Vietnam Initiative for Energy Transition

BIOMASS CO-FIRING AND RENEWABLE PORTFOLIO STANDARD SCENARIOS TO 2030

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This report is written by Mrs. Truong An Ha (Research Analyst), Mrs. Tran Hoang Anh (Research Analyst) and Dr. Ha Duong Minh Xavier (Research Director), Vietnam Initiative for Energy Transition.

This report is reviewed and commented by Mr. Mathis Rogner and Mrs. Mentari Pujantoro of Agora Energiewende; Mrs. Ngo Thi To Nhien (Executive Director) and Mr. Duong Viet Duc (Power grid analyst) of Vietnam Initiative for Energy Transition.

We welcome all feedbacks on the content presented in this report. The authors sincerely thank you and hope that our work could contribute to future decision-making in biomass's planning and development in Vietnam.

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Vietnam Initiative for Energy Transition

7th floor – 18 Ly Thuong Kiet Building

Hoan Kiem, Ha Noi, Vietnam

Telephone: +84 (0) 243 204 5554

Website: **www.vietse.vn**

Email: **info@vietse.vn**

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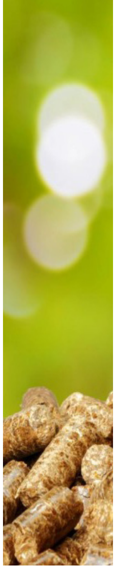


Summary of recommendations

- Vietnam has abundant biomass potential. It is time to implement additional policies such as the Renewable Portfolio Standard to boost the development of the biomass power sector, especially through the deployment of co-firing biomass in existing coal power plants.

- Apply Renewable Portfolio Standard at 13% in 2030 in all coal power plants and meeting the requirement with co-firing technology will help the sector to achieve biomass power development targets set in the Vietnam Renewable Energy Development Strategy.

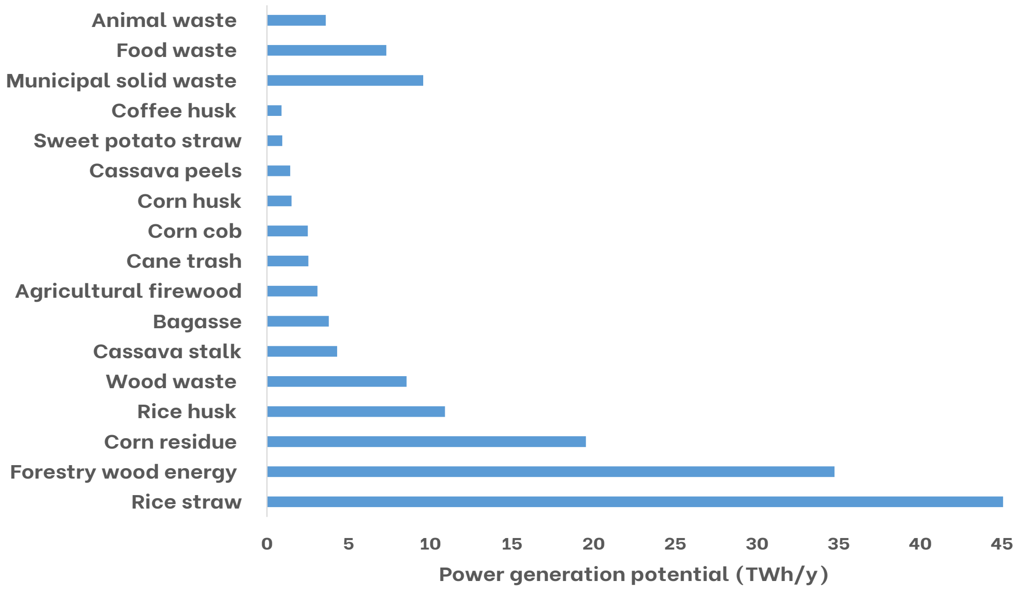
- Co-firing utilizes agricultural residues which has positive impacts on energy security, local air quality improvement, greenhouse gas emission reduction, and waste management.

- Increase the capacity factor of existing coal power plants combined with the deployment of co-firing technology can curve the demand for new coal capacity and fossil fuel import.

- A pilot project in retrofitting existing coal power plants in parallel with establishing biomass supply chains is the next step to unlock biomass potential in Vietnam. Legal documents on supporting mechanisms for biomass power, i.e. Feed-in Tariff, should explicitly include co-firing technology as a subject to such incentives.

1 Introduction

Vietnam is rich in biomass resources, especially from agricultural residues. The total biomass production in Vietnam is estimated at 1500 PJ/y. Theoretically, this amount of biomass could provide up to 150 TWh/y (Figure 1), about 72% of the total power consumption of the country in 2019. The efficient utilization of such potential could help Vietnam power sector to increase the penetration of biomass in the electricity mix and mitigate dependence on coal and other imported fossil fuels.



Source: Author estimation

Figure 1: Theoretical potential power generation from biomass in Vietnam

We describe and evaluate three scenarios for biomass development in Vietnam until 2030 with co-firing technology deployment in coal power plants under different implementations of Renewable Portfolio Standard - RPS (see Box 1): (i) *No new policy* scenario (ii) *RPS by plant* scenario and (iii) *RPS flexible* scenario where RPS is applicable for the five power generation entities: EVN, GENCO1, GENCO2, GENCO3, TKV and PVN.

Box 1: Renewable Portfolio Standard (RPS)

Renewable Portfolio Standard (RPS) is a mechanism that mandates the minimum share of electricity generation from renewable resources.

This mechanism was introduced in the National Strategy for Renewable Energy Development to 2030 with visions to 2050 (Decision 2068/QD-TTg dated 25/11/2015 by the Prime Minister):
Generation and distribution utilities with capacities larger than 1 GW (excluding BOT projects) must produce/provide at least 3% of their electricity from renewable sources (except for hydropower with capacity > 30 MW) in 2020, rising to 10% in 2030 and 20% in 2050.

Box 2: Co-firing technology

Co-firing is the technology that involves the burning of biomass along with coal in coal power plants. This technology has been commercialized in many countries, demonstrating its feasibility on increasing the share of biomass in electricity mix and reducing greenhouse gas and air pollutant emissions by substituting part of the coal consumed in coal power plants with biomass. Co-firing utilizes the existing infrastructure of coal power plants, thus reducing investment costs compared to dedicate biomass power plants. More details about this technology could be found in the International Energy Agency report (IEA-ETSAP and IRENA, 2013).

No new policy scenario: is the business-as-usual scenario where only existing support mechanisms continue to be implemented. These policies are Feed-in-Tariff for (i) waste to power (10 UScent/kWh), (ii) landfill gas recovery (7.28 UScent/kWh)[1], (iii) Combined Heat and Power (CHP) (7.03 UScent/kWh) and (iv) non-CHP projects (8.47 UScent/kWh)[2]. In *No new policy* scenario, co-firing technology is not deployed. This is the reference scenario to compare the impacts brought by co-firing technology applications under the Renewable Portfolio Standard policy.

RPS by plant scenario: In this scenario, the Renewable Portfolio Standard is applied for all existing coal power plants and coal power plants that scheduled to operate before 2030, according to the report updating implementation progress of power projects. The mandate share of renewables in power generation applied for the scenario is 3% from 2020 and 10% from 2030, as stated in the Vietnam Renewable Energy Development Strategy to 2030 with visions to 2050 (Decision 2068/QD-TTg dated 25/11/2015 of the Prime Minister) (see Box 1).

RPS flexible scenario: In this scenario, the mandated share for Renewable Portfolio Standard is applied for the power producers (except BOT projects) that have a total capacity larger than 1 GW at 3% in 2020, 10% in 2030. The power companies that would be subjected to RPS are EVN, GENCO1, GENCO2, GENCO3, TKV, and PVN. Figure 2 presents the share of capacity by energy source of these companies. It shows that fossil fuel, mostly coal, still dominate the capacity mix of these companies.

In the two RPS scenarios, we evaluate the potential of biomass co-firing technology deployment for the plants/power companies to fulfill RPS requirements.

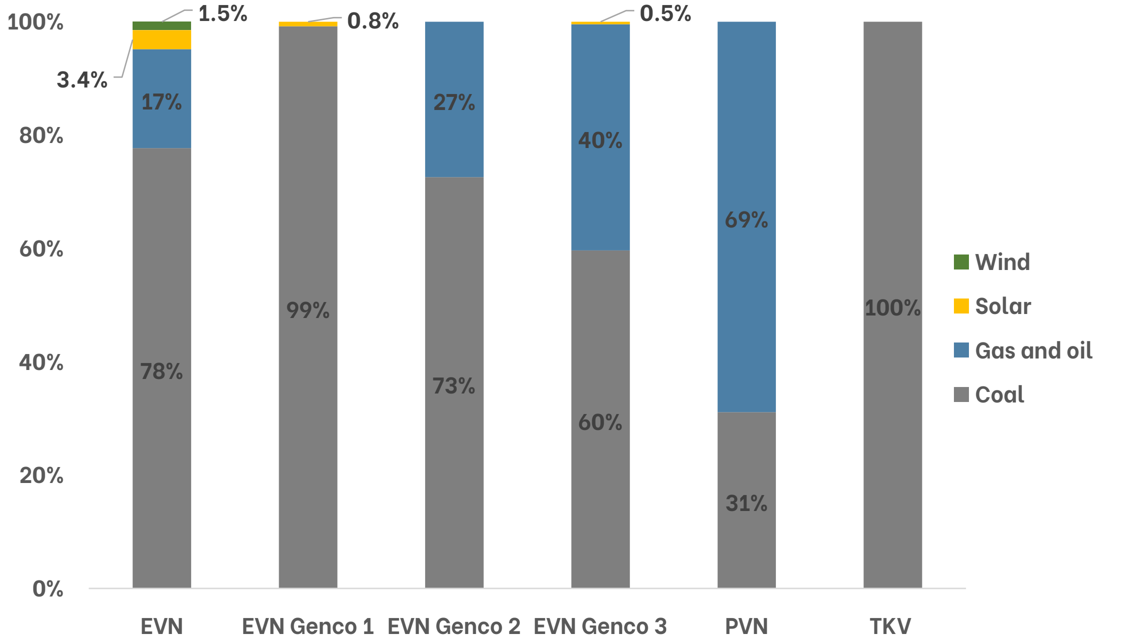
Scenario evaluation is based on the criteria including:

- Biomass-based electricity generation;
- Amount of biomass required;
- Amount of coal saving;
- Costs, and greenhouse gas emission reduction.

In *No new policy* scenario, we based our assumptions on the list of operating, approved and announced biomass power projects. We evaluate our RPS scenarios using a

[1] Decision 31/2014/QD-TTg dated May 2014.

[2] Decision 08/2020/QD-TTg dated April 2020.



Source: (3) (4) and author estimation

Figure 2: Installed capacity (MW) by energy sources of the companies subjected to RPS

spatial explicit optimization approach with BeWhere, a techno-economic engineering model for renewable energy systems optimization. The BeWhere model has been adopted for co-firing biomass with coal in Vietnamese coal power plants (Hoang Anh TRAN, Piera Patrizio, and Juraj Balkovic 2019). These costs include investment cost for co-firing adaptation, fuel cost (coal and biomass), operation and maintenance cost, and biomass transportation cost from supply sites to the plants.

[3] Report 58/2019/BC-BCT dated June 2019.

[4] Decision 2068/2015/QD-TTg dated November 2015.

2 Scenarios analysis

In *No new policy* scenario, three biomass power generation technologies are considered: dedicated biomass power plants, cogeneration in sugar mills and waste-to-power.

The supporting mechanisms for the development of biomass dedicated power plants have been established since 2014 with the Avoided Cost Tariff at about 7.34-7.55 UScent/kWh. Rice husk power plant is the technology that received the most attention as the husk is produced concentratedly in rice mills. Although several investors have showed their intentions to invest in rice husk power plants, there is no such plant built in Vietnam as of today. The reason given by investors was the supporting level of Avoided Cost Tariff is not enough for the project to overcome economic barriers. Since 25/04/2020, the Feed-in Tariff for biomass power plants has been raised to 8.47 UScent/kWh. However, rice husk power plant investors argue that the Feed-in Tariff should be at least 9.58 UScent/kWh to realize the projects. In the *No new policy*, we assume that there will be no dedicated biomass power plants to operate before 2030.

For sugar mills using bagasse to generate power, the FIT at 5.8 UScent/kWh was applied from 2014 to April 2020. This tariff, according to investors, is too low (lower than the average power purchase price from coal power plants at about 7 UScent/kWh) to promote the development of such technology. With the increased FIT after April 2020, the sugar mills are encouraged to expand the capacity of their CHP units. However, Figure 1 shows that bagasse theoretical is moderate, and the existing CHP capacity in sugar mills could utilize about 50% of this potential at most, equivalent to 1.4 TWh/year. With the current project pipeline, assuming all approved and announced projects operate as scheduled, the power generation could reach 2 TWh. According to the Sugar Development Plan (Decision 1369/QD-BNN-CBTTNS), the sugar cane production is stabilized at 20 – 24 Mt/year. Even when all produced bagasse is used for power generation purposes, the maximum electricity produced is only at 4 TWh/year.

Waste-to-power plants are being developed as the pressure for municipal waste treatment is increasing. Ho Chi Minh City plans to increase waste to power capacity to 98 MW by 2021, 138 MW by 2025, and 198 MW by 2030. Hanoi has three projects in its pipeline with a total capacity of 102 MW, Hau Giang province plans to have 12 MW, and Phu Tho intends to have 18 MW. Assuming all projects in construction and approved will be completed as scheduled, the added capacity will be 250 MW with power generation at 1.1 TWh/year in 2030.

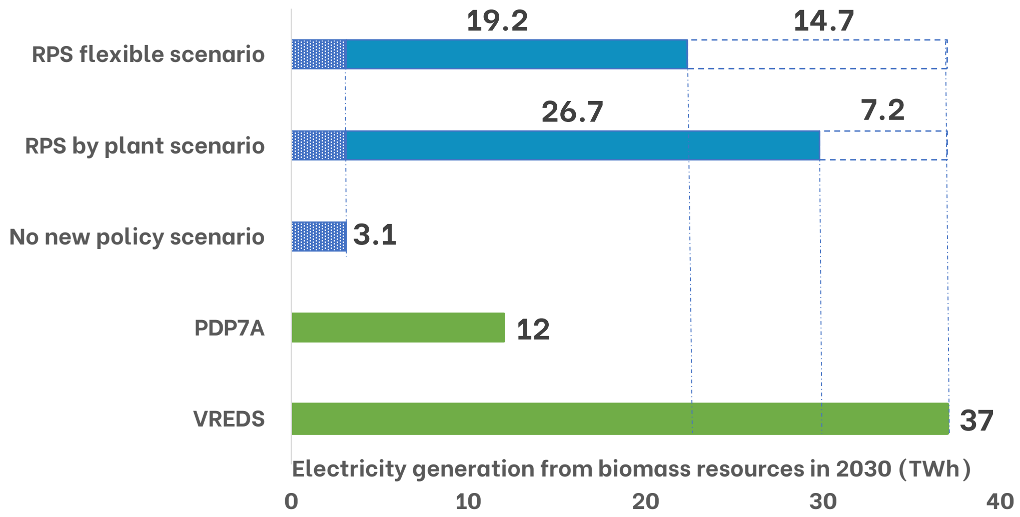
Our estimation shows that in the *No new policy* scenario, the biomass-based power generation would be 3.1 TWh/year in 2030.

In *RPS by plants* and *RPS flexible* scenarios, simulation results show that it is technically feasible to deploy co-firing in the Vietnam context. The output of these scenarios is compared against the *No new policy* scenario and the biomass power targets set by Vietnam's government:

- Power Development Plan in the 2011-2020 period with visions to 2030 (PDP7A).
- Vietnam National Renewable Energy Development Strategy to 2030 with visions to 2050 (VREDS).

In the *RPS by plants* scenario, the amount of electricity generation from biomass with co-firing technology is 7.1 TWh in 2025 and 26.7 TWh in 2030 (Figure 2). This accounts for 1.8% of power demand in 2025 and 4.8% of power demand in 2030 foreseen in PDP7A. In this scenario, co-firing mobilizes 258 PJ of biomass by 2030, accounting for 17% of the theoretical potential of lignocellulosic biomass in Vietnam and reducing 38.6 $MtCO_{2eq}$ by 2025 and 106 $MtCO_{2eq}$ by 2030. The biomass power capacity from co-firing is 1.19 GW in 2025 and 4.46 GW in 2030. With the investment cost of about 430-900 USD/kW (depends on the co-firing technologies deployed), total investment cost by 2030 is estimated between 1.9 – 4 billion USD. Avoided amount of domestic coal import is 6 Mt by 2025 and 13.7 Mt by 2030, and imported coal is 9 Mt by 2025 and 27.6 Mt by 2030. Using the cost for importing coal in 2018 (data from Custom of Vietnam) at 112 USD/t, co-firing could save 1 billion USD from reducing coal imports by

2025 and 3 billion USD by 2030. Reducing domestic coal consumption could save 420 million USD by 2025 and 860 million USD by 2030. Levelized cost of electricity from co-firing technology is estimated over a 25-year lifetime at 7.2 – 7.7 UScent, higher than coal at 6.6 – 7 UScent/kWh (Table 1).



Source: Author estimation

Figure 3: Power generation from biomass in 2030 of the three scenarios compared to targets in the PDP7A and Vietnam Renewable Energy Development Strategy (VREDS)

In *RPS flexible* scenario, although EVN, GENCO 1, 2 and 3 have already invested into some wind and solar projects (for example Phuoc Thai 1, Vinh Tan, Mien Trung solar power and Phu Lac wind power), however, the share of these renewable sources is small compared to total power generation. Wind and solar power generation in 2019 of EVN is 2.3% of the total power generation of the company. This share is 0.3% and 0.2% in GENCO1 and GENCO3, respectively. GENCO2, TKV, and PVN do not have any solar and wind projects in operation in 2019. When RPS is imposed, these companies still need to generate 4.8 TWh in 2025 and 19.5 TWh in 2030 from renewable sources. Our simulations show that co-firing could fill in the gap. Biomass-based power generation could reach 19.2 TWh by 2030, reducing 68.5 $MtCO_{2eq}$ in this scenario. The domestic coal saving is 6.8 Mt in 2025 and 17.7 Mt in 2030, while imported coal saving is 2.5 Mt in 2025 and 8.7 Mt in 2030. These numbers are lower than those of *RPS by plants* scenario. Yet, the cost for producing a unit of electricity is higher. In the *RPS by plants* scenario, the Levelized cost of electricity (LCOE) ranges from 7.2 – 7.7 UScent/kWh compared to 7.3 – 8.5 UScent/kWh of the *RPS flexible* scenario. The levelized cost, calculated for a 25-year lifetime, includes investment, fuel, operation and maintenance, and biomass transportation cost.

Scenario	Year	Biomass-based electricity (TWh)	Emission reduction (Mt CO_2 eq)	Coal saving (Mt)		
				Total	Domestic	Import
RPS by plants	2025	7.1	38.6	15.1	6	9.1
	2030	26.7	105.8	41.3	13.7	27.6
RPS flexible	2025	4.6	24.1	9.3	6.8	2.5
	2030	19.2	68.5	26.4	17.7	8.7

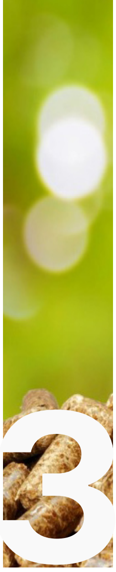
Source: Author estimation

Table 1: Comparison of simulation results of 02 RPS scenarios for 2025 and 2030

In *RPS by plants* scenario, biomass power target set in the Vietnam Renewable Energy Development Strategy could be met if the RPS is raised to 13% in 2030 instead of 10%. In *RPS flexible* scenario, even when RPS is increased to 20% plus some old and low-efficiency coal power plants are converted to 100% biomass, there is still a gap of 14.4 TWh to reach the 2030 target.

The deployment of co-firing technology in coal power plants, however, requires additional cost for retrofitting, which could increase the electricity generation cost. As calculated above, the cost to produce 1 kWh from co-firing is about 7.2 – 7.7 UScent/kWh, higher than the average cost of electricity production from pure coal (about 6.6 – 7 UScent/kWh). These numbers imply that the direct economic to the coal power plants when operating with 100% coal is higher than co-firing. However, the economic viability of co-firing depends on various factors, of which the most important ones are input fuel prices (coal and biomass). Higher coal prices and lower biomass prices could increase the profitability of co-firing and vice versa. Moreover, if the increased FIT at 8.47 UScent/kWh is applicable for co-firing technology, it will increase the economic attractiveness of investing in this technology.

From the macroeconomic perspective, substituting part of coal consumption in coal power plants has a positive impact on the trade balance and national energy security as Vietnam is now a net coal importer. The amount of coal imports is projected upward. Co-firing can also provide socio-economic co-benefits, especially from air pollutant emission reduction.



3 Policy recommendations

Based on the analysis, we propose several recommendations for the development of biomass power sector to utilize abundant biomass resources in Vietnam through the deployment of co-firing in coal power plants.

Implementation of Renewable Portfolio Standard will promote the development of biomass power sector, primarily through the deployment of co-firing biomass with coal in coal power plants.

The biomass-to-power potential in Vietnam, although abundant, has not yet been effectively exploited. Existing policies for biomass power development, first implemented since 2014, have not significantly facilitated the growth of the market and increased the share of biomass in power generation. Thus, the government should set specific targets for each period and establish suitable market supporting mechanisms to boost the development of the biomass power sector. International experiences show that the implementation of the Renewable Portfolio Standard has positive impacts on increasing the share of biomass in the electricity mix.

Apply Renewable Portfolio Standard at 13% in 2030 in all coal power plants, and meeting the requirement with co-firing technology will help the sector to achieve biomass power development targets set in the Vietnam Renewable Energy Development Strategy.

Our analysis shows that the scenario where co-firing in coal power plants can generate an additional 26.7 TWh power in 2030. The simulation result shows that the potential of biomass in Vietnam is sufficient to supply biomass feedstock for co-firing in coal power plants in 2030. Our assessment suggests the RPS application for coal power plants is suitable and helps increasing biomass utilization efficiency as well as contributing to reducing greenhouse gas emission from coal power plants.

The biomass power development target in Vietnam Renewable Energy Development Strategy can be met with co-firing technology if the Renewable Portfolio Standard is at 13% in 2030 instead of 10%, as stated in the Strategy.

Co-firing using agricultural residues has positive impacts on energy security, local air quality improvement, greenhouse gas emission reduction, and waste management.

Studies show that co-firing with agricultural residues (especially rice straw, the largest biomass potential in Vietnam) is a cost-effective way to utilize biomass for power generation while reducing greenhouse gas and air pollutant emissions through co-benefits: (i) offset coal consumption in coal power plant and (ii) reduce the open burning of residues (residues burned in the plant's furnace at higher efficiency and the air pollutants are filtered by plant's control system such as Electrostatic Precipitators, DeNOx and DeSOx). Truong and Ha-Duong (2018) estimated that co-firing rice straw at a 5% mixing rate on heat basis can reduce SO2, NOx, and PM10 by 3-10%. This reduction provides significant health benefits. In our simulation, RPS scenarios demonstrated the emissions reduction potential of co-firing technology up to 106 MtCO2 by 2030. The economic value of these emissions reductions depends on the climate protection policy of each nation. If Vietnam were to apply the carbon tax rate of China or Singapore at 5 USD/tCO2, the economic value will be about 500 million USD. The scenario evaluation also shows the positive impact of co-firing to national energy security through the mobilization of domestic biomass resources and reducing coal import up to 27 Mt/year in 2030.

Increase the capacity factor of existing coal power plants combined with the deployment of co-firing technology can curve the demand for new coal capacity and fossil fuel import.

Co-firing technology provides the flexibility for coal power plants on fuel inputs. Existing coal power plants in Vietnam have capacity factors ranging from 55-73% (equivalent to operating 4800 – 6400 hours per year). Theoretically, the capacity factor of coal power plants can be increased depending on the technology, fuel supply, and other technical factors. If 10 coal power plants in Vietnam, each has installed capacity about 1 GW, increase their capacity factors by 10% and mobilized biomass for the increased fuel demand, then this will compensate for the need to build one new 1 GW coal power plants without increasing coal consumption. However, increasing the capacity factor of coal power plants means the fuel demand will increase. If coal is still used to satisfy the increased demand, then the greenhouse gas emission and imported coal dependency will grow. Increasing capacity factor coupled with biomass co-firing will not extend the demand for coal while delivering socio-economic-environmental co-benefits.

A pilot project in retrofitting existing coal power plants in parallel with establishing biomass supply chains is the next step to unlock biomass potential in Vietnam. Legal documents on supporting mechanisms for biomass power, i.e., Feed-in Tariff, should explicitly include co-firing as a subject to such incentives.

Co-firing technology has several advantages, including (i) lower investment cost compared to dedicated biomass power plants (430 – 900 USD/kW for the former and 1800 – 6000 USD/kWh for the later) (IRENA 2013; 2012) because it can utilize existing facilities of coal power plants, (ii) continuous biomass supply is not required, (iii) possibility of converting coal units to biomass power units. Our analysis demonstrates the potential of deploying biomass co-firing technology in Vietnam.

The economic viability of co-firing depends on market prices of coal and biomass as well as supporting mechanisms i.e., FIT, carbon credits, or renewable credits. International experiences show that co-firing is rarely done without incentives. Hence, it needs supporting policy to realize the technology in Vietnam. For example, regulations on mechanisms to support the development of the biomass power sector should have explicit terms for applying FIT to co-firing technology. Most potential biomass resources (rice straw, rice husk and other agricultural and forestry residues) are scattered. Establishing biomass supply chains and secured biomass supply contracts are essential elements to ensure biomass can be provided in large quantities for co-firing. This will help reducing biomass prices and increase the economic profitability of co-firing.

There are still technical and economic issues related to co-firing technology that are country-specific: biomass collection and distribution system, quality of biomass, boiler technology, and impacts of mixing fuel to boiler operation and efficiency. Therefore, a pilot project applying co-firing in Vietnam is needed to address these issues. The testing can be started in small and old coal power plants with low efficiency, such as Ninh Binh Coal Power Plant. The plant located in an agricultural-residue-rich area and also was a test case for co-firing domestic anthracite with imported coal.

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Vietnam Initiative for Energy Transition

Address: 7th floor – 18 Ly Thuong Kiet Building
Hoan Kiem, Ha Noi, Vietnam

Telephone: +84 (0) 243 204 5554

Website: www.vietse.vn

Email: info@vietse.vn