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SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY INTEGRATION (SARI/EI)

Economic Benefits from Nepal-India Electricity Trade

South Asia Regional Initiative for Energy Integration

Executive Summary

May 2015 – September 2016

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Preface

We are happy to present the “Economic Benefits from Nepal-India Electricity Trade” report with long-term perspectives, carried out under the South Asian Regional Initiative for Energy Integration (SARI/EI) project of USAID. It was felt that macroeconomic benefits of the power trade can help to bring wider consensus among power sector experts, economists, financers and policy makers. We had many stakeholders’ discussions and focused group discussions with electricity planners. It was a painstaking and novel exercise where the power system models of two countries were linked during seasons and peak and off-peak hours on one day of every month to capture the compatibility for trade. It assesses the scope for trade and gain to both the countries. This gave us very different insights than doing it once based on annual overall demand and supply. We also linked this to the macro models of each country to capture macroeconomic benefits, especially to Nepal. Our aim was to see if Nepal could transform its economy as Bhutan did and reach another level altogether in less than two decades.

Before the modelling work, the expectations were that India could always accommodate Nepal’s exports from hydropower. However, now it seems that Nepal will go through a long phase of importing from India during the construction stage of hydropower plants, before exporting.

We are now encouraged to also link Bangladesh and India. We intend to complete the Bangladesh–India exercise and link it to the Nepal–India exercise. This may transform the economies of the two countries and make a case for regional integration among BBIN (Bangladesh, Bhutan, India and Nepal). The link can be extended to the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) involving countries along the Bay of Bengal.

We are grateful to the USAID for supporting this fascinating modelling exercise. I am grateful to our Nepalese, Indian and USAID colleagues who assisted our work. I thank the IRADe team that worked diligently, enthusiastically and relentlessly for many months.

Jyoti Parikh

Professor Jyoti Parikh, PhD
Executive Director, IRADe

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Executive Summary

The Integrated Research and Action for Development (IRADe) under the ongoing South Asia Regional Initiative for Energy Integration (SARI/EI) programme sponsored by the US Agency for International Development (USAID) has attempted to analyse the impact of the Cross-Border Electricity Trade (CBET) in the South Asian region. The study, "Economic benefits from Nepal–India electricity trade" is first such effort, while analysing the other countries in the region with a possibility of forming a power pool is in the pipeline.

Hydropower is one of the few of Nepal's resources, which remains primarily unexploited. While development of hydropotential and electricity trading with India has benefited neighbouring Bhutan significantly in its socioeconomic development, *electricity trade between Nepal and India can benefit both the countries. Nepal can gain by developing its major resource, hydropower potential, for which it will have a market and export earnings can boost its economy and human well-being. India, on the other hand, can promote renewable energy sources like solar and wind power whose intermittency can be balanced by import from Nepal's flexible hydropower.*

The IRADE study assesses the time-dependent potential power trade and the price of tradable electricity over the period 2012–2050 consistent and sustainable with the country's macroeconomic framework. It also quantifies and analyses the socioeconomic benefits of CBET (arising from investment, export revenue, reduced electricity price) between India and Nepal taking into account its macroeconomic response. All costs in the study are at 2011–12 prices, unless stated otherwise. The study is designed to answer the following key questions, which would interest a range of stakeholders (policy and decision makers, planners, investors and so on):

- How much electricity can be traded, at what mutually agreeable price and during what period of the year?
- What would be the impact of trade on living standard measured through per capita consumption levels?
- How would per capita electricity use change?
- What would be the impact on capacity creation and investment potential?
- What are the macroeconomic benefits to Nepal and India in terms of growth in GDP, investment (in rest of the economy) fuelled by impact from electricity trade such as export earnings and investment in the sector?
- What are the consequential environmental benefits?

To answer these complex techno-economic questions, the study developed a modelling system, which deploys two types of models with a 30-year perspective: power system model that balances demand and supply on an hourly basis and a macroeconomic model that factors in the impact on various sectors of the economy and its development. Iterative linkage between these models produces consistent solutions. The modelling system is used to analyse three scenarios. The BASE scenario assumes no increased interconnections across countries beyond what are currently in place (as in 2011–12), therefore each country independently makes its own capacity investments to satisfy its projected demand profile.

The Accelerated Power Trade (APT) scenario allows full potential of electricity trade. A scenario, Delayed Capacity Addition (DCA), on delay in hydropower project implementation by five years in Nepal due to delays in decisions to initiate projects and their implementation has been developed as well, since delay may not only postpone the earning from exports, but may even increase the imports until the projects are implemented. We compare the results of the APT scenario with the BASE scenario to quantify the macroeconomic benefits of trade and compare the DCA scenario with the APT scenario to assess the cost of delay. Key findings of the study are highlighted here separately for Nepal and India.

Nepal

Electricity trade with India would help Nepal to develop its hydropower potential and export electricity to India. The study demonstrates that a large economically feasible electricity export potential exists. Nepal also makes substantial economic gains from the trade. Given the long construction period of the hydropower projects, export starts only from 2025. Since investment on hydropower plant construction starts before or around 2020, electricity demand increases resulting in higher electricity import during 2020–25 in trade case. Nepal will export 18 bkWh in 2025, which steeply rises to 93 bkWh by 2035 and then flattens out from 2040 at around 115 TWh as its domestic consumption increases. In the DCA scenario, exports are also delayed, but grow rapidly. It may be noted that India needs to import electricity from Nepal even after its own hydropower potential of 145 GW is fully utilised.

In terms of capacity, in 2030, maximum 13 GW could be available for export during the rainy season or post-rainy season months in the evening, which is also the peak hour in the Indian power system. In the dry months, export falls. Available export capacity almost doubles in 2045. Peak load capacity requirement in the Indian system is substantially high, so contribution from export in 2030 and 2045 is less than 5%. However, it would still reduce the investment in peak capacity in India and peak could be met at lower cost than the options available in India. More importantly, as India would likely have large solar PV in the system supplying capacity in the evening, exported capacity helps to counter the intermittency. The export earnings for Nepal are substantial at NPR 310 billion in 2030 and go up to NPR 1069 billion by 2045 (Table 1E). It comprises of around 5% to 6% of GDP, is as high as 25% of total investment in 2040 and is still 15% in 2045. Between 2030 and 2045, marginal cost of electricity export is in the range of 4.79 to 9.31 NPR/kWh and would be slightly higher in DCA.

Table 1E: Nepal's Export Revenue from Electricity Trade

	2020	2025	2030	2035	2040	2045
Net Revenue from Trade for Nepal: Export – Import (billion NPR)						
APT	-6	44	310	565	840	1069
DCA	0	-0.4	246	460	693	998

Power trade would supply electricity at cheaper price to the people of the importing country, and the exporting country earns export revenue. The study demonstrates some macroeconomic benefits and improvement in the quality of life. For example, power trade leads to significant growth in household per capita consumption, an indicator of improvement in well-being, with per capita consumption reaching a level of NPR 2,84,000 per person in 2045 at 2007–08 prices compared with the BASE scenario where it reaches NPR 2,30,000 per person.

Export revenue and investment contributes to higher GDP, which in the APT scenario in 2045 is 39% more over the BASE scenario (Figure 1E). With DCA, the gain is only 14% in 2045. This also shows how expensive even a five-year delay in capacity addition can be.

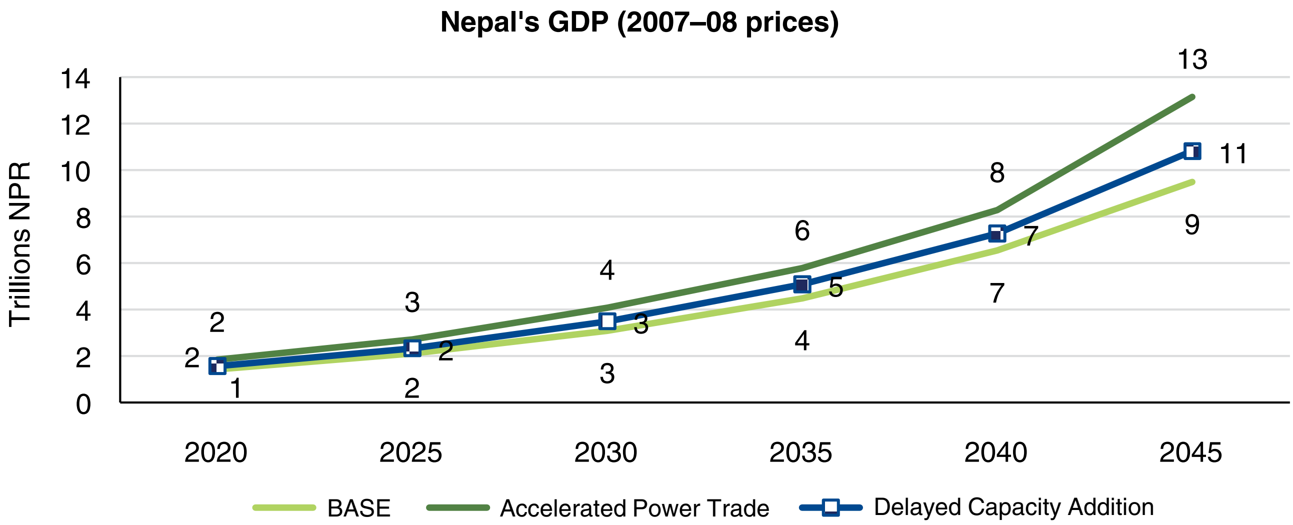

Figure 1E: Growth of GDP of Nepal

The per capita consumption of electricity correlates well with a country's social well-being as measured by the UN Human Development Index (HDI). An HDI of 0.8 or higher corresponds to almost 3,000 kWh per capita. Per capita electricity demand in Nepal was very low at 139 kWh/year in 2012, but grows to 1,010 kWh/year in 2045 in the BASE scenario (Figure 2E). With accelerated trade, as income and other indicators get better, so does per capita electricity consumption, which increases to 1,500 kWh/year in 2045, an increase of 49% over the BASE scenario. With DCA, the increase in per capita electricity demand is only 10% above the BASE in 2045, justifying the acceleration of the trade process.

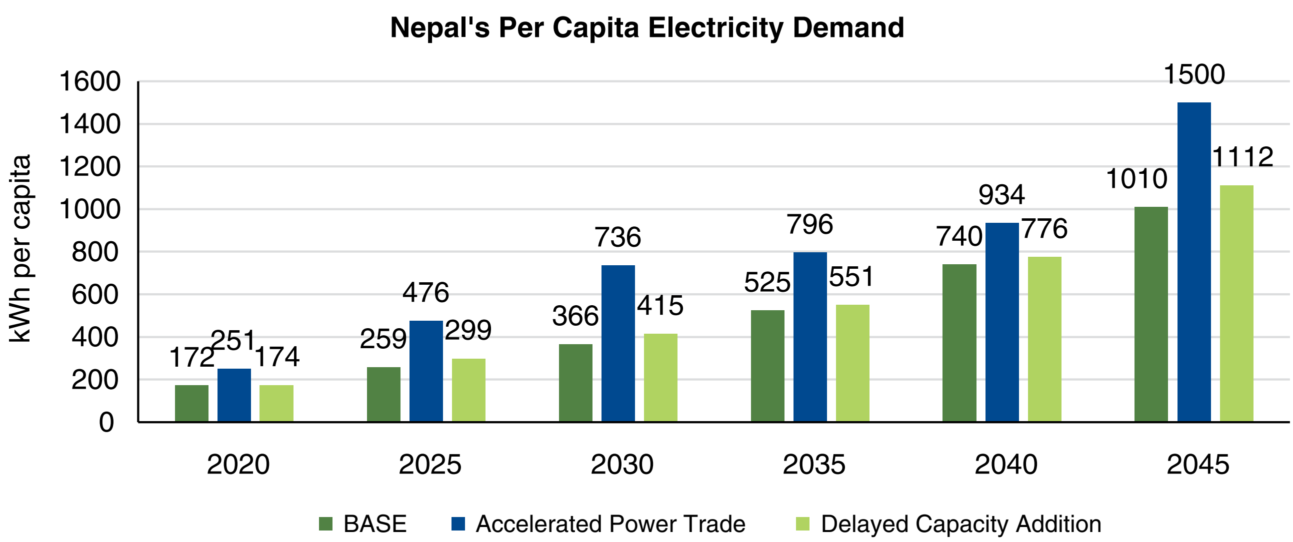

Figure 2E: Per Capita Electricity Demand

With the increase in domestic consumption and export, electricity generation in 2045 is many times higher at 202 bkWh with APT, as compared to only 42 bkWh in the BASE scenario and is almost entirely from the hydropower resources. This would lead to a huge increase in installed capacity build-up, 34 GW in 2045 in the trade scenario as compared to only 8.9 GW in the BASE scenario (Figure 3E). It should be noted that maximum capacity economically exploitable is assumed as 42.13 GW; however, 34.4 GW is macro-economically viable exploitable capacity, complying with the investment availability, Balance of Payment constraints of the country and so on. Notably, the bulk of the capacity in APT is in the form of ROR plants, which are easier and cheaper to construct.

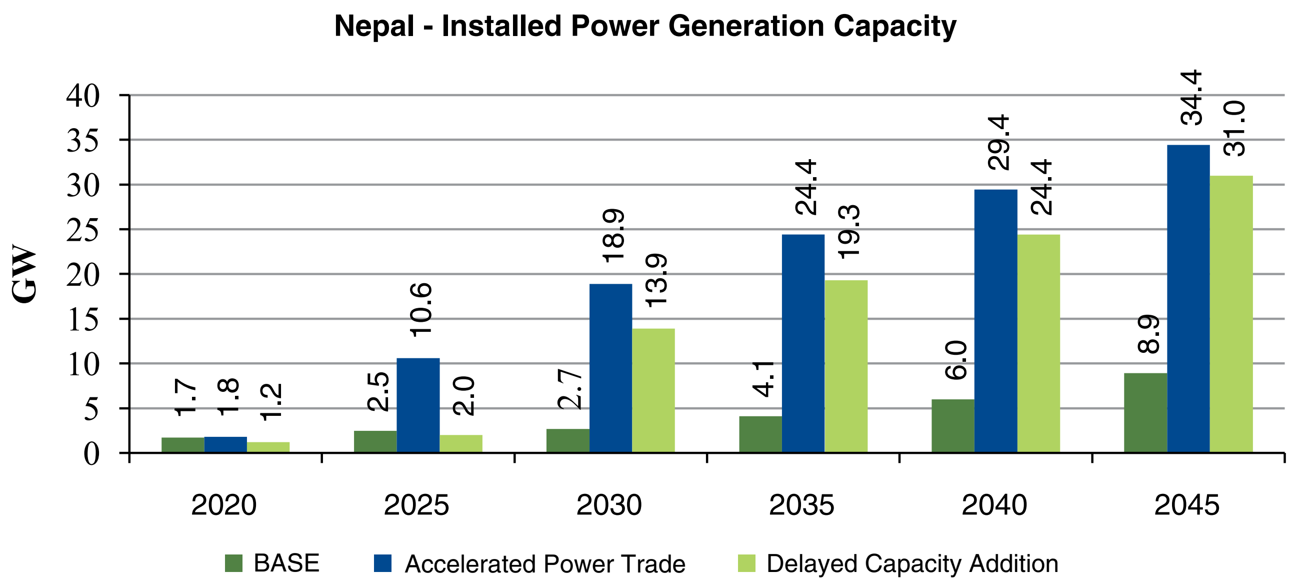

Figure 3E: Build-up of Power Generation Capacity in Nepal

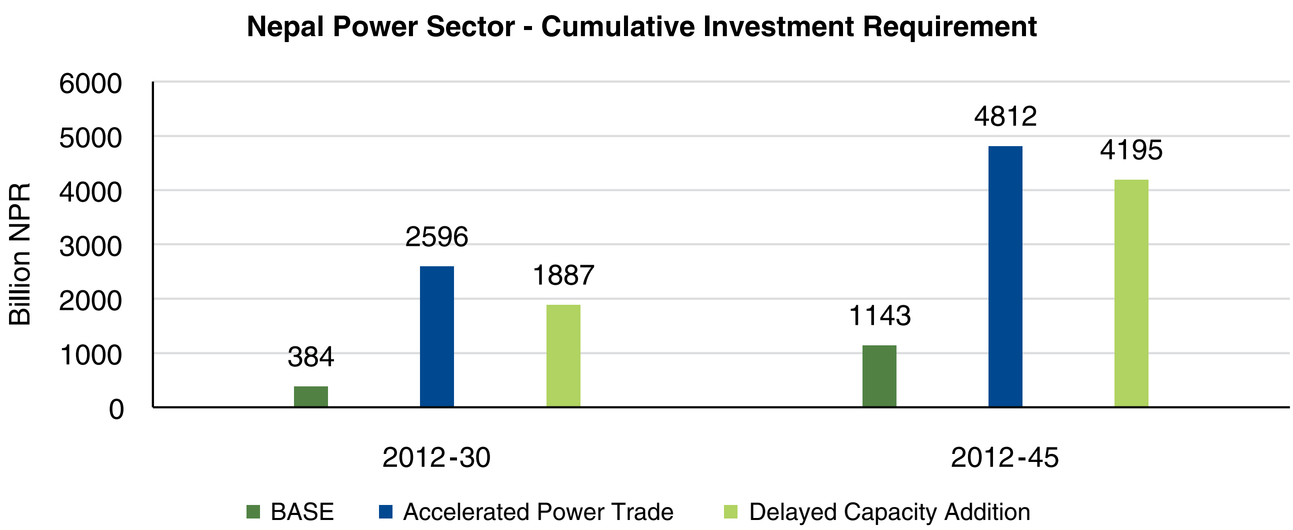

Figure 4E: Cumulative Investment in Nepal's Power Generation Capacity

Investment is important information for many stakeholders. Nepal needs cumulative investment of NPR 384 billion (US$ 5.4 billion) to build hydropower capacity over the period 2012–30 in BASE scenario (Figure 4E). Average annual investment requirement is NPR 21 billion. If we consider the period 2012–45, cumulative investment is NPR 1143 billion. As expected in the APT scenario, investment is many times higher at NPR 2,596 billion and NPR 4,812 billion, respectively, during 2012–30 and 2012–45. However, this much investment remains within the tolerance limit of all macroeconomic parameters in the country. Investment in delayed scenario is lower than in the trade scenario, but it is substantially higher than in the BASE scenario. Of note, a large part of this investment is foreign direct investment (FDI).

Another important effect is the structural changes of the economy with trade. The share of industry in GDP becomes 30% compared to 21% in the BASE scenario, indicating more industrialisation, therefore higher employment, technological modernisation, improvement in human skill and so on.

India

India is a much larger economy and the share of the power sector in GDP is insignificant. Moreover, import constitutes only 2–2.5% of total electricity generation requirement. Thus, trade consequences on India's economy would be relatively negligible; however, they do exist. More than macroeconomic gain, India gains in terms of lower electricity system cost, because India can forgo some of the investment it would have to make on capacity to meet its demand due to electricity trade. Import of electricity from Nepal reduces its need for generation, capacity creation and the investment for it.

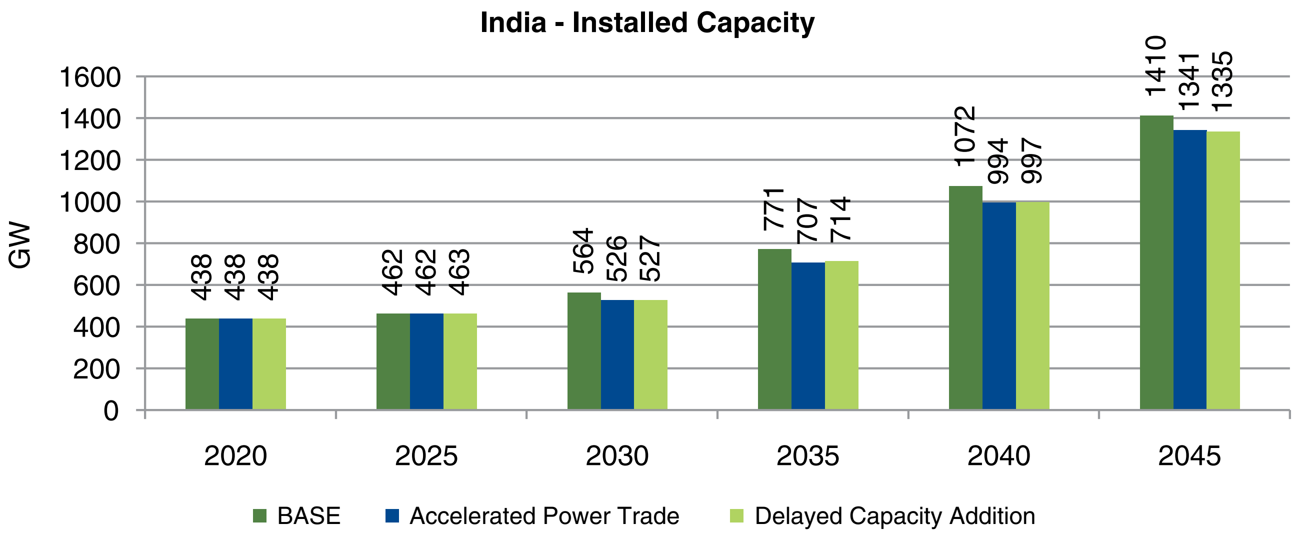

Figure 5E: India's Power Generation Installed Capacity

India, which observes peak demand in the evening, expects to have a large presence of solar PV in its power system due to its renewable policy. Therefore, the most important benefit imported capacity available in the evening brings is by helping to meet the evening peak when large solar capacity would not be available. Additionally, since Nepal's electricity is based on hydropower plants and India's power system is primarily coal based, imports from Nepal would cut down not only India's carbon emissions, but also global emissions.

Lower investment requirement to meet the same demand and reduced electricity cost result in welfare gain to India in terms of higher private household consumption (Figure 6E). With electricity trade, the Indian GDP is marginally below the GDP in the BASE case. This is expected as in the Trade scenario, India can forgo some investments in capacity additions to meet its power demand. Lower creation of capacities implies lower domestic electricity production to meet the same demand. Lower production would imply lower GDP in power sector and by inter-sectoral linkage lower GDP in other sectors too.

Electricity import reduces the generation from coal and gas. Lower use of coal in power generation and lower GDP pulls down the national demand for coal and gas. Coal consumption in India's economy reduces by 143 MT in 2030 and by 353 MT in 2050, respectively, under the APT scenario compared to the BASE scenario. Corresponding figures for gas consumption are respectively 2 BCM and 6 BCM. This results in lower production and imports of coal and gas. This in turn further lowers the investment requirement and provides gains on the Balance of Payments by saving foreign exchange due to lower import requirements. All these together add to higher consumption gain and environmental gain for India.

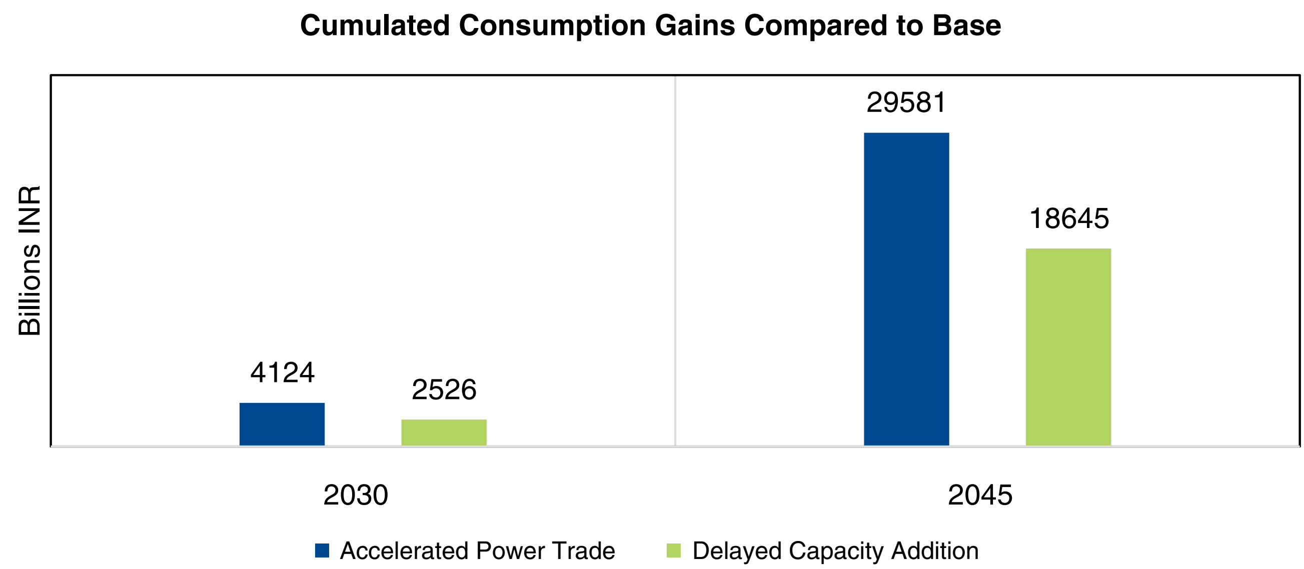

Figure 6E: Electricity Trade Impact on India's Cumulated Total Consumption (2012–2045)

In the BASE scenario, the Indian power system will remain heavily dependent on coal. Electricity trade with Nepal primarily replaces thermal generation based on coal. This helps in reducing the cumulated CO_2 emissions from Indian Power Generation over the period 2012–2045 by about 3.6 GT in the APT and 3.5 GT in the DCA scenario compared to the BASE scenario (Figure 7E). Given India's desire to play an important role in combating global climate change, this reduction is important and is more significant because it happens without compromising the growth, development and living standard of its people.

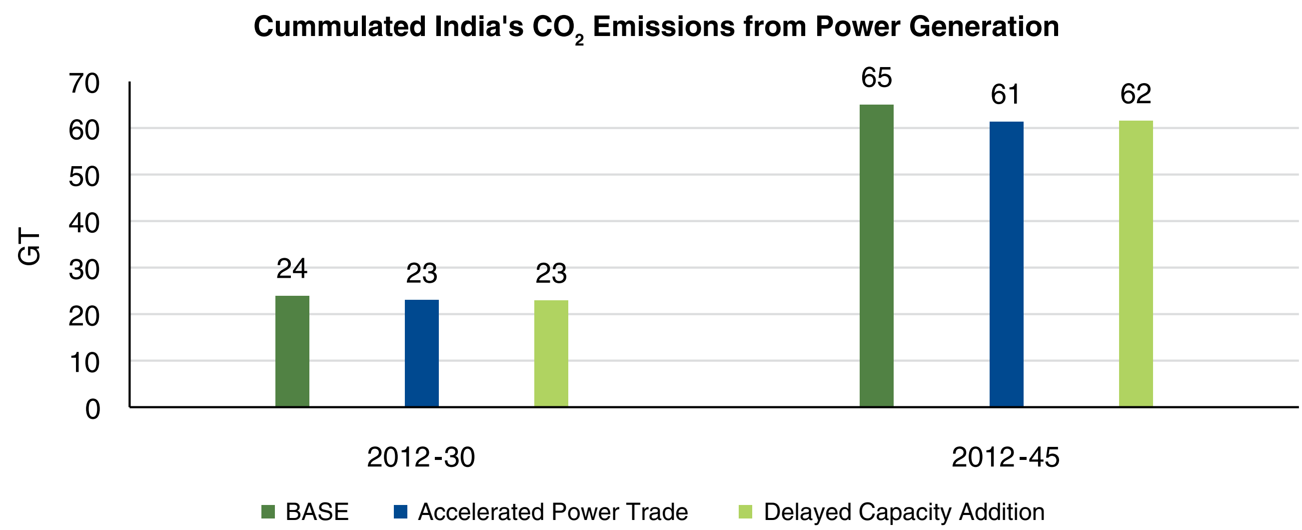

Figure 7E: Impact of Electricity Trade on India's Cumulated CO_2 Emissions from Power Sector

The study shows the following from the development of Nepal's hydropower potential and electricity trade:

- Both Nepal and India gain significantly economically and environmentally;
- Meeting the evening peak in India when its large solar PV capacity would not be available becomes easier and cheaper;
- Benefits are significantly lowered by delay.

In addition, even though significant exports to India begin only from 2025 because capacity development will take time, Nepal could benefit through larger import of electricity from India fuelling its construction activities and economic development by early development of transmission infrastructure. Therefore, *the sooner the decision on trade, earlier the benefits.*

For electricity trade to materialise, policy, institutional and technical infrastructure are necessary. Nepal is currently importing from India, so technical infrastructure (interconnection) exists. However, that needs to be largely enhanced if the type of trade potential that the study indicates is to be realised. Building hydropower projects and transmission infrastructure is highly investment intensive. Without a stable, long-term conducive policy and an institutional environment in place, which ensures payment security, it is unlikely that investors will put their money in this risky business. To keep the framework insulated from political volatility, a legislative framework may be more desirable.

The good news is that the Parliament of Nepal endorsed the SAARC Framework Agreement for Energy Cooperation on 30 August, 2016 to conduct CBET. Recently, India has taken the lead in integrating the electricity grids of the countries in South Asia. The government has issued guidelines on CBET policy to enable Indian producers to seamlessly exchange power with neighbouring nations. However, more work at intra- and inter-country level is needed.

This study has assessed the economic, environmental and developmental benefits that can accrue to Nepal and India through bilateral trade. It has also developed what we consider a robust methodology to quantify the macroeconomic feedback and socioeconomic benefits to India and Nepal, which could be extended to other countries of the South Asian region to understand the benefits in the larger region. We are already in the process of exploring the scope and impact of bilateral trade between Bangladesh and India. It would be a natural step to extend it to multilateral trade. We believe that much larger gains can be obtained if multilateral trade takes place, first among Bangladesh, Bhutan, India and Nepal (BBIN) and then extended to Myanmar.

Acknowledgements

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We are grateful to the project team of SARI-EI and the Project Director Mr. V.K. Kharbanda for their inputs and valuable suggestions on the model results that greatly helped refine and present the results. Additionally, we thank Dr. Pradeep Dadhich who in his initial capacity as Senior Project Consultant played a very important role in getting stakeholder interest and further discussions for the initial model building activities. We also thank Dr. Manoj Kumar Singh, Mr. Bhaskar Karmakar and Ms. Swati Khurana for their efforts in the initial stages of the project.

Finally, we thank the IRADe administration for their unflinching efforts in organising meetings in India related to the project and their support during travel to Nepal for meetings and workshops.

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ABOUT SARI/EI

Over the past decade, USAID's South Asia Regional Initiative/Energy (SARI/E) has been advocating energy cooperation in South Asia via regional energy integration and cross border electricity trade in eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka and the Maldives). This fourth and the final phase, titled South Asia Regional Initiative for Energy Integration (SARI/EI), was launched in 2012 and is implemented in partnership with Integrated Research and Action for Development (IRADe) through a cooperative agreement with USAID. SARI/EI addresses policy, legal and regulatory issues related to cross border electricity trade in the region, promote transmission interconnections and works toward establishing a regional market exchange for electricity.

ABOUT USAID

The United States Agency for International Development (USAID) is an independent government agency that provides economic, development, and humanitarian assistance around the world in support of the foreign policy goals of the United States. USAID's mission is to advance broad-based economic growth, democracy, and human progress in developing countries and emerging economies. To do so, it is partnering with governments and other actors, making innovative use of science, technology, and human capital to bring the most profound results to a greatest number of people.

ABOUT IRADe

IRADe is a fully autonomous advanced research institute, which aims to conduct research and policy analysis and connect various stakeholders including government, non-governmental organizations (NGOs), corporations, and academic and financial institutions. Its research covers many areas such as energy and power systems, urban development, climate change and environment, poverty alleviation and gender, food security and agriculture, as well as the policies that affect these areas.

For more information on the South Asia Regional Initiative for Energy Integration (SARI/EI) program, please visit the project website:

www.sari-energy.org