Policy Brief

For Preparation of Just Energy Transition Partnership Implementation in Vietnam

ELECTRICITY PRODUCTION ASPECT

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Key messages

The Political Declaration on Just Energy Transition Partnership (JETP) was reached between Vietnam and the International Partnership Group (IPG) on December 14, 2022 to mobilise USD 15.5 billion from international public and private finance to support the implementation of just energy transition in Vietnam. The main objective of JETP is to focus on the green energy transition while ensuring equity. This is to be achieved through the ambitious target of reducing the coal power capacity projected in the master plan from 37 GW to 30.2 GW by 2030. Along with that is the goal to raise the percentage of renewable energy (RE) in Vietnam's electricity grid from 36% expected in the 2030 plan to at least 47%, mainly through solar and offshore wind power. Other priorities include upgrading Vietnam's electricity grid to ensure transmission stability when RE capacity increases, national energy security, and economic development. In addition, the Political Declaration also mentions the development of battery storage technology, green hydrogen, and the establishment of RE technologies as well as a center of excellence in Vietnam to support a fair and sustainable energy transition, consistent with the socio-economic goals of the country.

The analysis of electricity generation sources (coal, gas, RE), the current status of the electricity grid, and the potential for developing hydrogen and storage technologies as well as the feasibility/necessity of the establishment of a center of excellence shows that electricity generation and transmission sector is facing a lot of challenges in order to reach the goal of just energy transition. The coal thermal plants are mostly new and thus early decommissioning would lead to a massive loss of capital investment not yet amortized; if one would attempt to co-fire biomass or renewable hydrogen-based fuels, the high cost of these alternative fuels, and achieve an optimal mixing ratio of ammonia would have to be addressed. The gas-fired power plants are suffering from high fuel costs (both for natural gas and in the future hydrogen) and be affected by coal plant retirement as the gas power plants would have to provide more baseload services. As for RE, the rapid increase in capacity in recent years has led to operational difficulties such as lack of grid stability, source-load imbalances, and oversupply in off-peak hours, and the “roller-coaster” of introducing and withdrawing incentive mechanisms for the sector has led to a “stop and go” in capacity additions. These gaps need to be addressed to ensure a sustainable and reliable electricity generation system.

In this context, the Consultant makes the following recommendations for the short-term goal of building an effective JETP RMP and the long-term goal of implementing JETP in Vietnam in regard to electricity production aspects.

The specific goals for the deployment of different sources and application of technologies of electricity towards JETP energy targets with additional financing sources are as follows that have been considered with the targets in the latest draft of the National Power Development Plan for the period of 2021-2030, vision to 2050 (PDP VIII).

Table 1: Summary of recommendations for the goals for deployment of different sources and technologies

	Recommendations
Coal thermal power	- Immediately stop planning new coal power capacity and only continue plants already under construction, as long as grid stability can be guaranteed. - Develop orientation policies as well as concrete roadmaps to convert from coal to biomass/ammonia with plants that have been in operation for up to 20 years when the price is suitable, starting with the most recent plants and gradually moving towards older plants. Stop operating coal power plants

	Recommendations
	with a lifespan of more than 30 years if not possible to convert to other fuels, provided that plants have been amortized.
Gas-fired thermal power	Ensure that currently operational combined cycle gas power plants are kept operational until the end of their technical lifetime and have access to gas either produced domestically or delivered as LNG. Consider the new build of gas power plants if a rapid fuel switch to renewable hydrogen or derived fuels can be ensured from 2035 onwards. - Deploy natural gas power plants as the third merit order category after intermittent renewable power, standard hydropower, and pumped storage hydropower; - Ensure fuel supply for the operation of gas power plants.
Hydropower	Expand pumped storage hydropower, starting the expansion of existing sites and preparing new sites in mountainous regions
Intermittent renewables (solar and wind)	- Focus on the sites most conducive to produce high plant load factors; - Consider solar thermal electricity with molten salt storage for baseload, if costs can be brought down below those of solar PV with battery/pumped hydro storage.
Battery Energy Storage Systems (BESS) and hydrogen produced from RE sources	Implement studies and policies to facilitate the application and deployment of BESS and production of hydrogen produced from RE sources, including: - In-depth studies on roadmaps, technologies, sites, and models for application and policies to facilitate the investment and deployment of BESS and hydrogen technologies in Vietnam; - Introduce incentive policies in the testing phase of technologies, with strong foreign funding.
Transmission grids	- Build new transmission lines to connect regions with high renewable power capacity to regions with high electricity demand, also internationally; - Combine different renewable power sources to balance the change in the production of a renewable power source; - Strategically use demand side management (DSM) to optimize the usage time of electricity in line with the power generation output

The non-exhaustive list of in-depth studies for energy transition has been proposed to recommend for the implementation from now until the approval of JETP RMP and during the implementation of JETP RMP.

1 Relevant Statements in the Political Declaration

The Political Declaration requires Viet Nam to develop a Resource Mobilisation Plan (RMP) to mobilise the USD 15.5 billion committed finance for the Just Energy Transition Plan (JETP). The JETP RMP addresses Viet Nam's specific needs and is approved by the International Partnership Group (IPG). The JETP RMP will provide support in the following energy aspects to ensure a just energy transition in Viet Nam.

> *b) accelerate the decarbonisation of its electricity system from the current net-zero planning peak of 240 $MtCO_2e$ by 2035 with international support (down from 280 $MtCO_2e$ before COP26)*

towards reaching a peak of no more than 170 $MtCO_2e$ emissions from electricity generation by 2030 enabled by meaningful and strong support from IPG partners in terms of finance as outlined under paragraph 18 and all technologies to scale up the deployment of renewable energy and the management of clean power systems.

c) work with Viet Nam and investors to reduce Viet Nam's project pipeline for coal-fired generation, currently standing at a planned capacity peak of 37GW, towards a peak of 30.2 GW, as well as providing a credible and ambitious emission reduction pathway to phasing out unabated coal-fired power generation after those dates.

d) accelerate the deployment of renewable energy and develop the technical expertise to support and manage a grid increasingly powered by variable renewable energy, with the aim of enabling Viet Nam to sustain a reliable grid and move beyond the current planned figure of 36% towards at least 47% of electricity generation coming from renewables including wind, solar and hydroelectricity power by 2030, enabled by international support

i) negotiate - with the support of partners - the halting of investment in coal-fired power plants to deliver these goals, where appropriate.

j) negotiate the closure of old, inefficient unabated coal-fired power plants to facilitate access to clean energy.

l) work towards the establishment of a centre of excellence for renewable energy in Viet Nam to share expertise, support the development of skills, technological and regulatory understanding and facilitate voluntary cooperation between Viet Nam and the private sector on technology transfer in order to accelerate and scale up the deployment of renewable energy and management of clean power systems in Viet Nam and the region.

k) develop the renewable energy industry including but not limited to developing renewable energy hubs, storage battery and renewable energy equipment manufacturing, and green hydrogen production, developing planning of offshore wind platforms combining with marine aquaculture and fishing logistics.

m) realise multi-purpose land use for renewable energy production, agriculture, aquaculture to improve production and processing of agricultural products through improved accessibility to energy and create jobs for rural workers. Accordingly, the Vietnamese Government will develop and adopt a JETP Resource Mobilisation Plan (JETP – RMP) to mobilise such finance for JETP, which will be "a part of the much larger investment needs for Viet Nam" (para. 19)[1].

This report will analyse the current situation of electricity production in Vietnam to point out the gaps that need to be filled to achieve the JETP target and make recommendations that Vietnam needs to implement for the JETP RMP construction phase.

2 Electricity generation and GHG emission reduction targets

In the Power Development Planning for the period of 2021-2030, vision to 2050 (PDP VIII)[2], under the direction of the Government on continuing the reduction of coal-fired thermal power capacity to be in line with the commitments at COP26 in December 2021, the development orientation of thermal power plants in Vietnam until 2050 is as the follows:

- Stop developing coal-fired power plants after 2030, and gas-fired power plants after 2035.

[1] European Commission. (2022) Political Declaration on establishing the Just Energy Transition Partnership with Viet Nam. https://ec.europa.eu/commission/presscorner/detail/en/statement_22_7724

[2] National Power Development Plan for the period of 2021-2030, vision to 2050 (PDP VIII)

- Coal-fired power plants are expected to be co-fired with biomass or ammonia after 20 years of operation with a co-fired combustion rate starting at 20% and gradually increasing to 100%. By 2050, there will be no coal-fired power plants in the pipeline.
- Gas power plants are expected to be co-fired with hydrogen after 2030, starting from 20%, and gradually increasing to 100%. In the future, when the technology is improved and the price of hydrogen will be reduced, new generation power plants using hydrogen can be built. As for the orientation to 2050, all gas power plants will switch to using hydrogen.

This power development plan requires high investment costs and the cost of electricity production by 2050 would increase by about 30% compared to the previous plan. The energy transition plan for Vietnam's power development needs strong support from the international community toward the national GHG emission reduction target. The following high scenario takes into account the risks in the deployment of several large power plants, including the possibility of not being able to deploy 6,800 MW of BOT coal-fired power plants.

Table 2: Capacity expansion in the operating high scenario of PDP VIII December 2022 (MW)[3]

Category	2025	2030	2035	2040	2045	2050
Peak demand	**61,357**	**93,343**	**128,791**	**162,904**	**189,917**	**209,332**
Total installed capacity	**107,999**	**156,444**	**235,759**	**339,189**	**445,612**	**538,429**
Total installed capacity excluding rooftop solar power, cogeneration	**98,794**	**145,989**	**221,704**	**317,131**	**416,381**	**501,608**
Domestic coal thermal power	17,630	17,163	9,059	6,057	3,372	0
Imported coal thermal power	12,437	12,964	14,078	9,280	0,263	0
Coal-fired thermal power converted to biomass/ammonia	0	0	6,990	14,790	18,642	0
Coal-fired power completely converted to biomass/ammonia	0	0	0	0	6,990	25,632
Combined cycle gas turbine and domestic gas thermal power	9,176	14,930	7,900	7,900	7,900	7,900
Combined cycle gas turbine using LNG	3,500	24,500	28,500	7,500	0	0
Domestic gas-fired thermal power with Hydrogen	0	0	7,030	7,030	0	0
Domestic gas-fired thermal power fully hydrogen-converted	0	0	0	0	7,030	7,030
Hydrogen-fired LNG combined cycle gas turbine	0	0	3,500	24,500	28,500	7,500
Fully hydrogen-converted LNG combined cycle gas turbine	0	0	0	0	3,500	24,500
LNG ICE	0	300	8,400	22,500	32,400	43,800
Oil thermal power	1,221	0	0	0	0	0
Large Hydropower	20,996	21,749	23,387	23,751	24,142	24,162
Small hydropower (<30MW)	5,799	7,197	10,267	10,663	10,997	11,854
On shore wind power	13,616	21,480	30,400	45,100	60,750	66,050
Offshore wind power	0	7,000	17,000	42,500	71,500	87,000

[3] National Power Development Plan for the period of 2021-2030, vision to 2050 (PDP VIII)

Category	2025	2030	2035	2040	2045	2050
Solar power	8,736	8,736	34,711	60,408	92,193	136,573
Biomass and other RE	1,180	2,270	3,290	4,960	5,210	6,015
Rooftop solar power	7,755	7,755	10,755	17,558	24,731	32,321
Co-generation	1,450	2,700	3,300	4,500	4,500	4,500
Import	4,453	5,000	7,742	10,242	11,042	11,042
Pumped hydroelectric energy storage and storage batteries	50	2,700	9,450	19,950	31,950	42,550

Table 3: Electricity output in the operating high scenario of the PDP VIII December 2022 (GWh)[4]

Category	2025	2030	2035	2040	2045	2050
Total electricity produced	**391,339**	**595,457**	**822,513**	**1,040,784**	**1,213,054**	**1,335,938**
Domestic coal thermal power	98,245	105,881	62,420	41,531	23,322	0
Imported coal thermal power	69,304	79,973	97,008	63,622	1,820	0
Coal-fired thermal power converted to biomass/ammonia	0	0	32,431	62,747	93,373	0
Coal-fired power completely converted to biomass/ammonia	0	0	0	0	29,694	82,102
Combined cycle gas turbine and domestic gas thermal power	26,816	52,406	54,425	60,839	60,054	57,439
Combined cycle gas turbine using LNG	16,973	118,490	182,843	54,367	0	0
Domestic gas-fired thermal power with Hydrogen	0	0	12,837	42,847	0	0
Domestic gas-fired thermal power fully hydrogen-converted	0	0	0	0	24,877	32,096
Hydrogen-fired LNG combined cycle gas turbine	0	0	6,405	128,056	149,875	38,049
Fully hydrogen-converted LNG combined cycle gas turbine	0	0	0	0	17,317	118,734
LNG ICE	0	234	3,350	10,616	33,411	78,919
Oil thermal power	514	0	0	0	0	0
Large Hydropower	74,390	75,494	76,514	76,634	77,029	77,034
Small hydropower (<30MW)	20,547	24,982	33,591	34,405	35,089	37,794
Onshore wind power	34,533	59,968	89,495	141,090	193,273	212,724
Offshore wind power	0,000	19,543	50,046	132,957	227,473	280,196
Solar power	26,708	26,708	71,835	121,800	180,210	258,440
Biomass and other RE	5,702	11,624	20,189	32,658	34,743	38,800
Rooftop solar power	-2,271	-7,455	14,678	41,013	78,66	95,89
Cogeneration	879	1,405	2,924	4,337	3,056	2,990
Import	16,789	18,791	27,216	34,652	37,031	37,036

[4] National Power Development Plan for the period of 2021-2030, vision to 2050 (PDP VIII)

Category	2025	2030	2035	2040	2045	2050
Pumped hydroelectric energy storage and storage batteries	0	-38	-1,015	-2,374	-5,248	-6,394

In the high operating scenario, the total installed capacity of power plants will reach 145,989 MW in 2030 and 501,608 MW in 2050 (excluding rooftop solar power and cogeneration). The share of the capacity of RE sources (excluding hydropower) will increase from 27% in 2030 to 58.9% in 2050. The share of electricity from these RE sources will increase from 19.8% in 2030 to 59.1% in 2050. The emissions of CO_2 will reach 239 million tCO_2-eq in 2035, 115 million tCO_2-eq in 2045, and an estimated 30 million tCO_2-eq in 2050 which will ensure meeting Vietnam's commitments at COP26.

According to the updated NDC 2022 and National Strategy on Climate Change for the period to 2050[5] (NCCS 2022), to achieve the net zero emission target by 2050, the energy sector (including sub-sectors: electricity generation, transportation, energy extraction, commerce, and civil) is allowed to emit a maximum of 457 million tCO_2-eq in 2030 and 101 million tCO_2-eq in 2050. The maximum allowed CO_2 emission considering the power generation industry alone is about 240 million tCO_2-eq and 30 million tCO_2-eq for 2030 and 2050, respectively.

This target for GHG emission reductions in the energy sector is based on the following assumptions on the capacities of electricity supply sources.

Table 4: Capacity assumption of electricity supply sources in updated NDC 2022[6]

Type	Capacity
E28. Developing small hydropower	Increase the capacity of small hydropower plants to 6,100 MW by 2025 and 7,300 MW by 2030.
E29. Developing concentrating solar power	Increase the capacity of solar power plants to 8,736 MW by 2025 and maintain the same capacity until 2030.
E30. Developing rooftop solar power	Increase the capacity of rooftop solar power plants to 7,755 MW by 2025 and maintain the same capacity until 2030.
E31 Developing onshore wind power	Increase the capacity of onshore wind plants from 518 MW in 2020 to 13,921 MW by 2030.
E32. Developing offshore wind power	Increase the capacity of offshore wind plants to 4,000 MW by 2030.
E33. Developing biomass power	Increase the capacity of biomass plants to 1,230 MW by 2030.
E34 Developing waste to energy incineration	210 MW and 350 MW waste to energy will be installed by 2025 and by 2030 respectively to replace CFPPs.
E35. Developing waste to energy landfill	30 MW and 50 MW waste to energy will be installed by 2025 and by 2030 respectively to replace CFPPs.
E36. Developing biogas power	20 MW and 30 MW biogas to energy will be installed by 2025 and by 2030 respectively to replace CFPPs.

[5] Decision No. 896/QD-TTg dated July 26, 2022 approving the National Strategy on Climate Change for the period to 2050

[6] Technical Report of Updated NDC 2022 (only in Vietnamese)

Type	Capacity
E37. Developing LNG-fired gas turbine combined-cycle power plants	LNG-fired gas turbine combined-cycle power plants will have been installed with the capacity of 3,500 MW and 23,900 MW by 2025 and 2030 respectively to replace CFPPs.
E38. Developing ultra-super- critical coal-fired power technology	9,600 MW and 15.600 MW of ultra-super-critical coal-fired power plants will have been installed by 2025 and by 2030 respectively to replace CFPPs.

The capacities of electricity supply from RE and low carbon technologies used in the updated NDC 2022 and NCCS 2022 are lower than the capacities of respective technologies in the draft PDP VIII.

3 Accelerating energy transition for thermal power plants

3.1 Current situation of Vietnam's electricity supply

The types of electricity sources are unevenly distributed across regions. Coal-fired power sources are concentrated in the North and the South. Power plants using domestic coal are concentrated in the North while the power plants using imported coal are mainly located in the South. Combined cycle gas turbine (CCGT) plants using gas and oil fuels are located in the South. Hydropower plants (including small ones) are distributed in all three regions. Wind and solar power sources are concentrated in the central and southern regions.

By the end of 2021, the total installed capacity of all types of electricity sources of the national electricity system reached 78,120 MW, of which the North 27,978 MW (36.2%), the Central 15,614 MW (17.8%) and the South 34,529 MW (46%). In 2021, the total additional capacity put into operation is 7,433 MW, including 3,227 MW of coal power, 594 MW of hydropower, and 3,612 MW of wind power. The installed capacity by types of electricity and regions in 2021 is shown below:

Table 5: Installed capacity by fuel types and regions as of the end of 2021 (MW)[7]

Type of power plant	North		Central		South	
	(MW)	(%)	(MW)	(%)	(MW)	(%)
Hydropower	9,554	34.15	5,848	38.09	1,991	5.77
Coal-fired	14,764	52.77	30	0.19	10,603	30.71
Oil-fired	199	0.71	138	0.88	1,242	3.60
Small hydropower	2,850	10.19	1,425	9.13	344	0.99
Gas-fired					24	0.07
CCGT					7,398	21.43
Biomass	25	0.09	238	1.53	62	0.18
Wind	0	0	2,158	13.82	1,967	5.7
Solar	97	0.35	2,667	17.08	6,140	17.78
Rooftop solar	489	1.17	2,437	15.61	4,734	13.71
Imported	0	0	572	3.66	0	
Diesel oil	0	0	0		24	0,07
Total	**27,978**	**100**	**15,614**	**100**	**34,529**	**100**

[7] National Power Development Plan for the period of 2021-2030, vision to 2050 (PDP VIII)

By the end of 2021, the total installed capacity of hydropower is 22,111 MW, coal-fired power is 25,397 MW; gas thermal power plant is 7,422 MW; wind power is 4,126 MW, solar power is 16,640 MW, imported is 572 MW (0.8% capacity, 1.2% output). According to Report No. 7194/TTr-BCT of November 2022 of the Ministry of Industry and Trade (MOIT) on PDP VIII, by the end of 2020, Vietnam's electricity system ranked second in Southeast Asia and 23rd in the world.

Table 6: Installed capacity by type for the period of 2010-2021 (MW)

Type of power plant	2010	2015	2016	2017	2018	2019	2020	2021
Large hydropower	8,180	16,587	17,824	19,288	20,170	20,632	20,859	22,111
Small hydropower		1,984	2,251	2,791	3,322	3,674	3,887	
Coal-fired	4,460	12,903	14,595	17,089	18,945	20,267	22,077	25,397
Oil-fired	925	875	1,439	1,439	1,579	1,579	1,579	1,579
Diesel oil	39	39	24	24	24	24	24	24
Gas-fired	7,650	7,998	7,467	7,467	7,467	7,467	7,422	7,422
RE	24	135	114	145	504	5,237	9,715	21,015
Biomass	24	45	24	55	175	175	325	325
Wind		90	90	90	243	377	538	4,126
Solar					86	4,685	8,852	8,904
Rooftop solar								7,660
Imported	1.000	800	800	1340	1372	1372	572	572
Total installed capacity	22,278	39,337	42,263	46,792	50,061	56,578	62,248	78,120

Table 7: Generated electricity by type for the period of 2010-2021 (GWh)

Type of energy	2010	2015	2016	2017	2018	2019	2020	2021
Hydropower	27,550	56,123	63,941	85,940	83,081	66,117	72,892	78,553
Coal-fired	17,988	56,469	68,351	67,714	91,654	120,157	123,177	119,000
Oil-fired	3,648	878	931	97	595	1,239	574	-
Diesel oil	906	114	251	53	156	974	489	7
Gas-fired	44,762	48,148	45,365	40,347	40,701	42,507	34,802	26,312
RE	49	191	323	558	997	5,892	10,897	31,456
Biomass	49	70	122	208	488	350	340	321
Wind		121	201	350	487	724	982	3,344
Solar					22	4,818	9,575	14,851
Rooftop solar							687	12,940
Imported	5,599	2,393	2,736	2,361	3,124	3,316	3,067	1,403
Exported	1,108	1,416	1,409	1,650	1,509	2,067	1,555	582
Total generated electricity	100,502	164,316	181,898	197,070	220,308	240,202	245,898	256,731

3.2 Coal thermal power

3.2.1 Current situation of coal-fired power plants

In 2021, the total annual output of coal-fired thermal power sources reached 119.0 billion kWh-reaching 94.6% of the plan). The new coal-fired power source put into operation in 2021 includes 5 generator units with a total installed capacity of 3,228 MW (in 2020 it is 1,810 MW), of which 2 generator units of Duyen Hai 2 power plant (2x614 MW), 1 unit of Song Hau 1 (600 MW) and 2 units of Nghi Son 2 power plant (2x700 MW)[8]. In general, in 2021, coal-fired power plants often operate unstably and suffer from breakdowns that led to the capacity decline, especially generator units with large capacity, which affects considerably the frequency quality and stable operation of the national electricity system. The list of coal thermal power plants is shown in the Annex of this report.

Table 8: Generated electricity by type in the electricity system 2021.

Generated electricity by type of electricity source in 2021 (*10^6 kWh*)	
Total generated in the electricity system	**256,731**
Hydropower	78,553
Coal-fired	119,000
Gas turbine & Steam tail	26,312
Oil-fired	0
Oil-power gas turbine	3
Gas-fired thermoelectricity	0
Wind	3,344
Solar	14,851
Rooftop solar	12,940
Biomass	321
Diesel	4
Imported from China	0
Imported from Laos	1,403

3.2.2 Challenges and recommendations to facilitate energy transition

Challenges

Coal-fired thermal power source plays a very important role in the electricity supply of Vietnam's electricity system as it is a stable and low-cost electricity source. Maintaining this electricity source in the coming years is still a necessary requirement to ensure an adequate and stable electricity supply and national energy security. However, the development of coal-fired power plants also sharply increases GHG emissions, negative environmental impacts, and dependence on imported energy.

There are orientations applied for coal-fired power plants to reduce GHG emissions: (i) not building new coal power plants after 2030 (ii) converting biomass and ammonia co-firing fuels for existing coal-fired power plants, and (iii) early retirement for existing coal-fired power plants that are not able to covert to co-firing fuels.

The fuel conversion process of coal-fired power plants must take into account the costs incurred by the fuel conversion process such as the cost of prolonging life, cost of renovation to be able to cofire with other fuels, efficiency reduction rate in the extension life period, efficiency reduction rate when co-firing with co-firing fuels, co-firing fuel prices... These costs are used to calculate the system-wide cost for the energy conversion scenario.

[8] Summary report on operation of electricity system – National Load Dispatch Center

For ammonia co-firing in pulverised coal-fired power plants, the mixing ratio of ammonia in coal-fired power plants is a major challenge. In addition, due to the high price of ammonia fuel, the co-firing of 20% ammonia in a coal-fired power plant will increase the Levelised Cost of Energy (LCOE) by 34% compared to those of 100% coal plants. The LCOE of cofiring biomass plants will increase by about 10% with 15% of biomass and 19% with 20% of biomass compared to those of the 100% coal fuel.

Recommendations

Based on the roadmap for fuel conversion and cessation of construction of new coal-fired power plants presented, the electricity source capacity expansion model will deploy more RE sources, and backup sources and enhance the transmission grid to meet the load demand at the lowest system cost.

In order to achieve the energy transition target with additional foreign financing, the roadmap for coal-fired power plants is proposed as follows:

- Immediately stop planning new coal power capacity and only continue plants already under construction until 2030 as long as grid stability can be guaranteed.
- Develop the orientation policies as well as concrete roadmaps to convert from coal to biomass/ammonia with plants that have been in operation for up to 20 years when the price is suitable. Stop operating plants with a lifespan of more than 30 years if not possible to convert to other fuels provided that plants have been amortized.
- Eliminate coal-fired power sources that are not able to convert to other fuel sources[9].

3.3 Gas-fired thermal power

3.3.1 Current status of gas-fired thermal power

The gas-fired power plants together with coal thermal power plants are the two main sources to maintain the stability of the electricity system in Vietnam. Therefore, the operation of the gas-fired thermal plants will be impacted by the JETP targets, and on the opposite side will also impact the implementation of the JETP. The total output of gas-fired thermal power plants in 2021 reached 26,312 billion kWh, equal to 75.8% of the year plan (34,478 billion kWh) and lower than in 2020 (34,657 billion kWh).

In 2021, the fuel oil (FO) thermal power source is not mobilised, the mobilsation of FO and DO thermal power sources are only when having incidents with the natural gas and when stopping the operation of the gas system for maintenance.

Total FO thermal power output is 0 million kWh and DO thermal power output is 3 million kWh[10]. The details of the sources of electricity generated by types and imported into the national electricity system in 2021 are summarised in the Table below.

Table 9: Generated electricity by types in the electricity system 2021

Generated electricity by type of electricity source in 2021 (*10^6 kWh*)	
Total generated in the electricity system	**256,731**
Hydropower	78,553
Coal-fired	119,000

[9] National Power Development Plan period 2021-2030, vision to 2050 (PDP VIII)
[10] Summary report on operation of electricity system – National Load Dispatch Center

Generated electricity by type of electricity source in 2021 (10^6 kWh)	
Gas turbine and Steam tail	26,312
Oil-fired	0
Oil-power gas turbine	3
Gas-fired	0
Wind	3,344
Solar	14,851
Rooftop solar	12,940
Biomass	321
Diesel	4
Imported from China	0
Imported from Laos	1,403

3.3.2 Challenges and recommendations to facilitate energy transition

Challenges

Similar to the energy transition for coal-fired power plants, the energy transition with gas-fired power plants will also have to take into account the costs incurred in the process of co-firing combustion with hydrogen fuel, the reduction rate performance in the extended life period, the rate of reduction in efficiency during co-fired combustion and fuel conversion, hydrogen price...

Based on the roadmap for fuel conversion and cessation of construction of new LNG gas-fired power plants, the co-fired conversion approach will aim to develop more sources of hydrogen production from RE or to import hydrogen, backup power, and improve the transmission grid to meet the load demand at the lowest system cost.

According to the report of ETN Global in 2020, turbine manufacturers around the world have confirmed that existing turbines can be co-fired to burn with Hydrogen at a rate of 30-50% and plan to use 100% hydrogen after 2030. With a co-fired combustion rate of 30% hydrogen or less, there is no need to renovate turbines, just renovate the fuel supply and control system of a plant.

Recommendations

- Ensure that currently operational combined cycle gas power plants are kept operational until the end of their technical lifetime and have access to gas either produced domestically or delivered as LNG. Consider the new build of gas power plants if a rapid fuel switch to renewable hydrogen or derived fuels can be ensured from 2035 onwards.
- Deploy natural gas power plants as the third merit order category after intermittent renewable power, standard hydropower, and pumped storage hydropower.

4 Accelerating RE deployment

4.1 Current status of RE sources

In the electricity industry, RE contributes 55.21% of the total installed capacity and 42.85% of the total electricity output in 2021, of which :

- Wind power accounts for 5.28% and 1.3% of total installed capacity and total electricity output, respectively.

- Solar power, including rooftop solar and concentrated solar power, is 21.2% and 10.8%, respectively.
- Biomass is 0.42% and 0.13%, respectively.
- Hydropower contributes the most, with 28.3% and 30.7% respectively[11].

Table 10: RE capacity in 2010-2021 (MW)

	2010	2015	2016	2017	2018	2019	2020	2021
Hydropower	8.180	18.571	20.075	22.079	23.492	24.306	24.746	22.111
Wind power	0	90	90	90	243	377	538	4.126
Concentrated solar power	0	-	-	-	86	4.685	8.852	8.904
Solar rooftop	0	-	-	-	-	-	-	7.660
Biomass	0	45	24	55	175	175	325	325

Source: Technical report on overview of private investment in Vietnam electricity system

Table 11: RE sources in 2010-2021 (GWh)

	2010	2015	2016	2017	2018	2019	2020	2021
Hydropower	27.550	55.712	63.491	85.940	80.081	66.117	72.892	78.883
Wind power					487	724	982	3.344
Concentrated solar power					22	4.819	9576	14.851
Solar rooftop							687	12.940
Biomass	49	143	122	208	488	350	340	321

Source: Technical report on overview of private investment in Vietnam electricity system

The list of RE power plants is listed in the Annex of this Report.

4.2 Challenges and recommendations to accelerate RE deployment

Challenges

Since a large amount of RE sources were added to the system in recent years, plus a number of other adverse objective causes, the operation of the electricity system is encountering many challenges.

An imbalance of source - load by regions in the deployment of RE when wind and solar power sources are developed and exploited.

In the noon's off-peak hours when the load tends to decrease, the solar power sources generate maximum output, causing oversupply and overload.

In order to achieve the RE deployment targets, it is necessary to issue a number of incentive mechanisms for the RE sector. Supporting mechanisms for RE include project development guidelines (PD), sample power purchase agreement (SPPA), FIT pricing, and avoidable cost tariff (ACT)[12].

The table below illustrates the main incentive mechanisms to promote the development of potential RE sources, including small hydropower, wind power, solar power, biomass, and solid waste.

[11] Technical report on overview of private investment in Vietnam electricity system
[12] Technical report on overview of private investment in Vietnam electricity system

Table 12: RE incentive mechanisms.

RE	Incentive mechanisms
Small hydropower	ACT
Waste-to-energy	FIT
Biomass	FIT
Solar power	FIT
Wind power	FIT

Source: Technical report on overview of private investment in Vietnam electricity system

Recommendations

- Expand pumped storage hydropower, starting the expansion of existing sites and preparing new sites in mountainous regions;
- Focus on the sites most conducive to produce high plant load factors for wind (and solar) power;
- Consider solar thermal electricity with molten salt storage for baseload, if costs can be brought down below those of solar PV with battery/pumped hydro storage.

5 Facilitating BESS and hydrogen production from RE

5.1 Current status

BESS

In the context that the electricity system will face many new difficulties and challenges in development, BESS can be considered an effective solution to solve and overcome certain difficulties and challenges including:

- Electricity grid overload caused by RE sources;
- Stabilise the frequency and reduce the reserve requirement for frequency control capacity of the generators in the system;
- Adjust and shift the load chart between peak/off-peak modes of the system.

Hydrogen production from RE

The development of technology in hydrogen production around the world has made substantial progress recently. To increase the efficiency of hydrogen production and lower the cost of hydrogen, producing hydrogen from surplus electricity generated by RE sources is one of the main solutions.

Given that Vietnam has a total potential of onshore wind power of about 217 GW and a total solar power potential is about 1,694 GW, the potential of solar power in particular and RE potential in Vietnam, in general, is very high, while the electricity system of Vietnam has not yet been able to absorb all RE sources that are currently generated, not to mention the new capacity will be put in the system in the future. An effective solution to handle the surplus capacity is to produce hydrogen in order to develop more RE resources.

5.2 Challenges and solutions to facilitate BESS and Hydrogen

BESS

The application and development of BESS can be challenging that ranges from the system design and battery sourcing to commissioning and testing to meet grid compliance requirements. Some other challenges include:

- Resources for maintenance and optimisation to maintain BESS for a long lifetime and high performance;
- The efficiency of BESS systems is less than 100%, so it will be necessary to increase the electricity output from other electricity sources in the system to compensate for the output consumed in the charging/discharging process of BESS;
- The penetration of RE is only about 15% in terms of capacity, equivalent to about 7% in terms of electricity generation;
- The investment in BESS to limit grid overload caused by RE sources is only a temporary solution.

Hydrogen production from RE

The development strategy is facing the following main challenges:

- Hydrogen production, transportation, and storage infrastructure are not yet developed;
- Hydrogen production technology has not been completely developed, leading to the high cost of hydrogen production and not yet being able to deliver economic efficiency;
- Mechanisms, policies, and incentives for the development of hydrogen and safety standards and regulations on the production, storage, transportation, and use of hydrogen have not been available.

Recommendations

- Implement studies and policies to facilitate the application and deployment of BESS and production of hydrogen produced from RE sources, including:
    - In-depth studies on roadmaps, technologies, sites, and models for application and policies to facilitate the investment and deployment of BESS and hydrogen technologies in Vietnam;
    - Introduce incentive policies in the testing phase of technologies, with strong foreign funding.

6 Enhancing and extending the transmission grids

6.1 Status of transmission grids

The electricity system of Vietnam is operated with many voltage levels, from medium voltage levels of 6÷35 kV to high voltage levels of 500 kV, 220 kV, and 110 kV. The 500 kV and 220 kV transmission grids are managed by the National Power Transmission Corporation (EVNNPT), and the distribution grids from 6 kV to 110 kV are under the management of regional Power Corporations.

Table 13: Amount of transmission/ distribution lines and substations in the period of 2015-2020

Year	2015		2016		2017		2018		2019		2020	
Amount	km	MVA	km	MVA	km	MVA	km	MVA	km	MVA	km	MVA
500 kV	6957	22500	7346	26100	7414	29400	7799	33300	8496	34050	8527	42900
220 kV	14198	39103	16589	45028	17126	48553	17861	57441	18391	62236	18477	67824
Total	21155	61603	23935	71128	24540	77953	25660	90741	26887	96286	27004	111724
Growth rate (%)												

Year	2015		2016		2017		2018		2019		2020	
500 kV	5.2	0.7	5.6	16.0	0.9	12.6	5.2	13.3	8.9	2.3	0.3	25.99
220 kV	8.1	11.6	16.8	15.2	3.2	7.8	4.3	18.3	3.0	8.3	0.47	8.98
Total	7.1	7.3	13.1	15.5	2.5	9.6	4.6	16.4	4.8	6.1	0.44	16.03

Source: EVN

Table 14: Total length of transmission/ distribution lines and substations by regions in 2020.

Voltage	Region	Line length (km)	Substation	
			Number of substations	Total capacity (MVA)
500 kV	North	2,991	14	16,500
	Center	2,831	7	7,200
	South	2,705	16	19,200
	Total	**8,527**	**37**	**42,900**
220 kV	North	7,362	57	30,629
	Center	4,626	22	7,693
	South	6,489	57	29,502
	Total	**18,477**	**136**	**67,824**
110 kV	North	12,106	385	36,857
	Center	4,832	141	8,304
	South	7,380	340	39,736
	Total	**24,318**	**866**	**84,897**

Source: EVN

Accordingly, the total length of 500 kV transmission lines has increased at an average of 4.15% per year in the period of 2016-2020. Within 5 years, the total length of 500 kV has been increased by 1,570 km. The capacity of 500 kV substation transformers also rose from 22,500 MVA in 2015 to 42,900 MVA in 2020 (the growth rate in 2016-2020 was 13.78 %/year). In the same period, the total length and the capacity of the 220 kV transmission line and the transformer substation also grew at similar rates, 5.41% and 11.64% on average.

In general, the annual investment in the construction and renovation of the electricity grid system has basically met the country's socio-economic development targets with the improvement in electricity quality over the years. Within 5 years (2016-2020), although the load grew at an average rate of 8.62%/year, the SAIDI index (average power outage time per customer in a year) decreased sharply from 2,281 minutes in 2015 to 356 minutes in 2020. However, there still exist some points on the grids that are fully loaded, locally overloaded, and do not meet the N-1 criteria and the redundancy factor, especially in the North and the South. In case of power failures, grid failures, or high load, the connecting lines are usually overloaded.

6.2 Challenges to enhance and extend the transmission grids to facilitate energy transition

A significant challenge in electricity grid development is that the RE sources that have been registered for investment and have been invested are much larger than expected.

By the end of December 2021, the proportion of unstable electricity sources (including wind, biomass, concentrated solar, rooftop solar power, and small hydropower plants) is quite high. The total installed capacity of these power plants is about 26,197 MW, accounting for 33.5% of the whole system's installed capacity. The increase in the proportion of RE sources has affected the system and market operation as follows:

- Difficulties for System and Market Operator (SMO) in the development of electricity market operation plans due to uncertainties in renewable electricity production forecasts;
- Difficulties for power plants in operation to offer in the electricity market due to uncertainties in renewable electricity production forecasts;
- Surplus solar power capacity at noon (11 am – 1 pm) affects economic regulation and operation of hydropower, coal-fired power, and gas-fired power plants;
- Local overloads in some areas with several renewable power plants lead to reduced capacity and increase supply costs;
- A large number of renewable power plant projects cause difficulties in monitoring, accounting, and controlling electricity systems in real-time[13].

Recommendations

Some solutions to increase grid flexibility and improve integration of RE sources:

- Research on cooperation and connection of power grids with countries in the Mekong sub-region and ASEAN countries at voltage levels of 500 kV and 220 kV;
- Build more transmission lines to connect with RE sources;
- Build High-voltage direct current (HVDC) transmission lines to reduce transmission losses;
- Apply the management of demand to optimize usage time with production output;
- Increase the flexibility of power plants, and build flexible power sources (ICE).

7 Facilitating the establishment and operation of the Center of Excellence for RE

The Center of Excellence in the power sector is still a very new concept in Vietnam with no existing experience. Hence, the study on the experience of existing Operation and Management Center (POM) models and the lessons learned with the Center of Excellence for Offshore Wind in Vietnam can be considered.

7.1 The Center of Excellence for Offshore Wind

Currently, the Institute of Energy (IE) is cooperating with Carbon Trust from the UK to establish the Center of Excellence for Offshore Wind. This center is under the study phase and is expected to be finalised in the near future.

The expected functions of the Center of Excellence:

- Conduct research
- Conduct the training and technology transfers
- Conduct strategic planning, supporting policy research
- Conduct other activities regarding human resource development

The design and functions of the Center are being consulted with relevant stakeholders to get feedback on the realistic application in Vietnam. The international case studies of similar Centers are being studied to draw lessons learned to set up the Center in Vietnam.

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[13] National Power Development Plan period 2021 – 2030, vision to 2050 (PDP VIII)

The following five objectives for the Center of Excellent for offshore wind in Vietnam are being considered:

Skills & training	Capacity building	Standards & accreditation	Research, development & demonstration	First-mover project accelerator
Focus on academic partnerships, practical skills, and training, apprenticeships, to bolster the local Offshore Wind workforce, supply chain	Focus on civil servants and key policy-making bodies to support informed decisions around Offshore Wind integration	Focus on streamlining high-quality standards across Offshore Wind development to increase confidence in the market	Focus on technology R&D to address Vietnam specific Offshore Wind challenges, to foster cross-sector collaboration	Focus on near term support for capacity targets whilst future financing/auction mechanisms are still under development

7.2 POM

Power Construction Consulting Joint Stock Company 2 (PECC2) has developed POM[14] that focuses on the operation, maintenance, and repair of power plant management and operation (solar power, wind power, thermal power, hydropower, and gas power) in Vietnam. Furthermore, EVN Northern Power Service Joint Stock Company (EVNNPS)[15] also has a similar model of POM in operation for many years however the POM developed by EVNNPS has no segment of RE plant operations.

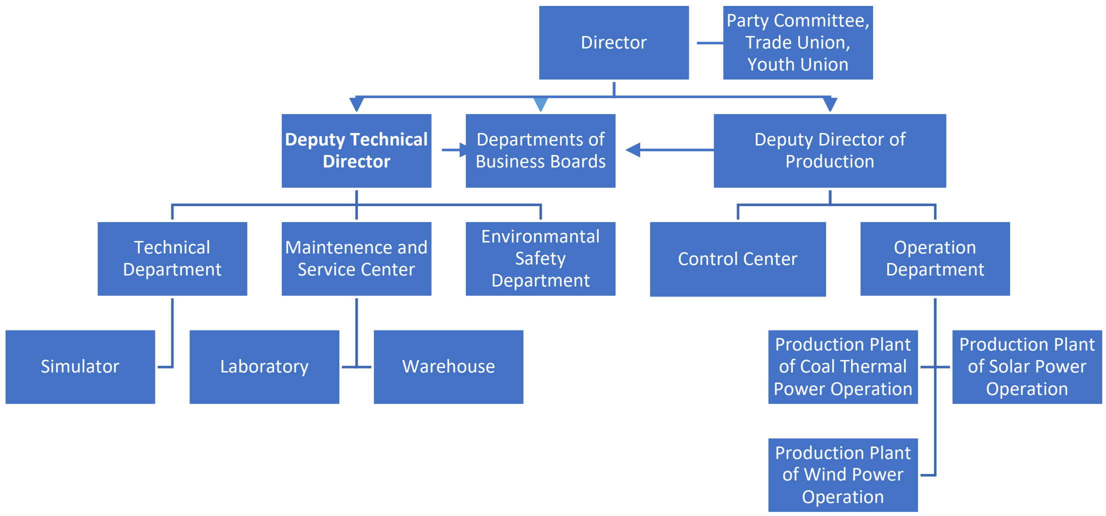
The main functions and missions of a POM include:

- Serving as a project management consultant and a project supervision consultant;
- Consulting on making technical evaluation reports for the project (Technical Due Diligence Report);
- Consulting and verifying the technical design, and construction design of the project;
- Consulting on project handover from trial and operation stages;
- Conducting maintenance, repair, and renovation;
- Conducting tests and experiments.

The organisational chart of PECC2 POM is presented as follows:

[14] PECC2POM. (2023) Introduction of PECC2POM – Operation and Management Center. https://pecc2pom.com/introduction/?lang=en/

[15] EVN North Power Service Joint Stock Company. (2023) https://evnnps.com. vn/



Source: PECC2 Branch - Power Plant Operation and Management Center

Figure 1: Organisation chart of PECC2 POM

8 Gap Assessment and Recommendations for the energy transition in electricity production for Vietnam

Experience from South Africa and Indonesia

With abundant coal resources, South Africa became the world's 13th largest GHG emitter in 2020 with a total emission of about 435 million tCO_2-eq, making the country the largest emitter in Africa[16]. 85% of electricity generation comes from coal; there are 15 CFPPs with a very high average age of 41 years providing 38.7 GW out of a total installed capacity of 52.5 GW of the whole country[17]. The electricity sector accounts for 41% of the country's CO_2 emissions. Eskom, the state-owned electricity monopoly, holds USD 32 billion in debt, which it is struggling to service, and it is characterised by high costs[18]. Therefore, the first priority in the JETP of South Africa is to speed up the phasing out of coal, then to finance innovative technical developments and investments, including electric vehicles and green hydrogen.

In Indonesia, coal has become the dominant fuel in power generation over the past two decades. Coal-fired generation increased more than five times from around 35 TWh in 2000 to nearly 190 TWh in 2021, accounting for nearly two-thirds of Indonesia's electricity generation. During the same period, oil use for power generation halved in absolute terms and its share shrunk from nearly a third in the mid-2000s to about 3% in 2021. Natural gas use in power generation has doubled since 2000, although

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[16] IDDRI. (2022). *Just energy transitions and partnerships in Africa: A South African case study/*. https://www.iddri.org/en/publications-and-events/report/just-energy-transitions-and-partnerships-africa-south-african-case.

[17] The World Bank. (2022). *World Bank approves $497 million in financing to Lower South Africa's greenhouse gas emissions and support a just transition.* https://www.worldbank.org/en/news/press-release/2022/11/04/world-bank-approves-497-million-in-financing-to-lower-south-africa-s-greenhousegas-emissions-and-support-a-just-transit.

[18] World Resources Insitute. (2021). *South Africa Foundation for a Just Transition.* https://www.wri.org/update/south-africa-strong-foundations-just-transition

in recent years it has stagnated and even declined slightly. Electricity generation from hydro, bioenergy, and geothermal increased by nearly four times over the two decades. Combined, these sources provided nearly 60 TWh of generation in 2021, almost a fifth of total electricity production. Wind and solar, on the other hand, are currently negligible in the generation mix, contributing only 1 TWh in 2021. Over the past decade, Indonesia's government has made efforts to reduce its dependence on fossil fuels. The National Energy Law in 2007 and the National Energy Policy in 2014 set goals of reaching a 23% share of renewables in total energy supply by 2025 and 31% by 2050 while increasing annual electricity availability to 2500 kWh per capita by 2025 and 7000 kWh by 2050[19]. Thus, the priorities of JETP of Indonesia are to accelerate the deployment of RE to at least 34% of all power generation by 2030 and the early retirement of coal power plants.

Compared to these two countries, Vietnam is much ahead in deploying RE with the current penetration rate of RE in the system already much larger than the rates in South Africa and Indonesia.

Although the JETPs in the three countries ultimately aim at raising the ambition to increase the GHG emission reduction target in each country, the specific lessons and recommendations for the energy transition in electricity production in Vietnam will obviously be not similar to those of the two other countries given the structures of the electricity production, RE deployment, sources, and potential differ considerably.

In general, what Vietnam can learn in preparing for JETP implementation and negotiations is to set the priorities for JETP finance in line with the national power development plan and roadmap. It should strongly be in favor of the support for the advanced technologies that are most suitable to and in accordance with Vietnam's potential, advantages, and conditions.

Gap Assessment and Recommendations

The targets related to energy committed in the JETP should be informed and reflected in the final approval of the PDP VIII, as discussed under the "challenges and recommendations" sections above.

Based on that the financial needs to meet the energy transition targets under the JETP should be calculated based on the approved final version of the PDP VIII.

In terms of facilitating the transition in energy production, there is a lot more effort to address the gaps in order to be able to set out a clear financial need table and roadmap for the transition. The gap assessment and recommendations for energy transition targets in energy production are identified in line with the key criteria to develop a country-based and comprehensive JETP RMP of Vietnam. They are summarized in the Table below.

Table 15: Gap Assessment and Recommendations for energy transition targets in energy production in Developing the JETP RMP in Vietnam

Criteria	Gaps in terms of energy transition	Recommendations for Vietnam
Negotiation dialogue	The ambition levels in the JETP and energy target should be in line with the strong, specific, and additional financial sources committed	Develop clear and specific demands for international public financing for the JETP that ensure that the burden of financing does not fall on the Vietnamese government or other Vietnamese stakeholders and that financial support committed is additional from the existing sources.

[19] International Energy Agency. (2022). *An Energy Sector Roadmap to Net Zero Emissions in Indonesia.* https://www.iea.org/reports/an-energy-sector-roadmap-to-net-zero-emissions-in-indonesia

Criteria	Gaps in terms of energy transition	Recommendations for Vietnam
Legislative environment	There are big gaps in the legal system to meet the JETP energy target	Short-term: Develop the studies on the comprehensive policies and a legal framework to support JETP energy targets Long-term: Develop and enhance the policies and a legal framework to implement JETP energy commitments and specific targets elaborated in JETP Resource Mobilisation Plan (JETP RMP)
The financing package, its structure, and the distribution of funds	Currently, there has been no assessment conducted on the financial requirements needed and strategies to structure and allocated financial support to meet the targets of JETP energy.	Short-term: Develop a specific target and structure and resources for financing energy elements in the JETP RMP that should be in line with the financial needs and investment plan under the approved PDP VIII. It should be led specifically by MOIT.
Evidence-based strategies and studies	The JETP in Vietnam is currently viewed as a high-level political commitment, lacking scientific studies and evidence-based background reports that can be justified for the measures and strategies proposed to develop JETP Resource Mobilisation Plan (JETP RMP) and then for implementation RMP later.	Short-term: - Conduct a detailed comparison of the JETP energy targets with the targets aimed under the PDP VIII as soon as the PDP VIII is approved. Provide the strategic recommendations if there are any discrepancies between the two groups of targets; - Commission a study on the financial need for meeting JETP energy targets to provide inputs and background for the development of JETP RMP. Long-term: - Commission in-depth research, and scoping studies as listed in the below list of the suggestive studies with timeline and stakeholders.
Engage the public and relevant stakeholders	The JETP is so far only defined on a high level and currently lacking the formal consultation and platform for engaging relevant stakeholders and the public, especially the strong engagement of MOIT and its bodies in charge of energy management and research (such as Institute of Energy) and key stake-owned enterprises in energy sector (Vietnam Electricity - EVN, Vietnam National Coal – Mineral Industries Holding Corporate Limited -	- Specially engage MOIT in the development and implementation of the JETP RMP. - Establish a formal platform for stakeholder engagement to facilitate information sharing and consultation during the development and implementation of the JETP RMP.

Criteria	Gaps in terms of energy transition	Recommendations for Vietnam
	Vinacomin, Vietnam Oil and Gas Group - PVN); and key private representatives of coal-fired thermal power plants, RE plants and potential investors) in the preparation and implementation of JETP RMP.	

Suggestive list for further in-depth studies

The non-exhaustive list of in-depth studies is proposed below that will be conducted in the period from now until the approval of JETP RMP and during the implementation of JETP RMP that are reflected in the challenges identified in this Study.

Table 16: Suggestive list for in-depth studies

Subject	Timeline	Stakeholders	Related to the challenges and recommendations identified above
A series of studies on fuel transition and roadmap for coal-fired power plants, including: - Biomass co-firing solutions for circulating boiling furnace coal-fired power plants; - Ammoniac co-firing solution for pulverized coal-fired power plants; - CO_2 capture and storage solutions for coal power plants. - The application of converting old coal-fired power plants at the end of their service life into BESS.	Now until 2024	Leading agency: MOIT Supporting by: Commission for the Management of State Capital at Enterprises (CMSC) and power plant companies	Accelerate the transition in coal-fired power plants
Study on the minimum capacity of coal power plants needed to guarantee grid stability	Now until 2024	Leading agency: MOIT	
Study on the lifetime of coal power plants needed until their amortization	Now until 2024	Leading agency: MOIT Supporting by: Commission for the Management of State Capital at	

Subject	Timeline	Stakeholders	Related to the challenges and recommendations identified above
		Enterprises, (CMSC) and power plant companies	
Conduct feasibility studies on fuel transition and roadmap for all coal-fired power plants	Now until 2024	Leading agency: MOIT Supporting by: Commission for the Management of State Capital at Enterprises, (CMSC) and power plant companies	
Studies on fuel transition and roadmap for gas power plants, including: - Hydrogen co-firing solutions for combined cycle gas thermal power plants; - CO_2 capture solutions for combined cycle gas thermal power plants.	Now until 2024 for hydrogen co-firing solutions; Now until 2024 for pre-study for CO_2 capture solutions; From 2024 for comprehensive studies for CO_2 capture solutions.	Leading agency: MOIT Supporting by: EVN and gas power plant companies	Facilitate the transition in gas power plants that is important and directly linked to the transition of the coal-fired power plants
Studies on the contributions and barriers to the application of the auction mechanism for RE project to meet the JETP target	Now until 2024	Leading agency: MOIT	Accelerate RE deployment
Study on the contributions and institutional, legal barriers to the application of the mechanism for implementing a direct power purchase agreement project to meet the JETP target	Now until 2024	Leading agency: MOIT	
Study on the process and procedures, and barriers for licensing and investment in offshore wind power projects	Now until the first half of 2024	Leading agency: MOIT Supporting by: MONRE	

Subject	Timeline	Stakeholders	Related to the challenges and recommendations identified above
Study on a price framework for electricity generation from pumped storage hydropower	2024 - 2025	Leading agency: MOIT, EVN	
Studies on the relative cost of concentrated solar power with molten salt storage compared to solar PV with BESS	Now until 2024	Leading agency: MOIT	Facilitate the deployment of BESS
Study on a price framework for electricity generation and storage from the battery energy storage system (BESS)	2024 - 2025	Leading agency: MOIT, EVN	
Study on optimization of combination of RE and BESS and providing recommendations on related policies	2024 - 2025	Leading agency: MOIT, EVN	
Feasibility study on installing BESS at solar power plants	Depending on the price mechanism available to BESS	Leading agency: the project developers of solar power plants	
Study on using the BOOT (Build - Own - Operate - Transfer) model to build a large-scale BESS project	Depending on the price mechanism available to BESS	Leading agency: MOIT, EVN	
Study and assessment of the solutions to produce green hydrogen from RE sources for electricity generation	2024 - 2026	Leading agency: MOIT, EVN	Facilitate the deployment of hydrogen production
Study technologies producing hydrogen, and recommend trial projects for hydrogen production.	2024 - 2025	Leading agency: MOIT	
Study on a roadmap to convert to use hydrogen as fuel	From 2025	Leading agency: MOIT	
Study on the potential sites for plants to produce hydrogen	2023 - 2024	Leading agency: MOIT	
Study on cooperation and connection of power grids with other countries in the Mekong River sub-region and ASEAN at 500 kV and 220 kV voltage levels to enhance the ability for system linking and power exchange	From 2025	Leading agency: MOIT Supporting agency: EVN and EVN Power Transmission Companies	Enhance and extend the transmission grids to facilitate energy transition

Subject	Timeline	Stakeholders	Related to the challenges and recommendations identified above
Study on building HVDC transmission lines	From 2025	Leading agency: EVN and EVN Power Transmission Companies	
Study on demand management to optimize the usage time of electricity in line with the variation of power generation output	From 2025	Leading agency: EVN and Director of National Power System Dispatching Center (A0)	
Background research on the roles, functions, and operations of the Center of Excellence under the JETP	2023 - 2024	Leading agency: MOIT (Institute of Energy)	Facilitate the establishment and operation of the Center of Excellence for RE
Study on the experience of existing POM models in Vietnam and the lessons learned for the Center of Excellence under the JETP	2023 - 2024	Leading agency: MOIT (Institute of Energy)	

Annex

Annex 1: List of coal-fired power plants

No.	Power plant/(COD)	Type/Technology	P design (installed capacity MW)*	Province/City
1	Hai Phong 1 (2011)	Coal thermal power/PC	600	Hai Phong City
2	Hai Phong 2 (2014)	Coal thermal power/PC	600	Hai Phong City
3	Mong Duong 1 (2015)	Coal thermal power/CFB	1080	Quang Ninh
4	Nghi Son 1 (2013)	Coal thermal power/PC	600	Thanh Hoa
5	Ninh Binh (1974)	Coal thermal power/PC	100	Ninh Binh
6	Pha Lai 1 (1986)	Coal thermal power/PC	440	Hai Duong
7	Pha Lai 2 (2001)	Coal thermal power/PC	600	Hai Duong
8	Quang Ninh 1 (2009)	Coal thermal power/PC	600	Quang Ninh
9	Quang Ninh 2 (2014)	Coal thermal power/PC	600	Quang Ninh
10	Thai Binh 1 (2017)	Coal thermal power/PC	600	Thai Binh
11	Uong Bi MR1 (2007)	Coal thermal power/PC	300	Quang Ninh
12	Uong Bi MR2 (2014)	Coal thermal power/PC	330	Quang Ninh
13	Duyen Hai 1 (2015)	Coal thermal power/PC	1245	Tra Vinh
14	Duyen Hai 3 (2016)	Coal thermal power/PC	1245	Tra Vinh
15	Duyen Hai 3MR (2019)	Coal thermal power/PC	688	Tra Vinh
16	Vinh Tan 2 (2014)	Coal thermal power/PC	1200	Binh Thuan
17	Vinh Tan 4 (2017)	Coal thermal power/PC	1200	Binh Thuan
18	Vinh Tan 4MR (2019)	Coal thermal power/PC	600	Binh Thuan
19	An Khanh (2015)	Coal thermal power/CFB	115	Thai Nguyen
20	Cam Pha (2009)	Coal thermal power/CFB	670	Quang Ninh
21	Cao Ngan (2006)	Coal thermal power/CFB	100	Thai Nguyen
22	Formosa Ha Tinh (2015)	Coal thermal power/PC	676.8	Ha Tinh
23	Hai Duong (2021)	Coal thermal power/PC	1200	Hai Duong
24	Mao Khe (2012)	Coal thermal power/CFB	440	Quang Ninh

25	Mong Duong 2 (2015)	Coal thermal power/CFB	1245	Quang Ninh
26	Na Duong (2005)	Coal thermal power/CFB	110	Lang Son
27	Nghi Son 2 (2022)	Coal thermal power/PC	1320	Thanh Hoa
28	Son Dong (2009)	Coal thermal power/CFB	220	Bac Giang
29	Thai Binh 2 (2021)	Coal thermal power/PC	1200	Thai Binh
30	Thang Long (2017)	Coal thermal power/PC	620	Quang Ninh
31	Vung Ang 1 (2014)	Coal thermal power/PC	1200	Ha Tinh
32	Duyen Hai 2 (2021-2022)	Coal thermal power/PC	1320	Tra Vinh
33	Formosa Dong Nai (Unit 1,2 - 2004/ Unit 3 -2018)	Coal thermal power/PC	450	Dong Nai
34	Song Hau 1 (2021)	Coal thermal power/PC	1200	Hau Giang
35	Ve Dan (2015)	cogeneration thermoelectricity	72	Dong Nai
36	Vinh Tan 1 (2018)	Coal thermal power/PC	1240	Binh Thuan
37	Nong Son (2014)	Coal thermal power/CFB	30	Quang Nam
38	Bauxit Lam Dong (auxiliary power)	Coal thermal power/PC	30	Lam Dong

Annex 2: List of gas thermal power plants

10	Power plant	Type	P design (installed capacity MW)*	Province/City
1	Thu Duc (backup power)	Gas turbines	66	Ho Chi Minh City
2	Can Tho (backup power)	Gas turbines	150	Can Tho City
3	Ba Ria (1992)	Gas turbines	388	Ba Ria Vung Tau
4	Phu My 1 (2001)	Gas turbines	1140	Ba Ria Vung Tau
5	Phu My 21 (1999)	Gas turbines	949	Ba Ria Vung Tau
6	Phu My 4 (2004)	Gas turbines	468	Ba Ria Vung Tau
7	Ca Mau 1 (2008)	Gas turbines	771	Ca Mau
8	Ca Mau 2 (2008)	Gas turbines	771	Ca Mau
9	Nhon Trach 1 (2009)	Gas turbines	465	Dong Nai
10	Nhon Trach 2 (2011)	Gas turbines	750	Dong Nai
11	Phu My 22 (2005)	Gas turbines	740	Ba Ria Vung Tau
12	Phu My 3 (2004)	Gas turbines	740	Ba Ria Vung Tau
13	Phu My Fertilizer (auxiliary power)	Gas thermal power	24	Ba Ria Vung Tau

Annex 3: List of RE power plants

No.	Power plant	Type	Design P (installed capacity MW)*	Province/City
1	Rac Soc Son	Biomass power	60	Hanoi City
2	SK An Khe	Biomass power	95	Gia Lai
3	Buorbon	Biomass power	49	Tay Ninh
4	DG AMACCAO Quang Tri 1	Wind power	49.2	Quang Tri
5	DG BT1	Wind power	109.2	Quang Binh
6	DG BT2 Phase 1	Wind power	100.8	Quang Binh
7	DG Cho Long	Wind power	155	Gia Lai
8	DG Dak Hoa	Wind power	49.5	Dak Nong
9	DG Ea Nam	Wind power	399.6	Dak Lak
10	DG HBRE Chu Prong	Wind power	50	Gia Lai
11	DG Hoang Hai	Wind power	49.6	Quang Tri
12	DG Hung Hai Gia Lai	Wind power	100	Gia Lai
13	DG Ia Bang 1	Wind power	50	Gia Lai
14	DG Ia Le 1	Wind power	51.2	Gia Lai
15	DG Ia Pet - Dak Doa 1	Wind power	99	Gia Lai
16	DG Ia Pet - Dak Doa 2	Wind power	99	Gia Lai
17	DG Nhon Hoa 1	Wind power	50	Gia Lai
18	DG Nhon Hoa 2	Wind power	50	Gia Lai
19	DG Nhon Hoi	Wind power	60	Binh Duong
20	DG Yang Trung	Wind power	125	Gia Lai
21	DG Bac Lieu	Wind power	99.2	Bac Lieu
22	DG BIM 4	Wind power	88	Ninh Thuan
23	DG Binh Dai so 2	Wind power	49	Ben Tre
24	DG Binh Dai so 3	Wind power	49	Ben Tre
25	DG Cau Dat	Wind power	60	Lam Dong
26	DG Chinh Thang	Wind power	49.8	Ninh Thuan
27	DG Dong Hai 1 - Phase 1	Wind power	50	Bac Lieu
28	DG Dong Hai 1 - Phase 2	Wind power	50	Bac Lieu
29	DG Dong Hai 1 Tra Vinh	Wind power	100	Tra Vinh
30	DG Hanbaram Lo 2	Wind power	69	Khanh Hoa
31	DG Hiep Thanh	Wind power	77.3	Tra Vinh

32	DG Hoa Binh 1	Wind power	50	Bac Lieu
33	DG Hoa Binh 1 - Phase 2	Wind power	50	Bac Lieu
34	DG Hoa Binh 2	Wind power	50	Bac Lieu
35	DG Hoa Binh 5	Wind power	79.8	Bac Lieu
36	DG Hoa Dong 2	Wind power	72	Soc Trang
37	DG Lac Hoa 2	Wind power	129.9	Soc Trang
38	DG So 7A	Wind power	50	Ninh Thuan
39	DG Tan Phu Dong	Wind power	75	Tien Giang
40	DG Tan Thuan	Wind power	75	Ca Mau
41	DG Thai Hoa	Wind power	90	Binh Thuan
42	DG Trung Nam	Wind power	151.95	Ninh Thuan
43	MT Cu Jut	Solar power	50	Dak Nong
44	MT Dien luc Mien Trung	Solar power	50	Khanh Hoa
45	MT Hoa Hoi	Solar power	214.16	Phu Yen
46	MT KN Van Ninh	Solar power	83.48	Khanh Hoa
47	MT Krong Pa	Solar power	49	Gia Lai
48	MT Long Son	Solar power	137.73	Khanh Hoa
49	MT Phu My 1	Solar power	100	Binh Duong
50	MT Phu My 2	Solar power	93.75	Binh Duong
51	MT Phu My 3	Solar power	80	Binh Duong
52	MT Xuan Thien EaSup 1	Solar power	100	Dak Lak
53	MT Xuan Thien EaSup 2	Solar power	100	Dak Lak
54	MT Xuan Thien EaSup 3	Solar power	100	Dak Lak
55	MT Xuan Thien EaSup 4	Solar power	150	Dak Lak
56	MT Xuan Thien EaSup 5	Solar power	150	Dak Lak
57	MT BIM 2	Solar power	249,346	Ninh Thuan
58	MT CMX Renewable VN	Solar power	143.77	Ninh Thuan
59	MT Dau Tieng 1	Solar power	150	Tay Ninh
60	MT Dau Tieng 2	Solar power	200	Tay Ninh
61	MT Dau Tieng 3	Solar power	150	Tay Ninh
62	MT GAIA	Solar power	75	Long An
63	MT Ho Bau Ngu	Solar power	50	Ninh Thuan
64	MT Hong Phong 1A	Solar power	150	Binh Thuan
65	MT Hong Phong 1B	Solar power	100	Binh Thuan

66	MT KCN Chau Duc	Solar power	58	Ba Ria Vung Tau
67	MT Loc Ninh 1	Solar power	187.5	Binh Phuoc
68	MT Loc Ninh 2	Solar power	187.5	Binh Phuoc
69	MT Loc Ninh 3	Solar power	125	Binh Phuoc
70	MT Loc Ninh 4	Solar power	163.2	Binh Phuoc
71	MT My Son	Solar power	50	Ninh Thuan
72	MT Ninh Phuoc 6.1 and 6.2	Solar power	49	Ninh Thuan
73	MT Phuoc Huu	Solar power	50	Ninh Thuan
74	MT Sao Mai	Solar power	196.35	An Giang
75	MT Thien Tan 1.2	Solar power	85.4	Ninh Thuan
76	MT Thuan Nam 19	Solar power	49	Ninh Thuan
77	MT Trung Nam	Solar power	204	Ninh Thuan
78	MT Trung Nam Thuan Nam	Solar power	450	Ninh Thuan
79	MT Trung Nam Tra Vinh	Solar power	140.8	Tra Vinh
80	MT Xuan Thien Thuan Bac Phase 1	Solar power	125	Ninh Thuan
81	MT Xuan Thien Thuan Bac Phase 2	Solar power	75	Ninh Thuan
82	Viet Nam Sugar Factory	Biomass electricity	60	Khanh Hoa

Annex 4: List of Hydropower plants (capacity larger than 30MW)

No.	Power plant	Type	Design P (installed capacity MW)*	Province/City
1	Lai Chau	Hydropower	1200	Lai Chau
2	Son La	Hydropower	2400	Son La
3	Ban Chat	Hydropower	220	Lai Chau
4	Hoa Binh	Hydropower	1960	Hoa Binh
5	Huoi Quang	Hydropower	520	Son La
6	Tuyen Quang	Hydropower	342	Tuyen Quang
7	Ialy	Hydropower	720	Gia Lai
8	Se San 3	Hydropower	260	Gia Lai
9	Se San 4	Hydropower	360	Gia Lai
10	Pleikrong	Hydropower	100	Kon Tum
11	Thac Mo MR	Hydropower	75	Binh Phuoc
12	Tri An	Hydropower	400	Dong Nai
13	Ban Ve	Hydropower	320	Nghe An
14	Khe Bo	Hydropower	100	Nghe An

15	Dong Nai 3	Hydropower	180	Lam Dong
16	Dong Nai 4	Hydropower	340	Lam Dong
17	Song Tranh 2	Hydropower	190	Quang Nam
18	Da Mi	Hydropower	175	Binh Thuan
19	Da Nhim	Hydropower	160	Lam Dong
20	Da Nhim MR	Hydropower	80	Lam Dong
21	Dai Ninh	Hydropower	300	Lam Dong
22	Ham Thuan	Hydropower	300	Binh Thuan
23	Trung Son	Hydropower	260	Thanh Hoa
24	A Vuong	Hydropower	210	Quang Nam
25	An Khe	Hydropower	160	Gia Lai
26	Song Ba Ha	Hydropower	220	Phu Yen
27	Song Bung 2	Hydropower	100	Quang Nam
28	Song Bung 4	Hydropower	156	Quang Nam
29	Quang Tri	Hydropower	64	Quang Tri
30	Thac Mo	Hydropower	150	Binh Phuoc
31	Buon Kuop	Hydropower	280	Dak Lak
32	Buon Tua Srah	Hydropower	86	Dak Nong
33	Srepok 3	Hydropower	220	Dak Nong
34	Ba Thuoc 1	Hydropower	60	Thanh Hoa
35	Ba Thuoc 2	Hydropower	80	Thanh Hoa
36	Bac Ha	Hydropower	90	Lao Cai
37	Bac Me	Hydropower	45	Ha Giang
38	Bao Lam 3	Hydropower	50.6	Cao Bang
39	Chi Khe	Hydropower	41	Nghe An
40	Chiem Hoa	Hydropower	48	Tuyen Quang
41	Cua Dat	Hydropower	97	Thanh Hoa
42	Hua Na	Hydropower	180	Nghe An
43	Huong Son	Hydropower	33	Ha Tinh
44	Long Tao	Hydropower	44	Dien Bien
45	Muong Hum	Hydropower	32	Lao Cai
46	Nam Chien 1	Hydropower	200	Son La
47	Nam Chien 2	Hydropower	32	Son La
48	Nam Cun	Hydropower	40	Lao Cai

49	Nam Muc	Hydropower	44	Dien Bien
50	Nam Na 2	Hydropower	66	Lai Chau
51	Nam Na 3	Hydropower	84	Lai Chau
52	Nam Phang	Hydropower	36	Lao Cai
53	Nam Toong	Hydropower	34	Lao Cai
54	Ngoi Hut 2	Hydropower	48	Yen Bai
55	Ngoi Phat	Hydropower	72	Lao Cai
56	Nhan Hac A	Hydropower	55	Nghe An
57	Nho Que 1	Hydropower	32	Ha Giang
58	Nho Que 2	Hydropower	48	Ha Giang
59	Nho Que 3	Hydropower	110	Ha Giang
60	Pac Ma	Hydropower	160	Lai Chau
61	Song Bac	Hydropower	42	Ha Giang
62	Song Lo 6	Hydropower	60	Ha Giang
63	Su Pan 2	Hydropower	34.5	Lao Cai
64	Suoi Sap 2A	Hydropower	49.6	Son La
65	Ta Thang	Hydropower	60	Lao Cai
66	Thac Ba	Hydropower	120	Yen Bai
67	Thai An	Hydropower	82	Ha Giang
68	Thuan Hoa	Hydropower	42	Ha Giang
69	Van Chan	Hydropower	57	Yen Bai
70	A Luoi	Hydropower	170	Hue
71	Alin B1	Hydropower	46	Hue
72	Binh Dien	Hydropower	44	Hue
73	Dak Drinh	Hydropower	125	Quang Ngai
74	Dak Mi 2	Hydropower	147	Quang Nam
75	Dak Mi 3	Hydropower	63	Quang Nam
76	Dak Mi 4	Hydropower	208	Quang Nam
77	Dak Re	Hydropower	60	Quang Ngai
78	Dak R'Tih	Hydropower	144	Dak Nong
79	Dong Nai 5	Hydropower	150	Lam Dong
80	Huong Dien	Hydropower	81	Hue
81	Krong H'nang	Hydropower	64	Dak Lak
82	Se San 3A	Hydropower	108	Gia Lai

83	Se San 4A	Hydropower	63	Gia Lai
84	Song Bung 4A	Hydropower	49	Quang Nam
85	Song Bung 5	Hydropower	57	Quang Nam
86	Song Con 2	Hydropower	63	Quang Nam
87	Song Giang 2	Hydropower	37	Khanh Hoa
88	Song Hinh	Hydropower	70	Phu Yen
89	Song Tranh 3	Hydropower	62	Quang Nam
90	Song Tranh 4	Hydropower	48	Quang Nam
91	Srepok 4	Hydropower	80	Dak Nong
92	Srepok 4A	Hydropower	64	Dak Lak
93	Thuong Kontum	Hydropower	220	Kon Tum
94	Vinh Son	Hydropower	66	Binh Dinh
95	Bac Binh	Hydropower	33	Binh Thuan
96	Can Don	Hydropower	77.6	Binh Phuoc
97	Da Dang 2	Hydropower	34	Lam Dong
98	Dam 'Bri	Hydropower	75	Lam Dong
99	Dong Nai 2	Hydropower	73	Lam Dong
100	Srok Phu Mieng	Hydropower	51	Binh Phuoc
101	Xekaman 1	Hydropower	290	
102	Xekaman 3	Hydropower	250	
103	Xekaman Xanxay	Hydropower	32	
104	Bao Lam 1	Hydropower	30	Cao Bang
105	Mong An	Hydropower	30	Cao Bang
106	Trung Thu	Hydropower	30	Dien Bien
107	Nam Na 1	Hydropower	30	Lai Chau
108	Nam Si Luong 1	Hydropower	30	Lai Chau
109	Cum Nam Tha	Hydropower	48.5	Lao Cai
110	Cum Nam Xay Luong	Hydropower	59	Lao Cai
111	Cum Ngoi Xan	Hydropower	49.5	Lao Cai
112	Minh Luong	Hydropower	30	Lao Cai
113	Seo Chong Ho	Hydropower	30	Lao Cai
114	Su Pan 1	Hydropower	30	Lao Cai
115	Suoi Chan 1	Hydropower	30	Lao Cai
116	Cum Que Phong	Hydropower	35	Nghe An

117	Nam Pong	Hydropower	30	Nghe An
118	Cum Nam Chim	Hydropower	36	Son La
119	Ta Co	Hydropower	30	Son La
120	Thanh Son	Hydropower	30	Thanh Hoa
121	Khao Mang	Hydropower	30	Yen Bai
122	Tram Tau	Hydropower	30	Yen Bai
123	Za Hung	Hydropower	30	Quang Nam
124	Son Tra 1A	Hydropower	30	Quang Ngai
125	Son Tra 1B	Hydropower	30	Quang Ngai
126	Dak Ba	Hydropower	30	Quang Ngai
127	Dak Psi 4	Hydropower	30	Kon Tum

Source: Summary report on electricity system operation – National Load Dispatch Centre