Chapter 5

Regional and Country Benefits

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Chapter 5

Regional and Country Benefits

1. Impact of Renewable Energy Trade at National and Regional Levels

On the basis of the existing bilateral electricity trade agreements within the BBIN network, the study has the following propositions:

(1) The impact of bilateral trade on trading partners and other neighbouring countries in the region when there is:
   a. change in electricity trade only; and
   b. change in electricity trade backed by technology improvement in the exporting country. This is a very important proposition because when we propose a change in electricity trade from an exporting to an importing country, it requires an increase in exportable electricity in the exporting country, which can be ensured only through technology improvement. Exportable electricity can be enhanced through demand-side management (including efficient end-use applications) and supply augmentation with additional capacity development and generation plan. However, a reduction in T&D loss, which is relatively high in South Asian countries, can also be a strategy to increase exportable electricity. All these measures are necessary for the enhancement of exportable electricity through technology improvement.

(2) Study the impact of multilateral trade on trading partners and the entire region.

Given the existing capacity and demand-supply scenario (in terms of mutual complementarity in renewable energy source potential and demand variability), bilateral electricity trade is already in place for India with Bhutan, Bangladesh, and Nepal. While Bangladesh is only an importing country, Bhutan and Nepal export and import electricity with India as per the demand-supply gap. Based on this, the following cases were analysed to estimate the impact of bilateral trade in terms of GDP and welfare (a more normative measure and defined as 'utility from GDP').

A. Bhutan to India
B. Nepal to India
C. India to Nepal
D. India to Bhutan
E. India to Bangladesh
F. Nepal to Bangladesh
G. Bhutan to Bangladesh

On the basis of India's One Sun One World One Grid initiative and recent developments, the following cases were also analysed:

H. India to Sri Lanka

Another case study was also analysed based on expert consultation conducted during the course of study (2021–22):

I. Pakistan to Afghanistan

The impact (in terms of GDP and welfare) of Bhutan to India electricity trade on Bhutanese and Indian economies (based on GTAP analysis) is as follows:

1.1. Case 1: Electricity Export from Bhutan to India: Without any technology change

Table 5.1. Bilateral Electricity Trade Benefits (GDP and Welfare) from Bhutan to India Electricity Trade

(million US$)

Country	Change in Welfare			Change in GDP		
	5%	**10%**	**20%**	**5%**	**10%**	**20%**
Bhutan	8.66	18.5	41.77	4.68	10	22.55
Sri Lanka	0.05	0.12	0.27	0.02	0.03	0.06
Pakistan	0.44	0.93	2.11	0.08	0.17	0.38
Nepal	−0.27	−0.57	−1.25	−0.06	−0.14	−0.3
India	3.74	8.07	18.69	3.5	7.63	17.63
Bangladesh	−0.01	−0.02	−0.04	0	0.02	0.03

GDP = gross domestic product.

Note: Due to data limitation, except for Pakistan−Afghanistan trade, 'Rest of South Asia' (which includes Afghanistan, Bhutan, and Maldives) includes Bhutan only in all other bilateral/multilateral cases.

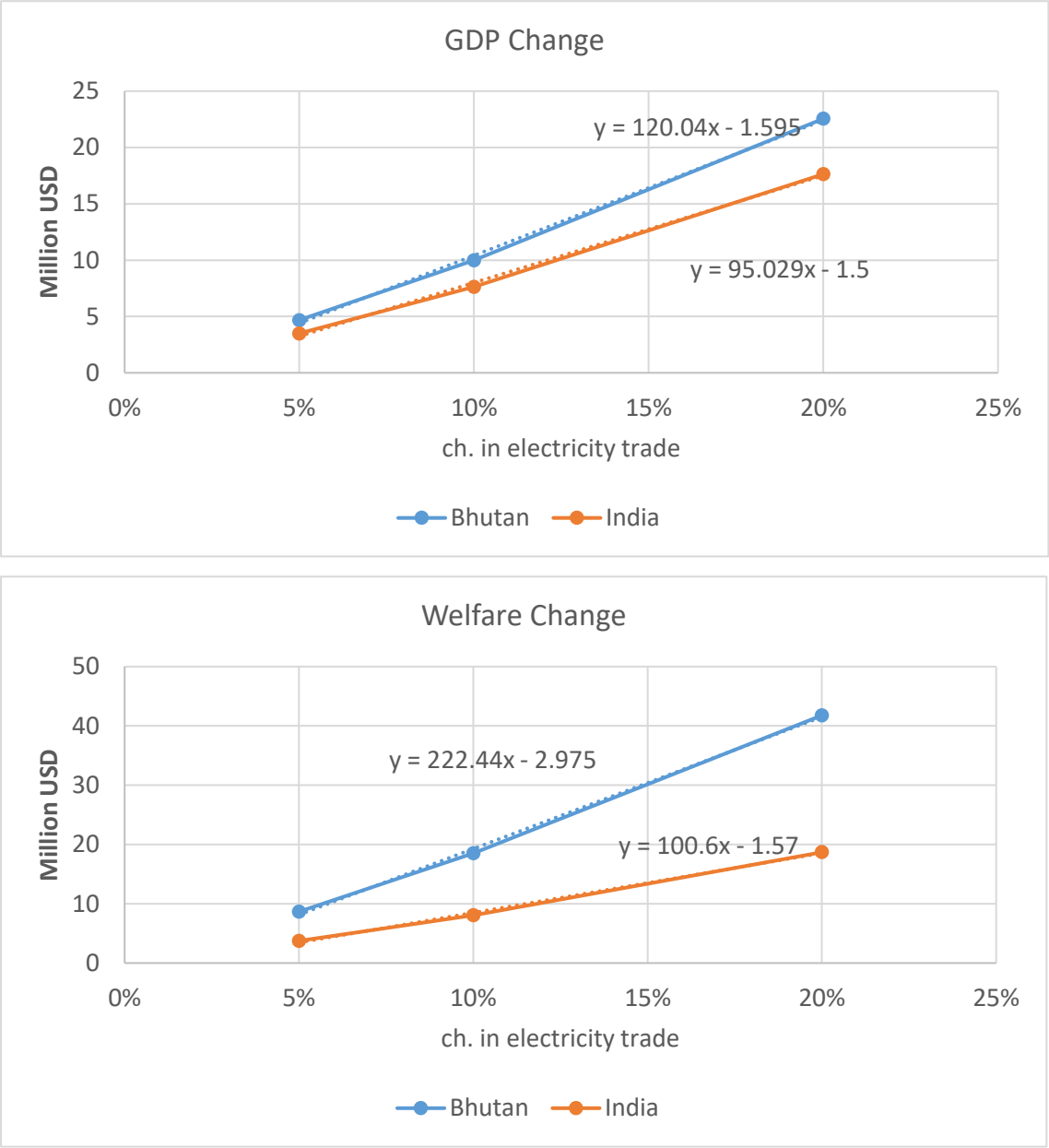
Source: TERI Estimations, 2022.

As indicated in Table 5.1, if electricity exports from Bhutan to India increased by 5% (over the existing trade level), the GDP in Bhutan and India will be $4.68 million and $3.5 million, respectively. Thus, bilateral electricity trade from Bhutan to India will have a positive impact on the GDP of both trading partners but it will be relatively higher for the exporting country. Similarly, the welfare of both trading partners will increase as a result of an increase in electricity trade with relatively higher benefits for the exporting country. This bilateral electricity trade agreement may have some adverse impact on the neighbouring partners who are already/potential trading partners with either/both of them.

If electricity trade from Bhutan to India increased by 10%, we can see that the scale of positive impact (for both GDP and welfare) is relatively higher (more than doubled) for both the trading partners, while the relative gain for the exporting country is even more. In the case of a 20% increase in existing electricity trade, the scale of impact is even higher for both the trading partners and for both GDP and welfare.

Grounded on the above concept of the potential growth path of bilateral trade in electricity, this study has developed a trade benefit trajectory based on the change in bilateral electricity trade. This trajectory (Figure 5.1) will help to measure the expected level of change in benefits (doubling/tripling or many-fold increase) from enhanced potential trade in electricity.

Figure 5.1. Trajectory of Trade Benefits for Bhutan and India Based on Bhutan to India Electricity Trade. (a) GDP and (B) Welfare



GDP = gross domestic product.
Source: TERI Estimations, 2022.

1.2. Case 2: Electricity Export from Bhutan to India: With Technology Upgradation in Bhutan

Table 5.2. Benefits (GDP and Welfare) from Bilateral Electricity from Bhutan to India

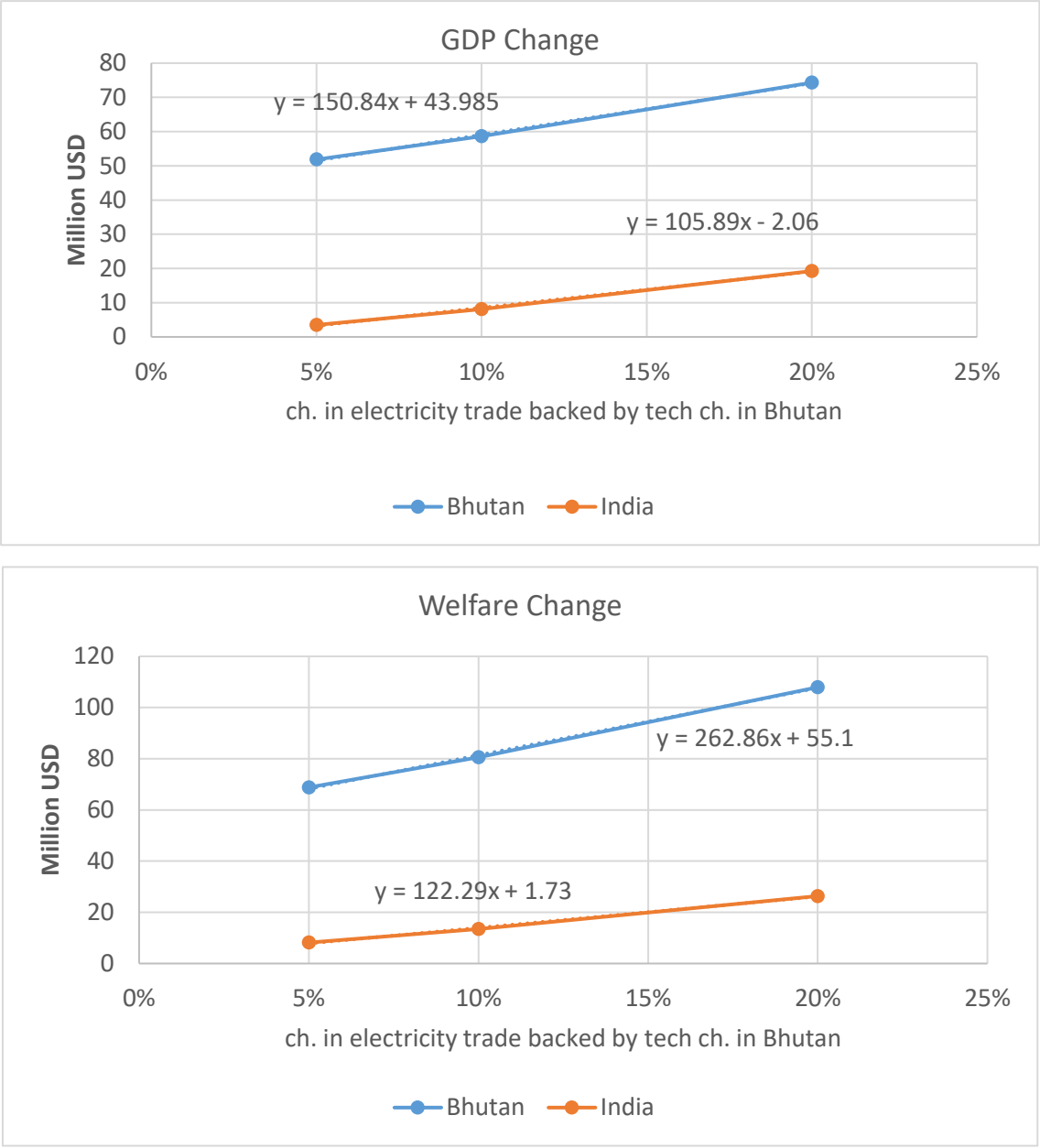
Country	Change in Welfare				Change in GDP		
	5%	10%	20%		5%	10%	20%
Bhutan	68.8	80.55	107.95		51.84	58.6	74.31
Sri Lanka	0.27	0.35	0.53		0.06	0.09	0.13
Pakistan	3.15	3.75	5.15		0.41	0.52	0.77
Nepal	−0.13	−0.47	−1.25		−0.06	−0.15	−0.33
India	8.17	13.47	26.35		3.5	8.13	19.25
Bangladesh	−0.07	−0.08	−0.11		−1.08	−1.08	−1.05

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.2 indicates that when existing electricity exports from Bhutan to India increase by 5% accompanied by relevant technology improvement (required to ensure a 5% increase in exportable electricity) in Bhutan, both Bhutan and India benefit, with relatively higher benefits for Bhutan (exporting country) in terms of both GDP and welfare. Moreover, the level of benefits in this case (increase in export backed by technology improvement in the exporting country) is comparatively higher than the potential benefits from a 5% increase in the export of electricity only.

These features remain true for a 10% and 20% increase in export also. However, when the study prepares the benefit trajectory (as indicated in Figure 5.2) from an increase in electricity trade with technology upgradation in the exporting country, it reveals that, while the level of benefits is higher, changing the scale (from 5% to 10% or 10% to 20% or similar change) will flatten compared to benefit trajectory of increase in trade only.

Figure 5.2. Trajectory of Trade Benefits for Bhutan and India from Bhutan to India Electricity Trade Backed by Technology Upgradation in Bhutan: (a) GDP and (b) Welfare



GDP = gross domestic product.
Source: TERI Estimations, 2022.

Similar analyses were done for all the above bilateral trade possibilities (Case B to Case I) and the detailed results are provided in the Annex.

1.3. Case 3: Electricity Export from India to Bhutan: Without Any Technology Change

Table 5.3. Benefits (GDP and Welfare) from Bilateral Electricity from India to Bhutan

Change in Electricity	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	0.38	0.82	1.93	0.18	0.64	1.09
	Sri Lanka	0	−0.01	−0.01	0	0	0
	Pakistan	−0.02	−0.03	−0.08	0	−0.02	−0.05
	Nepal	0	−0.01	−0.01	0	0	0
	India	0.32	0.68	1.58	0.21	0.49	1.18
	Bangladesh	0	−0.01	−0.01	0	0	0
	Rest of World	−0.57	−1.23	−2.87	0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

As indicated in Table 5.3, if electricity exported from India to Bhutan increases by 5% (over the existing trade level), the change in GDP of India and Bhutan will be $0.21 million and $0.18 million, respectively. Thus, bilateral electricity trade from India to Bhutan will have a positive impact on the GDP of both trading partners, with higher relative benefits for the exporting country. Similarly, the welfare of both trading partners will increase as a result of an increase in electricity trade. As mentioned previously, Bhutan's electricity generation almost entirely depends on hydropower, which reduces during the winter season. Due to a lack of generation diversity, Bhutan primarily imports electricity from India during this period. Without importing power, Bhutan will be unable to manage its economic activity during this time. Thus, the increase in India's electricity export to Bhutan (which is entirely during the winter) results in relatively higher utility for Bhutan. This enhanced bilateral electricity trade may have some adverse impact on neighbouring countries due to their potential electricity trade relationship with either of these two trading partners.

When the existing electricity trade from India to Bhutan increases by 10%, we can see from Table 5.3 that the scale of positive impact (for both GDP and welfare) is comparatively higher for both the trading partners and the relative gain for the exporting country is even more. Similarly, in the case of a 20% increase in the existing electricity trade, the scale of impact is even higher for both partners in terms of GDP and welfare.

1.4. Case 4: Electricity Export from India to Bhutan: With Technology Upgradation in India

Table 5.4. Benefits (GDP and Welfare) from Bilateral Electricity from India to Bhutan Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country		Change in Welfare			Change in GDP		
	Country	5%	10%	20%	5%	10%	20%
	Bhutan	0.37	0.82	1.93	0.21	0.45	1.07
	Sri Lanka	−0.01	−0.01	−0.02	0	0	−0.01
	Pakistan	−0.01	−0.03	−0.07	0	−0.02	−0.05
	Nepal	0	0	−0.01	0	0	0
	India	13.22	13.59	14.48	11.38	11.49	11.62
	Bangladesh	−0.01	−0.01	−0.02	0	0	−0.02
	Rest of World	−2.48	−3.14	−4.78	0	0	0

GDP = gross domestic product.

Source: TERI Estimations, 2022.

Table 5.4 indicates that when the existing electricity export from India to Bhutan is increased by 5% accompanied by relevant technology improvement in India, benefits are positive for both Bhutan and India, with relatively higher benefits for India (exporting country) in terms of GDP and welfare. Even if electricity export leads to economic benefits, due to infrastructural bottlenecks, the exporting country may not have sufficient exportable surplus of electricity. Hence, technology upgradation is essential for an exporting country so that it can produce surplus electricity.

Moreover, the level of benefits in this case (increase in export backed by technology improvement in the exporting country) is comparatively higher than potential benefits from the same 5% increase in the export of electricity only. Here the benefit for India is much higher compared to Bhutan because technology upgradation provides other positive externalities also in the exporting countries. Similarly, 10% and 20% increase in electricity trade in presence of technology upgradation will result in higher levels of economic benefits for the trading partners with relatively more benefits available to the exporting country (India).

1.5. Case 5: Electricity Export from India to Bangladesh: Without Any Technology Change

Table 5.5. Benefits (GDP and Welfare) from Bilateral Electricity from India to Bangladesh

Change in Electricity	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	−0.45	−0.84	−1.48	−0.24	−0.46	−0.8
	Sri Lanka	−0.01	−0.03	−0.06	0	−0.01	−0.01
	Pakistan	−0.03	−0.05	−0.1	0	0	−0.02
	Nepal	−0.51	−0.95	−1.68	−0.13	−0.24	−0.42
	India	0.97	1.96	4.01	0.24	0.86	2.02
	Bangladesh	0.09	0.52	1.04	0.56	2.02	5.06
	Rest of World	−0.74	−1.61	−3.69	0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

As indicated in Table 5.5, if electricity export from India to Bangladesh increases by 5% (over the existing trade level), the change in the GDP of India and Bangladesh will be $0.24 million and $0.56 million, respectively. Thus, bilateral electricity trade from India to Bangladesh will have a positive impact on the GDP of both trading partners. Similarly, the welfare of both trading partners will increase as a result of an increase in electricity trade. Bangladesh is currently struggling with a power crisis and the import of electricity from India is essential for its economic development. Due to the importance of reliable electricity import from India, the trade impact in Bangladesh is relatively high. When electricity trade between India and Bangladesh increases by 10%, it suggests that the magnitude of the positive impact (on both GDP and wellbeing) is comparably greater for both trading partners. The relative gain for the exporting country is significantly greater; and this holds true when trade increases by 20%.

1.6. Case 6: Electricity Export from India to Bangladesh: With Technology Upgradation in India

Table 5.6. Benefits (GDP and Welfare) from Bilateral Electricity from India to Bangladesh Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country		Change in Welfare			Change in GDP		
	Country	**5%**	**10%**	**20%**	**5%**	**10%**	**20%**
	Bhutan	−0.65	−1.05	−1.69	−0.36	−0.57	−0.92
	Sri Lanka	−0.19	−0.20	−0.23	−0.08	−0.08	−0.09
	Pakistan	0.1	0.07	0.03	0.02	0.02	0.02
	Nepal	−0.44	−0.88	−1.61	−0.1	−0.21	−0.39
	India	516.24	517.23	519.29	455.12	455.78	455.98
	Bang	0.56	0.88	1.52	4.91	9.83	20.39
	Rest of World	−76.84	−77.72	−79.81	−16	−16	−16

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.6 indicates that when existing electricity export from India to Bangladesh is increased by 5% accompanied by relevant technology improvement in India, the benefits are positive for both the countries with higher benefits for India (exporting country) in terms of GDP and welfare. The level of benefits, in this case, is relatively higher than a 5% increase in the export of electricity only. Here the change in GDP and welfare for India is much higher compared to Bangladesh because of positive externality of technology improvement in India. For both a 10% and 20% increase in electricity trade, technology improvement in India results in more economic benefits for Bangladesh, with marginally higher benefits for India.

1.7. Case 7: Electricity Export from India to Sri Lanka: Without Any Technology Change

Table 5.7. Benefits (GDP and Welfare) from Bilateral Electricity from India to Sri Lanka

	Country	Change in Welfare				Change in GDP		
		5%	10%	20%		5%	10%	20%
Change in Electricity	Bhutan	0	0	0		0	0	0
	Sri Lanka	1.46	1.52	1.58		0.69	0.76	1.08
	Pakistan	0	0	0		0	0	0
	Nepal	0	0	−0.01		0	0	0
	India	2.67	2.77	2.98		2.25	2.28	2.48
	Bangladesh	0	0	−0.01		0	0	0
	Rest of World	−0.88	−1.03	−1.34		0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

As indicated in Table 5.7, if electricity export from India to Sri Lanka increases by 5% (over the existing trade level), the change in GDP of India and Sri Lanka will be $2.25 million and $0.69 million, respectively. Thus, bilateral electricity trade from India to Sri Lanka will have a positive impact on the GDP of both trading partners, with higher relative benefits for the exporting country. The welfare of both trading partners will also improve as power trade increases.

When electricity trade from India to Sri Lanka increases by 10%, the scale of positive impact (for both GDP and welfare) is comparatively higher for both the trading partners and the relative gain for the exporting country is even more. This holds true even when the increase is 20%. India–Sri Lanka electricity trade may not have much implication for the neighbouring partners due to the absence of electricity trade (actual/potential) relationship of Sri Lanka with other neighbouring partners. However, a large increase in India–Sri Lanka trade (e.g. 20%) can have marginally adverse implication for India's trading partners (like Nepal or Bangladesh).

1.8. Case 8: Electricity Export from India to Sri Lanka: With Technology Upgradation in India

Table 5.8. Benefits (GDP and Welfare) from Bilateral Electricity from India to Sri Lanka Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country		Change in Welfare			Change in GDP		
	Country	**5%**	**10%**	**20%**	**5%**	**10%**	**20%**
	Bhutan	−0.02	-0.03	-0.02	-0.02	-0.02	-0.07
	Sri Lanka	43.34	49.02	51.62	36.01	40.26	45.56
	Pakistan	0.1	0.12	0.02	0.02	0.02	-0.05
	Nepal	0.03	0.04	0.01	0.01	0.02	-0.02
	India	77.4	103.17	156.08	68	90.63	114.81
	Bangladesh	−0.03	-0.04	-0.05	-0.03	-0.05	-0.04
	Rest of World	−22.29	-27.49	-8	-8	-8	30

GDP = gross domestic product.

Source: TERI Estimations, 2022.

Table 5.8 indicates that when existing electricity export from India to Sri Lanka increased by 5% accompanied by relevant technology improvement in India, the benefits are positive for both nations, with higher benefits for India (exporting country) in terms of both GDP and welfare. The level of benefits, in this case, is higher than the potential benefits from the same percentage of increase in the export of electricity only. Due to positive externality of technology advancement, the scale of economic benefits is higher. Moreover, for actual realisation of electricity trade from India to Sri Lanka, a technological upgrade is required, namely the use of a high-voltage direct current (HVDC) connecting line through the sea.

1.9. Case 9: Electricity Export from India to Nepal: Without Any Technology Change

Table 5.9. Benefits (GDP and Welfare) from Bilateral Electricity from India to Nepal

Change in Electricity	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	−0.01	−0.03	−0.06	−0.01	−0.01	−0.03
	Sri Lanka	0.0	−0.01	-0.01	0.0	0.0	0.0
	Pakistan	0.0	0.0	0.0	0.0	0.0	0.0
	Nepal	0.73	1.59	3.76	0.38	0.83	1.95
	India	0.25	0.54	1.25	0.45	0.92	2.09
	Bangladesh	0.0	−0.01	−0.01	0.0	0.0	0.0
	Rest of World	−0.71	−1.55	−3.64	0.0	0.0	0.0

GDP = gross domestic product.

Source: TERI Estimations, 2022.

As indicated in Table 5.9, if electricity exports from India to Nepal increases by 5%, the change in the GDP of India and Nepal will be $0.45 million and $0.38 million, respectively. Thus, bilateral electricity trade from India to Nepal will have a positive impact on the GDP of both trading partners, with higher relative benefits for the exporting country India. Similarly, the welfare of both trading partners will increase as a result of the increase in electricity trade. Nepal's electricity is generated almost entirely from hydropower and there has not been any other diversified option for generation. For this reason, Nepal is very much dependent on India during the winter season when hydropower generation is limited. Thus, electricity imports from India results in higher level of welfare in Nepal. When electricity export from India to Nepal increases by 10%, the table indicates that the scale of positive impact is comparatively higher for both trading partners. In the case of a 20% increase in existing electricity trade, the scale of impact is even higher for both the partners for both GDP and welfare.

1.10. Case 10: Electricity Export from India to Nepal: With Technology Upgradation in India

Table 5.10. Benefits (GDP and Welfare) from Bilateral Electricity from India to Nepal Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	−0.22	−0.23	−0.27	−0.13	-0.13	−0.15
	Sri Lanka	−0.18	−0.18	−0.19	−0.08	−0.08	−0.08
	Pakistan	0.12	0.12	0.13	0.03	0.03	0.03
	Nepal	10.81	13.68	17.86	8.41	10.86	11.99
	India	515.52	515.81	516.53	455.25	455.78	455.98
	Bangladesh	−0.30	−0.30	−0.31	−0.25	−0.25	−0.25
	Rest of World	−76.81	−77.65	−79.76	−16	−16	−16

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.10 indicates that when existing electricity export from India to Nepal is increased by 5% accompanied by relevant technology improvement in India, benefits are positive for both Nepal and India, with relatively higher benefits for India in terms of GDP and welfare. Technology improvement in the exporting country leads to a higher exportable surplus of electricity, along with other positive externalities. Thus, export backed by technology improvements leads to higher level of economic benefits. For 10% and 20% increase in electricity trade backed by technology upgradation in exporting country led to even higher levels of benefits.

1.11. Case 11: Electricity Export from Nepal to Bangladesh: Without Any Technology Change

Table 5.11. Benefits (GDP and Welfare) from Bilateral Electricity from Nepal to Bangladesh

	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
Change in Electricity	Bhutan	−0.02	−0.05	−0.11	−0.01	−0.03	−0.06
	Sri Lanka	0	0	0	0	0	0
	Pakistan	0	0	0	0	0	0
	Nepal	1.08	2.35	5.51	0.27	0.59	1.38
	India	0.02	0.04	0.09	0	0.13	0.13
	Bangladesh	0.74	1.66	4.01	0.19	0.42	1.0
	Rest of World	−0.88	−1.91	−4.48	0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.11 shows that if Nepal's electricity exports to Bangladesh increase by 5% (over the current trade level), the change in GDP for Nepal and Bangladesh will be $0.27 million and $0.19 million, respectively. Hence, bilateral energy trade from Nepal to Bangladesh will enhance both the trading partners' GDP, with greater relative gains for the exporting country. Similarly, the well-being of both trading partners will improve as electricity trade enhanced. Electricity trade between Nepal and Bangladesh is very important for Bangladesh. It is because Bangladesh not only suffers from an electricity deficit but it also is struggling to generate electricity from renewable sources. The electricity imported from Nepal is primarily renewable power (generated by hydro in Nepal). Thus, this electricity trade helps Bangladesh not only to meet its power demand but also meet its renewable target. The level of benefit increases with increase in electricity trade.

1.12. Case 12: Electricity Export from Nepal to Bangladesh: With Technology Upgradation in Bangladesh

Table 5.12. Benefits (GDP and Welfare) from Bilateral Electricity from Nepal to Bangladesh Backed by Technology Upgradation

Change in electricity with technology improvement in exporting country	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	−0.29	−0.32	−0.39	−0.14	−0.16	−0.20
	Sri Lanka	−0.04	−0.04	−0.04	−0.01	−0.01	−0.01
	Pakistan	0.07	0.07	0.07	0	0	0
	Nepal	90.84	92.41	96.3	50.16	50.56	51.56
	India	3.45	3.48	3.55	1.13	1.13	1.25
	Bangladesh	0.99	2.09	3.56	0.47	0.85	1.50
	Rest of World	−49.52	−50.8	−53.98	−8	−8	−8

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.12 indicates that when existing electricity export from Nepal to Bangladesh is increased by 5% accompanied by relevant technology improvement in the export country, benefits are positive for both Nepal and Bangladesh, with higher benefits for the former. This is because technology improvement leads to more exportable surplus electricity for Nepal. Nepal can reap a huge benefit even from the positive externality of infrastructure development and export more electricity to its neighbouring countries (like India), who also benefit, as depicted in the table. The scale of benefits increases with increasing levels of electricity trade backed by technology upgrades in Nepal.

1.13. Case 13: Electricity Export from Bhutan to Bangladesh: Without Any Technology Change

Table 5.13. Benefits (GDP and Welfare) from Bilateral Electricity from Bhutan to Bangladesh

	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
Change in Electricity	Bhutan	0.93	1.99	4.53	0.5	1.08	2.45
	Sri Lanka	0.01	0.01	0.03	0	0	0.01
	Pakistan	0.05	0.1	0.22	0.02	0.02	0.05
	Nepal	−0.07	−0.16	−0.35	−0.02	−0.04	−0.09
	India	−0.19	-0.4	−0.9	0	0	0
	Bangladesh	0.22	1.03	2.77	0.4	1.47	3.44
	Rest of World	−0.28	−0.6	−1.38	0	0	0

GDP = gross domestic product.

Source: TERI Estimations, 2022.

As shown in Table 5.13, if Bhutan's electricity export to Bangladesh increases by 5% (over existing trade), the change in GDP for Bhutan and Bangladesh will be $0.5 million and $0.4 million, respectively. Hence, bilateral energy trade from Bhutan to Bangladesh will enhance both trading partners' GDP, with greater relative gains for the exporting country. Similarly, the well-being of both trading partners will improve as electricity commerce expands. Electricity trade between Bhutan and Bangladesh is very important for Bangladesh because, as noted, it suffers by not only from an electricity deficit but it is also struggling to generate electricity from renewable sources. The electricity imported from Bhutan is primarily renewable power (hydropower). Thus, this electricity trade helps Bangladesh not only to meet its power demand but also meet its renewable target. The level of benefit increases with any electricity trade increase.

1.14. Case 14: Electricity Export from Bhutan to Bangladesh: With Technology Upgradation in Bhutan

Table 1. Benefits (GDP and Welfare) from Bilateral Electricity from Bhutan to Bangladesh Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Bhutan	59.5	60.78	63.79	46.47	47.2	48.93
	Sri Lanka	0.21	0.22	0.24	0.05	0.05	0.05
	Pakistan	2.68	2.74	2.89	0.33	0.34	0.36
	Nepal	0.1	0.01	-0.22	−0.01	−0.03	−0.09
	India	3.35	3.09	2.51	−0.38	−0.38	−0.38
	Bang	3.06	5.02	8.66	1.97	3.0	5.48
	Rest of World	−22.49	−22.89	−23.85	0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.14 indicates that when existing electricity export from Bhutan to Bangladesh is increased by 5%, accompanied by relevant technology improvement in Bhutan, benefits are positive for both Bhutan and Bangladesh, with higher benefits for the exporting country. This is because, technology improvement leads to more exportable surplus electricity for Bhutan. Bhutan can reap a huge benefit even from the positive externality of infrastructure development and export more electricity to its neighbouring countries (like India), who also benefit, as depicted in the table. Scale of benefits increases with increasing levels of electricity trade backed by technology upgradation in Bhutan.

1.15. Case 15: Electricity Export from Pakistan to Afghanistan: Without Any Technology Change

Table 5.15. Benefits (GDP and Welfare) from Bilateral Electricity from Pakistan to Afghanistan

Change in Electricity	Country	Change in Welfare			Change in GDP		
		5%	10%	20%	5%	10%	20%
	Afghanistan	0.56	1.22	2.84	0.33	0.72	1.69
	Sri Lanka	0	0	−0.01	0	0	0
	Pakistan	0.63	1.35	3.09	0.11	0.25	0.58
	Nepal	0	0.01	0.01	0	0	0
	India	−0.02	−0.04	−0.09	0	0	−0.13
	Bangladesh	−0.01	−0.01	−0.02	0	0	−0.02
	Rest of World	−0.89	−1.93	−4.43	0	0	0

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.15 indicates that if electricity export from Pakistan to Afghanistan increases by 5% (over the existing trade level), the change in the GDP of Afghanistan and Pakistan will be $0.33 million and $0.11 million, respectively. Thus, bilateral electricity trade from Pakistan to Afghanistan will have a positive impact on the GDP of both trading partners. Scale of economic benefits increases with increasing level of electricity trade for both partners and for both GDP and welfare.

1.16. Case 16: Electricity Export from Pakistan to Afghanistan: With Technology Upgradation in Pakistan

Table 5.16. Benefits (GDP and Welfare) from Bilateral Electricity from Pakistan to Afghanistan Backed by Technology Upgradation

Change in Electricity with Technology Improvement in Exporting Country		Change in Welfare			Change in GDP		
	Country	**5%**	**10%**	**20%**	**5%**	**10%**	**20%**
	Afghanistan	8.66	9.33	10.98	6.84	7.22	8.18
	Sri Lanka	0.08	0.08	0.07	0.03	0.02	0.02
	Pakistan	147.42	148.15	149.92	126.42	126.56	126.92
	Nepal	0.07	0.07	0.08	0.01	0.01	0.01
	India	1.44	1.42	1.37	−0.38	−0.50	−0.50
	Bangladesh	−0.23	−0.24	−0.25	−0.22	-0.22	−0.22
	Rest of World	−31.43	−32.49	−35.04	−8	−8	−8

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.16 indicates that when existing electricity export from Pakistan to Afghanistan is increased by 5% accompanied by relevant technology improvement in Pakistan, benefits are positive for both countries. However, Pakistan will witness higher benefits due to positive externality of technology improvement. Moreover, scale of benefits will increase with higher levels of electricity trade.

2. Regional Integration

In terms of renewable energy resource and demand pattern complementarity, the scope of electricity trade is more in the case of multilateral or regional arrangements compared to the bilateral trade agreement. Here, the study explored two different scenarios:

(1) Bhutan-India-Nepal
(2) Bhutan-Bangladesh-India-Nepal (BBIN)

Due to limited data availability, regionalisation potential with all eight members could not be explored.

2.1. Regional Integration: Electricity Trade Only

Table 5.17. GDP and Welfare Impact of Bhutan–India–Nepal Trilateral Trade in Electricity Only

Country	Welfare	GDP Change
Bhutan	18.76	10.11
Sri Lanka	0.11	0.02
Pakistan	0.96	0.17
Nepal	9.78	4.07
India	9.83	8
Bangladesh	-0.04	0.03

GDP = gross domestic product.
Source: TERI Estimations, 2022.

Renewable energy generation resource and demand pattern complementarity are most pronounced in the case of Bhutan, India, and Nepal. India is already engaged in huge electricity trade with these two countries on a bilateral basis. But Bhutan and Nepal have also become part of the India Energy Exchange with the aim to trade power from a common pool as and when required. This case will indicate the change in benefit level and sharing when the bilateral trade of India with Bhutan and Nepal is upgraded to trilateral trade between Bhutan-India-Nepal. Table 5.17 indicates that trilateral electricity trade results in higher benefits (compared to bilateral trade benefits from Bhutan to India, India to Bhutan, Nepal to India, and India to Nepal) for participating countries in terms of both GDP and welfare. Moreover, more countries get benefitted from such trade arrangements.

2.2. Regional Integration: Electricity Trade Backed by Technology Upgradation in Exporting Countries

Table 5.18. Bilateral Trade versus Multilateral Trade: Benefit Sharing across Countries

Country	GDP				Welfare			
	BBIN	BBIN+P	BBIN+SL	BBIN+P+SL	BBIN	BBIN+P	BBIN+SL	BBIN+P+SL
Bhutan	49.59	49.57	49.57	49.57	62.74	62.7	62.7	62.7
Sri Lanka	−0.23	10.98	−0.21	10.98	−0.25	14.38	−0.22	14.37
Pakistan	0.38	79.5	79.88	79.88	3.14	94.95	95.32	95.35
Nepal	53.19	53.2	53.20	53.20	98.62	98.64	98.63	98.64
India	1137	1136.63	1136.75	1136.63	1295.47	1296.23	1296.67	1296.79
Bangladesh	21.09	21.05	21.05	21.06	37.45	37.32	37.31	37.31

BBIN = Bhutan-Bangladesh-India-Nepal.
BBIN+P = BBIN + Pakistan.
BBIN+SL = BBIN + Sri Lanka.
BBIN+P+SL = BBIN + Pakistan + Sri Lanka.
GDP = gross domestic product.
Source: TERI Estimations, 2022.

Table 5.18 indicates that when electricity trade increases backed by technology improvement in exporting countries, benefit sharing across countries is more profound in multilateral/regional arrangements, as compared with all previous cases,[3] especially bilateral trade.

Based on these two results (refer to Tables 5.17 and 5.18), it can be expected that larger benefits will be available when more countries join the energy cooperation framework/electricity trade network for effective and efficient utilisation of available power supply. Moreover, technology upgradation in the exporting country will increase the level of benefits for participating countries. In the case of multilateral/regional arrangement, more countries are getting benefitted who were not part of benefit sharing from a bilateral agreement between the two other countries.

Tables 5.17 and 5.18 also indicate that India is going to reap huge benefits from such multilateral/regional trade arrangements. In regional cooperation in energy, due to economic size and central location, India will play the most important/pivotal role. It has already proposed to create the 'One Sun One World One Grid' network to connect its neighbours and exchange power among the common grid-connected countries. In the case of regional

[3] i.e. bilateral trade with an increase in electricity export, bilateral trade with an increase in electricity export backed by technology upgradation in exporting country, and multilateral trade in electricity.

electricity trade with technology improvement in exporting countries, the level of benefit will be significantly higher for India because of its central role in this initiative and its economic size. However, benefits shared by other participating countries are also significant, especially when compared to their respective economic size, infrastructure, and market bottlenecks.

The major findings of the study are as follows:

- Bilateral trade in renewable energy leads to GDP as well as welfare gain for both trading partners.
- Benefit is higher when renewable energy trade is backed by technology improvement in the source/exporting country.
- Regional trade is more beneficial than bilateral trade.

The above empirical analysis indicates that bilateral renewable trade/cooperation provides economic benefits to the participating countries as well as the entire region. However, the benefit scale can be enhanced for the participating countries and the entire region if multilateral renewable energy cooperation can be arranged. Thus, the null hypotheses C1H0 and C2H0 corresponding to research Question 3 can be fully accepted. Bilateral energy cooperation already exists between India and Bhutan, India and Nepal, and India and Bangladesh. But BBIN regional cooperation is in progress through cross-border grid integration and electricity trade via the India Energy Exchange. Bhutan and Nepal are already part of the India Energy Exchange. The realisation of this BBIN network will help Bangladesh to import power supply even from Nepal and Bhutan. Thus, BBIN will not only help increase the level of benefit but also widen the scope of spill-over benefits to a larger number of countries. India's One Sun One World One Grid initiative is expected to integrate other South Asian countries into the regional energy cooperation and provide more benefits. However, the initiative can be further extended to Southeast and East Asia and West Asia in the near future.