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Looking Beyond the State Targets: Renewable Energy for Export

Tamil Nadu Case Study

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Introduction

New technologies bring new opportunities. As solar- and wind-based generation gets increasingly cheaper,[2] transmission to larger balancing areas becomes physically possible, and provisions for efficient power trade, a reality. In India, this can bring a unique opportunity. Many renewable-rich locations can strategically plan renewable energy capacities for exports through enabling industrial policies.

Examples for this can also be found globally. For instance, the northern German state of Schleswig-Holstein has aimed to achieve nearly 300% of its gross electricity consumption from renewable sources by 2025, with the access stated for export.[3]

Honing economic prosperity by constructively using one's natural and demographic advantage is not new. China utilised its high-skilled, low-cost labour for smart phone manufacturing; Germany applied its scientific and technological advancement to become a major supplier of drugs and pharmaceuticals, and Saudi Arabia leveraged its abundant oil supplies for economic growth.

As for India, the country generates some of the cheapest solar- and wind-based power in the world, and it is getting progressively cheaper.[4] Furthermore, an existing, fully synchronised national power grid and ongoing reforms in the wholesale markets (initiated through the launch of the real-time market and green term-ahead market) create a perfect foundation for beneficial power trade across Indian states.

In fact, the phenomena of siting power plants in states where the cost of generation and wheeling power to load centres is cheaper, is not new. Back in 1964, five regional electricity boards were established to facilitate interstate power transactions. This paved the way for the establishment of Government of India-owned generating companies like National Thermal Power Corporation (now, NTPC) and National Hydroelectric Power Corporation (now, NHPC). These companies now have large-generation capacities and transmission lines shared by several states.

Furthermore, thermal capacities were increasingly set up in the eastern and northern regions of India thanks to abundant access to low-cost, pithead coal. Power these regions generated was transmitted to high demand load centres in western and southern states.

The advent of much cheaper renewables is once again reorienting the energy-economy geography to a cost-effective optimum, where renewable-rich states have an opportunity to beneficially utilise their unused renewable energy potential for trade, while low renewable energy-potential states can more easily access cheaper electricity.

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[2] Henbest, S., (2020, 28 January). *The first phase of the transition is about electricity, not primary energy*. BloombergNEF. https://about.bnef.com/blog/the-first-phase-of-the-transition-is-about-electricity-not-primary-energy

[3] Jenniches, S., (2018, October). Assessing the regional economic impacts of renewable energy sources – a literature review. *Renewable and Sustainable Energy Review, 93*(C), 35-51. https://www.sciencedirect.com/journal/renewable-and-sustainable-energy-reviews/vol/93/suppl/C

[4] International Renewable Energy Agency. (2020). *Renewable power generation costs in 2019*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf

While new opportunities abound, they do come with challenges. The prevailing pandemic and the concomitant slump in the state economies has resulted in mounting deficits for both the distribution companies (discoms) and the state exchequer. This makes availability of cheaper power in the near-to-medium term crucial for economic recovery. We have already seen states benefiting from the availability of cheap power in the markets during the lockdown.[5] The associated macroeconomic benefits of new capital investments in renewable capacity addition are unequivocally important, helping to put the economic bandwagon back on track.

Fully functional wholesale power markets provide an opportunity for all states to leverage their respective energy endowments to the fullest and compete to provide or acquire the cheapest power through the markets.

The competitive advantage, however, will surely lie with the states that quickly align this opportunity with their industrial policies to either supply the cheapest power to the market or create the ability to use cheaper power from markets for growth.

This policy brief attempts to make a case to state-level policymakers, industrial chambers, public and private investors, and distribution companies, to look towards renewable energy as a commodity for trade and promote it as an industrial policy.

The brief initially explores the role of wholesale markets in integrating incremental renewable energy in the energy mix. Next, with the help of a stylised case study, we illustrate various macroeconomic impacts of renewable energy trade. The study takes a representative case of Tamil Nadu exporting its cheap, wind-based power, which, in aggregate, can help meet the existing non-solar renewable purchase obligations for select northern states: Delhi, Punjab and Haryana.

Tamil Nadu represents the opportunities all renewable energy-rich states have by exporting renewables while the three importing states reflect how non-renewable energy rich states can benefit from cheaper power while also meeting their policy obligations.

The quantitative analysis has been performed using a publicly available, dynamic, macroeconometric simulation model for Indian states: E3-India.[6] We find that both renewable energy-exporting and importing states are better off as a consequence of renewable energy trade in a number of ways:

- Incremental investments in wind capacity by Tamil Nadu lead to enhanced direct and indirect demand along with reduction in cost of electricity production. This brings favourable economic outcomes on state GDP, employment and household income.

[5] Tenddulkar, S. (2017, 1 November). Tamil Nadu trades wind for profit. *Wind Power Monthly*. https://www.windpowermonthly.com/article/1448415/tamil-nadu-trades-wind-profit

[6] E3-India. https://www.e3indiamodel.com/

- The renewable energy-importing northern states of Punjab, Haryana and Delhi benefit due to availability of potentially cheaper electricity and its concomitant positive impacts on state GDP, employment and income.
- Coal-based generation in the power mix goes down in all the states, but the overall macroeconomic impact of the renewable energy trade is positive for both exporting and importing states.

The trade helps in enhancing public health benefits as coal-power linked carbon, nitrogen oxides, sulphur oxides and particulate emissions reduces for all partners.

Renewable Energy as a Trade Commodity and the Role of Wholesale Power Markets

Over the past few years, aggressive renewable energy targets, combined with falling costs of technology and supportive policies, have been key investment drivers in renewable energy capacity in India. As of February 2021, the installed capacity of solar- and wind-based energy stands at roughly 39.08GW and 38.68GW respectively.[7] India still has a long way to go to meet the 2022 target of 100 GW solar capacity and 60 GW wind capacity set by the Ministry of New and Renewable Energy.

Renewable energy-rich states, which are expected to meet a higher share of the existing target, often raise concerns regarding the integration of such high levels of intermittent capacity and their own appetite for absorbing a higher share of renewable energy generation, especially in case of a slower growth in electricity demand. The proposed wholesale power market reforms can provide an effective solution by enabling trade of low-cost, surplus renewables across Indian states and beyond.

India's technical potential for solar- and wind-based generation is estimated at 749 GW and 302 GW respectively and stands largely underutilised. Table 1[8] details the technical potential, existing policy targets for 2022 and existing installed renewable capacity for some key states. For an accelerated deployment of renewable energy capacity, state-level policymakers, state energy and commerce departments and industrial associations also need to look at additional opportunities and co-benefits associated with renewable scale-up. In addition to existing state targets, export of renewable electricity to other states and neighboring countries provides a lucrative business opportunity and therefore should be promoted as an industrial policy.

If we keep aside technical constraints for a moment, electricity is comparable to any other good produced for export by a state. A state often uses its intrinsic competitive advantage to sell a product profitably for consumption outside its boundary. In a similar way, electricity from renewable sources can be promoted by high-renewable-potential states for

[7] Government of India, Ministry of New and Renewable Energy. (2021). *Programme/Scheme wise Physical Progress in 2020-21 & Cumulative upto Feb, 2021*. https://mnre.gov.in/the-ministry/physical-progress

[8] Government of India, Ministry of Statistics and Programme Implementation, Central Statistics Office. (2019). *Energy Statistics 2019*. http://mospi.nic.in/sites/default/files/publication_reports/Energy%20Statistics%202019-finall.pdf?download=1

consumption in other states thereby reaping the maximum benefits of the available technical potential in these states. Thermal and hydro power plant capacity in several states exhibit similar trends where that state's natural resource endowments have incentivised central generators, as well as private players, to invest in generation capacity beyond the needs of the state.

So, India's high solar and wind potential presents a unique opportunity for some states to take advantage of their natural resource endowment and transform it into one of the drivers of economic growth in their region. This proposition is no different than coal-rich states exporting coal to the rest of India and supporting their state economy.

Some states have taken a leap in the direction. For instance, the state of Andhra Pradesh announced the "Andhra Pradesh Renewable Energy Export Policy 2020" in July 2020, which explicitly promotes the development of renewable energy capacity beyond the existing state or central targets.[9]

Table 1. Renewable energy potential and installed capacity across states

State	Installed capacity (MW)		Share of 2022 target[10] (MW)		Potential (MW)	
	Wind	**Solar**	**Wind**	**Solar**	**Wind**	**Solar**
Andhra Pradesh	4092	3560	8100	5357	44229	38440
Gujarat	7359	2763	8800	8020	84431	35770
Karnataka	4753	7274	6200	5697	55857	24700
Madhya Pradesh	2519	2237	6200	5636	10484	61660
Maharashtra	5003	1663	7004	9692	45394	64320
Rajasthan	4299	4844	8600	5672	18770	142310
Telangana	128	3620	2000	4457	4244	20410
Tamil Nadu	9285	3788	11900	8884	33800	17670

Role of Wholesale Markets

Wholesale power markets play a crucial role in facilitating both the integration of renewable energy and providing avenues to renewable energy generators for selling power. Presently, India's wholesale power market is driven by long-term bilateral contracts,

[9] Government of Andhra Pradhesh. (2020, 17 June). *Energy Department - Andhra Pradesh Renewable Energy Export Policy, 2020 – Orders – Issued*. https://nredcap.in/PDFs/Pages/AP_RE_Export_policy_2020.pdf

[10] National Institute for Transforming India, Government of India. (n.d.) *State renewable energy capacity addition roadmap*. https://niti.gov.in/writereaddata/files/Executive-Summary.pdf

which constitutes close to 89% of all electricity transactions.[11] Almost all of the renewable power sold today is through such contracts.

Discoms have been in a financial stress for a long time, and the slow growth of commercial and industrial (C&I) demand, along with falling costs of non-discom alternatives, is a looming threat to their current business. Discoms are therefore hesitant to enter into additional long-term contracts whether for renewable or conventional power.[12]

The Karnataka Electricity Regulatory Commission had in fact ordered the state renewable energy procurement body, Karnataka Renewable Energy Development Ltd., to stop bidding on large scale projects due to the reduced appetite of discoms.[13]

Given that long-term bilateral contracts are the primary mode of wholesale transaction, the inability of discoms to enter into new contracts is likely to dampen the prospects for renewable energy developers. In addition, states with increasing renewable capacity deployment are finding it difficult to absorb higher shares of intermittent generation within their territory.

State government support is therefore only one half of the picture. India needs a national level market to aid investments in renewable energy and provide multiple avenues for transactions by leveraging the regional and geographic heterogeneity in energy resource endowment.

Well-designed markets have the ability to absorb higher share of intermittent renewable energy while providing the necessary flexibility at low costs. Larger balancing areas and faster markets are the key ingredients of such market design.

Over the past few years, India has made great efforts towards redesigning wholesale markets and laying out a roadmap for market reforms. The real-time market, one of the proposed market segments, was launched in June 2020 and allows for both larger balancing areas and faster markets. Larger balancing areas allow discoms and generators to take advantage of the diversity in load and generation patterns of different geographies to manage imbalances more efficiently and at a low cost. European countries have long pushed for greater interconnection capacities between countries and an integrated power market to take advantage of geographical diversities, which help balance the demand and supply dynamics in a rising renewable energy scenario.

On the other hand, faster markets[14] allow discoms and generators to correct their position closer to delivery and reduce their deviation from schedule before gate closure. Currently,

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[11] Central Electricity Regulatory Commission, Economics Division. (2020, June). *Monthly report on short-term transactions of electricity in India.* http://cercind.gov.in/2020/market_monitoring/MMC%20Report%20June%202020.pdf

[12] Chatterjee, A. (2020, 25 August). *India's solar power story disrupted as renewable energy finds no buyers.* Financial Express. https://www.financialexpress.com/industry/how-discoms-are-threatening-to-disrupt-indias-solar-power-story/2064233

[13] Thomas, T. (2019, 2 May). Karnataka puts a stop of new solar energy projects. *Live Mint*. https://www.livemint.com/industry/energy/karnataka-puts-a-stop-on-new-solar-energy-projects-1556771536456.html

[14] In this paper, faster markets refer to markets with higher time granularity and shorter gate-closure periods. Time granularity of five or 15 minutes would be better than one hour as distribution companies and generators can respond to changes in load or variation in renewable energy production more closely. Similarly, gate closure that takes place 30 minutes before delivery period, as compared to two hours, provides more opportunities for correcting day-ahead positions, optimizing procurement costs and integrating variable

there is very little merchant renewable energy capacity in the country that can participate in the real-time market directly. The presence of faster markets, however, allows the discoms to balance their portfolio better. Variation in renewable energy does not have to be managed by ramping up thermal or hydro generation. Instead, the discoms can either buy or sell power through the market to balance their position.

In addition to the real-time market, the green term-ahead market which was launched in September 2020, on the India Energy Exchange is expected to facilitate more transactions by allowing resource-rich and resource-deficit states to trade renewable energy in the open market and balance their renewable purchase obligation (RPO) targets.[15] Such platforms are also expected to provide necessary demand pull for renewable energy-rich states to promote development of renewable energy capacity beyond their current targets and utilise such platforms to sell their power in absence of long-term contracts.

The power procurement strategies of discoms are also evolving with the times. Discoms are motivated to actively optimise their power procurement through a mix of short- and long-term power contracts. Several discoms have taken advantage of the low prices cleared in the power exchanges to optimise procurement.[16] It is therefore expected that the volumes in short-term markets, especially through exchanges, may rise in the coming years, especially with the string of wholesale market reforms planned. This would be good news for renewable energy generators, who would be able to take advantage of their near-zero, marginal, cost generation and competitively participate in the market to sell their power.

In the next section we go beyond power sector dynamics and try to establish a macroeconomic proposition of efficient renewable energy trade between states. We do this by constructing a simple market model design where a single renewable-rich state of Tamil Nadu leverages its wind potential to export power to meet the existing non-solar RPOs for the northern states of Punjab, Haryana and Delhi.

The case study has been primarily designed to get deeper insights on the state level macroeconomic dynamics for renewable energy trade. In reality under fully functional wholesale markets, multiple sellers and buyers from different states will compete for the price discovery.

State level strategic support to create a competitive edge in the market will be vital for market players, thus the need for renewable energy trade to be seen under the ambit of strategic industrial policy.

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renewable generation. For more insights and examples refer to: International Renewable Energy Agency. (2019). *Increasing time granularity in electricity markets: Innovation landscape brief*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Increasing_time_granularity_2019.pdf?la=en&hash=BAEDCA5116F9380AEB90C219356DA34A5CB0726A

[15] Gupta, U. (2020, 4 November). Green term-ahead trading records 151% growth. *PV Magazine.* https://www.pv-magazine-india.com/2020/11/04/green-term-ahead-trading-records-151-growth

[16] Indo-Asian News Service. (2020, 6 August). Low demand shifting volumes to power exchanges. *ET Energyworld*. https://energy.economictimes.indiatimes.com/news/power/low-demand-shifting-volumes-to-power-exchanges/77384172

Renewable Energy for Trade: Case Study

Renewable Energy Export from Tamil Nadu to Delhi, Punjab and Haryana

Tamil Nadu is one of the key players in renewable space, with total installed capacity of more than 14.2 GW (second only to Karnataka), and has the distinction of already meeting its non-solar RPO obligations in the year 2019.[17] On average, the state meets 16.25% of its demand through renewable sources annually. renewable energy penetration, however, reaches 25%-35% in high wind-generation months (May-September).[18]

The growing renewable energy sector in the state is primarily driven by private players and increasingly faces numerous challenges. The wind-based capacity addition is on decline due to payment delays and limitations imposed on power banking options by the Tamil Nadu Generation and Distribution Corporation. Furthermore, the high costs associated with existing power purchase agreements (PPAs) for older solar capacities had led to a curtailment of solar-based generation. All this has impacted investor sentiments with private players aspiring for better returns on investment than currently possible.

Given the immense renewable energy generation potential in the state, we explore the prospects of renewable energy as an export commodity for the state of Tamil Nadu primarily driven by the following three facts:

1. The state has a high renewable energy endowment, with advanced technical capabilities for manufacturing, capacity deployment and grid integration of renewables, which already provides a competitive advantage for Tamil Nadu in trade.
2. The state has high wind penetration in its generation portfolio is better synergised to meet peak load demand at the lowest production cost, offering a strategic advantage to be leveraged amongst peers.
3. A comparatively higher penetration of deflationary wind is expected to bring production cost for electricity down in the state faster than other regions in high wind-generation months of May through July, coinciding well with the evening peaks of the summer months in the northern states of India.

Mapping Macroeconomic Impacts of Renewable Energy as a Trade Commodity

Adding renewable capacity is an economic activity expected to create both direct and indirect demand in the economy. Furthermore, cheaper power brings in associated benefits, like decrease in electricity prices for domestic consumers and industries, and greater competitiveness of tradable goods for trading partners.

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[17] Jairaj, B. & Krishnan, D. (2020, 18 February). TN can become clean energy leader. *The Hindu Business Line*. https://www.thehindubusinessline.com/opinion/tn-can-become-clean-energy-leader/article30844363.ece#

[18] Central Electricity Authority, G O & D Wing, Operation Performance Monitoring Division. (2020, 3 February*). Energywise – Perfomance Status All India – Regionwise*. https://cea.nic.in/old/reports/monthly/generation/2020/January/actual/opm_02.pdf

We use E3-India[19] to assess the impacts of renewable energy trade on Tamil Nadu as an exporter and the three northern states of Punjab, Haryana and Delhi as importers of cheaper power. The model helps us to estimate various direct, indirect and multiplier effects of scaling up renewable energy capacities and reducing electricity costs at the state level.

In order to assess the economic value of creating mechanisms that allow greater renewable energy trade between renewable energy-rich and -deficient states, we simulate scenarios where the state of Tamil Nadu, with its high wind potential, invests to develop additional wind capacity. The additional capacity is used for trading with the low renewable energy-potential northern states of Punjab, Haryana and Delhi, enabling them to closely meet their existing non-solar RPO (10.5% of total power purchase)[20] from 2022 through 2030.

Scenario Preparation

In the trade scenario, we design a renewable trajectory for Tamil Nadu so the state is able to meet almost 50% (34.8 GW) of the existing state technical potential for onshore wind (68.75 GW) by the year 2030. It is assumed that Tamil Nadu systematically develops more than 8.8 GW of wind capacity dedicated to exports, while 18.9 GW is used to meet the state's own energy demand.[21] In the case of a baseline scenario, an additional 14.1 GW of wind capacity is installed by 2030 and used within the state. The dedicated "for export" renewable energy generation capacity in Tamil Nadu is equivalent to the total aggregate demand for non-solar RPO's existing in the northern states of Punjab, Haryana and Delhi. These states do not have the requisite regional potential to meet the existing non-solar renewable purchase obligations through local resources.

Scenario Details

Two scenarios were designed for the analysis: a baseline scenario and a trade scenario. In order to create a realistic design for high renewable penetration scenarios, it's necessary that various constraints of real-time grid balancing are integrated in the analysis. We therefore keep the state-level installed capacity for solar and wind by the year 2030 comparable to evaluated baselines and high renewable energy scenarios of the Energy Transition Commission (ETC) report[22] — *Renewable power pathways: Modelling the integration of solar and wind in India by 2030* — that integrates production-cost based modelling to determine ability of renewable energy capacity scale-up for various states, while balancing for the grid requirement.

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[19] Cambridge Economics. *E3-India: A state-level E-3 model of India*. https://www.camecon.com/how/e3-india-model/

[20] Government of India, Ministry of Power. (2018, 14 June). *Order No. 23/03/2016-R&R, Order on 14 June, 2018*. https://powermin.nic.in/sites/default/files/webform/notices/RPO_trajectory_2019-22_Order_dated_14_June_2018.pdf

[21] The E3-India model allows us to construct an array of probable scenarios with different generation technology capacities; we are discussing one such scenario.

[22] Energy Transitions Commission. (2020, July). *Renewable power pathways: Modelling the integration of wind and solar in India by 2030*. https://www.energy-transitions.org/publications/renewable-power-pathways

In the TERI-ETC analysis, grid balancing from 169 GW of wind 229 GW of grid-connected solar is balanced along with 60 GW of storage in a high renewable energy scenario with the help of the grid balancing production cost model PyPSA.[23]

Table 2[24] provides details of capacity calibration at the national level for the analysis.

Table 2. Capacity calibration at the national level

	Capacity by 2019 (GW)			Capacity by 2030 (GW)		
Scenario	**Thermal**	**Wind**	**Solar**	**Thermal**	**Wind**	**Solar**
Baseline	231	38	35	260 *(263)*	129 *(130)*	188 *(189)*
Trade scenario	231	38	35	260 *(263)*	171 *(169)*	222 *(229)*

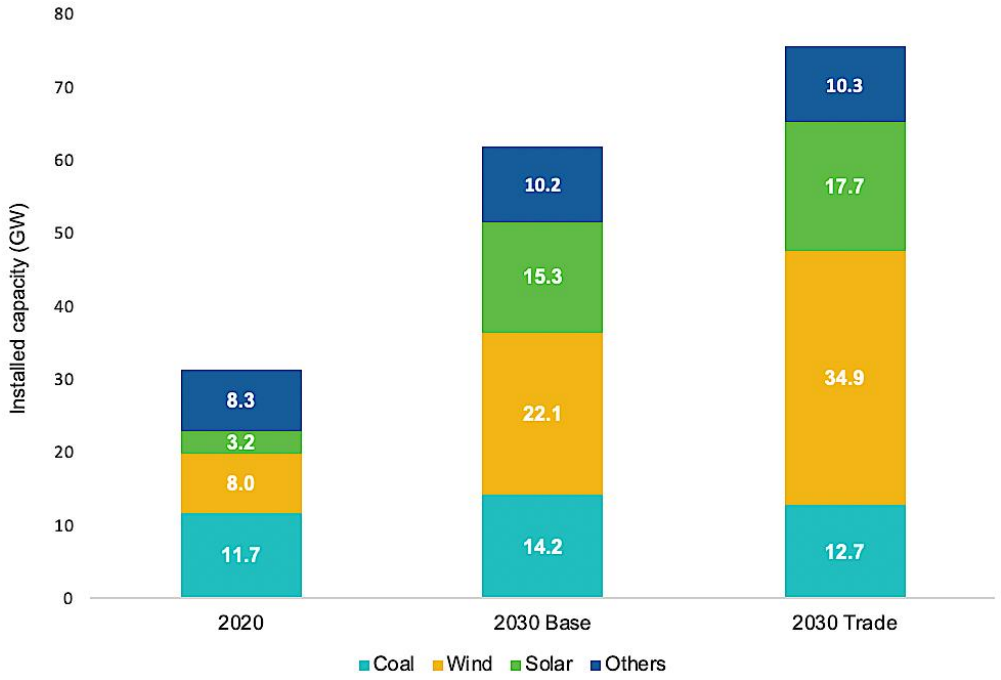
Note: ETC scenario capacities in parenthesis.

In our analysis, the baseline line scenario closely follows the ETC-TERI baseline. In the trade scenario, however, total wind allocation for Tamil Nadu was increased to achieve close to 50% of the state technical potential capacity (~34.8 GW) by 2030. The overall generation capacity for offshore wind is comparable with the ETC scenario at the national level. Figure 1 illustrates change in capacity mix for Tamil Nadu for the baseline and trade scenarios between 2020 and 2030.

[23] Energy Transitions Commission. *About Power Sector Modelling for 2030* [data set]. http://103.11.86.171/home

[24] The adjustment of capacity numbers is endogenously done in the E3-India model using the novel Future technology transition module. This is leading to a marginal difference between ETC and our scenarios.

Figure 1. Generation capacity mix of baseline and trade scenarios for Tamil Nadu



The total wind power exported from Tamil Nadu is comparable to the existing non-solar RPO (10% of the portfolio) for the three northern states of Haryana, Punjab and Bihar from 2022 through 2030. E3-India estimates demand for electricity endogenously with supply matched to meet the demand. The total power to be traded from 2022 through 2030 is detailed in Table 3. The total imported power was adjusted to reduce the generation cost of power for these states proportionally to the entire generation mix. The cost of wind generation for Tamil Nadu was fixed at 2.9 rupees (INR) per kWh on the basis of the latest power purchase agreement for wind signed by the Tamil Nadu Generation and Distribution Corporation.[25] The export margin for electricity trade is fixed at 50 paise per unit, and the state electricity services sector is set to receive remittances from importing states for this sale.

[25] Verma, A. (2020, 21 February). TNERC approves Rs 2.91 tariff for procurement of 441 MW wind power. *Suar Energy International*. https://www.saurenergy.com/solar-energy-news/tnerc-approves-rs-2-91-tariff-procurement-441-mw-wind-power

Table 3. Total renewable energy power traded across the states

States	2022	2023	2024	2025	2026	2027	2028	2029	2030
RE import (GWh)									
Haryana	3343	3536	4172	4362	4580	4788	5108	5468	5989
Punjab	4634	4703	4760	4821	4897	4899	5075	5321	5866
Delhi	4481	4771	5080	5410	5761	6128	6524	6951	7415
RE export (GWh)									
Tamil Nadu	12,458	13,010	14,012	14,593	15,238	15,815	16,707	17,740	19,270

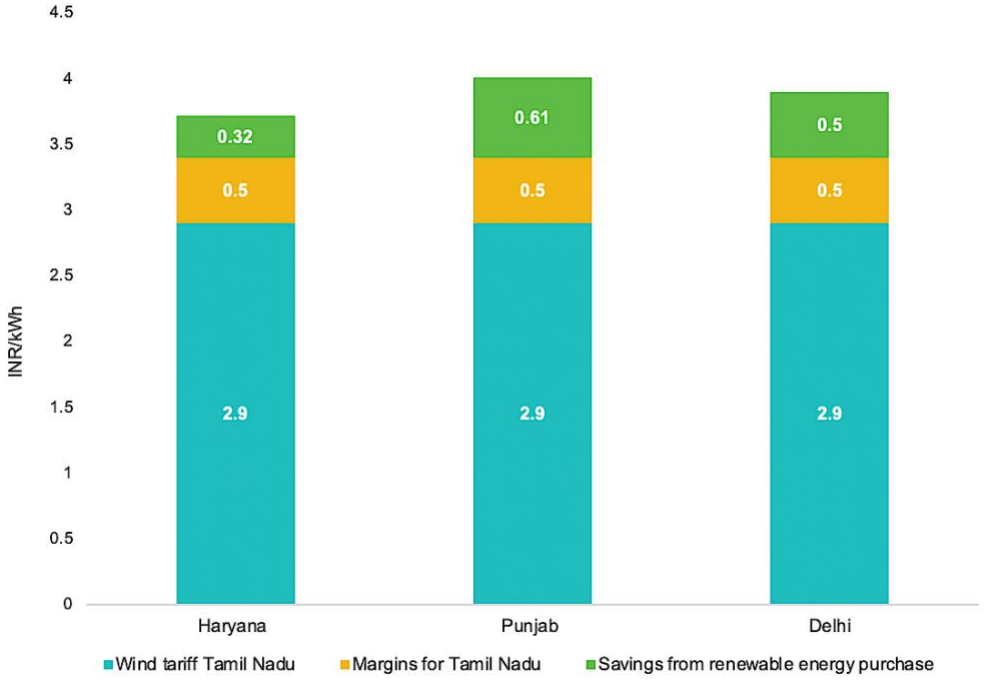
Although the projected cost of power production for solar- and wind-based generation may further fall close to 14-22% by 2030, we have considered a fixed margin for Tamil Nadu until 2030 to account for overheads to exports, in terms of margins attributed to power exchanges, greater infrastructure requirements and cost for trading long distances. Currently, all solar and wind projects commissioned through December 2022 are eligible for availing exemptions from interstate transmission system charges, as well as losses on transmission for 25 years, as provided by Ministry of Power.[26]

The importing states pay for cheaper renewable energy from Tamil Nadu, which is attributed as an increase in commensurate value of import of power by the electricity service sector for Punjab, Haryana and Delhi. The reduction in the electricity cost due to imports of cheaper renewable energy is modelled as a pass through to consumers by an equivalent negative tax on the electricity rates for all consumer categories. The saving margins per unit have been estimated as INR 0.62, INR 0.32 and INR 0.50 for Haryana, Punjab and Delhi respectively, as shown in Figure 2. The margins have been estimated considering the average power purchase costs of discoms from the importing states, as obtained from CERC's average power procurement cost report. In a fully functional markets these margins are expected to vary with time and market conditions.[27]

[26] The Press Trust of India. (2020, 17 June). Power ministry may consider extension of ISTS charges waiver beyond 2022. *ETEnergy World*. https://energy.economictimes.indiatimes.com/news/power/power-ministry-may-consider-extension-of-ists-charges-waiver-beyond-2022/76416338#:~:text=Last%20year%20in%20November%2C%20the,of%20electricity%20for%2025%20years

[27] Central Electricity Regulatory Commission. (2019, 7 May). *Petition No. 05/SM/2019. Order on 7 May, 2019*. http://www.cercind.gov.in/2019/orders/05-SM-2019.pdf

Figure 2. Trade margins for renewable energy-exporting and -importing states



In the trade scenario, a reduction in the cost of power procurement due to cheaper renewable energy-based imports is fully passed on to consumers in the states of Punjab, Haryana and Delhi.[28] This leads to reductions in the input costs of electricity across the various economic sectors in the respective importing states. In reality, however, the savings may not be totally passed to consumers and could also be used to reduce the existing deficits and subsidy burdens by the states.

Direct and Indirect Impacts of Renewable Energy Trade Across States

The impacts of scaling wind capacities in Tamil Nadu are captured by the E3-India model in two ways: 1) the effects of incremental investments in the economy, and 2) the effects of deflationary wind in the state energy mix. An increase in energy sector investment creates demand for materials, fuel and labor, which leads to a concomitant increase in income flow. This then leads to further demand for goods and services as a recursive loop in the economy. E3-India captures these interactions and provides estimates for both short- and long-term combined effects associated with energy-economy interactions.

In the case of the renewable energy importing states of Haryana, Punjab and Delhi, the positive macroeconomic impacts of shifting to low-cost electricity and the negative ones due to reduced generation from state-based coal generation capacities is captured. The analysis therefore not only captures both the primary and secondary impacts of change in

[28] The possibility of using the savings from the imports to reduce the regulatory assets of discoms or diversion for other outlays also exist but has not been modelled in the existing scenarios

energy sector dynamics due to trade, but also any adverse impact on the economy due to the change in sectoral outputs from the reduction of coal generation. (Refer to the E3-India technical manual for details.) Figure 3 details the overall reduction in the cost of electricity and the increase in demand for electricity amongst the trading states.

Figure 3. Change in electricity demand and production costs

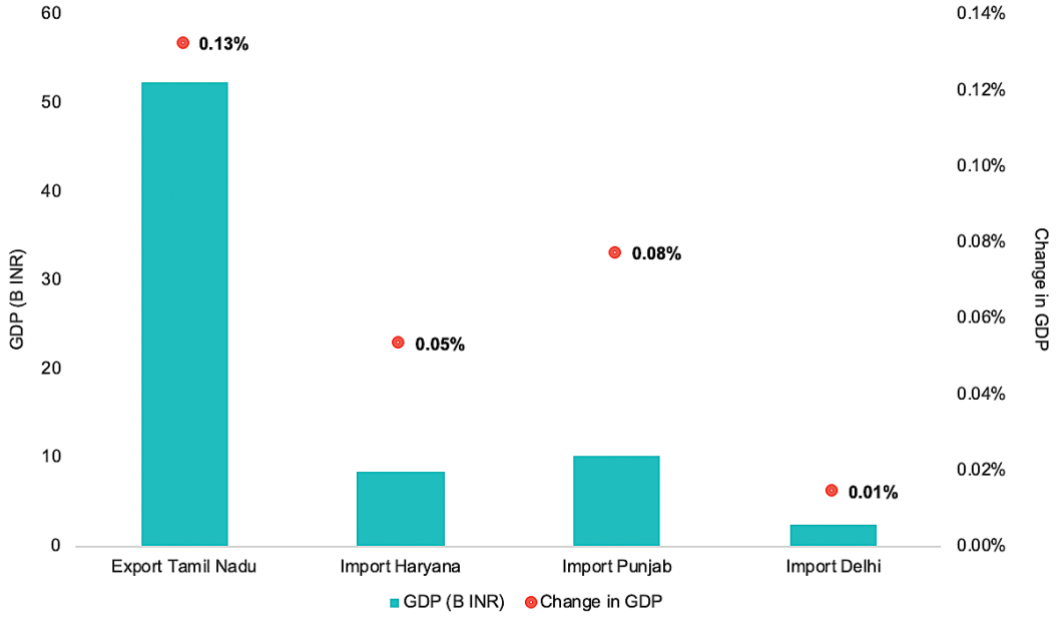
Scaling wind capacities in Tamil Nadu leads to more than a 2.9% reduction in the production cost of electricity and close to a 1.9% concomitant increase in electricity demand in the trade scenario for Tamil Nadu. The renewable energy importing states also show a reduction in electricity cost of between 0.5% and 1.81% by 2030. The simultaneous demand for electricity increases by 0.2%, 0.59% and 0.61% for Delhi, Haryana and Punjab respectively. The electricity price reduction in these states leads to lower cost of industry output impacting key economic indicators, such as GDP, employment, and rural and urban household incomes.

Impacts on State Gross Domestic Product

The change in state gross domestic product (SGDP) is one of the key macroeconomic indicators estimated in the study. The SGDP is estimated in E3-India as an identity that aggregates the total consumption expenditure, investment, final government expenditure and total trade balance for the state. The impacts on SGDP will be different for the exporting and importing states, as illustrated in Figure 4.

For the state of Tamil Nadu, the analysis captures an increase in both direct and indirect demand due to wind installation. We find that an enhanced trajectory of wind capacity addition will lead to a cumulative increase of 0.13% GDP.

Figure 4. Change in state gross domestic product across states

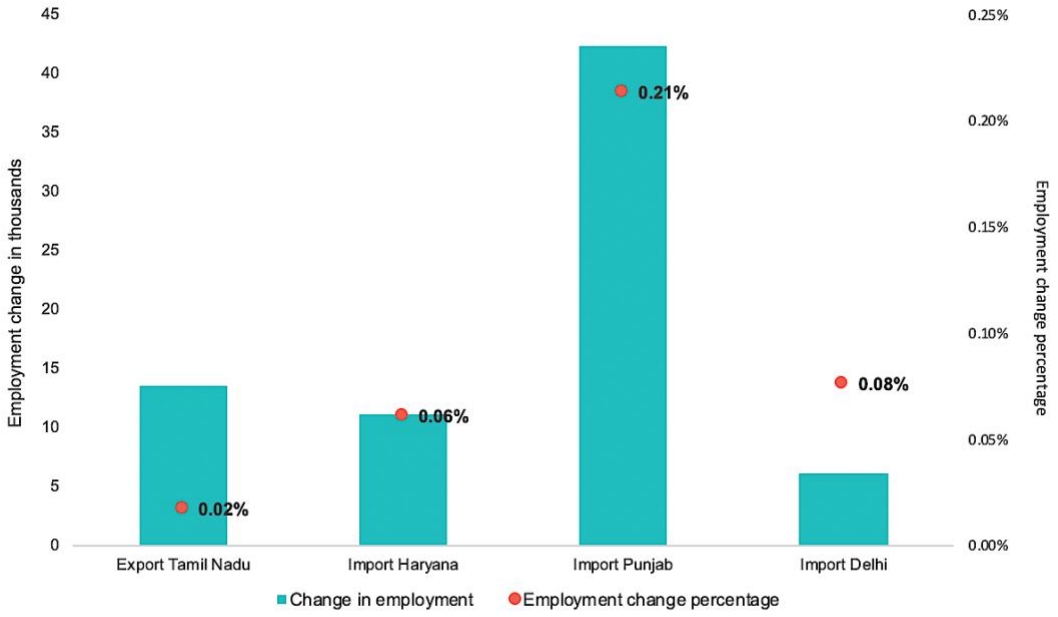


The imports of cheaper renewable power increased the gross output for the states, but the increases in imports in the electricity sector is counterbalanced by the impacts of reduction in electricity generation within the state, leading to only a marginal increase of 0.05%, 0.08% and 0.01% in GDP for Haryana, Punjab and Delhi respectively by 2030.

Impacts on Total and Sectoral Employment in Renewable Energy Trading States

The overall change in regional employment is positive for both the exporting and importing states, as illustrated in Figure 5. Additional wind capacity installation creates more than 13,000 (a 0.02% increase) new direct and indirect jobs for Tamil Nadu. The overall employment also goes up in importing states of Haryana, Punjab and Delhi by 0.06%, 0.21% and 0.08% respectively for the trade scenario. The increase in employment is the highest in Punjab, with about 27,000 more jobs by 2030 in the trade scenario.

Figure 5. Impacts on employment across region and sectors



We further studied the distribution of the employment impacts across key economic sectors, thus mapping direct, indirect and induced employment generated for the trading states (Figure 6). Each state has a unique economic structure primarily defined by its distinct natural endowment and time-prevailing political economy aspirations.

Furthermore, with electricity in the concurrent list, the state plays a primary role in determining the electricity tariff for different consumers by providing specific incentives to various sections and consumers. Along with the prevailing cross subsidies available for agricultural and domestic consumers, many small, micro and medium enterprises also receive incentives like electricity tax exemptions and subsidies.

In addition, special economic zones constituted under the state's industrial growth policies also attract special packages and incentives in cost of supply to bring more investments into the import states. The price-demand elasticity of different sectors within a state will therefore be different and determined by state-specific policies. These interactions are captured in E3-India through sector and state specific energy demand equations estimated econometrically from underlying time-series data (1995-2016).

Figure 6. Impacts on sector-wide employment across states

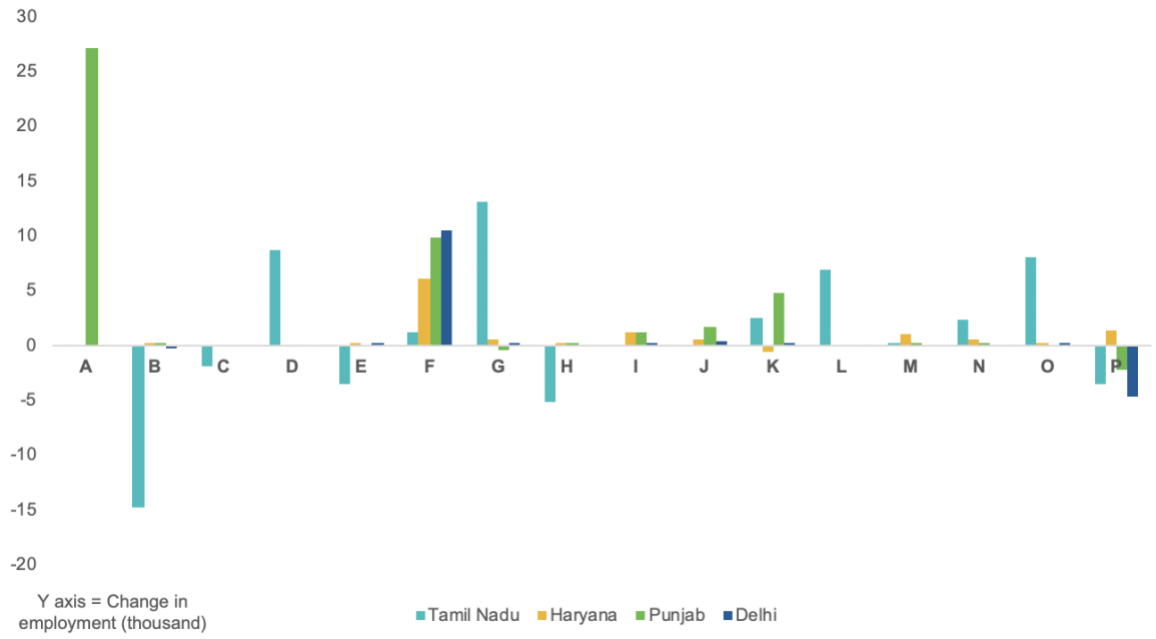


Figure 6 key			
A	Agriculture	I	Hotels and catering
B	Forestry	J	Other business services
C	Coal	K	Land transport
D	Oil and gas	L	Water transport
E	Electrical engineering and instrumentation	M	Other transport equipment
F	Construction	N	Electricity supply
G	Other manufacturing	O	Water supply
H	Food, drink and tobacco	P	Others

The employment impact of renewable energy trade will be more pronounced and dispersed for Tamil Nadu due to new investments in wind capacity addition and reduction in electricity production cost for the trade scenario.

The supply chain for wind generation technologies is embedded in the state, which engages in both the manufacturing of components and generation of wind power. In the trade scenario we find a shift in employment from a primary sector — such as forestry and food processing — to high value-added sectors like manufacturing and water transport, along with oil and gas services.[29]

This indicates a positive growth trajectory, with labor moving up the value chain from the primary or agro-based sectors to manufacturing, along with more export prospects indicated by an increase in jobs in water transport sector.

The sector-wise employment changes in the renewable energy-importing states of Haryana, Punjab and Delhi are primarily driven by sector-specific, price-demand elasticity for electricity. We find that for Punjab, where the average power-purchase cost is highest in the import group, the reduction in cost of electricity leads to a substantial increase in agriculture-based employment. For the other two states, the highest increase in employment can be attributed to the construction sector, indicating a strong link between the electricity sector and construction activities in the states.

In reality, however, the reduction in the cost of production or procurement of electricity may not be directly passed on to consumers. For instance, in Punjab, where the electricity tariff for agriculture is already highly subsidised, the best benefit can be reaped by state governments in terms of a reduced burden of electricity subsidies. The bottom line is that a reduction in electricity production or procurement cost has tangible economic benefits for all the states.

Impacts on Household Income

We further study distributional impacts on rural and urban incomes for the trade scenario (Figure 7). The change in incomes can mainly be attributed to the indirect demand created by new capacity installations and reduction in production cost of electricity that is directly passed on to consumers as savings. The household incomes for the state increase between 0.17% and 0.19%. The change in income is highest in rural middle-income group; the lowest is for urban high-income households.

The Indian wind supply chain is already localised to an extent of 80%-85% by value with imports limited to castings and power electronics.[30] Tamil Nadu is already regarded as the wind power and automotive hub of India, with two major wind turbine companies — Nordex Group and Vestas — operating state-of-the-art production facilities in Chennai. For enhanced, onshore wind capacity installation, the state is therefore expected to have large multiplier and cross-sectoral impacts, flowing down to rural and urban household incomes.

In the case of importing states, an increase in household income is highest for Punjab, between 0.16% and 0.17%, followed by Haryana (0.07%-0.08%) and Delhi (0.05%-

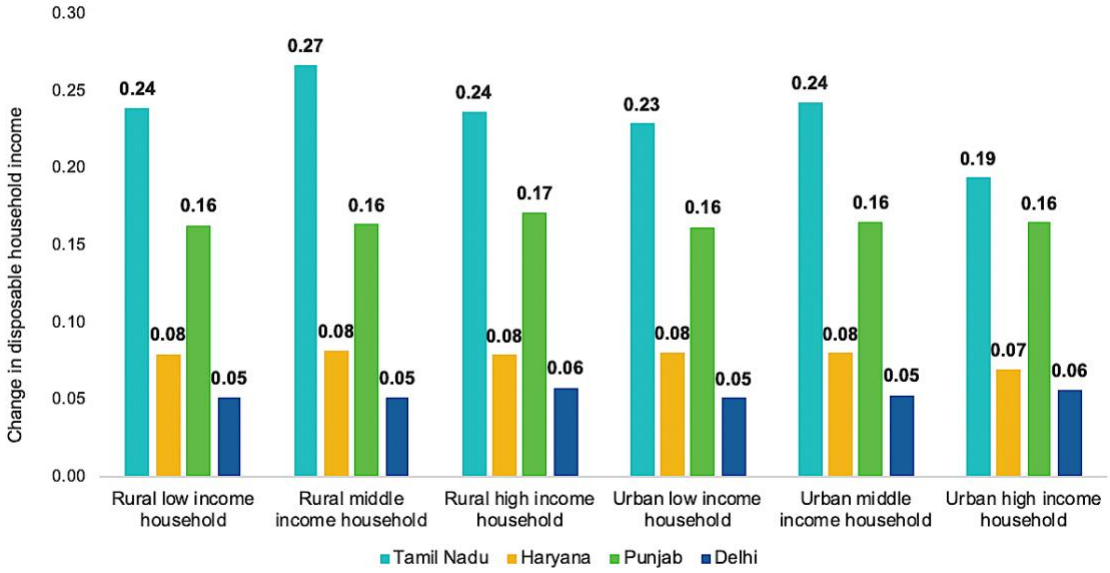
[29] Exports through Tamil Nadu ports.

[30] Jain, S. (2020, 20 July). Modi's mission could put Indian wind power back on level terms with solar. *Recharge*.

https://www.rechargenews.com/transition/modis-mission-could-put-indian-wind-power-back-on-level-terms-with-solar/2-1-845252

0.06%). Overall, for the importing states, rural middle- and high-income households show a preferably higher increase in income, indicating a higher sensitivity of these groups to the cost of electricity.

Figure 7. Income effects across rural and urban households for renewable energy trading states

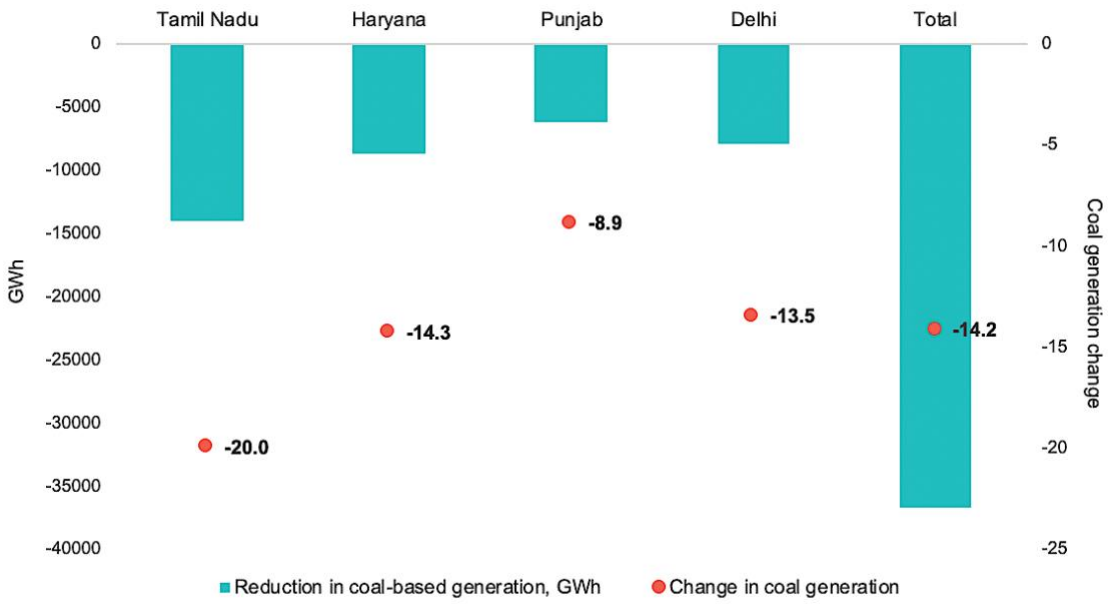


Impacts on Coal-Based Generation and Carbon Emission Across Trading States

Renewable energy trade facilitates greater integration of clean energy in the mix, with coal-based generation coming down in both renewable energy exporting and importing states (Figure 8). The trade leads to a reduction of 22.7 TWh in coal-based generation by 2030. Tamil Nadu will reduce 13.94 TWh of coal-based generation within the state and also supplies cheap wind power to the importing states.

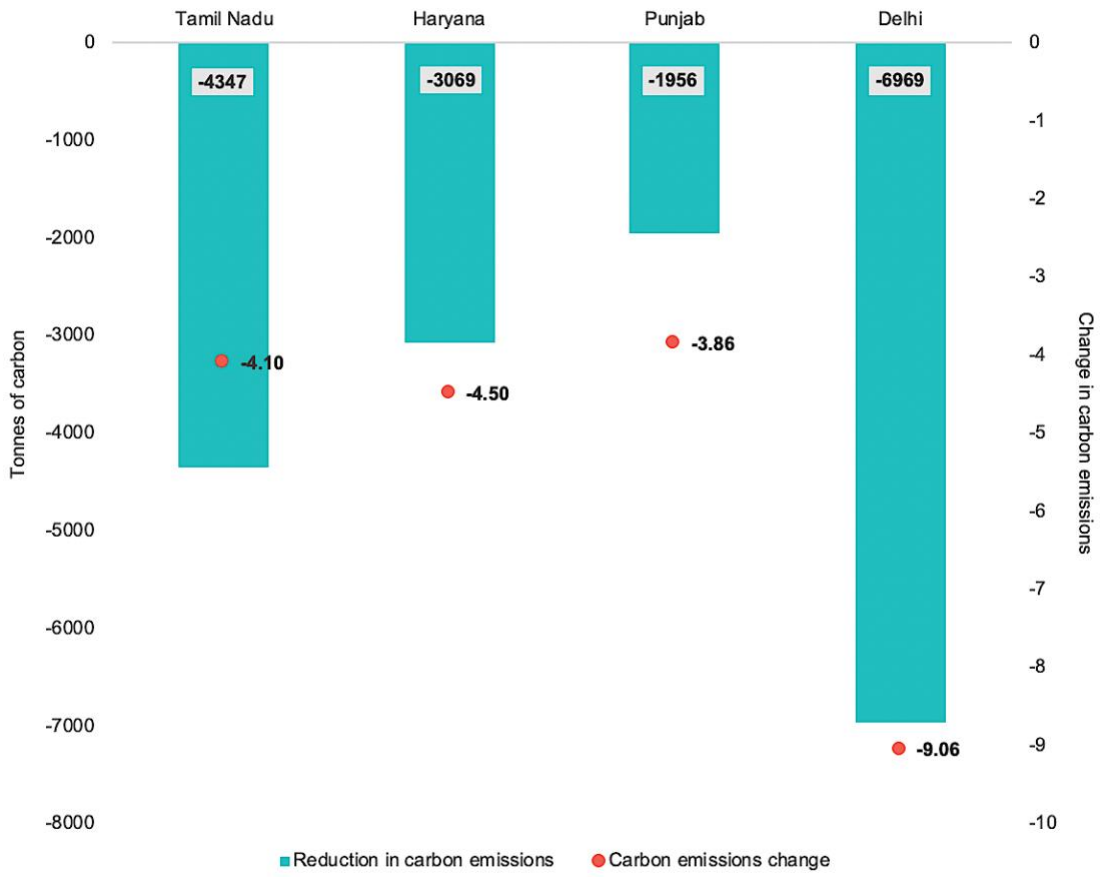
This reduction of coal-based generation also leads to certain sector-specific, negative, economic impacts in the renewable energy importing states, such as a reduction in output of electricity sector for Haryana, Punjab and Delhi due to coal phase-out. The overall economic trajectory remains positive due to augmented benefits from low-cost power inputs to various sectors of the economy.

Figure 8. Change in coal-based generation across the trading states



Overall, renewable energy trade will reduce 6.9 million tonnes of carbon emission from the energy mix of Tamil Nadu, Punjab, Haryana and Delhi (Figure 9). As coal generation goes down, this will also mean a concomitant reduction of nitrogen oxides and sulphur oxides in these regions, thus improving the air quality and public health benefits without adverse impacts on the state economy.

Figure 9. Change in carbon emissions due to renewable energy trade



The regional trade of renewables, facilitated by wholesale markets, can thus provide a crucial opportunity to the trading states, not only for regional economic development but also decarbonization and better environmental and public health outcomes.

Conclusions

Effective renewable energy trade brings economically desirable outcomes for all the trading states and also reduces overall coal-based generation in these regions. Tamil Nadu, as a renewable energy exporter, benefits not only from the additional revenues in power sales, but also additional investments for renewable capacity scale-up. The wind supply chain is already well integrated in the state economy and can provide a strong competitive advantage for the state as a wind energy exporter in the wholesale power market, along with evident macroeconomic benefits.

The state policymakers should therefore strategically endorse renewable energy trade as an industrial policy, thereby providing better opportunities to enable independent power producers to compete in the market by honing this competitive advantage.

Furthermore, the proposition of cheaper power provides opportunity for renewable energy importing states (Haryana, Punjab and Delhi) to benefit from greater value additions in

other sectors of the economy, such as agriculture, construction and service sectors. Although coal-based power generation takes a hit in these states, the adverse impacts are counterbalanced by the overall positive macroeconomic impacts associated with the availability of cheaper electricity.

Options to trade cheap renewables provide greater flexibility to trading states for managing their power portfolio economically and also enable them to address their regional environmental concerns cost effectively. As provisions for larger balancing areas, unified wholesale power markets and utility-scale storage become reality, it will be theoretically possible for renewable energy-rich states to leverage 100% of their technical potential and export cheap power for sale to other regions.[31] Exploiting such a natural competitive potential, however, is not easy due to pre-existing regulatory and financial barriers for trade, plus the emerging economic uncertainties due to COVID-19.

Lower than expected demand growth along with surplus capacities may inevitably dampen the prospects of developers to take advantage of new market possibilities in the power sector. One silver lining, however, is that demand weakening has prompted discoms to actively optimise their power procurement costs and aggressively scout for low-cost power from the market,[32] making renewable energy trade a lucrative option.

Moving ahead, establishing renewable energy as a trade commodity warrants thinking beyond the existing power sector framework of supply matching demand at a state level, to a more holistic industrial policy. To make this a reality, extending this framework will need to be augmented by redefining the policy, regulatory and financing structures.

For establishing renewable energy as a lucrative trade product, the necessary condition will be to minimise cost and maximise trade margins for generation. This opens avenues for reconfiguring energy generation mix in a way that provides the lowest cost RE for the highest possible duration. For the renewable-rich states, it will be beneficial to promote greater deployment that extends beyond their own obligations and demand. This will also provide opportunities to reap further benefits through various grid flexibility mechanisms.

This work is an initial attempt to provide greater insights on intrinsic macroeconomic benefits associated with renewable energy trade, using a stylised model with only limited players. In reality a fully functional wholesale market will provide an efficient platform for all renewable-rich states to leverage their competitive advantage and export renewables to other states, bringing down the cost of procurement for all importing entities and concomitant benefits. As presented in this report, the impact of policies favoring renewable energy trade is widespread and goes beyond the energy sector.

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[31] Tenddulkar, 2017.

[32] Thomas, T. (2020, 28 May). Power utilities turn to cheaper exchange power as prices crash. *Mint*. https://www.livemint.com/industry/energy/power-utilities-turn-to-cheaper-exchange-power-as-prices-crash-11590636539577.html

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