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Transitions to sustainable energy in Asia: challenges and opportunities for gender equality

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A. Explicit and implicit gender biases in existing systems of energy production.

Drawing on the existing body of literature on the subject, the gender issues in energy production and distribution in South Asia, can be summarized as follows.

- Women's health and security: An important characteristic of the energy mix of countries in South Asia is their heavy dependence on traditional use of fuels (wood, agricultural residues, and animal dung) in meeting total energy consumption. The IEA (2013)[1] estimates that the percentage of the global population dependent on the traditional use of biomass for cooking has increased and that this deteriorating situation is primarily due to population growth outpacing the provision of clean cooking facilities. Additionally, new research now finds that there are 3.6 million premature deaths each year, higher than previous estimates, as a result of household air pollution using solid fuels (Lim and others, 2012). Although there is an increasing understanding amongst governments and energy sector agencies in South Asia on the importance of prioritizing investments in the provision of clean and safe cooking energy, much more needs to be done. Similarly, while street lighting can improve women's safety and mobility, these services too are often not prioritized for investment (ADB, 2012).

- Affordability: Where modern energy services are available lack of affordability prevents access to these services by the poor. Tariff levels, for example, generally don't take into account women's lower incomes thus limiting women's access to energy services. Public consultation processes, including assessing communities willingness to pay, are not always gender or socially inclusive. Various policy instruments exist, such as affordable tariffs, subsidies and schemes, as well as revolving funds providing cheap credit to connect, which need to be utilized and adapted to target the poor, women and disadvantaged consumers in the lower consumption band. (Clancy and others, 2012)

- Livelihood opportunities and employment: Lack of electricity, including poor and unreliable quality of supply resulting in prolonged outages or shortages, also make it difficult for poor households, including women, to maximize potential opportunities such as the functioning of women's small and microenterprises (Masse, 2003). While the energy sector can provide employment opportunities for women and men, persistent gender inequalities in secondary and higher education, as well as gender stereotypes in the labor market, restrict women's participation in the sector. Women's access to opportunities for technical and skills training are also limited.

- Capacity development and technical and skills training. Technical and skills training are an importanat factor in women's employment in the industry but access to them by women is often limited. Case studies demonstrate positive and significant results when special measures are taken to provide poor women with the opportunities to access technical training.[2]

- Awareness-raising and user education: Household energy efficiency is of special relevance to women. However, user education programs in the safe and efficient use of electricity at the household level, which should complement energy efficiency projects, are overlooked or not effectively targeted at women household consumers. (ADB, 2012) Case studies also show that where women are given the opportunity and provided with the appropriate training they have proven themselves capable of designing, assembling and operating renewable energy technologies. The example of Barefoot College in India, which has used innovative techniques to train poor rural

[1] IEA, World Energy Outlook 2013.

[2] See Barefoot College Stories. Accessed at: http://www.barefootcollege.org/solutions/solar-solutions/stories/

women, with low-levels of literacy, in solar energy technology, is well documented. Poor women from Asia, Africa and Latin America have been trained in the assembly, operation and maintenance of solar PV home systems and solar lanterns. These women are known as 'barefoot women solar engineers'.

- Gender roles in decision making: The types of fuels used, the amount of energy purchased, the devices and technology chosen, as well as domestic infrastructure related to ventilation, lighting priorities, energy-based equipment purchased, are usually made by the male head of the household, but affect women's daily lives in very immediate and practical ways (Masud and others, 2007). Women and men's perception of the benefits of modern energy can be different. Women would place a greater emphasis on benefits related to improving health care and children's education, reducing expenditure, reducing their workload, and improving household safety.

- Access to information: Where radios and television sets are purchased for leisure and entertainment, both women and men have identified the access to information and entertainment as a benefit (UNDP, 2004). These can also have unexpected results on the self-esteem and empowerment of isolated and confined women, particularly as they become aware of modern labor saving alternatives and lifestyles, that they may otherwise be ignorant about. (Mohideen, 2013).

Employment

84% of STEM bachelor students in industrialised economies are male and there has been a 12% reduction in women participating in STEM since 1991. Only 10% of patents have female inventors listed. However, there are 40% more citations per patent from gender diverse compared to single gender authored patents.

The International Renewable Energy Agency (IRENA) (2016) estimates that global renewable energy employment increased by 5% in 2015 to 8.1 million. An additional 1.3 million people are employed in large hydro. Jobs continued to shift toward Asia and the share of the continent in global employment increased to 60%.

Solar PV was the largest renewable energy employer with 2.8 million jobs worldwide in 2016, an 11% increase from2014. Bioenergy is a key employer, with liquid biofuels accounting for 1.7 million, biomass 822,000, and biogas 382,000 jobs. Direct jobs in large hydro fell to 1.3 million due to a drop in new installations.

China led employment with 3.5 million jobs, a minor reduction of 2%.

In India, the solar and wind markets have seen substantial activity, as the ambitious renewable energy targets are translated into concrete policy frameworks. Solar PV employs an estimated 103,000 people in grid-connected (31,000 jobs) and off-grid applications (72,000 jobs). Reaching the government's goal of 100-GW PV by 2022 could generate 1.1 million jobs. However, given that 30% of these jobs would be highly skilled requires stepping up training and educational initiatives. The Indian wind energy industry employment has remained steady at 48,000 jobs.[3]

Gender disaggregated employment data in the renewable energy sector is scarce. IRENA's preliminary research based on an online survey of 90 private sector companies from 40 countries indicates that the renewable energy features more gender parity than the broader energy sector. The companies represented the entire value chain of the renewable energy sector, including manufacturing, O&M, and policy making. Women represented 35% of the workforce, compared with 20%-25% of the workforce in the overall energy sector.

[3] International Renewable Energy Agency (IRENA). 2016. Renewable Energy and Jobs – Annual Review 2016.

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CASE STUDY: Madhya Pradesh, India
Source: India Gender Equality Results Case Study: Enhancing Energy-Based Livelihoods For Women Micro-Entrepreneurs, Asian Development Bank, 2018

Introduction

The Enhancing Energy-Based Livelihoods for Women Micro-Entrepreneurs is a technical assistance (TA) project that supplemented the Asian Development Bank (ADB)-financed Madhya Pradesh Energy Efficiency Improvement Investment Program. It aimed to enhance the benefits of the program for women through capacity development, energy-based enterprises, as well as the provision of business development services (BDS).

Under the TA project, a total of 20,729 women members of 2,803 self-help groups (SHGs) in program covered areas attended the integrated enterprise module (IEM) training, 506 of whom attended the gender and energy training and were BDS providers and trainers, and 1,650 attended the skills development training; 517 of the 1,650 were trained in BDS; and 63 women entrepreneurs accessed BDS through SHG assistance.

Barriers

a. Social and political norms and practices affecting women’s access to energy
b. Limited economic opportunities
c. Lack or inadequate access to energy resources. Reliance on traditional biomass for household energy.
d. Lack or Limited Access to Energy-Related Services

Challenges encountered

Despite the many facilitating or helping factors, several challenges were met:

- The high rate of violence against women and women’s fear of violence restricted their mobility and made them miss available economic opportunities.
- The deeply rooted social and cultural gender stereotypes and practices affected the community mobilization activities.
- Human resources with combined knowledge and understanding of enterprise development in the energy sector and the underlying gender dynamics were not readily available locally.
- Inadequate and unreliable public transport restricted the mobility of women. This hindered the women entrepreneurs from going to markets and other places.

Approaches

Key interventions that helped address gender issues and meet project goals were the following:

- Gender action plan. Focused on building user awareness on safe and efficient use of electricity, building capacities of women microentrepreneurs and women SHGs, and developing microenterprises headed by women.
- Gender action plan as loan covenant.
- Evidence-based gender assessment.
- The project liaised with existing poverty alleviation scheme and programs of the state and central government.
- Partnership with non-government organizations.
- Mobilization of women self-help groups.
- Inclusion of gender indicators in project monitoring system.

Results

The project enabled 590 women to upgrade their existing businesses using energy-based technologies or start new nonconventional trades such as bulb assembling, refrigeration services,

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etc. The impact assessment studies showed that the improved power supply and capacity development resulted in (i) increase in the income of women entrepreneurs from low-income households, (ii) increase in the number of earning women, (iii) increase in the propensity of women to save, (iv) decrease in time spent by women on household chores, (v) reduction of women's time poverty and drudgery and men's increased willingness to share household chores, and (vi) increase in women's participation in decision-making in the household.

Lessons

Some lessons drawn included:

- Ensuring women's meaningful involvement to energy efficiency as entrepreneurs is long-term process. Additional efforts toward capacity building are crucial to ensure the sustainability of these initiatives.
- The transformation of deep-rooted social and cultural constraints requires long- term and focused interventions.
- Improving power supply and providing training on the safe and efficient use of electricity are not enough to move low-income households to adopt labor-saving household appliances and safe cooking technologies. Targeted interventions are needed to create positive results in these areas.

B. Multiple pathways

Multiple pathways to address gender equality through energy have been identified.

Electricity and network technologies
Jacobsen (2011) assesses four network technologies – water, electricity, internet and other telecentre services, mobile phones – in the framework of multiple pathways to change gender equity through technology. She concludes that electricity provision is "more promising" as it substitutes for physical labor and complements a wide range of productive activities. Internet services, while minimally utilised by women in low-income countries, significantly reduces transaction costs on information flows. Mobile phones, however, reduces the physical labor of travel (to access information, for example), reduces the costs of money transfers and increases the ability of women entrepreneurs to coordinate their family work and working lives. Given their relatively low cost and multiple uses, they are widely used in many poor rural communities in Asia. But significantly, Jacobsen concludes, how changes in gender equity can be credited to any one or any set of technologies "may be ultimately unanswerable given the holistic nature of transformation" (pp. 31).

Beyond traditional roles and towards women's empowerment
Skutch (1998) points out that as access to energy services is primarily a welfare function as they don't challenge systemic gender inequality: "A welfare approach aims to lighten women's daily problems, but not structurally to change their roles .." (pp. 948). The goal of women's "empowerment", however, presupposes a transformation in gender roles and relations to enable women "to break through tradition if they wish to, and to take on new roles and challenges". This may not always be a realistic goal in energy as they are rarely the "steering objectives or outcomes" of energy projects (Skutch, 2005, pp. 39-40).

In addition to welfare, income and empowerment, Skutch (2005) also identifies an additional reason, i.e. project efficiency. While the aim here is not gender equality, failure by project management to recognise that men and women have different needs and have different access to resources, means that projects can easily miss their target, of benefiting consumers by addressing their needs. Therefore she suggests that the process by which the energy service is planned, implemented and maintained, if done in a gender sensitive manner, maybe more empowering than the energy technology itself. (Skutch, 2005)

Clancy concurs with Skutch and examines the evidence supporting whether or not there are changes in gender relations and finds that the evidence is mixed. While in Sri Lanka, men were found to share household work such as ironing after household electrification, in Bangladesh no changes in the gender division of labor were found. Therefore the "[a]ccess to modern energy appears to enable women to fulfill their traditional roles (to their satisfaction and well-being) rather than bringing significant transformation in gender roles" (Clancy and others, 2011, pp. 21). Clancy concludes that "energy access alone is not sufficient, and other contextual factors such as legal and policy frameworks are needed to support such a change" (pp. 21).

Increasing the "economic worth" of women's labor
While these multiple pathways or gender goals are inter-dependent and overlap, however, it is worth asking if some pathways more conducive to enabling the transformation of gender relations? Kelkar and Nathan (2005) propose that a key factor to promote the rural fuel transition in Asia from unhealthy fuelwood (and related traditional biomass), to electricity and improved biomass technology, "is to increase the productivity of women's income-earning labor in order to bring about an economic worth in the use of women's labor and thus induce a change in the household energy

use system" (pp. 25). They use research conducted in China and other parts of rural Asia, which found that when there were opportunities for women to significantly participate in income earning activities, this was a strong incentive to economize on women's unpaid labor time in fuel collection and other household tasks.

In China the improved stoves program has been most successful in villages where women have significantly participated in income-earning activities in industry and commercial production of livestock and vegetables, where the drive to economize on women's labor in fuel collection and housework, resulted in a high adoption rate of improved stoves. Similarly studies on micro-credit in Bangladesh have found that women are more likely to assert their role in household decision making, with increases in their economic activity and income. This proposition could be extended to suggest that women's economic empowerment related to energy access is, therefore, a more conducive pathway to enable the transformation of gender relations. (Kelkar and Nathan, 2005)

However, the causality can also work both ways, i.e. in social contexts where women have a higher economic and social status, they can (and in many instances do) exert greater influence on public policy, expenditure, including access to (energy) services, and its use. For example, Kelkar and Nathan's case study of the Luoshui village in Yunnan, China, includes reference to the historical background of the area when "people began to seize political power" and the "gendered division of labor tended to be equal" (pp. 29). Kelkar and Nathan point out: "It is not energy itself that has certain inevitable consequences, but the economic and social situation in which technologies are introduced and the balance of forces at any time" (pp. 17).

C. A nexus approach in power systems design

The following energy service systems modeling for rural electrification uses a nexus approach, integrating gender equity considerations with technical, economic and climate-related considerations. It attempts to find an optimal solution to the following key criteria; technical, economic, environmental, social and institutional. The social incorporates gender equality indicators – women's time saved on household tasks and income.

Food processing and water pumping have an important bearing on women's labor time devoted to onerous household chores (also referred to as women's time poverty). Following the World Bank framework and multitier matrix for measuring access to household electricity services as a guide, Tier 3 provides adequate levels of electricity access to provide pumped water, and is an important threshold level of energy access to lay the basis for reducing women's labor time-poverty. Tier 3 is also the threshold level of access to operate medium power appliances. This indicates that it is an important level of access to provide electricity for productive use, such as establishing small enterprises, which can contribute to women's economic empowerment. According to the World Bank matrix 1.0 Kwh of daily supply capacity – or 365 Kwh of annual supply capacity – is the minimum required to provide electricity coverage for at least 50% of working hours that is, Tier 3 level of access. A minimum of 3.4 Kwh of daily supply capacity – or 1241 Kwh of annual capacity supply – is required to cover most of working hours that is, a Tier 4 level of access. It is also assessed that Tier 4 levels of access are also more reliable, affordable, convenient and safe and therefore are less likely to impact negatively on productive activities.

Energy pathways and related models need to give special consideration to providing electricity to meet Tier 3 levels of access as a threshold to enable important gender benefits that is, ~ 365-1250 Kwhs of annual supply capacity. However, there are also several caveats that apply, which should be noted here. The framework does not take into account affordability, reliability, resilience or scalability, for example. There is also an assumption that the grid or even mini grid is based on conventional AC power and not DC powered minigrids with DC appliances.

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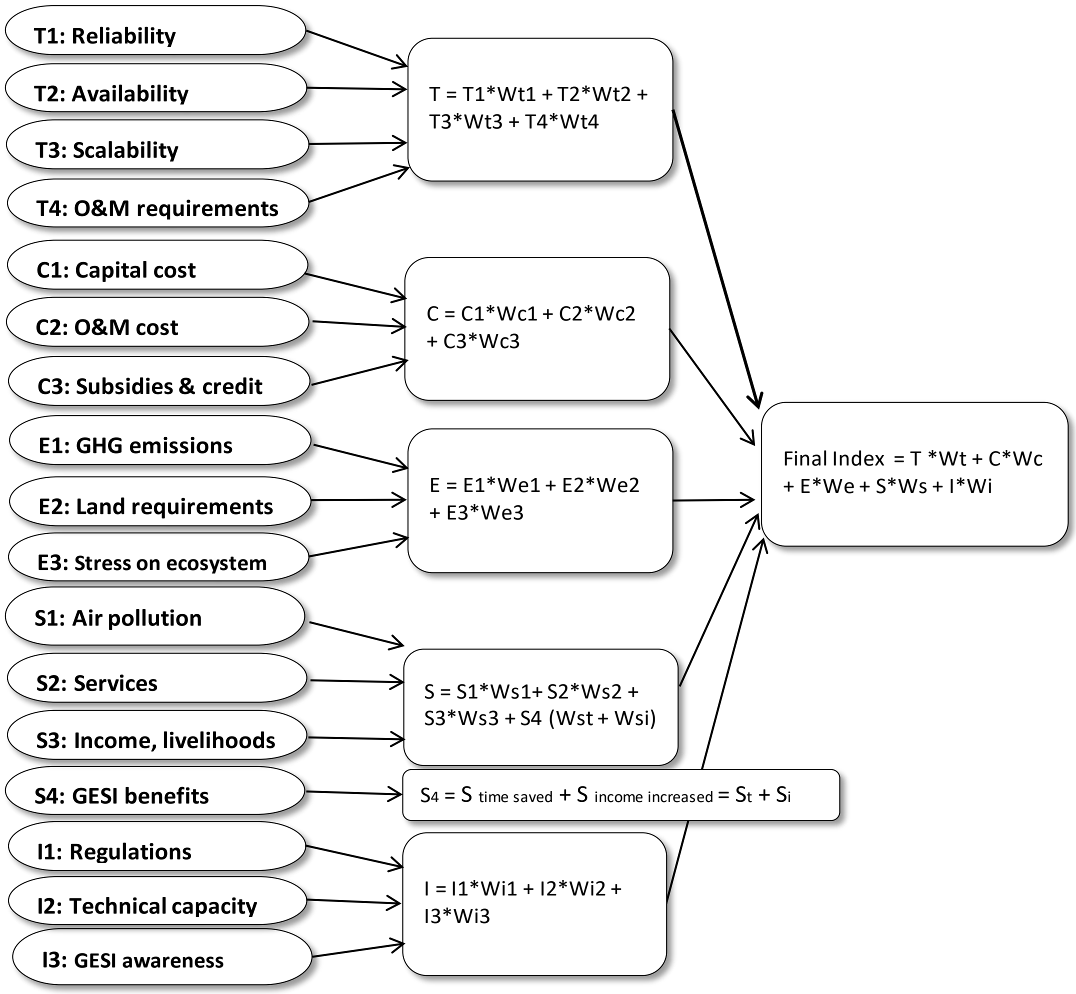
Gender indicators integrated into an energy services model and algorithm



T -- Technology
C -- Cost
E -- Environment
S -- Social
I -- Institution

D. Renewable energy

Developing renewable energy supplies as the primary energy sources has been identified as being fundamental to sustainable development, thus heavily influencing and becoming an increasing focus in gender and development studies and practice. These studies, drawing extensively from the experience of renewable energy programs in Asia and Africa, show that women need renewable energy to: address the 'biomass cooking crisis', i.e. fuel scarcity and women and children's health and safety problems associated with the use of traditional biomass for cooking energy; to reduce women's socially necessary but unpaid (and therefore unrecognized and undervalued) labor time associated with reproductive labor at the household level; give women more efficient energy choices to aid their work especially in the context of increased urbanization, and; for women's microenterprise development, to increase their livelihood opportunities and income by improving the productivity and quality of their enterprises (Ceceslski, 2000).

The introduction of small-scale renewable energy systems to electrify rural communities in development projects, also highlights a relatively recent problem of, who owns the technology. A review of the AEPC biogas program in Nepal found a massive gap in biogas plant ownership, by gender and caste. While only 17.2% of the biogas systems were owned by women, this was distributed unevenly amongst castes and ethnic minorities. The gap in ownership was found to be 26.25 percentage points in favour of those belonging to the Brahmin upper caste and -7.42 percentage points against those belonging to the lower caste Terai communities. This also illustrates the fact that women are not a homogenous grouping and that gender analysis has to take into account class, caste, ethnicity (and race) as determining social factors. A key recommendation of the review is revealing: the need to promote the technology as a 'social product' in order to address the gender and social equity gaps in ownership. (Tamrakar, unpublished)

Studies also emphasise the importance of women's traditional knowledge in natural resource management, and the importance of tapping into and developing this knowledge, as an integral part of renewable energy development. However, indigenous women, who hold much of this traditional knowledge, continue to experience gender discrimination compounded by the added marginalisation endured by indigenous peoples, much of it as a result of their lack of access to traditional lands (Kelkar, 2010).

E. Small or large-scale solutions?

An implicit assumption in gender and development practice is that small-scale systems are more enabling for 'bottom-up' participatory approaches, thus providing greater opportunities for participation by poor women and other marginalized groups. Some studies show that small-scale infrastructure projects, specifically decentralize renewable energy distribution systems and technologies, are more conducive to improving access to services by the poor, i.e. below-poverty-line, compared to large-scale conventional energy projects. These findings have gender implications in relation to poor women's access to energy services.

A study by International Rivers (2012), which is a critique of the infrastructure strategies and track record of the Group of 20 and the World Bank in Africa finds that big infrastructure projects tend to prioritize the demands of industrial consumers over the basic needs of the poor, urban and rural populations and small farmers, who have very different infrastructure needs. That they tend to entrench the power of vested interests and encourage corruption rather than democratic control. The gender implications are drawn out in relation to women's access to cooking energy, where the report finds that from 2000-2008, less than 1% of the World Bank's investments were for cooking and biomass energy, both in Africa and globally. The report recommendations are to massively scale up financial and policy support for decentralized infrastructure projects such as water and energy.An ActionAid (2011) study supports similar findings in the case of India. According to the report between the years 2002 to 2009, the addition of over 33,000 megawatts of coal-fired power plants and large hydropower, only marginally increased the number of electrified villages, that is, 18,000 villages, and improved overall electrification by only 5 percent. The study finds that the addition of electricity generation from conventional power plants has not sufficiently addressed the issue of electricity access for the rural poor. The study identifies pico, micro and small hydropower, solar and wind hybrid systems and solar home systems, biogas for household scale digesters and small scale biomass gasifiers, as particularly appropriate for off-grid rural areas. These technologies can provide for lighting and small electric needs, pumped water, small and micro-enterprises and clean cooking, thus contributing to reducing women's labor time on household chores, improved health due to reduced indoor air pollution and women's income generating activities.

According to Verzola (2007) small-scale decentralized community managed energy systems, are more consistent with the ideals, principles and practices of democracy, and are more open to transparency and accountability mechanisms and processes and are therefore less prone to corruption. Versola argues that highly centralized energy system modalities are mutually supportive of the vested interests of those who control highly centralized economic and political power. Given the problems of corruption associated with large-scale infrastructure projects, community managed systems for example, are more open to transparency and accountability mechanisms and processes and are therefore less prone to corruption.

Chow (2003) speculates that rather than adopting a system with large central-station power plants generating electricity and distributing it over long distances, developing countries, especially the poorest, can leap over stages by adopting smaller and less capital-intensive micro-turbines and renewable sources of electricity generation such as biomass, wind, and solar that are closer to the point of use. He compares it to the phenomenon where the developing countries leaped directly to cellular communication bypassing the paired-copper-wired grid telecommunication systems that characterised telephony in the industrialised countries. While these applications will bring with them their own particular sets of problems, it will also help the developing countries avoid others.

F. The energy transition and disruptive technology

There is a consensus among scientists that a transition to carbon-free energy is essential for human survival. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992. The agreement negotiated by representatives of 196 state parties at the 21st Conference of the Parties of the UNFCCC in Le Bourget, near Paris, France, and adopted by consensus on 12 December 2015, known as the Paris Agreement, set targets for emmissions reductions aimed at restricting the rise in average global temperature to 1.5°C relative to the pre-industrial level.

While there is debate on whether the targets set are adequate to achieve the aim, a rapid transition in energy technology is required.

What are termed 'disruptive technologies' are important in this transaction. The concept of disruptive technologies has gained wide currency, starting with the revolution in information and communications technology and the radical changes this brought to economics and society. 3-D printing, autonomous vehicles, genomics and "the internet of things" are among the technologies predicted to bring about similar disruptions.

Renewable energy is a disruptive technology. Of course, the results of keeping fossil-fuel based energy would also be disruptive – but in an entirely negative way. Combining renewable energy with other disruptive technology has the potential of achieving the energy transition while at the same time creating other positive changes, including in gender equality. A key disruptive technology in this regard is the "smart grid".

G. The Smart Grid

A smart grid is an electrical grid that includes various operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electric power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.

A smart meter enables two-way data transfer between the customer and the distributor; data examples are electricity consumption, electricity production, tariff options (time of use), and grid health.

Grid integration of renewables and fault tolerance are integral to the smart grid operation. Ideally, a grid could be powered entirely with renewable sources and battery storage, or, as we might expect, could work with base loads as load followers or as a base load with load followers (or some other combination). Fault tolerance involves fault detection and self-healing; this can mean that if a fault is detected, the fault area can be isolated from the grid and operation can continue.

All of these ideas contribute to the definition of the smart grid; however, this definition is ever changing and so we need to maintain flexibility in our future visions. Essentially what we are looking at is power production and distribution in a modern world where innovations in communications, controls, measurement, sensors, automotive, renewable energy, and many other areas, technical or not, will govern its structure and operation.

Smart grid incorporates smart end use based on home and community area networks, rooftop solar (RTS) PV systems, smart metering and control systems in households, and electric vehicles. Smart end use presupposes end user education and participation both in urban and nonurban settings.

In general, smart grid provides opportunities for GESI integration in the following key aspects: (i) demand management in households and community; and (ii) mini-grid-based systems with GESI-inclusive consideration related to women's participation as producers and entrepreneurs, managers, technicians, and consumers.

The experience in Europe has shown that the main motivational factors winning consumer support for smart grids are environmental concerns and control and reduction of electricity bills. Interestingly, environmental concerns are a greater motivator than the control and reduction of electricity bills. Successful projects have involved proactive consumer engagement strategies. A major concern has been privacy and data retention.

Smart grid – Assumptions & Risks:

- Consumer willingness to pay
- Low levels of consumer engagement
- Consumers willingness to change behaviour patterns
- Utilities willingness to engage with consumers
- Uneven distribution of benefits – lack of IT access and literacy
- Consumers loss of control
- Loss of privacy

Smart grid – Benefits:

- Improving access and household electrification rates
- Enhanced environmental sustainability
- Lower electricity bills
- Increased resilience and therefore safety (reduction of hazard exposure, fewer emergency workers)
- More control ("empowering")

Opportunities:

- Solving the access problem
- Greater empowerment of end-user households and communities
- Decentralisation provides greater opportunities for diversity and inclusion in management/participation
- Employment generation
- Income generation through energy sales
- Reduce vulnerability of 'energy poor' (pre-paid meters and energy displays)

Smart grids bring in a new paradigm of active distribution that can change the role of the consumer, communities and society transforming "passive" users into "active" players – both as producers and consumers, or "prosumers".

Smart grids enable **Community Energy Systems**
(i) citizens running projects through communities, such as cooperatives or development trusts;
(ii) a cooperative, democratic, or non corporate structure in which individuals participate actively in decision-making;
(iii) tangible local benefits to women and men living or working close to projects;
(iv) profits returning to the community or being reinvested in other community energy schemes.
(Source: IRENA, 2016)

This can help build **Resilient Communities:** "The capacity of communities to cope with and recover positively from disasters, learning from such stress, activating their inner resources and performing better in future in the face of adversity." (Source: Pierluigi Mancarella. 2017.)

H. Policy and regulatory framework

Tariffs
A study examining electricity tariffs in six countries of South Asia: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka finds that the lifeline block of an increasing block tariff appears in most countries to be the only instrument to implement socially inclusive tariffs. The lifeline block (or blocks) is arbitrarily defined, with no significant analysis of its relevance in meeting the basic needs or the channel to reach its intended target beneficiaries. Improved analysis of impacts, such as providing more information on who pays for the subsidies, analyzing and presenting subsidies (and surcharges) in regulatory documents, and indicating the subsidy amount in the bills issued to customers, would assist the overall process of delivering relief to socially disadvantaged customers.

The performance of lifeline tariffs in reaching their implied or defined objectives is weak due to (i) limitations in defining what the lifeline quantity of electricity is, (ii) poor targeting of the subsidies received, and (iii) shortcomings of the governments in meeting the subsidy payments to utilities. Cross-subsidies within the electricity sector (i.e., charging other customers higher than what it costs to supply electricity to them) is the most common way of meeting the social objectives of tariffs.

Some governments pledged a direct, well-calculated subsidy to customers through utilities, and honored and paid the subsidies so pledged.

Studies in many countries, especially those with very low connection rates (e.g., in Africa) as well as those with high (almost 100%) connection rate (e.g., Sri Lanka), have shown that customers cannot benefit from lifeline tariffs because some simply cannot afford the cost of house wiring and the cost of connection to grid. In countries with lower connection rates, the reason is widespread poverty. The economic cost of extending the grid would not yield its intended benefits, unless such projects are accompanied by a mechanism to support house wiring and to pay the electricity connection cost.

The results indicate that regulatory reforms have been implemented in all countries, with varying degrees of analysis, depth, and success. All countries have a regulatory commission or an equivalent arrangement. Tariff filings and determinations are regular in some countries, but occasional in others. Electricity utilities are increasingly required to be technically and financially independent; most countries have unbundled the vertically integrated utilities to separate corporate entities.

Country subsidies varied from (i) 100% free electricity to rural households in Bhutan, (ii) free electricity to households with handlooms and power looms, and (iii) up to 5% subsidy for small industries in Tamil Nadu.

In Tamil Nadu, the special tariff for handlooms (free electricity to households with handlooms and power looms) and up to a 5% subsidy for small industries are expected to be serving the female-dominated industry and trade in woven fabrics. In Sri Lanka, gender balance is adequate at formal vocational training registration (within 40% at technician training levels), but women lag behind men in enterprise-based craft training. The reasonable gender balance indicates that a share of subsidies granted to small industries and some commercial customers reach women, directly or indirectly.
Special tariffs and subsidies that support cottage and small industries, and businesses—which in some countries are driven by women entrepreneurs and have women as majority employees—would directly benefit women and assist in empowering women.

All over South Asia, there is societal expectation that electricity should be subsidized, judging from various statements of political and administrative authorities; and objections from customer groups often appear in the press when subsidies are proposed to be withdrawn or reduced. Pricing electricity by purpose rather than by voltage is widespread throughout South Asia. However, pricing of other commodities including other forms of energy (e.g., gasoline, diesel, gas) and utility services (e.g., water, telecommunication services) is largely accepted by society in terms of place of delivery and quantity delivered, with no reference to the purpose for which the service is used or to the income level of the buyer.

Policy and regulatory environment for renewable energy development
Among South Asian countries, India, Nepal, the Maldives, and Sri Lanka positively encourage renewable energy development through net metering schemes that are open to any type of customers, including households. India allows customers to connect net metered renewable energy-based systems to the grid through the customer's own existing electricity connection. For example, Gujarat allows up to 50% of contract capacity to be connected as net metered facilities, while Andhra Pradesh imposes a limitation of 1 MW per customer. Tamil Nadu specifies that a solar PV system capacity should not be more than the approved load of the service connection. "It is also advisable to have a solar PV system size that has an annual estimated generation of not more than 90% of the estimated consumption," states the guidelines for Tamil Nadu. Similar arrangements exist in many states of India.

Sri Lanka has allowed net metered solar PV since 2008 for renewable energy-based electricity production, and has achieved a capacity of about 40 MW by end 2016. Customers are not paid for any surplus energy banked on the grid, which will be returned to customers whenever required over the 10-year contract period (on a one-to-one basis with no banking fees). Customers with net metered renewable energy have now reached about 8,000, about 0.1% of the total customer base. In late 2016, the government announced an enhanced scheme, in which surplus energy can be sold to the grid at SLRs22 per kWh for 7 years, and at SLRs15.50 per kWh over a further 13 years. Additionally, in case the customer wants to be a micro-power producer, a stand-alone solar PV system can be installed and energy sold to the grid at the same prices as above.

Examples of renewable energy opportunities for livelihood support

The Andhra Pradesh net metering announcement specifies that permission will be given to a group of persons to set up solar power projects up to 1 MW and will be treated as collective generation for supply of power to the households of each group member. Distribution companies will set off the above energy from the consumed energy of individual service connections, and the balance (either excess or deficiency) can be billed on a net metering basis.

In 2016, Sri Lanka announced a further concession for electricity to be sold to the grid, where a household may rent its roof space to a third party to develop solar PV facilities. The government issued guidelines for such ventures and even went to the extent of recommending the rental of SLRs500 per month to be paid by the developer to the owner for the use of roof space plus the payment of the customer's monthly electricity bill up to 60 kWh/month (Sri Lanka's lifeline+ consumption level). The guideline provides an opportunity for low-user households to earn an extra income; their electricity costs up to the _____ would be fully paid for 7 years. From the 8th year onward, the guideline states that 50% of the income from solar PV system should be paid to the household by the developer.

Community-owned renewable energy facilities

A similar initiative was proposed in Sri Lanka in the first wind park, where a block of 25 MW out of 375 MW was proposed to be designated as a "community wind block," where the local community would be invited to invest, arranged by a semi-government investment bank. The objective was to ensure that landowners and other local interest groups would not be left out of the benefits of the renewable energy source in the then remote area of the north-west, where wind resources are abundant. However, this proposal is yet to be implemented, while the first 100 MW of the 375 MW resource is now under implementation.

Subsidies: Nepal case

The data from Nepal shows a strong correlation (R ~ 0.9) between the technology deployed, measured in number of units as a percentage of the overall target, and subsidies disbursed, measured as a percentage of the budget allocation. This is an indication that targeted subsidies can significantly influence the uptake of technologies, especially in low-income and BPL communities.

The Subsidy Policy for Renewable Energy 2012 would have guided the implementation of the NRREP for the period that the data was collected.[4] The purpose of these policies is to address problems of differential access based on remoteness, gender, ethnic, caste, and other social inequities to promote the uptake of renewable energy technologies in rural poor communities.

Key social objectives of the Subsidy Policy for Renewable Energy 2012 are included in the following policy objectives:

[4] In 2016, a new subsidy policy replaced the 2012 policy.

- **Policy 7.1:** "To increase the access to the renewable energy technologies to low income households by reducing the initial upfront cost"
- **Policy 7.2:** "To maximize the service delivery and its efficiency in the use of renewable energy resources and technologies in the rural areas ... and minimize regional disparity"
- **Policy 7.3:** "To support use of energy for productive purpose thereby creating rural employment and enhancing livelihood of rural people particularly women, poor and socially excluded group, vulnerable community"
- **Policy 7.4:** "To ... reduce the growing gap of electricity supply, consumption between rural and urban areas"
- **Policy 7.7:** "To encourage rural households in the use of renewable energy services thereby contributing to better health and education conditions of people"

An additional subsidy category applies exclusively to socially disadvantaged groups such as marginalized castes and ethnic communities, as well as households headed by women.[5] For example, households in very remote communities connected to small hydro systems receive a subsidy of NRs20,000 and an additional subsidy of NRs2,000 if they are also headed by women. Solar PV pumps for pumping water, which are managed by the community, receive a subsidy of up to 70% to cover up-front costs. In the case of households headed by women, they qualify for an additional subsidy of NRs2,500. Single women wanting to start up or develop their small enterprises can receive an additional subsidy of up to NRs10,000, provided the enterprises use energy from renewable sources. Through the provision of such additional subsidies, the policy promotes a progressive system of subsidies, explicitly weighted toward enabling the most deprived, rural poor, and women to access renewable energy technologies.

The benefits of the microhydro programs include:

- Increases in household incomes by up to 52% in program areas, compared to the national average of 46%, over the same period;
- Improvements in childrens education, with an increase of approximately 0.6 years more schooling, completed by girls;
- Improved health outcomes, with a significant reduction in the number of hours suffered by women from respiratory ailments – almost halved, from approximately 9.7 hours per month, to 5 hours per month;
- Reduction in women's labour-time spent on household chores and in agro-processing, with savings of approximately 155 hours annually of women's labour time, from the use of mechanised electrical mills for pounding and grinding of grains.

Policy implementation

According to several AEPC staff members, "The biggest gap, is the translation of policy, in the field" (Raj Kandel, Engineer and Program Officer, Planning). Longwe (1997) has described this as a problem of "policy evaporation" in relation to gender-oriented policies 'evaporating' in the bureaucracy of international development agencies.

While the reasons identified by AEPC staff include institutional problems, such as the lack of capacity to implement the policies, there are other contributing factors which go well beyond such internal considerations. This includes the very low level of socio-economic development in remote communities. Other issues, broadly cover human resource management problems, such as the lack

[5] Households headed by women are referred to as "single women" in the subsidy policy.

of availability of skilled and experienced staff for recruitment and, once recruited, a high turn-over of skilled staff leaving for greener pastures, thus causing problems of staff retention.

I. Some conclusions

Technology is not purely technological. Technology is a social product. The process of creating and producing technology is a sociotechnical process, where men and women, organizations, culture and knowledge are combined. Gender is integral to this sociotechnical process. Technology shapes gender and gender shapes technology at every level. They are also historically contingent and context driven – situated in time and place.

While there is demonstrable evidence that energy services improve women‘s welfare, the question remains posed whether it transforms gender roles or leads to women‘s empowerment. Energy access itself is not necessarily sufficient and other contextual factors, such as policy and legal frameworks are needed to support women‘s empowerment.

There are multiple pathways to address gender equality considerations through energy provision and these pathways are inter-dependent and overlap. Increasing the economic worth of women‘s labor could be more conducive than other pathways to enable the transformation of gender relations – women‘s economic empowerment.

Energy system design and modeling should include a social pillar' as an important and even essential component of the system design. Gender equity considerations can be integrated into this social component.

Gender considerations in energy system design and modeling need to prioritize two important general criteria: (i) reducing or saving women‘s labor time spent on household chores, and (ii) support women‘s economic empowerment. These criteria can also be quantified.

Prioritizing women‘s time and economic empowerment criteria also necessitates integrated solutions. This includes a nexus' approach that links energy to water and sanitation, low-carbon transport and communication, among others, that is the basis for the development of smart communities'.

Disruptive technologies', such as smart and agile power systems driven by innovation in renewable energy technologies, based on distributed energy sources such as minigrids, can result in community energy' systems for smart communities'. These systems can simultaneously foster high-level technology innovation and provide solutions for inclusive energy access. They necessitate interoperability' with end-users, women and men, and are conducive to gender-inclusive processes.

Smart grid incorporates smart' end-use, based on home and community area networks, rooftop solar PV systems, smart metering and control systems, energy management systems and electric vehicles for urban transport and energy storage. Smart' end-use presupposes end-user education and participation both in urban and non-urban settings and are conducive to gender-inclusive processes.

Demand management and distributed generation – specifically microgrids – are important entry points for gender integration/mainstreaming in smart grid.

Small power producers are emerging as the backbone of new energy industries, such as the solar PV sector. With the right policy environment, strategies and plans, women and marginalized groups can be enabled to participate in these industries from their inception.

Technology innovation is enabled by the policy and regulatory environment. This includes financial assistance and tariff incentives to promote technology uptake, especially in BPL, women and marginalized communities. Social criteria – including gender and social inclusion criteria -- can be effectively integrated to promote technology uptake.

The collection of technology data needs to reflect the energy transition from the old grid to the new one. It needs to have a greater focus on information relevant for distributed generation, in both on and off-grid systems. This requires accurate information at the community and household level and for small power producers.

There are big technological and social challenges in energy system transition. Low-carbon technologies bring challenges and opportunities. We need to rethink engineering modelling so as to incorporate socio-economic aspects and develop comprehensive socio-technical operational and planning frameworks. Social aspects need to be incorporated into techno-economic models.

Resilience to climate change needs to be integrated in planning from a socio-techno-economic perspective.

The energy transition potentially provides important opportunities, including for promoting gender equity and social inclusion.

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