DEEP DE-CARBONIZATION AND REGIONAL EQUITY

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Abstract

This paper presents a preliminary assessment of the nature and extent of the financial impact of the mitigation policies centered on deep decarbonization of India's electricity sector on the budget deficits of the states with relatively low endowments of solar and wind power. The impact could be quite substantial, adding 8.66% to the combined deficits of the VRE poor states under fairly conservative assumptions. The impact is most severe on the three coal-rich states of Jharkhand, Odisha and Chhattisgarh. Absent an acceptable framework for an equitable sharing ofcosts and benefits across the states and with the centre, these developments could impede the realization of the national goals for climate change mitigation.

India's ambitious targets call for a deep de-carbonization of the electricity sector through an accelerated deployment of renewable energy and reduced use of coal. This could exacerbate existing regional inequalities, between the states in the west and the south and those in the north and east. While variable renewable energy (VRE) sources namely, solar and wind are concentrated in a few states in the western and southern parts ofthe country, coal reserves occur mainly in the eastern part that also happen to have the lowest VRE endowments. As the share of VRE in electricity production and consumption rises, these locational characteristics and the dominant role of state ownership in the electricity sector together play into the finances of the VRE poor states through higher expenditure and lower revenues.

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I Introduction

The paper is organized in four parts. Part I starts with an outline of India's commitments regarding climate change mitigation, subsequent policy initiatives and implementation experience. While examining the nature, extent and implications of the geographical concentration of energy resources, VRE and coal, the paper also looks at other existing income and development divergences between the VRE rich and VRE poor states. It goes on to briefly examine the characteristics of the framework for deficit management and the nature and characteristics of the electricity sector at the sub national level and ends with the formulation of the research question. Part II presents the data sources and outlines the methodology. Part III summarizes and discusses the results and specific policy recommendations.

Part I

II Policy and Implementation Experience

Total GHG emissions in India are of the order of 2800 $MTCO_2$ eq. The energy sector accounts for nearly 75%. Of this, electricity production contributes nearly 40%. (MOEFCC, Biennial Update Report, 2021). Unsurprisingly, India's NDC commitments seek to address these concerns through the reduction of the emissions intensity of its GDP by 33 to 35 percent by 2030 from the 2005 level and the attainment about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. To match these commitments, India has announced a set of ambitious targets for electricity generation through renewable sources-targeting 175 GW by 2022 and 450 GW by 2030. (BUR, pp 23), designed to gradually reduce the dependence on coal. At present, the share of non-fossil sources in the total power generation capacity of close to 400 GW is about 38%. The share of renewables in generation capacity is close to 25% and is expected to go beyond 50% by 2030. Renewables share in actual generation has grown from less than 5% in 2006 (not including small hydro) to 23.92% in 2020 (definition of Renewable Energy Sources (RES) expanded to include small hydro) and is expected to rise to 30% by 2030. (CEA). Changes in the energy mix through the next decade to 2030 have been built into the National Electricity Plan and the Optimal Generation Mix (OGM) for 2029-30 and are set out in Table 1 below. It is expected that OGM, under which the VRE share to rise from about 18% in 2022 to about 30% in 2030, will require about 895 MT of coal @ 0.7 kg/ Kwh (CEA2020-p 36), nearly 555 MT lower than the coal requirements were the share of VRE to remain unchanged during 2022-2030 (BAU).

Table 1. Optimal Generation Mix (CEA Projections)

	2022		2027		2030	
	Capacity (GW)	Gross Generation	Capacity (GW)	Gross Generation	Capacity (GW)	Gross Generation
	BAU	*Billion KWh*		*Billion KWh*	*OGM*	*Billion KWh*
Solar	100	162	175	283	280	484
Wind	60	112	100	188	140	309
VRE	160	274	275	471	420	793
Others	316	1292	344	1576	397	1725
Total	476	1566	619	2047	817	2518

Source: Optimal_mix_report_2029-30_FINAL.pdf (cea.nic.in)

India has more than 1050 GW of VRE potential-solar (749) and wind (302) combined. (Table 2). Less than 10% has been exploited. Almost all of the immediately realizable potential is in eight major states, that is states with populations in excess of 20 million, located mainly inthe west and south. It is possible to easily categorise the states as VRE rich and VRE poor. The former group will have Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana, each with VRE potential greater than 5% of the total. They account for nearly 67% of the total VRE potential in the country. We have included Telangana in this category even though it does not meet the 5% criterion because it has been an early mover and has an installed VRE capacity larger than all the VRE poor states put together. On the other hand, 10 other major states, (categorized as VRE Poor each with less than 5% of the total potential in the country) in the east and the north, including three of the largest in terms of population, Uttar Pradesh, Bihar and West Bengal have a much lower (13%) share of India's VRE potential. Wind power potential is particularly skewed.

The latter have only 1.6% of the total wind power potential, while the former have 98%. The distribution of solar energy potential is relatively less skewed, respectively 54 and 17%. The skewness shows up more in the pattern of actual installed capacity across the groups. More than 94% of the total VRE capacity installed so far (2020) is located in the eight VRE rich states. The VRE poor states have only 4.8%-all solar. They have no wind power installations. Five sparsely populated Himalayan states, Jammu & Kashmir (112 GW solar potential), Himachal Pradesh (33.84 GW solar), Uttarakhand (16.8 GW solar), Arunachal Pradesh (8.65 GW solar) and Sikkim (4.94 GW solar) are very well endowed and together have close to 25% of the total assessed solar potential of 749 GW. Despite the endowment, they are unlikely to play a role in the renewables-based generation scenario in 2030. The solar potential is located in inaccessible and ecologically fragile trans-Himalayan zones. The land requirements for solar stations could prove to be a major obstacle (Dutta, 2021). While much has been done to try to enhance the ability of the Indian grid to absorb large amounts of VRE, this is arguably the most underinvested part of the energy transition so far. It would only be logical to assume that investors would be more interested in the more accessible VRE sites with the necessary ecosystems to start with before looking at the trans-Himalayan zones. The leading states have already built up a considerable momentum in the exploitation of their VRE potential and they have so far tapped only 10%.

The point is that in the coming decade, the VRE rich states will continue to dominate and maintain their present share of 95% in the total VRE basket-88% in solar and more than 99% for wind. The VRE rich states are unlikely to go beyond 10% of the solar capacity and could look to a token wind capacity of 62.5 MW -all from Kerala. This conclusion will have an important role in determining the respective share of the two groups in the VRE generation profile of 2030. Unless things change drastically in the future, the VRE rich states are likelyto be better able to exploit their VRE potential and maintain their lead through the next decade up to 2030.

This dynamic will only be exacerbated by the fact that the majority of upcoming VRE commissioning will likely happen through private sector companies. Historically, power sector siting in India has been both technically and politically determined; for example, the original NTPC power plants of Farakka, Ramagundam, Singrauli and Korba were partly chosen because of their ability to supply electricity to multiple states power at the same time.This was possible because state-owned entities were commissioning these power plants and were balancing between technical and political criteria. The majority of India's VRE grid- connected capacity is being constructed by private companies, and cross-subsidization dynamics and other kinds of budgetary support will not be easily available to such entities. They will naturally gravitate towards regions and sites with greater insolation and wind densities, predominantly in VRE rich states. Not surprisingly, there has been muted participation and success of VRE poor states' auctions for renewable energy asset construction.

Table 2. VRE in India

Sl. No	State	Potential Solar (GW)	Potential Wind (GW)	Potential VRE (GW	Solar Installed (GW)	Wind Installed (GW)	VRE Installed (GW)	Potential Exploited. (GW)
		GW	GW	GW	GW	GW	GW	%
1	Maharashtra	64.32	45.39	109.71	1.80	5.00	6.80	6%
2	Tamil Nadu	17.67	33.80	51.47	3.92	9.30	13.22	26%
3	Andhra Pradesh	38.44	44.22	82.66	3.61	4.09	7.70	9%
4	Telangana	20.41	4.24	24.65	3.62	0.13	3.75	15%
5	Karnataka	24.70	55.06	79.76	7.28	4.79	12.07	15%
6	Gujarat	35.77	84.43	120.20	2.95	7.54	10.49	9%
7	Rajasthan	142.31	18.77	161.08	5.14	4.30	9.44	6%
8	MP	61.66	10.48	72.14	2.26	2.52	4.78	7%
	VRE rich	**405.28**	**296.40**	**701.68**	**30.57**	**37.67**	**68.24**	**10%**
1	West Bengal	6.26	0.00	6.26	0.11	0.00	0.11	2%
2	UP	22.83	0.00	22.83	1.10	0.00	1.10	5%
3	Bihar	11.20	0.00	11.20	0.15	0.00	0.15	1%
4	Jharkhand	18.18	0.00	18.18	0.04	0.00	0.04	0%
5	Odisha	25.78	3.09	28.87	0.40	0.00	0.40	1%
6	Assam	13.76	0.00	13.76	0.04	0.00	0.04	0%
7	Kerala	6.10	1.70	7.80	0.14	0.06	0.21	3%
8	CG	18.27	0.08	18.35	0.23	0.00	0.23	1%
9	Punjab	2.81	0.00	2.81	0.95	0.00	0.95	34%
10	Haryana	4.56	0.00	4.56	0.25	0.00	0.25	6%
	VRE poor	**129.75**	**4.87**	**134.62**	**3.41**	**0.06**	**3.47**	**3%**
12	VRE Rich +Poor	535.03	301.27	836.30	33.98	37.73	71.71	9%
13	Total India	749.00	302.00	1051	34.63	37.74	72.37	
14	% Total India	71.43%	99.8%	79.57%	98%	99.97%	99%	

*VRE poor -states with < 0.5 GW installed capacity
Source : MNRE Annual Report 2019-20. (file f-1597797108502.pdf (mnre.gov.in))

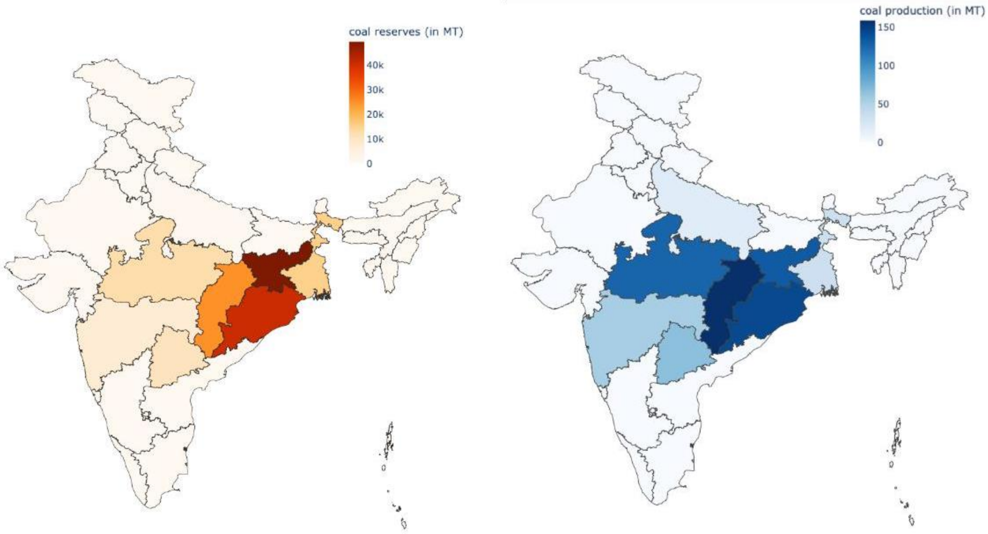
Like VRE, coal reserves are also regionally concentrated, with six states accounting for more than 87% of the proven coal reserves and more than 80% of the annual coal production. Royalty on coal production forms a major source of state governments' non-tax revenues[i]. Coal producers are also required to deposit specified amounts to a district level statutory body-the District Mineral Fund (DMF) to be used for the welfare and development of the coal mining areas. The federal government collects an additional amount by way of coal cesswhich is partly shared with the respective state governments through a separate mechanism. Of these states, three, Jharkhand, Odisha and Chhattisgarh have 71% of the proven coal reserves and currently contribute about 60% to the total production of 730 MT. Goingforward to 2030, the pattern of production is unlikely to change across states, given the typically long time horizons in coal mine development. Coal production is dominated by thegovernment, with nearly 90% of the total production in 2020-22 coming from government agencies[ii]

Table 3. State-wise Coal Reserve and Production (2019-2020)

State	Coal Reserves (MT)	Coal Production (MT)
	2019	2019
Maharashtra	7624	55
Tamil Nadu	0	0
Andhra Pradesh	0	0
Telangana	10622	66
Karnataka	0	0
Gujarat	0	0
Madhya Pradesh	12597	126
Rajasthan	0	0
VRE rich	30843	246
West Bengal	15189	34
Uttar Pradesh	884	18
Jharkhand	49469	132
Odisha	40872	143
Chhattisgarh	24985	158
VRE poor	131399	485
Total India	162867	731

Source: Provisional Coal Statistics (ProvisionalCoalStatistics2019-20.pdf (coalcontroller.gov.in))

FIGURE 1: Map of Coal Reserves and Production (2019-2020)



India's electricity sector is largely state-owned. Though the share of the private sector generation has grown over the past decade, the distribution segment is still very much a preserve of the state governments and state-owned distribution utilities (PFC). Distribution tariffs typically do not cover the full cost of supply and state governments pay significant amount subsidies to the utilities every year (Ref) through their annual budgets. As a whole, these subsidies account for a substantial proportion of the total budgetary deficit (around 9- 10%) and are a major reason for the parlous financial position of the state governments. Several measures have been taken over the years to address this issue. They have not achieved the desired results. (Uday). Instead, the states' deficit and contingent liabilities have worsened[iii]. It is expected that demand will come back to the pre-Covid level by end 2021-22. The subsequent trajectory would in all probability follow the general trend of economic recovery.

The state distribution utilities continue to be responsible for the 24*7 supply of quality power and any shortcomings on these counts would reflect adversely on the state governments and have serious political consequences. The FRBM Act 2003 (Fiscal Responsibility and Budget Management) forms the basis of deficit management in India. The parent law imposed specific deficit targets (3% of the GDP on the federal government. Italso set limits on the quantum of government guarantees and similar contingent liabilities. Following the recommendations of the Finance Commission (Twelfth Finance Commission), a constitutional body set up every five years to recommend principles and procedures for the devolution of resources between the federal and the state governments, all states enactedtheir respective FRBM laws. As a result, their financial management appears to have been streamlined and in general states have remained within the 3% limit. A long- term study (Reserve Bank of India, 2020) showed that average fiscal deficit across states remained at 2.7% over a fairly long period. Post Covid, the 3% ceiling has been breached. It has been temporarily increased to 5% , subject to a set of fairly tough conditions. See (RBI: Study of States Budget, 2022-23). Whether the enhanced limits would be scaled back and if so,in what time frame, remains to be answered, but it can be reasonably assumed that the enhanced statutory limits on state government deficits are unlikely to go up again anytimein the future.

India's GDP growth has been impacted by the Covid epidemic. Estimates indicate that India's GDP shrank by nearly 8% during 2020-21. A number of projections have been made about the national GDP in the coming years. One of the more optimistic scenarios entails the full restoration of the GDP to the pre-Covid level by end FY 2022. Thereafter, the GDP is expected to grow at 6.5-7% annually (World Bank), Economic Survey.

Over the years, GDP growth has not been uniform across the states. During 2012-2019, the eight VRE rich states grew at an average rate of 7.75% at constant, 2011 prices, outperforming the VRE poor states which grew at 6.5%.. Not only have they grown faster, their economies are also more than 150% bigger in absolute terms. Maharashtra has the largest GSDP among all states and with the other VRE rich states, Tamil Nadu (GSDP rank 2), Gujarat (4), Karnataka (5), Rajasthan (7), Andhra Pradesh (8), Telangana (9) and Madhya Pradesh (10), occupies 8 out of the top 10 positions in terms of absolute GSDP, whereas most VRE poor states, are at the opposite end, Jharkhand (19), Chhattisgarh (18), Assam (17),Odisha (16) and Bihar (14). Though it is certain that as in the past, growth across states will vary over the decade through to 2030, the post-Covid growth path is far from clear.

For the last thirty years, India has been making progress towards having a national power grid. While certain islands and corridors of congestion still exist, it is easier for states to buy power from national power exchanges than ever before, and many states have made out-of-state power sales and purchases a central part of their energy policy (eg. Gujarat, Rajasthan, Chhattisgarh). Rapid VRE growth in certain states will inevitably lead to higher inter-regional power transfers. During certain seasons and times of day, it is quite possible that renewable generation could be the dominant source of power generation in certain states within the next decade One of the emergent problems in such a system is how to maintain system stability. As Lion Hirth has shown, as the proportion of VRE in a power grid increases, the system maintenance costs also increase significantly, especially when RE penetration rates exceed 15% of total power generated for solar, and 30% of total power generated for wind.[v] Discoms have to deal with all kinds of prediction problems, in particular: the unpredictability of VRE generation (when the sun isn't shining or the wind isn't blowing)

For VRE surplus states, the only way out to ensure system integrity without exports, would be to curtail VRE generation which would militate against the climate change mitigation targets and affect the commercial viability of VRE generators with low utilization factors in China[vi] and EU[vii]. In fact, the Government of India has been pushing to designate renewable energy sources as "must run" resources for precisely these reasons. Minimal curtailment through well-managed exports emerges as a crucial factor in the growth of VRE over the coming decade.

On an all- India basis, at 1200 hrs during 2021-22, - the average position of solar generation shows a surplus of 347 GW. But at a regional level, the western region shows a big surplus- 9785 GW, whereas the northern region has a similar deficit-6405 GW[viii]. Hence exports will have to happen between regions and to Bangladesh or Nepal. India's ability to trade power with neighboring countries has been enhanced considerably in the last decade, but so far this transmission capacity is underutilized. With regional trade in VRE resources becoming amajor focus of policy, there will have to be major efforts to bundle such power with traditional resources to provide predictable supplies of power, either bilaterally or through exchange-based transactions. Entities like NVVNL and PTC have been doing this domestically, but so far, such products have not been used in cross-border power trading.

In Tamil Nadu, 2022 projections show a 50% share of VRE in the total installed capacity of 48GW, supplying 51% of the annual energy requirement of 316 Twh. VRE remains higher than 50% for a third of the time. On a high RE day in June, with 86% VRE penetration, the system load within Tamil Nadu (22.5 GW) is unable to absorb all the power from VRE 19.4, nuclear 2.2 and coal 3.3. It has to export up to 2.5 GW[ix].

Similarly, in another high VRE state, Andhra Pradesh, in 2022, VRE (19 GW) is almost equal to non VRE (20 GW). Wind and solar together supply 51% of the total energy of 160 Twh . Atits highest, VRE will meet 98% of the peak load. On high RE day-Sept 4, 2022, the system load-10.1 GW, is 30% lower than the VRE generation, 13.3 GW. Even with coal and hydro at bare minimum- respectively 0.6 and 0.7 GW, exports of 4.5 GW are essential. Averaged over the year, the state will have to export 8.4 TWh, even after 5.6% curtailment on wind and solar. Curtailments are expensive. 1% VRE curtailment in 2022 in the state would be equal to 1.6 billion kwhr valued at Rs 4.8 billion @ Rs 3/kwhr[x].

Thus, inter-state electricity exports would be absolutely necessary. It would extremely difficult, if not impossible for the VRE rich states to manage without major curtailments in VRE. During the lockdown period, Germany managed to cross the 50% mark in renewables penetration (37% VRE). This was made possible by sharp increase in inter-country electricity exports and imports to approximately 111 billon kwh in 2021, nearly 20% of Germany's own system demand[xi]. Other countries or states (in the US) also show a similar characteristics. For example (as its share of solar power grew beyond 15%), California had tooffload nearly 18% of its power sales in 2017 free of cost to Arizona[xii].

The extent of VRE exports would primarily depend on the willingness and ability of the "importing" states. Rather than a purely techno-economic matter related to the national climate commitments, it is most likely to be a political issue related to the rise in deficits, sustained resources outflows and perceived loss of autonomy over a critical sector of enormous significance to public order and the political fortunes of the parties in power. A similar situation exists in the US where VRE sharing has been the subject of intense political give and take[xiii]. The geography and siting of VRE and its inevitable rise over the next few decades is likely to have major consequences for Indian political geography; The freight equalization scheme (FES) was started in 1956 with the explicit objective of ensuring balanced regional development in India by subsidizing the long distance transportof key industrial inputs like iron and steel, cement and fertilizers. In 1950, West Bengal and Bihar had more than 90% of India's iron and steel production and close to 50% of allengineering industries based on iron and steel. They also had most of India's iron ore and coal deposits. Over a 35 year span, until it was closed in 1991, FES neutralized this regional advantage and enabled users at the opposite ends of the country, the west and the south to get access to iron and steel at the same price. (Manufacturing Underdevelopment: Firth and Liu, 2018). Though there is mixed evidence regarding the success of FES, it is quite clear that the neutralization of locational advantages were irreversible in the long run. (Political implications of Inter-state Disparity, Dasgupta and Ghosh, EPW, 44(26-27), June 2009).

Part II

III Data and Methodology

- VRE data -potential and installed capacities have been sourced from the Annual Reports of the Ministry of New And Renewable Energy of the Government of India. (MNRE, Annual report 2019-20)[xiv]. Data pertaining to the build out of VRE capacity up to 2030 is from the Central Electricity Authority (Report on Optimal Generation Capacity Mix 2029-30). Coal production and reserves have been sourced from the report of the Coal Controller, Government of India[xv]. Royalty rates are from the Ministry of Coal website.

- Population data for 2020 the states is from the UIDAI. (UIDAI). State GSDP figures are from the National Statistical Organization, Ministry of Statistics and Programme Implementation (MOSPI).

- Electricity demand by state is from the annual report on state utilities published by the Power Finance Corporation (PFC). The following assumptions have been used in the subsequent analysis. These are also represented visually in Figure 2. The electricity distribution sector continues on a "Business As Usual" trajectory. The economy is expected to fully recover from the effects of the lockdown by 2022. Thus GDP, electricity demand and coal production are expected to come back to the 2019- 20 level by 2022.

- World Bank's growth projections for the post-Covid era (World Bank) have been used to project GSDP data from 2022 to 2030. We have assumed that all states growat the same rate irrespective of their VRE endowments. Electricity demand is also expected to grow uniformly across the states at rates equal to the rates for the general economic growth.

- This is necessitated by the paucity of standardized projections for state-level economic growth and electricity consumption. Available literature indicates that electricity demand growth is elastic with respect to economicgrowth, but the elasticities are typically much lower than 1 (https://doi.org/10.3390/en10030347). For our analysis, we have taken the elasticity tobe unity, given the possibility of sharper demand growth following the enforced lockdown.

- State level fiscal deficits in 2030 have been fixed at 5% of the GSDP (RBI).

- Coal production has been projected from 2022 to 2030 under two scenarios-BAU-where VRE share in actual generation remains unchanged and OGM-under which VRE capacity grows much faster. (Table 1). State -wise production under BAU and OGM is estimated assuming that production shares remain unchanged throughout the period 2019-2022-2030.

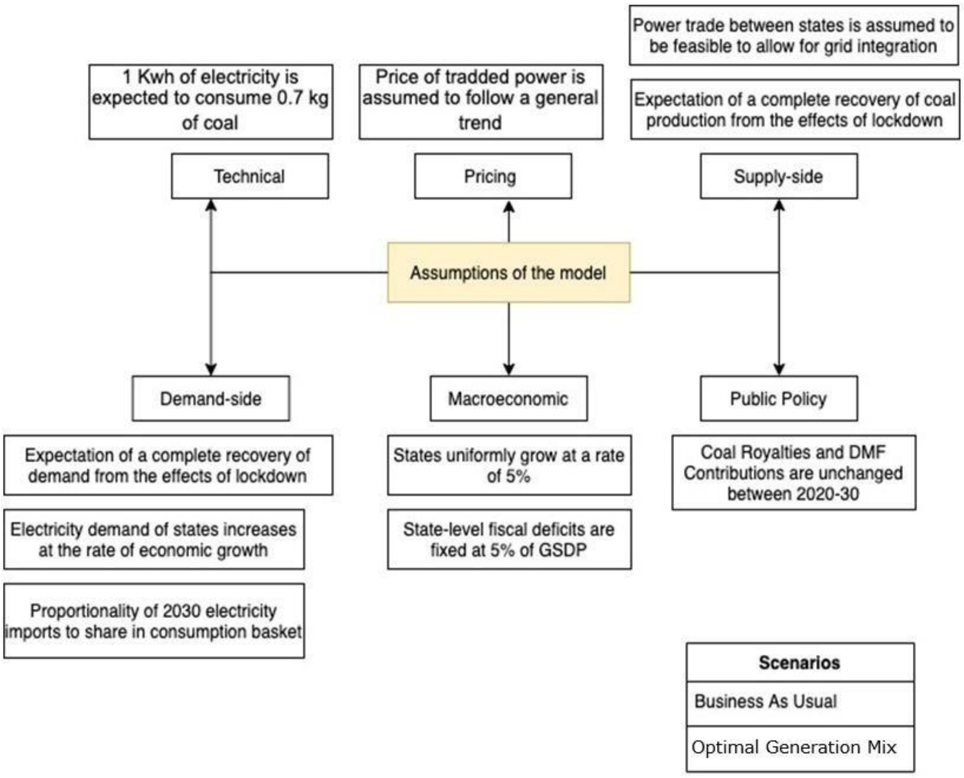
- 1 Kwh of electricity is expected to consume 0.7 kg of coal. Coal royalty rates and DMF contribution have been kept unchanged over 2022-2030 @ Rs 120/ Tonne.

- Price of traded power is assumed to start from Rs 3/ Kwh in 2022 - equal to the general trend in rates determined by state regulators and is then expected to grow @ 5% per year through to 2030.

- Power trade between VRE rich and VRE poor states takes place so as to enable smooth grid integration, starting with 10% net exports out of the VRE rich states to the VRE poor. If we go by the experience in Germany, California and selected Indian states, 10% net exports will seem to be on the conservative side at nearly 60% VRE penetration in 2030 with no curtailments.

- In 2030, electricity imports by state are proportional to the share of the respective state in the overall consumption basket of the VRE poor states.

Figure 2: Summary of Model Assumptions

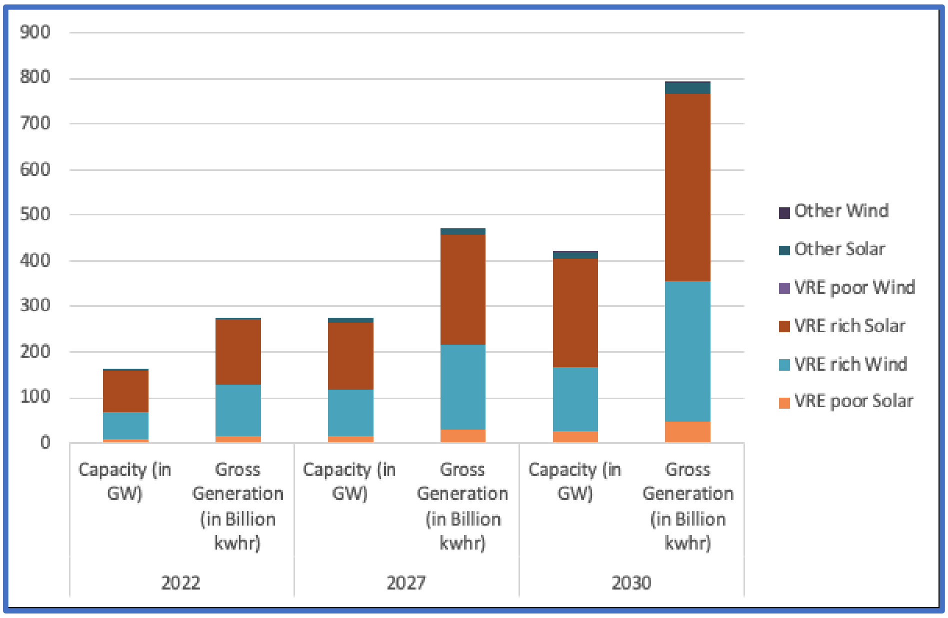


We start by categorizing the major Indian states into two categories, VRE rich and VRE poor,depending upon their installed VRE capacity-those with < 0.5 GW are called VRE poor. This is done on the basis of latest data on the assessed VRE potential and installed capacity. This categorization into VRE rich (8 states) and VRE poor (10 states) ends up covering 18 of the 29 sub-national administrative units in India, with 95% of the population and 94% of the GSDP. Together these 18 units account for 71% of the total solar potential, 99.76% of the wind potential and 80% of the total VRE potential in the country. Between them they also account for 99% of the total VRE capacity installed so far. Exclusion of the 11 smaller sub- national units is unlikely to affect the analysis in any material sense. The overall generation mix through to 2030 set out in Table 1 in Part I can then be re-arranged as shown in Table 4 below into VRE rich and VRE poor. VRE rich states continue to maintain their much larger share in installed solar capacity (88%) up to 2027, after which it declines slightly to 85%. In 2030, the 8 VRE rich states produce nearly 15 times more VRE than the 10 VRE poor states.

Table 4. Optimal Generation Mix-VRE rich and VRE poor (projected)

	2022		2027		2030	
	Capacity (GW)	Gross Generation (Billion kwhr)	Capacity (GW)	Gross Generation (Billion kwhr)	Capacity (GW)	Gross Generation (Billion kwhr)
Solar	100	162	175	283	280	484
Wind	60	112	100	188	140	309
Total VRE	160	274	275	471	420	793
Other sources	316	1292	344	1576	397	1725
Total	476	1566	619	2047	817	2518
VRE Rich						
Solar	88	142.56	148.75	240.55	238	411.4
Wind	60	112	100	188	138.6	305.91
Total VRE	148	254.56	248.75	428.55	376.6	717.31
VRE poor						
Solar	10	16.2	17.5	28.3	28	48.4
Wind	0	0	0	0	0.063	0.14
Total VRE	10	16.2	17.5	28.3	28.063	48.54

Figure 3: OGM Generation Mix (Capacity and Gross Generation)(projected from model)



We also see the huge difference in the share of VRE in 2030 in electricity consumption (demand) between the two groups. In the VRE rich group, the share of VRE is close to 60%.In the other group it is about 6%.

The GSDP has been projected to 2030 in two steps. First, we accept the official projection thatthe national GDP will return to its pre-Covid value by end FY 2022 and hence the 2019-20 GSDP figures are simply taken as the base in 2022. We then project this forward to 2030. While doing so, we use the World Bank's projection that post 2022, that the economycontinues to grow at 7% through to 2030. Disaggregated GSDP growth rates for individual states are not available and, in any case, the general trend is unlikely to be affected to a significant extent. We could use the pre-Covid growth rates for each state, but that is likelyto be more speculative. For simplicity, we assume that all states grow at the same rate as the national economy during 2022-2030.

For electricity, demand projections shown in Table 1 have been made by the Central Electricity Authority. CEA projections are at the national level. We try to generate the demand estimate from state data through a bottom up approach using actual utility level demand data obtained from the utilities.(PFC) Here again, we assume that the demand atthe end of FY 2022 will stand restored to the 2019-20 levels following the post Covid fluctuations during 2020-21 and 2021-22. Generation by private sector utilities and captive units have been included. The share of captive power is assumed to remain the same over 2022-2030. For 2022, captive power data has been taken from MOSPI. (MOSPI). Demand is gross of ATC losses. The final demand figure is quite close to the CEA's estimates. States' budget deficits have been set at 5% of GSDP in 2030, assuming that the post-Covid facilitation permitting higher deficits under the FRBM law continues through the decade.

Based on the above, we can estimate GSDP, electricity demand, power imports, budget deficit and imports as a % age of deficits in 2030 for the 18 major states under consideration (Table 5 and Figure 4).

Figure 4: State-Wise Electricity Import Projections

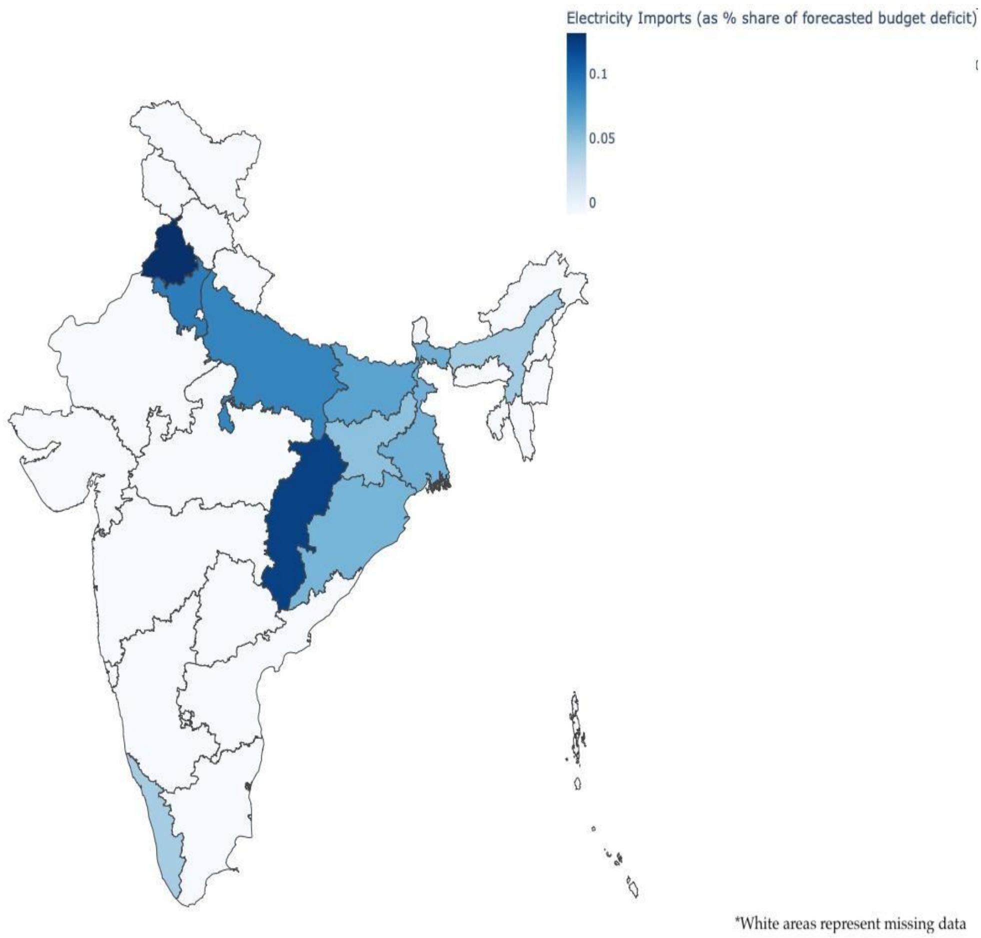


Table 5: State-Wise Electricity Demand Projections

	Projected	GSDP	Projected	Electricity	Electricity	Budget deficit	Electricity	Value	% Imports
	Population	2022	GSDP	Demand	Demand 2030	2030 Rs tr @	Exports/ Imports	of Imports	to deficits
State	2020		2030	2022	Billion kwhr @		Billion kwhr		2030
			7.00%	Billion kwhr	7.0%	5%			
	million	Rs tr	Rs tr					Rs Billion	
Maharashtra	123.10	28.19	48.44	143	246	2.42			
TN	77.80	17.97	30.88	94	162	1.54			
AndhraPradesh	53.90	9.71	16.68	68	116	0.83			
Telangana	38.50	9.57	16.44	69	119	0.82			
Karnataka	67.60	16.29	27.99	68	117	1.40			
Gujarat	63.80	16.30	28.01	106	182	1.40			
Rajasthan	81.00	9.99	17.16	82	142	0.86			
Madhya Pradesh	85.30	9.37	16.10	73	125	0.80			
VRE rich	591.00	117.39	201.70	704	1209	10.08	120.92		
West Bengal	99.60	12.07	20.74	56	97	1.04	16.1	61	5.89%
Uttar Pradesh	237.90	16.88	29.00	115	197	1.45	32.8	124	8.58%
Bihar	124.80	5.94	10.21	32	55	0.51	9.1	35	6.78%
Jharkhand	38.60	3.29	5.65	13	22	0.28	3.6	14	4.88%
Odisha	46.40	5.48	9.42	25	42	0.47	7.0	27	5.67%
Assam	35.60	3.35	5.76	11	19	0.29	3.1	12	4.13%
Kerala	35.70	8.55	14.69	27	46	0.73	7.7	29	3.97%
Chhattisgarh	29.40	3.45	5.93	33	57	0.30	9.6	36	12.26%
Punjab	30.10	5.40	9.28	56	97	0.46	16.1	61	13.21%
Haryana	28.20	7.80	13.40	55	95	0.67	15.8	60	8.99%
VRE poor	706.30	72.21	124.07	423	727	6.20	120.92	460	7.41%

The coal requirement for electricity production in 2030 with enhanced renewables has been estimated at 895 MT(CEA 2020). Without enhanced renewables, using the generation mix asof 2022, the coal requirement @).7kg/kwh would be 1450 MT. Thus deep renewables are expected tp reduce total coal consumption by 555 MT. The total requirement under enhanced renewables is pro-rated across the coal-producing states using their respective shares in 2022, assuming no changes in the respective shares, to obtain an estimate of coal production by state in 2030.

Under existing legal requirements, coal mining entities have to pay royalty to the respective states. Private players have to contribute up to an additional one third of the royalty to the District Mineral Fund (DMF), to be used for local development. Though the royalty rates vary by the quality of coal, ranging from Rs 250 per MT for the best grade coking coal to approximately Rs. 60 for the lowest grade, Rs 120 /MT would be a reasonable average for the total payments to theDMF and the state governments. The royalty rates change very infrequently. The last revision was made in 2012. Inter-state political economy plays a major role in decisions regarding coal royalty rates As of 2019, the aggregate revenues from coal royalties, DMF contributions, state GST, and coal cesses added up to between 4-12% of annual state's own revenues in India's four major coal states (Athawale et al. 2019).[xvi] It would not be unreasonable to assume that the existing royalty rates will not decrease under any circumstances through the present decade ending 2030; Using the present average royalty rates and the state-wise projected coal production in 2030 we can obtain the lower bound onthe likely quantum of total royalty flows in 2030.

Each kwhr of electricity uses 0.7 kgs of coal on average. VRE generation of 793 billion kwhr in 2030 thus translates to 555 MT of coal less of coal used as compared to the Business As Usual (BAU) scenario without VRE expansion. In financial terms, this entails a royalty lossof Rs 66.6 billion spread across all the coal producers. The VRE poor states account for two thirds of the total revenue loss. Within the group of 10 VRE poor states, five also happen to be coal producers, West Bengal and Uttar Pradesh, in addition to the three big producers, Jharkhand, Chhattisgarh and Odisha.

While the entire sub-group loses out, the impact is most severe on the latter, adding up to 4.86% to the projected deficit in 2030.

Table 6: BAU and OGM Revenue Scenario Projections

States	Production 2022 MT	% share in production	BAU Production MT 2030	BAU Royalty +DMF @ Rs 120/T Rs Million	Production 2030 OGM MT	Royalty +DMF 2030-post-OGM @ Rs 120/T Rs Million	Revenue Loss Rs Billion OGM	Deficit Rs tr 2030	Revenue Loss as % deficit
MH	54.7	7.5%	108.5	13025.6	67.0	8040.0	5.0	2.3	0.21%
TN	0.0		0.0	0.0	0.0	0.0	0.0	1.5	0.00%
Andhra Pradesh	0.0		0.0	0.0	0.0	0.0	0.0	0.8	0.00%
Telangana	65.7	9.0%	130.3	15632.6	80.4	9649.1	6.0	0.8	0.76%
Karnataka	0.0		0.0	0.0	0.0	0.0	0.0	1.4	0.00%
Gujarat	0.0		0.0	0.0	0.0	0.0	0.0	1.4	0.00%
MP	125.5	17.2%	248.9	29871.4	153.6	18437.9	11.4	0.8	1.38%
Rajasthan	0.0		0.0	0.0	0.0	0.0	0.0	0.8	0.00%
VRE rich	246.0	33.6%	487.7	58529.6	301.1	36126.9	22.4	9.7	0.23%
WB	33.7	4.6%	66.8	8011.5	41.2	4945.0	3.1	1.0	0.31%
UP	18.3	2.5%	36.3	4354.1	22.4	2687.5	1.7	1.4	0.12%
Jharkhand	131.8	18.0%	261.2	31349.4	161.3	19350.2	12.0	0.3	4.44%
Odisha	143.5	19.6%	284.5	34136.0	175.6	21070.2	13.1	0.5	2.90%
CG	158.1	21.6%	313.5	37619.3	193.5	23220.2	14.4	0.3	4.97%
VRE poor	485.3	66.4%	962.3	115470.4	593.9	71273.1	44.2	3.4	1.30%
Total India	731.3		1450.0	174012.0	895.0	107400.0	66.6		

OGM -Optimal Generation Mix 2030BAU-Business as usual

Research Question:
Given these characteristics of the Indian transition to deep VRE, what will be the likely impact on state government finances of the skewed geographical endowments of solar, windand coal resources?

Part III

IV Results and Discussions

Tables 1 and 6 together yield the generation mix in 2030 across the two groups as shown in Table 7 below.

Table 7: Aggregate Results for VRE Poor and Rich State Groups

	VRE Poor	VRE Rich	VRE Poor	VRE Rich	% VRE in	% VRE in
	Total Utility Demand	Total Utility Demand	VRE Generation	VRE Generation	VRE Poor	VRE Rich
2022	423	704	16.2	254.56	3.83%	36.17%
2030	727	1209	48.54	717.31	6.68%	59.32%

VRE shares differ quite sharply across VRE Rich and Poor, with the difference rising from 32.34% in 2022 to 52.64% in 2030. In particular, the former group shows an extremely high degree of VRE penetration, that will have to managed for sustainable grid operations through several measures, inter-state transfers being the most important. If we start with 10% net exports from the VRE rich to the VRE poor states , the latter will have to buy the power, most likely to be VRE, by curtailing their own thermal generation, even if those are price competitive. In doing so, they, operate as they do through state-owned Discoms will have to pay for the power imports either using their own resources or through higher government subsidies. Without a major reform in the distribution business, it is hard to visualize a situation without higher state government payouts. Net exports@ 10% probably represents the lower end of the surplus VRE in a no curtailment scenario.

On the coal front, the OGM case, leads to lower royalty payments to the state governments, enhancing the deficit from the revenue side. Combining the two, we get the following picture (Table 8 below).

Table 8: Projected Fiscal Impacts on VRE Poor States

10% net exports in 2030	% Electricity Imports 2030 to deficit	% Coal Royalty Loss 2030 to deficit	Total Impact Deficit 2030	Total Impact GSDP
West Bengal	5.89%	0.30%	6.18%	0.31%
Uttar Pradesh	8.58%	0.11%	8.70%	0.43%
Bihar	6.78%	0	6.78%	0.34%
Jharkhand	4.88%	4.25%	9.13%	0.46%
Odisha	5.67%	2.78%	8.45%	0.42%
Assam	4.13%	0	4.13%	0.21%
Kerala	3.97%	0	3.97%	0.20%
Chhattisgarh	12.26%	4.86%	17.12%	0.86%
Punjab	13.21%	0	13.21%	0.66%
Haryana	8.99%	0	8.99%	0.45%
Total VRE poor	7.41%	1.25%	8.66%	0.43%

Deep renewables penetration and the ownership pattern of the distribution business together appear to lead to a noticeable deterioration in the deficit position of the states located in the VRE poor zone. The enhanced deficits are higher than the FRBM limit of 5% by as much as 13.18% for Chhattisgarh, a low GDP state that is simultaneously a major coal producer and a VRE importer. These levels of higher deficits and sustained resource outflows from a certain group of states to another on account of natural resource endowments and national policies will attract political attention. It is also difficult to avoid comparisons with the Freight Equalization Scheme, except with a role reversal. Now the VRE poor states will be committing vast quantities of budgetary resources to purchase power from VRE rich states.

Climate mitigation has so far mainly been dealt with by the central government. Though states have largely been kept out of national decision making on issues of climate change, they were not seriously concerned with this exclusion because these climate related decisions not have significant impacts on state finances or state entitlements. With sharp deteriorations in fiscal deficits arising out of climate change mitigation measures, it is likely to become an essentially political issue between the Centre and the states.

Under Article 253 of the constitution, the states are obliged to fall in line with international commitments made by the central government. However, the continued inadequacy of the consultative process between the Centre and the States in climate change policy formulation in general and in particular, the unilateral enhancements of renewables targets to 175 GW and beyond (450 GW) by the central government post Paris and the UN conference, will have to be addressed. This is not the first issue where the fiscal consequences of Central decision has serious impacts on the economic agency of states, but it certainly one of themost consequential. From creation of spot markets for power (Market Based EconomicDispatch), restricting financial flows to states from state lending organizations (REC/PFC) based on performance improvements, clawing back Central PSU dues from states' RBIaccounts, privatization of discoms, there are clearly many axes of policy friction between Centre and states related to the power sector. In theories of market-preserving federalism, like the ones proposed by Weingast, sub- national entities in a federation (or Union in India), willingly give up some privileges and rights to be part of national markets.[1] (Weingast, 1995).

At least in theory, the gains from being part of the national market are larger than the incremental losses in agency that are required to participate in such a market. These are the kinds of principles of cooperative federalism that led to the formation of the European Common Market, and were also articulated when the Goods and Services Tax (GST) was adopted in India in 2017. Unfortunately, in the Indian power sector there is no unified entity where such discussions happen to reach political settlement on this complicated matter. The Forum of Regulators has some such conversations, but rarely has the political authorization to make big decisions. Conversations on power, power sector finance, and coal frequently happen in different ministerial silos, making it very difficult to reach a consolidated solutionon this topic. As the magnitude and the tone of these federal power conversations worsens, there is a desperate need for a site of resolution for Centre-state power sector conflicts.

The Indian Constitution (Article 263) provides for such situations. The Inter-state Council, despite the recent centralising tendencies, has the mandate to look into such issues-"Inter- State Council is a recommendatory body with duties to investigate and discuss the subjects of common interest between the Union and State(s) or among the States, making recommendations particularly for better coordination of policy and action on these subjects and deliberating upon such other matters of general interest to the States.“

The quantum of inter-regional fund flows perhaps lends more urgency to a serious consideration to the idea of having the Inter-State Council to also double up as a standing mechanism for fiscal federalism and to prepare a strategy for climate investment and financing. Many countries have seen robust development of Just Transition frameworks and mechanisms to deal with the future consequences of energy transitions and their impacts on fossil-fuel rich regions. While we have seen the emergence of such conversations in a few Indian state (eg. Jharkhand's Just Transition Task Force), Central government ministries have shown little interest in formalizing such arrangements so far making such efforts decidedly one-sided and frequently under-resourced. States also seem to have very limited ability to participate beyond an initial consultative process with the Finance Commission in the dialogue on fiscal frameworks and federalism.

V Sensitivity Analysis and Conclusions

For the base case, where all states grow equally, maintain the same electricity demand response and have a relatively small electricity trade-10% with traded prices starting from Rs3 and growing @3% thereafter, the total impact-a sum of electricity imports and loss of coal revenues is substantial. The combined deficits of the VRE poor states increases by 8.66%. In terms of their combined GSDP, it is also not negligible-0.43%. There are large interstate variations. The rise in deficit ranges between 6.78 for Bihar to 13.21% for Punjab and 17.12% for Chhattisgarh. The last two also show the maximum impact on GSDP.

As the quantum of trade rises, keeping other parameters constant, so does the impact on deficits and GSDP. For all VRE poor states, the additional deficit nearly doubles to 16%. The impact on GSDP also doubles to 0.81%.

If, in line with the historical trends, states grow at different rates, VRE rich at 7% and VRE poor at 5%, then the impact is more severe. The electricity import liability goes up to 18.18% for the VRE poor group as a whole. For Chhattisgarh is goes up by more than a third and for Punjab by more than a fourth. For three states, UP, Punjab and Chhattisgarh, the impact on GSDP goes beyond 1%.

Moderation of the demand response, with the elasticity of electricity demand with respect to economic growth, from 1% to 0.75%, also appears to lower the impact. However it need not be so. It may also result in the VRE rich states pushing higher quantities into the trading market which could adversely affect the deficits of the VRE poor.

Keeping the trading prices constant or allowing them to rise at lower rates-say 1% per year over 2022-2030, will ameliorate the impact to some extent. This could happen if VRE prices continue to fall after the initial uptick due to the recent import duties or if the grid integration charges fall substantially.

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