Adopting Green Ammonia in Tamil Nadu's Fertiliser Sector: Policy Routes via Green Hydrogen

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Summary

Farmer spreading fertilizer in a cotton field

This policy brief outlines strategies for Tamil Nadu's transition to green hydrogen and green ammonia, employing a mixed-method approach that combines qualitative insights from stakeholder engagement with quantitative cost analysis modelling. To enhance and optimise green hydrogen energy infrastructure in Tamil Nadu, particularly in the fertiliser sector, we suggest that the state government:

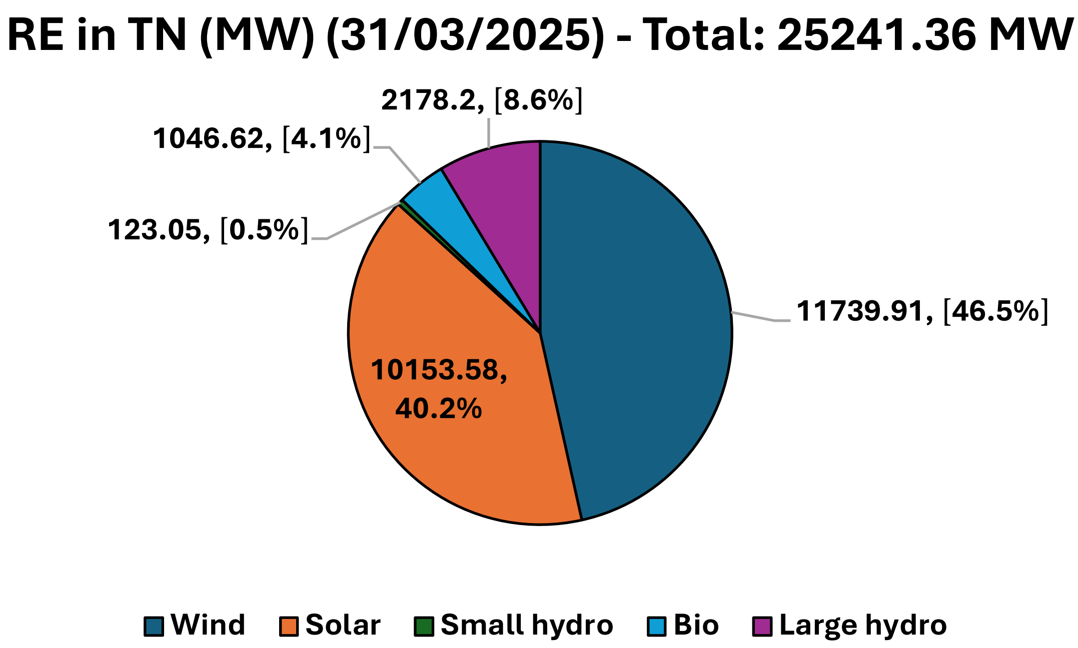
- **Establish Viability Gap Funding (VGF) and Production-Linked Incentives (PLI)** to support early-stage green hydrogen and domestic electrolyser manufacturing.
- **Mandate green ammonia blending** (20% by 2030) to promote green urea production and subsidise its adoption.
- **Invest significantly in skill development programmes** to build a workforce ready for green hydrogen and ammonia technologies.
- **Expand funding for research and design (R&D)** in advanced electrolyser design, renewable energy integration, and hydrogen infrastructure to achieve cost parity with grey hydrogen.
- **Facilitate access to innovative financing mechanisms** such as green bonds and carbon credits to lower financial barriers.

1. Introduction

India launched the National Green Hydrogen Mission (NGHM) in January 2023, aiming for zero emissions by 2070 and intending to establish itself as a global centre for green hydrogen production and export [1]. With its significant renewable energy resources, [2] industrial base, and strategic coastal location, Tamil Nadu is uniquely positioned to lead India's transition to a green hydrogen economy (**Figure 1**).

This document outlines policy actions for Tamil Nadu to transition to green hydrogen and green ammonia, particularly in the fertiliser industry, using stakeholder input and cost analysis. The sector chosen for the study is the fertiliser sector, primarily because agriculture serves as the main livelihood of the state and contributes to 13% of the state's GDP. Accelerating this transition through targeted policies and incentives will help achieve India's 2070 targets.

Figure 1: *Renewable Energy of Tamil Nadu (TN) as of March 2025: Data Sourced from [2].* Note: RE = Renewable Energy



The fertiliser industry in India relies on imported natural gas. Decarbonising the fertiliser sector by embracing green ammonia, particularly urea manufacturing, is vital for ensuring food security and reducing reliance on natural gas imports while helping India achieve net-zero emissions in the agricultural sector [3,4]. Recent investment commitments (**Table 1**) in green hydrogen infrastructure in the Thoothukudi district of Tamil Nadu, at ₹53,638 crores, are projected to create 4,800 jobs, underscoring Tamil Nadu's potential. To achieve successful implementation, it is essential to have supportive state-level policies, infrastructure, and clear regulations.

Table 1: *Green Hydrogen Investments in Tamil Nadu*

	Group	Location	Investment & Job Creation
Hydrogen Valley Innovation Hub [5]	Indian Institute of Technology Madras (IIT Madras), Hyundai Motor India Limited (HMIL), and Guidance Tamil Nadu	Chennai	**₹180 crores**, with HMIL investing **₹100 crores** for its capital expenditure requirements.
Global Investors Meet [6]	Reliance Industries Limited	Tamil Nadu	Investment in renewable energy and green hydrogen projects in the state.
	Tata Power	Tirunelveli (Solar Plant)	Total investment of **₹70,800 crores**, creating **3,800 jobs**
	Sembcorp	Thoothukudi	Proposed investment of **₹36,238 crores**, creating employment for over **1,500 people**.
	Leap Green Energy Pvt. Ltd.	Thoothukudi	Investment of **₹17,400 crores**, creating over **3,300 jobs**.
	Gentari (Petronas), Greenko's AM Green	Tamil Nadu	Two renewable energy projects are planned: one with Greenko's AM Green venture for potential European buyers and the other to supply renewable ammonia to Petronas' refinery.
	ACME	Tamil Nadu	Proposed projects with buyers in South Korea and Japan that could produce about 3 million tons per year of renewable ammonia [7].
VOC port, Thoothukudi (Tuticorin) [8,9]	Government of India	Thoothukudi	Several projects, including retrofitting existing ships to run on green hydrogen and its derivatives.

1.1. Enhancements in Tamil Nadu State Policies for a green hydrogen economy

Tamil Nadu has a solid foundation for green hydrogen integration through its policies, including the Solar Energy Policy (2019) [10], Industrial Policy (2021) [11], Energy Policy Note (2024–25) [12], and Agriculture Policy Note (2024–25) [13]. However, they lack specific measures for green hydrogen and ammonia. Enhancements are recommended to support the green hydrogen economy in meeting the state's climate and energy goals. Integrating production and electrolyser manufacturing incentives could expedite Tamil Nadu's transition to a sustainable hydrogen economy.

For example, the **Solar Energy Policy**, which aims to promote solar energy growth in the state, can be improved in the short to medium term (2025–2030) by establishing green hydrogen production zones within solar parks and incentivising the co-location of electrolysers with solar installations. The **Industrial Policy**, which currently prioritises emerging sectors, can be further developed over the medium to long term (2028–2035) to specifically support green hydrogen and electrolyser manufacturing through fiscal incentives and preferential land allocation.

Additionally, while the **Energy Policy Note** establishes sectoral targets for renewable energy, it does not require its application for green hydrogen. This policy could be strengthened in the medium term (2028–2030) by implementing renewable energy mandates for producing and utilising green hydrogen, thereby ensuring alignment with demand and aiding grid planning.

Lastly, the **Agricultural Policy Note**, which encourages sustainable methods and alternative fertilisers, can introduce blending mandates for green ammonia and provide financial and infrastructure support to fertiliser producers adopting green ammonia in their supply chains. These changes, scheduled for the medium to long term (2028–2035), would accelerate emissions reductions in the fertiliser sector while promoting the early development of the green hydrogen market.

2. Methodology

This policy brief draws on a mixed-method approach combining qualitative and quantitative insights. Twenty expert stakeholders across the power, agriculture, transport, and research sectors were surveyed to assess awareness, barriers, and readiness for green hydrogen adoption (**Table 2**). In parallel, we applied GeoH2, a geospatially optimised model specifically developed for calculating the spatial variation of the levelised cost of hydrogen (LCOH) and evaluating cost-effective green hydrogen production and distribution pathways across Tamil Nadu [14]. In addition to LCOH, calculations were extended to include LCOA (Levelised Cost of Ammonia) and LCOU (Levelised Cost of Urea) to assess downstream viability in the fertiliser sector. This dual approach enabled us to identify infrastructural gaps, assess techno-economic viability, and propose actionable policy interventions relevant to statewide adoption, particularly concerning the fertiliser sector.

Our area of interest is the Thoothukudi district, which was identified as a potential site based on the Analytical Hierarchy Process (AHP) analysis. AHP is a decision-making method that assists in resolving problems involving multiple criteria. It compares the criteria in pairs to establish a priority ranking [15]. The potential of Thoothukudi district as a Hydrogen Valley comes from high solar irradiance and consistent wind patterns along the Gulf of Mannar, which are crucial for green hydrogen production, and its coastal location. The V.O. Chidambaranar Port provides excellent connectivity for distribution and export. The existing industrial cluster, including chemical industries and thermal power plants, offers potential early adopters of hydrogen technology, ensuring stable demand for the project's viability.

Table 2: *Survey respondents by sector*

Sector	No. of Responses
Transport	1
Supply-side	1
Power	3
Agriculture	9
R&D Institutions and Think Tanks	6

3. Key Insights

3.1. Unlocking Green Hydrogen for Green Ammonia: Stakeholder Perspectives on Gaps and Readiness

The stakeholder survey, aimed at gathering comprehensive insights into public perception, knowledge gaps, and the practical challenges that might hinder the advancement of a green hydrogen ecosystem, revealed that:

1. Significant challenges for green hydrogen development include limited existing infrastructure, high upfront costs, and insufficient workforce training
2. Other barriers to green hydrogen adoption include low public awareness and technological and regulatory hurdles, particularly in electrolyser manufacturing.

3. Respondents emphasised the need for robust R&D funding and financial support, advocating for subsidies and streamlined regulations, expecting public funding via government grants and public–private collaborations.
4. Specifically, from the fertiliser sector:
   4.1. Discussions highlighted a lack of awareness about green hydrogen and ammonia.
   4.2. The industry emphasises skill development in green ammonia and sustainable fertiliser use, requiring collaboration with universities.
   4.3. However, challenges such as high costs and infrastructure issues point to a need for financial incentives and regulatory reforms to stabilise local fertiliser prices.

3.2. Cost Barriers to Green Hydrogen and Implications for Green Ammonia in the Fertiliser Sector

Tamil Nadu's annual green hydrogen demand is estimated at 100 kT, primarily for converting to ammonia in Thoothukudi. This analysis considers values based on reference studies for greenfield renewable plants aimed at producing green hydrogen, excluding the impact of the grid electricity account [16,17]. The demand centre (represented by the black star in **Figure 2**) is located at the major fertiliser plant of Southern Petrochemical Industries Corporation Ltd. in Thoothukudi (hereby referred to as SPIC).

Figure 2: *Spatial Variation of LCOH for Tamil Nadu at the base scenario. The black star represents the location of the demand centre, the black dot represents the location with the minimum LCOH, and the black '+' represents the location with the maximum LCOH.* Note: SPIC=Southern Petrochemical Industries Corporation; LCOH=Levelised Cost of Hydrogen. *Source: Author's elaboration*

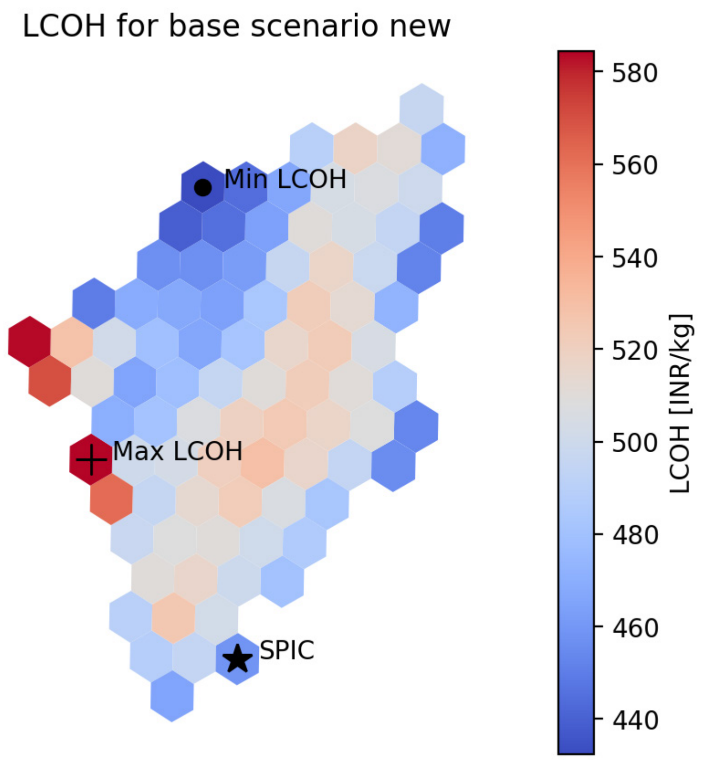
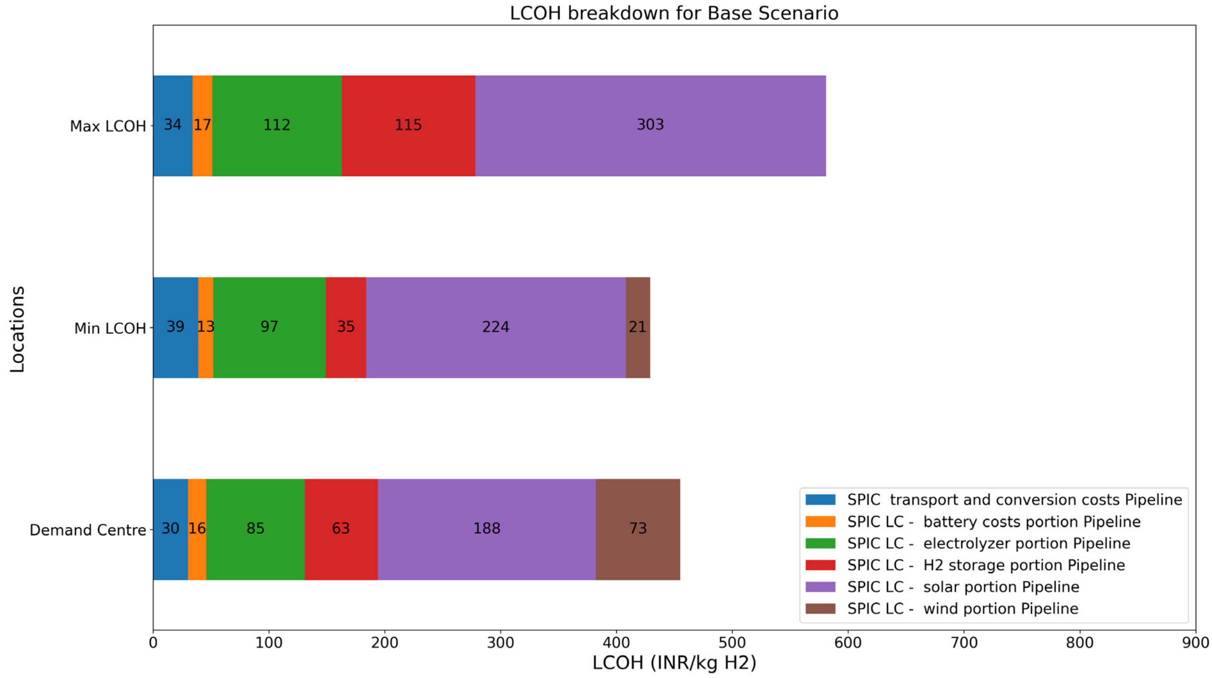
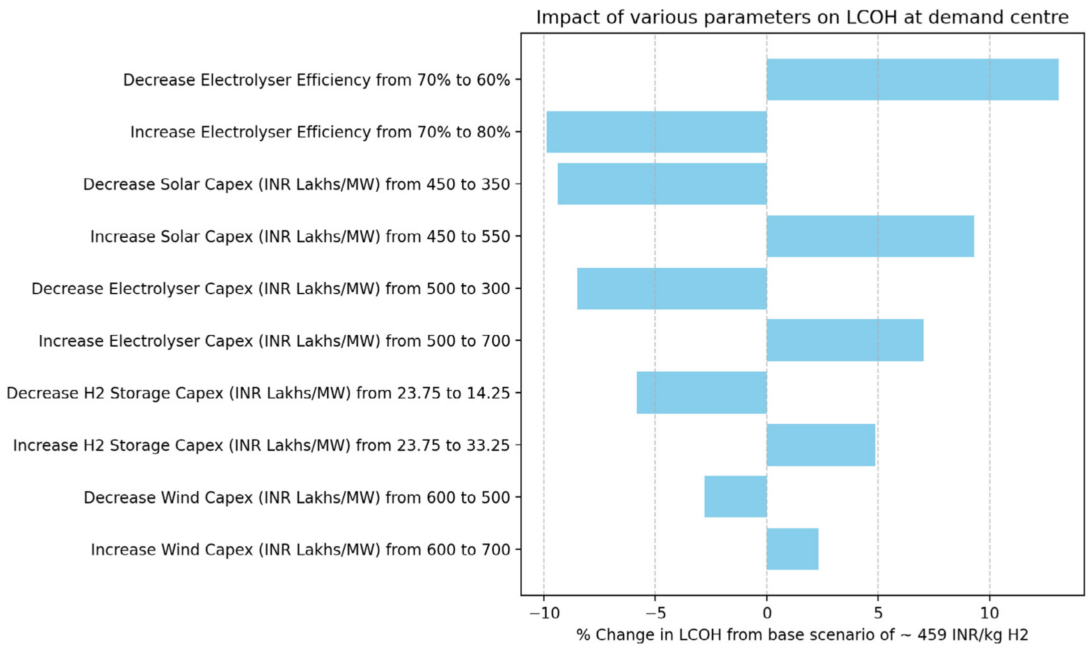


Figure 3: *LCOH broken down by contributions from different components.* Note: SPIC=Southern Petrochemical Industries Corporation; LC=Levelised Cost. *Source: Author's elaboration*



The LCOH required to meet the 100kT per annum demand across Tamil Nadu varied from approximately **₹430/kg H2 to ₹580/kg H2**. Spatial variation arises from renewable energy potential and land costs (**Figure 2**). The LCOH breakdown shows renewable generation and electrolysis as the leading hydrogen cost contributors (**Figure 3**) [18].

Figure 4: *Sensitivity of LCOH to variation in different parameters. Source: Author's elaboration.*



The sensitivity analysis of LCOH to various key parameters confirms that electrolyser efficiency and CAPEX are among the most influential drivers of hydrogen cost (**Figure 4**). The sensitivity chart also suggests that in an optimistic future scenario – if all favourable changes occur simultaneously, such as higher efficiency and lower costs – the hydrogen cost might decrease from the **baseline of ₹459/kg to approximately ₹292/kg**, which is consistent with other findings [19, 20]. Even after cost reductions and potential technological advancements, the LCOH of green hydrogen remains approximately 1.5 times higher than conventional grey hydrogen (priced at ₹160–200/kg H2) produced using natural gas as a feedstock, highlighting the need for further policy support, such as carbon pricing or subsidies [21].

Green ammonia can help decrease emissions in the fertiliser sector, particularly in urea production. Cost-related challenges, due to the high cost of green hydrogen, create a barrier to immediate adoption. However, a gradual and phased approach to integrating green ammonia through blending could be a feasible solution [22]. Considering the high cost of green ammonia (LCOA for the base scenario is approximately ₹92/kg of NH_3), a 20% blending rate is currently recommended as a starting point for decarbonising the fertiliser sector. At this blending percentage, the LCOU (₹52/kg Urea) is consistent with other studies performed in India [23, 24].

3.3. Quantifying the Climate Impact of Green Hydrogen

Produced from renewables, green hydrogen can significantly reduce emissions when it replaces grey hydrogen. We use two concepts (**Figure 5**) to understand and quantify the environmental benefits of adopting green hydrogen [25, 26].

Figure 5: *Quantification of environmental benefits of green hydrogen*

Marginal Abatement Cost (MAC)

Additional cost required to avoid one tonne of CO_2 emissions by switching from a conventional (grey) process to a green process.

Emissions Savings

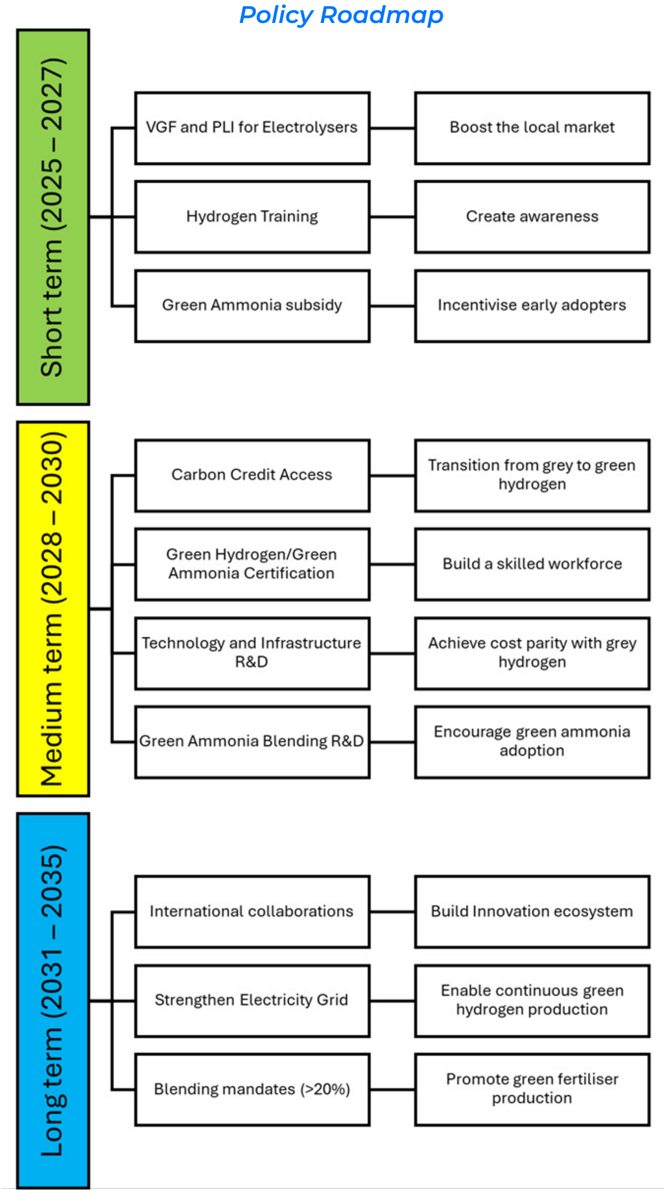
The CO_2 emission difference between conventional and green processes.

In the absence of a policy, the abatement cost for adopting green hydrogen at the demand centre is ₹25,900 ($300) per tonne of CO_2. Transitioning to green hydrogen can substantially reduce carbon emissions (**approximately 10 kg CO_2 saved per kg of hydrogen produced**). Although current marginal abatement costs remain high, robust policy interventions like Viability Gap Funding (VGF), Production-Linked Incentives (PLI), carbon pricing, and innovative financing mechanisms can significantly lower barriers to adoption.

4. Policy Imperatives: Enabling Green Hydrogen and Green Ammonia in Fertiliser Decarbonisation

The proposed policy roadmap considers stakeholder viewpoints, spatial cost modelling, and techno-economic insights (**Figure 6**):

Figure 6: *Green Hydrogen and Ammonia Policy Roadmap*



A phased and focused policy strategy is advised to foster the development and enhancement of hydrogen energy infrastructure in Tamil Nadu, specifically targeting the fertiliser industry and the Thoothukudi area.

In the **immediate term (2025–2027)**, the priority should be on reducing risks for initial investments and boosting local electrolyser manufacturing through Viability Gap Funding (VGF) and Product-Linked Incentives (PLI) schemes, developing foundational skills with hydrogen training initiatives, and supporting early adopters in the fertiliser sector via green ammonia subsidies.

For the **medium term (2028–2030)**, policies should shift towards bolstering infrastructure, increasing R&D efforts, and establishing supportive regulatory frameworks, which include certification processes and access to carbon credits.

Long-term initiatives (2031–2035) should reinforce this ecosystem through international partnerships, improving electricity grid integration, and implementing blending mandates exceeding 20%, which will propel large-scale decarbonisation of fertiliser production. These collaborative actions will diminish emissions, stimulate green job creation and investment, and boost industrial competitiveness in Tamil Nadu.

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