

Green energy for development in Nepal

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In their outline of ongoing rural electrification in Nepal, the three authors note that the country is endowed with large amounts of renewable energy resources but still trapped in imports of fossil fuels, a major drain on the national economy. They argue that the ongoing process of rural electrification is progressing well but unevenly and that challenges lie ahead for reaching the poorest communities. The authors call on government agencies and donors to consider strengthening credit opportunities for renewable energy at the local level. They say that market-based rural electrification mechanisms can function well in least developed countries, subject to understanding the peculiarities of the local demand, anchoring efforts on locally available human and natural resources and creating mechanisms of support to improve affordability.

Green energy for sustainable development

Poor countries have a pressing development agenda. Although increased understanding about the role of energy for promoting sustainable development has led to many policies for electrification in developing countries, orchestrating the energy transition from traditional to modern and more efficient energy technologies and services remains a major challenge both nationally and globally. In fact, energy provision to large poor populations can be a difficult and costly proposition with negative environmental impacts unless coupled with strategies to trigger socio-economic development.

How can the green agenda contribute to address this challenge? The green economy is understood as a key element in sustainable development, one that requires addressing whole production, exchange and consumption chains, and transforming them into resource-efficient and environmentally-sound processes over time. This is a major task that stretches from local to global levels of action. On the other hand, promoting sustainable development in the face of major national needs requires activating weak markets and boosting jobs and incomes, often within a context of precarious institutional set ups, constrained financial resources and stringent global competitiveness. Thus, the promotion of the green economy and sustainable development requires the identification of strong entry points that can satisfy multiple agendas at various scales at the same time.

In other words, actions need to be simultaneously pro-development and pro-environment. There need not be a contradiction between the two as long as local potentials and needs are understood and taken as starting points. Energy provision, for example, can serve both national and global agendas if solutions with low environmental impacts are put into practice to provide energy services for productive activities that can boost local economies. Electrification efforts in Nepal serve to show that markets for renewable energy technologies can, in fact, be created in remote and poor areas. At the same time, bottlenecks constrain the production and use of renewable fuels in the transport or generation of bioelectricity within the context of significant opportunities for ethanol production, agricultural modernisation and local-based electrification solutions. Support from the international community can help address these bottlenecks.

Electricity provision in Nepal

Nepal is among the poorest and least industrialised countries in the world, with nearly one third of the population still living below the country's poverty line. It is a land-locked country with a population of 28.6 million inhabitants. Globally, the country is mostly known due to Mount Everest, the highest mountain peak in the world. Nepal is basically an agrarian country with more than 80% of the population living in rural areas. According to the Asian Development Bank, Nepal has the highest Gini-Coefficient in South Asia (0.47), indicating large income inequalities (ADB, 2011).

Nepal's per capita energy consumption is one of the lowest in the world. A Nepalese citizen consumes 14.28 GJ/year (measured in total primary energy supply), or only 6% of the energy consumed by the average Swedish citizen (IEA, 2010). More than 56% of the total population lacks access to electricity. However, the pace of electrification has increased significantly along with the introduction of specific support programmes and policies. Access to electricity has increased from 15% to 44% in the last 15 years.

Market-oriented policies for renewable-based off-grid technologies have been used as a mechanism to promote rural electrification in Nepal. This has resulted in an expansion of the rural electrification market based on renewable energy (RE) such as micro/mini hydro and solar photovoltaic (PV). Along with increased market size, entrepreneurial forces have been triggered and the number of installation and manufacturing companies, as well as non-governmental organisations (NGOs) working in the RE sector has doubled in the past 10 years. The experience of Nepal shows that it is possible to mobilise private finance and small business under a strong umbrella of public coordination to create markets for renewable energy even in poor remote areas of developing countries (Mainali, 2011).

RE-based off-grid electrification in Nepal builds upon the country's high availability of natural resources. The definition of rural energy subsidies and delivery mechanisms, the periodic revision of subsidy policies (revision 2000, revision 2006 and recent revision 2009), the rural energy policy 2006, and the exemption of import tax and value added taxes (VAT) on RE equipment have been instrumental in the development of RE-markets. Subsidies have served to channel demand towards solar home systems and micro-hydro solutions by making them more affordable to villagers. There has also been an increase in the local equity share invested in renewables over time. Thus remittances from Nepalese expatriates seem to be playing an important role in the electrification process. However, remittance flows are intertwined with the global economy and, as such, could be reduced in the face of financial downturns, constraining the pace of rural electrification. In this context, the limited availability and access to affordable credit for electrification remains a major challenge (Mainali and Silveira, 2011).

Distributional analysis of rural electrification in Nepal has shown that, after the introduction of solar PV in 1991, electrification coverage has grown significantly. Analysis has shown that off-grid rural electrification in general, and solar home systems in particular, helped overcome some of the economic constraints of extending transmission lines, thus speeding up the electrification process. However, analysis has also revealed that only parts of the population have been supplied, the technology distribution is uneven, and real challenges remain ahead if the poorest are to be reached. Therefore, in the long run, government agencies and donors should consider strengthening the credit opportunities for renewable energy at the local level. In addition, a decentralised and more efficient subsidy delivery could better spread the benefits of subsidies, ultimately helping intensify the electrification process.

The institutional and regulatory frameworks supporting the formation of RE-markets are evolving, and the peculiarities of the market are increasingly understood by policy makers and market players operating in rural areas. Adjustments are needed with the purpose of intensifying the electrification process and alleviating poverty throughout the country. Our studies have shown that the market-based rural electrification mechanism can function well in least developed countries. For that, it is necessary to understand the peculiarities of the local demand, and to anchor efforts on locally available resources, both natural and human capital, as well as to create mechanisms of support to improve affordability.

Renewable transport fuels and bioelectricity – an untapped opportunity in Nepal

Commercial energy amounts to only 12% of the total energy consumed in Nepal, and consists of fossil fuels (i.e. petroleum and coal) and grid connected electricity, especially from large hydropower plants. The other 88% consists of traditional energy sources, basically biomass. The contribution of electricity in the primary energy share is only 1.8%. Although the use of modern renewables (i.e. biogas, micro-hydro, and solar) increased approximately three-fold between 1999 and 2009, it has a negligible share in the total consumption (less than 1%). Nepal does not have fossil fuel reserves. Therefore, petroleum and coal are imported, placing a huge burden on the national economy. The government has refrained from passing the full costs of oil imports to the users due to potential political unrest.

A major untapped opportunity remains that can help Nepal address energy security and costs in transport as well as intensify the electrification process with bioelectricity. The transport sector is the largest consumer of petroleum products. Two major renewable fuel options are at hand to improve the energy base of the transport sector: one is based on the huge potential to generate electricity from hydropower; the other is based on bioethanol from molasses.

Battery-operated electric vehicles (3-wheeler) are already in use in the Kathmandu Valley and can continue playing an important role if electricity generation capacity expands and is used to charge batteries. Nepal is one of the countries with the highest hydroelectricity potential per capita in the world. Yet the expansion of installed capacity of hydroelectricity has progressed at a very slow pace. Nepal has added only 507 MW hydropower capacity to its matrix (from public finance) since the 1950s against a development target of 3785 MW (i.e. 13.4% of the target). Electricity demand is increasing at an average rate of 10% per year and Nepal produces less than half of its needs in the dry season when not enough water is available for electricity generation. As a result, the country is at present facing a huge crisis of electricity supply.

The second option is related to the immediate potential that exists in Nepal to produce ethanol from molasses to offset the use of gasoline. Nepal produced 2.6 million tonnes of sugarcane in 2006/07 using 64 thousand hectares of land. Approximately 70% of the total sugarcane produced in the country is used in sugar manufacturing, thus 1.8 million tonnes of sugarcane are presently available for sugar mills. With that, Nepal can immediately produce 18 million litres of bioethanol annually. The production would be based on molasses, a bi-product, thus not compromising the production of food products (i.e. sugar and traditional sweeteners).

The Government of Nepal has already decided, in principle, to blend 10% ethanol in petrol. Yet, this has not been implemented due to technical, economic and institutional problems. Kathmandu Valley consumes 70% of the gasoline imported to Nepal, or 71,338 m³ annually. Most light vehicles (cars, jeeps and vans) use gasoline and a huge fleet of two-wheeler motor-bikes also consume gasoline. Using E10 in the Kathmandu Valley, Nepal can save 4,860 m³ of gasoline per year, which equates to a reduction of 6.8 % in gasoline imports and significant savings for the country. As much as 14% of import reduction is possible if vehicles go for E20. The use of E20 in the Kathmandu Valley would equate to direct savings of USD 10 million (Silveira and Khatiwada, 2010). The introduction of E20 can contribute towards avoiding 23,397 tonnes of CO_2 emissions, which is 14% of the total annual emissions from gasoline (2006/07).

Exploring synergies to provide energy and promote sustainable development

The agricultural sector employs 74 % of the labour force in Nepal (CBS, 2008). The increase in sugarcane production observed in the last decades was mainly the result of expansion of planted area, while improvement in yields was only marginal. The average cane yield in Nepal is only 40.6 tonnes per hectare. In comparison, sugarcane yields in India reached an average of 68.2 tonnes/ha in 2001/02. In Brazil, sugarcane productivity is steadily increasing and yields already surpassed 80 tonnes/ha in 2004. There is potential to increase yields significantly in Nepal, subject to innovation practices which are well-known and proven in agriculture.

In recent studies, we have developed the entire life cycle analysis for the estimation of energy and greenhouse gas (GHG) balances of sugarcane-based bioethanol in Nepal: energy (fossil and renewables) and material flows inventory from sugarcane farming (human labour, irrigation, and fertilizers/chemicals), transportation, sugar cane milling, fermentation, distillation and dehydration and treatment of wastewater have been analysed for the production of anhydrous ethanol (Khatiwada and Silveira, 2009 and 2011). Bagasse as a source of renewable energy is used to generate heat and electricity required for sugarcane milling, distillation and dehydration processes.

Molasses is converted into anhydrous ethanol fuel (EtOH). Distillery waste water effluent is treated prior to disposal, generating biogas which is later fed as fuel into the boilers. Overall, analysis indicates that the production and use of bioethanol as transport fuel reduces life cycle GHG emissions compared to conventional gasoline. In addition, analysis shows that significant improvements can be achieved in the total energy balance of bioethanol production if modern technology processes are properly applied and better synergies for multiple services are implemented.

At present, sugar industries in Nepal are self-sufficient in energy requirements. However, excess bagasse can be used to provide surplus electricity to replace dieselpowered electricity to local industries. With more efficient use of bagasse and cane trash, surplus bioelectricity can be generated also to promote electrification in the country. The evaluation of one sugar mill in Nepal showed that 17% excess bagasse is available at present, after internal energy requirements are met (Khatiwada and Silveira, 2009). Improvements based on readily available knowledge and technologies can further enhance the energy exchange and gains of the land and biomass resources available in Nepal. Overall, there is a large potential for improvements along the sugar-ethanol production chain including: **(a)** modernisation of agricultural practices and improvement of cane yields; **(b)** efficient use of cane bagasse and trash to generate bioelectricity; and **(c)** upgrading and optimisation of industrial operations.

Another important synergy that can be achieved with the use of bioelectricity is related to the possible complementarity with hydropower. Most hydropower plants in Nepal are of the run-of-the-river type. This means that they are subject to seasonal river flows, and cannot provide electricity in their full capacity in the dry season. Nepal can hardly afford to run thermal plants with imported fossil fuels. In any case, this would not be a sustainable alternative. Lack of proper infrastructure is the cause of frequent power shortages and blackouts which are detrimental to the development of the country. Financial resources are needed to plan and develop the necessary infrastructure and better utilise the country's hydroelectric and biomass potential.

Installation of high pressure boilers and turbines in sugar mills, replacing inefficient low pressure turbines, would open opportunities to supply additional electricity to the grid. Since the dry season and the period of operation of the sugar mills coincide, the complementarity of the two sources is evident. For instance, 313 GWh of surplus electricity could have been sold to the grid in 2006/07 (Khatiwada et al., 2011). Instead, 329 GWh were imported from India in the same year (NEA, 2010).

This means that bioelectricity could cover about 35% of the total electricity demand during the sugarcane crushing period (dry season or 150 days between December and May), equivalent to 95% of the electricity imports from India. With demand for electricity increasing rapidly, it is important to make sure that sustainable alternatives are chosen as new investments are made to expand capacity. Proven technologies based on abundant natural resources available in the country are low-risk attractive options.

Matching local and global agendas

Nepal is a country endowed with large amounts of renewable energy resources, providing a significant opportunity to develop a sustainable energy system. Unfortunately, the country is still trapped in imports of fossil fuels. Fossil fuel costs have become a major drain on the national economy, compromising political stability and development. Consequently, immediate societal and environmental gains can be achieved by using renewable alternatives to provide energy services and build a solid basis for a green economy in the country.

By using natural resources wisely, with technologies that are readily available, Nepal can pursue development while also shifting its economy towards more environmentally sound paths and contributing to the global green agenda. For developing countries, finding alternatives based on local resources means not only the opportunity to increase energy security but also to develop local economies and improve the trade balance. From regional and national solutions, there will also be opportunities for expanding towards global solutions as green international markets expand.

Many opportunities for sustainable solutions to meet energy needs exist in Nepal. Biomass, solar and hydropower can all contribute in different ways to meet energy requirements, while also triggering modernisation in agriculture and industrialisation, and increasing energy security. There is no contradiction between the energy options that are attractive to the country and the goals of developing a global green economy from the energy point of view. In addition, recent experiences in the country indicate that poverty can be reduced through the formation of markets for green technologies for electrification.

One of the Millennium Development Goals is to develop a global partnership for development. The role of donors is key in this context, for example, helping developing nations focus on renewable solutions, bridging financial constraints, facilitating institutional development and improving technology affordability. Nepal and other LDCs are largely dependent on development aid, so it is important to sensitise donors about the potential that these countries have and the specific context in which technologies are to be deployed.

Awareness about RE-technologies and willingness of people to invest and pay for electricity has increased significantly in the past years. However, there is still a huge financial gap between the cost of electrification and its affordability to the poor. Bridging this gap is a crucial issue that needs to be addressed for the smooth expansion of rural electrification. In addition, access to electricity in itself is not sufficient to bring about rural economic growth – a supportive environment for productive activities is also needed. This is better achieved by exploring synergies between energy and other productive activities.

By exploring its bioethanol potential, Nepal can address multiple problems to improve energy security and reduce reliance on imported fuels, control local and global environmental impacts, while also triggering the modernisation of agriculture and improving the total efficiency of its energy

system. Residues from the sugar-ethanol industry can serve to further promote electrification in the country. Favourable governmental policies, proper institutional mechanisms and coordination amongst concerned stakeholders, including private and public sectors, are required to guarantee a sustainable energy path. Both the political and institutional concerns have become the most urgent issues to address at this stage when mature conversion technologies are already available and accessible.

Conclusions

Not only are the poor outside food markets but many have limited access to basic services such as education, health and energy. Properly applied to the benefit of development, the environmental and green economy agendas can make clear contributions to employment generation and the formation of markets for green technologies. Examples can be found in the energy sector. By exploring the potential for biofuel production that exists in many developing countries today, significant fuel substitution can be accomplished in the transport sector while also creating conditions for increased electricity generation.

Energy access can play a role and become a vector to promote sustainable development in developing countries while contributing to the shift towards a global green and low carbon economy. The story of Nepal illustrates that well. The story is similar in many other poor countries in Africa and Asia that are dependent on oil imports. Agriculture needs modernisation, not least to produce more food; industries wait for a dynamic push of markets; and large populations need jobs, income, electricity and transport fuels.

Many LDCs are strongly dependent on development assistance to reform institutions, make infrastructure investments and support the generation of markets. Donors often operate through projects and are increasingly emphasising global agendas. By strengthening the multiple objectives of projects and the links with local and national contexts, better momentum can be achieved. Planning for social, economic, spatial and environmental balance simultaneously is crucial for correcting distorted processes of regional degradation and turning them into processes of sustainable development. Turning the energy sector green and increasing energy access are essential steps in these processes. Clean energy provision is a central element of the green economy, which needs to be simultaneously pursued nationally and globally ◂

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