Climate Solutions Partnership

Summary Report

SCENARIO DEVELOPMENT AND POLICY RECOMMENDATIONS FOR THE ENERGY TRANSITION TOWARD THE NET ZERO TARGET FOR TAY NINH PROVINCE

December 2024

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I. Motivation, Objectives, Scope, and Limitations of the Study

The world has been making strong efforts to tackle climate change and prevent its severe impacts on the natural environment and human existence. Under the Paris Agreement, many countries have committed to keeping the global temperature rise below 2°C above pre-industrial levels and striving not to exceed 1.5°C. In line with this trend, Prime Minister Pham Minh Chinh made a strong declaration at COP26 regarding Vietnam's Net Zero target by 2050. One of the critical steps to achieve this goal is the approval of the "National Strategy on Climate Change to 2050," which outlines targets for nationwide emission reductions, boosts renewable energy, and improves energy efficiency. Additionally, Vietnam is implementing numerous forest planting and protection projects to increase the CO_2 absorption capacity from the atmosphere. Improving infrastructure, promoting green transportation, and adopting clean technologies in industrial production are also essential factors in the emission reduction strategy.

However, centrally governed provinces/cities currently lack specific strategies and plans to contribute to Vietnam's overarching goal. Aiming to examine a typical case, this report assesses the current and future energy demand of Tay Ninh Province across various sectors, calculates and analyzes the province's potential contributions to the national greenhouse gas reduction target, and proposes scenarios and policies to leverage the province's strengths in energy and transportation toward the Net Zero target, while also taking advantage of external support in certain situations.

II. Methodology of the Report

The report is developed by maximizing the use of information provided from official sources, as well as the latest available plans and policies. Before proposing scenario calculations, the report analyzes the current energy usage in the province (electricity, petroleum, gas) and makes future projections, incorporating the Provincial Power Development Plan and other methods. The potential for electrification in the transportation sector is determined based on projected petroleum demand. The potential of renewable energy sources (ground and rooftop solar power, wind power, biomass energy, small hydropower, etc.) is qualitatively assessed based on the province's terrain and climate characteristics and quantitatively evaluated using data from the National Power Development Plan VIII (PDP8), the Provincial Plan, population forecasts, and land use in industrial zones. The energy-saving targets are determined based on the provincial Energy Conservation and Efficiency Program up to 2025, with an orientation towards 2030, combined with Vietnam's general targets in the National Comprehensive Energy Plan for the period 2021–2030, with a vision to 2050. The potential for emission reduction from natural and planted forests is evaluated based on Tay Ninh's forest area and past CO_2 absorption statistics for forests in the Southeast region.

After forecasting energy demand and assessing the potential of renewable energy sources and forests, the report presents different scenarios based on: 1) Varying levels of energy conservation and efficiency; 2) Varying contributions of renewable energy sources; and 3) Varying levels of electrification. Non-viable or ineffective scenarios are excluded from detailed calculations. The calculation results in the proposed scenarios will quantify the necessary resources in the energy and transportation sectors to achieve the Net Zero target by 2050. This will help Tay Ninh Province optimize costs and time in formulating appropriate policies and plans in the future, aligned with the National Sustainable Development Goals.

The general flowchart for the report's execution process (data collection, potential assessment, scenario development) is shown in Figure 1. However, due to limited data resources and time constraints, the report inevitably includes certain assumptions to simplify the calculation model while maintaining the necessary accuracy in line with theoretical foundations and practical conditions. These assumptions include:

- Ignoring technical constraints of grid infrastructure.
- The forecast for electricity demand until 2035 is based on the Tay Ninh Power Development Plan for the period 2016–2025, with a view to 2035. Forecasts for 2040, 2045, and 2050 are derived from an extrapolation model based on past and projected data up to 2035.
- The projected emission factor of the power grid until 2050 is assumed based on the maximum allowable greenhouse gas emissions for the electricity production sector in the draft National Comprehensive Energy Plan to 2050 and Vietnam's projected electricity demand from PDP8 for the period 2021–2030, with a vision to 2050.
- Output and land area required for solar power are calculated per unit of installed capacity, derived from statistics of solar power plants in the province in 2023.
- The population forecast to 2050 is based on data from the Statistical Yearbook from 2010 to 2022. The average household size (persons per household) is assumed to be the same as in 2023.
- The projected demand for gas fuel is based on 2023 demand and population forecasts.
- The projected energy demand is considered the baseline scenario. The energy demand for scenarios that consider energy-saving targets will be directly reduced by a percentage from the baseline.
- The potential emission reduction from forests is based on statistics from the 2022 report "Forest Carbon Market in Vietnam: Legal Basis, Opportunities, and Challenges" by authors Pham Thu Thuy, Tang Thi Kim Hong, and Nguyen Chien Cuong.
- The petroleum demand forecast to 2050 is based on projected goods and passenger transport volumes.

In addition to the energy sector, which is the largest emitter, other sectors such as agriculture, LULUCF (Land Use, Land-Use Change, and Forestry), and waste management also contribute significantly to greenhouse gas emissions, impacting the Net Zero target. Coordinated resource use and collaborative action across these sectors are crucial for comprehensive and sustainable emission reduction. However, due to data and time constraints, this report focuses on analyzing the role of the energy sector. The report provides general observations and recommendations for other sectors as follows:

Agriculture is a major source of methane (CH_4) and nitrous oxide (N_2O) emissions, mainly from livestock and cultivation activities. To reduce emissions in this sector, improvements in cultivation techniques, appropriate fertilizer use, and sustainable livestock management are needed. The development of advanced technologies such as precision agriculture and organic farming also helps mitigate greenhouse gas emissions from agriculture.

LULUCF is an important sector related to changes in forest area and land use. Although Tay Ninh does not have extensive forested areas, sustainable forest management, forest

restoration and conservation, and deforestation prevention contribute to increasing greenhouse gas absorption. Reforestation projects should also be promoted in efforts toward Net Zero.

Waste management has significant potential for emission reduction, particularly through enhanced recycling, appropriate waste processing, and minimized incineration. The adoption of new technologies in waste treatment and the use of energy generated from processing can help reduce methane emissions from landfills.

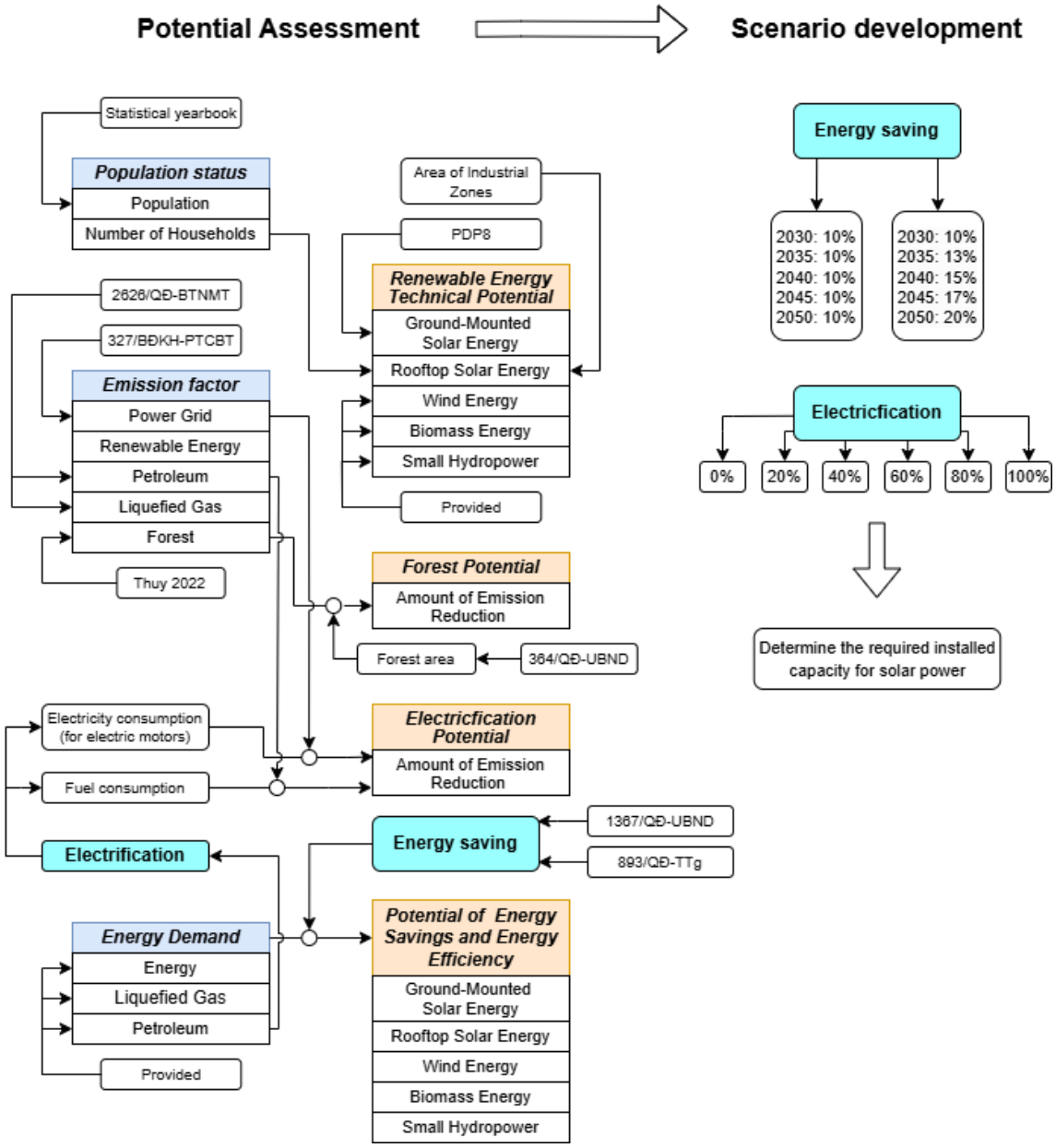

Figure 1: General Diagram of the Reporting Process

III. Energy Demand Forecast

1. *Electricity Demand Forecast*

The report will directly use the forecasted electricity demand for the period 2025 - 2035 from the Power Development Plan of Tay Ninh Province for the period 2016 - 2025, considering the year 2035. The report will present load growth scenarios for the period 2035 - 2050 based on extrapolation methods from past data and the forecast results for the period 2025 - 2035.

The electricity demand and the average growth rate of electricity demand in Tay Ninh until 2020 and the forecast until 2035 are presented in Table 1. The logarithmic extrapolation function can generalize well for the known data and show the saturation trend in the growth rate (Figure 2).

Table 1: Electricity demand and growth rate of electricity demand (2015 - 2035)

Year	**2015**	**2020**	**2025**	**2030**	**2035**
Electricity demand (GWh)	2,259	4,352	7,235	10,930	15,658
Period		**2015 – 2020**	**2020 – 2025**	**2025 – 2030**	**2030 – 2035**
Average growth rate (%)		14.01	10.70	8.60	7.45

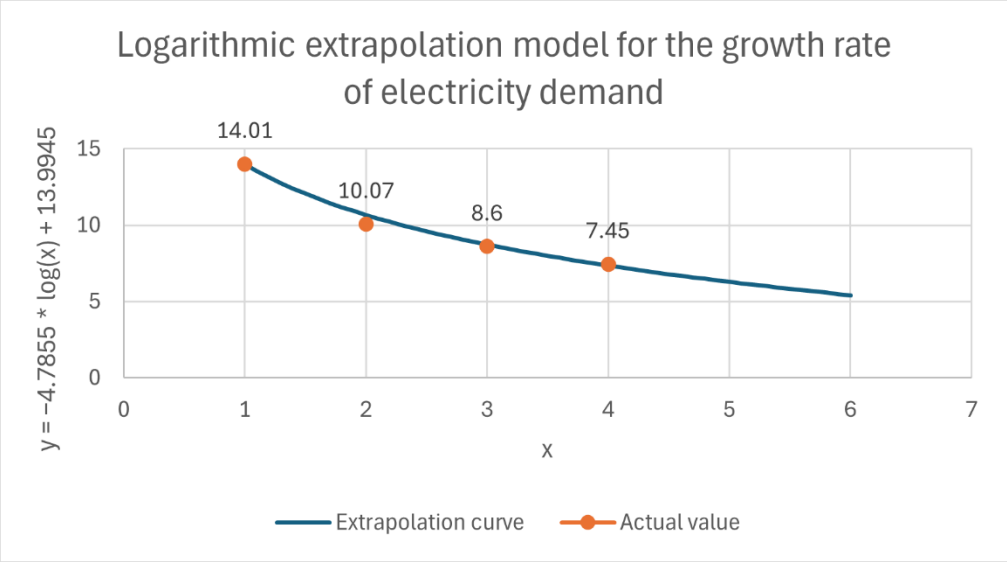

Figure 2: Logarithmic extrapolation model for the growth rate of electricity demand

Figure 3 shows the electricity demand of Tay Ninh Province (2015 - 2050). Accordingly, Tay Ninh is forecasted to consume 21,235 GWh of electricity in 2040, 27,634 GWh in 2045, and 34,719 GWh in 2050.

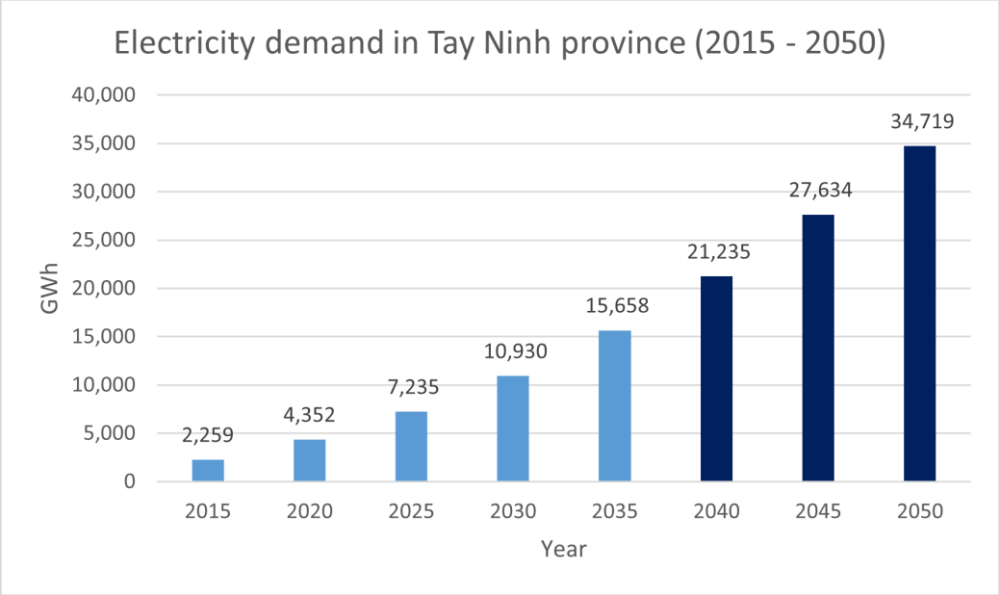

Figure 3: Electricity demand in Tay Ninh Province (2015 - 2050)

2. *Gas consumption demand forecast*

Based on the population forecast, the number of households in 2023 is 322,528 households. According to statistics from 2023, each household will consume an average of 0.084 tons of LPG. Assuming the gas demand of each household remains stable over the years and the ratio of gas demand between residential and industrial areas remains the same as in 2023, we can calculate the gas fuel demand of Tay Ninh until 2050, as shown in Table 2.

Table 2: Forecast of gas fuel consumption in Tay Ninh until 2050

Year	Residential gas consumption (tons/year)	Industrial gas consumption (tons/year)
2023	26,993	2,847
2024	27,385	2,888
2025	27,615	2,912
2030	28,765	3,034
2035	29,916	3,155
2040	31,066	3,276
2045	32,216	3,398
2050	33,366	3,519

3. *Petroleum consumption demand forecast*

The specific forecast results for the volume of passenger and freight transport until 2050 are shown in Table 3.

Table 3: Forecast of passenger and freight traffic by 2050

Year	Passenger traffic (thousands of people.km)	Freight traffic (thousands of tons.km)
2025	1,817,299	1,475,477
2030	2,180,233	1,766,875
2035	2,543,167	2,058,274
2040	2,906,101	2,349,673
2045	3,269,035	2,641,071
2050	3,631,969	2,932,470

The total petroleum consumption in the province reaches nearly 400,000 m³. Assuming that the volume of petroleum consumed is directly proportional to the volume of goods and passenger transport (considering each passenger as 60 kg/person), we can forecast the petroleum consumption of the province until 2050 as shown in Figure 4.

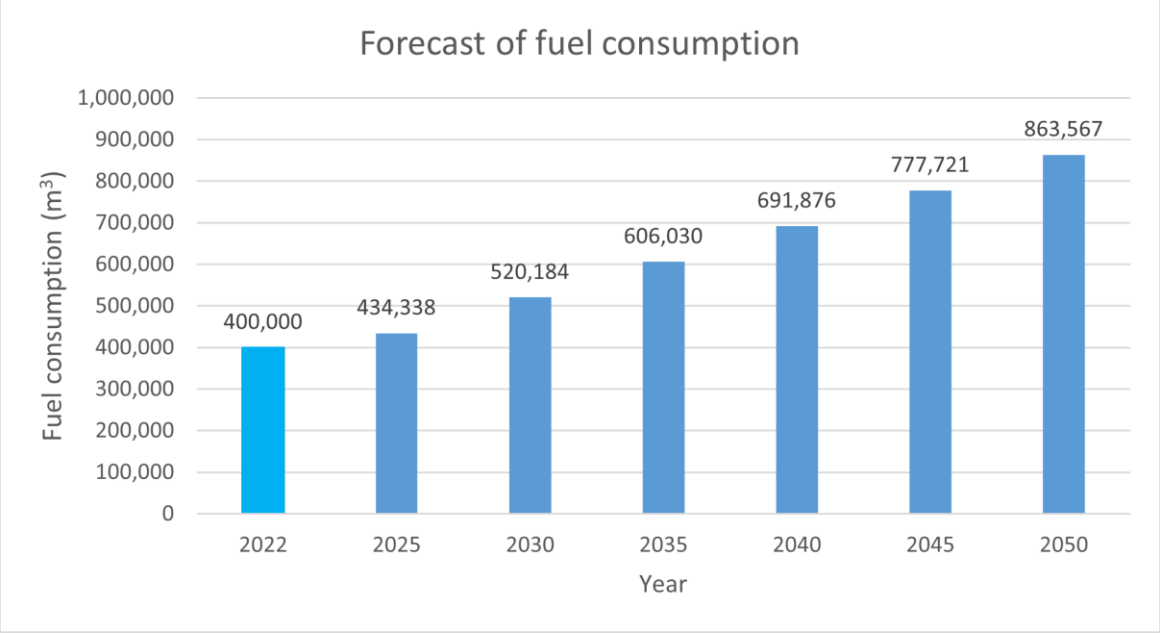

Figure 4: Forecast of fuel oil consumption by 2050

IV. Potential of Renewable Energy Sources

The technical potential of ground-mounted solar power is 49,538 MWp. Each MWp of solar capacity generates an average of 1.76 GWh of electricity annually or 4.82 MWh daily. The potential for rooftop solar in residential areas is estimated at 800 MWp to 1,500 MWp by 2050 (the actual potential capacity of solar power for industrial zones and clusters can reach 4,530 MWp with an output of 7,973 GWh/year, approximately 19 times the total capacity of rooftop solar installed per household in the 4 kWp/household scenario, illustrated in Table 4).

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Table 4: Potential for rooftop solar power in residential areas (2025 - 2050)

Year	Number of households	Total installed capacity for the options (kWp)		
		2 kWp/hh	3 kWp/hh	4 kWp/hh
2025	328,636	657,271	985,907	1,314,542
2030	342,007	684,013	1,026,020	1,368,026
2035	355,378	710,755	1,066,133	1,421,510
2040	368,749	737,497	1,106,246	1,474,994
2045	382,120	764,239	1,146,359	1,528,478
2050	395,491	790,981	1,186,472	1,581,962

Tay Ninh Province has evaluated Dau Tieng Lake as one of the most favorable areas for implementing solar power projects. The total area of Dau Tieng Lake is 27,000 hectares, of which approximately 20,000 hectares are suitable for installing solar power systems. Based on scenarios where 40% to 90% of the flooded area is utilized, the feasible total installed capacity for solar power in the Dau Tieng Lake area and the corresponding annual electricity output could reach between 9,287 GWh and 20,874 GWh.

Most of Tay Ninh's terrain is flat, resulting in very limited potential for hydropower development. Currently, aside from the two operational plants, CS2 and Dau Tieng, each with a capacity of 1.50 MW, there are virtually no plans or regulations for developing hydropower, even in the eighth power development plan and the province's plan. In 2022, the electricity output of the two plants was 2,516.78 MWh and 6,128.63 MWh, respectively. However, this output only accounts for a very small fraction of the province's total electricity production, especially when compared to solar power.

Tay Ninh currently has the Bourbon biomass power plant with an installed capacity of 49 MW. Additionally, according to PDP8, Tay Ninh has other biomass power projects with a total installed capacity of 101 MW. Thus, the potential for biomass power can be considered as 150 MW.

Tay Ninh Province is located deep inland, with the nearest straight-line distance to the coast being about 100 km, and has low wind speeds. Therefore, there is generally little potential for large-scale wind power development in Tay Ninh. However, the use of small wind turbines, which can generate power even at night, is a promising solution to consider, contributing to meeting the electricity needs of households or industrial zones and reducing greenhouse gas emissions.

V. Energy Saving and Efficiency Objectives

By 2025, Tay Ninh Province aims to achieve an energy saving level of 5% compared to the total energy consumption across the province. By 2030, the province targets a minimum energy saving level of 8% to 10% of the total energy consumption in the industrial sector,

which is also a national goal. Currently, Tay Ninh has only established energy-saving goals up to 2030, while long-term objectives for the period from 2035 to 2050 will need to align with the overall national targets for each phase.

The national energy-saving target for 2050 is set at approximately 15% to 20% compared to the typical development scenario. Consequently, if conditions allow, Tay Ninh's energy-saving scenario could achieve a 20% reduction by 2050. As a result, the saved electricity demand could reach 6,944 GWh by that year, thanks to efficient energy management and advancements in technology that enable industrial machinery and equipment to reduce electricity consumption (Figure 5).

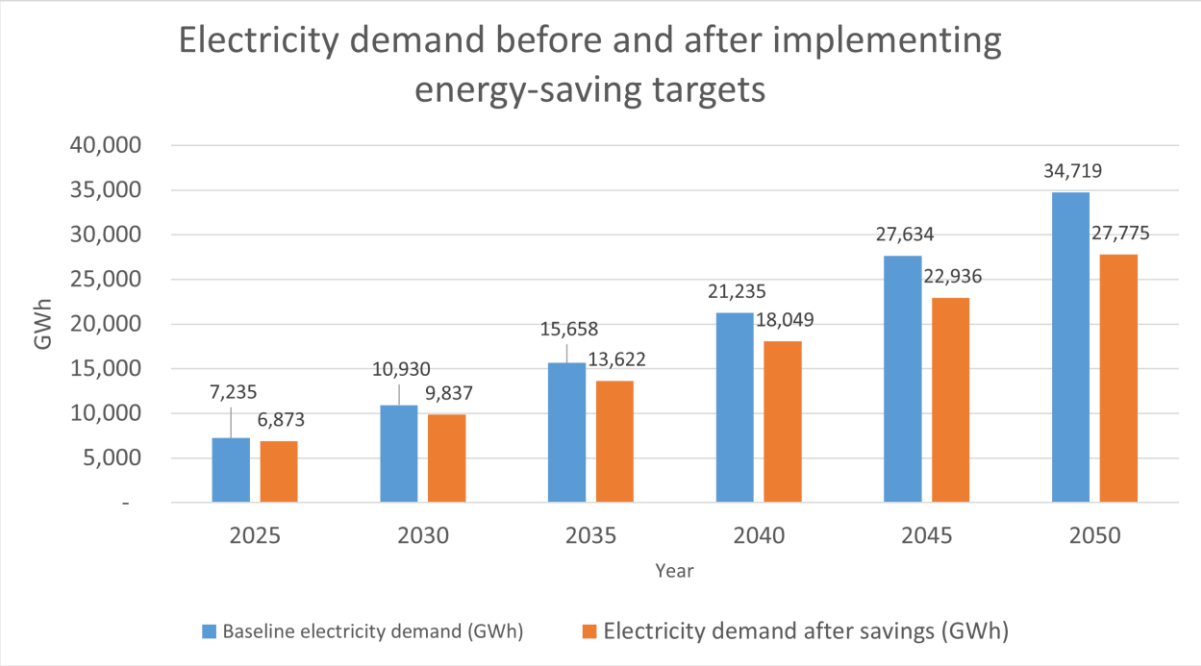

Figure 5: Electricity demand before and after implementing energy-saving targets

VI. Emission Reduction Potential of Forests

According to the report on the forest status of Tay Ninh Province, as of December 31, 2022, the total area of forest and land planned for forest development is 73,272.53 ha, including:

- Forested area: 66,569.09 ha, comprising 46,424.97 ha of natural forest and 20,144.12 ha of planted forest (including 1,272.30 ha of planted forest that has not yet met the criteria to be considered forest).
- Non-forested area: 6,703.44 ha, including 938.79 ha of land with regenerated wood and 5,764.65 ha of other areas.

According to the national forest status report in 2023, Tay Ninh has a forest area of 66,491 ha, ranking third in the Southeast region, following Dong Nai (181,627 ha) and Binh Phuoc (159,502 ha). The forest coverage rate in Tay Ninh is 16.21%, also ranking third in the region, behind Dong Nai (28.92%) and Binh Phuoc (22.57%). In the period from 2010 to 2020, the forests in the Southeast region had an average annual net reduction in emissions/increased absorption of 2.18 $MtCO_2$/year. Considering the total forest area of 479,871 ha, the average

reduction in emissions per hectare of forest in the Southeast region is 5.06 tCO_2/ha/year.

Due to the lack of detailed statistics for Tay Ninh, the report uses the value of 5.06 tCO_2/ha/year for the average reduction in emissions in the Southeast region to roughly estimate the potential for emission reduction and carbon neutrality based on the province's forest resources in the future. The calculation results are presented in Table 5. Accordingly, forestry activities are expected to absorb an average of about 371,000 tons of CO_2 per year from the carbon absorbed by forests while being incorporated into biomass. Natural forests and existing planted forests will contribute up to 90.85% of the total CO_2 reduction. In the long term (up to 2050), areas that are currently non-forested (but are planned to become forested) will contribute approximately 9.15% to future emission reductions.

Table 5: The carbon emission reduction potential of forests in Tay Ninh.

		Area (ha)	Emission reduction amount (tCO2/year)	Contribution level (%)
With forest	**Natural forest**	46,424.97	234,896.10	63%
	Planted forest	20,144.12	101,923.07	27%
Without forest	**Regenerated wood**	938.79	4,749.99	1%
	Others	5,764.65	29,167.36	8%
Total (ha)		**73,272.53**	**370,736.52**	**100%**

VII. Electrification Potential in the Transportation Sector

Assuming an ideal scenario where all transportation activities are electrified, all energy derived from fossil fuels for these activities would be replaced by electric energy. Figure 6 illustrates the emissions levels of transportation activities under two scenarios: full non-electrification and complete electrification. These scenarios help Tay Ninh identify the significant differences that would arise from implementing electrification in transportation.

In reality, complete electrification is nearly impossible; however, various electrification scenarios, including partial and full electrification, will be explored. The reduction in greenhouse gas emissions is substantial in the electrification scenario, as the emissions factor from the power grid significantly decreases when Vietnam aims for Net Zero.

The electrification process demands substantial related resources. Firstly, the infrastructure for electric vehicles is still lacking and incomplete. Charging stations are few and unevenly distributed. Secondly, the initial investment costs for electric vehicles and the electricity grid infrastructure remain high, placing significant economic pressure. Additionally, although battery technology has improved in terms of storage capacity and longevity, charging times can take nearly an hour for fast charging and up to 12 to 15 hours for a full charge. This considerably impacts the flexibility and convenience of users. Finally, changing consumer habits and mindsets poses a significant challenge, as many people remain familiar with and trust traditional petroleum-powered vehicles. All these factors can hinder the electrification of transportation, despite its considerable impact on achieving the Net Zero target. However, if

Tay Ninh has a clear orientation and specific roadmap, demonstrating a strong commitment, along with close cooperation among various departments, businesses, and the public, overcoming these challenges to electrify a substantial portion of the transportation sector in the province is entirely achievable.

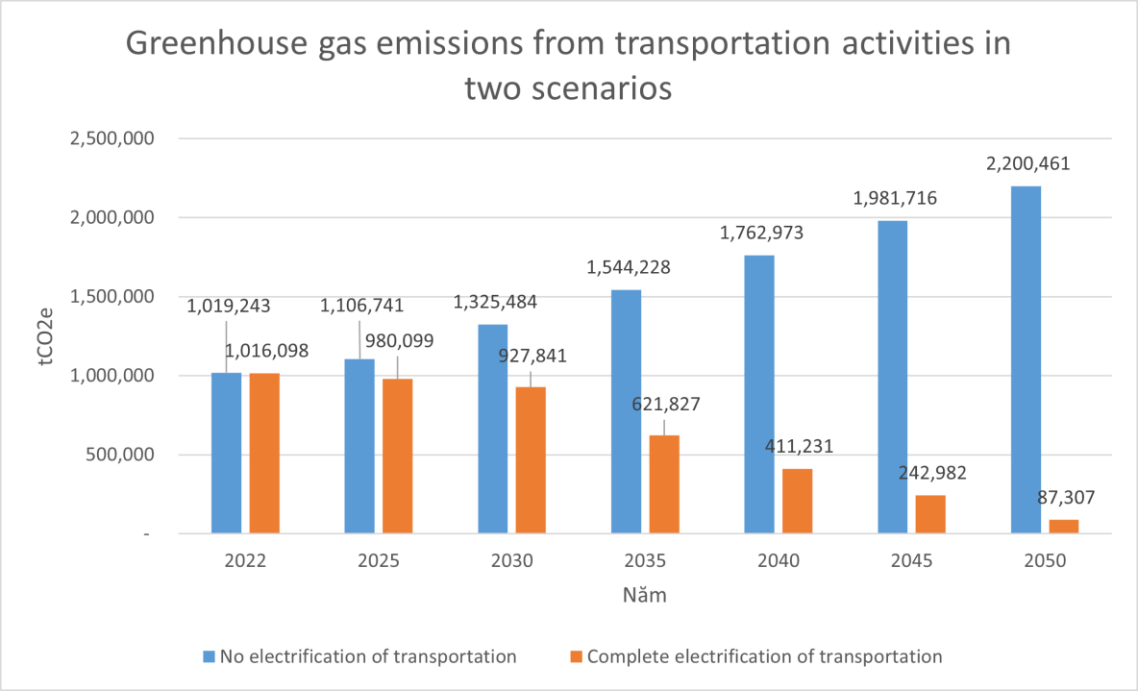

Figure 6: Greenhouse gas emissions from transportation activities in two scenarios.

VIII. Developing Scenarios Towards Net Zero Targets

The preliminary Net Zero scenarios are summarized in Table 6. All scenarios are based on the following assumptions:

- The net emissions target will progressively decrease each year, reaching zero by 2050.
- The installed capacity of biomass energy is maintained at 49 MW.
- The installed capacity and energy output of small hydropower is kept at 3 MW and 8,645 MWh, respectively, for all years.
- The net capacity factor of biomass energy is 65%.
- The carbon absorption capacity of forests remains constant at 370,737 tCO_2/year over the years.
- Due to its significant potential, solar energy will serve as the balancing source to achieve the emissions reduction targets.

Table 6: Overview of Net Zero scenarios.

Criteria	Scenario	Feature
Achieve the energy-saving goal for 2030	In all scenarios	All achieve the target
Load		The load develops as forecasted.
Forest		The forest area remains unchanged.
Energy savings ratio from 2030 to 2050.	A	Maintain a ratio of 10% from 2030 to 2050
	B	Gradually increase from 10% in 2030 to 20% in 2050
Level of electrification in 2050.	0	0%
	2	20%
	4	40%
	6	60%
	8	80%
	10	100%

The consolidated scenarios calculated in detail include:

- **Scenario I.A.0**: Achieve energy-saving targets as outlined in the provincial Energy Efficiency Program aimed at 2030. The energy-saving rate from 2030 to 2050 remains the same as in 2030. Maximize the utilization of solar energy resources to achieve Net Zero.
- **Scenario I.B.0**: Achieve energy-saving targets as outlined in the provincial Energy Efficiency Program aimed at 2030. The energy-saving rate from 2030 to 2050 gradually increases from 10% to 20%. Maximize the utilization of solar energy resources to achieve Net Zero.
- **Scenarios I.B.2 to I.B.10**: Achieve energy-saving targets as outlined in the provincial Energy Efficiency Program aimed at 2030. The energy-saving rate from 2030 to 2050 gradually increases from 10% to 20%. Combine renewable energy resources and electrification at levels of 20%, 40%, 60%, 80%, and 100% to achieve Net Zero.

The carbon net emissions targets for Tay Ninh in the Net Zero scenarios are illustrated in Figure 7. The emissions level for 2025 is assumed based on the current energy usage status and the proportion of renewable energy sources as they stand today.

The proportion of electricity, petroleum, and gas demand in 2050 is illustrated in Figure 8. In all scenarios, the electricity demand consistently represents the largest share. For scenarios I.A.0 and I.B.0, electricity demand accounts for 80% of the total energy demand in Tay Ninh, compared to 19% for petroleum and only 1% for gas. The share of electricity in scenarios I.B.2 and I.B.4 rises to 83.32% and 86.72%, respectively, exceeding that of scenarios I.A.0 and I.B.0 due to the electrification of transportation, which has shifted part of the energy consumption from petroleum to electricity. Scenarios I.B.6, I.B.8, and I.B.10 even feature a higher

proportion of electricity.

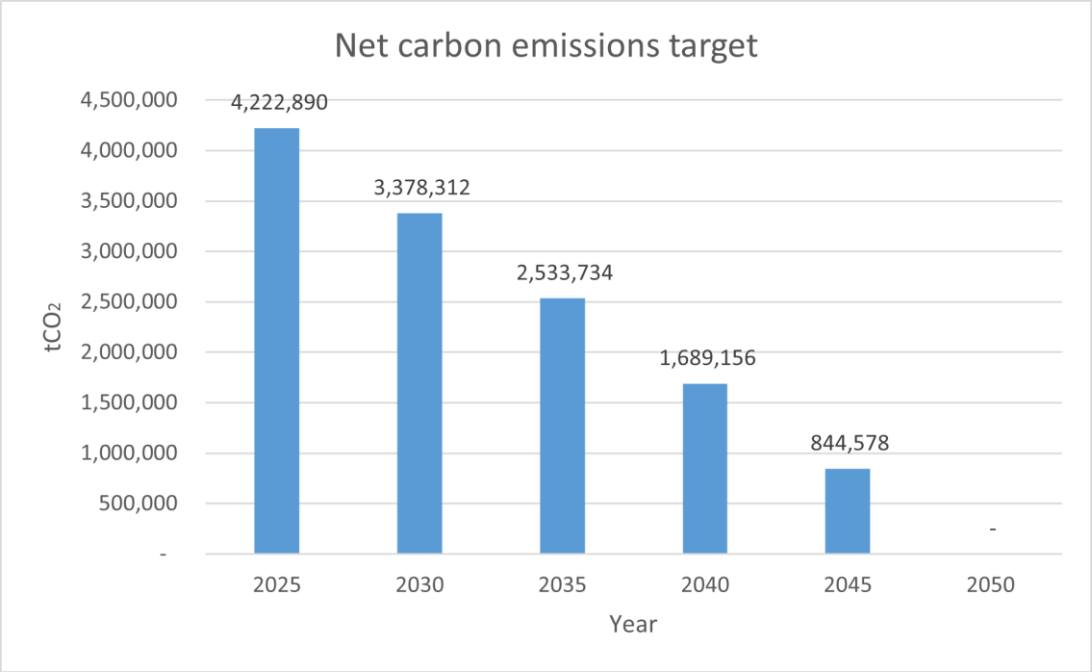

Figure 7: Carbon emission targets of Tay Ninh in the Net Zero scenarios

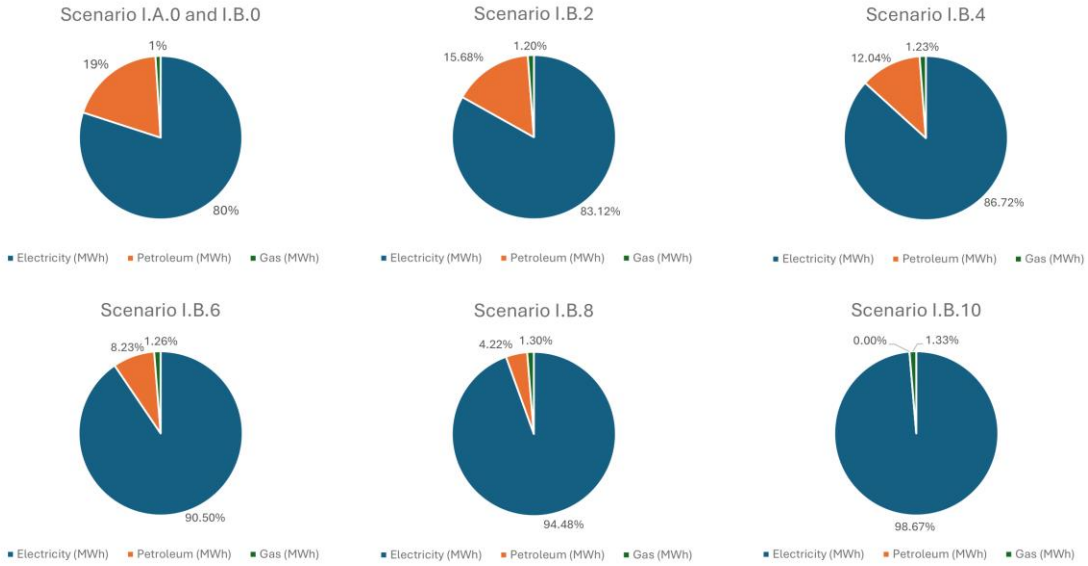

Figure 8: The percentage of electricity, petroleum, and gas demand in 2050.

The solar electricity generation and installed capacity in different scenarios are illustrated in Figure 9 and Figure 10. For scenario I.A.0, to achieve Net Zero by 2050, Tay Ninh will require 60,687 MW of solar power. This figure is quite high compared to the technical potential for ground-mounted solar power, which is 49,538 MW. In scenario I.B.0, due to higher energy-saving goals, Tay Ninh needs to invest less in renewable energy sources while still reaching the Net Zero target. However, by 2050, the required solar power capacity of

53,832 MW in this scenario remains significantly high compared to the technical potential.

The calculations for scenarios I.B.2 to I.B.10 demonstrate the impact of transportation electrification. In the case of substituting 20% of fuel oil used in transportation with electricity (scenario I.B.2), Tay Ninh will only need 46,708 MW of solar power by 2050, which is considerably lower than in the non-electrified scenarios. This number will continue to decrease as the rate of electrification increases, alleviating the pressure to install excessive solar power capacity during the 2045-2050 period. If a 100% electrification rate is achieved (scenario I.B.10), Tay Ninh will only need 18,211 MW of solar power by 2050.

In all scenarios, the installed solar capacity increases significantly during the 2045-2050 period to meet carbon neutrality goals. This is due to emissions primarily coming from petroleum, necessitating renewable energy sources to produce significantly more electricity than the province's demand to support other regions. Therefore, Tay Ninh should establish plans and policies to encourage solar installations in earlier stages to avoid significant pressures during the final five-year stretch.

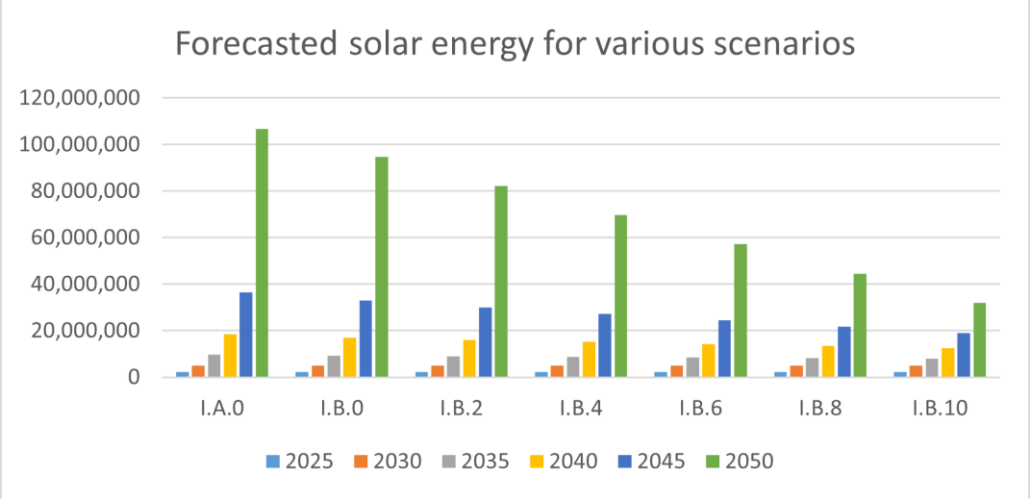

Figure 9: Forecasted solar energy for various scenarios

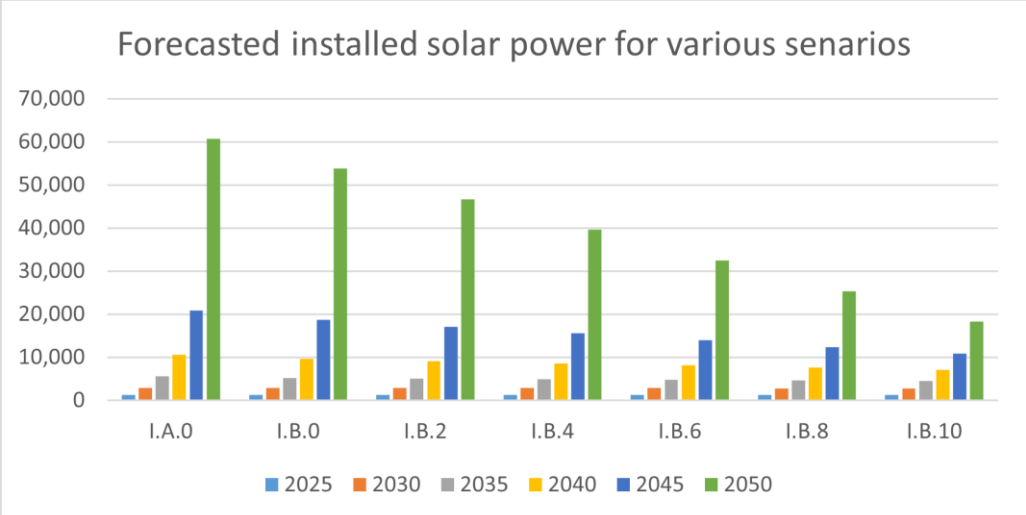

Figure 10: Forecasted installed solar power for various scenarios

IX. Policy Recommendations to Achieve Net Zero Goals

1. Development of Renewable Energy Sources

a) Enhance the Reliability and Security of the Power System

With the installation of rooftop solar systems in households and industrial zones, regulations and policies for selling electricity to the grid are crucial to ensure grid stability. If scenarios fail to meet energy-saving or electrification targets as expected, significant investments in grid infrastructure will be necessary to accommodate about 40 - 50 GW of solar power in the future.

b) Adjust Land Use Planning

The installation and construction of ground-mounted solar systems or solar projects on Dầu Tiếng Lake must consider land use regulations and planning. Therefore, it is essential to revise and adjust laws, policies, and planning mechanisms that are incompatible with land and forest use to align with Net Zero objectives.

c) Integrate Energy Storage Systems (BESS)

Currently, BESS is not widespread in Vietnam's power system due to cost factors. Thus, implementing policies and support mechanisms for storage systems is necessary, especially in the context of booming renewable energy.

d) Design Incentive Mechanisms for Renewable Energy

On July 3, 2024, the government issued Decree No. 80/2024/ND-CP regarding the direct power purchase mechanism between renewable energy producers and large electricity consumers (DPPA mechanism). Tay Ninh's authorities could also develop their own incentive mechanisms and policies for solar energy to promote investment in technology, construction, and installation of solar power, as well as to establish appropriate electricity pricing mechanisms to attract investors.

2. Electrification of Sectors

a) Enhance Charging Station Installation and Transportation Infrastructure Development

Decision No. 876/QD-TTg, approved on July 22, 2022, outlines the action program for green energy transition, reducing carbon and methane emissions in the transportation sector, promoting the shift from fossil fuel-powered vehicles to electric ones during 2022-2030, and aiming for 100% electrification of road vehicles by 2050. Tay Ninh needs to propose its own supportive policies and mechanisms, coordinating with those of neighboring provinces and national policies to facilitate the transition to electric vehicles, reducing fuel consumption and carbon emissions from transportation.

b) Encourage Transition from Gas Stoves to Electric Stoves

Electrification in households can also be achieved by transitioning from gas stoves to electric or induction stoves and replacing gas-fueled devices with electric ones. To achieve this, Tay Ninh needs to promote public awareness, encourage citizens to make the switch, and implement financial incentive policies for users, along with support for manufacturers and distributors.

3. *Energy Conservation and Efficiency*

- Raise Awareness Among Businesses and Citizens about Energy Conservation
- Replace, Repair, and Install Modern Equipment and Technologies.
- Establish Regulations and Mechanisms to Ensure Businesses Align with Provincial Energy Conservation Goals.

4. *Additional Measures*

Besides reducing greenhouse gas emissions, enhancing Tay Ninh's capacity to absorb CO_2—by increasing afforestation, protecting forests, and boosting forest cover—should also be part of the roadmap toward achieving Net Zero by 2050. Policies and regulations for sustainable forest management and protection are essential to increase carbon stocks and balance emissions within the province.