvest. They find that female-dominated user groups both are more likely to have the rights to harvest trees and bushes and meet a significantly higher proportion of their fuelwood needs (84% compared to 59% for male-dominated groups).²² Interestingly enough, while the rights of groups with balanced participation were similar to those of female-dominated groups, the actual fuelwood needs met were similar to those in male-dominated groups. Sun et al concludes that “decentralization tends to significantly expand user groups’ rights to bushes but actual fuelwood harvests have fallen with decentralization. Thus while decentralization strengthens users’ rights, users themselves appear to have adopted stricter access rules. Over time, users’ property rights to trees have decreased, and actual fuelwood harvest have increased.”

As with any resource of value, there is a risk of institutional capture by those with more power. Several studies, all from India and Nepal, have found that there is a bias in the design of community forestry groups, whereby most benefits accrue to richer households and to men, and that less benefit, or more cost, accrues to poorer households and women (Agarwal, 1997; Sarin, 1998; Agarwal, 2001; Kumar, 2002; Adhikari, 2005).

²² The proportion of female members in the user group is also positive and statistically significant at the 1% level in a multi-variate analysis of harvested amounts from the forests. The analysis also shows a significant negative effect of decentralization on harvesting.

Agarwal and Adhikari both argue that the lack of participation by women in decision-making by the forestry group contributes to this bias. Cornwall (2003) suggests that women will not gain real influence through simple placement in various committees, but rather, empowerment depends on how and whether those women raise their voices and, when they do, whether there is a discernable effect on policy. The relationship between the representation of women and their participation is empirically investigated by Agarwal (2010) for 135 community forestry institutions in India and Nepal. She finds that women's proportional strength in the executive committee is consistently important – it increases the likelihood of women attending executive committee meetings, speaking up at them, and being office bearers. The study lends support to a threshold of at least 25-33% representation by women to have a positive effect. Furthermore, leadership training increases the chance of women becoming office bearers. A particularly interesting finding is that where women experience fuelwood shortages and conflicts with guards, they are also more likely to attend and speak up at meetings. There is therefore a case for complementary thresholds, training, and priority to landless and disadvantaged women.

However, it is important to maintain mixed management groups with both men and women. Sun et al (2011) and Mwangi et al (2011) give both empirical and experimental evidence that mixed groups are more efficient than all-female groups for forest management, partly because all-female groups have a tendency to be marginalized. The positive effects of women's participation can go far beyond implications for energy supply and have positive effects on forest regeneration, incidence of illegal harvesting, and the capacity to manage and resolve conflicts (Sun et al 2011).

To conclude, there is a serious challenge for interventions to secure local participation while not marginalizing women and potentially worsening their situation. The goal should be to move women beyond token participation to real influence. Quotas for women's representation in management institutions are an option to consider, for example via a threshold requiring one-third of positions of voting power be held by women. However, real sustainable change would require a combination of more profound improvements in democratic institutions and empowerment of women to enable them to represent themselves in these institutions.

3 Access to Improved Cooking Technologies

3.1 Describing the interventions

Improved cookstoves have the potential to reduce indoor air pollution, improve the health of women and children, and cut time spent collecting fuelwood. However, penetration remains very low everywhere except in China, and few studies exist that identify the barriers to greater uptake.

The definition of an improved stove depends on: (i) type of traditional stove, (ii) aim of the design improvement, and (iii) affordability. Here we draw on a summary provided by a recent World Bank (2011) report. “Traditional cookstoves can range from three-stone open fires to substantial brick-and-mortar models and ones with chimneys. An improved stove can be designed to improve energy efficiency, remove smoke from the indoor living space, or lessen the drudgery of cooking duties. In the early stages of most improved stove programs, many models were designed so that even the poorest customers could afford them. Valued at about US\$5 or less, these cookstoves represented an improvement over a three-stone open fire; nonetheless, they were rudimentary devices. Today there is growing sentiment to support a wider variety of more refined cookstoves, which are sometimes more expensive. Given the many cookstoves used by rural and urban populations in developing countries, improvements can differ markedly by country or region. Thus, “improved cookstove” is an umbrella term encompassing an array of diverse cookstoves. Only China has a high percentage of households that have adopted better cookstoves, at about 40 percent, while adoption in the other regions generally has ranged between 5 and 10 percent.” Socio-cultural barriers prevent many women from accessing and using improved stoves and clean fuels. Thus, any evaluation of the impacts of such access and use must account for these barriers – either through some feature of the quasi-experimental design or by including proxies (e.g., relative power and or education of woman), of these barriers in multivariate regressions.

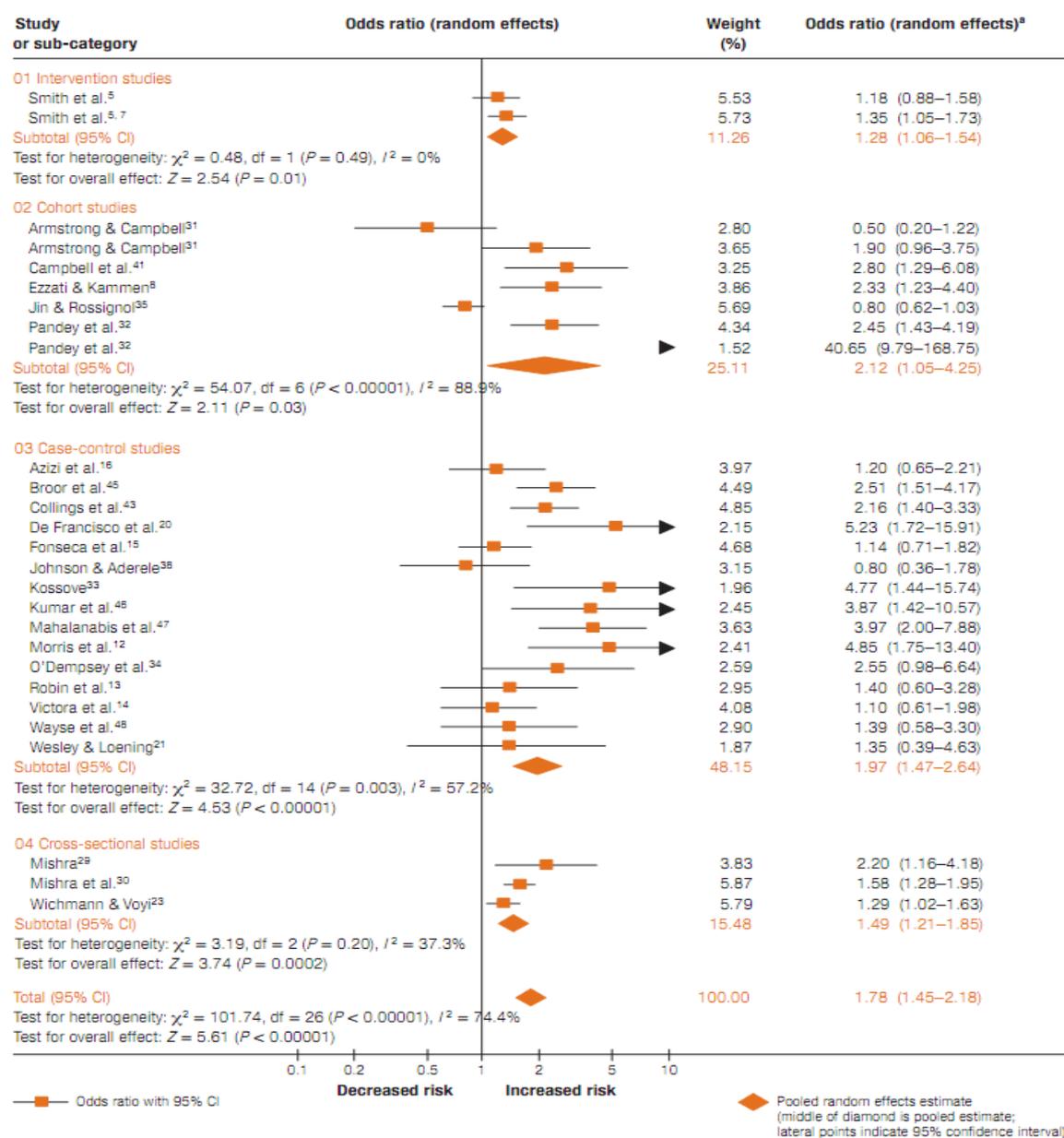
How might these technologies and associated choices differentially impact women? The most plausible impacts are on the health of women and children, largely from reduced indoor air pollution, and time savings in fuelwood collection. Cooking with biomass results in indoor-air pollution (IAP) that causes a variety of respiratory illnesses such as chronic obstructive pulmonary disease (COPD), asthma, bronchitis, and pneumonia (Bruce et al., 2006). Because cooking and fuelwood collection are time intensive activities, technological efficiencies could generate savings in time spent cooking and collecting fuelwood that would, presumably, mainly benefit women. As discussed in Section 1.2.2, one would assume that a technology that relaxes women’s time constraint will release time that will be gainfully employed in other welfare enhancing behaviors such as income generation, education (especially for school-aged girls) and leisure. This in turn could empower women within households and communities. However, even if these gains are realized, there may be no gender differentiated gains for women relative to men. For example, most households who use biomass for cooking typically live in 1 or 2 room houses. Thus, even if the woman cook bears the brunt of the IAP exposure, men in the same houses are exposed to a high level of IAP because they are often inside the same confined unventilated home during the peak cooking hours in the early mornings and evenings.

3.2 Welfare implications

The literature on the health impacts of household energy interventions is reasonably robust, best highlighted by a recent meta-analysis of 25 studies (Dherani et al., 2008), which shows that cooking with biomass (compared to cooking with clean fuels or improved stoves) increases the risk of pneumonia by 80%.

There are three problems with the otherwise careful and comprehensive literature review by Dherani et al. (2008, see also Table 3). First, in the interest of being inclusive, the authors include several studies that would not satisfy our criteria, for example, they include a large number of case-control studies that do not fully eliminate rival hypotheses. Second, the studies do not differentiate impacts for women and men. Finally, the meta-analysis focuses on pneumonia only. Except for an older review by Bruce et al. (2000), there is no similar recent assessment of other respiratory diseases such as COPD, asthma, bronchitis.

Table 3: Pneumonia impacts (odd-ratios) of biomass cooking compared to improved cookstoves and cleaner fuels.



(Forest plot for all studies included in meta-analysis: comparison of higher versus lower exposure)

Source: Dherani et al. 2008.

An ongoing literature assessment by Lewis and Pattanayak (2011) has begun to address this gap by identifying studies that explicitly measure and estimate gender differentiated impacts of biomass burning. A preliminary assessment suggests that the impact of household cooking technology on

women relative to men is ambiguous. Some studies show women gain relative to men (e.g., Dossing et al.; Ezzati et al., 2000; Mishra et al., 1999; Pandey et al., 1984; Xu et al., 2007), others suggest men gain relative to women (e.g., Cetinkaya et al., 2000; Chapman et al., 2005; Liu et al., 2007; Menezes et al., 1994), and yet others show no differences (e.g., Albalak et al., 1999). Thus, the overall finding is ambiguous in terms of the gender differentiated health impacts of cooking interventions. Although all of these are public health studies attempting rigorous causal inference, they do not satisfy all the methodological requirements summarized in section 1.3. For example, many report separate estimates of impacts of stoves on women's health and on men's health, but do not test for statistical difference between the two estimates. Better designed studies may find clear differentiation of impacts, but the currently available literature does not necessarily eliminate all potential confounders.

Further, too few studies go the extra distance of measuring intermediate outcomes along the causal chain such as exposure to IAP from biomass fuel based cooking (see for example, Zhou et al. 2006). Two of studies that do measure exposure - Ezzati and Kammen (2002) and Balakrishnan et al. (2002) - also report exposures by gender. In their cross-sectional evaluation of 530 adults in India burning biomass fuels or improved fuels (LPG, biogas, kerosene), Balakrishnan et al. (2002) find that women cooks are exposed to statistically significantly higher exposure to respirable particulate matter compared to non-cook men. Ezzati et al. (2000a, 2000b) find a similar result in a sample of 345 adults from rural Kenya.

Now consider the non-health impacts of cooking technologies, where we expect to find a shallower and patchier literature because our earlier observation that applied work in resource and environmental policy analysis has typically used a lower standard of evidence compared to the biomedical and public health fields (Ferraro & Pattanayak, 2006; Frondel and Schmidt, 2006; Pattanayak, 2009). We start with perhaps the most plausible impact - time allocation of women, for example, impact on cooking and fuelwood collection time as compared to impacts on men's efforts in these activities. We were not able to find studies that have examined differential savings in time by women compared to men. For example, Pattanayak et al. (2004) show that households that own stoves are likely to spend less time collecting fuelwood from a forested park in rural Indonesia, but do not break out the impact by gender. Chen et al. (2006) find no impact on time spent collecting fuelwood in China, but also do not separate results by gender. In contrast, Ezzati and Kammen (2002) report time activity budgets by gender and age, but not by gender by stove type, even though the same data set has been used to examine the exposure to IAP by gender and by stove (Ezzati et al., 2000a, 2000b). In general, many studies report time activity budgets by gender (Bardasi & Wodon, 2006; Charmes, 2006) or by stove ownership (Barnes & Sen, 2004), but almost never a cross-tab of the two. While this type of cross-tab would not eliminate rival hypotheses, it would provide a helpful foundation. Perhaps the fact that women will save more time compared to men is considered obvious and not subject to any of the usual biases - nevertheless, it would be helpful to back-up the "obvious" with numbers. Furthermore, differences in how men's and women's time is valued could lead to further differences in welfare impact. Unfortunately, we are not aware of studies that do a careful job of time accounting and valuation differentiated by stove/fuel type and gender.

Given the narrowness of the time allocation literature, we look at studies on the amount of fuelwood collected, relying on the assumption that the time spent collecting fuelwood and cooking is correlated with the quantity of fuelwood collected (Chen et al., 2006; Edmonds, 2002; Edwards & Lagnap, 2005; Nepal et al., 2011; Pant et al., 2010). The evidence from the small empirical literature on the quantity of fuelwood collected is, however only suggestive of the effectiveness of energy interventions in reducing fuelwood collection for the following reasons. First, except for Nepal et al. (2011), these studies do not directly model fuelwood use/collection as a function of household energy *per se*; instead, they focus on the link between fuelwood use and resource policies (e.g., community forest

management, protected areas) and control for household energy (e.g., dummy variable for stove) as an incidental potentially nuisance covariate. Nevertheless, the negative and statistically significant sign on the coefficient for this variable suggests that improved household technologies are negatively correlated with fuelwood use. Second, none of these papers model the amount of fuelwood collected by women per se; instead they look at the total collected. So we would have to assume that the proportion of time or proportion of fuelwood collected by women does not change with the cooking technology. Given this assumption, stove use will reduce time spent collecting and cooking with fuelwood in the same proportion, but different absolute amounts, for women and men. Short of making such assumptions, we cannot rule out alternative hypotheses and claim that use of stove or an alternative fuel (e.g., kerosene) causes a greater reduction of fuelwood collection by women relative to men.

Given the thinness of the previous literature, we also cast the net wider to consider any empirical evaluations that may have adopted a direct (“reduced form”) strategy of examining final outcomes such as livelihood strategies, income earned, educational endpoints and empowerment. Of course, now the causal chain is even longer, and muddied by many other moderating factors that could influence the impact. Therefore, it should come as no surprise that we could not find any quasi-rigorous evaluations that show indirect or direct benefits of cooking interventions on livelihood activities, girl’s education, women’s empowerment, etc.

3.3 Lessons from project implementation

As mentioned earlier, none of the major cookstove initiatives (for example in Guatemala, Tanzania, Thailand, India, or GTZ’s HERA project) have been evaluated using the standards described in this report, but at several recent attempts by the Bank to assess household energy, access and gender issues offer directions for the Bank in this area. These directions seek to avoid direct consumption subsidies and instead promote uptake and supply.

Various recent Bank thinking (contained, inter alia, in World Bank, 2011 and 2010a) suggest the importance of the following

- Combining supply-side, demand-side, and institutional capacity building to promote, regulate, monitor & evaluate (M&E) and finance (e.g., carbon financing) at national, regional and local scales
- Promoting demand by assessing consumer needs, generating public awareness and offering micro finance, but not direct subsidies
- Involving local CBOs and NGOs in partnerships with private (e.g., stove manufacturers) and public (e.g., governments and donors) sectors and women in policy making (“dialogues and operations”)
- Developing infrastructure to design and test stoves to satisfy performance standards on safety, energy efficiency and durability
- Seizing the momentum and global spotlight on clean household energy and its gender dimensions
- Producing strategic upstream analytical work to inform dialogue and supporting technical assistance
- Mainstreaming household energy access interventions in lending operations

Unfortunately the academic one-off studies provide at most one or two sample points in support of some of these lessons (e.g., lack of consumer knowledge of the scope and magnitude of IAP). So in the spirit of ‘evidence-based-practice’ how much faith should we put in the lessons learned above?

China's National Improved Stove Program is perhaps the major government-donor intervention that has been examined with the greatest degree of rigor. However, the political economy, as well as the administrative, geographic and technological capacity, of China has not and cannot be replicated and sustained by most other poor countries that need cooking interventions.

4 Access to Electricity and Motive Power

4.1 Intended outcomes and impact pathways

The literature on gender and energy suggests that providing electricity to communities and homes and motive power for tasks that are typically considered women's work can promote gender equality, women's empowerment, and women's and girls' access to education, health care, and employment. There is an ample case study literature documenting how many of these benefits accrue to women in communities that receive electricity or motive power. However, there are also numerous cautionary tales about the difficulties of sustaining and scaling up interventions, and the need for complementary investments in order for women to fully realize the potential benefits of electricity.

4.1.1 Interventions

Most gender benefits of providing electricity and motive power accrue because women tend to spend more time at home, are responsible for household chores that can be carried out more productively with electricity, and because certain tasks that are culturally defined as women's work can benefit from motive power.

In this section, we consider evidence on gender-differentiated impacts of improved access to electricity and motive power.²³ Interventions include expanding the electricity grid, building community infrastructure (e.g., micro-grids, grain mills), or subsidizing household/farm systems (e.g., solar lighting systems, water pumps). Rural electrification is a large component of this portfolio, with 120 projects funded by the World Bank from 1980 to 2007, according to IEG (2008). Because electricity is typically not used for cooking or heating in most developing countries, the gender dimensions of interventions to increase access to electricity or motive power are less clear as in the previous two sections, which focused on woodfuel collection and cooking technologies, both largely the domain of women. However, providing electricity to homes is often considered to favor women because they spend more time at home and are responsible for more household chores (cooking, acquiring water, laundry, childcare, etc.). And motive power systems can be tailored to help with post-harvest operations that are culturally defined as women's work in particular settings (Gordon 2000). Electricity at the community level also can have gender differentiated impacts, e.g. if it has a greater marginal impact on the mobility of women and girls by alleviating safety concerns or if it generates relatively more employment in sectors open to women.

There are also potential gender differentiated impacts on the production side of energy, e.g., in employment by the electricity utility, and biofuel production. Several well-known projects have explicitly sought to engage women on the production side, e.g. in marketing of lights and appliances in Bangladesh (Mondal et al. 2010), and in managing engines that run mills or grinders in West Africa (Nygaard 2010). A recent review of gender issues in World Bank infrastructure projects notes that a "rural energy project in Yemen is investing in social mobilization and training activities to build women's capacities to participate fully and become decision makers in new local cooperatives that are being set up to manage the new schemes and collect user fees" (World Bank 2010a). Involving women is often hypothesized to have benefits for project management, resulting in less corruption, greater efficiency, or longer-term sustainability (see next section). Nonetheless, gender targeted activities remain somewhat rare in energy projects funded by the World Bank. For example, according to World Bank (2010a), from 1995 to 2009, the World Bank funded 371 projects in the energy and mining

²³ Motive power is any source of mechanical energy, that is, any means of supplying power to an engine, vehicle, or machinery, such as a grinding or milling apparatus or a water pump.

sector, but only 30 of those included targeted gender activities explicitly designed to reduce gender inequalities in project benefits or to empower women directly to better their lives.

4.1.2 *Desired outcomes*

Rural electrification projects often seek to promote gender goals through benefits such as lighting, television, and appliances powered by electricity thereby extending the working day, facilitating access to information, improving the safety and quality of light, increasing the productivity of time in reproductive chores, and expanding income-generating opportunities.

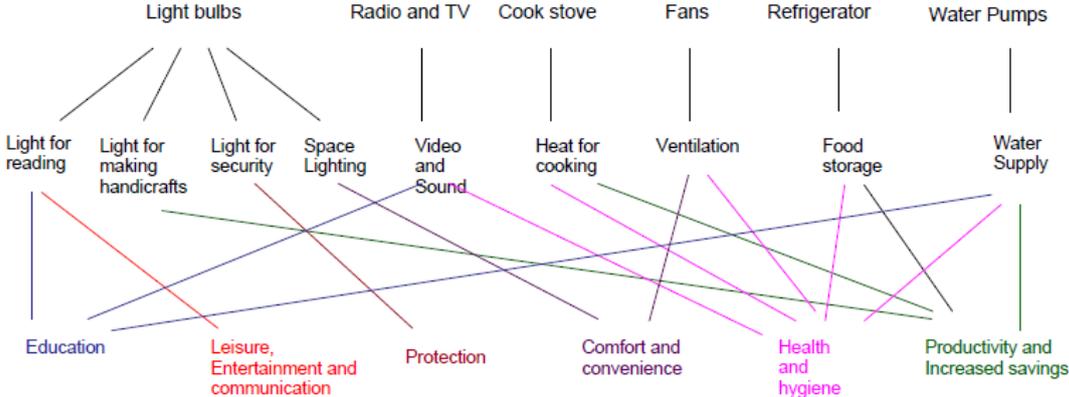
The motivation for seeking to engage women, and indeed a commonly stated motivation for many rural electrification projects, is to “promote gender equality and empower women,” the third of the Millennium Development Goals (MDG).²⁴ Reference is also sometimes made to MDG targets such as “achieve full and productive employment and decent work for all, including women and young people” (under the goal of eradicating extreme poverty and hunger), “ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling” (under the goal of universal primary education), and “achieve universal access to health” and reduce maternal mortality and the under-five mortality (under the goals of improving maternal health and reducing child mortality). This framing of the goals is meant to capture a long list of electricity’s potential benefits to women, which have historically been under-valued by governments and the international development community, because they are not related to “productive activities” that directly generate income (Cabraal et al. 2005). For example, Bernard (2010) traces how motivations for rural electrification programs have evolved over the years, following changes in development paradigms, and describes widespread disenchantment with rural electrification programs in the 1980s because of “the rare productive use of the electricity provided,” with “electrical consumption ... mostly related to house illumination and radios and televisions.”

Illumination, television, and appliances powered by electricity provide direct benefits by extending the working day, facilitating access to information, improving the safety and quality of light (as compared to kerosene lamps or candles), increasing the productivity of time allocated to “domestic” or “reproductive” chores, and expanding possibilities for income-generating activities at home (see figure excerpted from ADB 2010). In turn, these direct impacts may lead to changes in women’s (and girls’) time allocation, including more time allocated to income-earning activities and studying. Simultaneously, greater access to mass media can influence knowledge about health, beliefs and attitudes about gender roles, and awareness of the rights of women. These changes in time allocation, knowledge, beliefs, and attitudes - along with the additional community-level benefits of electricity in health posts, schools, and other public spaces - are expected to provide indirect benefits such as improving women’s health and girl’s educational attainment. There could also be further effects on fertility (e.g., due to the influence of television, or shorter nights)²⁵ and investments in home improvements that do not directly use electricity, such as improved cookstoves (e.g., because of complementarities with lighting, or the general modernizing influence of electricity). Below, we group impacts on fertility and cookstoves with health impacts. While they have received less attention in quantitative impact assessments, negative effects of electricity on women are also sometimes posited, such as longer work days with less leisure time for women, which may maximize overall household utility but be detrimental to women in the household.

²⁴ As noted by Cabraal et al. (2005), the expected benefits of electrification projects could equally well be framed in terms of Sen’s “freedoms, e.g., political freedom, opportunities to receive basic education, opportunities to receive health care, and freedom to participate in the labor market.”

²⁵ Reducing fertility per se can be a controversial goal, but better family planning is an objective of World Bank interventions in the health sector (IEG 2009). Reduced fertility may be taken as a readily observable proxy for improved access to family planning.

Figure 4: Electricity Use in Rural Households



Notes:
 Light is also used for reading entertainment magazines and newspapers (Valencia, 1990)
 Light for security provides protection.
 Light for making handicrafts increases productivity, especially among women (Barnes, 1988).
 Space lighting adds to productivity, since some activities could be done in the evening, thus extending working hours (Barnes, 1988)
 Video and audio provide access to information that leads to nonformal education.
 Video and audio also build up knowledge about health and hygiene, especially among women.
 The use of electric stoves for cooking substitutes the use of fuelwood, thus improving indoor air quality
 The use of electric stoves also speeds up food preparation, thus extending working hours (Barnes, 1988)
 Food preservation reduces time in food preparation, thus extending working hours (Barnes, 1988)
 Water supply enhances health and hygiene, and decreases time for water collection especially among children and women, resulting in better education (i.e., lower absenteeism, longer study time) and productivity.

Source: ADB, 2010.

4.1.3 Impact pathways

In general, lighting and TV are the first common uses of electricity, accounting for at least 80% of rural electricity consumption, and therefore also present the most likely impact channels. Electricity displaces more expensive candles and kerosene lamps, thereby reducing indoor air pollution and fire and burn risk, and providing higher quality light. Lighting and television help improve access to information, the ability to study, and extend the effective working day. Lighting also improves the productivity of many household activities.

The impact of home electrification on the women who live in that home depends on (i) how much, how long, and how reliable is the electricity supply; (ii) where lighting is installed; and (iii) what appliances are purchased. There is ample discussion of these inter-related issues in the literature, with many authors noting that when electricity is limited (either by supply or affordability), household decision-makers - and in particular male heads of household - may opt to light social areas and buy televisions before installing lighting and appliances that facilitate household chores such as cooking. As described in the previous section, electricity is rarely employed as thermal energy for cooking; households are far more likely to replace solid fuels with gaseous fuels such as LPG, natural gas, and biogas. WHO/UNDP estimate that only 6% of the urban population in developing countries relies on electricity to cook and only 2% of the rural population uses electricity to cook. ESMAP (2004) further notes that even appliances like grinders, which could save women significant time and labor in cooking, are rarely purchased, with some exceptions such as electric rice cookers in East Asia (IEG 2008). In general, lighting and TV are the first and most common uses of electricity, accounting for at least 80% of rural electricity consumption according to IEG (2008), and therefore also present the most likely impact channels.

These impact channels could operate through at least four different mechanisms. First, electricity displaces candles and kerosene lamps, thereby reducing indoor air pollution, fire risk, and burn hazards, and providing higher quality light. Many studies have found that electricity is cheaper per

lumen than candles and kerosene, although it is also less flexible, in that it cannot be taken to a neighbor's house or saved for future use. Second, both lighting and television may affect access to information and ability to study. Third, both can affect time allocation as well as total time available, since lighting extends the effective working day, and television adds a new activity that did not previously absorb any household time. Fourth, in addition to affecting time allocation, lighting can affect the productivity or sheer practicality of household activities, e.g., decreasing injuries from cutting and chopping in poor light, increasing the effectiveness of study time, increasing the desirability of indoor toilets, and perhaps changing cooking patterns and practices.

Other potential uses of electricity, as well as motive power, could reinforce many of these mechanisms. For example, pumps for irrigation or drinking water can significantly decrease the time absorbed by water-related tasks that typically fall on women and girls. This in turn could release time for attending school or for income earning activities (see Koolwal and van de Walle (2010) for limited evidence on this, as described in section 2). Likewise, the potential time-savings from appliances that facilitate domestic tasks such as cooking and laundry are often noted, although in reality, purchases of these appliances are typically lower priorities and much less common than installation of lighting and television.²⁶

Electricity in a community can also have impacts on women in that community, in addition to or even if not installed in their homes. The potential impact channels in this case include lighting in public spaces (streets and gathering places), electricity used in productive activities that generate new employment and economic activity, and lighting and communications in health posts and schools.

4.2 Evaluation of impacts

Considering the funds invested in electrification projects, there are surprisingly few robust studies of their impacts. Even less is known about gender differentiated impacts.

Bernard (2010) finds that “while funding for rural electrification (RE) programs often rests on their supposed impacts on such outcomes as health, education, or poverty level, there is still very little empirical evidence to substantiate them.” Most quantitative assessments of electricity projects focus on the direct benefits, calculated either by the avoided cost method (estimating benefits by the avoided costs of the various devices that are replaced by electrification, including kerosene, diesel generation for auto battery charging, candles, and dry cells batteries) or by estimating demand functions (Meier et al. 2010). There is less quantitative evidence on indirect outcomes such as improved educational outcomes for children, expanded income generation opportunities, and reduced burns and respiratory disease associated with kerosene lighting - and even less evidence differentiated by gender.

On the other hand, there is a vast literature that describes the *potential* impacts of electricity and motive power on women and girls, including many claims that these differ from impacts on men and boys (DFID, ND; Panjwani 2005). Many of the claimed impacts are highly intuitive and logical,

²⁶ Availability and adoption of a broader range of appliances is argued to have increased women's participation in the labor force, as well as affecting fertility, in developed countries. For example, Cavalcante et al. (2008) find that in OECD countries, decreases in the prices of home appliances have led to a “sizeable, statistically significant and robust increase in female labor force participation.” In the US, Coen-Pirani et al. (2010) find that “diffusion of household appliances accounts for about forty percent of the observed increase in married women's labor force participation rates during the 1960s.” One question worth further exploration (perhaps including rigorous tests through experimental design built into future electrification and multi-sector projects) is the degree to which these same impacts could be expected from the combination of electrification and more affordable appliances in the different cultural settings of developing countries today. For example, electrification may have few positive impacts in the least developed countries unless combined with efforts to make appliances more accessible, affordable, and culturally desirable.

especially under a *ceteris paribus* assumption (i.e., no other behavioral responses to the intervention). However, the claims are largely based on qualitative or correlation analysis, and thus do not rule out rival explanations such as systematic differences in the communities or households that receive the electricity or motive power. Thus, Heltberg's (2004) conclusion still rings true: "better empirical evaluations of the impact of electrification are also called for, moving beyond mere correlations between having electricity and socio-economic outcomes."

There is a nascent literature on the causal impacts of electrification that seeks to address the challenges inherent to assessing infrastructure projects (Estache 2010). This includes a very shallow evidence pool on gender differentiated impacts. Because of the limited number of studies that both differentiate impacts by gender and employ quantitative methods to assess causality, we review both the published and the gray literature on electricity and motive power, applying the inclusive screening criteria described in section 1.3.²⁷ We find essentially no quantitative causal impact evaluations of projects that explicitly targeted benefits to women, but we do examine a few interventions that are widely cited as success stories of engaging women in the supply of electricity. In the next section on policy recommendations, we briefly comment on implications of the broader literature on the benefits of women's participation for project administration and efficiency.

4.2.1 *Methods employed to assess impacts*

While a long list of potential benefits of electrification to women have been posited, not all claims have been backed up by evidence. Methodologies for establishing causality and ruling out rival explanations are important because better-off communities and households are more likely to connect.

The increased emphasis on rigorous impact evaluation of development interventions described in section 1.3 also applies to rural electrification (RE) (Peters 2009). Recent and on-going studies are providing more credible evidence of impacts by applying creative strategies to address the non-random distribution of energy interventions (e.g., avoiding overestimation of welfare benefits when better-off households are more likely to connect, or underestimation of impacts when less privileged areas are targeted for RE, as in Dinkelman forthcoming). While these quasi-experimental evaluations have high internal validity, issues remain with external validity. In particular, they risk underestimating benefits, because of a focus on easily measurable outcomes (e.g., cash income rather than quality of home life), shorter time frames than required to observe final impacts (Peters 2009), and lack of consideration of gender-differentiated impacts. Thus, it is important to interpret these impact evaluations in the context of the slightly larger literature that simply conditions on observables (using matching or multivariate regression) and the much larger literature that employs reflexive or retrospective questions to elicit information on project impacts. This larger literature has generated a long list of potential benefits of electrification to women, which are intuitively logical but which have been assessed based only on anecdotal evidence, reflexive or retrospective reports of impacts and changes, or statistical correlations.²⁸

Specific hypotheses about gender-differentiated impacts of electricity that have been rigorously tested using quasi-experimental methods include reduced time on household chores – including collecting and cooking with fuelwood, increased income-generating activities - including employment outside the home, improved maternal health, reduced fertility, increased educational attainment, and

²⁷ Estache (2010) notes that in the energy sector, "there is a fair amount of ongoing evaluations (e.g. Afghanistan, Bangladesh, El Salvador, Ethiopia, Mozambique, Pakistan, Peru, Tanzania, Vietnam ...) but it is too early to draw major conclusions from these projects."

²⁸ For example, the impacts of electricity in a community may be difficult to estimate separately from the impacts of electricity in homes due to data constraints. However, reflexive and retrospective reports by women in communities that have received electricity can still paint a compelling picture of the perceived impacts.

improved status of women. Methods employed to test these hypotheses include instrumental variables, careful construction of control groups (e.g., through propensity score matching), difference-in-difference, and fixed effects estimation based on panel data. Because these are recent studies, most results have not yet appeared in the peer-reviewed literature. They include Gonzalez-Eiras and Rossi (2007) on health outcomes in Argentina; IEG (2008) on health knowledge and behaviors in a cross-section of countries; ADB (2010) on a range of health, education, time allocation, and empowerment outcomes in Bhutan; Khandekar et al. 2009a and b on education in Bangladesh and Vietnam; Jensen and Oster (2009) on the impact of cable television (made possible by electrification) on women's status in rural India; and perhaps most often cited, Dinkelman (forthcoming) on employment in South Africa and Grogan and Sadanand (2009) on fertility in Guatemala. With the exception of Gonzalez-Eiras and Rossi (2007), most of these studies focus on rural electrification, which is more likely than urban electricity projects to present sufficient variation in space and time to allow identification of impacts. In the following sections, we summarize the evidence from these studies of gender-differentiated impacts of electricity, beginning with the impacts of electricity in the home and ending with impacts of electricity in the community and of women's involvement on the supply side of energy, including motive energy. The specific methodologies underlying these findings are reported in footnotes.

4.2.2 Time allocation and employment

A few studies convincingly identify gender-differentiated, causal impacts of rural electrification. Dinkelman finds that electrification of rural communities in South Africa results in a 9 percentage point increase in female employment, but no comparable increase in male employment (Dinkelman forthcoming). Grogan and Sadanand (2009) obtain a similar estimate of a 9 percentage-point increase in female employment, versus no impact on male employment, from rural electrification in Guatemala. Both studies attribute this largely to the fact that electricity frees up women's time by increasing the efficiency of domestic chores, especially cooking. These results are broadly consistent with other studies that draw on large samples of electrified and non-electrified households and control for numerous potential confounders. For example, ADB (2010), Barkat (2002), and Chowdhury (2010) find that electrification reduces the time that women spend collecting fuelwood (in Bhutan) and increases the evening time they allocate to income generating activities and the probability of employment (in Bangladesh). It is also consistent with the conclusion that electrification has greater positive impacts on women when accompanied by effective social marketing and financing schemes for appliances that reduce the time required for domestic chores (e.g., ESMAP 2004) or enterprise services for women to take advantage of electricity services (e.g., project in Niger Basin cited by World Bank 2010a).

4.2.2.1 Time allocation to domestic chores

Studies find some impact of electrification on women's time allocation, different from the impact on men's time allocation, but not in all dimensions or in all ways expected.

Many studies compare the average time allocation of rural men and women in households and communities that have electricity vs. those that do not (e.g., ESMAP and EnPoGen studies in India and the Philippines). In the case of activities that are not possible without electricity (such as watching TV in regions where batteries are not used to power TV), the time allocated to the activity is clearly a result of having electricity. However, in general, it is not possible to conclude anything about the causal impact of electricity from these comparisons, because differences in time allocation are just as likely to reflect the particular characteristics of households and communities that obtain electricity as they are to reflect the impacts of electrification.

Studies that control for confounders (characteristics that influence the probability of obtaining electricity as well as the outcome of interest) typically find some impact of electrification on women's

time allocation, different from the impact on men's time allocation, but not in all dimensions or in all ways expected. For example, in Bangladesh, Barkat (2002) finds that having electricity in the home has a large, positive, and statistically significant effect on the time spent by the female head of household on income generating activities in the evening, while there is no impact on men; however, impacts on time in building human capital and in social activities are slightly larger (in terms of coefficient size) for men than for women.²⁹ In Bhutan, ADB (2010) concludes that electricity results in women spending 28 minutes per day less collecting fuelwood, as compared to 21 minutes per day less for men.³⁰ In Guatemala, Grogan and Sandanand (2009) estimate that electricity results in women spending 34% less time cooking, but they find no impact on time spent caring for children. They find no impact on time allocation to either of these activities by men, who spend virtually no time caring for children or cooking regardless of whether their home has electricity.³¹

In the discussion of health impacts below, we return to the question of why electrification appears to affect time spent collecting and the probability of cooking with fuelwood, despite the fact that electricity generally does not substitute for fuelwood as a source of thermal energy.

4.2.2.2 *Employment and earnings*

Rural electrification has been convincingly demonstrated to increase women's work outside the home, especially for younger cohorts of women, most likely by increasing the supply of women's time and boosting the demand for labor in small enterprises.

There is particular interest in the impact of electrification on income-earning opportunities and employment of women outside the home. The motivation is described by Koolwal and Van de Walle (2010): "it is widely believed that greater participation by women in market-based activities would yield desirable development outcomes. Work allowing women enhanced control over the resources they produce can raise their financial independence, their status and bargaining power inside the household, and also raise child welfare, on the grounds that extra income to women is likely to be invested in children." As described above, electrification is widely claimed to reduce the time that women spend on household chores, thereby creating the potential for them to earn more income.³²

Many researchers have examined whether women actually do shift time into income-generating activities in or outside the home, often by gathering reflexive or retrospective reports or estimating simple correlations or cross-tabs. Their findings vary substantially. For example, Masse and Samaranayake (2002) found that 80% of women in Sri Lanka reported that electrification *had* saved them time, but only 5% used that saved time on "productive" activities, while Meikle and North (2005) reported that half of the women in one village and two-thirds in another village in Tanzania *would* aim to undertake an income generating activity if they had access to electricity. This is broadly consistent with Lucas et al. (2003), who found that communities without electricity in China "viewed the connection to the grid as an essential step on the way to greater productivity, higher incomes and a better way of life," whereas in communities with electricity, "the major benefits which came most

²⁹ Barkat's (2002) results are based on Tobit models of time allocation in the evening (after 6PM) controlling for household characteristics including age, size, number of household members generating income, literacy, wealth, income, and expenditures on fuels.

³⁰ ADB (2010) employs kernel matching based on propensity scores estimated with a rich set of variables describing the households' human capital and physical assets, as well as infrastructure and public services in the village.

³¹ Grogan and Sandanand (2009) estimate Tobit models of time spent caring for children yesterday and time spent cooking yesterday on electricity, controlling for 10-year age group dummies, the highest grade level attained by the respondent, a rural dummy, controls for the number of adults and children under 18 in the household, and regional dummies. Their results are robust to controls for wealth, and to dropping households with different electricity status than community.

³² Electricity or motive power can also reduce paid employment that is traditionally held by women. Cecelski (2004) gives the example of mechanized rice milling, which reduces income for some groups of women, even while it raised income for other groups.

readily to mind were concerned with the quality of life, not production. Lighting, television and reduced labor on domestic tasks usually ranked highest. Only on reflection was it argued that by increasing the length of the working day and reducing labor requirements for household chores, more time was available for production or other income generating activities.”

This suggests that more careful empirical analysis may uncover effects not identified in the more descriptive literature, as well as providing more certainty about attribution. Including covariates in a multivariate model is a first step towards ruling out possible rival explanations related to non-random access to electricity and contemporaneous changes. Barkat’s (2002) study of time allocation in Bangladesh, described above, is an example of this approach. Chowdhury (2010) also employs this strategy of including community and household characteristics as covariates in her models. Based on a 2004-05 survey of married couples, and 2000 – 2004 data on infrastructure in Northwest Bangladesh, she finds that village access to electricity in 2000 significantly increases the probability that women will have non-farm employment in 2004-05. After controlling for electrification status in 2000, electrification status in 2004 has no effect, suggesting that there is a time lag in the employment impact. Chowdhury interprets this impact as a result of expansion of job opportunities in the non-farm sector, where there is less discrimination against women.³³ She also asserts that “the availability of electricity reduces time spent on activities related to lighting and cooking such as collecting firewood or drying cow dung.” She does not compare the probability or hours worked in non-farm paid employment by women and men, and thus it is not possible to determine whether the impacts differ by gender. Dinkelman’s forthcoming article in the *American Economic Review* on South Africa provides more persuasive evidence of a substantial, statistically significant, gender differentiated, causal impact of electrification on employment.³⁴ Specifically, female employment increases by 9 to 9.5 percentage points, or between 30 and 35 percent from baseline, in the wake of an electrification of a village in rural KwaZulu-Natal, as compared to no significant impact on men.³⁵ This result is strongest for women in the 30-34 age group, most likely because they have fewer childcare responsibilities.

Employing a similar strategy to Dinkelman (forthcoming), Grogan and Sadanand (2011) find that “household electrification causes rural women to be about 23% more likely to work outside the home, but that there are no such effects for men in Nicaragua.”³⁶ They find the greatest impacts in a younger cohort of women (20-35). In Guatemala, Grogan and Sadanand (2009) find women in villages with electricity are 9 percentage points more likely to be employed (marginal effect at the mean), and they see a five-fold increase in time spent working, versus no impact on men’s probability of employment

³³ Chowdhury (2010) only reports coefficients from probit and poisson models, not marginal effects. The coefficient on electricity in 2000 is not as large or as statistically significant as the effect of a public phone in the village, for example, but is more significant than the effect of a paved road in the village. Using a fitted value for electricity in the home (predicted from village price of electricity and land owned by household), Chowdhury (2010) also finds that electricity reduces the time spent on unpaid households work (but it is unclear how or whether she accounts for pre-estimation of the electricity variable in this regression).

³⁴ Employment in South Africa is determined by a census question on whether a person (age 15 – 59) works, including formal work for salary or wage, informal work such as making things for sale or rendering a service, or farm work.

³⁵ Dinkelman (forthcoming) uses gradient of the land as an instrument for electrification, and includes as covariates 1996 household density; fraction of households living below a poverty line; distances to the grid, road and town; fraction of adults that are white or Indian to proxy for local employers; fraction of men and women with a completed high school certificate; and two standard proxies for community poverty, the share of female-headed households and the female/male sex ratio, plus district fixed effects.

³⁶ Grogan and Sadanand (2011) use municipal population density in 1971 and the interaction of population density with mean slope gradient of municipal land as instruments for household electricity connection in 2005, and include multiple controls at municipal and household level (e.g., capturing characteristics of labor market and general infrastructure).

or time working outside the home.³⁷ While these studies only provide evidence from a few developing countries, they do find similar impacts in different cultural contexts, and their careful quantitative estimates are consistent with a common (but certainly not universal) finding in the much larger case study literature.

Both Dinkelman (forthcoming) and Grogan and Sadanand (2009) examine whether the effects on female participation in the labor force and women's earnings could be due to increases in the demand for labor. Grogan and Sadanand (2009) discredit this rival hypothesis by showing that there are no effects on men in the same households (as also found in Nicaragua by Grogan and Sadanand (2011)), while Dinkelman (forthcoming) finds similar effects for men and women and concludes that there probably are multiple impact pathways, with rural electrification both increasing the supply of women's time and increasing the demand for labor in small-scale enterprises (but she rules out large scale industrialization by showing that there are no spillovers between communities).

4.2.3 *Education and health*

There is evidence that electrification at community and household level has education and health benefits, there is less evidence of gender differentiated impacts. There is also evidence that electrification reduces fertility rates in rural areas from a range of studies, with positive impacts for women. One probable channel for the impact of electrification on fertility is through television, which is generally the second use of electricity after lighting.

4.2.3.1 *Education*

Electrification can have clear positive impacts on the education of boys and girls, and the evidence is mixed on whether boys or girls benefit the most.

It is commonly asserted that access to electricity can reduce the demand for child labor, including girls labor, and increase girls' school attendance and educational attainment. For example, UNDP (2005) states that "in rural areas, energy services that reduce the drudgery of daily chores like fetching water and collecting fuelwood are often more effective at increasing girls' opportunities for schooling as well as for after-school study." This same document presents interesting albeit essentially anecdotal evidence of gender-differentiated impacts in a Mali case study. In contrast, Khandekar et al. (2009a and 2009b) do not find any systematically greater impact of home electrification on girls as compared to boys, in terms of studying time or grades of school completed in Bangladesh and Vietnam.³⁸ In both studies, electrification did have positive impacts on education of both boys and girls, but there was not any clear evidence that this was biased either for or against girls (cf. Gustavsson 2007 in Africa). Barkat (2002) also found no difference across boys and girls in Bangladesh (see footnote 15). On the other hand, using propensity score matching (described in footnote 16), the ADB (2010) did find evidence of larger positive impact on girls in Bhutan (0.64 increase in years of education for girls vs. 0.41 increase for boys). Thus, the quantitative evidence of gender-differentiated impacts on education resulting from home electrification is decidedly mixed.

³⁷ The results for Guatemala are based on Probit and Tobit regressions of current employment status and time spent working for money yesterday, on electricity, controlling for 10-year age group dummies, the highest grade level attained by the respondent, a rural dummy, controls for the number of adults and children under 18 in the household, and regional dummies. Because there is no effect on men, Grogan and Sadanand (2009) argue that this is equivalent to a difference-in-difference approach. Employment refers to a person (age 20 - 55) working outside the home in paid employment.

³⁸ The study in Bangladesh employs propensity score matching using demographics, education, wealth and village prices, and distance from electricity line as an instrumental variable, while the methods applied in Vietnam are fixed effects regressions including controls for demographics, education, wealth, water, and commune prices and roads estimated with data pre-processed through propensity score matching.

4.2.3.2 Health

The health benefits of electricity stem from cleaner air, reduced risk of burns, fires, and accidents, better nutrition and food safety from refrigeration, and improved health knowledge from access to mass media.

Having electricity in the home can positively impact health through (a) cleaner air (Pokhrel et al. 2010; ADB 2010) and reduced risk of burns and accidental fires (Peck et al. 2008) from kerosene as well as other liquid fuels and candles used for lighting; (b) fewer accidents (e.g., cuts and burns) due to improved lighting; (c) better nutrition and food safety due to refrigeration of food; and (d) improved health knowledge through better access to mass media and more time to read (IEG 2008). While these benefits surely accrue to women because they spend time in the home, there is little empirical evidence that women benefit significantly more than men. The most suggestive evidence is (i) the persistent finding that electricity is associated with reduced use of fuelwood for cooking (with health impacts, as discussed in section 3), and (ii) impacts on reproductive and maternal health and fertility, which is gender-differentiated by definition.

4.2.3.3 Fuelwood use

A number of studies have found that electricity is associated with reduced use of fuelwood, whether measured as time collecting fuelwood or choice of cooking technology, although the reason therefore is far from obvious and rival explanations are possible (e.g., Heltberg 2004, Barnes and Sen 2003, Barnes et al. 2004, ADB 2010, Grogan 2011).

In some cases, the link between electricity and reduced use of fuelwood may be because households adopt electricity for at least some of their cooking needs. For example, Dinkelman (forthcoming) finds that the introduction of electricity in a community decreases the proportion of households using wood as their main cooking fuel by 27 percentage points, while cooking with electricity increases by 23 percentage points, in rural KwaZulu-Natal in South Africa.³⁹ This average effect is largely a result of fuel-switching by households in the second and third richest quintiles, who can afford complementary investments in new appliances and to pay electricity bills. More commonly, access to electricity is associated with switching to modern cooking fuels and technology other than electricity. For example, Grogan and Sadanand (2011) and (2010) cross-tabulate household electrification and gas or propane for cooking in Nicaragua and Guatemala. In Nicaragua, they find that within income quintiles, electrified households are much more likely to cook with gas in both 1993 and 2005. The same pattern holds in Guatemala, although they report only a simple cross-tabulation with no covariates.

With few exceptions (such as Bhutan, Nambia, South Africa), electricity is not used for cooking in developing countries (IEG 2008; Barnes et al. 2009). Thus, the correlation between electricity and reduced fuelwood use may, possibly, reflect omitted variables that drive placement of electricity projects and household connection decisions. For example, Barnes et al. (2004) speculate that “one possible explanation is that access proxies for market development. In that case, fewer barriers would constrain other modern fuels in cities where electricity is available.” However, they also lay out a possible causal chain: “availability of lighting and other appliances spurs people to a greater acceptance of modernity and modern fuels.” ESMAP (2004) suggests another possibility: “households with electricity might possibly be able to cook the evening meal just before it is consumed. With the exception of fresh breads and rice, households without electricity often prepare the evening meal during the daylight hours and then reheat it in the evening.” This debate has not been resolved, as the

³⁹ Dinkelman (forthcoming) using land gradient to instrument for electrification, and includes as covariates household density; fraction of households living below a poverty line; distances to the grid, road and town; fraction of adults that are white or Indian to proxy for local employers; fraction of men and women with a completed high school certificate; the share of female-headed households; the female/male sex ratio, and district fixed effects.

suspicion remains that electricity is unlikely to have a causal impact on choice of cooking fuel, yet empirical analysis has not been able to rule out this possibility.

4.2.3.4 *Maternal health and fertility*

In addition to reducing indoor air pollution from lighting and possibly cooking and heating, electricity has been hypothesized to affect health through refrigeration (improving nutrition and decreasing food poisoning) and access to information. IEG (2008) finds evidence for both of these pathways in multivariate regressions for multiple countries, but does not distinguish by gender. There is also evidence of reduced fertility, possibly via television, in that census data from across Latin America suggests a systematic negative association between birth propensities and household electrification status in rural areas.

Using secondary data on all of Argentina except Buenos Aires from 1990 and 2000, Gonzalez-Eiras and Rossi (2007) investigate the determinants of birth weight, which is partly a function of mothers' well-being during pregnancy (Agénor et al. 2010 summarizes evidence on this link).⁴⁰ They find a 20-24% decrease in the proportion of children born with very low weights (and a 5-6% decrease in low birth weight) in provinces where electricity had been privatized. They argue that privatization increases both the number of households with access to electricity and the reliability of the electricity supply, which in turn mean that more households acquire refrigerators and that food stays consistently cold, which in the final step in the causal chain allows for a more varied diet and a reduction in food-borne illnesses.

Turning to fertility, Grogan (2011) documents that birth propensities are significantly higher among women in unelectrified rural households in Argentina, Bolivia, Brazil, Mexico, Panama, Peru and Venezuela. Grogan (2011) and Grogan and Sadanand (2009) provide careful analyses of the impacts of electrification on fertility in Colombia and Guatemala, arguing in both cases that it does reduce the number of children born. In Colombia, electrification reduced birth propensity (in the year prior to the 1993 census) by 6%, mostly among women who already had at least two children.⁴¹ In Guatemala, women who were under 30 at the time electricity was installed in their communities have 28% fewer children than women who were older when electricity arrived, controlling for spatial and temporal covariates.⁴² In Bhutan, ADB (2010) finds that 0.04 fewer children had been born within 3 years of the survey in households in communities with electricity.⁴³ While each of these studies is limited by available data, and together they only cover three developing countries, together they do strongly suggest the possibility that rural electrification has a causal impact on fertility.

⁴⁰ Gonzalez-Eiras and Rossi (2007) use difference in difference estimates, with controls for GDP, unemployment, income inequality, public spending, political party, water privatization; and year and province fixed effects. Their results are not robust to dropping provinces with high rates of missing values, or to standard errors clustered by province. They therefore call for caution in drawing policy conclusions from their results.

⁴¹ Grogan (2011) instruments electrification of a village with historical education levels in the municipal capital (argued to be exogenous because most migration is rural to urban, and argued to reduce the cost of electrification by increasing development and hence the number of grid connections) and gradient interacted with education. Gradient along with numerous other municipal, household, and individual characteristics are included as controls.

⁴² Grogan and Sadanand (2009) regress the number of children born on age at the time electricity was installed in the community, controlling for current age, age when improved water and sanitation introduced to community, and either community fixed effects or department fixed effects with controls for community characteristics (whether has various levels of schools, located on paved road, affected by Hurricane Mitch, and is rural), with standard errors clustered at the community level. One weakness of this study is the high level of aggregation of many variables.

⁴³ The estimate reported by ADB (2010) is the average treatment effect on the treated, based on kernel matching using (i) human capital assets—household size, age of the head of the household, whether head of household is literate, number of literates in the house, gender of the head of household, marital status of the head of household, and religion of the head of household; and (ii) physical assets - household's holdings of land, main source of drinking water, type of house, whether household owns cows, bulls, poultry, and horse, and (iii) village-level control variables: distance from the village to district headquarter (the seat of local government), size of the village measured by the area of the village, population of the village, time taken to nearest road, and primary school. While this is a rich set of covariates, it does not include characteristics of the women.

Basten (2009) reviews the literature on how television programming influences fertility, and Jensen and Oster (2009) find both that the introduction of cable television to rural villages in India is strongly related to electricity access, and that cable has a negative effect on fertility over and above any impact of electricity itself.⁴⁴ La Ferrara et al. (2008) find that the introduction of a television network carrying popular soap operas reduces fertility by a small amount in both aggregate and individual level regressions. In Cote d'Ivoire, Peters et al. (forthcoming) find that "those in rural areas with electricity have 0.1333 ($p=0.066$) less children than rural residents without electricity. By contrast, urban residents with electricity have 0.121 ($p=0.035$) more children than city dwellers lacking electricity."⁴⁵ This, together with IEG's (2008) finding that electricity reduces fertility even after controlling for television watching in many countries, suggests that there may be more impact channels than simply better access to information on family planning. To the extent that electricity increases the efficiency of work typically allocated to children (such as pumping water), it could directly reduce the demand for children (Dasgupta, 1993). Electric lights effectively make the night shorter, providing alternative recreational activities and less privacy for intercourse (cf., Burlando 2010). On the other hand, electricity can decrease the cost of raising children, which may explain the positive effect of electricity on fertility in urban Cote d'Ivoire (cf., Greenwood et al. 2005 and Cornwell and Robinson 1988 for the US, with conflicting evidence presented by Bailey and Collins 2009).

4.2.4 *Women's empowerment and gender roles (via television)*

There is a small but important body of evidence on the impacts of television on gender roles and women's empowerment, substantiating the frequent references to this in the case study literature and identifying a potential causal mechanism for greater women's empowerment in electrified vs. non-electrified villages in Bangladesh as identified by Barkat (2002) and impacts of electrification in Bhutan found by ADB (2010). For example, Chong and La Ferrara (2009) find that access to the television network that carries telenovelas in Brazil resulted in higher divorce rates, which the broader literature suggests may be related to empowerment of women although it may have adverse consequences for children. More directly, Jensen and Oster (2009) find that access to cable television results in lower acceptance of spousal abuse, lower son preference, more autonomy, and greater likelihood of sending young girls to school in rural India. This suggests a potentially important impact channel for achieving the third Millennium Development Goal, albeit depending on the complementary input of television programming that directly or indirectly promotes women's empowerment. The impact may stem from imitation of role models of emancipated women in fictional TV dramas.

Cecelski (2004) argues that the question of "rural electrification's impact on gender relations" is critical and neglected. She notes that some researchers are skeptical about the possibility that electricity alone could empower women, but suggests that there are several possible pathways. For example, ESMAP studies in India and the Philippines found that women in electrified households read more, and EnPoGen studies in Sri Lanka and Indonesia concluded "that electrification strengthened women's position in the household, by encouraging families to spend time together in the evening and giving women the same access to entertainment and information from TV" (Cecelski 2004). Barkat (2002)

⁴⁴ Jensen and Oster (2008) estimate fixed effects regression of fertility on cable in village, including interactions between a year indicator and state dummies, income, education, age and age-squared, village population density, electrification status and distance to nearest town. Their estimates are essentially for changes in attitudes and behaviors within a certain person, with the fixed effects absorbing all time-invariant characteristics of the person and the household (such as the type of job held by the husband). They also examine pre-trends, and find that areas which get cable next year have no apparent changes in attitudes and behaviors this year, supporting their conclusion of causal impacts.

⁴⁵ Peters et al. (forthcoming) estimate Poisson regressions of the number of children born since 1980 as a function of electricity in the community, electricity interacted with rural vs. urban status, and characteristics of the household and women. Thus, they rely on these covariates in the multivariate regression model to control for any selection bias related to the expansion of the electricity grid.

presents suggestive evidence for women's empowerment and greater role in household decision making in villages with electricity, compared to villages without electricity, in Bangladesh.

One study that has examined these issues using a sampling and estimation approach designed to identify causal effects is ADB (2010). Their survey of rural Bhutan elicited information on women's involvement in decision-making. Based on propensity score matching, they found that electricity significantly increased women's participation in decisions related to health and education, but not finance. Focus group participants explained "that access to electricity empowers women through health, education, gender equality, and domestic violence awareness programs on television. Thus, women are becoming more assertive and confident. Further, on average, women save 1.5 hours every day in cooking, which enables them to attend village meetings and voice their concerns." ADB (2010) argues that "the impact of television as a medium of news and information cannot be overstated. An overwhelming 86.8% of electrified households, and nearly 70% of unelectrified households, agree that television is a good source of news and information." And ESMAP (2004) argues that "reading and watching TV are significant factors in raising awareness, broadening horizons, and educating rural women and thus should be seen as status-enhancing activities."

Thus, the primary story here appears to be about television. It is clear that across cultures, one consistent, immediate impact of electrification is that people spend more time watching television, whether because households buy televisions or because of the decreased cost of watching television previously powered by battery.⁴⁶ For example, IEG (2008) found that across countries, electrification explains 20% of increases in TV ownership over time (coefficient = 0.47, statistically significant at 5% level). IEG (2008) further argues that having a television in the home (as opposed to a public place) is particularly important for women's access. Many studies report mixed feelings about television, for example, concerns that it takes time away from studying (ESMAP 2002 on the Philippines), that it competes with other potential appliance purchases and electricity uses that would facilitate household chores, e.g., cookstoves and other kitchen implements (Cecelski 2004), that it undermines traditions and encourages migration to urban areas (ADB 2010), and that it undermines social capital (Olkean, 2009, however, found no significant affect on women's groups). This parallels broader concerns about the negative impacts of television such as reduced studying time and social interaction within the family, reinforcement of negative stereotypes about women in advertising (Furnham and Mak 1999), "overconsumption" and regret over time spent watching television (Gui and Stanca 2009), and increased obesity resulting from decreased physical activity and increased consumption of unhealthy but heavily advertised foods, both in developed (Marshall et al. 2010, Swinburn and Shelly 2008) and developing (Xu et al. 2007, Morales-Ruán et al. 2009) countries. This literature provides an important caveat regarding the long-term impacts of television on society.

However, the evidence points to positive impacts when television is introduced in rural communities after electrification. There is evidence that access to television improves women's standing as measured on several dimensions. Jensen and Oster (2009) find that access to cable television results in lower acceptability of spousal abuse, lower son preference, more autonomy, and greater likelihood of sending young girls to school in rural India.⁴⁷ The effects are large: "equivalent in some cases to about

⁴⁶ Television is one of a broader suite of communication benefits made possible by electrification, including the internet, ability to inexpensively charge cell phones, and lower operating cost and therefore longer hours listening to radio. However, most qualitative assessments identify television in the home as the most likely to have gender-differentiated impacts, and the empirical impact evaluations identified also focus on television.

⁴⁷ Based on fixed effect (village and individual) regression on cable in village, including interactions between a year indicator and state dummies, income, education, age and age-squared, village population density, electrification status and distance to nearest town. Their estimates are essentially for changes in attitudes and behaviors within a certain person, with the fixed effects absorbing all time-invariant characteristics of the person and the household (such as the type of job held by the husband). They also examine pre-trends, and find that areas which get cable next year have no apparent changes in attitudes and behaviors this year, supporting their conclusion of causal impacts.

five years of education” within the surveyed population. The changes were accomplished despite there being little or no direct targeted appeals such as public-service announcements. Cable television programming that features urban lifestyles and emancipated women with jobs and few children may achieve these impacts when people emulate what they come to perceive as desirable behaviors and attitudes. Chong and La Ferrara (2009) find that access to the television network that carries telenovelas in Brazil resulted in higher divorce rates, which the broader literature suggests may be related to empowerment of women although clearly it can also have negative consequences for children. There have been more studies of the impacts of particular television programs designed to promote smaller families, reduce ethnic tensions, or deliver public health messages. Of course, these programs are not a result of electrification per se, but they do suggest that public support for programming with a social message could be an important complement to electrification, with all the accompanying caveats about the relative disadvantage of the public sector in producing or even influencing programming that people want to watch.

This small but important body of evidence on the impacts of television on gender roles and women’s empowerment, substantiating the frequent references to this in the case study literature and identifying a potential causal mechanism for greater women’s empowerment in electrified vs. non-electrified villages in Bangladesh as identified by Barkat (2002) and impacts of electrification in Bhutan found by ADB (2010). This suggests a potentially important impact channel for achieving the third Millennium Development Goal, although clearly it depends on household’s ability to buy, rent, or otherwise view television and the complementary input of television programming that promotes women’s empowerment directly (via public service-type content) or indirectly (via emulation of the different lifestyles portrayed in television dramas).⁴⁸

4.2.5 *Electricity in the community*

Electricity in the community can have positive effects on women and girls, for example through improving school quality (e.g., by encouraging teachers to stay in the community and allowing them to prepare lesson plans), health care (e.g., by providing refrigeration to maintain cold chain), security (e.g., by allowing for street lighting), social capital (e.g., by lighting community spaces where women can gather in the evenings), and economic options (e.g., by improving communications with the market, and processing/storage facilities). There are also potentially strong interaction effects among these, e.g., “In Tunisia, families felt that girls were safer walking to school in early morning, due to street lighting, and school administrators felt that this was an important factor in increased school attendance by girls” (Cecelski et al 2005 as cited in Energia 2006).

Many of these effects of electricity in the community are intuitive and logical, especially if all else is held equal when electricity is introduced. However, the evidence for gender-differentiated effects is mostly anecdotal, or based on reflexive or retrospective reports by women living in areas that have received electricity. For example, a DFID review gives the following example: “street lights provided an improved sense of peace and order in the Philippines, and lighting makes it easier to respond to emergency situations. ... Lighting for ball games and festivals also promoted safe community activities” (DFID, ND). In the case of street lighting, there seems to be limited evidence from developing countries even of the anecdotal type, relative to the number of times that this impact is listed in project reports and reviews of the electricity sector. Many cite the review of policy options for reducing violence in Latin America by Buvinic et al. (1999), but that document and the literature on crime prevention in developing countries in general is based on limited empirical evidence (Bowles et

⁴⁸As an example of this approach, IEG (2008) mentions the Energy for Rural Transformation Project in Uganda, which has promoted gender-specific TV and radio communications to raise health awareness.

al. 2005). A meta-analysis of the effect of improved street lighting on crime in the US and UK did find a statistically significant impact (Welsh and Farrington 2008; Farrington and Welsh 2004), but did not differentiate crime rates by victims' gender.

In terms of education, there is some empirical evidence of impacts, e.g. on absenteeism, but gender-differentiated impacts have only been found in particular settings; for example, Ghuman and Lloyd (2007) find that female teachers - required for girls' schools in Pakistan - are less likely to be absent when electricity and other infrastructure amenities are available. While acknowledging that it is difficult to establish attribution, Kirubi et al. (2009) describe multiple plausible channels through which electricity can improve school quality (from improving sanitation, to employing mass media to prepare children for standardized exams, to photocopies of exams, to additional teaching hours in the morning and evening). Bacolod and Tobias (2006) find that electricity in schools is among the most important factors in quality of education in the Philippines, but they do not differentiate by gender. In a recent working paper, Huisman et al. (2010) find that electricity has the strongest correlation with school enrollment of any infrastructure variables, and that the correlation for girls is slightly larger than for boys in rural areas, when conditioned only on age of the children.

4.2.6 Supply side interventions

Engaging women in the supply of electricity and motive energy can also increase their welfare but the evidence is scarce. There is a clear need for rigorous studies to identify which design elements are key to obtaining benefits for women in the supply of energy interventions

Another channel for increasing women's welfare - including through empowerment and employment - is by engaging them in the supply of electricity and motive energy. For example, positive impacts on women have been reported for micro-hydro projects in Nepal, Peru, and Solomon Islands that deliberately sought to involve women in the management and construction of village energy grids. While these and similar examples are often cited, the evidence is generally qualitative, based on the retrospective or reflexive reports of key informants in the participating villages, and generally is not reported in the peer-reviewed scientific literature. Thus, while the descriptive evidence in these case studies can be compelling, there is little basis for drawing generalized conclusions. Two of the most widely cited projects that were structured to give women responsibility for management and supply of energy are the multi-function platform in West Africa and solar energy Bangladesh.

The multi-function platform (MFP) is perhaps the most widely cited project to deliver motive energy that specifically benefits women, although there are other many other case studies of small projects to install mills with the aim of reducing women's workload in post-harvest operations (see Panjwani 2005). The MFP was first developed in Mali and has received almost universally positive reviews (e.g., Africa Recovery 1999, Anderson et al. 2005, Brew-Hammond and Crole-Rees 2004, Burn and Coche 2000, Denton 2004, UNDP 2010). For example, in a representative passage, Denton (2004) writes:

Women in rural areas, because of gender-ascribed roles, are often left to cater for the energy needs of their families. These needs involve doing intensive, physically demanding and repetitive chores from an agriculture, livestock and basic subsistence perspective. Hence rural women are not able to use their time to engage in productive activities or simply to rest. The MFP relieves them of these activities and puts them in a situation where they are beneficiaries of improved energy services and owners and managers of the technology. The technology is owned by a group of women or a women's association trained in business management and development skills to provide energy services to both women and men. As a result, the MFP has successfully unleashed an entrepreneurial dynamic and changed the social and economic roles of women.

Although access to its management is not limited to the community, the nature of community life is such that, for now, the private sector has not responded to the challenges of managing the MFP in huge numbers. The fact remains that the platform has strong benefits particularly when social mobilization is achieved but in the absence of organizational skills and with limited resources, the community is not always able to exploit the gamut of potentially attractive benefits that the platform offers, particularly in other sectors.

This passage both describes the hoped for benefits of the MFP, and hints at its limitations, especially the difficulties of scaling up and sustaining the program. Nygaard (2009) argues that the features of the program that have made it popular with the international donor community are precisely those most difficult to implement in practice: management by women's associations, multi-functionality, and use of biofuel as a sustainable energy source. Based on project documents and internally-commissioned reviews, she concludes that the project as conceptualized has generally not been successful, although single-purpose engines run on conventional fuels and managed by the private sector show more promise. There is a clear need for rigorous, independent, quantitative assessment of the causal impacts of the MFP type interventions that continue to be implemented throughout Africa (e.g., UNDP 2008, Modi 2010).

A second frequently cited case is solar energy in Bangladesh, especially the Char Montaz project (Berthaud et al. 2004). As described by Mondal et al. (2010), there have been many projects to promote small-scale renewable energy in Bangladesh. As with the MFP in West Africa, these efforts have garnered support from international donors, but also like the MFP, they have faced challenges scaling up and sustaining operations as originally conceived by the project - including ensuring that the poor have access to project benefits and that women have a strong role in management (e.g., Wong 2009). For example, the Char Montaz project established a cooperative of women to construct and sell battery-powered lamps in connection with home solar systems but soon found that the market was limited. Several reviews of the first phase of the project suggested that the market could be expanded by offering credit (Berthaud et al. 2004, Mondal et al. 2010). According to World Bank (2010), "an assessment in 2009 revealed that the small cooperative has become a medium enterprise, serving most of the coastal areas and employing 170 people. The small island has become a bustling commercial area and communities acknowledge the women's cooperative as the initial spark for the modernization process." As with the MFP, rigorous, independent assessment of the impacts of Char Montaz and other renewable energy projects modeled on that experience would be useful.

5 Reflections and Implications

In this section, we reflect on and draw tentative conclusions based on the peer reviewed literature and World Bank documentation reviewed in the previous sections. We follow the same structure as before with separate sections for increased access to woodfuels, improved cooking technologies and electricity but we start with some general reflections.

5.1 General implications

Energy interventions may not always have the intended impacts, and more effort therefore should go into designing and targeting interventions based on a context-specific understanding of how household decisions are made. The impact of interventions that are designed to promote the use of new cooking technology and electricity in homes fundamentally depends on household decision-making, and in particular, how women's preferences, opportunity cost of time, and welfare are reflected in those decisions. For example, differences in how men's and women's time is valued could lead to further differences in the actual and perceived welfare impact, and therefore household choices.

This review shows that gender implications are not always conceived of in the planning of energy projects and seldom carefully evaluated. This has also been found in previous ESMAP and Bank studies, and it is what motivated, among others, the Africa Renewable Energy Access program (AFREA). Given the vulnerable situation of many women and the potential welfare gains that can be achieved if they are reached, there seems to be a strong case for specific gender analysis tools for fuelwood supply, cookstove, and electrification projects (see e.g. Clancy et al., 2007; and Making Energy Work for Women and Men: Tools for Task Teams, World Bank 2010f). Such approaches would most likely point to the need to focus directly on more clearly female dominated activities such as cooking (rather than on collection) since that is where the most obvious time savings and health impacts are. Still, for such interventions to be successful they need careful design and targeting to meet the needs and constraints of the recipients, which again, is likely to emphasize the importance of complementary interventions.

There are several reasons to expect that the determinants and rates of adoption of new cooking technology and electricity may be different for female-headed vs. male headed households, including differential poverty rates, legal and cultural constraints, and influence of women's preferences, welfare, and opportunity cost of time on household decision-making. Thus, although the majority of poor women are not part of female-headed households, this is still a category that should be carefully considered in planning interventions in the household energy sector.

Complementary interventions that encourage women's participation in household decision-making and increase the perceived opportunity cost of their time also increase the likelihood that women will benefit from energy related interventions. Economic rationality is a powerful force in household decision making, even in contexts where cultural factors are seemingly predominant. If women are given education, rights and access to assets, health care etc., then the risk that they will be captured in unproductive and unhealthy energy production and consumption is much lower.

There are strong cross-cutting links to other sectors and interventions that affect the impact on women from energy projects. Among these are education of girls, reforms in local democracy and their management of natural resources, tenure reforms, investment safeguards for large scale land

acquisitions, infrastructure investments (both roads and building codes), and mass media that portray women with jobs, decision-making power, fewer children, and perhaps even improved cookstoves and modern kitchen appliances.

Increasing women's participation in management groups (e.g., community associations that manage forests, rent or sell stoves and lamps, or regulate use of electricity from micro-grids) can achieve a win-win for women and for project management. Involving women in these groups can alleviate bias against women's resource use and may help improve the quality of management and reduce corruption. Women's participation in such groups can be increased through targets or quotas that ensure a minimum level of women representatives, and by avoiding barriers such as restricting membership to household heads or scheduling meetings during hours of women's peak workloads. There is a body of case study evidence that women's participation can increase the efficiency of project implementation. Starting with the most general evidence, Dollar et al. (2001) show that women's participation in politics is negatively correlated with corruption. Anderson et al. (2008) conclude from the behavioral economics literature that "women appear more socially minded than men." Anecdotal evidence suggests that women out-performed men, saved costs, and enhanced group functioning in projects in Peru, Venezuela, and Paraguay. Sun et al (2011) report on positive effects of women's participation on rights to harvest, collection, forest regeneration, incidence of illegal harvesting and the capacity to manage and resolve conflicts. Peterman et al. (2010) report more mixed evidence, including Agarwal's finding that women's participation improved forest management in India, but case studies in Kenya where women's participation had no impact on water management, and others where women's participation in groups especially as treasurers is valued because they are considered less vulnerable to corruption (in Kenya and Mozambique).

More impact evaluations of energy projects would be most welcome and should take gender into account. Overall, there is a great predominance of gray literature dealing with energy-gender relationships and strikingly little rigorous impact evaluations, given the size of energy interventions and the commitment to gender equality expressed in the Millennium Development Goals and the World Bank Group's *Gender Equality as Smart Economics* Gender Action Plan. Section 1.3 of that Plan suggests minimal requirements for such evaluations – i.e., empirical estimates of outcomes of interest both for men and for women, both with-without and before-after interventions, using an experimental or quasi-experimental design with a large sample. Thus, the Bank Group should consider rigorous impact evaluations of energy projects, using designs that allow identification of the factors that influence outcomes. These factors could include design elements of the interventions and external conditions (e.g., energy and labor scarcity, road quality, educational inputs). The ultimate purpose of such evaluations would be to increase the impacts and contributions to gender equality and empowerment of women of gender investments.

5.2 Increased access to woodfuels

All analyses of existing household energy use and scenarios of future household energy use point to the fact that woodfuels are, and will continue to be, an important part of the energy mix, particularly in Sub-Saharan Africa and South Asia. Although there might not be a "fuelwood crisis" of the dimension argued for in the 1970s, there is still a rationale for interventions to promote fuel-constrained households' adoption to scarcity and to reduce forest degradation associated with woodfuel demand.

There is currently a notable increase in the demand for land in developing countries, including large-scale commercial plantations (Deininger and Byerlee, 2011), stemming from high agricultural prices, and biofuel and climate policies (e.g., bio-energy plantations, CDM and REDD+ projects). All-in-all,

this decreases the availability of land for woodfuel collection, often with adverse gender impacts.⁴⁹ And, because demand for energy is inelastic, adaptation to increased scarcity is costly for poor households in terms of e.g. increased time for collection, greater proportion of disposable income allocated for energy or decreased quality of fuel (Cooke et al, 2008). The Bank should support safeguards of local rights to woodfuel collection, or alternative means of energy supply, where large-scale biofuel, REDD, or agricultural projects are implemented.

Access to woodfuel could be increased by inducing private supply of woodfuel, subsidize community investments, address institutional failures that counteract collective action on commons, and enable utilization of government land, e.g. through Joint Forest Management. Fundamental to any such intervention is the functioning of the tenure system. An energy-gender perspective on the land tenure and land administration reforms could therefore have profound effects on woodfuel supplies.

Private supply of woodfuels is increasing in importance. Shively (1998) pointed out the importance for the investment decision that prices remain high and risk is reduced. Secure private tenure rights can decrease risk and the devolution of *de facto* open access government land to more efficient local management can keep woodfuel prices more stable. For women to benefit more effectively, such reforms would need to include specific rights to land and trees for wives and daughters (on par with husbands and sons). Women can also benefit from supplementary activities such as silvi-cultural training and micro-credits. Producer cooperatives have also increased the value added of forest owners.

Community and peri-urban plantations and community based forest management: plantations have lost some of its previous attraction to donors but can be expected to have a major revival as part of various carbon sequestration initiatives (Paquette and Messier 2010). This can be instrumental since the underlying problem in the mismanagement of most commons is under-investment (Swanson, 1992). Despite the academic leaps in understanding the functioning of CPR management, spearheaded by Ostrom, there is still much to learn about how external actors, such as governments and donors, can support a process that both leads to sustainable resource management and equitable distributions. Section 2.3.3. noted the importance to give particular emphasis to the representation of disadvantaged women in such management committees if their interests are to be taken into consideration.

Charcoal projects have the potential to reach also urban beneficiaries. The charcoal trade also gives rise to a large number of jobs. Charcoal is, however, not a very sustainable source of energy to invest in from a climate change perspective, as long as traditional kilns are used.

5.3 Increased access to improved cooking technologies

The Bank Group should facilitate tapping into carbon finance and technical assistance to promote improved cooking options. It should also consider a program of rigorous impact evaluations and participatory monitoring of household cooking and energy projects, as well as analytical work on the gender dimensions of political economy.

Political economy studies may consider whether empowering women leads to improved provision of public goods for the local community and the household. Although there is some evidence that

⁴⁹ For the book "Rising Global interest in farmland" the World Bank made an in-depth inventory of large scale land acquisitions in 19 countries. One of the findings was that "[m]any of the projects studied had strong negative gender effects, either by directly affecting women's land-based livelihoods or, where common property resources were involved, by increasing the time required of women to gather water or firewood and take care of household food security. In many cases, it was presumed that land rights were in the name of men only, and consultations were limited to males in the community, leaving women without a voice. Bargaining power within the household was affected in unpredictable ways (Deininger and Byerlee, 2011:69-70).

women leaders are more likely to provide local public goods, including manage local forests for fuelwood, cooking technologies are essentially private goods and services. Yet, there is some evidence that cooking technologies have positive secondary benefits for the local environment (e.g., reducing watershed degradation, and biodiversity habitat loss) and regional climate (e.g., reducing black carbon emissions). Furthermore, within the household, cooking and the kitchen constitute 'household public goods', which improve household health, for example. So does putting women in charge of the communities and the households improve the quality of local forests, indoor air quality and household health? Studies that examine positive shocks to women's income, especially studies on the impacts of women's participation in microcredit and micro-savings programs on health investments will offer some insights.

Promotion of clean cooking technologies is undergoing a revival rooted in concerns over the climate change impacts of biomass burning and because of the availability of better and cheaper improved stoves. Although there are some uncertainties about the climate science (Bond, 2007), there is now a mechanism for finance and technical assistance (e.g., monitoring, reporting and verification for carbon offsets and CDM projects) because clean fuels and improved stoves can generate certified emission reductions (World Bank, 2011). The Bank and its partners on the ground have considerable expertise and infrastructure in this context. So even if the local and regional benefits to women of improved cooking options are ambiguous at this stage (and at least no study suggests that they are negative), the precautionary principle for climate mitigation strategies implies the Bank Group should facilitate tapping into carbon financing and technical assistance to promote improved cooking options.

A side benefit of this strategy of demonstrating that emission reductions are additional combined with the tradition of evidence-based practice and causal impact analysis in public health, suggests that cooking interventions should be evaluated more rigorously and more comprehensively. These evaluations would yield better estimates of savings in time spent collecting fuelwood and cooking and in amount of fuelwood collected. Furthermore, the Bank has been a champion, trainer, and clearing house for rigorous M&E in the social sectors and it could consider drawing on its vast experience and extensive network of researchers to build a strong culture of rigorous impact evaluations and participatory monitoring of household cooking and energy loans and technical assistance projects.

Such learning efforts would help accomplish three outcomes. First, demonstrating that a particular program yields benefits can be used to set priorities and mobilize support to expand or modify programs. Second, even though specific programs show great promise, they might not work under all field conditions. Program outcomes can be highly variable, with some interventions and programs in some settings showing little impact. Good evaluations can identify why this might happen and what adjustments can be made to correct it. Finally, impact evaluations are often conducted in close collaboration with regional governments, local NGOs, and partners in academia and community organizations. Thus, good evaluations affect stakeholders by stimulating dialogue and raise awareness about effective policy tools.

5.4 Increased access to electricity

The limited evidence on the gender-differentiated impacts of electricity and motive power suggests a potential for complementarities between investments in electricity and in new cooking technologies, with resulting benefits for family health and income. The evidence also suggests that the social benefits of electricity can be enhanced in situations where mass media present an image of empowered women and gender equity. As mentioned, the two important impact channels, related to the two most common uses households make first when they receive electricity: illumination and television.

Lighting appears to free up women's time by increasing their available hours and their efficiency in completing the household chores that typically are their responsibility. This creates possibilities for them to invest more in childcare and housework, increase leisure including reading, participate in social and community activities, and earn income. All of these have the potential to increase women's well-being. In particular, rigorous impact evaluations in selected country case studies have found that electricity increases the probability of women working for income. The authors of these case studies concluded that this impact is at least partially due to changes in cooking practices, with households at least partially switching to electricity or propane. Thus, investments in electricity and in new cooking technologies could be highly complementary, with resulting benefits for both family health and income, both in regions where electricity is an accepted technology for cooking and regions where it is a complement to new cooking technology. The association between electrification and adoption of new cooking technologies has been noted across many countries for many years. Recent impact evaluations lend credence to the idea that this is at least partially a causal relationship, and not simply due to omitted variables.

Television viewing is clearly facilitated by electrification, which both reduces the cost of watching TV (as compared to batteries) and encourages the expansion of broadcast signals and cable access. Many authors have suggested that women would be better off if households invested more in appliances that directly reduce the time and effort required to complete household chores (e.g., food processors) rather than television. However, recent evidence suggests that television may in fact convey significant benefits for women in terms of increased gender equity. As with employment, the causal evidence is limited to select countries, but it is consistent with a broader literature that documents the important role of television programming in shaping social norms. Thus, the social benefits of electricity are likely to be larger when mass media present images of empowered women and gender equity. In settings where that is not the case, joint promotion of electricity and gender-positive television content merit consideration.

Electrification has been shown to have benefits for women and girls, but not necessarily greater benefits than for men and boys. This does not imply that these impacts are any less important. And we note that there are many reports of energy projects, including of motive power projects such as the multi-function platform in West Africa and solar home systems in South Asia that do generate multiple benefits specifically for women and girls. To the best of our knowledge, however, there are not any impact evaluations of these interventions that meet current standards for evidence. Therefore, in electricity as in other dimensions of the energy sector, there is a continuing need for well-targeted and well-designed evaluations.

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