GWEC
GLOBAL WIND ENERGY COUNCIL

TAMIL NADU WIND ENERGY ROADMAP

HARNESSING NET ZERO OPPORTUNITIES

SED Fund

Deloitte.

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AUTHORS

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FOREWORD

As India's wind power and manufacturing hub, Tamil Nadu is a focal point of the wind industry in Asia. With over 100 GW of wind energy generation potential across the onshore and offshore wind, it is imperative for the state to continue harnessing its naturally and abundantly available clean energy resources to meet its climate and energy ambitions.

With this potential ahead, GWEC is proud to unveil the "Tamil Nadu Wind Energy Roadmap: Harnessing Net Zero Opportunities", developed with support from the SED Fund and jointly authored with Deloitte. This Roadmap identifies high-impact and concrete opportunities to increase the demand and supply of wind energy in the state, in the context of the Government of Tamil Nadu's pioneering endeavours for advancing climate action and decarbonising its economy.

As home to India's 51% of captive wind and 17% captive solar capacity, Tamil Nadu has set important benchmarks for the rest of the country. But furthering the share of renewable energy in the electricity mix, enacting rapid decarbonisation of manufacturing activity and exploiting the potential for green hydrogen and green ammonia production requires going beyond a business-as-usual approach. The current projected compound annual growth rate of 6% for wind capacity additions will only grow Tamil Nadu's wind fleet by three times from now to 2030 – this will be insufficient to accomplish the kind of economic and system transformation that is needed.

Building upon the recommendations in this landmark roadmap, it will be pivotal for Tamil Nadu to undertake a combination of institutional regulatory reforms, the creation of enabling policy frameworks, upgrades and additions to existing power and transmission infrastructure and swift interventions to boost demand and supply for renewable electricity. It will also be necessary to implement a robust and comprehensive tool for measuring and reporting progress to ensure that the state remains on track for its climate and energy goals while continuing to attract sustainable investment in pathbreaking sectors like wind energy and manufacturing.

I convey my appreciation to HE Thiru M K Stalin, Hon'ble Chief Minister of Tamil Nadu, for his leadership on climate planning to date, and also recognise the institutionalisation of Tamil Nadu Green Climate Company and Tamil Nadu Governing Council on Climate Change (GCCC) as positive steps in the state's pathway for transformation. GWEC stands ready to continue supporting the Government of Tamil Nadu and related stakeholders in scaling up onshore and offshore wind power generation and building a thriving supply chain for the region in the future.

BEN BACKWELL

CEO, Global Wind Energy Council

LEADERS SPEAK

Tamil Nadu's progressive investment policies continue to recognize the high potential of the renewable energy sector, including wind energy, and its interlinkages with the state's ambitions for trade promotion, giving a boost to manufacturing and enhancing the investment climate.

TMT POOJA KULKARNI (IAS)
MD AND CEO, GUIDANCE TAMIL NADU,
GOVERNMENT OF TAMIL NADU

Blessed with abundant renewable energy resources, rich experience, and a growing appetite for green power, Tamil Nadu is the land of opportunities. The state's climate ambitions very well recognize the pivotal role of renewable energy, including wind energy, that has a dominant share in both the installed renewable energy capacity and the assessed potential. Harnessing the full potential and complementarity of wind and other clean energy resources is necessary to create new avenues for investments, including in emerging areas such as green hydrogen and offshore wind. All of these will contribute significantly to socio-economic growth in the state and the country.

SUMANT SINHA
CHAIRPERSON, GWEC INDIA AND CEO,
FOUNDER AND CHAIRMAN OF RENEW POWER

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ABBREVIATIONS

Abbreviations	Description
C&I	Commercial & Industrial
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
CUF	Capacity Utilization Factor
DISCOMS	Distribution Companies
EHS	Environment, Health and Safety
EPS	Electric Power Survey
ESG	Environmental, Social, and Governance
FOWIND	Facilitating Offshore Wind in India
FY	Fiscal Year
GDP	Gross Domestic Product
GSVA	Gross State Value Addition
GW	Gigawatt
IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency Ltd.
IRENA	International Renewable Energy Agency
kWh	Kilowatt Hour
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoU	Memorandum of Understanding
MU	Million Units
MW	Megawatt
NBFC	Non-Banking Financial Company
NIWE	National Institute of Wind Energy
NRDC	National Research Development Corporation
NSDC	National Skill Development Corporation
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
R&D	Research & Development
RE	Renewable Energy
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
RTC	Round the Clock
SECI	Solar Energy Corporation India Ltd.
TANGEDCO	Tamil Nadu Generation & Distribution Company Ltd.
TN	Tamil Nadu

EXECUTIVE SUMMARY

Tamil Nadu is one of the pioneer states for renewable energy in India. The state has a major role to play in fulfilling the country's commitments towards climate change.

India has set an ambitious climate ambition. As per the Climate Transparency Report 2021, India was the only G20 country that was on track to meet 2-degree goal under the Paris Agreement. At the Conference of Parties (COP26) in 2021, the country further raised its ambitions —500 GW of non-fossil energy capacity by 2030 and meeting 50 per cent of its energy[1] requirements from renewable energy by 2030. India also aims to achieve its net-zero goals by 2070. It has steadily become a major market for renewable energy (RE) and ranks fourth globally in terms of installations for both solar and wind energy. The country has committed to harnessing 50% of its electricity requirement from RE by 2030.[2] Favourable policy and regulatory environment, coupled with competitive RE tariffs, have been instrumental in the rapid rise of RE in the country.

Tamil Nadu, being a major industrial hub and the second largest contributor to India's Gross Domestic Product (GDP), has a crucial role to play in fulfilling India's climate change commitments. The state is responsible for 8% of India's power demand and ranks third in the total installed power generation capacity.[3,4] With several automobile parks, textile parks and food parks, it is the most industrialized state in India.[5] The state has shown rapid proliferation of Electric Vehicles (EVs) in recent years and aims to achieve 30% EVs in the total vehicle sale by 2030,[6] which will further contribute to its electricity demand.

Fostering the transition from thermal to RE generation is a must

Although Tamil Nadu is the second largest contributor to India's GDP, it ranks eighth among all the states in emissions. The state is estimated to contribute nearly 5% or ~ 172.84 MT CO_2e of the nation's emissions. Out of this, approximately 50% of the emissions are attributable to electricity generation alone.[7] As a climate champion, the state has already been undertaking pioneering interventions as part of its climate ambitions. By further increasing the share of renewable energy in its electricity generation mix, Tamil Nadu has the potential to (further) bring down the carbon footprint of electricity generation. Existing plans for power generation capacity (over 35 GW) addition prioritizes solar, storage, pumped hydro/hydro and thermal projects. Despite wind's 84% share in the state's renewable energy potential, there is no plan for wind capacity addition.[8]

With 9.6 GW of installed wind capacity, Tamil Nadu is the wind powerhouse in the country. However, it has added less than 400 MW of wind power capacity in 4 out of the last 5 financial years. Inadequate demand for wind power has led to manufacturers raising concerns who have made huge investments in setting-up manufacturing units. It is estimated that a minimum of 5 GW of annual wind capacity addition in the country is needed to cut business risk of wind manufacturers and to be able to enhance the competitiveness of wind power generation. As per the central government's draft policy for repowering, Tamil Nadu appears to have 4 GW of capacity that stands as eligible for repowering.[9] However, an actual potential can only be ascertained after a

1 CEA, Draft National Electricity Plan, 2022, details available at https://cea.nic.in/wp-content/uploads/irp/2022/09/DRAFT_NATIONAL_ELECTRICITY_PLAN_9_SEP_2022_2-1.pdf

2 CEA, Draft National Electricity Plan, 2022, details available at https://cea.nic.in/wp-content/uploads/irp/2022/09/DRAFT_NATIONAL_ELECTRICITY_PLAN_9_SEP_2022_2-1.pdf

3 CEA General Review 2021, details available at https://cea.nic.in/wp-content/uploads/general/2020/General_Review_2021.pdf

4 Guidance Tamil Nadu, details available at https://investingintamilnadu.com/DIGIGOV/index.jsp

5 Reserve Bank of India's (RBI) seventh edition of its annual report Handbook of Statistics on Indian States 2021-22

6 Tamil Nadu EV Policy, 2019, details available at https://e-vehicleinfo.com/wp-content/uploads/2021/09/1-d912b949e0-1.webp

7 India GHG Platform, details available at https://www.ghgplatform-india.org/economy-wide/

8 Policy Note 2022-2023 of the Energy Department of the Government of Tamil Nadu

9 MNRE Draft Repowering Policy, 2022, details available at https://mnre.gov.in/img/documents/uploads/file_f-1666005996212.pdf

ground survey is administered. The state may also explore the possibility of advancing the uptake of repowering among captive/group captive users by facilitating access to low-cost finance.

Further, 35 GW of offshore wind potential off the coast of Tamil Nadu has already caught the eyes of prospective investors and government agencies. There is a much higher investment and job creation potential in offshore wind as compared to other renewable energy projects. Hence, the state government prioritize the creation of an enabling environment to attract and support the offshore wind industry. This endeavour might require synergistic partnerships with multi-lateral development banks and other financial institutions for attracting innovative and low-cost financing to support — interventions for capacity building and strengthening policy and regulatory measures, project risk mitigation, and infrastructure development including port upgradation. In addition, building on best-practice from Vietnam, the state may consider partnership opportunities with the NIWE to explore near-shore potential. Most importantly, the state and centre may identify common ground for benefits sharing and close coordination.

Harnessing full-potential of renewable energy resources is becoming enormously important

Tamil Nadu's power demand is projected to increase by Compounded Annual Growth Rate (CAGR) of 6% in the coming decade. Its peak demand is expected to grow by around 30% in the next five years, that is by 2027.[10] The major part of the incremental demand is likely to be met through RE capacity additions. Tamil Nadu Electricity Regulatory Commission (TNERC) has set an RPO target of 41% by 2030,[11] which is slightly lower than the MNRE suggested RPO target of 43%. Considering that the share of RE generation in the state is around ~18%[12] of the overall generation mix, which is higher than the all-India RE generation share of 11%, it could consider an RPO target higher than as suggested by the MNRE. Nevertheless, as the share of RE in the overall generation mix increases, the state shall require dispatchable RE to maintain grid stability. The intermittency associated with RE still poses a challenge for maintaining grid stability. Thus, to ensure grid balancing, energy security and clean energy transition, a basket of renewable energy sources, including wind energy, must be harnessed to its full potential. The state has 124 GW of wind potential out of which 103 GW (68 GW of onshore and 35 GW of offshore wind) is wind energy and 17 GW is solar energy. ***So far, only one-tenth of the state's wind potential and one-third of its solar potential has been harnessed.***

Greening of the manufacturing sector catalyzes consumption of green power and boosts economic growth opportunities

While Tamil Nadu is home to India's 51% of captive wind installed capacity and 17% of captive solar installed capacity, it also stations 27% of the country's captive thermal generation capacity. New and emerging power demand centres such as data centres and electric mobility have been growingly found to be magnets for RE power consumption. As the gateway of opportunities in southern India, Tamil Nadu is already witnessing a huge surge in fresh investments in these areas. Meeting reliable and 24x7 and 365 days of green power requirements in these industry segments would require innovative tenders that promise a higher capacity utilization factor (CUF) and round-the-clock (RTC) availability. Owing to the unavailability of the state's own RTC generation, serving such a need in the long term would become difficult.

Several states in India, such as Karnataka, Rajasthan and Gujarat, have already legitimized their wind-solar hybrid policy. This allows them to attract innovative RTC projects. Tamil Nadu

10 20th Electric Power Survey Report, details available at https://cea.nic.in/wp-content/uploads/notification/2022/11/20th_EPS____Report___Final___16.11.2022.pdf

11 Tamil Nadu Electricity Regulatory Commission, RPO Regulations, 2020, details available at TNERC_RPO_Order_12082020.pdf (recregistryindia.nic.in)

12 CEA, Monthly Renewable Energy Generation Report (March 2022), details available at RE_Generation_Report_Oct__2022.pdf (cea.nic.in)

must introduce an enabling policy and regulatory framework to harness RTC projects.

Through a partnership between the Industry Department and the Energy Department of the Government of Tamil Nadu, the state may introduce a "Green Power Marketplace" during forthcoming editions of the investor summit. Also, phase-wise targets for inviting investments and detailed project reports that have a net zero plan (along with budgeted financial allocations) must be prioritized by the state government. These endeavours could further boost the greening of the state's manufacturing sector.

Meeting emerging priorities such as green hydrogen and green ammonia demands undeterred support for clean energy capacity addition

Both the central and the state governments want to harness the hydrogen economy which facilitates emissions mitigation in the hard-to-abate sectors such as oil & gas, cement, steel and fertilizer among others. However, a major challenge remains in making green hydrogen production and consumption economically attractive. Over 40% of the green hydrogen production cost is built from the cost of electricity. Depending on the type of electrolyzer used, hydrogen production is estimated to consume 10-50 units of electricity per kg of green hydrogen. Also, the co-location of green power generation and hydrogen production is believed to bring down the cost of green hydrogen production. It is estimated that by 2030, the state may require an RE capacity of ~5 GW to produce green hydrogen.[13] Here, harnessing hybrid-solar-storage hybrid projects shall prove to be of immense value.

Tamil Nadu must further scale up its share in the global wind supply chain and thereby amplify socio-economic benefits

Tamil Nadu is among the world's only a few hubs that have an existing and complete value chain for wind manufacturing. However, in India, over 80% of the manufacturers have now become dormant due to a lack of adequate demand in the domestic market. Many of the wind turbines deployed in Tamil Nadu were manufactured by these manufacturers. If they are out of business, operations and maintenance of the already deployed units might pose a challenge. Between, not just the wind manufacturing sector in India, but also manufacturers in Europe are facing turbulent times. The global pandemic followed by the Russia-Ukraine war has led to a massive escalation in commodity costs and the overall cost of production. There is also a looming fear of recession. This is when by mid-century a need for deploying over 10 times the current global installed wind capacity has been estimated by leading institutions such as the IEA and IRENA. Micro-small and medium enterprises constitute a major share of Tamil Nadu's wind manufacturing sector. Incidentally, Indian wind exports have led to a trade surplus during the past several years. Also, sourcing from India has gained momentum post turbulence caused by the COVID-19 pandemic. Tamil Nadu is well placed to leverage its existing leadership and enhance its share in the global wind supply chain. The state government must identify partnerships that might also equip existing onshore wind value chain stakeholders with the requisite skills and exposure to support their graduation to offshore wind. Most importantly, the state must pursue institutional interventions to boost exports in international wind demand markets. Tamil Nadu has abundant and sufficient skilled manpower in the wind energy sector through upskilling in certain areas such as leadership, environment, health and safety (EHS), designing, artificial intelligence and data analytics may be considered. Similarly, collaboration with South-East Asian nations may be undertaken to share expertise and promote cross-functional training.

Tamil Nadu, being an established wind equipment manufacturing hub, can take the lead in wind equipment manufacturing and cater to not only the country's demand but also the Asia Pacific (APAC) region. Additionally, the Government of Tamil Nadu may consider developing Wind Equipment Manufacturing Park to aggregate wind developers, OEMs, component manufacturers and users/off-takers to drive economies of scale and attract more investment. The wind equipment manufacturers

13 Refer to Annexure VI

can be offered other benefits such as subsidies/tax benefits for manufacturing of special components, low-interest loans, formation of trade institutions, etc. to encourage wind equipment manufacturing. A parallel can be drawn from the "Furniture Park" launched in 2022 in Thoothukudi, Tamil Nadu[14]. The park's first phase is expected to be operational by 2028 and will generate investment close to INR 15 billion–INR 18 billion and employ nearly 1.5 lakh people.

Measuring progress and attracting new-age finance

Tamil Nadu's economic aspirations, climate ambitions and clean energy transition goals would need new and innovative financing. While, financial institutions are introducing stringent conditions for fossil-fuel expansion, innovative and attractive instruments such as blue and green bonds, sovereign bonds, long term patient capital from pension funds have been observed to gain momentum. In the past, Tamil Nadu's textile industry leveraged captive wind units which helped them increase their export revenue. Building on such experiences and the growing demand for green power, the state may tap finance to scale-up green manufacturing as well as renewable energy projects. Building on its pioneering institutional and policy measure for climate change mitigation and fast-paced transition towards clean energy in the industry sector, the government may consider introducing a "Green Transition Tracker" tool and dashboard for the industry. The tool may be designed to adequately capture and showcase the state's progress on — (a) the transition from thermal to renewable energy (b) the greening of manufacturing (c) the transition in hard-to-abate sectors. Such a tool may allow a preliminary level of due diligence and thereby enable industries to leverage climate finance and carbon markets. It is envisaged that the successful design, development and phased roll-out of such a comprehensive and robust tool may help the state become the most attractive destination for green investments and climate finance.

Estimates from the roadmap also suggest that prioritizing capacity addition and upgrade of the state's power evacuation and transmission shall be a primary determinant of 3 out of 5 high-impact opportunities identified in this roadmap. If legacy challenges[15] that are detrimental to wind capacity addition persist further, in the low case, the state may only be able to add 4 GW of additional wind power capacity by 2030. Consequently, it may lose its dominant share in India's installed wind capacity. In the base case, the state may be able to add another 13 GW of wind capacity by 2030 and attract over USD 700 billion of investments that could create over 70 thousand direct jobs and more than 100 thousand indirect jobs.

14 https://thefederal.com/states/south/tamil-nadu/tamil-nadu-prepares-to-set-up-indias-maiden-furniture-hub-in-thoothukudi/

15 Permits and clearances, land acquisition, pending payments and lack of adequate power evacuation and transmission infrastructure clubbed with very low or limited state wind tenders.

OBJECTIVE & METHODOLOGY

Objectives

Acknowledging massive opportunities in Tamil Nadu, this roadmap aims at:

- Assist the Government of Tamil Nadu's efforts to harness renewable energy, particularly wind energy;
- Encourage policy clarity on capacity targets and timelines in both onshore and offshore wind;
- Identify barriers and opportunities for the growth of wind energy in the state, including the rollout of necessary standards, infrastructure requirements including port/rail/road infrastructure development, and capacity-building needs; and
- Identify the business case for offshore wind in the state in terms of job creation, inward capital investment, manufacturing activity, cleaner power sector, improved diversity and gender balance in the workforce among others.

This work envisaged advancing consensus building on the following key aspects:

- **Constitution of inter-departmental wind working group**
- **Rollout of necessary standards**
- **Convergence of priorities of various departments for infrastructure requirements including port/rail/road infrastructure development**
- **Prioritization of financial allocations and incentives**
- **Capacity-building needs including gender diversity considerations, among others**

Methodology

The following constitute the key elements of methodology:

- Review of wind energy sector policies and reports
- Estimation of economic impacts of onshore and offshore wind energy
- Analyse social benefits
- Mapping of key stakeholders in Tamil Nadu's local wind supply chain
- Estimation of potential for clean power consumption by state's manufacturing sector
- Mapping of existing wind-related skills development opportunities/gaps
- Consensus building on key aspects

*** The activities are not necessarily sequential. Some of the items overlap, and there are also iterations.**

GLOBAL ENERGY TRANSITION

Global leaders are increasingly turning to renewable energy to ensure energy security and clean energy transition. In the last decade, there has been a two-fold increase in the global solar and wind capacity additions. It is estimated that the rising demand from the new end-use sectors such as electric vehicles, electric cooking, green hydrogen, etc. will further drive the future demand for renewable energy.

Climate change is a major challenge and its detrimental impacts are already visible in the world. The 21st Conference of Parties (COP 21) set out a road map to mitigate the effects of climate change. A total of 194 countries have joined the Paris agreement and committed to limiting the global temperature increase below 2°C, preferably 1.5°C, compared to pre-industry levels. In the subsequent COP meetings, many of the countries continued discussions on the actions that will enable them to tackle global warming and work towards their declared commitments. The International Renewable Energy Agency (IRENA) noted that a consensus emerged among the countries, that an energy transition grounded in renewable sources of energy and efficient technologies is the only way to limit the global warming to 1.5°C by 2050.[16]

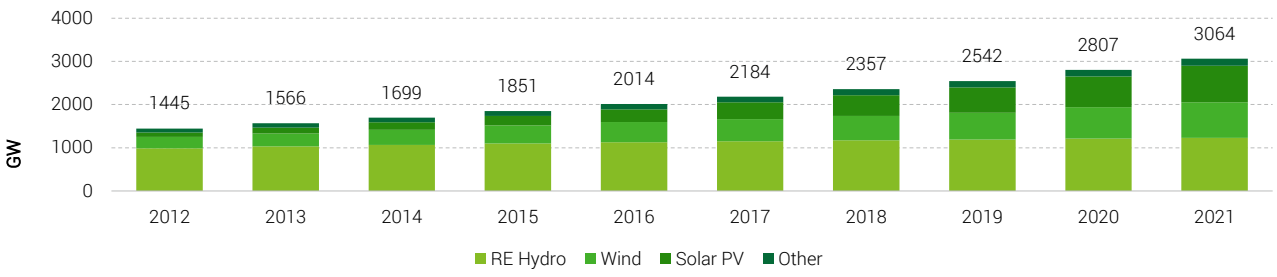
The COVID-19 pandemic and the subsequent Russia-Ukraine war have raised energy security and supply chain concerns across the globe. Leaders have realized that accelerating the energy transition is essential for achieving long-term energy security, energy access to deprived population, price stability and national resilience; and renewable energy (RE)-based electrification can be a key driver to achieve this.

Globally, the deployment of Renewable Energy is steadily increasing in comparison to conventional energy sources. As shown in Figure 1, **from 2011 to 2021,** wind and solar led the renewable energy penetration with a **CAGR of ~9%**. As per the estimates of International Energy Agency (IEA) and IRENA, renewable energy will reach **70% of electricity generation mix by 2050.**[17] The low carbon strategies being adopted in the end-use sectors, such as electric vehicles (EVs), electric cooking, etc. will further drive the demand for Renewable Energy. Also, with the increasing demand for green hydrogen, Renewable Energy can provide the critical link between green hydrogen production and low carbon growth of hard-to-abate sectors such as industry and heavy transport.

However, G20 comprising developed and developing nations, including India, and which represents more than 80% of global GDP, 75% of international trade and two-thirds of the world's population is attributable to three-quarters of global emission.

As per the Climate Transparency Report 2021, among all the G20 nations, India was reported as the only country that was compatible with 2°C goal commitments under the Paris Agreement.

Figure 1: Global renewable energy installed capacity addition trend



Source: IRENA RE Capacity Statistics (April 2022)

16 IRENA, World Energy Transition Outlook 2021

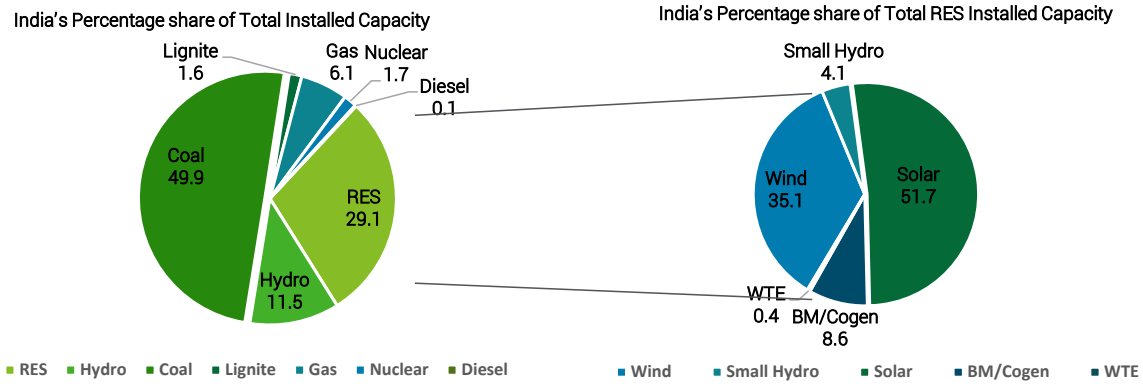
17 IRENA, World Energy Transitions Outlook 2021

ENERGY TRANSITION IN INDIA

Globally, India ranks fourth both in renewable energy installations and in solar and wind installations. Going beyond its earlier Nationally Determined Contributions (NDC), India announced more ambitious targets at the COP26. India's Panchamrit aims to achieve 500 GW of non-fossil fuel-based capacity by 2030, meet 50% of its energy requirement from renewable energy by 2030 and achieve Net-Zero target by 2070.

As of October 2022, India has a total installed capacity of electricity generation of around 407 GW[18] in which thermal energy is the largest contributor, with a share of ~58% followed by RE with ~29% share (Figure 2).

Figure 2: India's electricity generation installed capacity mix as of October 2022



Source: Central Electricity Authority (October 2022), Installed capacity report October 2022

The electricity mix has gone through changes in the recent past, due to the higher growth of renewables as compared to non-renewable sources. Figure 3 shows the change in the installed capacity mix over the past few years. It may be seen from the figure that the share of RE has grown at a CAGR of ~18% from FY 15 to FY22, whereas the share of thermal sources has grown at a CAGR of ~ 3% in the same period.

The growth in RE needs to be seen also in the backdrop of its improved cost competitiveness, especially solar and wind energy, that have become more cost competitive in recent years. At the same time, investments in thermal sector have plateaued due to stringent environmental norms and lack of policy support. In order to increase the uptake of RE, the Ministry of Power has notified in its order, a year-wise trajectory to replace thermal generation with RE. As per the order, 58,000 MU of thermal generation has to be replaced by renewables by 2026.[19]

Even public sector units (PSU) such as NTPC, ONGC, OIL etc., which have been predominantly dependent on fossil fuels, are working towards adding renewables to their portfolio. The falling tariffs of solar and wind energy have contributed significantly to increased capacity addition. Favourable policy[20] and regulatory regimes, availability of low-cost financing, aggressive bidding and falling component costs[21] have been the major contributors to lower tariffs. Figure 4 shows the falling tariff trends of RE, it is evident from the figure that over a period the thermal tariffs

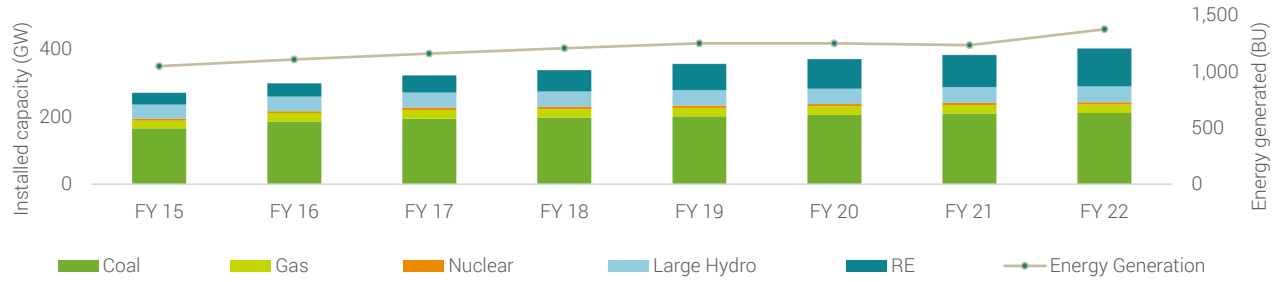
18 https://powermin.gov.in/en/content/power-sector-glance-all-india

19 Ministry of Power (26 May 2022), Trajectory for replacement of thermal energy with about 58,000 MU of RE by 2025-26 - https://powermin.gov.in/sites/default/files/Trajectory_for_replacement_of_Thermal_Energy_with_about_58000MU_30%2C000MW_of_RE_by_2025_26.pdf

20 Refer to Annexure V for the recent policy interventions

21 There has been an increase in tariff after commodity boom post Russia-Ukraine War

Figure 3: India's growth of installed capacity and energy generation

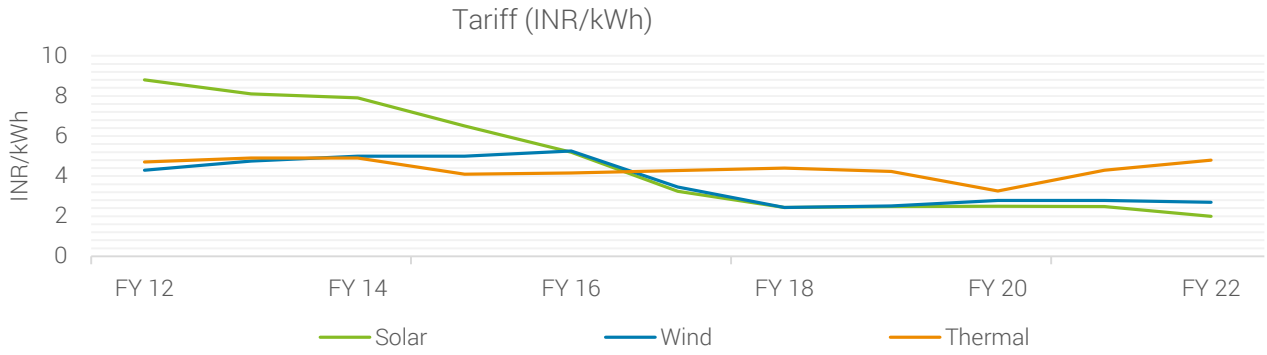


Source: Central Electricity Authority, Installed capacity reports - 2015 to 2022

have increased and with the current coal shortages and reliance on import coal, thermal tariffs are expected to rise further.

Going beyond its earlier NDCs, India further raised its climate action ambitions at the COP26 to meet the Paris Agreement target of 1.5°C goal. In its

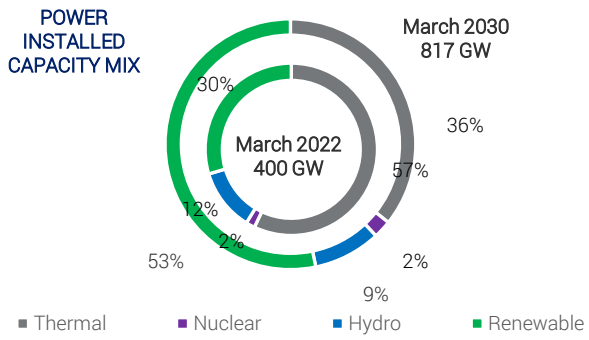
Figure 4: Tariff Trends



Source: SECI Bids, CEA, Deloitte Analysis

In recent years, the central government has also undertaken several enabling policy measures to further boost the growth of renewable energy sector. For example, 58,000 MU of thermal power is likely to be replaced with 30 GW of renewable energy[22]. Similalrly, the Ministry of Power, revised its earlier notification for flexibility in the generation and scheduling of thermal/hydro power stations and permitted bundling with RE and storage power and allowed thermal/hydro plants to generate RE[23]. In its Optimal Generation Mix Report 2020, CEA has recommended (Figure 5) that 53% of installed capacity should be contributed by RE. Thus the role of wind energy is extremely pivotal here (Box 1).

Figure 5: Estimated share of total installed capacity by 2030



Source: CEA Optimal Generation Mix

"***Panchamrit***", announced at COP26 by the Hon'ble Prime Minister of India, the country pledged to achieve 500 GW of non-fossil fuel-based capacity, along with 50% of share of renewable energy in the energy supply mix by 2030. The Panchamrit

22 https://www.thehindubusinessline.com/economy/government-to-replace-58000-mu-thermal-power-with-30-gw-re-by-fy26/article65484463.ece

23 https://powermin.gov.in/sites/default/files/Scheme_for_Flexibility_in_Generation_and_Scheduling_of_Thermal_Hydro_Power_Stations.pdf

also targets reduction of the projected carbon emissions by 1 billion ton and reducing the carbon intensity of India's economy by less than 45%, by 2030. ***Subsequently, India aims to achieve Net-Zero target by 2070. To achieve this, industrialized states must proactively undertake climate action efforts.***

Wind energy is pivotal for India's COP26 commitments

In line with India's commitment of 500 GW of non-fossil based installed capacity by 2030, the Draft National Electricity Plan (NEP), 2022 estimates that the country will reach a cumulative RE installed capacity of ~ 344 GW by 2027 and ~570 GW by 2032. However, the intermittency of renewables still poses a challenge to the grid stability. Therefore, there is a need for dispatchable clean power to address the growing demand, where wind, in the form solar-wind-battery hybrid installations can play a crucial role.

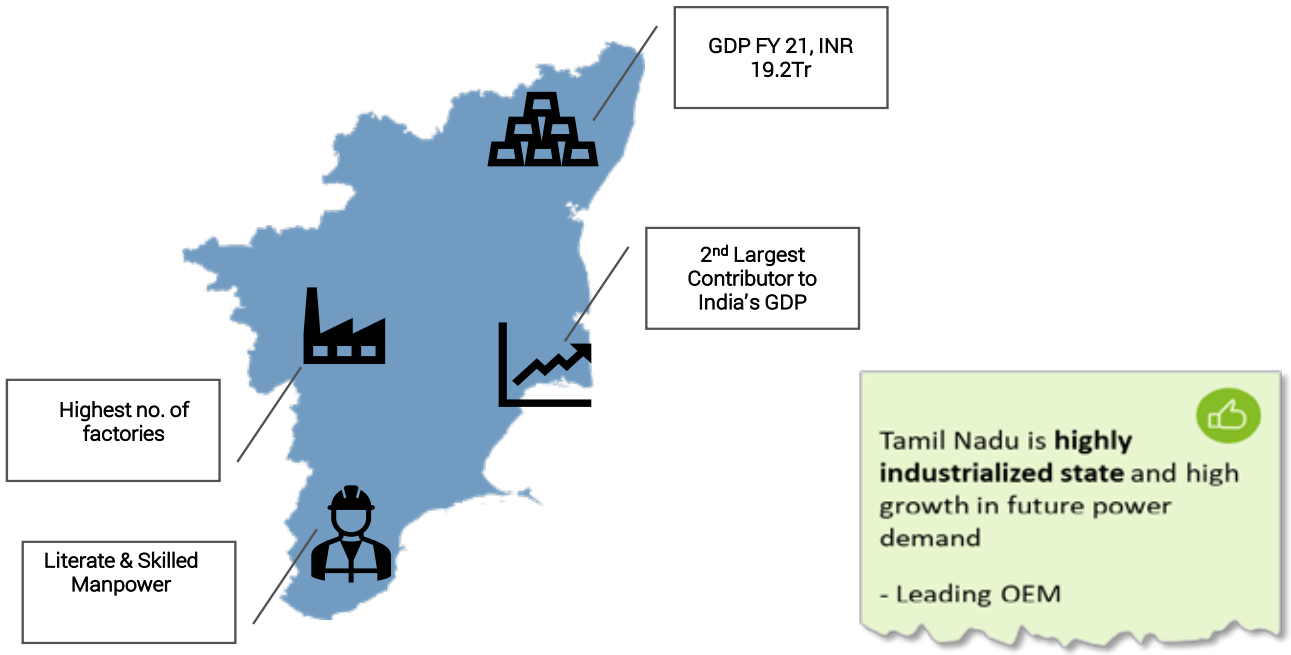
Wind power is one of the oldest and most efficient technologies to produce clean energy. The draft NEP estimates that by 2027, the wind generation is expected to be ~ 170 BU, with cumulative installed capacity of ~80 GW. Similarly, by 2032, the wind generation would be ~ 305 BU with a cumulative installed capacity of ~134 GW. To complement this, the Ministry of Power has set wind RPO target of 6.94% by 2030, to encourage a greater share of wind energy in RE.

Between FY16 and FY21, wind installations grew at a CAGR of 5% compared to solar installations CAGR of 34% during the same period. Solar without wind/battery creates imbalance in the grid due to intermittency. Solar energy is available only for few hours in the day and cannot be harnessed during the monsoon season. Wind is available throughout the year, but its full potential can be harnessed only in certain locations. Therefore, a diverse green portfolio including a major share of wind has to be maintained to complement solar and to achieve grid balance. Also, the efficiency of wind power generation is more compared to solar, and wind can be harnessed during non-solar hours. Realizing this MNRE in the year 2022, has come up with the RPO targets pertaining to Wind and Battery where it has specified that by 2030 wind RPO would be of 6.94% and it has to be met by energy produced by projects commissioned after 2022.

TAMIL NADU: ECONOMY

Tamil Nadu is the second largest contributor to India's GDP. The manufacturing sector is the largest driver of the GDP, with ~25% contribution to the state GSVA. The state's industrial policy aims to increase this contribution to 30% by 2025 and achieve a 15% annual growth rate in the sector during this period. This increase in its economic activity is estimated to significantly increase the power demand of the state.

Figure 6: Tamil Nadu is a highly industrialised state



Tamil Nadu is one of India's well-developed industrial powerhouses (Figure 6) and is the second-largest state economy. It has been contributing 8.4% of the national GDP. Between FY 12 and FY21, Tamil Nadu's nominal GDP increased at a CAGR of 10%. The share of the manufacturing sector in the state's Gross State Value Addition (GSVA) has consistently increased over the past decade and in FY20 it contributed 25%.

According to the state's Industrial Policy, 2021, Tamil Nadu plans to achieve an annual growth rate of 15% in the manufacturing sector till 2025. Further, it aims to achieve investments worth INR 1,000 billion between 2020 and 2025. The policy targets generation of 2 million employment opportunities and an increase in manufacturing sector's contribution to 30% of GSVA.[24]

The state's Industrial Policy is supplemented by Tamil Nadu Aerospace & Defence Industrial Policy 2019 – applicable to all the firms involved in aerospace/ defense related engineering, designing, and manufacturing. Similarly, the Tamil Nadu EV policy advocates the adoption of EVs, EV manufacturing and strengthening the charging infrastructure. The state aims to become 1 out of 3 most attractive investment destinations in Asia by 2030. ***This implies, the state shall have to put in place policy and institutional measures to drive new investments, which are now growingly inclined towards green investments, sustainability, and climate action linked financing.***

24 Guidance Tamil Nadu; https://investingintamilnadu.com/DIGIGOV/TN-pages/industrial-policy.jsp?pagedisp=static

TAMIL NADU: CLIMATE ACTION

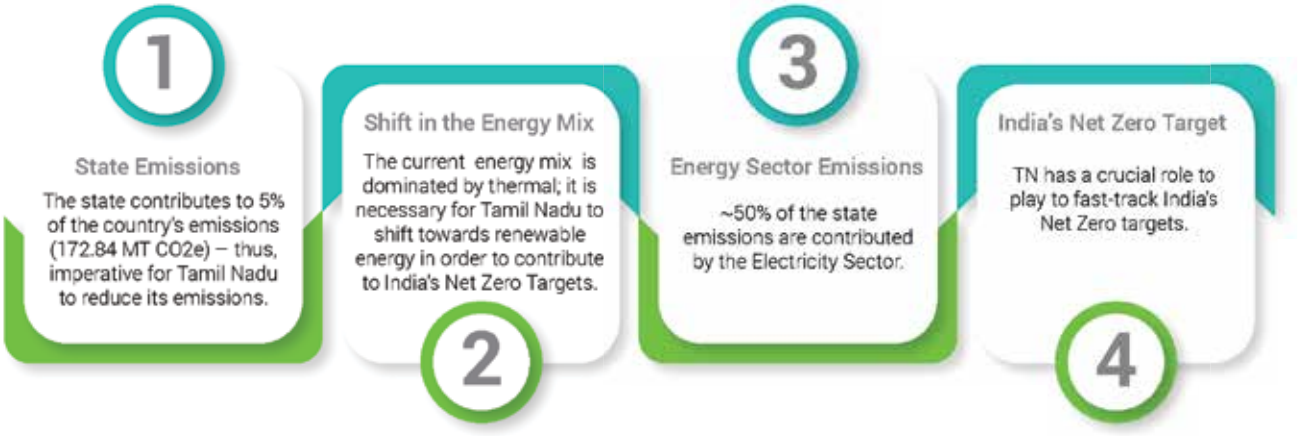
Tamil Nadu is a climate champion. At par with India's National Action Plan on Climate Change, the Department of Environment of the Government of Tamil Nadu established a the Tamil Nadu Climate Change Cell (TNSCCC) on 1st December 2014. In early 2022, Tamil Nadu *government also established the first Special Purpose Vehicle (SPV)* - Tamil Nadu Green Climate Company - to professionally manage three critical natural conservation missions: Tamil Nadu Climate Change, Tamil Nadu Green, and Tamil Nadu Wetlands. The SPV's objective includes developing, implementing, and monitoring a state-wide programme for climate change adaptation and mitigation, wetlands mapping and restoration, and increasing the state's forest and tree cover to 33% over the next 10 years. It will also methods that will minimize greenhouse gas emissions, benchmark industries to shift towards green manufacturing, and promote environmentally friendly technology to ensure a sustainable future.

In 2022, the Tamil Nadu government established a 22-member Tamil Nadu Governing Council on Climate Change. The Council will give policy direction to the Tamil Nadu Climate Change Mission, advise on climate adaptation and mitigation initiatives, provide guidance to the Tamil Nadu State Action Plan on climate change, and guide the climate action implementation plan. Based on the strategies in place, the council will monitor outcomes and deliverables on a regular basis. Furthermore, it will provide a consistent and steady push for research, cooperation, and multidisciplinary work in close contact with researchers.

Although, Tamil Nadu is the second largest contributor to India's GDP, Tamil Nadu ranks eighth among all the states in emissions. The state contributes to nearly 5% of the nation's emissions amounting to ~ 172.84 MT CO2e (Figure 7). Out of this, approximately 50% of the emissions are contributed by the electricity sector alone. Thus, by increasing the share of wind in its energy mix, Tamil Nadu has the potential to bring (further) down its carbon footprint and have a significant impact in reducing the carbon emissions of the country.

For meeting its climate ambitions, Tamil Nadu must accelerate transition to clean energy.

Figure 7: Need for Energy Transition



TAMIL NADU: POWER CONTEXT

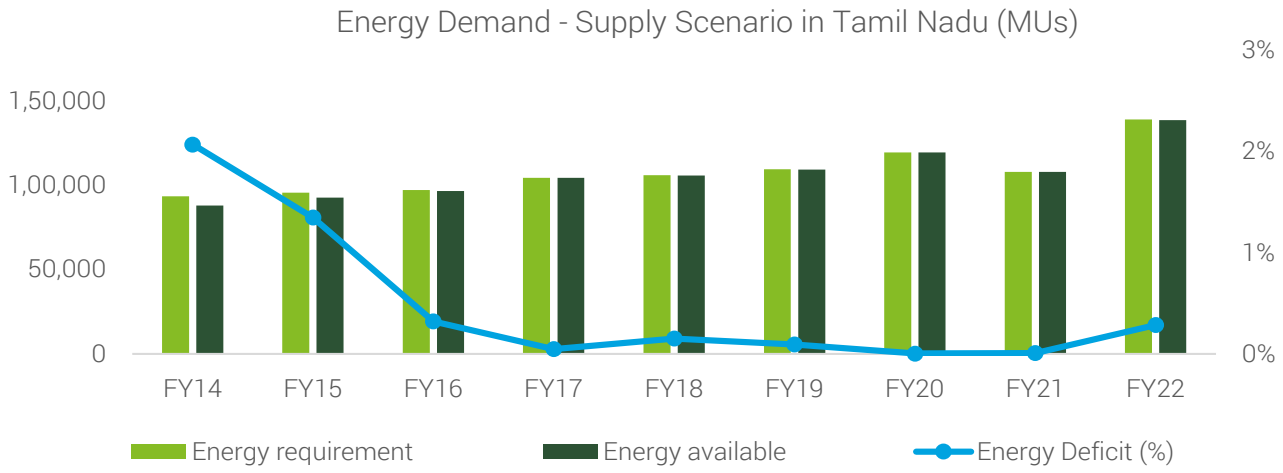
Tamil Nadu contributes to nearly 8% of India's electricity demand and ~9% of electricity generation capacity. The power demand of the state is growing steadily and there has been a significant decrease in its energy deficit in the last decade.

Apart from having a high economic growth aspirations and transformative climate ambitions, Tamil Nadu is also a pioneer state in implementing 24×7 power to all target. The state has already achieved 100% village electrification level by 2016[25]. The power demand of Tamil Nadu has been historically growing at ~5% CAGR. As depicted in Figure 8, the energy deficit of Tamil Nadu has significantly come down in the last five years to almost 0%. This is due to the steady increase in installed generation capacity at ~7% CAGR, from 2014 to 2022.

wind sites in the region and as a result legitimised policies that promoted wind energy generation and manufacturing in the state. The installed onshore wind energy capacity of the state is 9.6 GW[27], and nationally it tops in installed wind power capacity. Currently wind contributes to 54% of all renewable energy produced in the state and plays a major role in meeting its power demand.

As shown in the subsequent Figure 10, the C&I segment constitutes the major share of the power sale mix, contributing to ~50% demand, followed by the domestic sector contributing ~30%.

Figure 8: Supply demand scenario in Tamil Nadu



Source: CEA Annual Report FY14 to FY22

Tamil Nadu has diversified its electricity generation portfolio. As shown in Figure 9, the state's installed capacity of 36.9 GW includes 47% of RE, 6% of hydro energy, 43% of thermal energy and 4% of nuclear energy.[26] ***Tamil Nadu is a leader in wind energy with 84% of its RE potential attributable to wind energy alone.***

In the early 1980s the state recognized the potential of wind power because of the good

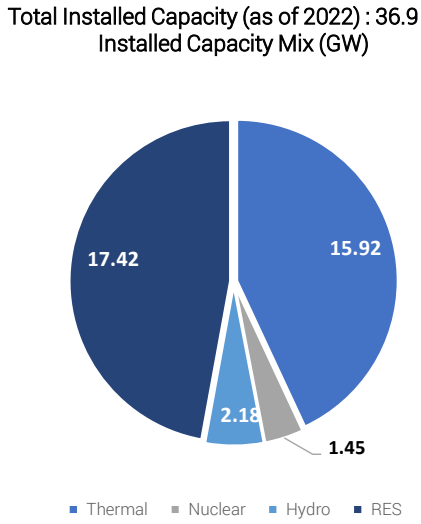
Tamil Nadu has nearly 17.6 GW solar potential, and ~100 GW (onshore and offshore) of wind potential. As of 2022, the state has installed solar capacity of ~5 GW, and installed wind capacity of 9.6 GW. Thus, ***Tamil Nadu has already exploited, close to1/3rd of its solar potential, while only approximately 1/10th of its wind potential has been tapped. However, the pace of wind capacity addition has massively slowed down in recent years.***

25 Ministry of Power, Power for all Tamil Nadu; https://cea.nic.in/wp-content/uploads/installed/2022/10/IC_Oct_2022.pdf

26 CEA Installed Capacity Report, 2022

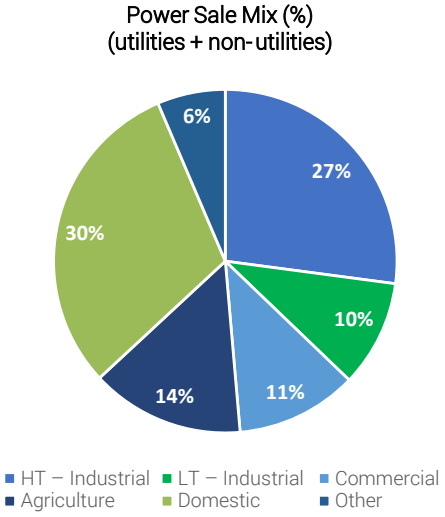
27 MNRE, Wind Power Installed Capacity 2022; https://mnre.gov.in/wind/current-status/

Figure 9: Installed Capacity Mix in Tamil Nadu



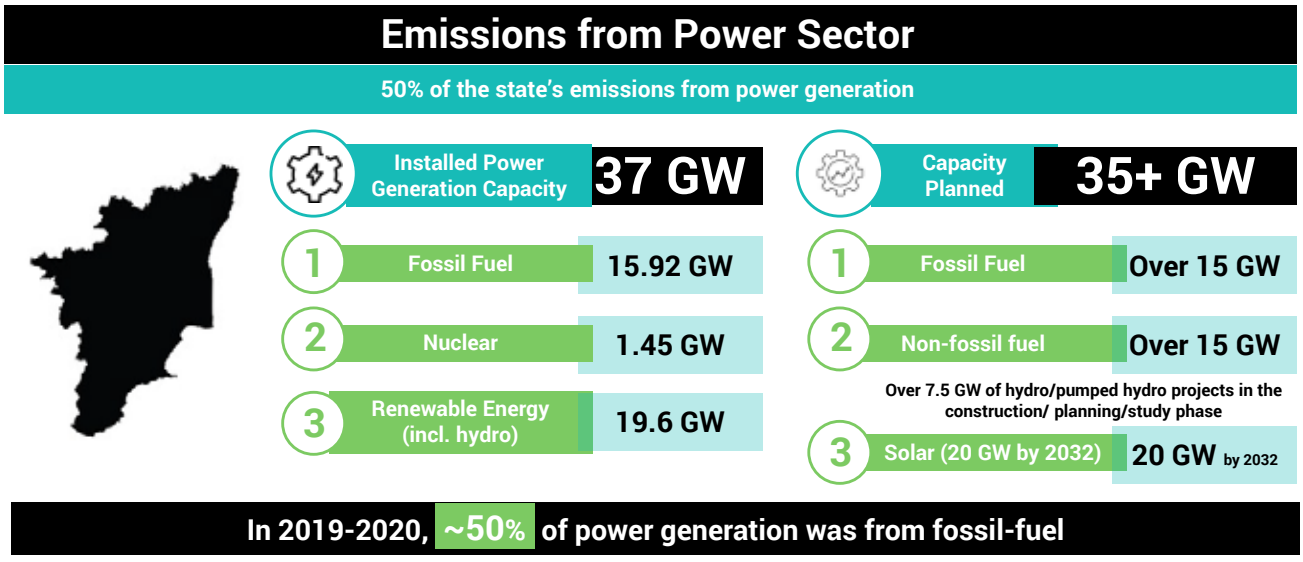
Source: CEA installed capacity report, 2022

Figure 10: Power sale mix in Tamil Nadu



Source: CEA General Review 2021

Figure 11: Tamil Nadu Installed and Planned Capacity



Source: CEA General Review 2022, India GHG Platform, Energy Policy 2022- 2023 of Govt. of TN

The state plans to establish 2 GW of renewable and solar energy parks. It also aims to harness 4 GW of offshore wind potential in the next five years. As of now, a capacity of around 6.2 GW is under construction, and nearly 13.8 GW of capacity is in various stages. However, this capacity is mostly dominated by thermal with minimal RE capacity (Figure 11). [28] **It is to be also noted that wind energy is not included in the planned capacity. To cater the raising demand and complement the other intermittent sources wind energy should be considered in the planned portfolio.**

The 20th EPS report estimates the energy requirement of Tamil Nadu to grow at ~6% CAGR in the coming decade, with ~30% growth in the peak demand by 2027. Textile parks, food parks, EV manufacturing parks, green hydrogen and data centres are some of the sectors that have been attracting investments. All these investments will

28 Prayas Energy Group, TANGEDCO's proposed capital investment plan; https://energy.prayaspune.org/images/pdf/tn_cip2020._437152743.pdf

Electric Vehicles

The government of Tamil Nadu rolled out its EV policy, which in line with the National Policy aims to have 30% of EVs in their vehicle sale mix by 2030

Green Hydrogen Hub

The state has the potential to replace 25% of its hydrogen requirement by green hydrogen by 2030

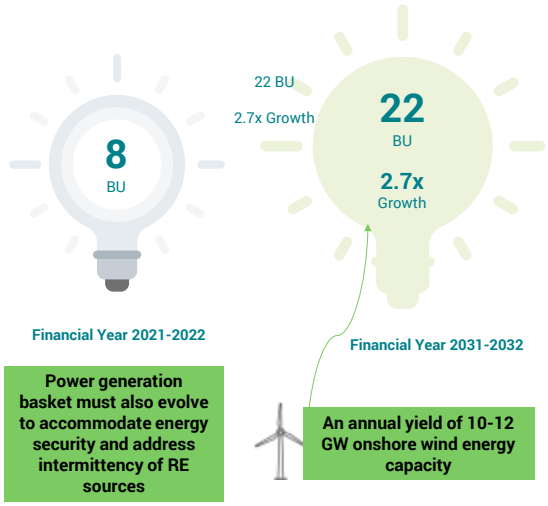
Data Centres

Tamil Nadu has an existing data center capacity of 57 MW, which is expected to be 79 MW by 2023. The state has already signed MOUs worth INR 89 Bn for the phased development of data centers

Growing Manufacturing Sector

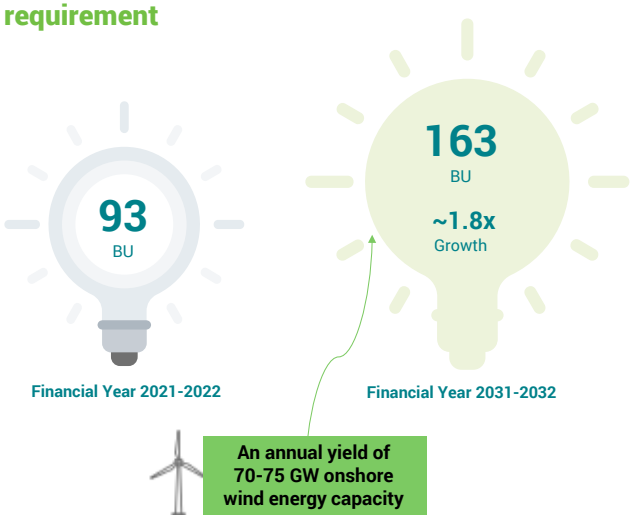
Tamil Nadu has achieved a compounded annual growth rate of 13% in manufacturing between 2014-15 and 2019-20; and aims to increase contribution of Manufacturing Sector to 30% of GSVA by 2030;

Figure 12: Projected C&I Demand



Source:20th EPS Report

Figure 13:Tamil Nadu projected electricity requirement



Source:20th EPS Report

add up to increase the power demand, which need to be met by reliable RE sources.

Figure 13 captures the projected energy requirement of Tamil Nadu as given by the 20th EPS report. The C&I sector will continue to be the highest contributor to the state demand. The power demand from C&I sector can be estimated from the EPS projections and is shown in Figure 12. Along the lines of state energy requirement, the C&I power demand is estimated to grow at a CAGR of 6.14%.

Potential wind capacity additions are estimated under three scenarios: low case, base case and high case. It is estimated that by 2030, Tamil Nadu can achieve an additional wind capacity of 4 GW in low case, 13 GW in base case and 25 GW in high case scenarios.

To achieve its set wind capacity addition target of 140 GW by 2030, India needs to make annual capacity addition of around 12.5 GW. Till 2022, Tamil Nadu has contributed 24.5% of the total wind installed capacity in India. In terms of potential, the state has approximately 10% of overall wind power potential in the country (at 120 m hub) out of which around 12.5 GW can be developed with a CUF of more than 35%[29]. As the pace of wind capacity addition has slowed down in recent years, there is an urgent need for policy and regulatory interventions in the state to support the growth of wind installations and realize the wind potential. Different scenarios were developed to estimate the capacity additions in the state.

It is observed that in the High Case scenario, the state shall continue to have capacity additions and maintain its dominant share in the wind installed capacity. In the Base Case scenario, the state may lose its dominance in wind share but still can contribute a significant share in wind capacity additions. On the other hand, in the Low Case scenario the state will lose its share in terms of both capacity and dominance.

Going forward, to realize state's economic aspirations, climate ambitions, clean energy transition goals and to meet emerging power demand, wind energy sector must be harnessed to

Figure 14: Summary of estimated cases

Low Case Scenario
Capacity Addition: 4 GW

- Low case is built based on the Business-as-usual case, low capacities additions would continue. It is assumed that there would be no special schemes or interventions are put in place and constraints are not eased to ramp the wind capacity.
- Under this scenario it is estimated that by 2030 additional 4 GW would be added by Tamil Nadu **resulting to the total capacity of 14 GW**

Base Case Scenario
Capacity Addition: 13 GW

- Base case is built based on the capacity addition trends both at state level and national level. It is assumed that there would partial policy interventions by easing few of the constraints that are restricting the capacity additions
- Under this scenario it is estimated that by 2030 additional 13 GW would be added by Tamil Nadu **resulting to the total capacity of 23 GW.**

High Case Scenario
Capacity Addition: 25 GW

- High case is built based on the assumption that the state fully utilizes the untapped potential with various policy interventions and by completely eliminating the constraints preventing the capacity additions.
- Under this scenario it is estimated that by 2030 additional 25 GW would be added by Tamil Nadu **resulting to the total capacity of 34 GW.**

In the **Base Case Scenario (**Figure 14**),** it is estimated that by 2030 nearly 16% of India's total installed capacity will come from Tamil Nadu by 2030. The capacity additions will be lower in the initial years, but as constraints get eased and policy interventions are introduced, the state will witness an increase in annual capacity addition in the later years. A similar approach has been considered for **Low Case and High Case** scenarios as well. Refer to Annexure I for detailed estimates.

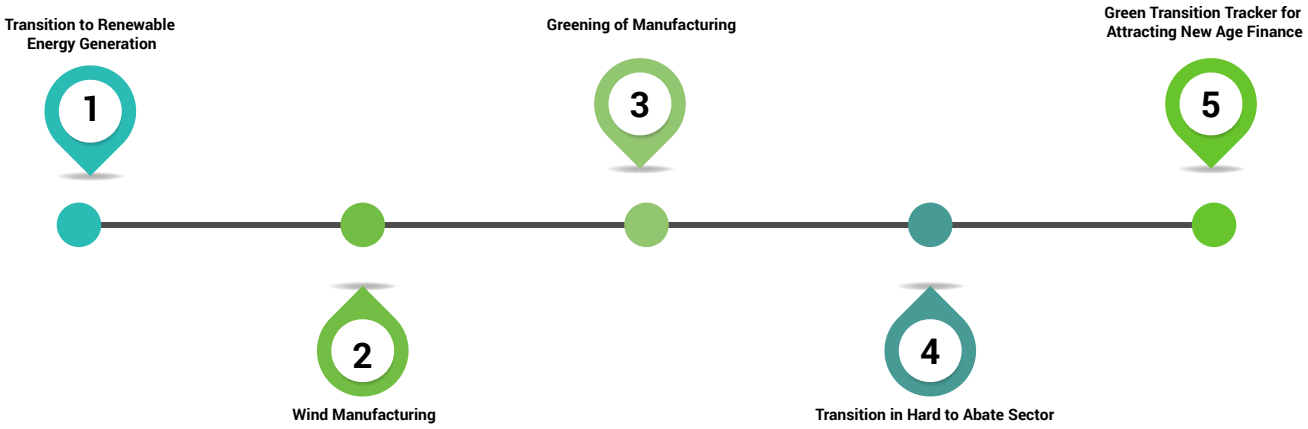
29 NIWE, India's Wind Potential Atlas at 120 agl (2019), details available at https://niwe.res.in/assets/Docu/India%27s_Wind_Potential_Atlas_at_120m_agl.pdf

HIGH IMPACT OPPORTUNITIES (HIOs)

For Tamil Nadu to realize its wind capacity addition, five high impact opportunity areas are considered namely: transitioning from thermal to renewable energy, Manufacturing of Green Technology, greening of manufacturing, green hydrogen and Green transition Tracker.

With the identified High Impact Opportunity areas (Figure 15), Tamil Nadu can target of achieving high case scenario which will aid the State in transition towards Net Zero

Figure 15: HIOs



Stakeholder Consultations

GWEC along with Deloitte conducted an extensive stakeholder survey to:

a. Understand the challenges faced by OEMs and supply chain players in the wind energy sector
b. Understand the challenges faced by wind industry and promote wind energy capacity addition
c. Identify high-impact opportunities in areas of wind equipment manufacturing and supply chain
d. Build consensus on financial and non-financial incentives, which would be required to push Tamil Nadu's wind manufacturing and supply chain to new frontiers

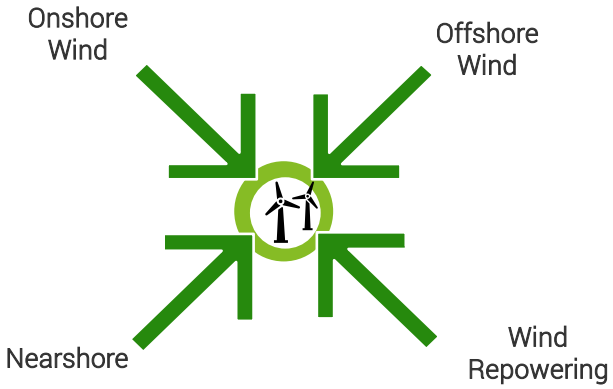
Every high impact opportunity and recommendations discussed further are based on the stakeholder comments and suggestions.

TRANSITION TO RENEWABLE ENERGY GENERATION

Tamil Nadu is a pioneer in wind energy. By tapping its untapped wind energy potential, the state could play a much more transformative role in terms of supporting local and national energy transition, security, and climate action goals.

Tamil Nadu's wind installed capacity as on March 2021 was 9.6 GW.[30] The National Institute for Wind Energy (NIWE) has estimated that the state has over 68 GW of onshore and over 35 GW of offshore wind power potential. For wind power generation capacity, the following (refer to Figure 16) must be prioritized by the state.

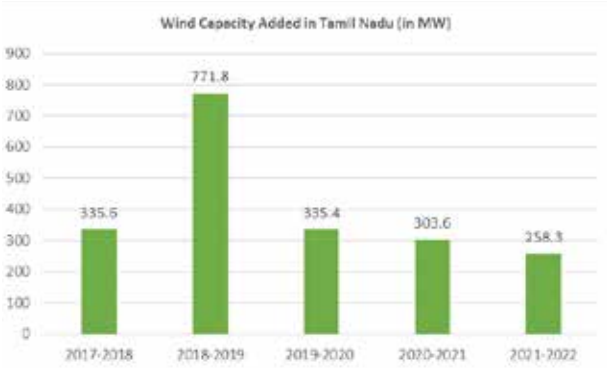
Figure 16: HIO 1 priority areas



Priority 1: Onshore Wind

The state is blessed with huge high wind potential sites in the districts of Kanyakumari, Madurai, Tuticorin, Coimbatore, Dindigul, Theni, Tirunelvelli and Pudikottai among others. Over 90 wind monitoring stations were operationalized during various times in the past few decades to ensure the richness of data for wind generation profiles and site characteristics.[31] Even though Tamil Nadu was an early starter, in recent years, less than 350 MW of onshore wind energy capacity has been annually commissioned in the state (Figure 17), except in 2018-2019. Also, as the state bids for wind have not been organized in the last few years, only through central SECI tenders, project capacities have been awarded to it. Out of close to 2.4 GW of wind capacity awarded from SECI central tenders, around 1.2 GW has been already commissioned and nearly 1.2 GW is yet to be commissioned (majorly Tranche IV, IX, and X projects).

Figure 17: Wind installed capacity trends



Source: GWEC Market Intelligence

The state may leverage both vanilla wind installations and hybrid (solar-wind/solar-wind-storage) projects to add more capacities of wind power to ensure grid balancing and energy security in the long run as the share of RE in the overall generation mix increases.

Priority 2: Offshore Wind

Offshore wind has a higher CUF in comparison to onshore wind and plays a role in the development

30 MNRE, Onshore Wind, details available at https://mnre.gov.in/wind/offshore-wind/

31 Details available at https://niwe.res.in/assets/Docu/lwms/LIST%20OF%20WMS%20AS%20ON%2031.10.22.pdf

Repowering: A case study of Denmark

To understand the drivers behind wind repowering decisions, the IEA Wind studied Denmark for insights on wind repowering decisions. Denmark has one of the oldest wind turbine fleets in the world and its wind industry makes up 47% of the country's annual electricity production.

The study found that between 2012 and 2019, 38% of wind energy projects in the country were classified as repowering projects. In 2019, the final year for which the data were analysed, repowering market share in Denmark jumped to an unprecedented level of 86% of gross added capacity and 87% of added wind turbines. This development heralded repowering as a major future investment activity, as markets matured in the United States and around the world.

For this same time period, the net capacity additions from repowered projects totalled 576.8 MW. Considering both greenfield and repowered wind energy projects, Denmark saw a 1.3 GW gain in capacity and a reduction of 109 wind turbines, enabling a substantial increase in wind energy production with fewer turbines.

The study found that estimated profits from repowering were not the only parameter that influenced decisions for the uptake of repowering. It was found that decision to repowering is also influenced by factors such as aesthetics, and its impacts on local communities, for example, noise reduction. The study also acknowledged repowering as a complex process of negotiation between developers and owners of old units/local communities, which requires time, energy and resources.

Source: IEA Study; https://www.energy.gov/eere/wind/articles/wind-repowering-helps-set-stage-energy-transition

of RTC power/dispatchable power as it complements other sources of renewable energy. Around 35 GW[32] of offshore wind energy potential exists off the coast of Tamil Nadu. Currently, eight zones have been identified as potential locations for offshore wind turbine installation in the state. In November 2022, MNRE released a draft tender that plans to commence the auction of 4 GW of offshore wind capacity in the state. This will help kickstart offshore wind capacity addition in Tamil Nadu as part of the wider 37 GW offshore wind tender trajectory off the coast of the state and off the coast of Gujarat.[33]

However, offshore wind projects are not currently economically viable as standalone projects and may need further incentives to become viable. The state may consider incentivizing off-takers and industrial consumers to procure power from these projects. It may also set targets to blend power from offshore with that of other technologies in the initial years. ***Most importantly, it must create an enabling environment: support the graduation of onshore wind stakeholders as offshore stakeholders as well***; identify opportunities for capacity building, strengthen the supply chain, and promote offshore wind manufacturing to facilitate round-the-year business case for ports investing in infrastructure upgradation, leverage technology and institutions interventions for fact tracking permits and clearances, strengthen coordination between central- and state-level agencies and mechanisms for benefit between centre and state as well as with local communities among others.

Priority 3: Repowering

As Tamil Nadu has been the pioneer in wind generation, it has some of the oldest wind turbines with older technology and lower CUF. Many of these turbines are located at the best sites for harnessing wind energy. For better utilization

32 MNRE, Offshore Wind, details available at https://mnre.gov.in/wind/offshore-wind/

33 Details available at https://coe-osw.org/strategy-paper-for-establishment-of-offshore-wind-energy-projects/

of wind resources and due to the issue of land availability, these old wind turbines need to be repowered. If the older turbines are replaced, they can give a CUF upwards of ~30%, compared to the existing ~14% (Box 3).

Under the draft Repowering Policy of the Government of India, all the turbines below 2 MW capacity are eligible for repowering. As of 2017, Tamil Nadu has nearly 12,000 turbines under this capacity. Considering 10 years from 2022, roughly 4.1 GW of capacity can be repowered.[34] Muppandal, Poolavadi, Kethanur, and Perungudi can serve as the immediate repowering sites.

At present, repowering in Tamil Nadu faces many bottlenecks; these include fragmented ownership of the wind farm, the need for upgrading the evacuation infrastructure, and the loss of generation during the repowering period.

The state must administer surveys to assess the repowering potential of the identified wind sites. It may also consider providing incentives[35] to compensate for the loss of revenue during the transition.

Priority 4: Nearshore Wind

Tamil Nadu can also explore sites for nearshore wind plants. Nearshore wind plants have comparatively lower costs of connection, foundation, and O&M. The state boasts of a long coastline, developed ports, and a wind manufacturing base near the coast, which can drive down the cost for nearshore installations. Parallels can be drawn from countries such as Vietnam (Box 4), which have successfully implemented nearshore projects.

Nearshore Wind: A case study of Vietnam

Vietnam is a desirable market for offshore and nearshore due to its long coastline of more than 3000 km and a good wind potential. By 2022, Vietnam had more than 7 GW of installed wind-generation capacity, more than one-third of which was nearshore, thanks to the government's attractive feed-in-tariff programme. These wind farms try to catch the greater wind speeds found at sea. The nearshore wind farms, which are many kilometres off the coast, have attracted significant investment from developers. Thus, nearshore, initially a niche market in the country, has now transformed into a real market segment.

Nearshore wind projects in the Mekong Delta region of Vietnam are primarily in rural areas where agriculture is the source of livelihood. Thus, the local economy in the region is still growing and therefore the presence of wind farms has benefited the local economy in a variety of ways.

It has brought both domestic and foreign contractors to the province, which have resulted in job generation for the local community either directly through the projects or indirectly through a need for accommodations. Additionally, it has developed the province's infrastructure by building roads for the wind project, which the local community can use for its everyday operations or for business. It has also helped in attracting significant tourism. Finally, since investments in wind projects are typically far bigger than those in other agricultural businesses, they provide a sizable contribution to the local GDP.

Source: Siemens Gamesa, details available at https://www.siemensgamesa.com/en-int/explore/journal/2022/06/vietnam-onshore-nearshore-project-asia-100-gw

34 MNRE Draft Repowering Policy, 2022, details available at https://mnre.gov.in/img/documents/uploads/file_f-1666005996212.pdf

35 Internationally, regulatory measures and financial instruments such as repowering certificates, feed-in-tariff, and other such instruments have been leveraged to advance the uptake of repowering

CHALLENGES & RECOMMENDATIONS

Evacuation, policy/regulatory challenges, and the financial health of the state DISCOM have slowed wind capacity addition in Tamil Nadu. The state is already expediting the resolution of these challenges to some extent. However, it may consider incentivizing offshore wind and exploring the alternative of nearshore wind.

Challenges: Tamil Nadu was one of the few states that supported the early RE additions and built an adequate evacuation infrastructure. But in recent years, the upgradation of transmission infrastructure has staggered. It is observed that the planned line capacity additions have been delayed by more than 5 years in the state.[36] To cater to its growing RE capacity additions, the state could focus on strengthening the transmission network. To fund the transmission network strengthening, the state could approach multi-lateral funding agencies and explore bidding options to private players through the PPP mode. Figure 18 highlights some of the challenges that persist in Tamil Nadu.

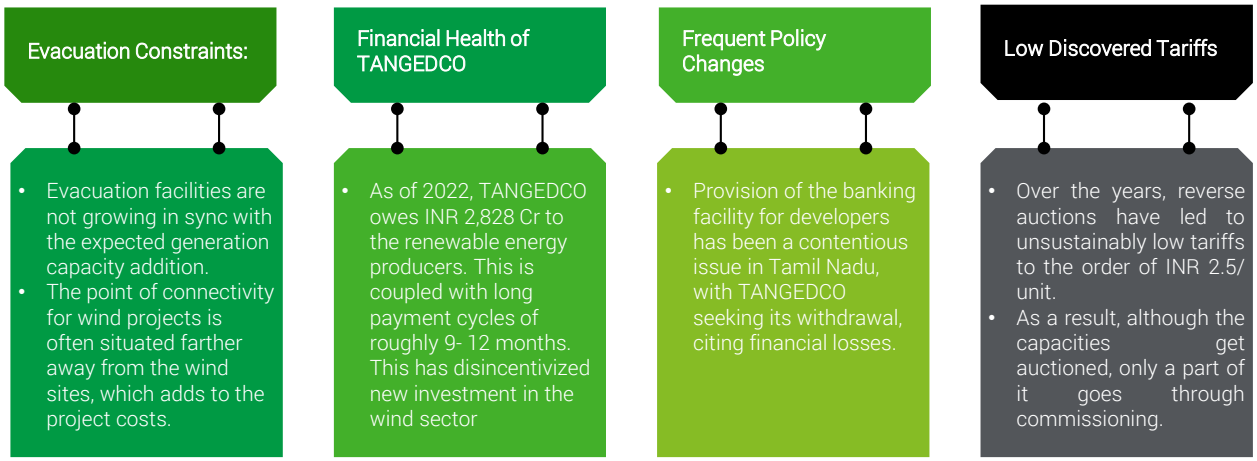
Recommendations: Interventions are required to meet the High Case scenario (see Figure 19), which will keep the wind capacity at the current share of 24% and retain the dominant position of the state in wind additions.

Socio-economic Benefits of Wind for Tamil Nadu

If the capacity additions in the wind sector are indeed realized, then the state has a huge potential to attract investments and created employment.

Impact on Investments: It is observed that the costs of onshore wind projects dropped from USD 1387/kW[37] in 2010 to USD 800/kW in 2020[38] with an annual reduction of ~5%. As the sector matures, it is estimated that in the coming decade the costs will further drop at an annual change of ~0.5%, resulting in the onshore wind project cost being USD ~780/kW by 2030.[39] Therefore, to an additional 13 GW under the Base Case scenario by 2030, it is estimated that Tamil Nadu will require a total of INR 746 billion (~USD 10 billion) (Figure 20). By assuming the debt-

Figure 18: Wind challenges



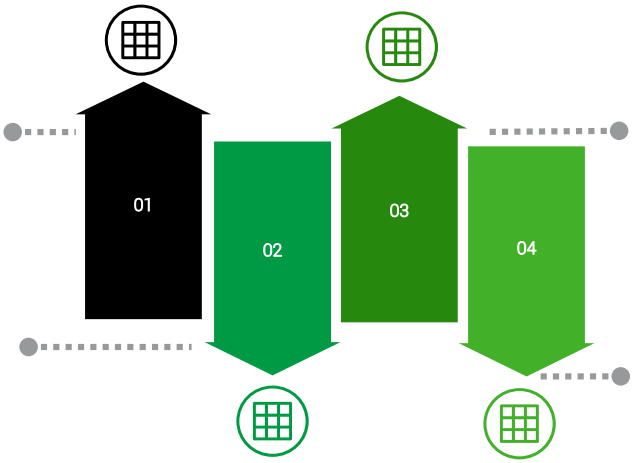
36 TANTRANSCO, Transmission Lines under Construction, 2022, details available at https://www.tantransco.gov.in/tantranscopdf/lines.pdf

37 IRENA, Renewable Energy Technologies: Cost Analysis Series, details available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2012/RE_Technologies_Cost_Analysis-WIND_POWER.pdf

38 Gujarat Industrial Development Corporation, details available at https://www.gidb.org/pdf/opportunityforinvestmentinGujarat.pdf

39 Assuming the commodity boom is a temporary phenomenon

Figure 19: Wind recommendations



Stable Regulatory Framework

- Promotion of waivers of wheeling charges (from existing 50%) and waiver of cross-subsidy charges (from existing 40%)
- Continued banking provisions.
- The state can provide a long-term visibility on the provisions of wheeling and banking throughout the lifetime of the project.

Focus on Repowering

- Site surveys need to be done to identify the actual potential
- Repowered wind clusters can be integrated with other RE to develop clusters for RTC/peak power and thereby design tariffs to appreciate business value.

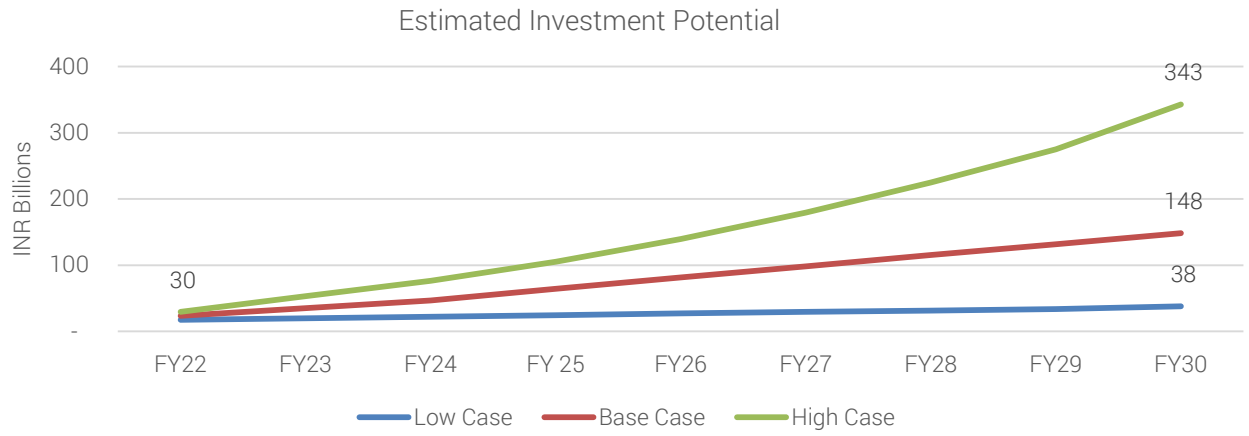
Focus on Nearshore

- Tamil Nadu has the potential to commission nearshore projects much before offshore – could be leveraged as a pilot before the actual commissioning of offshore projects

Incentives for Offshore

- The state can consider incentivizing the industrial consumers to procure power from these projects, by waivers on transmission, wheeling and cross-subsidy charges.
- The state can also support identification of off-takers and introduce a target for blending during the initial years

Figure 20: Investment potential of wind capacity additions



equity ratio to be 75:25, around INR 186 billion (USD 2.5 billion) equity infusion is required.

Impact on Jobs: Investment in wind power capacity addition leads to employment creation. As per the global job scenario in wind energy, IEA estimated that wind has the potential to create

Figure 21: Impact on direct jobs

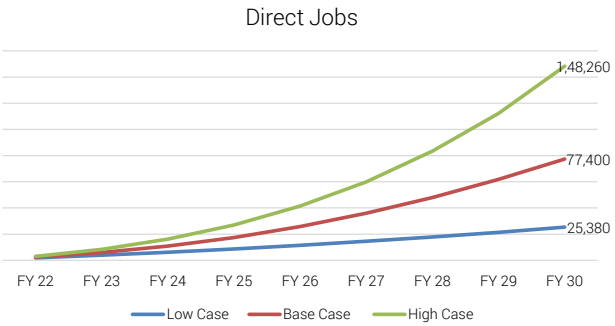
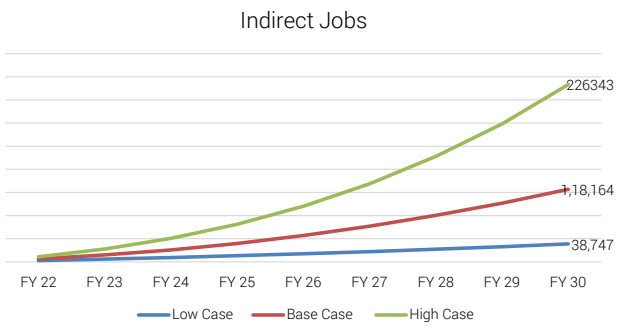
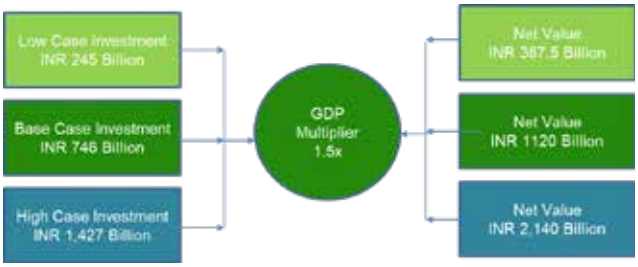


Figure 22: Impact on indirect jobs



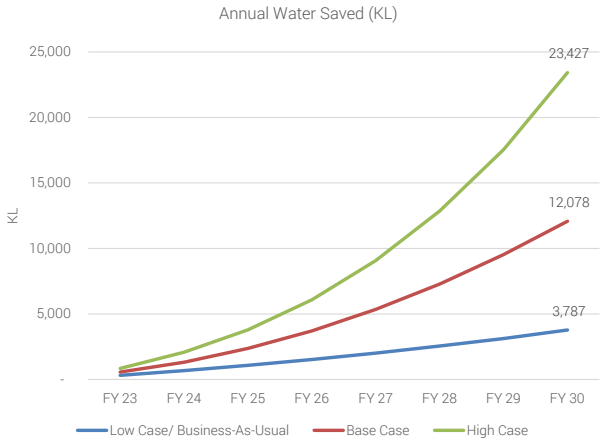
HIGH-IMPACT OPPORTUNITY 2

Figure 23: Impact on GDP



5.76 direct jobs/MW through plant construction, manufacturing, commissioning, etc., 9.16 indirect jobs/MW through supporting activities such as supply, transportation, scrap, etc., and 0.29 jobs/MW through O&M. To summarize, it is approximated that wind has the potential to create 6 direct jobs/MW and 9.15 indirect jobs/MW.

Figure 24: Impact on water saved



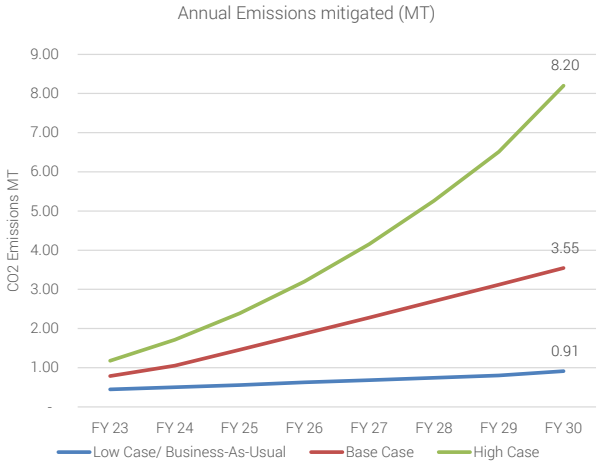
Therefore, an additional capacity of ~13 GW under the Base Case scenario has the potential to generate 77,000 direct jobs (Figure 21) and 118,000 indirect jobs (Figure 22) for the entire project lifetime.

Impact on GDP: International Monetary Fund (IMF) estimates that RE investments could result in a GDP multiplier of 1–1.5x. Considering the Base Case scenario and the resultant investment required, it is estimated that the GDP contribution under the Base Case scenario would be INR ~1120 billion. The resulting outcomes of the other cases could be shown in Figure 23.

Other Social Benefits: *Opting for wind energy will also result in social benefits such as saving water and mitigating emissions arising out of thermal energy generation. As per industry reports, a thermal power plant requires nearly 600 litres of water for a million units of generated electricity. It can be estimated that over the years, switching to wind energy will save nearly 12 million litres of water annually in the Base Case scenario.*[40]

Taking a similar approach, research reports suggest that nearly 800 tonne of CO2 emissions are associated with 1 MU of electricity generation

Figure 25: Emissions mitigated (in MT)



40 Tuticorin Plant Study, details available at https://www.tangedco.gov.in/linkpdf/tttps.pdf

41 Epa.gov, details available at https://www3.epa.gov/ttnchie1/conference/ei20/session5/mmittal.pdf

42 IPCC, Technology-specific Cost, details available at https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf

WIND MANUFACTURING

Supporting wind manufacturing will enable long-term investments in the sector. It will improve competitiveness and profits for the stakeholders, which will further attract investors.

Wind manufacturing is a mature industry in India with nearly 75% localization.[43] Tamil Nadu is one of the pioneer states in wind manufacturing facilities. It has sufficient land availability, workforce capabilities, and skilled labour. Due to its cost competitiveness, robust wind energy value chain and cutting-edge technology, Tamil Nadu is well positioned to further scale up as the export hub for the wind industry and become an important part of the global supply chain. If proper incentives and promotion schemes are put in place, Tamil Nadu can become the manufacturing hub for the Asia-Pacific countries.

Stakeholders Say

Promoting localization and indigenous manufacturing can help lower the costs of major components, thereby reducing significant turbine costs. (In a typical onshore wind project, the turbine accounts for 70% of the cost while the surrounding infrastructure makes the remaining 30%.) However, the existing supply chain faces many challenges.

Chinese equipment suppliers end up being more competitive – **Industry Expert**

Let there be state level bid processes, without e-reverse auctions. – **Industry Expert**

Existing export incentives are not attractive, plus, Increased GST (12% instead of 5%) has further impacted economics – **Leading OEM player**

Lack of firm orders to the component manufactures leading to <25% plant utilization – **A key C&I player**

Trade linkages may be built with APAC markets. Most Southeast Asian countries have trade facilitation/promotion offices in Chennai, with whom we may collaborate. – **Industry Expert**

Scaling-up of Wind Manufacturing Capacity

As per the Global Wind Report 2022, published by GWEC, India has an 8.5% share in the global supply chain while the world's wind energy installations stand close to 850 GW. The IEA and IRENA have also estimated over 8000 GW (out of which 2000 GW is estimated to be offshore wind) of global wind deployment to meet climate targets by mid-century.[44]

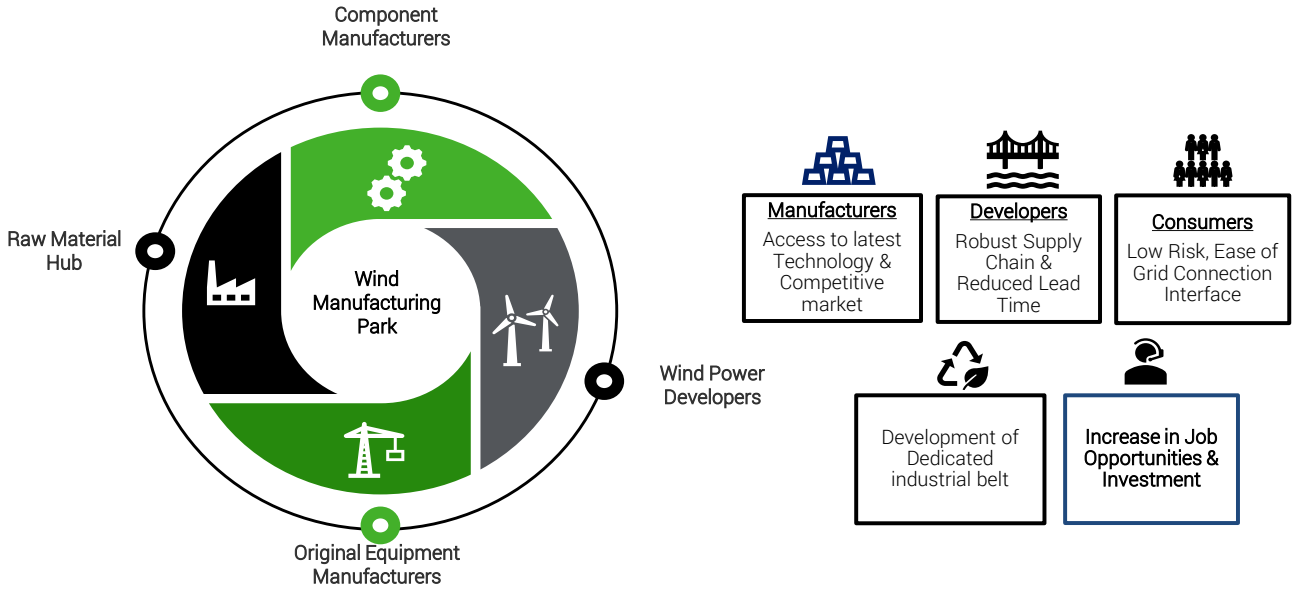
Owing to the slowdown in wind capacity addition in the state and the country, and the massive escalation in the cost of components, retaining the sustenance of wind manufacturers has become a priority. ***In the past few years, over 30 manufacturers have become inactive and, at the present, only 8 manufacturers are active. To sustain their activity, an annual onshore wind capacity addition of at least 5 GW has been emphasized.***[45] To tap the potential and further enhance the state's footprint in wind exports, it is important to promote and scale up the wind manufacturing sector in the state. Box 5

43 Indian Wind Turbine Manufacturers Association (IETMA) IWTMA

44 Details available at https://gwec.net/global-wind-report-2022/

45 Details available at https://gwec.net/accelerating-onshore-wind-capacity-additions-in-india-to-achieve-the-2030-target/

Figure 26: Manufacturing park illustrative



summarizes the key concerns/recommendations received from the consultations undertaken.

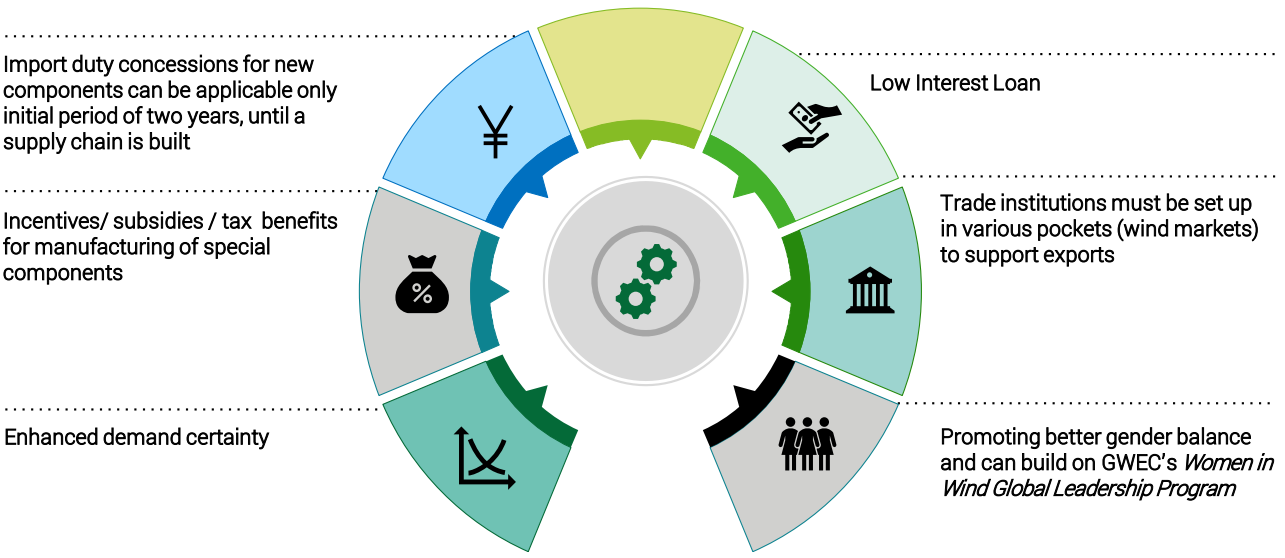
Wind Manufacturing Park

A wind manufacturing park (Figure 26), aggregating multiple stakeholders such as manufacturers, wind power developers, etc. as a single cluster, can support driving economies of scale, lowering costs as well as increasing the competitiveness of wind. The development of manufacturing parks/hubs by the state government can eliminate the risks in the procurement of land as it increases competition. Similarly setting up wind manufacturing parks in proximity to C&I consumers/end users would help them reap the benefits of RTC power at lower costs. These synergies will further generate incremental revenue for the state government through both direct sources and indirect sources.

Other Recommendations

Figure 27 highlights some of the recommendations that the state can undertake to promote local manufacturing and build Tamil Nadu a Manufacturing hub for Asia pacific Countries. Annexure VII shows the existing wind components export market.

Figure 27: Recommendations on wind manufacturing



"In the International Renewable Energy Agency (IRENA) and International Energy Agency (IEA) roadmaps for a 1.5°C pathway published last year, wind energy becomes a central pillar of the global energy system by 2050, with more than 8,000 GW of wind capacity generating more."

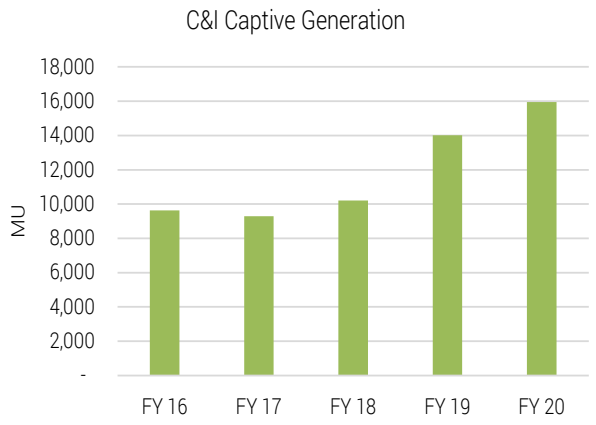
— Global Wind Report 2022

HIGH-IMPACT OPPORTUNITY 3

Being an industrial state, C&I consumers form a major portion of its electricity consumption (Figure 29). Post-2020, the state has been focusing on indigenous manufacturing and production, which has increased energy demand from this sector.

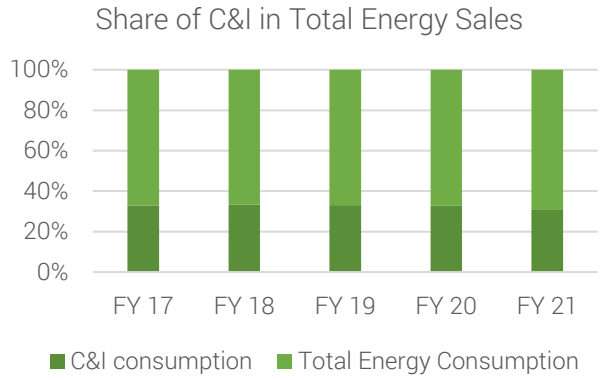
The demand for green energy in the state has been further propelled by RPO/RECs on the C&I customers procuring power through open access. Furthermore, a few multinational companies have declared their voluntary net-zero commitments by cutting down emissions in the entire supply chain.

Figure 28: Captive demand



Source: EPWRF India Time Series Data

Figure 29: Share of C&I in total sales



Source: CEA

Figure 30: Resource-wise captive installed capacity

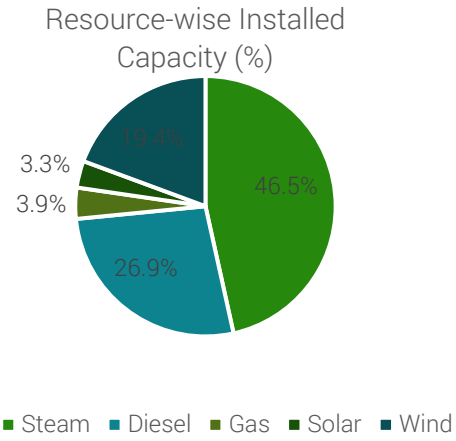


Figure 28 shows the rising captive demand by C&I customers. The C&I sector in Tamil Nadu has a captive installed capacity of ~7.7 GW (Annexure II), which is dominated by thermal energy (Figure 30). The textile, electrical engineering, and iron and steel industries constitute nearly 50% of the installed capacity. The wind has only 19.4% (~1.5 GW) of the installed capacity share and in FY20 its share was only ~11% in the total captive generation.[46]

However, this scenario is likely to change, with the growing emphasis by multinational corporations to achieve net zero. Companies like Shell India, Vedanta Group, JSW Steel, and ITC Limited (refer to Annexure III), which operate in the hard-to-abate sectors, have established their sustainability targets and are **transitioning from thermal to dispatchable RE. Thus, the C&I captive segment can be a major demand driver of wind energy in Tamil Nadu.**

Boxes 6 and 7 highlight the necessity of a green manufacturing hub and the benefit of consuming power from captive or through open access.

46 CEA General Review 2021; details available at https://cea.nic.in/wp-content/uploads/general/2020/General_Review_2021.pdf

GREENING OF MANUFACTURING

Green Manufacturing Hub

The wind potential of Tamil Nadu can be tapped to support the growing manufacturing sector demand.

Tamil Nadu's manufacturing sector's contribution to the state has been consistently increasing in the past decade and in 2020-21, it contributed 33% of GSVA. The state aims to achieve a 15% growth rate in the manufacturing sector by FY25.

Tamil Nadu houses highly energy-intensive industries such as textile, iron and steel, paper, cement, plastic, fertilizer, and so on. The top **1000** industries have electricity consumption of **~18,250 MU and** an installed capacity of **~6.5 GW.** The captive generation is dominated by thermal energy and the share of renewables is only **~16%.**

For instance, iron and steel industry derives **~40%** of its electricity requirement from captive consumption and has RE penetration of **~15%** in its generation. Similarly, the paper industry derives **~84%** of its electricity requirement from captive generation and has RE penetration of only **1.2%**. This percentage is equally low in sugar, cement, and mining industries.

Thus, there is a huge potential to create a green-powered manufacturing hub in the state, especially considering the sectors need for competitive renewable power.

The C&I players have mandated RPO targets

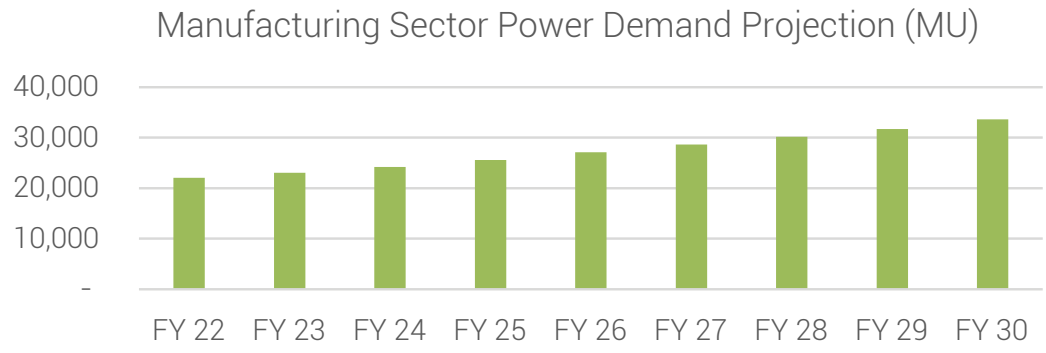
The states utilities as well as the major C&I players have RPO targets, which are progressively being increased **to 41% of** their power requirement

Net Zero Targets

Major C&I players have their net zero targets. Investors and financial markets are increasingly expecting a credible ESG plan and a path to net-zero carbon emissions

Cost Considerations

With players opting for group captive/ OA plants, availability of green power can ensure power supply at cheaper costs



C&I Consumption

Long-term power requirement of a C&I customer can be catered by three different routes, namely: (i) State DISCOM – TANGEDCO, (ii) Open Access through a generator/power producer, and (iii) captive/ group captive. Each of the three modes can be explored as done here:

1. Purchase through the state DISCOM:

As per the FY 2022-23 Tariff Order, True Up order of Tamil Nadu Electricity Regulatory Commission (TNERC), the grid tariff for an industrial consumer will be INR 7.21/ unit, payable to the DISCOM (Energy charges of INR 6.75/unit along with weighted average time of day charges, considering 24 hour operations).

2. Under Open Access and Captive:

The industrial consumer has to pay an ex-bus charge to the generator, along with the open access charges. For instance, the ex-bus charge of a wind generator is assumed to be INR 4/ unit. The major open access charges applicable for the consumer are transmission charges, wheeling charges, and cross-subsidy surcharge. The landed cost of power through open access, for a consumer connected to the distribution network is determined to be as tabulated here:

Components	UoM	Open Access	Captive
Ex-bus charge	INR /unit	4.0	4.0
Inter-state Transmission Charge	INR /unit	0	0
Intra-state Transmission Charge	INR /unit	0.11	0.11
Wheeling and Distribution Charge	INR /unit	0.48	0.48
Cross-subsidy Surcharge	INR /unit	1.07	0
Additional Surcharge	INR /unit	0.7	0
Other Charges	INR /unit	0	0
Landed OA Tariff (inclusive of all losses)	INR /unit	6.62	4.82
Benefit Over Grid Tariff	INR/unit	0.59	2.39

Thus, going for Open Access or captive is more competitive for an industrial consumer, over purchasing power from the grid. However, even when compared between captive and open access, the landed cost of power is the lowest through captive mode. This is owing to exemptions on the cross-subsidy surcharge and additional surcharge– thereby making captive preferable to open access.

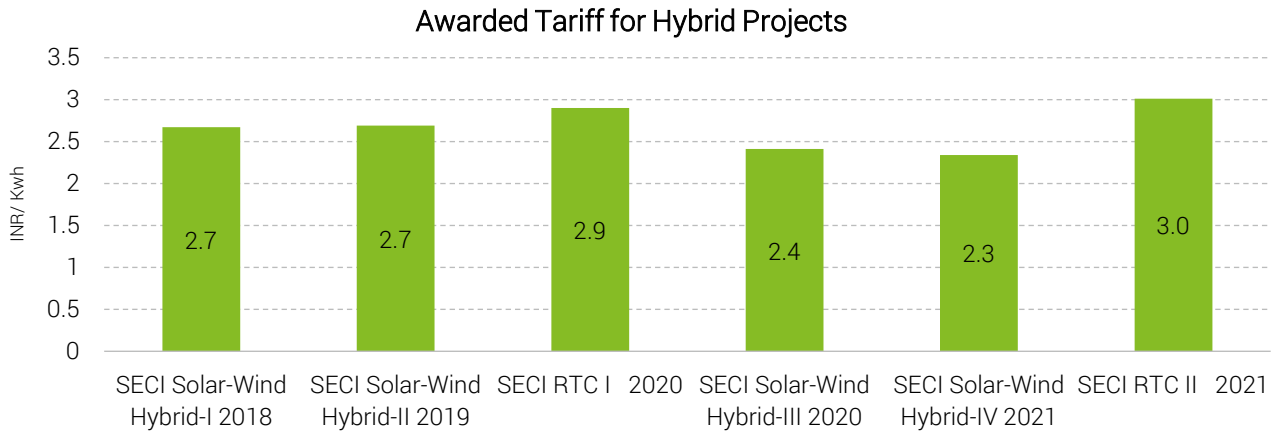
RECOMMENDATION: HYBRID POLICY

With increased RE penetration, dispatchable RE is going to play a major role in providing stability. Round the Clock in the form of wind–solar hybrid, or a combination with storage, could give a high CUF (of 45–55%), with relatively similar tariffs as vanilla wind/solar installations. Hence, the state should encourage hybrid installations. Considering this, it is recommended that the state should have a dedicated hybrid policy.

Intermittent renewables are challenging because they disrupt the conventional methods for planning the daily operation of the electric grid. Increased RE presence may lead to associated challenges such as grid instability and variability in generation. Power fluctuates over multiple time horizons, forcing the grid operator to adjust its day-ahead, hour-ahead, and real-time operating procedures.

Despite this, none of the hybrid projects currently under construction located in the state (they are primarily in Rajasthan, Gujarat, and Karnataka).[47] (The state has a single solar–wind hybrid project supplying power to the C&I consumers: 226 MW, operational since 2019). This is partly due to the constraints in land availability and poor financial health of TANGEDCO, and partly due to the lack of a focused hybrid policy.

Figure 32: Hybrid and RTC tariff trends



Source: SECI Tenders

One option to reduce the variability associated with RE is to complement it with conventional power or battery energy storage systems (BESS). Alternatively, wind-solar hybrid projects can also be promoted. A combination of wind and solar energy can yield higher levels of electricity, as solar power can meet the daytime demand and wind power generation tends to be stronger at night. Adding battery storage to the mix can ensure uninterrupted power for close to 24 hours.

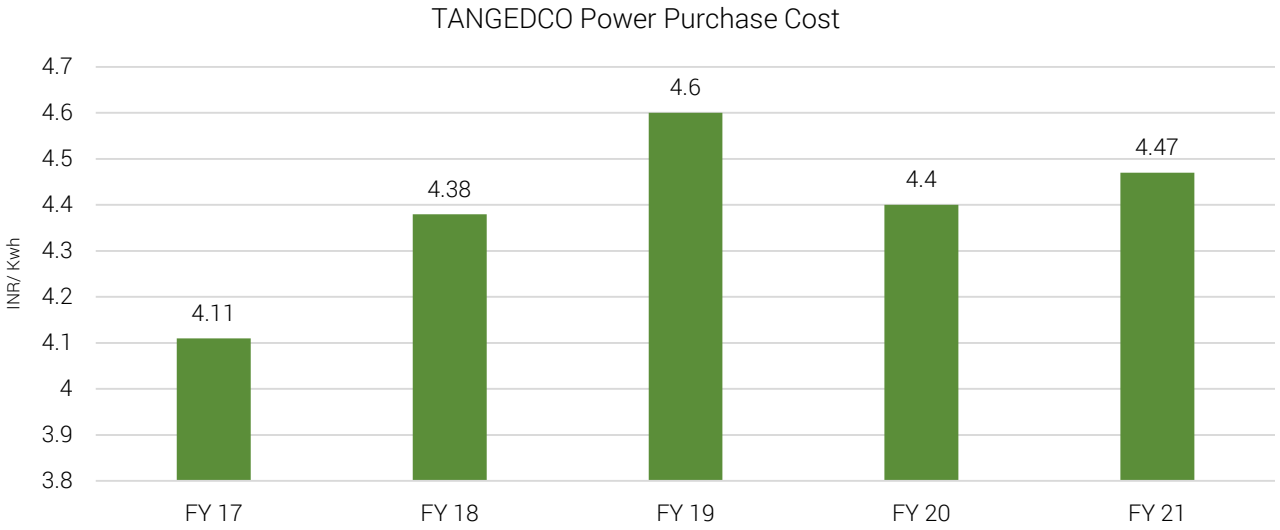
SECI awarded its first hybrid tender in 2020. Since then, a total capacity of ~5 GW of hybrid projects has been awarded, of which ~4 GW is under construction. Tamil Nadu was one of the first states identified with a high hybrid potential.

Hybrid systems are reliable cost-competitive solutions compared to conventional power. Figure 32 shows the tariff trends of various hybrid and RTC tenders.

Procuring RTC power can improve TANGEDCO financials. The average RTC tariff is INR 3/kWh (USD 0.04/kWh). Observing the Power Purchase Cost trend of TANGEDCO (Figure 33), the difference in tariff between RTC and average power purchase cost is INR1.4/kWh (USD 0.017/ kWh). Moreover,

47 CEA – Quarterly Report on under construction Renewable Energy Projects – Jun 2022, details available at https://cea.nic.in/wp-content/uploads/rpm/2022/11/Report_on_Under_Construction_Renewable_Energy_projects_June_2022.pdf

Figure 33: TANGEDCO power purchase cost



Source: TNERC Tariff Order

it is observed that the marginal power purchased in Merit Order is approximately INR 10/kWh (USD 0.13/kWh) during peak hours, which allows RTC power to save up to INR 7/kWh (USD 0.09/kWh).

Therefore, it is suggested that the state could promote more hybrid/dispatchable RE tenders that can lower the APPC of TANGEDCO. This minimizes the cross-subsidy between the consumer categories, resulting in lower C&I tariffs thereby promoting more investments in the state.

Thus, on account of both cost competitiveness and grid stability, choosing hybrid installations make a strong case for Tamil Nadu and it should consider rolling out a hybrid policy. The state can draw parallels from Rajasthan, Karnataka, and Gujrat, which have a state hybrid policy (Box 8).

Hybrid Policy: A case of Rajasthan

Rajasthan in its state policy has identified a target of adding 3.5 GW of capacity under hybrid policy. It has set detailed targets and outlined the incentives and timelines for hybridization of projects.

Some of the incentives provided are as follows:

- Banking charges adjusted in kind at 10%, permitted for captive consumption and third-party sale investment.
- Subsidy of 75% of state tax due and deposited for 7 years.
- 100% electricity duty exemption for 7 years.
- 100% conversion charges benefits given in stages as notified by the state.
- Water Resource Department, Government of Rajasthan will allocate the required quantity of water for cleaning or auxiliary consumption of the plant, subject to the availability of water in the nearest available source.

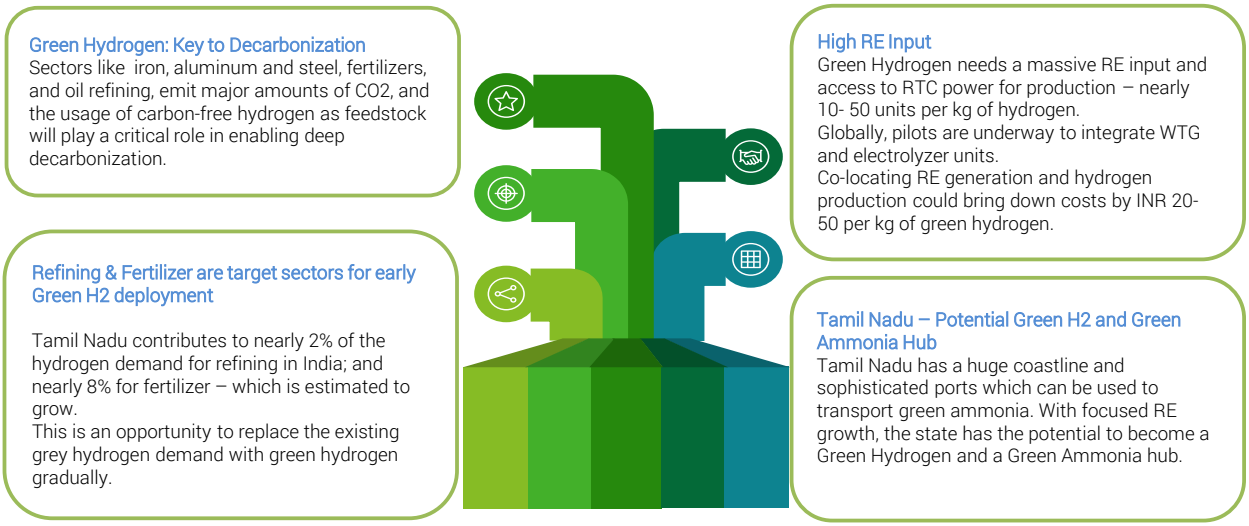
TRANSITION IN HARD TO ABATE SECTOR

Tamil Nadu is home to some of the hard-to-abate sector industries. These are majorly Petroleum and Refiningand Fertilizer industries. The state has the potential to replace 25% of its grey hydrogen demand with green hydrogen by 2030. The availability of RTC power will be a major enabler in meeting this demand.

Substantial electricity input, equalling nearly 50 units per kg, is required to produce green hydrogen. As per the 20th EPS report, India's hydrogen demand is projected to be 10 MT by 2030. Considering Tamil Nadu contributes roughly 10% of India's hydrogen demand, it is estimated that around 5 GW of RE capacity is required to produce green hydrogen in the state. Thus, harnessing wind, especially in hybrid form, will aid in hydrogen production (Figure 34).

Many challenges exist in the development of green hydrogen, with financial viability being the biggest hurdle. Electrolysers form the major chunk of the cost component for green hydrogen production. The state has to promote green hydrogen manufacturing parks to propel the demand. The demand for green hydrogen can also be channelized by initiating green hydrogen mandates. Also, Tamil Nadu with its geographical advantage can harness the available offshore wind potential to complement the green hydrogen production, as the capacity utilization factor for offshore is higher with consistent wind speeds. Box 9 provides insight into how offshore enables green hydrogen.

Figure 34: Potential of Tamil Nadu to be green hydrogen hub



PosHYdon: Offshore powered Green Hydrogen

Iv-Offshore & Energy, a Dutch Engineering Company, has created a platform that has the capability of generating 400 kg of green hydrogen per day.

The pilot project known as 'PosHYdon' is the world's first project to validate the integration of three energy systems – offshore wind, offshore gas, and offshore hydrogen. The electricity generated by offshore wind plant is used to power the hydrogen plant, converting the seawater into demineralized water and then into green hydrogen via electrolysis.

The project also serves a lever for grid balancing, by preventing the grid overload due to wind offshore generation and channelling it for green hydrogen production.

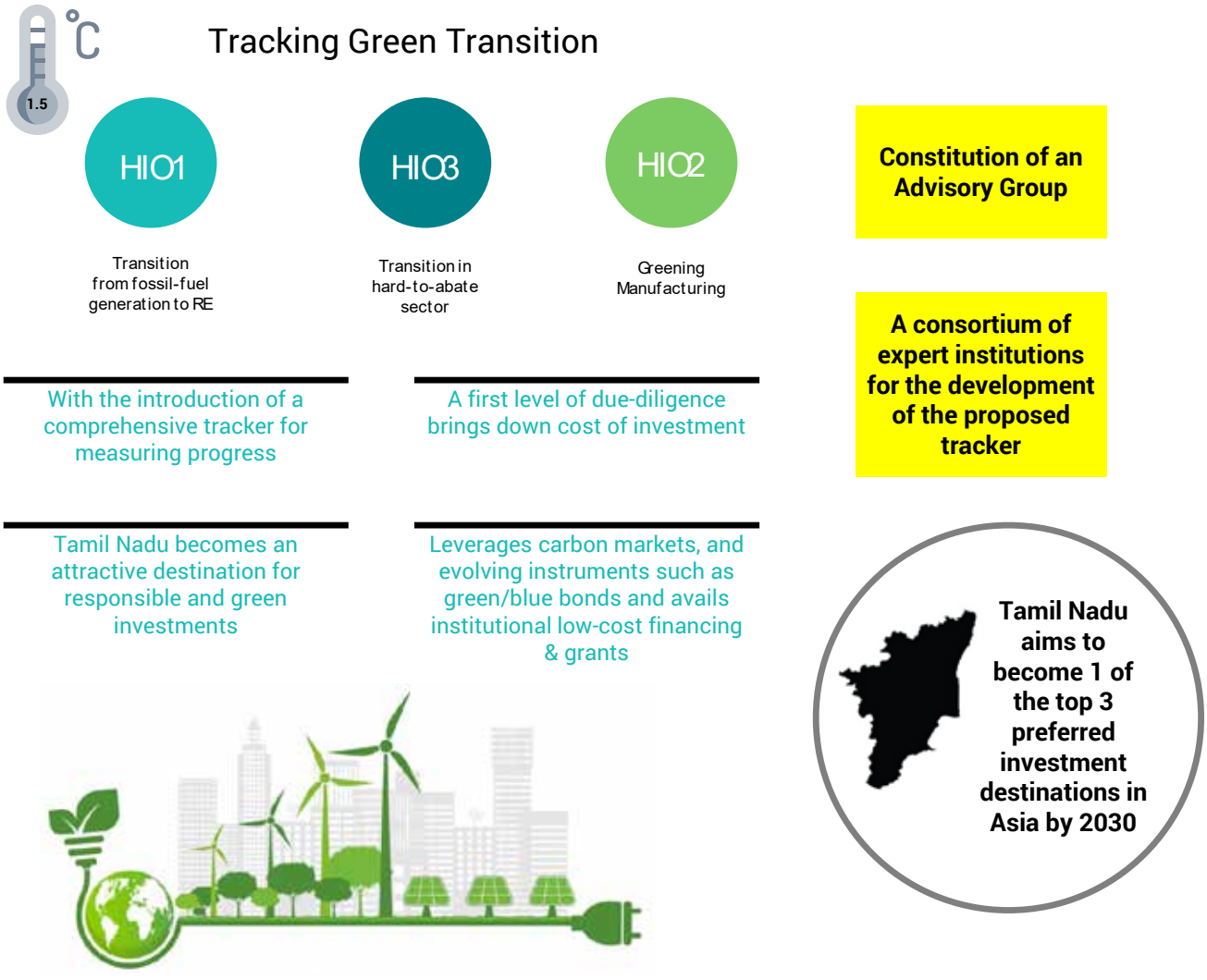
The Dutch government has provided the DEI+ subsidy for the development and is confident of the success and scalability of the project.

Source: iv-groep, Netherland, details available at https://iv-groep.nl/en/pressrelease_poshydon

GREEN TRANSITION TRACKER FOR ATTRACTING NEW AGE FINANCE

There is a growing appetite among financial institutions including multilateral development banks (MDBs) for investments that are linked to social, environmental, and climate goals. It is recommended that an industry-wide green transition tracker and dashboard may be designed and rolled out by the state. The tracker can help in the systematic tracking of emission mitigations, which can be translated to carbon credits and harnessed in the carbon market. The robust tracker may also bring down the cost of financing due to the reduced need for investor due diligence. Further, it may provide a clearer picture of entities' net-zero targets and their compliance, hence reflecting their sustainability standards. This will help in attracting instruments such as Green and Blue Bonds, or ESG funds as investors are proactively embracing socially responsible investing opportunities (Figure 35).

Figure 35: Attracting new age financing

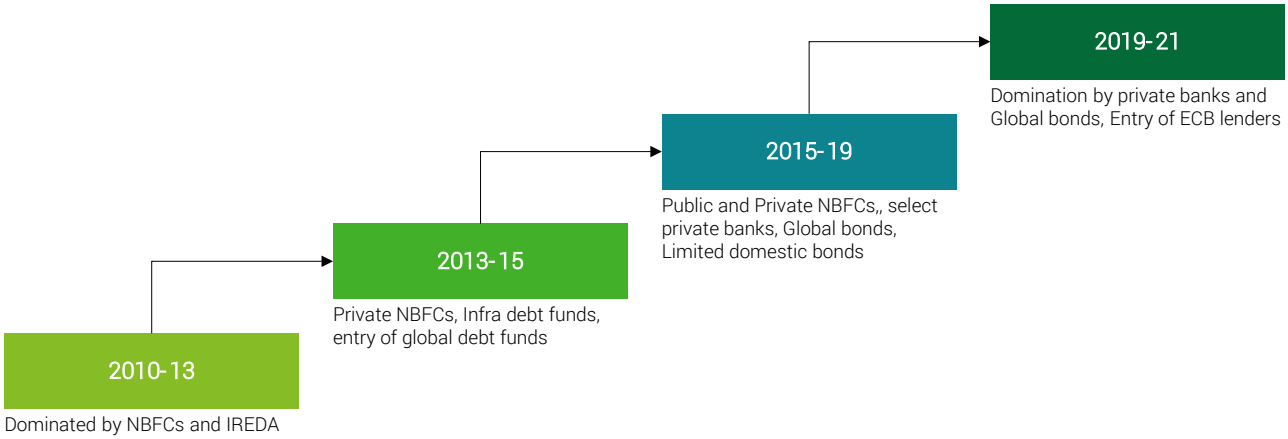


Transmission Infrastructure

With the rising RE penetration, the integration of RE resources with conventional sources is being given special attention. To cater to the demand, more robust infrastructure needs to be developed, which can withhold the intermittency and thereby increase grid security. As of November 2022, Tamil Nadu has achieved a milestone of consistently evacuating 120.25 MU wind energy for over six days. This was achieved through the complete discontinuation of wind power curtailment and instead selling the excess wind power to the power exchanges. It is expected that there will be more absorption of wind power in the grid going forward.

Under the Green Energy Corridor Phase 2 project, MNRE plans to build extra high-capacity substations and transmission lines in Tamil Nadu to evacuate RE. The project will entail the construction of three 400- kV substations at Tirunelveli's Samugarengapuram and three 23-kV substations in Tiruppur's Poolavadi, Kanyakumari's Muppandal, and Coimbatore's Kongalnagaram. The estimated total cost of the green energy corridor Phase 2 project is ~INR 7.2 billion (USD 0.09 billion). Of the total project cost, 33% will be in the form of a central government grant. TANGEDCO will be able to manage an additional 4000 MW of green energy after the project is completed.[49]

Figure 36: Financing trends in RE



Effective development of the Green Energy Corridor has proved vital in addressing the connectivity and evacuation constraints both at inter-state and intra-state transmission levels. The first phase of this project aimed at constructing 1068 ckm of transmission lines and 2250 MVA substations in Tamil Nadu. As of 2021, 1058 ckm of transmission lines have been constructed and 1850 MVA substations charged. The Phase 1 cost was nearly INR 20.49 billion, which was funded by a grant from the MNRE and borrowings from funding agencies (the funding mechanism consisted of 40% grant from the Central Government, 20% from the state equity, and the rest 40% loan from KfW Development Bank).[48]

Financing Ecosystem

The bulk of financing in wind energy has been from the local finance sector. Most of the finance in this industry is provided by low-interest loans, debt funds, cash credits, equity funding, green bonds, and so on.

According to the Institute for Energy Economics and Financial Analysis (IEEFA) analysis, investments in RE generation in India totalled USD 6.4 billion in FY20/21. From April to July 2021, the impetus expanded substantially, with investments totalling USD 6.6 billion.

Equity investment in the sector is provided by

48 MNRE – Green Energy Corridors, details available at https://mnre.gov.in/green-energy-corridor

49 Press Information Bureau, News reports, details available at https://mnre.gov.in/green-energy-corridor

a wide spectrum of domestic and international investors, including family businesses, developers, institutional investors, and private equity and venture capital.

In terms of debt, wind projects continue to obtain long-term debt covering almost 75–80 % of project expenses. Increased debt component results in higher returns and reduced tariffs. Debt obligations are paid through project cash flows and secured by loan repayment covenants, providing more certainty in debt repayment. Interest rates for wind project loans from nonbanking financial organizations (NBFCs) have fallen by about 100 basis points to a range of 9.25–10%, with even lower debt available from banks at 8.75–9.50%. Bilateral and multilateral assistance with currency hedging mechanisms can be easily obtained to finance wind projects. As of April 2017, India, one of the top ten global green bond issuers, had issued USD 3.2 billion in bonds. Figure 36 shows the evolution of financing trends in India.

According to the responses gathered from various stakeholders, domestic funding is sufficient to meet the investment required for wind capacity expansion. Several domestic financial institutions including SBI, IREDA, Yes Bank, Indus Bank, etc. have prioritized and are interested in financing RE investment. However, a few have expressed concerns about future investments in the state due to the underdeveloped bond market, an increase in NPAs, and TANGEDCO's weak financial health.

LABOUR AND SKILLS

Necessary skill sets have been obtained by the workforce in the wind sector through various training programmes imparted by institutes and industries across the nation, which in turn is facilitating Just Transition. Government initiatives and international collaboration are also playing an important role in creating the required talent pool.

In India, 81 GW of renewable energy capacity addition has resulted in generating approximately 111,400 jobs throughout multiple renewable project phases, such as business development, design, building and commissioning, operation and maintenance as of August 2021. Of these, 77% of workers are in the solar industry (85,900), representing 42 GW of installed capacity and the balance (25,000) are in the wind sector (39 GW capacity).[50]

The skills needed at various phases (Figure 37) may be obtained through technical diplomas or vocational training and do not require any advanced technical training, except for the construction and commissioning phases that require a highly competent team. The availability of a trained workforce is enabled by current training programmes available, which satisfy the industrial demands. Given the sector's maturity in Tamil Nadu, corporations have also built in-house training programmes that offer most of the skilling for each phase of deployment. Figure 38 highlights a few of the institutes that offer skill development training in the wind sector (refer to Annexure V).

Figure 37: Skills required at various phases of wind project

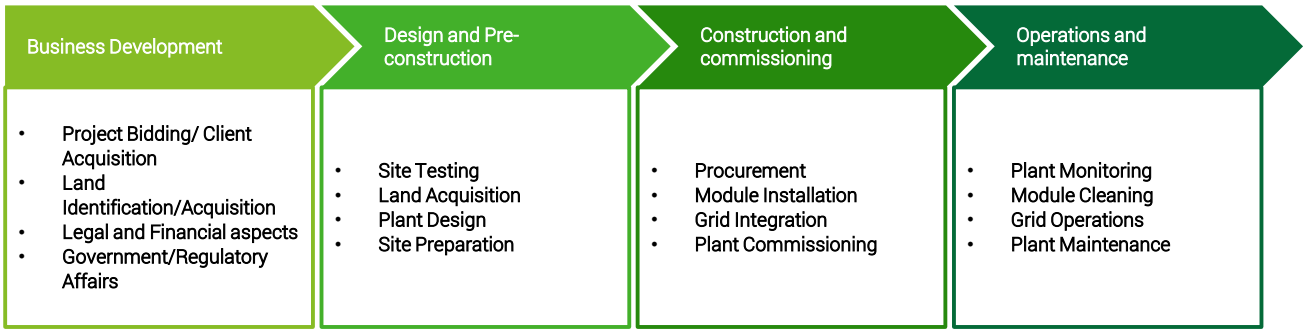
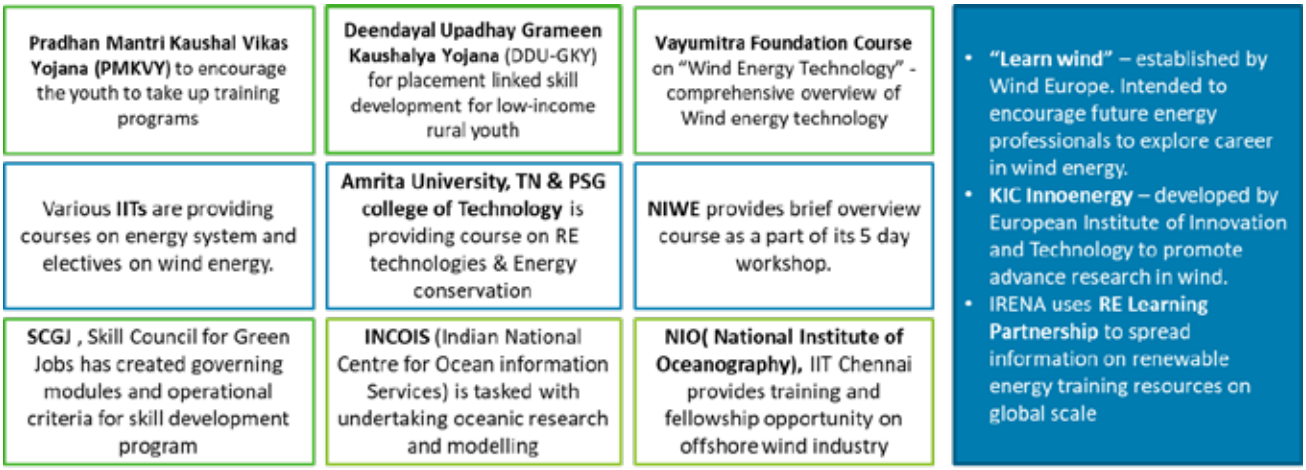


Figure 38: Skill development institutes/trainings/initiatives globally and in India



50 Centre for Environment Education- National Research Development Corporation, details available at https://www.nrdc.org/sites/default/files/indias-clean-energy-workforce-450-gw-target-report.pdf

Tamil Nadu needs to put more emphasis on R&D, an area in which it currently lags. Government initiatives and market investment should be increased to enable consistent RE growth and job creation in the clean energy sector. In order to facilitate Just Transition, an appropriate framework and methodology must be devised based on the current technical and scientific capabilities. International collaboration with South-East Asian nations may be used to share expertise and promote cross-functional trainings.

Key Recommendations[51]

Immediate Action Points

- The state can consider rolling out a hybrid policy while continuing to promote vanilla wind projects as well. Hence, state tenders with guaranteed time-bound payment security mechanisms must be prioritized.
- The state should try to harness the repowering potential and surveys should be conducted to identify the true repowering potential of the sites.
- For offshore wind, the state must harness strategic partnerships for capacity building and also leverage low-cost financing and development assistance for setting-up risk mitigation and infrastructure upgradation funds
- The state can encourage the creation of manufacturing parks to drive economies of scale and make wind more competitive.
- Other incentives like subsidies, import duty concessions to incentivize domestic manufacturing and low-cost financing can also be considered for manufacturers.
- A green energy marketplace can be introduced as part of the forthcoming edition of the investor summit.
- The state can consider acceptance of new investment DPRs that already have net-zero trajectory defined (phased introduction).

Medium-Term Action Points

- The state can explore nearshore potential.
- The state may leverage the renewable energy basket available in a specific geography to develop RTC and Peak Power clusters and design resultant tariffs which appreciate the business value delivered by the cluster.
- Offshore wind manufacturing must be explored to facilitate an attractive business case of investment in port upgradation infrastructure.
- The state can consider introducing an industry-wide green transition tracker to facilitate responsible investments and harness carbon markets in the state. The state can constitute a High-Level Working Group to guide the work on Tracker.

Legend:

- Energy Department
- Industry Department
- Environment & Industry Department

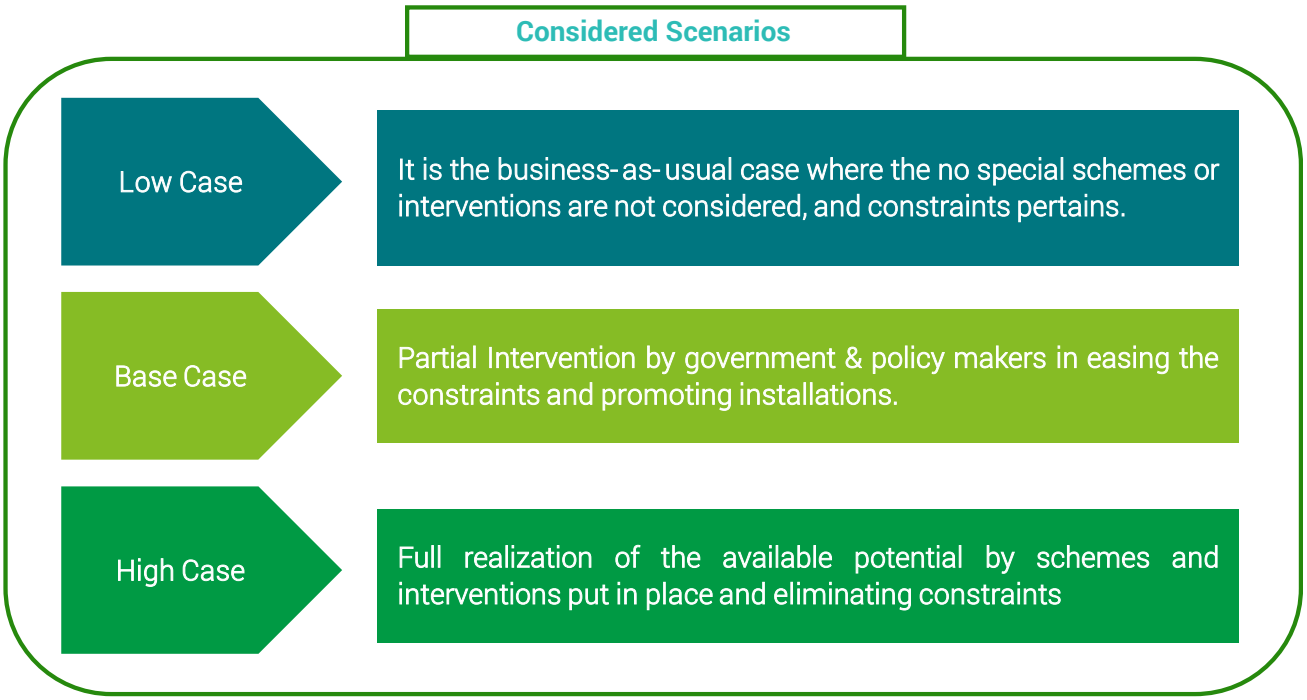
51 Stakeholders responsible for the actions are mentioned in the legend.

ANNEXURES

Annexure I: Scenario Analysis

Three different scenarios are built based on the success factors of the interventions, namely Low/Business-as-usual case, Base case, and High case in estimating the capacity additions, investment requirements, and jobs multiplier.

Figure 39: Scenario analysis for wind generation



To achieve the set target of 140 GW by 2030, an annual capacity addition of 12.5 GW is to be achieved. Tamil Nadu, being the front-runner in wind installations, has effectively contributed to 24.5% of the total installed capacity. In terms of potential, it has approximately 10% of the overall wind potential in India (at 120 m hub). Though historically Tamil Nadu has done well in terms of capacity additions, in recent times, the growth has become stagnant. Policy and regulatory interventions are needed to support wind installations. With this background, different cases were developed to estimate capacity additions.

The low case is built based on the Business-as-usual case and it is assumed that low capacities additions would continue. It is also assumed that there would be no special schemes or interventions put in place and constraints not eased to ramp the wind capacity. Under this scenario, it is estimated that by 2030 an additional 4 GW would be added by Tamil Nadu resulting in a total capacity of 14 GW.

The base case is built based on the capacity addition trends both at the state level and at the national level. It is assumed that there would be partial policy interventions by easing a few of the constraints that are restricting the capacity additions. Under this scenario, it is estimated that by 2030 an additional 13 GW would be added by Tamil Nadu resulting in a total capacity of 23 GW.

Figure 40: Approach for estimating wind capacity addition

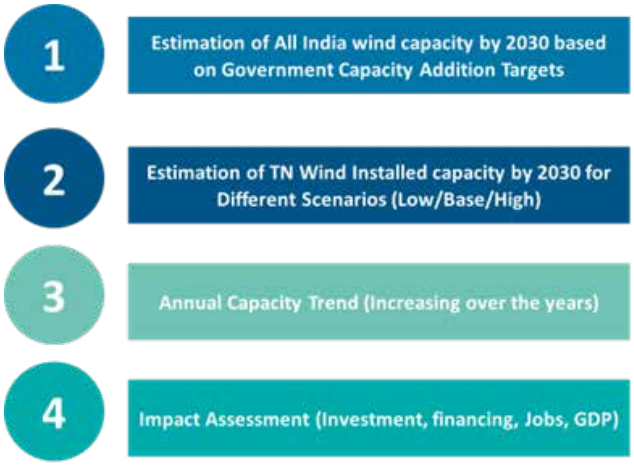


Figure 41: Impact analysis of base case estimationaddition

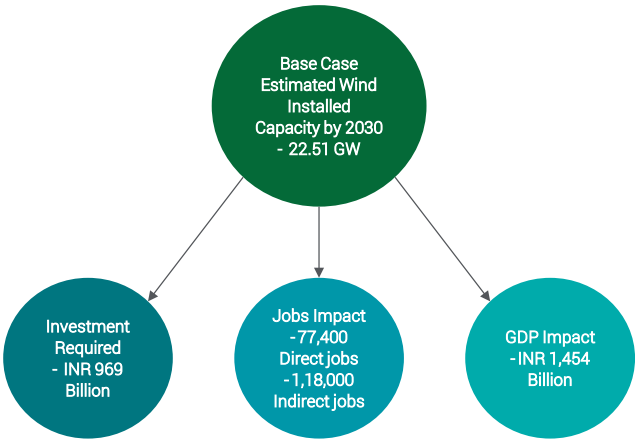


Figure 42: Estimated wind capacity addition

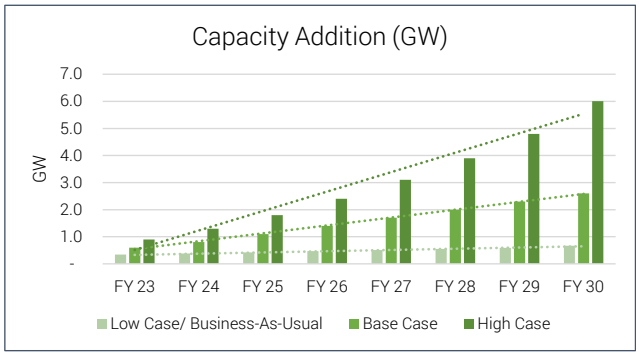
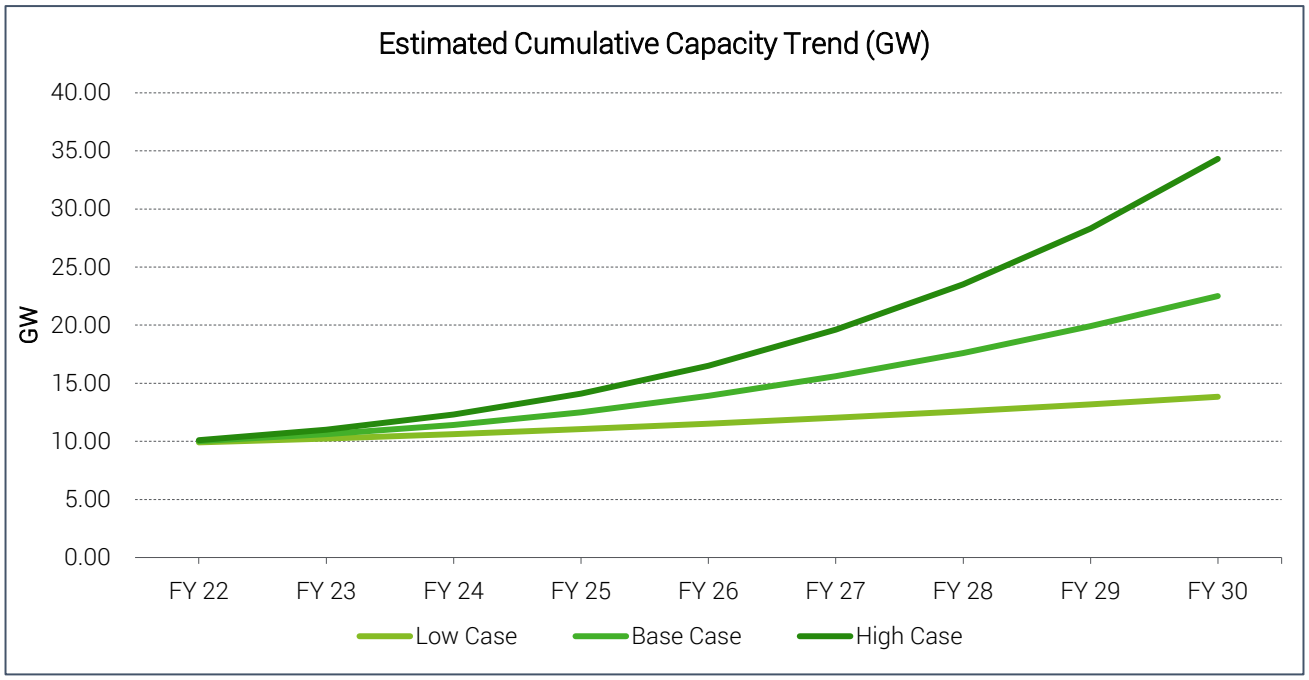


Figure 43: Cumulative wind capacity addition



The high case is built based on the assumption that the state fully utilizes the untapped potential with various policy interventions and by eliminating the constraints preventing capacity additions. Under this scenario, it is estimated that by 2030 an additional 25 GW would be added by Tamil Nadu, which will result in a total capacity of 34 GW.

Following are the estimated capacity addition trends in the three scenarios:

Wind Capacity Addition Mix

With the increasing need for sustainable dispatchable power, significant capacity addition is expected from the hybrid segment rather than plain vanilla projects. With the growing C&I demand and need for RE power, a portion of capacity addition is expected from C&I consumers. Offshore, however, is not expected to have a significant impact till 2030 but will play a major role after that.

Figure 44: Split between capacity added in base case

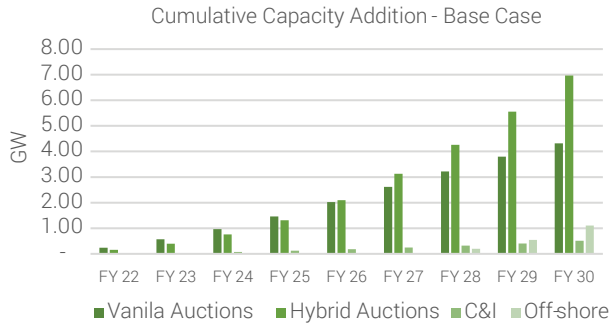


Figure 45: Split between capacity added in high case

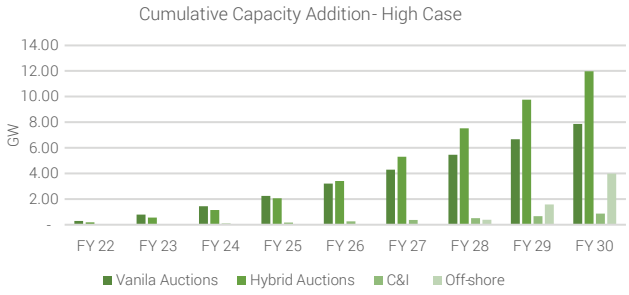
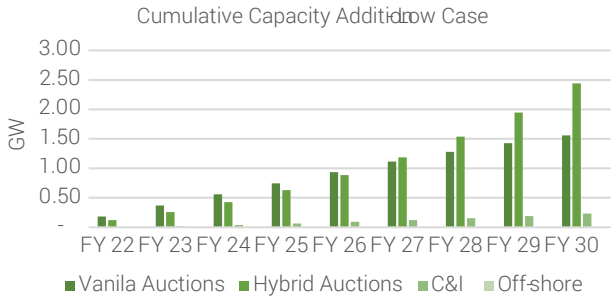


Figure 46: Split between capacity added in low case



ANNEXURE II

CAPTIVE CAPACITY AND THE SHARE OF RENEWABLE ENERGY IN TAMIL NADU

S. No.	Industry Type	No. of Industries	Installed Capacity (MW)	RE (Solar and Wind) Capacity as % of Total Capacity (respective industry)	Total Energy Consumption (MUs)	% of Consumption from Captive
1	Textile	370	1288.0	49.3%	4760.9	20.3%
2	Iron and Steel	85	546.9	15.7%	1828.7	39.9%
3	Automobiles	63	258.7	11.5%	1797.6	13.4%
4	Chemical	46	402.9	6.9%	1455.6	42.6%
5	Paper	23	271.6	1.2%	1343.6	84.0%
6	Cement	27	378.6	1.4%	1153.0	71.4%
7	Rubber	18	114.7	16.1%	1029.5	4.7%
8	Mineral Oil and Petroleum	7	170.8	0.0%	810.2	93.5%
9	Light Engineering	68	208.8	17.8%	717.8	19.7%
10	Sugar	42	528.0	0.0%	382.0	86.3%
11	Plastic	10	73.8	8.2%	348.6	75.0%
12	Fertilizer	9	45.3	0.0%	286.6	12.5%
13	Electrical Engineering	34	1291.7	8.8%	221.2	25.5%
14	Food Products	33	113.3	8.7%	216.0	32.1%
15	Heavy Engineering	4	28.5	44.2%	110.4	12.0%
16	Non-Ferrous	6	16.2	0.0%	51.6	4.3%
17	Aluminium	7	11.1	47.9%	28.4	4.6%
18	Mining and Quarrying	2	16.7	0.0%	17.9	30.7%
19	Misc.	146	881.6	9.4%	1689.2	13.9%
Total Tamil Nadu		**1000**	**6647.4**	**16.1%**	**18248.7**	**35.4%**

Source: CEA CPP list 2018-19

ANNEXURE III

NET-ZERO STRATEGIES ADOPTED BY MAJOR C&I PLAYERS

Sector	Company	Sustainability Target	Expansion plans
Petroleum, Oil and Gas	Shell India	RE100 target by 2060	Global shifting from oil and gas to solar and wind
	Chennai Petroleum Corpn. Ltd.	Energy conservation schemes for fuel savings	Refinery expansion undertaken. Future project comprises a new refinery setup in the state
	Sai Regency Power Corporation (P) Ltd		
Metals and Collieries	Vedanta Group	Net zero by 2050	Investments in BALCO's smelter capacity expansion
Textiles	Vardhman Textiles	Promoting use of solar products; green energy initiatives using biogas plants	Yarn capacity expansion under progress
Iron and Steel	JSW Steel Ltd.		
Paper	ITC Limited, (Paper Boards & Speciality Papers Div.)	2030 goals include reduction in specific energy by 30% and specific GHG by 50% along with increasing renewable energy share to 50% and sourcing 100% of purchased electricity from renewables.	
	Tamil Nadu Newsprint & Papers Ltd.,	Minimizing waste generation through solid waste to high grade cement plant, more captive power generation	Mill capacity expansion plan under implementation

Source: Secondary Research, Deloitte Analysis

ANNEXURE IV:

SKILL AREAS FOR THE SUCCESS OF WIND INDUSTRY

Skill areas identified as being important to the future success of the offshore wind industry are as follows:

Skill Area	Details
Asset management	• Environmental asset management • Compliance and governance
Project management	• Handling high-value contracts
Leadership	• Managing and organizing teams • Upskilling workforce
Engineers	• Mechanical, electrical, and control and instrumentation and high voltage • IT and associated network skills
Scientists	• Environmental and physical sciences • Marine biology, geophysics, physics, environmental monitoring, oceanography.
Technicians	• Blade and turbine maintenance • High voltage technicians
Health and Safety	• Advanced first aid and rescue • Safety rules and regulations
Soft skills	• Teamwork, problem-solving, etc.
Training and technical standards	• Standardized training • Re-skilling personnel who are changing sectors
Vessels and logistics solutions	• Reducing direct costs, increasing access, and mitigating health and safety (H&S) and environmental risks • Access systems, enhanced marine co-ordination software, personnel tracking systems, and next-generation workboats
Turbine technology	• Development of innovative materials and components for next generation of larger capacity, higher reliability turbines
Artificial intelligence and robotics	• Remote surveillance and inspection of offshore assets • Drones and remote operated vehicles (ROVs)
Data analytics	• Harvest asset performance data and use that to optimize system performance, monitor and plan the replacement of failing equipment, and improve the general management of assets
Foundation, subsea cables, and transmission	• Optimize transmission systems • Cabling concepts and installation techniques • Fixed and floating concepts for low-cost foundations

Source: Secondary Research, Deloitte Analysis

ANNEXURE V

GOVERNMENT INITIATIVES TOWARDS PROMOTING GREEN POWER

ISTS Charge waive offs on RE & storage projects *(MOP Order 23rd November 2021)*	• ISTS charge **waive off on RE Projects including Wind, Solar Projects, PSS and BESS extended till June 2025** for projects commissioned up to June 2025. • The projects could be set up for **captive use or sold to an entity under competitive bidding***, power exchanges and bilateral arrangements. • Gradual increase in ISTS charges for projects commissioned after June 2025, to reach applicability of **100% ISTS charge by July 2028**
Transmisison planning, & GNA	• LTA to be transitioned as GNA. Introduction of GNA regulation as per which IPPs are not required to specify the target beneficiaries while seeking GNA .
Bulk consumers connecting to ISTS grid *(CERC Order dated Jan 2022, facilitating RIL to seek connectivity))*	• Regulator is easing out the process for the Bulk consumers to connect to the ISTS Grid. • CERC has given liberty to the **Bulk consumer to approach any licensee to construct Dedicated transmission** line to connect to ISTS Grid.
Green Open Access prioritized- OA 2022	• Green Energy OA Rules 2022 has proposed to promote RE Open Access, wherein, **OA for non-fossil fuel sources would be given priority over open access from fossil fuel.** • Green Energy OA Rules 2022 has proposed **restricted increase in the CSS for Green OA consumer. AS not applicable** for Green OA consumer.
RE power achieved grid parity	• RE power is available to consumer at a much affordable price vis-à-vis grid tariff. Government has taken appropriate measures to enable RE power achieve grid parity.

** CERC in its Draft amendment to transmission pricing regulation has proposed waiver off GNA charges for RE projects getting commissioned by 30th June 2025*

Source: Secondary Research, Deloitte Analysis

ANNEXURE VI

RATIONALE FOR HYDROGEN DEMAND ESTIMATION

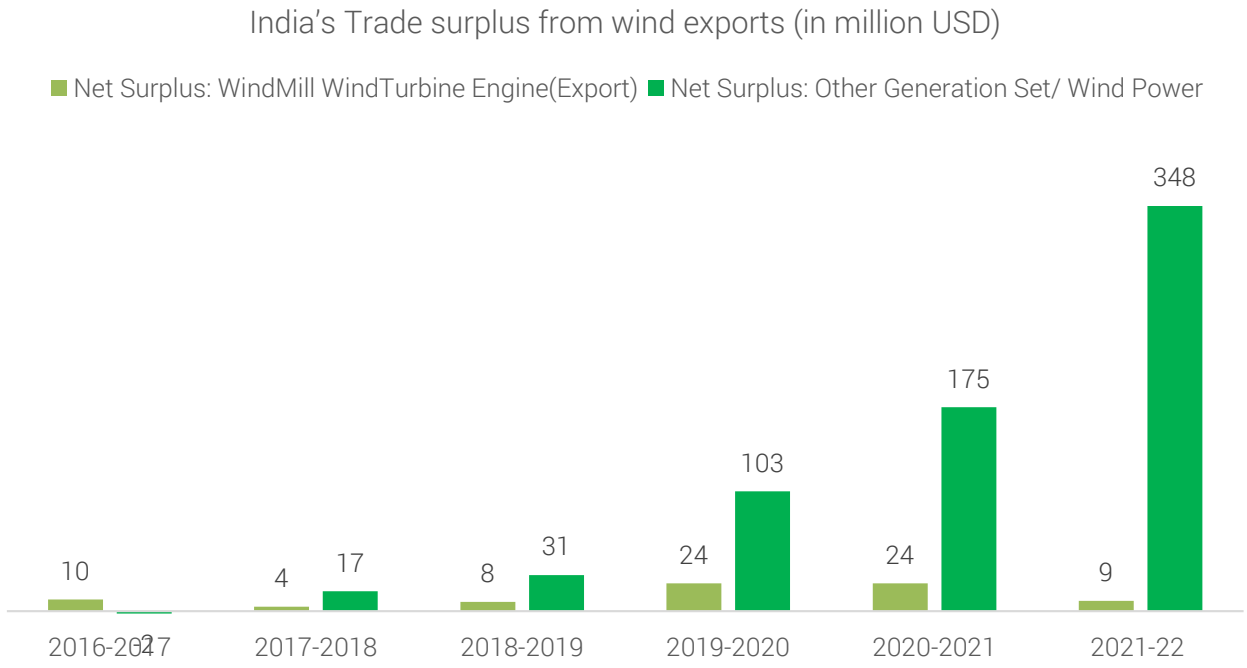
According to the National Hydrogen Mission,[52] 2022, the demand for hydrogen is expected to see a five-fold jump to 28 MT by 2050. Considering the current demand of 6 MT (FY22) and future demand of 28 MT (FY50), a CAGR of 5.27% is observed, for the demand for hydrogen. Considering the same CAGR, it is estimated that the demand for hydrogen would be around 10 MT by 2030.

Currently, Tamil Nadu has a 10% share in the overall hydrogen demand in the country. Assuming that the same share continues in the future years also, and that 25% of the hydrogen requirement is catered by green hydrogen, the demand for green hydrogen in the state of Tamil Nadu is expected to be 0.25 MT by 2030. Considering the electricity requirement of 50 kWh per kg of hydrogen generation, and a RE CUF of 28% (assuming a mix of solar and wind sources), around 5 GW of RE capacity is to be installed to produce green hydrogen in the state.

52 MNRE, National Hydrogen Mission, details available at https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/mar/doc202232127201.pdf

ANNEXURE VII

INDIA'S TRADE SURPLUS FROM WIND EXPORTS



Source: GWEC Market Intellegence.

Why wind energy is the key?

Renewable Energy (RE), including wind energy, ramp-up is required to **transition** from thermal/fossil fuel to non-fossil fuel

To ensure **energy security** while executing a low carbon emission growth strategy

Wind round-the-clock (RTC) projects to **ramp up capacity utilization factor (CUF)** of utility-scale renewable power projects

To harness **benefits:** socio-economic, environmental, and climate benefits and to be able to **attract investments**

Source: Energy Statistics 2022; WRI 2022 and GWEC Analysis

Tamil Nadu has an existing wind ecosystem comprising power generators as well as manufacturers

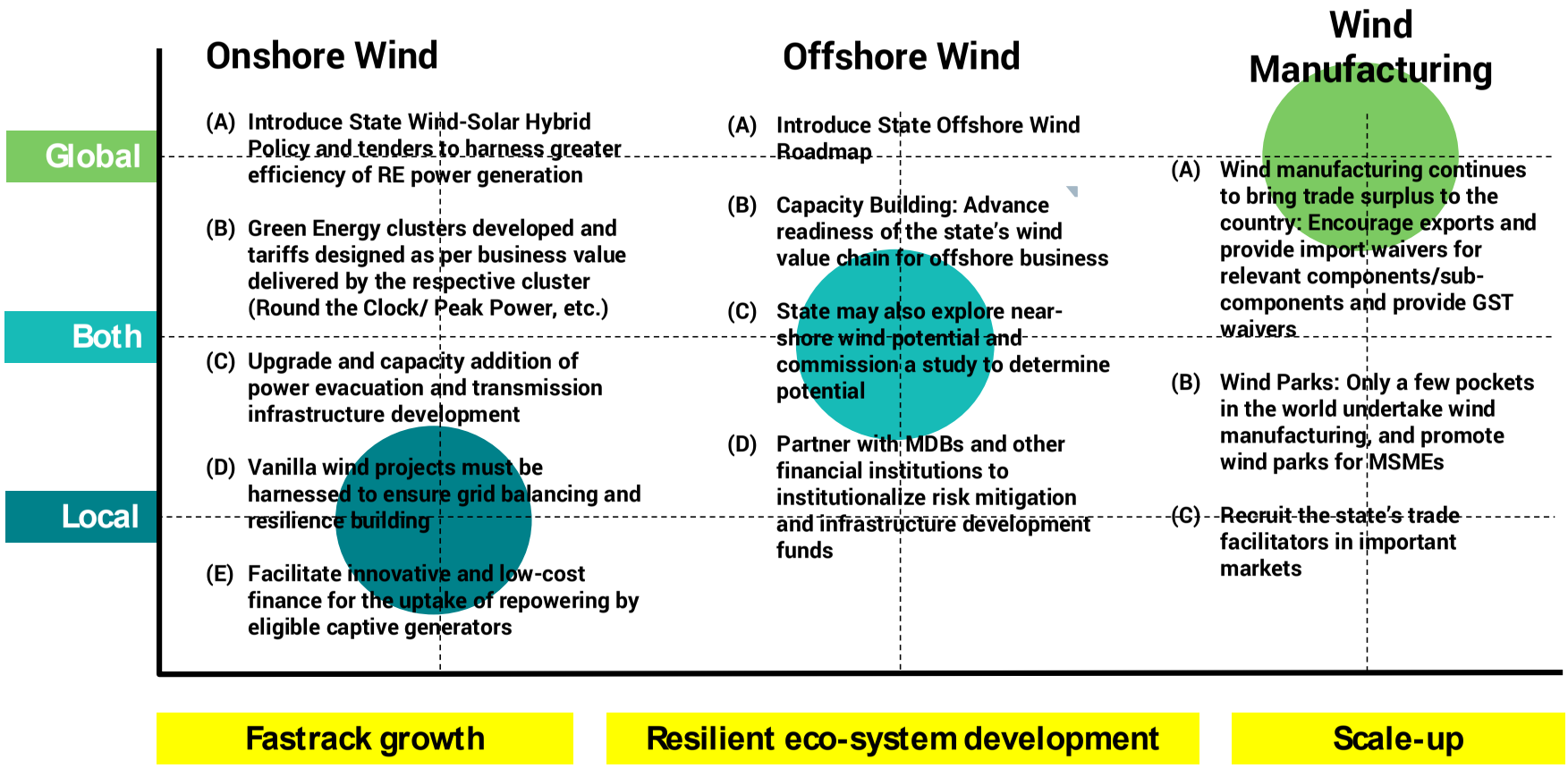
68.8 GW
wind potential
+
35 GW
Offshore wind
= ~84%
of the state's RE potential (doesn't include large hydro)

9.7 GW
installed wind capacity

17.7 GW
solar potential

5 GW
solar installed capacity

Unlocking Wind Potential



Fastrack growth | **Resilient eco-system development** | **Scale-up**

Majorly less than 350 MW annual onshore capacity addition during the last five years	5 GW of annual onshore wind capacity addition is a minimum requirement for the sustenance of wind manufacturing	India lacks a first-hand experience in offshore wind	Only 8 WTG manufacturers active in India	~ 80% of WTGs manufacturers now inactive in the country during last few year

GWEC INDIA

GWEC India – a single advocacy and research body representing the entire value chain of India's wind industry, from IPPs to OEMs to end-users to service-providers – will work closely with central and state governments to improve the enabling environment for sector growth, creating the conditions for inward investment in the tens of billions of dollars. It will give government of all levels an efficient and transparent channel to consult with industry, and connect policymakers and public expectations with market reality.

India needs a transparent, neutral, cohesive and credible industry group that represents the interests of all wind sector stakeholders, working according to the best international practices of advocacy. GWEC India will convene the many voices across the private sector to speak as one on key issues (see Agenda below), highlighting the most critical priorities and pressing recommendations for the wind industry. This single platform providing unified messages to policymakers will be far more powerful than disparate interests nudging public officials in a scattershot approach.

India's federal government structure lends itself to large differences in regulatory environments, customer preferences, development timelines and local/state priorities. GWEC India will consolidate the wind industry around a common strategy which focuses resources on those high-potential markets where it can build volume and scale expeditiously. Only through greater collaboration and engagement will the sector be able to clear its present-day roadblocks and come close to delivering on its potential by 2022, 2030 and beyond.

GWEC INDIA
GLOBAL WIND ENERGY COUNCIL

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