



Subsidized Deforestation:

10 Years of Biomass Power in South Korea



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Subsidized Deforestation: 10 Years of Biomass Power in South Korea

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Key Findings

- » Biomass power, a false climate solution that burns wood to generate electricity, has surged 42-fold over the past 10 years in South Korea, with the use of imported and domestically sourced wood pellets growing by factors of 28 and 15, respectively.
- » Biomass for electricity emitted approximately 11 million tCO₂ in 2022 alone, which exceeds all the annual forest carbon sink enhancements the government has committed to achieving by 2050, effectively nullifying the government's net-zero commitments in the forest sector.
- » South Korea relies 84% of its wood pellet usage on imports, with more than half coming from Vietnam and the rest from Russia, Indonesia, Malaysia, and Canada, whose supply chains are riddled with legality and sustainability risks.
- » Domestically sourced biomass fuels are found to involve high volumes of roundwood, rather than by-products, and 87% of forest residues for biomass are collected through clear-cutting, with 40% of the permits exclusively issued for logging for biomass.
- » The government plans to increase the use of forest residues for biomass sixfold by 2050, burning more than half of all the domestically harvested wood for energy, which will result in an additional 93 million tCO₂ emissions.
- » As excessive Renewable Energy Certificate (REC) weightings in the country's Renewable Energy Portfolio (RPS) ensure the profitability of biomass, removing these subsidies would be the most effective way to phase out biomass power.

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Abbreviations

AR6	<i>Sixth Assessment Report</i>
AVP	An Viet Phat
Bio-SRF	Bio-solid refuse fuel
Carbon Sink Master Plan	<i>Master Plan for Carbon Sink Improvement</i>
CO ₂	Carbon dioxide
Electricity Basic Plan	<i>Basic Plan for Long-Term Electricity Supply and Demand</i>
ETS	Emission Trading System
Forest Biomass Guidelines	<i>Regulation on the Promotion of the Use and Dissemination of Forest Biomass Energy & Guidelines for Certification of Unused Forest Biomass</i>
Forest Resources Act	<i>Creation and Management of Forest Resources Act</i>
Forestry Sector Carbon Neutrality Strategy	<i>Forestry Sector Strategy to Achieve Carbon Neutrality by 2050</i>
FSC	Forest Stewardship Council
Glasgow Declaration	<i>Glasgow Leaders' Declaration on Forests and Land Use</i>
GHG	Greenhouse gas
KEEI	Korea Energy Economics Institute
KEPCO	Korea Electric Power Corporation
KOEN	Korea South-East Power
IPCC	Intergovernmental Panel on Climate Change
KFS	Korea Forest Service
LCA	Lifecycle analysis
LCOE	Levelized cost of electricity
LULUCF	Land Use, Land-Use Change, and Forestry
ME	Ministry of Environment
MOTIE	Ministry of Trade, Industry and Energy
NIFoS	National Institute of Forest Science
PEFC	Programme for the Endorsement of Forest Certification
REC	Renewable Energy Certificate
Renewable Energy Act	<i>Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy</i>
RPS	Renewable Energy Portfolio
SFM	Sustainable forest management
SOU	State-owned utility
Timber Use Act	<i>Act on the Sustainable Use of Timbers</i>
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Burning Forests, South Korea's #2 Renewable Energy

As the world strives to transition away from fossil fuels, many countries are increasingly relying on a “quick fix” to produce clean energy. Much of the developed world is championing biomass-based power—the burning of wood for electricity and heat. Yet, biomass is an intrinsically flawed solution to climate change. Recent findings in climate and forest sciences consistently indicate that burning biomass emits more greenhouse gases (GHGs) than fossil fuels. Deploying biomass on a large scale would lead to devastating land-use changes that result in far-reaching consequences, including deforestation, biodiversity loss, violating the rights of Indigenous Peoples and local communities, and delayed climate action in meeting the Paris Agreement goals.

South Korea, Asia's fourth-largest economy and the world's ninth-biggest carbon-emitting nation, is also enamored with the false solution of biomass. It has become the second-largest source of renewable energy for the country, surpassing wind energy by sixfold. This dramatic rise was a result of a deliberate policy choice by the Ministry of Trade, Industry and Energy (MOTIE) and the Korea Forest Service (KFS).

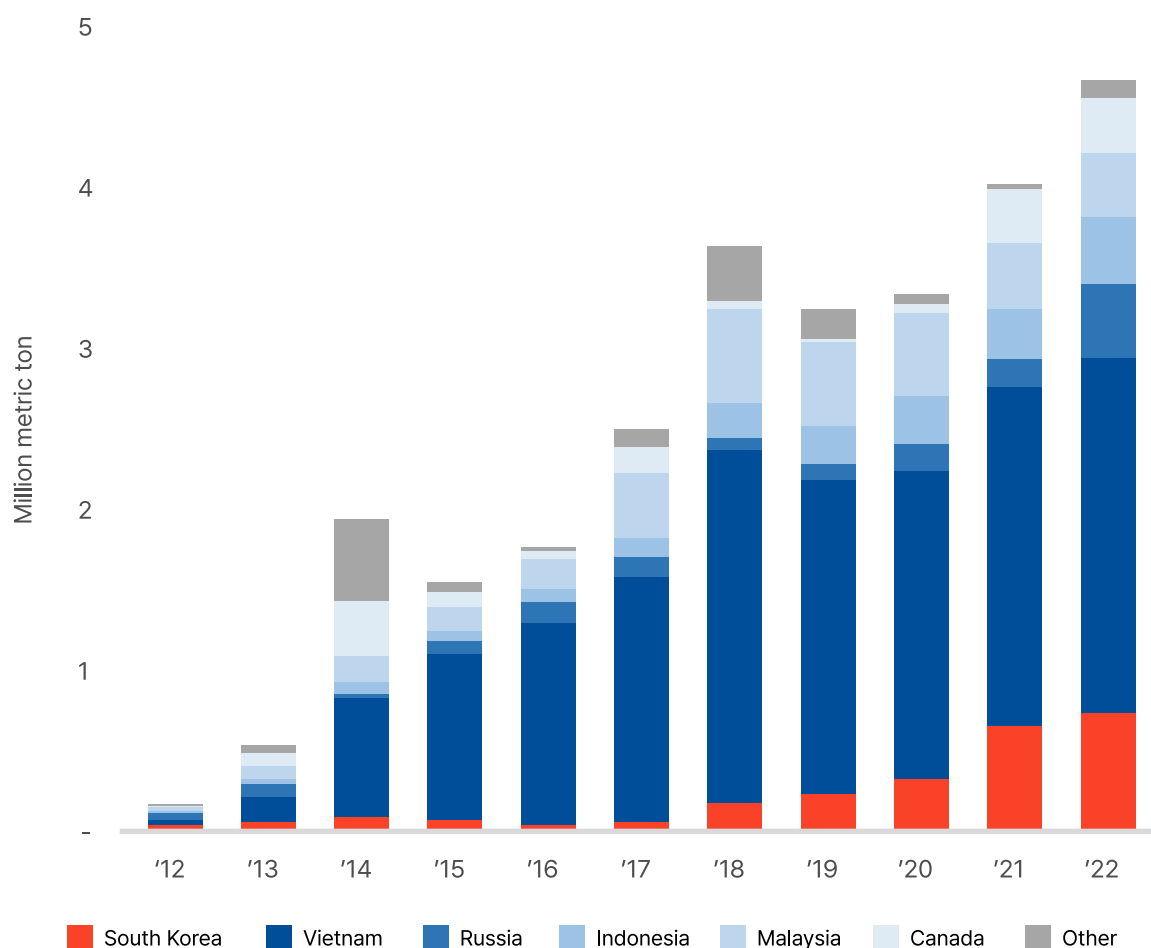
Over the past decade, biomass power generation has grown by a staggering 42-fold, with the use of both imported and domestically sourced wood pellets increasing by factors of 28 and 15, respectively. In particular, the raiding of domestic forests to feed the biomass industry has increased more than fivefold since the introduction of the heightened policy incentives in 2018. To this date, the industry and government alike have justified such forest loss as a result of “utilizing forest residues.”

The expansion of biomass in South Korea is mainly driven by the Renewable Energy Portfolio Standard (RPS). Under this scheme, high indirect subsidies, known as the Renewable Energy Certificate (REC) weightings, buffeted the profitability of renewable energy sources in the country. Adopted in 2012, these support measures resulted in state-owned coal power plants benefitting from coal and biomass co-firing. The RECs for co-firing were eventually scaled back over the years of controversy, but even greater weightings are now granted to biomass-only facilities, doubling down the pressure on domestic forests.

Today, South Korea relies 3.9 million metric tons, or 84.2% of all wood pellets, on imports.

Over half of these come from a single country, Vietnam. Other top source markets by volume include Russia, Indonesia, Malaysia, and Canada. In South Korea, the top three wood pellet mills process much of the domestically sourced 737 thousand tons yet still plan to add more than 50% capacity by 2026.

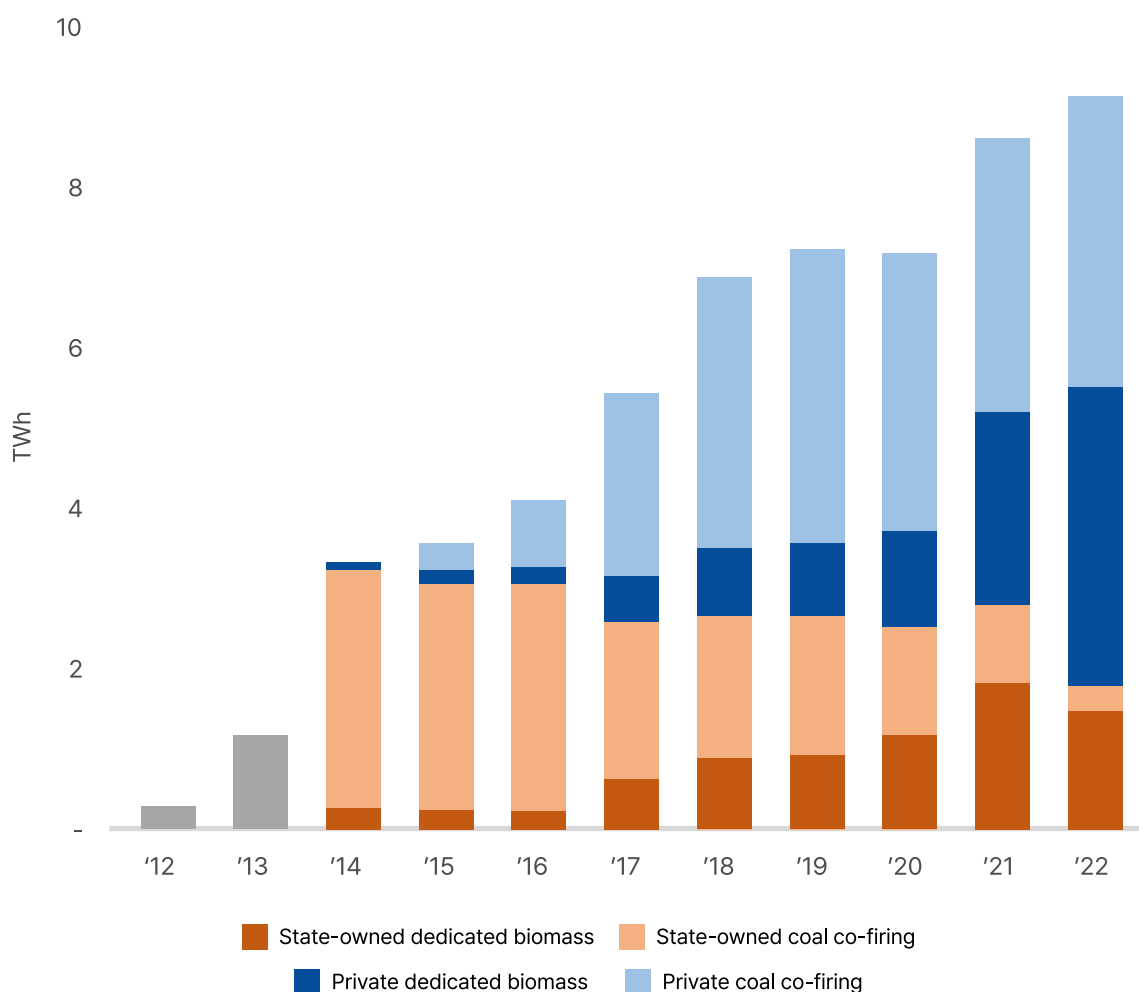
° Total wood pellet consumption in South Korea by country of origin, 2012–2022



Sources: Korea Forest Service; Korea Customs Service.

In terms of electricity generation, 24 utilities are operating 28 dedicated biomass plants, while an additional 10 are running 42 co-firing units, many of which are managed by private power companies. Furthermore, five more plants are currently in the pipeline, set to increase the existing fleet by more than half by 2026. Without substantial policy revisions, the government's ongoing support for biomass power is likely to further exacerbate the paradox of burning forests both at home and abroad, all under the pretext of addressing climate change.

° Biomass electricity generated in South Korea by combustion type, 2012–2022



Sources: Ministry of Trade, Industry and Energy, 2023; Korea Energy Agency, 2022.

Hidden Emissions of Biomass Power in South Korea

Contrary to the myth perpetuated by the industry that biomass is a clean source of energy, biomass power emits more carbon dioxide (CO₂) per unit of energy than coal, oil, or gas. These high emissions are attributed to the low calorific value of wood, which makes it an inherently inefficient fuel source.

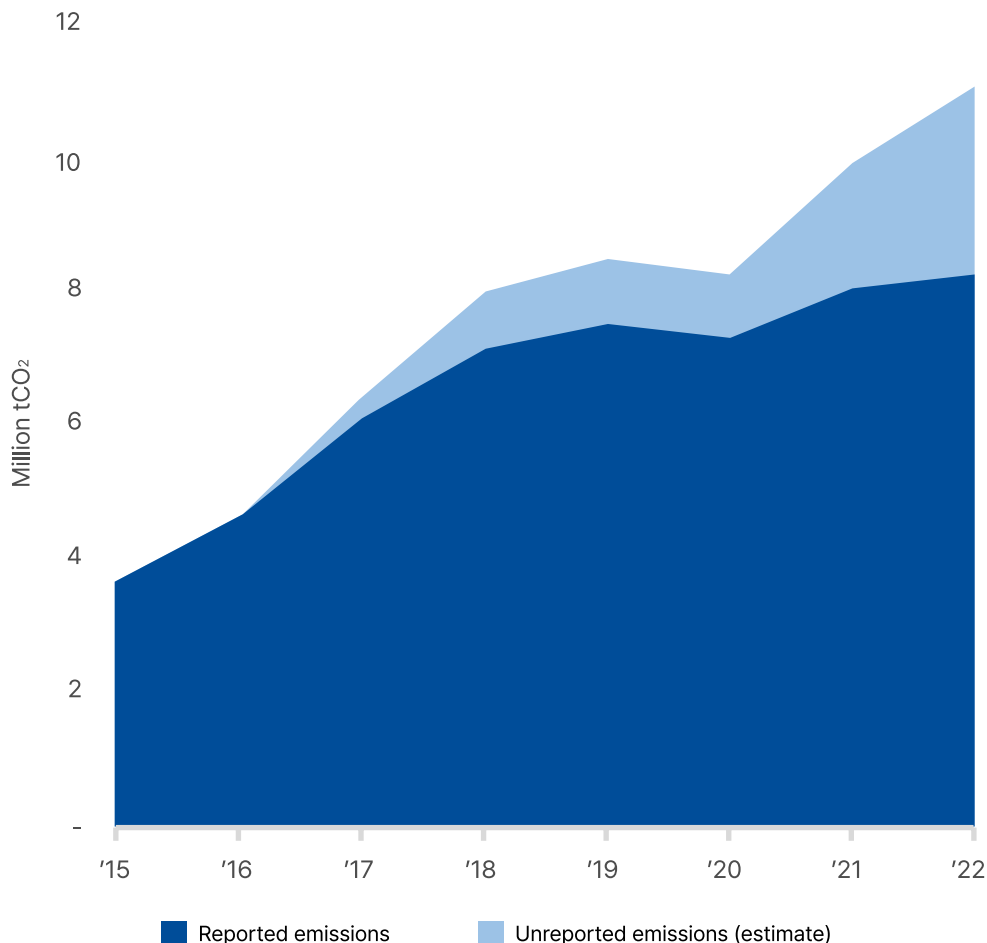
However, biomass emissions at the point of combustion are accounted for in the Land Use, Land-Use Change, and Forestry (LULUCF) sector, instead of the Energy sector, as per the guidelines from the Intergovernmental Panel on Climate Change (IPCC). This unresolved peculiarity in international carbon accounting creates the misleading impression that biomass is zero-emission energy, despite the IPCC's clarification that this technicality does not automatically render biomass as carbon-neutral. In practice, the global warming effect of GHGs

from biomass is comparable to that of fossil fuels. Burning biomass, in itself, is fuel combustion emitting carbon and cannot be equated to a “clean” or “zero-carbon” source of energy like solar or wind power.

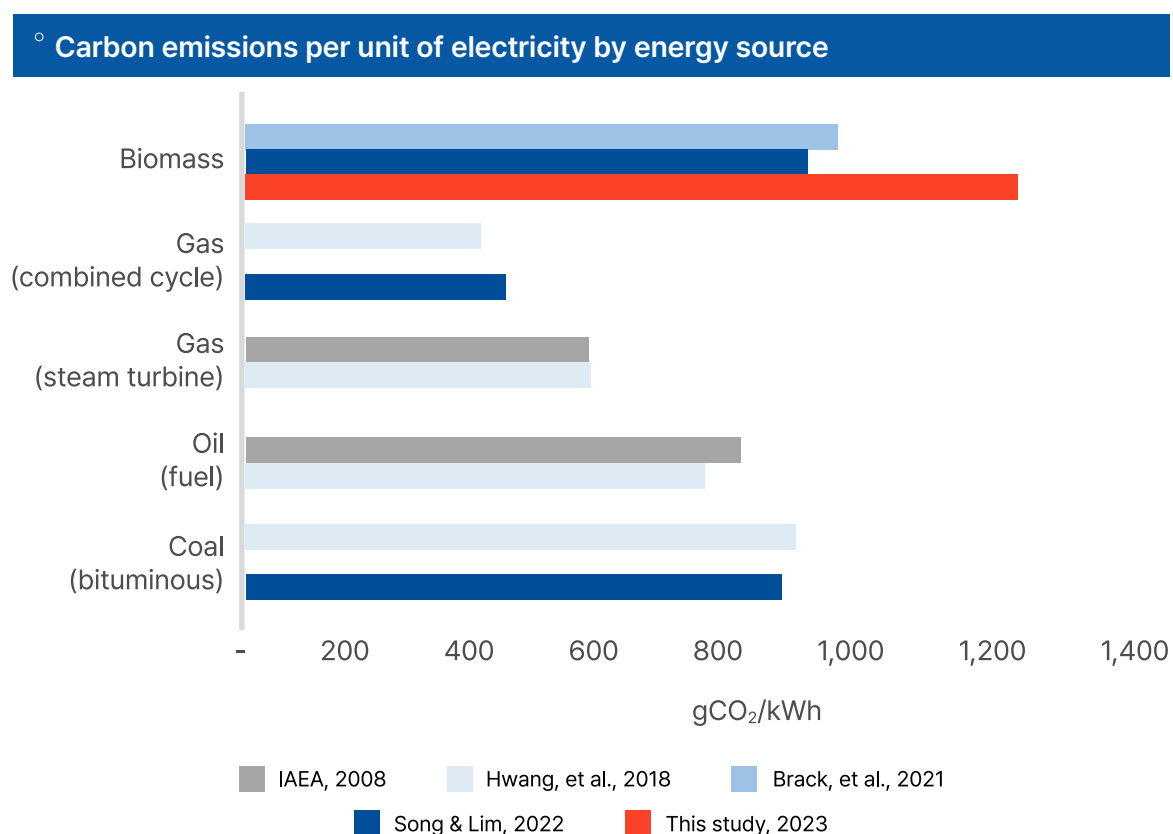
To date, the South Korean government has refused to disclose the CO₂ emissions of biomass power in any of the country’s GHG accounts. The public had no access to this critical data to monitor high-emission activities and hold both the government and private sector accountable. This report represents the first comprehensive analysis conducted in South Korea to unveil the hidden emissions of biomass on a national level.

It is estimated that the biomass power fleet in South Korea emitted 11 million tCO₂ in 2022. This amount is comparable to half of the country’s Agriculture sector emissions and exceeds all the annual forest carbon sink enhancements the government committed to achieving by 2050. Since more than half of all biomass fuels are imported and not accounted for in South Korea’s GHG accounts, this level of emissions effectively negates the government’s net-zero commitments for the forestry sector.

Carbon emissions of biomass power fleet in South Korea, 2015–2022



The research also indicates a threefold increase in emissions since 2015, cumulatively exceeding 60 million tCO₂ over the last eight years. It is estimated that burning one ton of biomass fuel results in an average emission of 1.6 tCO₂, with the generation of 1 kWh of electricity leading to the release of 1.2 kgCO₂. It should be noted that this research investigated only the smokestack emissions, which should be part of the Scope 1 direct emissions of any biomass plant. The entire lifecycle emissions would be even greater if Scope 2 indirect and Scope 3 supply chain emissions are included.



Sources: Song & Lim, 2022; Brack, et al., 2021; Hwang, et al., 2018; IAEA, 2008 (as cited in Hwang, et al., 2018); compiled by author.

The high GHG emissions of biomass conclusively invalidate the claim that biomass contributes to achieving carbon neutrality. Instead of replacing coal, biomass competes with other types of renewable energy for REC subsidies. Logging activities eventually result in the loss of carbon sequestered in forests, with reforestation efforts often falling short of the amount needed to offset the damage.

Even under an ideal scenario in which deforested areas are promptly reforested, for the new trees to grow and absorb the equivalent of the carbon released takes anywhere between 30 to 100 years or even longer. During this time, elevated atmospheric GHG concentrations

would continue to exacerbate the climate crisis. Biomass depletes the remaining international carbon budget without delivering any mitigation benefits, thereby directly undermining the objectives of all climate initiatives.

Forest Biomass, Major Driver of Forest Loss

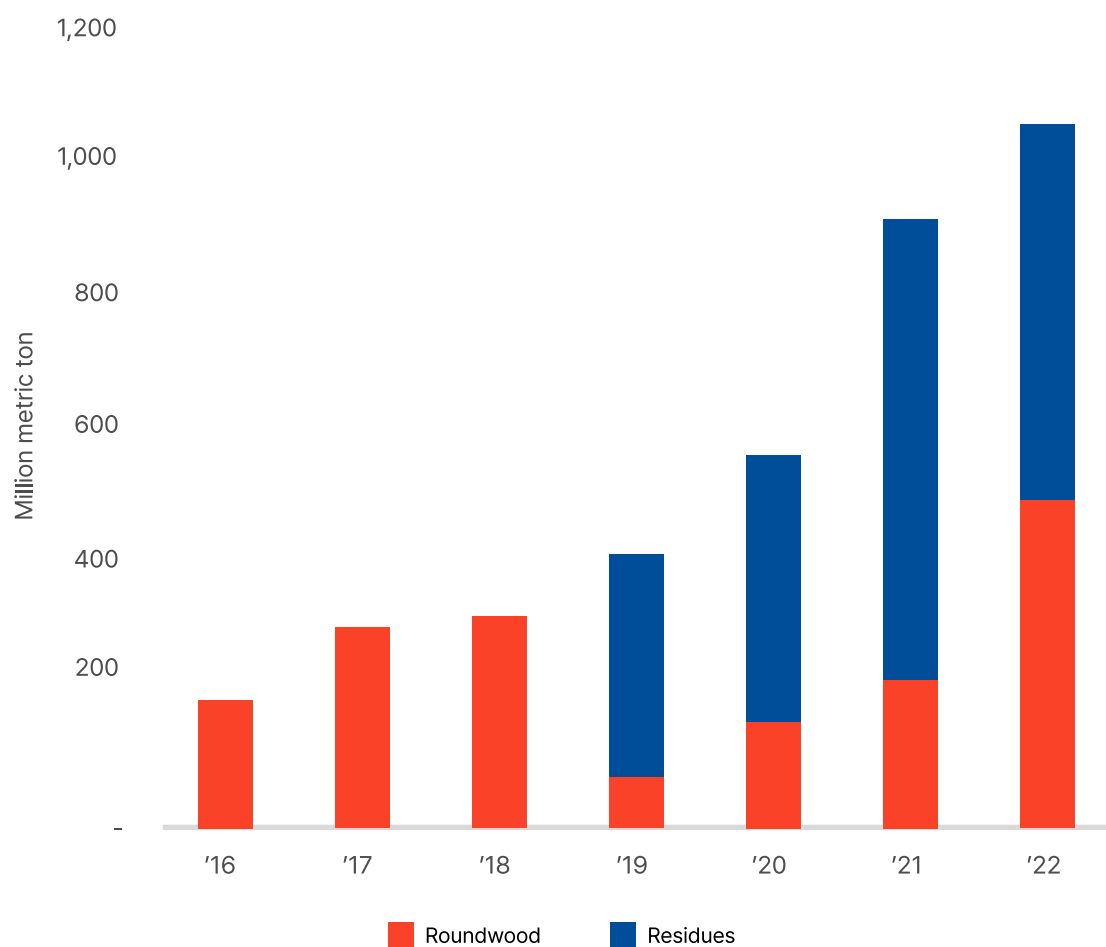
Forest biomass, by definition, inherently involves deforestation and forest degradation as it sources the feedstocks from forests. Despite a series of revisions over the years, the REC scheme in South Korea still heavily subsidizes imported biomass. The *Regulation to Promote Legal Timber Trade*, South Korea's timber legality scheme, is not designed to ensure the sustainability of imported wood pellets. This regulation merely requires a review of the legal compliance of permits from the producer country via a superficial document check at customs, without any substantial due diligence taking place. As a result, it fails to proactively identify the sustainability and legality risks inherent in the supply chain.

Vietnam, South Korea's largest wood pellet trader, is considered a high-risk country for illegal timber, as shown in the instances of fake Forest Stewardship Council (FSC) certifications and possessing a general lack of rigor in sustainable sourcing and verification. Despite repeated scandals, South Korean authorities have yet to take action on Southeast Asian pellet supply chains.

Imports of Russian wood pellets have surged by over 500% since the Russian invasion of Ukraine in 2022, when Russian wood was declared "conflict timber" and subjected to sanctions by international forestry certifications and the European Union (EU). Pellets from Indonesia and Canada have also raised mounting criticism for intensive logging of primary and natural forests, yet South Korea has increased imports from both countries.

South Korea's energy and forestry laws not only allow the use of domestic roundwood outright but actively subsidize it, often falsely classifying it as forest residues. Over the past five years, the influx of roundwood into wood pellet production has increased by more than five-fold. Illicit attempts at disguising high volumes of roundwood biomass as forest residue fuels to receive high REC weightings are widespread.

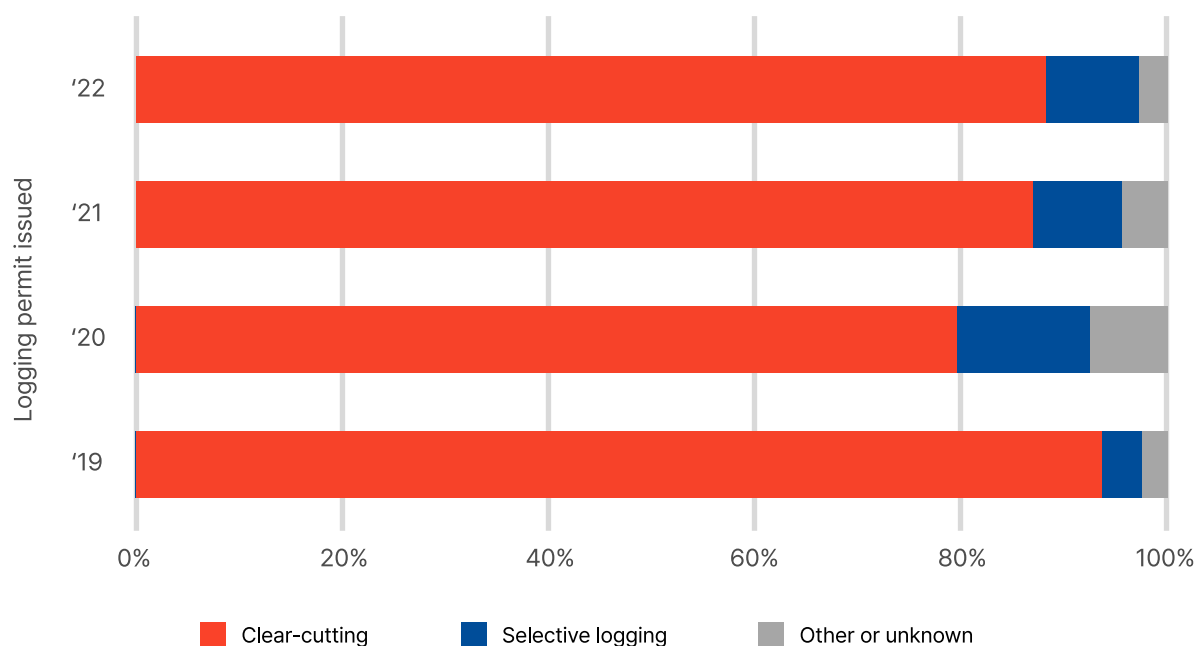
° Wood used for biomass fuels in South Korea by wood type, 2016–2022



Source: Korea Forest Service, 2013–2023.

In terms of forest residues themselves, this research has identified that an average of 87% are harvested through clear-cutting (removing all the trees in an area of forest). Of all the logging licenses that permitted the collection of forest residues for biomass, 40% are exclusively granted for biomass extraction and 22% came back with more residues for fuels than actual harvests, collectively indicating that the primary purpose of logging has shifted to feeding the biomass industry. These findings contradict the KFS claims that only forestry by-products with no other uses are utilized for biomass power. Evidently, forest biomass has become a major cause of forest loss in South Korea.

° Certified forest residues in South Korea by means of logging, 2019–2022



Source: Korea Forest Service, 2023; compiled by author.

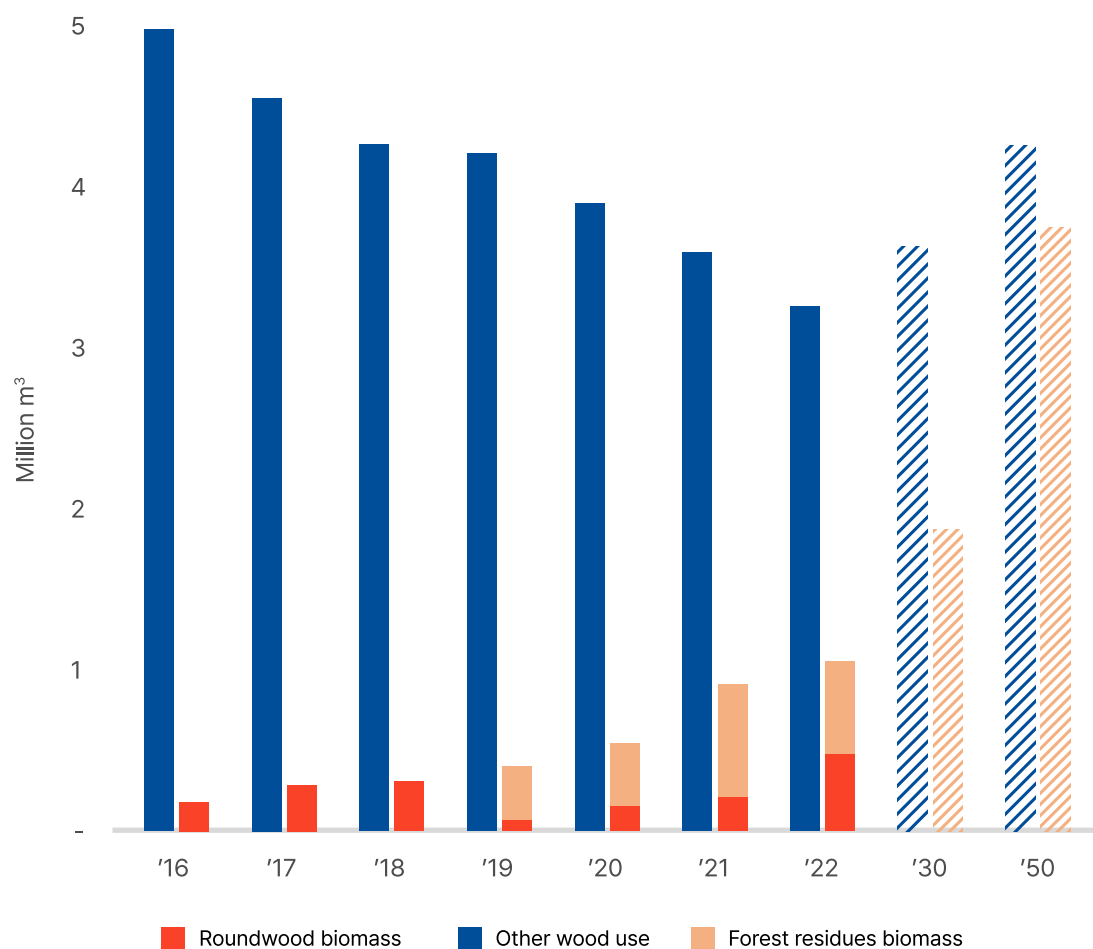
Subsidized and Outsized Market for Biomass

The fundamental problem with South Korea's biomass-related legislation and policies is that they fail to consider the numerous adverse climate and environmental impacts. Forest biomass is an expensive energy source, with its electricity cost higher than that of solar or onshore wind. The creation of this industry thus was only possible by the MOTIE's generous REC weightings, which effectively guarantee corporate profits for deforestation.

These subsidies have created unfair competition with clean renewable energy sources and caused market distortion in the forestry sector. Additionally, the introduction of additional credits for biomass from forest residues, when power plants already receive high legacy weightings, has resulted in an uncontrolled expansion of the overall biomass market. Critics urge the government to abolish REC weightings for biomass power, as the MOTIE is scheduled to update the scheme in the second half of 2024.

The KFS's *Forestry Sector Strategy to Achieve Carbon Neutrality by 2050*, finalized in 2021, also builds on from the faulty assumption that all biomass is inherently clean. The Strategy sets a controversial annual production target of 3 million tons of forest residues by 2050, which equates to half of the country's timber being incinerated as fuelwood, emitting over 93 million tCO₂ cumulatively.

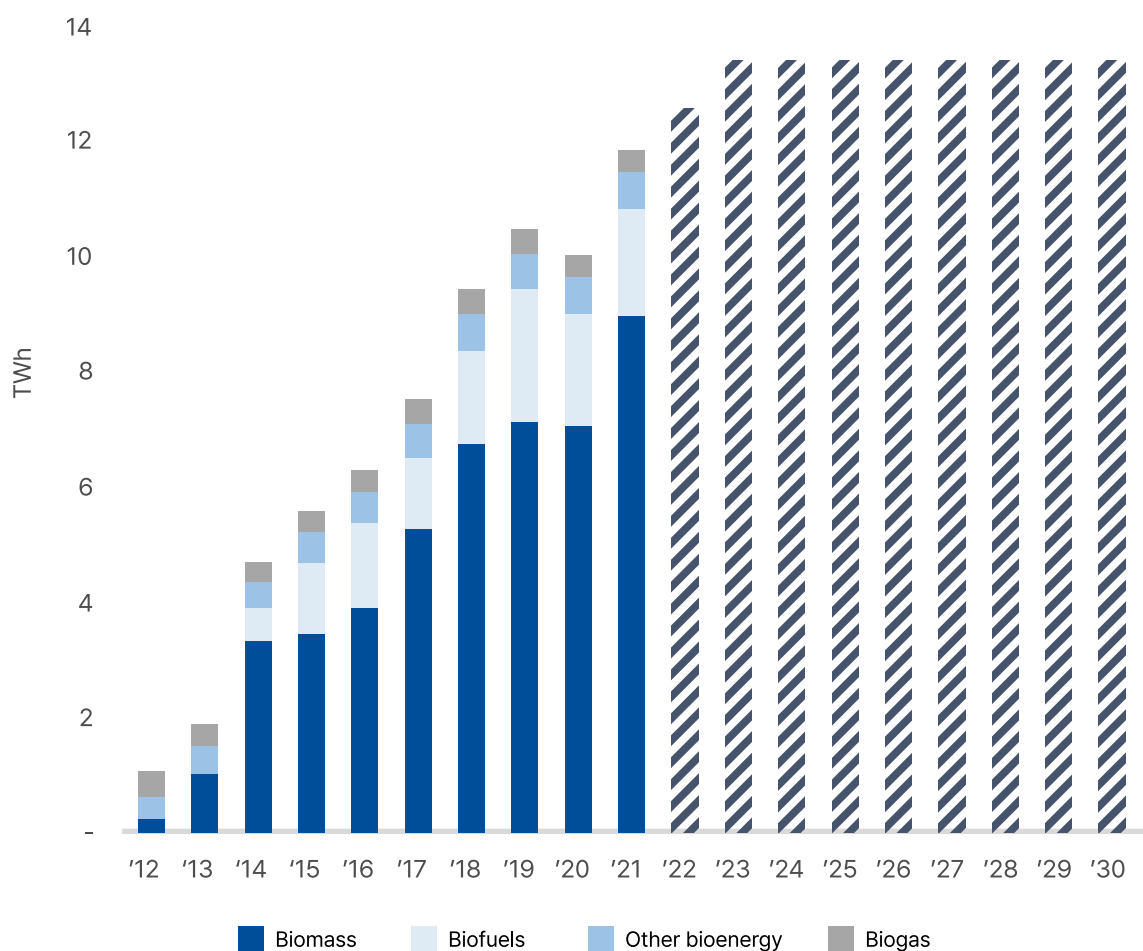
° KFS domestic production targets for forest biomass



Source: Korea Forest Service, 2021; compiled by author.

In 2022, the Yoon Suk-yeol administration presented its own forest policies, such as the *Forest Renaissance Strategy* and the *3rd Master Plan for Carbon Sink Improvement* yet followed the footsteps of the previous government's policies. Notably, the overt promotion of forest biomass in these initiatives deviates from the consensus reached through public-private consultations in 2021. These ambitious plans of the KFS in recent years also contradict the MOTIE's *10th Basic Plan for Long-Term Electricity Supply and Demand*, which calls for freezing the bioenergy generation capacity at 2023 levels. To halt deforestation and forest degradation both at home and abroad, there is an urgent need for a thorough overhaul of the premises and directions of energy and forest policies.

° MOTIE outlook on bioelectricity generation



Source: Ministry of Trade, Industry and Energy, 2023; compiled by author.

Policy Recommendations

A. Resetting of Policy Direction and Withdrawal of Production Targets

Recognizing that biomass cannot be considered equal to genuine renewables due to its carbon-emitting nature, the government should undertake a comprehensive overhaul of energy and forest policies. To mitigate climate change and achieve net-zero goals, it is crucial to shift the policy emphasis from quantitative targets to an immediate halt to coal co-firing and a time-bound phase-out of industrial scale biomass.

Specifically, the MOTIE should reduce the projected capacity for bioenergy in its electricity plans. The objective should be to phase out biomass power in the early 2030s, in line with

the coal phase-out schedule compatible with the 1.5° C mitigation goal. The KFS should retract the production targets for forest residues specified in its forestry plans.

B. Prohibition on Use of Domestic Roundwood and Imported Biomass

Recognizing that forest biomass intrinsically leads to deforestation and forest degradation, the government should ensure transparency and traceability throughout the biomass supply chains.

The MOTIE and the KFS should investigate the use of roundwood, from logging to mills, power plants, and REC-issuing practices. The use of timber for biomass above the grade of fuelwood should be strictly prohibited, with pellet and chip production allowed only on an exceptional basis when it is proven to have no other uses.

Imported biomass, which emits GHGs during transportation and has unverifiable sustainability status, should be disqualified for REC weightings and subject to a time-bound phase-down.

C. Limit on Forest Residues Use to Small-Scale and Decentralized Plants

Recognizing that the current definition and scope of forest residues for biomass are overly broad and vague that this institutional gray area is allowing for intensive logging for large power utilities, the government should introduce feedstock restrictions to prevent such exploitation.

The primary purpose of using forest residues lies in the resource circulation of low-value by-products derived from conventional forestry activities. The KFS should exclude wood from large-scale land conversion, wood harvest, species conversion, and precautionary logging from natural disasters from the scope of eligible forest residues.

Priority use of these residues should be granted to small-scale and decentralized heating facilities located in the same region where the forest residues are collected. In parallel, the MOTIE should prohibit their burning in large power plants with high GHG emissions.

D. Cancellation of Renewable Energy Certificates for Biomass

To effectively phase out biomass power in South Korea, the MOTIE should abolish the REC weightings for biomass, which have been propping up this inefficient and expensive power source.

The earliest opportunity for this will be the 4th triennial revision of the weighting scheme scheduled for 2024. The REC weightings for regular wood pellets and chips, forest residues, and bio-SRFs (solid refuse fuels) for future facilities should be immediately removed, irrespective of the country of origin or combustion type.

The legacy REC weightings given to facilities that began operations prior to 2018 and have been subject to interim measures should be phased out by 2025. The current REC weightings given to facilities that commenced operations between 2018 and 2023 should be phased out by 2028. As an exception, small-scale and decentralized combined heat and power facilities using locally sourced forest residues can maintain their current weightings.

1. Introduction

Over the years, the international community has diligently crafted strategies to address the pressing double crises our time, those of the climate and ecosystems. Significant milestones symbolizing the international commitment include the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement in 2015 and the Convention on Biological Diversity (CBD) Global Biodiversity Framework in 2022. Built upon the well-established consensus that time is rapidly running out for the entire biosphere, the recently released *Sixth Assessment Report (AR6)* by the Intergovernmental Panel on Climate Change (IPCC)¹ unequivocally reiterates the need for immediate and deep reductions in greenhouse gas (GHG) emissions to avert the impending “climate time bomb.”²

The recommendations from the academic community, spearheaded by the IPCC, have always remained the same. The most efficient and cost-effective option to tackle the climate crisis lies in solar and wind energy thanks to their unparalleled potential for emissions reduction. While the conservation and restoration of forests and other ecosystems may entail comparatively higher costs, they can yield mitigation effects on par with those of solar and wind.³

This pivotal role of forests in combatting climate change was reaffirmed when 145 countries participated in the Glasgow Leaders’ Declaration on Forests and Land Use (Glasgow Declaration) during the UNFCCC 26th Conference of the Parties (COP26) in 2021. As per the Glasgow Declaration, nearly every nation, including South Korea, has pledged to halt and reverse forest loss and land degradation by 2030.⁴

1 Intergovernmental Panel on Climate Change. (2023). *Climate change 2023: Synthesis report*. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. <https://doi.org/10.59327/IPCC/AR6-9789291691647>

2 United Nations. (2023, March 20). *Secretary-General calls on States to tackle climate change ‘time bomb’ through New Solidarity Pact, Acceleration Agenda, at launch of Intergovernmental Panel report*. <https://press.un.org/en/2023/sgsm21730.doc.htm>

3 Intergovernmental Panel on Climate Change. (2023). *Figure: SPM.7* [Figure]. IPCC Sixth Assessment Report. Working Group III. Mitigation of Climate Change. <https://www.ipcc.ch/report/ar6/wg3/figures/summary-for-policymakers/figure-spm-7/>

4 UK Government. (2021, November 2). *Glasgow Leaders’ Declaration on Forests and Land Use*. UN Climate Change Conference UK 2021. <https://webarchive.nationalarchives.gov.uk/ukgwa/20230418175226/https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use/>

Despite South Korea having an ambitious target to achieve net-zero emissions by 2050, it falls woefully short at 57th out of 60 countries in an assessment of climate change responses in 2023. This underperformance stems from the downgrading of renewable energy targets for 2030 and the controversies surrounding its forest policies based on the clear-cutting of existing forests and planting new trees.⁵ Simultaneously, the government vigorously advocates the expansion of forest biomass energy, incentivizing it by issuing Renewable Energy Certificates (RECs) with weightings equal to or higher than those for solar and wind.

Forest biomass, which generates energy by burning wood from forests, is innately more akin to fossil fuels than clean renewables. In 2022 alone, biomass emissions reached approximately 11 million tCO₂ in South Korea, with an average emission per unit of energy exceeding that of fossil fuels. The scientific community warns that achieving carbon neutrality using biomass, even by planting new trees where those were felled, would require several decades to over a century.

Nevertheless, an exclusive focus on quantitative expansion without consideration of sustainability has propelled biomass to snowball into the second-largest source of renewable energy in South Korea, dwarfing wind energy production by nearly sixfold.⁶ Meanwhile, the government's commitment to transitioning from large-scale electricity-only biomass to less environmentally detrimental small-scale and decentralized energy production has been sidelined.

The core of any energy transition with the aim of near- and mid-term climate change mitigation and carbon neutrality must be clean renewable energy, such as solar and wind. The primary focus of nature policies should be on conservation efforts aimed at preventing deforestation and forest degradation. The increase of carbon sinks should primarily occur through reforestation and afforestation on abandoned lands and other suitable areas rather than through a cycle of logging and replanting in existing forests.

5 Climate Change Performance Index. (2022). *Republic of Korea*. <https://ccpi.org/country/kor/>

6 Korea Energy Agency. (2022). 2021년 신재생에너지 보급통계 [Data set]. New and Renewable Energy Center. <https://www.knrec.or.kr/biz/pds/statistic/view.do?no=170>

During this process, using forest biomass for energy should be restricted to feedstocks that meet stringent criteria, allowing no room for adverse impacts on the health of forests both domestically and globally. The existing REC weightings that incentivize combustion in large power plants should be promptly eliminated.

In light of these considerations, this report aims to offer a comprehensive overview of the state and limitations of forest biomass in the South Korean context. Subsequently, the report underscores the issues associated with support schemes for biomass and their role as a major driver of deforestation and forest degradation. Lastly, it provides policy recommendations to the South Korean government for an effective and immediate phase-out of forest biomass.

2. Overview of Forest Biomass for Energy in South Korea

The term “biomass” originally falls within the realm of ecology, encompassing all organic matter present within a specific area or volume, primarily describing its physical quantity. The contemporary usage of the term has been slightly shifted to refer to the utilization of organic matter as an energy source for various human needs, most notably electricity and heat. In accordance with common conventions and the context of the South Korean laws, this report adopts the term “bioenergy” to describe all energy derived from the conversion of organic matter.

Within bioenergy, solid fuels employing wood as a primary source are collectively labeled as “biomass.” Biomass includes a range of materials such as wood pellets, wood chips, firewood, charcoal, and bio-SRFs (solid refuse fuels). In this category, the report further distinguishes “forest biomass,” which comprises raw materials obtained from forestry operations or collections, and “other woody biomass,” which consists of feedstocks originating from diverse industrial sectors, including waste wood and plant-based SRFs (Table 1).

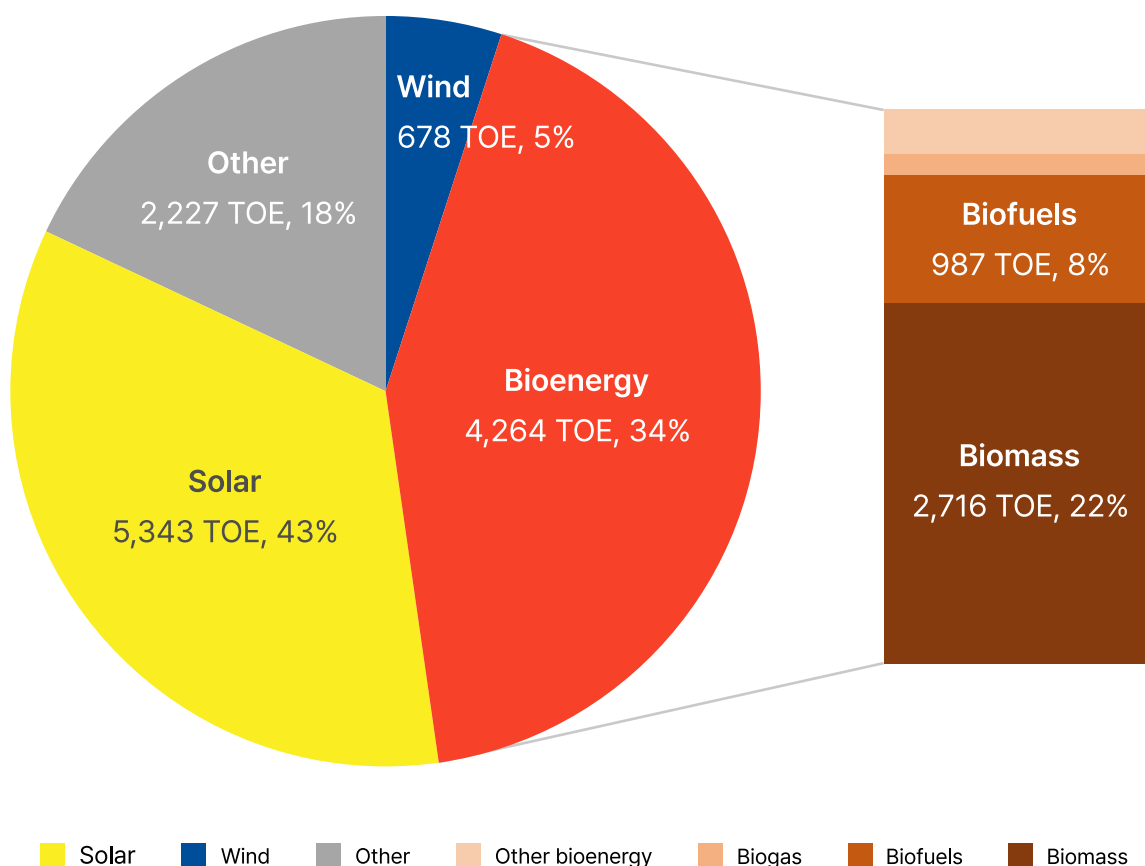
Table 1. Categorization of biomass energy

Renewable energy					
Solar, wind, etc.	Bioenergy				
	Biogas	Liquid biofuels	Biomass		
			Other woody biomass	Forest biomass	
			Bio-SRFs	Wood chips	Wood pellets

2.1. Forest Biomass, Country's Second-Largest Source of Renewable Energy

This study primarily focuses on forest biomass. In South Korea, bioenergy contributes to 34.1% of domestic renewable energy production, with biomass accounting for 63.7% of all bioenergy. This makes bioenergy the second-largest source of renewables, following solar power and heat, and surpassing wind energy by over six times (Figure 1).

° Figure 1. Renewable energy produced in South Korea by source, 2021



Source: Korea Energy Agency, 2022.

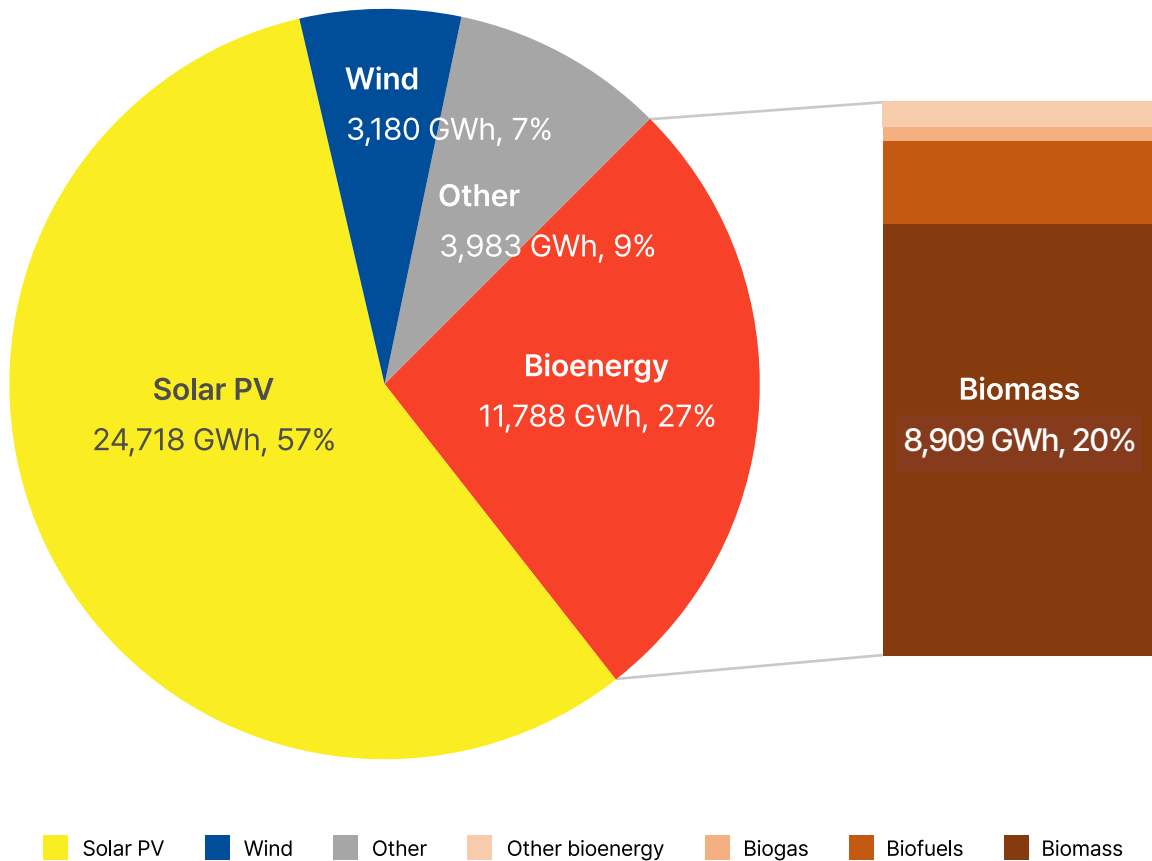
Contrary to many European countries where biomass is predominantly used for residential heating, biomass in South Korea is almost exclusively utilized for electricity generation in thermal power plants (Figure 2),⁷ with 75.3% being derived from forest biomass (Figure 3).⁸

7 Korea Energy Agency. (2022). 2021년 신재생에너지 보급통계 [Data set]. New and Renewable Energy Center. <https://www.knrec.or.kr/biz/pds/statistic/view.do?no=170>

8 Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power generation* [Data set submitted to National Assembly].

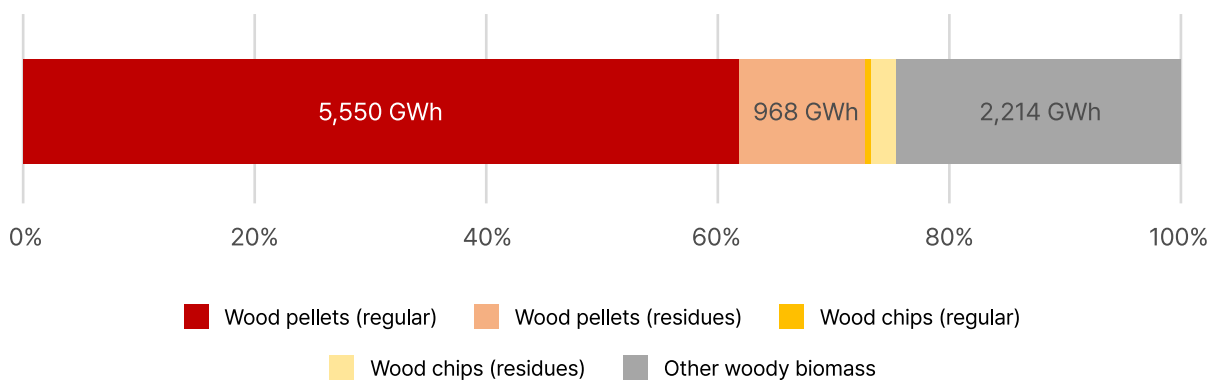
Because combustion-to-electricity conversion is generally inefficient, and even more so when fueled by low-energy wood, South Korea’s use of forest biomass tends to have disproportionately pronounced impacts on the climate and environment.

° Figure 2. Renewable electricity generated in South Korea by source, 2021



Source: Korea Energy Agency, 2022.

Figure 3. Biomass electricity generated in South Korea by feedstock type, 2022



Source: Ministry of Trade, Industry and Energy, 2023.

2.1.1. Wood Pellets and Chips, Conventional Biomass Fuels

The primary raw materials used in forest biomass include wood pellets and wood chips. Wood chips are produced by shredding timber into square-shaped chips, whereas wood pellets are crafted by further drying and compacting those chips into small cylindrical pellets. Therefore, wood pellets require a more intricate and energy-intensive production process, yet their relatively lower moisture content and higher spatial efficiency make them the more widely used option.

Both wood pellets and chips are made of various types of wood, including roundwood and lower-grade timber, as well as forestry residues from logging operations. Among these, imported wood pellets in their final product form are the most prevalent wood fuels used in South Korea.

2.1.2. Forest Residues, Government's New Policy Focus

The Korea Forest Service (KFS)⁹ outlines specific criteria for domestically sourced wood designated as "unused forest biomass," a synonym for forest residues. Feedstocks for wood pellets and chips that are collected and certified in accordance with the *Regulation on the Promotion of the Use and Dissemination of Forest Biomass Energy* and its corresponding *Guidelines for Certification of Unused Forest Biomass* (hereinafter collectively referred to as the "Forest Biomass Guidelines") can be classified as fuels derived from forest residues. This certification results in the issuance of higher REC weightings compared to regular biomass. REC weightings serve as a policy subsidy that ensures the profitability of biomass energy, playing a pivotal role in propelling the growth of the biomass industry in South Korea.

9 산림바이오매스에너지의 이용·보급 촉진에 관한 규정. Korea Forest Service Public Notice No. 2021-25. (2021).

2.2. Governance Framework of Forest Biomass Policy

Within the current policy framework, forest biomass serves a dual role as both a renewable energy source and a forestry product. Various government organizations, including the Ministry of Trade, Industry and Energy (MOTIE) responsible for energy, the KFS overseeing wood pellets and chips, the Ministry of Environment (ME) managing GHG emissions, and local governments issuing logging permits, all share the responsibility for governing forest biomass. Among these, the MOTIE, leading renewable energy policy, and the KFS, responsible for forest policy, wield the most substantial influence over the expansion of forest biomass and its environmental implications.

2.2.1. Energy Governance by Ministry of Trade, Industry and Energy

The MOTIE formulates policy directions for renewable energy, considering factors such as diversifying energy sources, ensuring stable supply, and reducing GHG emissions, among others. These strategies are aligned with national plans, including the *National Framework Plan for Carbon Neutrality and Green Growth*, *Master Plan for New and Renewable Energy*, and *Basic Plan for Long-Term Electricity Supply and Demand* (Electricity Basic Plan).

These high-level plans do not provide explicit details on bioenergy. While the Electricity Basic Plan outlines the expected installed and generation capacities of bioenergy facilities, covering not only biomass but also biogas and biofuels, it lacks specific targets for each type of bioenergy. As a result, the policies that significantly impact biomass power generation are the Renewable Portfolio Standard (RPS) and the associated REC weightings.

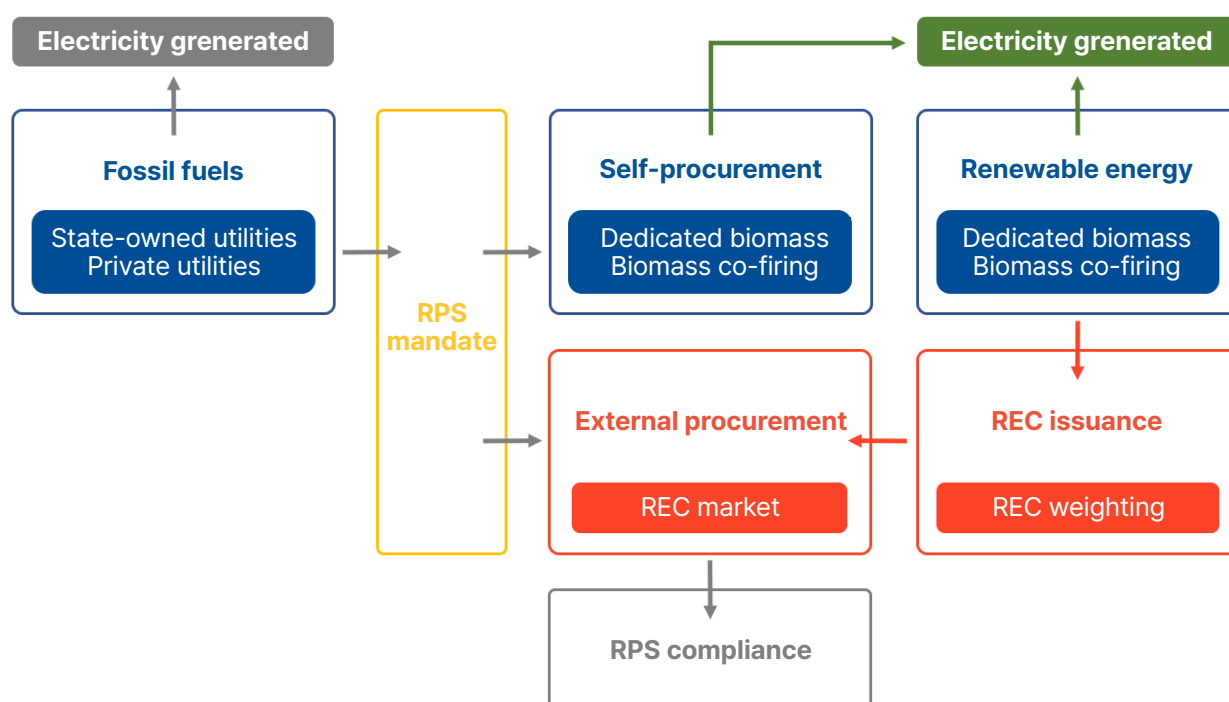
2.2.1.1. Renewable Portfolio Standard

The RPS stands as a central policy mechanism that has guided the adoption of renewable electricity in South Korea since its inception in 2012. Large power utilities with an installed capacity of 500 MW or more (i.e., mandatory suppliers) are obligated to supply a certain percentage of their total power generation from renewable energy sources. These mandatory suppliers encompass the subsidiaries of the state-owned utility (SOU) Korea Electric

Power Corporation (KEPCO) and private utilities operating large fossil fuel power plants.

As of 2023, the mandate stands at 13%, with a gradual increase to reach 25% by 2030. Mandatory suppliers can fulfill this requirement by either generating renewable energy themselves or purchasing RECs on the certificate trading market to demonstrate compliance (Figure 4).

° Figure 4. Operational flowchart for RPS in the context of biomass



2.2.1.2. Renewable Energy Certificate Weightings

RECs represent credits issued by applying weightings to the amount of electricity generated from renewable sources. Electricity producers can trade these certificates in the market on the prices determined by the supply and demand dynamics. But REC revenues can vary significantly even for the same amount of energy generated, as the weightings are contingent on the energy source and the type of facility. This variability makes REC weightings the most direct and critical means through which the government manages the profitability of renewable energy, including biomass.

REC weightings undergo triennial revisions as stipulated in the *Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy* (Renewable Energy Act)

and its delegated regulations. These revisions take into account factors such as environmental considerations, technological development, industrial impact, generation costs, resource availability, GHG reduction effects, impact on power supply stability, and community acceptance. These weightings are also subject to change on an ad-hoc basis. The most recent regular revision took place in 2021, with the next scheduled for the second half of 2024.

2.2.2. Forestry Governance by Korea Forest Service

The KFS strongly advocates forest biomass as an integral part of the overarching *6th National Forest Plan* of 2017 and the related *K-Forest Plan* of 2020. The *Forestry Sector Strategy to Achieve Carbon Neutrality by 2050* (Forestry Sector Carbon Neutrality Strategy), introduced in 2021 in the Moon Jae-in administration, detailed the objectives of the earlier plans by setting higher annual production targets for forest residues for biomass and harvested wood. Subsequently, the recently unveiled *Forest Renaissance Strategy* and the *3rd Master Plan for Carbon Sink Improvement* (3rd Carbon Sink Master Plan) under the Yoon Suk-yeol administration largely built on from the previous government's Forestry Sector Carbon Neutrality Strategy, affirming the KFS's lasting commitment to the scaling of forest biomass.

The regulatory framework for wood pellet and chip production in the country is anchored in the *Creation and Management of Forest Resources Act* (Forest Resources Act). Detailed specifications for wood products are outlined in the *Act on the Sustainable Use of Timbers* (Timber Use Act) and its delegated regulations. Both domestically produced and imported wood pellets and chips must adhere to the quality standards established by the Timber Use Act, while wood pellets of foreign origin are required to clear the customs per the *Regulation to Promote Legal Timber Trade* (Table 2).

Table 2. Forestry governance on biomass by origin of feedstocks

Domestic forest biomass fuels			
	Logging	Pelletizing/chipping	
Regular forest biomass			
Supervising agency	Korea Forest Service	Korea Forest Service	
Relevant regulation	<i>Forest Resources Act</i>	<i>Timber Use Act</i>	
Required document	Logging permit	Quality standard	
Forest residues			
Supervising agency	Korea Forest Service, Local governments	Korea Forest Service	
Relevant regulation	<i>Forest Resources Act, Forest Biomass Guidelines</i>	<i>Timber Use Act</i>	
Required document	Logging permit, Forest residues application	Quality standard	
Imported forest biomass fuels			
	Logging	Pelletizing	Importing
Supervising agency	Producer country government	Producer country government	Korea Forest Service, Korea Customs Service
Relevant regulation	Producer country forestry law	Producer country forestry law	<i>Timber Use Act, Regulation to Promote Legal Timber Trade</i>
Required document	Producer country logging permit	Producer country business permit	Quality standard, Timber legality document

These requirements primarily seek to standardize the technical specifications for industrial and residential purposes rather than serve as substantial and meaningful criteria for evaluating the environmental sustainability of wood products. Furthermore, because the Timber Use Act does not impose restrictions on the use of high-quality roundwood for fuel, even high-value lumber is allowed to be utilized as forest biomass.

2.2.2.1. Imported Forest Biomass

Imported biomass fuels account for 77.4% of all forest biomass used in South Korea. These imports continue to grow substantially each year, despite the KFS's key policy objective to

enhance the country's wood resource independence.¹⁰ Citing the need to support the importers, the KFS has yet to introduce measures to limit the imports of wood pellets. Despite the overdependence, imported biomass thus largely exists in a governance gap within the broader forestry policy framework.

The sole South Korean guideline concerning imported wood is the *Regulation to Promote Legal Timber Trade*, the country's legal system concerning timber, which ensures that the product has been harvested and produced through legitimate procedures in the exporting country. All imported wood pellets must undergo customs clearance in accordance with the Regulation to prove legality, in addition to meeting the Timber Use Act's quality standards. Importers are required to submit a logging permit, export license, or a voluntary forest certification.

However, akin to the wood pellet quality standards, the *Regulation to Promote Legal Timber Trade* primarily focuses on confirming the legality from a technical standpoint, rather than assessing the product's sustainability. At large, the KFS's governance of forest biomass is limited to providing standards in the form of mere technicality.

2.2.2.2. Domestic Forest Residues

The KFS places a significant emphasis on forest residues for biomass as a policy priority and has established additional rules and procedures to grant them a unique status. The Forest Biomass Guidelines define forest residues as "products that do not meet the roundwood standards or are difficult to collect for practical use."¹¹ Despite this definition, the Guidelines permit the classification of quality wood that meets the Timber Use Act's roundwood standards as residues.

The contradiction arises because the Forest Biomass Guidelines are not designed to adhere to the cascading principles that respect the actual value of the wood and its potential uses in the context of resource circulation. As per the Forest Biomass Guidelines, the collection

¹⁰ Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power fuel input* [Data set submitted to National Assembly].

¹¹ 산림바이오매스에너지의 이용·보급 촉진에 관한 규정. Korea Forest Service Public Notice No. 2021-25. (2021).

and certification of forest residues require additional applications following the issuance of a logging permit. However, due to the ambiguity in the definition, determining whether the harvested wood qualifies as residues is effectively left to the discretion of operators, resulting in the illicit trade of undeclared or substandard timber for biomass.

Regrettably, the KFS and local governments lack the authority and capacity to penalize illegal activities in the collection and distribution processes. This makes biomass power plants highly likely to receive questionable wood pellets and chips with forest residues certificates attached, which serve as supporting evidence for high REC weightings.

2.3. Growing Use of Forest Biomass

Forest biomass supply chains can be broadly divided into upstream and downstream categories. The upstream sector encompasses two primary components: 1) the imports of wood pellets and 2) the domestic production of wood pellets and chips, which use roundwood and forest residues.

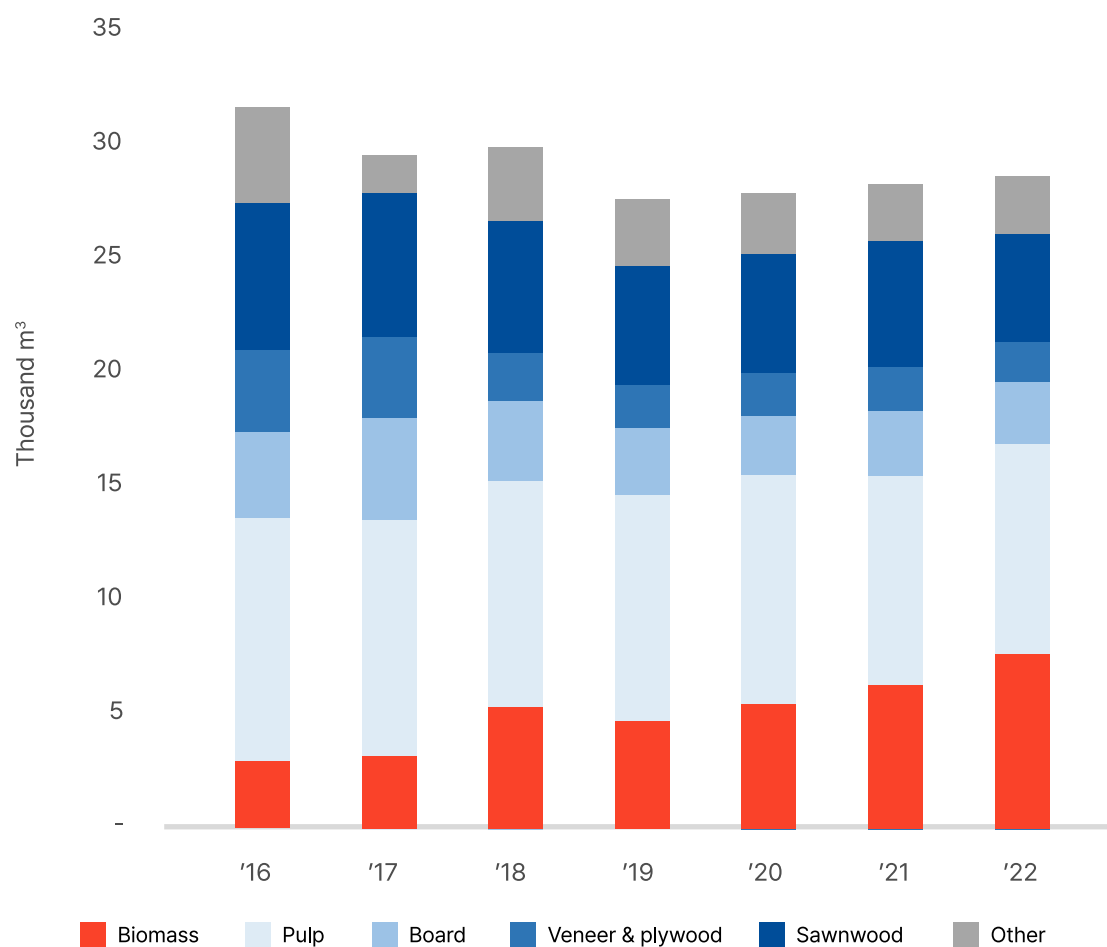
The downstream sector in the energy industry can be further divided into two categories: 1) coal and biomass co-firing and 2) dedicated biomass burning. Since the adoption of the RPS in 2012, the South Korean biomass industry has experienced a highly alarming 42-fold growth in its market size.

2.3.1. Upstream Supply Chain: Forestry Sector

The South Korean use of forest biomass, which includes both imports and domestic sources, has spiked by more than 2.5 times compared to 2016. In 2022, South Korea consumed a total of 7.6 million m³, or 24.6% of its total wood demand, for forest biomass (Figure 5), substantially exceeding the total domestic wood supply of 4.3 million m³.¹²

12 Korea Forest Service. (2013–2023). 목재수급실적. https://www.forest.go.kr/kfsweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_04_03_02&cmsId=FC_003649

° Figure 5. Total wood consumption in South Korea by use type, 2016–2022

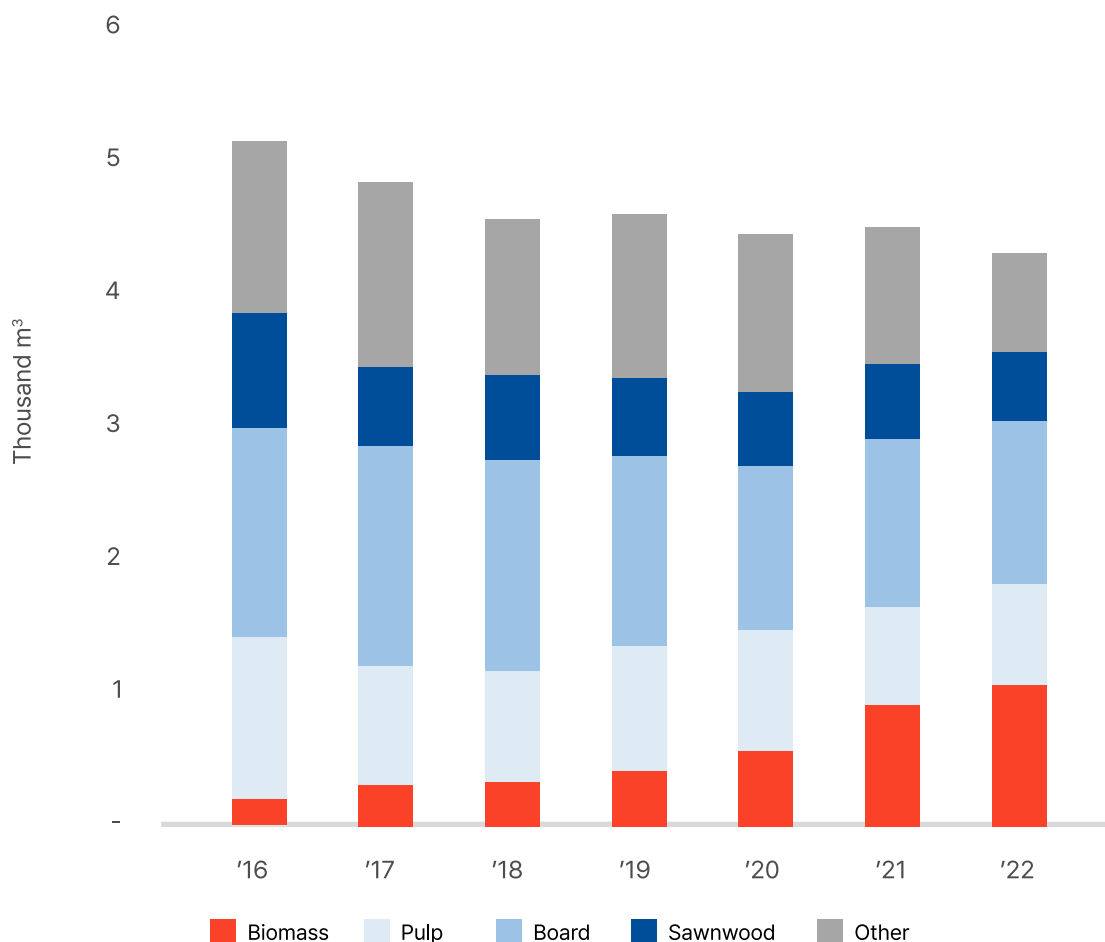


Source: Korea Forest Service, 2013–2023.

Contrary to this upsurge, overall domestic wood usage has declined, particularly in the pulp and board sectors that have seen a drop of 29.4% since 2016 (Figure 6).¹³ These industries are facing severe competition with the biomass industry over feedstocks. The shift can be attributed to government policies favoring biomass, redirecting limited domestic wood resources toward low-value and short-lived fuel use.

13 Korea Forest Service. (2013–2023). 목재수급실적. https://www.forest.go.kr/kfsweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_04_03_02&cm-sld=FC_003649

° Figure 6. Domestically sourced wood consumption in South Korea by use type, 2016–2022



Source: Korea Forest Service, 2013–2023.

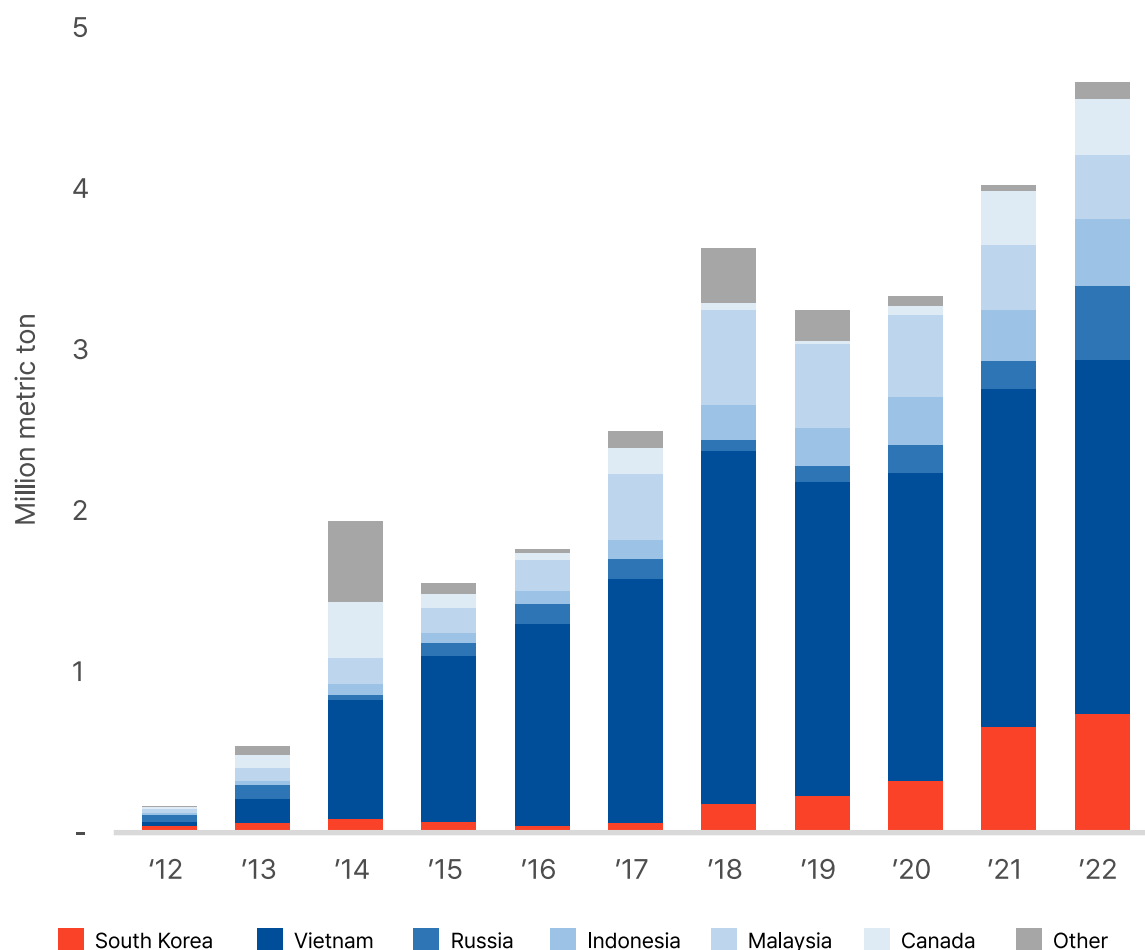
2.3.1.1. Trends of Foreign Biomass Fuel Imports

The increasing demand for biomass is linked to the exponential growth of wood pellet usage, the primary feedstock for forest biomass. South Korea's wood pellet consumption has grown from 174 thousand metric tons in 2012 to approximately 4.7 million tons in 2022, marking an almost 28-fold increase. In 2022, the country imported 3.9 million tons, equivalent to 84.2% of all pellets, with 56.2% from Vietnam (Figure 7).^{14, 15}

14 Korea Forest Service. (n.d.). 연도별 목재펠릿 생산량. https://www.forest.go.kr/kfsweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_11_04_02&cmsId=FC_000811

15 Korea Customs Service. (n.d.). 수출입무역통계 [Data set]. <https://unipass.customs.go.kr/ets>

° Figure 7. Total wood pellet consumption in South Korea by country of origin, 2012–2022



Sources: Korea Forest Service; Korea Customs Service.

Imports of Canadian wood pellets have increased since 2021 due to offtakes from Drax, which operates wood pellet mills in British Columbia (BC). Drax owns the world's largest dedicated biomass power plant in the United Kingdom (UK) and has faced mounting criticism for GHG emissions in the UK and forest clearing in BC.^{16, 17}

Imports from Russia have also significantly risen in 2022, following Russia's invasion of Ukraine and the subsequent designation of Russian wood as "conflict timber." With the in-

16 Crowley, J. & Robinson, T. (2022, October 3). Drax: UK power station owner cuts down primary forests in Canada. *BBC*. <https://www.bbc.com/news/science-environment-63089348>

17 Harrison, T. & Fox, H. (2023, July 31). *Biomass plant is UK's top emitter*. Ember. <https://ember-climate.org/insights/research/drax-co2-emissions-biomass/>

ternational society imposing sanctions on these imports, many of these pellets originally intended for the European market are now being redirected to South Korea.¹⁸

2.3.1.2. Trends of Domestic Forest Biomass Production

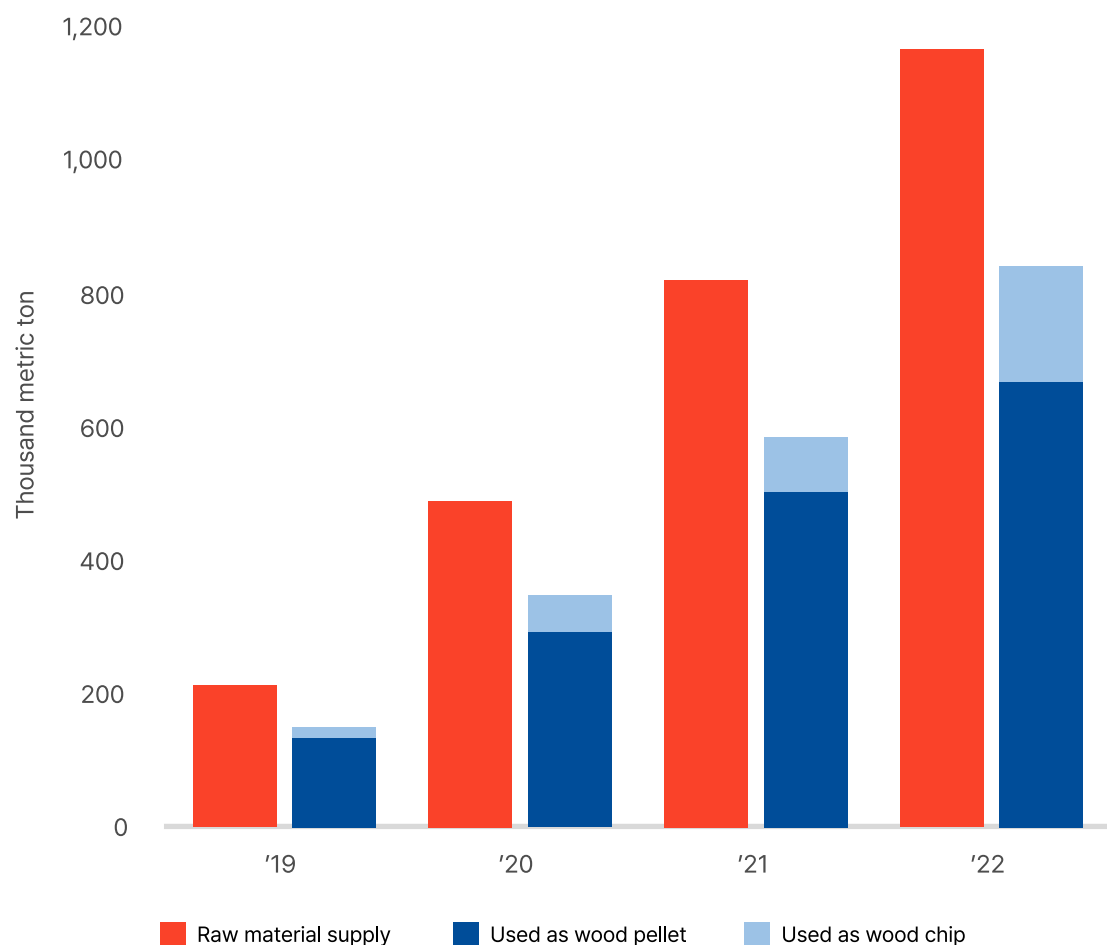
Simultaneously, domestic wood pellet production, which was 51 thousand tons in 2012, has grown nearly 15-fold, reaching 737 thousand tons in 2022 (Figure 7).¹⁹ The significant surge has particularly been pronounced since 2018 due to the increase in the RPS mandate and the government's heightened support for forest residues at that time. In 2022, forest residues supply as raw material reached 1.2 million tons, marking a fivefold growth from 2018 (Figure 8).²⁰

18 Catanoso, J. (2023, January 24). The EU banned Russian wood pellet imports; South Korea took them all. *Mongabay*. <https://news.mongabay.com/2023/01/the-eu-banned-russian-wood-pellet-imports-south-korea-took-them-all/>

19 Korea Forest Service. (n.d.). 연도별 목재펠릿 생산량. https://www.forest.go.kr/kfswweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_11_04_02&cmsId=FC_000811

20 Korea Forest Service. (n.d.). 미이용 산림바이오매스 공급(이용)량. https://www.forest.go.kr/kfswweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_11_07_03&cmsId=FC_003565

° Figure 8. Forest residues production as biomass in South Korea by fuel type, 2019–2022



Source: Korea Forest Service.

Across the country, 43 wood pellet and chip mills are in operation to process these feedstocks,²¹ with SY Energy, SY Portu, and Eco Energy One being the major players. The combined maximum production capacity of these three mills stands at 800 thousand tons per year, effectively monopolizing the wood pellet market. These mills are planning on further increasing their capacity to 1.3 million tons per year by 2026.

21 Korea Forest Service. (2022). 2021년 기준 목재이용실태조사 보고서.

2.3.2. Downstream Supply Chain: Power Sector

The root cause of the rapid growth of biomass over the past decade can be traced to the growing demand from the power sector. The government's classification of biomass as renewable energy and the issuance of high REC weightings have positioned biomass an attractive alternative for major coal power plants, particularly for the five public utilities owned by KEPCO.

Soon after, private power utilities were also incentivized to join the biomass market, drawn by the high revenue generated from REC sales. As a result of this influx, South Korea's biomass electricity has increased by 42-fold, from 293 GWh in 2012 to 8,909 GWh in 2021. The installed capacity has also expanded seven-fold over the same period, from 300 MW to 2,195 MW.²²

2.3.2.1. Biomass Co-Firing and Dedicated Burning

In the early years of biomass adoption, co-firing wood pellets mixed with coal in existing coal power plants was the most common practice. However, a notable shift occurred with the conversion of KEPCO-owned Korea South-East Power (KOEN)'s Yeongdong Unit 1 to biomass-only in 2017 and the subsequent conversion of Unit 2 in 2019: dedicated biomass-burning increased as a result.

Criticisms were raised that public utilities were effortlessly fulfilling their RPS mandate through coal co-firing, without being encouraged to make meaningful investments in genuine renewables.²³ In response, the MOTIE in 2020 halved the REC weighting applied to the SOUs' co-firing in existing power plants from 1.0 to 0.5.²⁴ Consequently, co-firing, which accounted for 91.6% of public utilities' biomass power in 2014, has decreased to 18.5% in 2022.²⁵

22 Korea Energy Agency. (2022). 2021년 신재생에너지 보급통계 [Data set]. New and Renewable Energy Center. <https://www.knrec.or.kr/biz/pds/statistic/view.do?no=170>

23 Byun, K. (2020, October 15). "바이오매스 혼소발전 REC 가중치 더욱 축소해야 한다". Energy Daily. <http://www.energydaily.co.kr/news/articleView.html?idxno=112633>

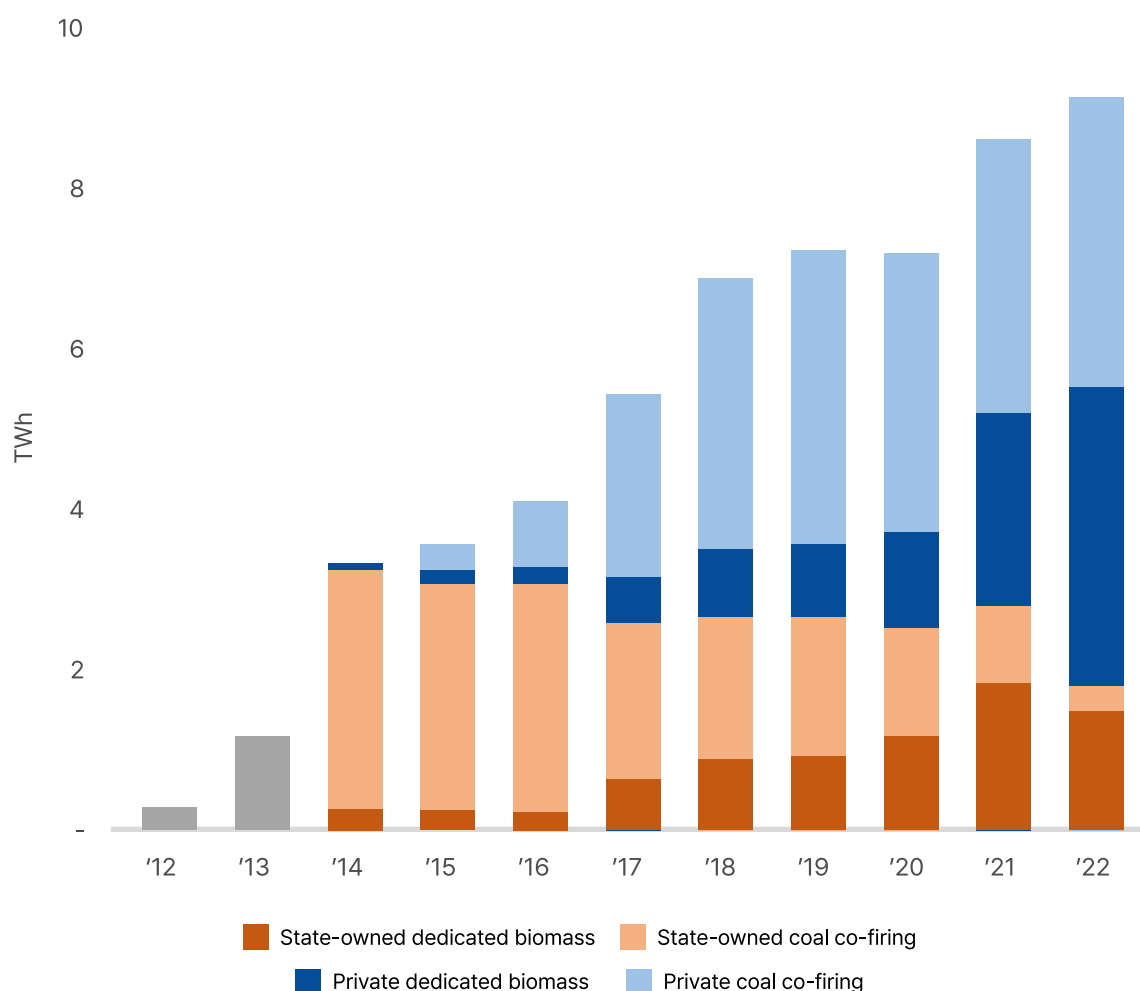
24 Jin, K. (2020, June 11). 발전공기업 바이오혼소 REC가중치 반토막. *Energy & Environment News*. <https://www.e2news.com/news/articleView.html?idxno=223208>

25 Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power generation* [Data set submitted to National Assembly].

Private utilities entered the biomass power market in earnest in 2015. In the following three years, private co-firing skyrocketed tenfold and has remained relatively stable since the 2018 removal of REC weightings for future co-firing facilities. Thus, while existing co-firing facilities continue to receive high REC weightings following the RPS guidelines' interim measures, power companies are less inclined to start additional co-firing projects.

However, in 2018, the REC weightings for forest residues reached a record high of 2.0, leading to an additional expansion of dedicated burning in private utilities. As a result, dedicated biomass now takes up 50.3% of all biomass burning in the private sector, a significant increase from 20.3% in 2018 (Figure 9).²⁶

° Figure 9. Biomass electricity generated in South Korea by combustion type, 2012–2022



Sources: Ministry of Trade, Industry and Energy, 2023; Korea Energy Agency, 2022.

26 Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power generation* [Data set submitted to National Assembly].

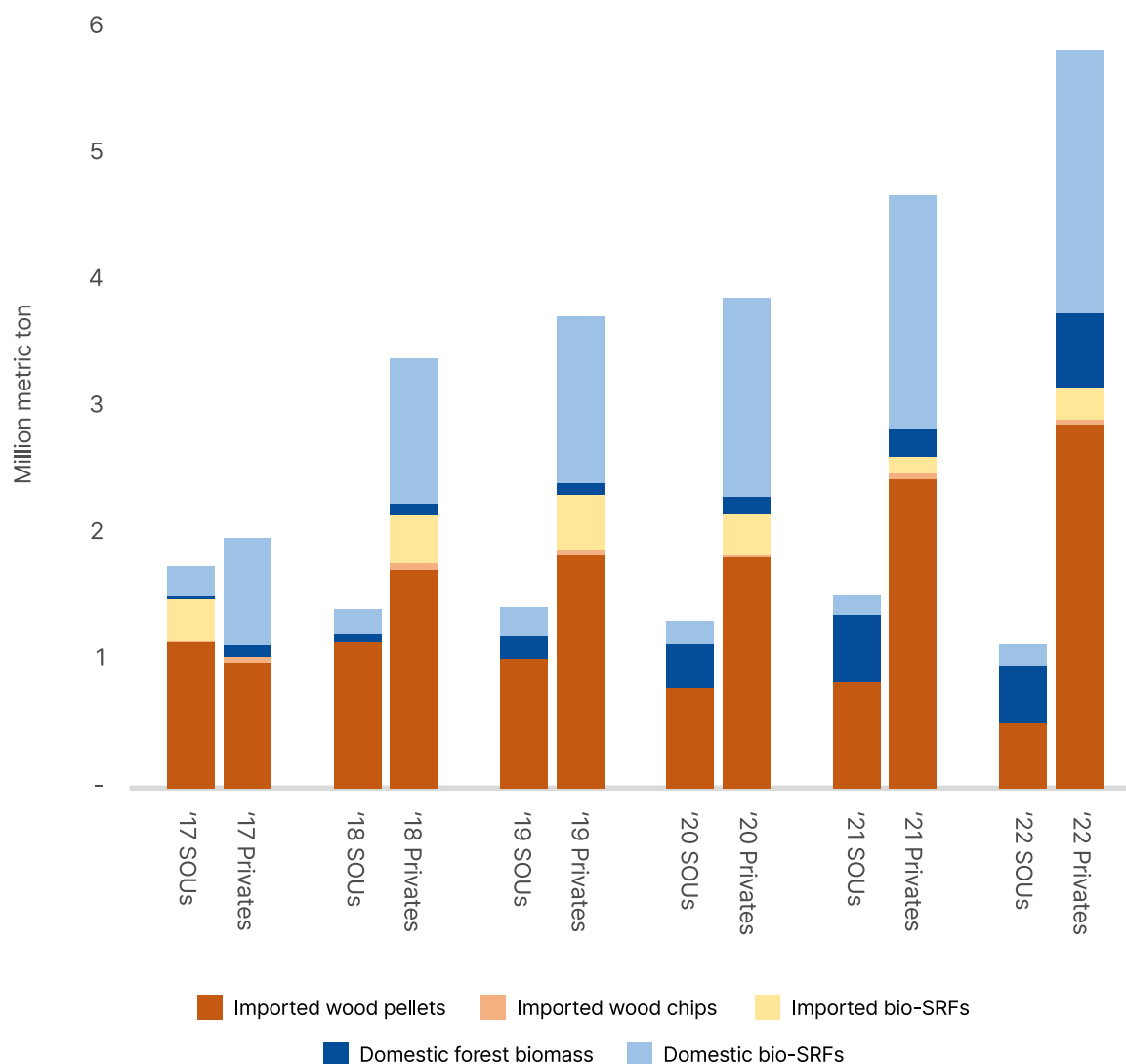
The South Korean biomass industry has recovered considerably from the COVID-19 pandemic of 2020 and the subsequent stagnation it caused. Unlike the decline in biomass generation by SOUs, private power companies have continued to operate co-firing facilities introduced from 2015 to 2018 and have also expanded the dedicated burning fleet. If the current policy continues to provide strong support for dedicated biomass while maintaining REC incentives for existing private co-firing, the expansion of biomass power at large is likely to accelerate for years to come.

2.3.2.2. Biomass Fuel Input to Power Plants

With the growth of biomass power followed the increase in the amount of biomass fuels used in the energy sector. In 2022, the figure recorded 6.9 million tons, with forest biomass accounting for 4.4 million. Notably, imported wood pellets constituted 77.4% of the total forest biomass, with 85.2% of the imported pellets being consumed by private utilities. Contrary to private utilities' heavy reliance on imported forest biomass, SOUs have largely switched to domestic fuels over the past years, now sourcing nearly half of all forest biomass from within the country (Figure 10).²⁷

²⁷ Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power fuel input* [Data set submitted to National Assembly].

° Figure 10. Fuel input to biomass power fleet in South Korea by ownership type, 2017–2022



SOU: State-owned utilities; Privates: Private utilities

Source: Ministry of Trade, Industry and Energy, 2023.

Additionally, some of the major co-firing private utilities' announcement to replace their 1.6 million tons per annum of imported wood pellets with domestic pellets from 2025 onwards could trigger changes in both the imported and domestic wood pellet markets.²⁸ This shift could further increase the demand for domestically produced biomass in addition to the already high demand for imported ones.

28 Ministry of Trade, Industry and Energy. (2021, September 1). 민간3사*, 국내 바이오매스(생물에너지원) 활성화를 위해 발 벗고 나서다. https://motie.go.kr/motie/gov_info/gov_openinfo/sajun/bbs/bbsView.do?bbs_seq_n=164505&bbs_cd_n=81

The use of domestically sourced wood pellets and chips also saw a substantial upswing from 2019 when forest residues were actively introduced to the market. In 2022, forest residues accounted for 84.5% of the total domestic forest biomass (Table 3), seemingly suggesting a shift from using roundwood as the primary feedstock to utilizing by-products.²⁹

Table 3. Fuel input to biomass power fleet in South Korea by feedstock type, 2014–2022

Thousand metric ton

	Forest biomass						Sum	Bio-SRFs		Grand sum
	Regular wood pellets		Resi- dues wood pellets	Regular wood chips		Resi- dues wood chips		Imptd	Dmstc	
	Imptd	Dmstc	Dmstc	Imptd	Dmstc	Dmstc				
'14	2,943			65			3,008	910		3,918
'15	2,671			104			2,774	922		3,696
'16	3,010			100			3,110	1,657		4,767
'17	2,133	50		39	78		2,300	340	1,093	3,733
'18	2,863	88		55	74	2	3,082	379	1,363	4,824
'19	2,878		164	40	57	25	3,164	437	1,557	5,158
'20	2,611		335	22	92	61	3,120	321	1,768	5,210
'21	3,282		584	44	86	88	4,085	131	1,987	6,203
'22	3,384	51	632	27	103	208	4,405	265	2,243	6,913

Imptd: Imported; Dmstc: Domestic

Source: Ministry of Trade, Industry and Energy, 2023.

However, given that the overall input of domestic forest biomass never ceased to increase and that larger amounts of roundwood is being categorized as forest residues, this transition has limited implications. Furthermore, data discrepancies between the MOTIE and the KFS raise concerns about the illicit mixing of roundwood and residues, which will be detailed later in this report.

²⁹ Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power fuel input* [Data set submitted to National Assembly].

2.3.2.3. List of Biomass Power Plants

The 6.9 million tons of biomass fuels are consumed by dozens of power plants scattered throughout the country. There are currently 24 power utilities operating 28 biomass power plants, with 10 companies operating 42 co-firing facilities. Altogether they constitute a total capacity of approximately 1,050 MW for dedicated biomass and 21,357 MW for co-firing.

Major utilities include KOEN, which converted the coal-fired Yeongdong Units 1 and 2 into the country's largest biomass burners; GS Group, which operates a 205 MW dedicated plant and a 170 MW co-firing facility; SGC Energy, with 160 MW dedicated plants and a 250 MW co-firing facility; CGN Daesan, which operates a 100 MW dedicated plant; and OCI SE with a 303 MW co-firing facility. Furthermore, most public power utilities are implementing biomass co-firing in their large coal power plants.³⁰

Biomass power plants that are being built or planned for construction include Samcheok Blue Power, the last coal power plant to be built in the country, as well as dedicated biomass power plants Gwangyang Biomass and Pohang Biomass. New biomass power plants in the pipeline have a total capacity of 562 MW. If all these projects proceed as scheduled, by 2026, the country's dedicated biomass fleet would grow by more than half of the current capacity.³¹

30 Ministry of Trade, Industry and Energy. (2022). *List of biomass power plants* [Data set submitted to National Assembly].

31 Korea Power Exchange. (2023, May 23). 2023년도 1분기 발전소 건설사업 추진현황. https://www.kpx.or.kr/board.es?mid=a10403040000&bid=0040&act=view&list_no=69518

3. Climate and Environmental Impacts of Forest Biomass

Power generation from biomass, which involves the combustion of wood to produce energy, inevitably leads to GHG emissions. The underlying principle closely parallels the combustion process of coal, as both biomass and coal primarily consist of hydrocarbons (C_nH_m). The combustion of these fuels produces water (H_2O) and CO_2 alongside the heat used for energy conversion.

Notably, wood exhibits lower energy efficiency compared to coal, as coal's higher carbon content (i.e., calorific value) results from the compression of organic matter in high-temperature and high-pressure underground conditions over billions of years. The historical shift from inefficient wood resources to more energy-intensive coal during the industrial revolution is a testament to the inherent inefficiency of wood energy in the modern era.

3.1. Carbon Emissions Higher than Fossil Fuels

The low energy content of biomass implies that more fuels should be burned to generate the same amount of energy, which releases more carbon into the atmosphere. The difference in fuel input volume becomes substantial when biomass power is utilized on an industrial scale. In practical terms, South Korean wood quality standards mandate a minimum calorific value of 3,940 kcal/kg for wood pellets and none for wood chips.³² In contrast, the average calorific values of bituminous coal, heavy oil, and gas used for power generation in the country were significantly higher, standing at 5,563 kcal/kg, 9,840 kcal/kg, and 13,083 kcal/kg, respectively.³³

Biomass thus emits an excessive amount of GHGs compared to its actual contribution to power supply. This is why biomass should not and cannot be equated on the same level with

32 목재제품의 규격과 품질기준. National Institute of Forest Science Public Notice No. 2020-3. (2020).

33 Korea Power Exchange. (n.d.). 발전연료 사용량 추이. Electric Power Statistics Information System. <https://epsis.kpx.or.kr/epsisnew/selectEkgFfuChart.do?menuId=060200>

clean renewables that tap into the boundless potential of solar and wind, without requiring anything that even barely resembles the notion of “fuel.”

3.1.1. Loophole in International Carbon Accounting

Despite high carbon emissions from biomass combustion, both the South Korean government and industry assert that bioenergy is a carbon-neutral energy source. This wrongly grounded claim stems from a misinterpretation of one of the IPCC’s international carbon accounting rules. The *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines) make an exception rule for bioenergy, including biomass.³⁴

Unlike other sectors that account for GHG emissions through fossil fuel combustion or industrial activities, the Land Use, Land-Use Change, and Forestry (LULUCF) sector is generally regarded as fluctuating carbon sinks due to forests absorbing and emitting CO₂. Wood used as raw material for biomass is therefore considered a carbon sink before fuel, as trees absorb CO₂ as they grow.

3.1.1.1. Accounting in Land Use, Land-Use Change, and Forestry Sector

For accounting purposes, any reduction in carbon sinks due to forest loss, including logging, is treated as emissions in the LULUCF sector. To avoid double-counting, the Energy sector, in turn, excludes biomass burning from its inventories. Yet, smokestack emissions from biomass combustion in power plants are still subject to reporting to the environment authority.

Because these emissions do not appear in the Energy sector, they are consequently omitted from the Emissions Trading Systems (ETS), corporate management goals, or even national GHG reduction targets. From the national net-GHG management vantage point, this ap-

³⁴ Intergovernmental Panel on Climate Change. (2006). *2006 IPCC guidelines for national greenhouse gas inventories*. Institute for Global Environmental Strategies. <https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

proach could seem valid, as all biomass emissions are supposedly factored into the LULUCF sector's forest carbon stock change.

Nevertheless, it is essential to note that the LULUCF sector only reports and accounts net changes in large-scale carbon stocks, often at a national level. The LULUCF sector is not designed to track emissions and sequestrations at the individual activity level. In practice, it is thus impossible to identify carbon stock changes resulting from harvesting for biomass fuels, making it challenging to trace the exact amount of above-ground carbon stock entering the Energy sector for combustion.

This peculiarity has mounting occurrences of "hidden emissions"—emissions that are "technically included" in the LULUCF sector and reported to the government but neither incorporated in the Energy sector nor clearly identified in the LULUCF sector itself.

3.1.1.2. Implications of Omission in Energy Sector

The carbon accounting rules that exclude biomass emissions from the Energy sector have inadvertently created a scenario where power plants that emit substantial amounts of GHGs are incorrectly perceived as zero-emission facilities. This loophole has further led to the prevalence of mixing biomass with coal in existing coal power plants to reduce emissions on paper and sometimes retrofitting them entirely to biomass-only burners to achieve the illusion of carbon-neutrality. Even large power plants, irrespective of their scale of combustion, often find themselves excluded from ETS obligations or emissions management, being left in a regulatory blind spot. The claims of biomass being carbon-neutral or renewable energy are based on these flaws in carbon accounting, not because biomass delivers any inherent or tangible climate benefits.

3.1.1.3. Carbon Accounting and Intergovernmental Panel on Climate Change

These carbon accounting rules were devised long before the emergence of biomass power as a significant industry, with the adverse consequences unbeknownst to the scientific community then. Now there is a growing sentiment that these accounting standards from

the past are failing to mirror the industrial landscape of the present.³⁵ The IPCC³⁶ also acknowledges these shortcomings, stating that “the approach of not including these emissions in the Energy sector total should not be interpreted as a conclusion about the sustainability or carbon neutrality of bioenergy.... The IPCC Guidelines do not automatically consider or assume biomass used for energy as ‘carbon neutral,’ even in cases where the biomass is thought to be produced sustainably.”

The IPCC’s intricate carbon accounting framework aims to comprehensively manage all GHG emissions at the national and, ultimately, global levels. The climate change impact induced by one ton of GHG emissions remains consistent, whether emitted in either the Energy or the LULUCF sector or elsewhere. Considering curbing the increase in GHG concentrations in the atmosphere is undoubtedly of the paramount focus in addressing the climate crisis, biomass power has every valid reason to be considered an emission activity subject to reduction targets.

3.1.2. Carbon Emissions of Biomass Power in South Korea

This report is the first South Korean study to present an analysis of the hidden carbon emissions from all biomass power plants in the country. The results further reveal that the government’s biomass policy treating biomass as renewable energy has increased the country’s GHG emissions.

South Korea, a Non-Annex I Party (i.e., a developing country) to the UNFCCC, is not obligated to report emissions from biomass combustion in its national inventories. Exploiting this disclosure gap, power plants in South Korea uniformly treat biomass as producing zero-emissions, marketing it as a carbon-neutral energy source. However, as mentioned earlier, even when these emissions are not accounted for in the Energy sector, the ME is in possession of most of the GHG reports submitted by the companies.

35 Pulles, T., Michael, G., & Klaus, R. (2022). CO2 emissions from biomass combustion Accounting of CO2 emissions from biomass under the UNFCCC. *Carbon Management*, 13(1), 181–189. <https://doi.org/10.1080/17583004.2022.2067456>

36 Intergovernmental Panel on Climate Change. (n.d.). *FAQs*. Task Force on National Greenhouse Gas Inventories. <https://www.ipcc-nggip.iges.or.jp/faq/faq.html>

3.1.2.1. Biomass Power Emits 11 Million tCO₂/year

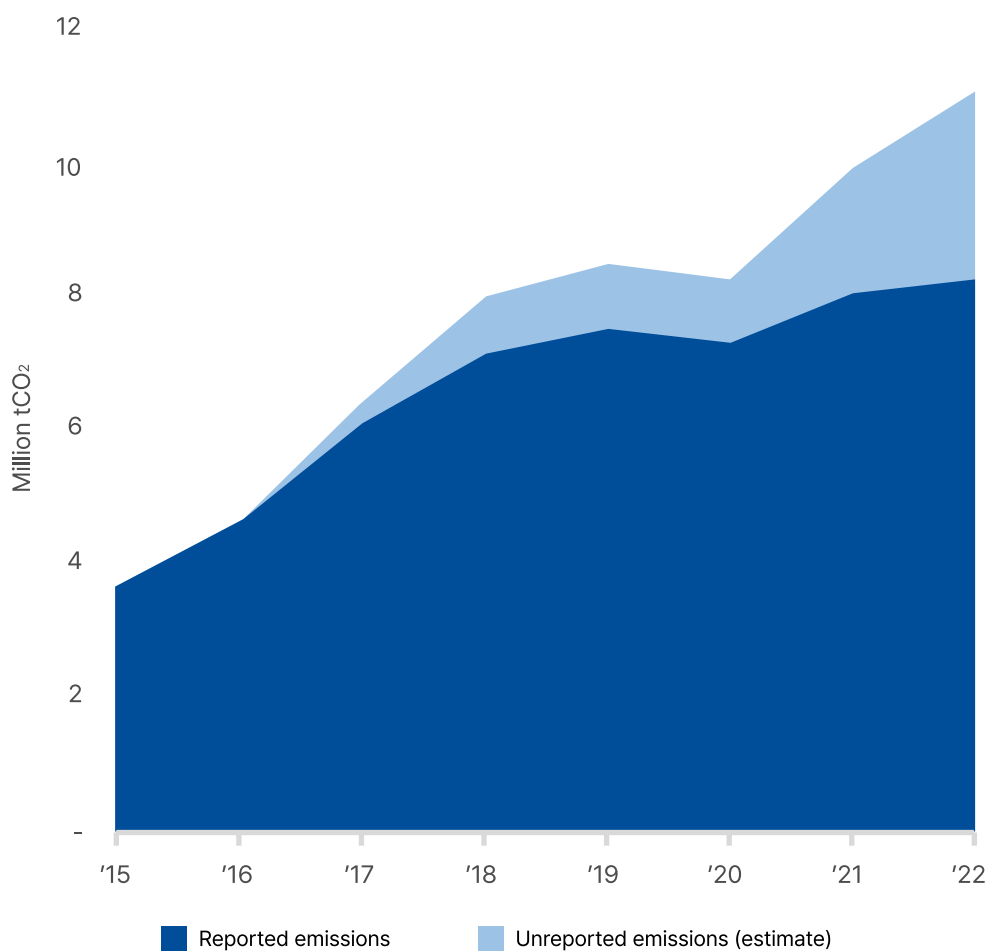
This report's analysis estimates that the biomass power fleet in South Korea emitted 11 million tCO₂ in the year 2022 alone through direct combustion.³⁷ This amount is comparable to half of the country's Agriculture sector emissions of 21.1 million tCO₂.³⁸ It also greatly exceeds the -8.4 million tCO₂ of annual forest carbon sink enhancements the government committed to achieving as part of the Carbon Neutrality Forestry Sector Strategy for 2050. Since more than half of all biomass fuels are imported and not accounted for in South Korea's LULUCF sector but in producer countries, this level of emissions effectively cancels out the government's forestry sector net-zero goals at the expense of developing countries' mounting mitigation burden.

Moreover, the analysis finds a threefold increase in emissions since 2015, when the relevant data from biomass power plants were first collected. The cumulative emissions are found to have exceeded 60 million tCO₂ over eight years (Figure 11), indicating that South Korea has transferred at least 36 million tCO₂ of these emissions solely to producer countries, constituting an act of climate injustice. Due to data gaps in 2015 and 2016, the actual amount of CO₂ emitted during this period is likely to be greater than reported.

37 Estimates are calculated based on the Ministry of Environment's (ME) data set submitted to the National Assembly on 17 operators subject to GHG cap-and-trade and target management. Because the ME's reported emissions cover approximately 76% of annual fuel input collected by the Ministry of Trade, Industry and Energy (MOTIE), the unreported emissions were estimated based on the MOTIE's fuel input data.

38 Ministry of Environment. (2022). 국가 온실가스 인벤토리(1990-2020) [Data set]. Greenhouse Gas Inventory and Research Center. <https://www.gir.go.kr/home/board/read.do?pagerOffset=0&maxPageItems=10&maxIndexPages=10&searchKey=&searchValue=&menuId=36&boardId=58&boardMasterId=2&boardCategoryId=>

° Figure 11. Carbon emissions of biomass power fleet in South Korea, 2015–2022



3.1.2.2. Interpreting Biomass Combustion Emissions

The findings of this study also provide the necessary information to determine the emissions per unit of fuel input and energy produced. Over the past eight years, burning one ton of biomass fuels released an average of 1,653 kgCO₂, corresponding to 1,222 gCO₂/kWh of electricity generated (Table 4).

Table 4. Emissions profile of biomass power fleet in South Korea, 2015–2022

	'15	'16	'17	'18	'19	'20	'21	'22	Average
Fuel input (kt)	4,535	5,488	3,733	4,824	5,159	5,210	6,203	6,933	
Electricity generated (GWh)	3,290	3,825	5,117	6,495	6,495	6,811	8,204	8,969	
Reported emissions (kCO₂t)	3,636	4,620	6,043	7,095	7,459	7,242	7,984	8,194	-
Unreported emissions (estimate) (kCO₂t)	No data	No data	322	843	956	954	1,864	2,804	
Gross emissions (estimate) (kCO₂t)	3,636	4,620	6,364	7,938	8,415	8,197	9,848	10,998	-
Emissions per unit of fuel (kCO₂t)	1,763	1,733	1,705	1,646	1,631	1,578,	1,588	1,586	1,653
Emissions per unit of electricity (gCO₂/kWh)	No data	No data	1,244	1,222	1,235	1,204	1,200	1,226	1,222

These values significantly surpass the range of 374–871 gCO₂/kWh reported by the International Atomic Energy Agency (IAEA) and previous studies analyzing domestic statistics of coal, oil, and gas.³⁹ The emissions from the South Korean biomass power fleet on average appear notably high even in comparison to 888 gCO₂/kWh of KOEN's⁴⁰ and 934 gCO₂/kWh of Drax's biomass power plants (Figure 12).⁴¹ It is a well-known fact that the emissions per

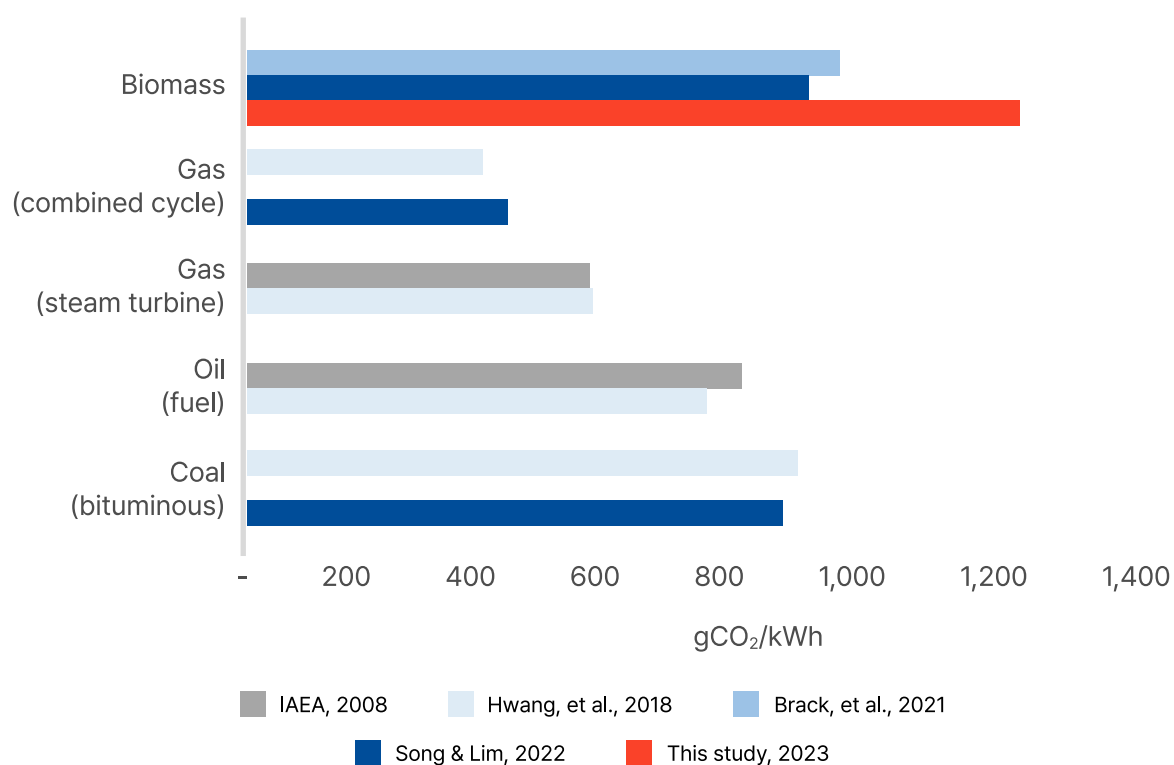
39 Hwang, W., Seo, H., & Lee, M. (2018). Comparison on the CO₂ emission indices with respect to fuels for power generation in Korea based on statistical data. *Transactions of the Korean Society of Mechanical Engineers B*, 42(2), 111–116. <https://doi.org/10.3795/KSME-B.2018.42.2.111>

40 Song, H. & Lim, J. (2022). *Forest biomass: Burning the bridge to a renewable future*. Solutions for Our Climate.

41 Brack, D., Birdsey, R., & Walker, W. (2021). *Greenhouse gas emissions from burning US-sourced woody biomass in the EU and UK*. Chatham House. <https://www.chathamhouse.org/2021/10/greenhouse-gas-emissions-burning-us-sourced-woody-biomass-eu-and-uk>

unit of energy from biomass are generally higher than those from fossil fuels, a point explicitly specified in the IPCC Guidelines (Table 5).⁴²

° Figure 12. Carbon emissions per unit of electricity by energy source



Sources: Song & Lim, 2022; Brack, et al., 2021; Hwang, et al., 2018; IAEA, 2008 (as cited in Hwang, et al., 2018); compiled by author.

Table 5. IPCC carbon intensity of energy sources at stationary combustion

	Coal (bituminous)	Oil	Gas	Biomass
CO ₂	94,600~96,100	69,300~77,400	56,100	112,000
CH ₄	1	3	1	30
N ₂ O	1.5	0.6	0.1	4

Source: Intergovernmental Panel on Climate Change, 2006.

⁴² Intergovernmental Panel on Climate Change. (2006). *2006 IPCC guidelines for national greenhouse gas inventories*. Institute for Global Environmental Strategies. <https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

In the EU, biomass accounted for 16.3% of the total emissions in the Energy sector in 2019, totaling 482 million tCO₂.⁴³ In the UK, although biomass contributed just over 4% of the total electricity supply in 2022, it emitted over 13 million tCO₂, representing approximately 20% of emissions from the entire power sector.⁴⁴ Such high emissions relative to its power supply capacity reaffirms that biomass power is not an efficient source of energy, especially when scaled to the current extent.

In contrast, the KFS, National Institute of Forest Science (NIFoS), and Korea Forestry Promotion Institute (Kofpi) claim that one ton of wood pellets can replace 604.65 kg of bituminous coal, leading to a reduction of 1.48 tCO₂.⁴⁵ However, a nuanced interpretation of this uncovers a paradox, suggesting that biomass is 40% less efficient than coal. The claimed reduction effect of 1.48 tCO₂ is nothing more than manipulating the IPCC's rules to avoid double-counting. To effectively address climate change, it is critical to comprehend and reduce emissions throughout the entire supply chain, from logging to combustion, rather than fixating on the carbon accounts of the Energy sector only.

As an example, recent emissions disclosure standards adopted by the private sector across the industries include direct emissions (Scope 1), indirect emissions (Scope 2), and supply chain emissions (Scope 3). These scopes and calculations pull emissions across various sectors and technically would fall under double-counting if assessed against the IPCC Guidelines. However, holding companies accountable for different scopes of emissions is a standard practice now because the global community has long concurred that every ton of emissions reduction across all established business relationships has its value.

43 Brack, D., Birdsey, R., & Walker, W. (2021). *Greenhouse gas emissions from burning US-sourced woody biomass in the EU and UK*. Chatham House. <https://www.chathamhouse.org/2021/10/greenhouse-gas-emissions-burning-us-sourced-woody-biomass-eu-and-uk>

44 Harrison, T & Fox, H. (2023, July 31). *Biomass plant is UK's top emitter*. Ember. <https://ember-climate.org/insights/research/drax-co2-emissions-biomass/>

45 National Institute of Forest Science. (2021, June 7). 방치보다 가치있는 미이용 산림 내 목재자원(산림바이오매스)의 이용.

3.1.2.3. Lifecycle Emissions of Forest Biomass

It is important to note that the biomass emissions at the point of combustion only consider the GHGs emitted when wood is burned at a power plant at the very end of the biomass lifecycle. Forest biomass entails additional emissions throughout the entire supply chain, including foregone forest growth, logging, transportation from forests to mills, pelletizing, and, in the case of imported biomass, maritime transportation to power plants. To capture the full extent of emissions from the biomass industry and impose the appropriate social cost of carbon, a comprehensive lifecycle analysis (LCA) across the entire supply chain must take place.

For example, Chatham House estimated the lifecycle emissions for the UK's Drax power plant burning wood pellets produced in the southeast United States (US). Out of the total emissions, smokestack emissions accounted for approximately 69%, residues decomposition and forest growth loss 21%, and emissions during other supply chain processes 9%.⁴⁶ When converted to the unit basis, these additional emissions before the combustion ranged from 297 to 528 gCO₂/kWh, further undermining the viability of biomass. While these findings are thought to be comparable to the South Korean imports of wood pellets from BC and Southeast Asia, no study has been conducted in this context.

3.1.3. Carbon-Neutral Myth of Biomass

The industry claims of biomass being carbon-neutral is predicated on the notion that the substantial amount of CO₂ emitted during combustion will eventually be reabsorbed by standing forests, forming part of a benign "cycle of carbon." This logic is riddled with critical inconsistencies in its fundamental premises as well as practicality and timeliness.

Achieving carbon neutrality with forest biomass, even in theory, takes a minimum of several decades and is rarely possible in real-world scenarios. This also means that the atmospheric GHG concentrations will stay elevated for decades to come, making biomass an energy source that exacerbates the climate crises in the meantime.

⁴⁶ Brack, D., Birdsey, R., & Walker, W. (2021). *Greenhouse gas emissions from burning US-sourced woody biomass in the EU and UK*. Chatham House. <https://www.chathamhouse.org/2021/10/greenhouse-gas-emissions-burning-us-sourced-woody-biomass-eu-and-uk>

3.1.3.1. Unproven Claims of Replacing Coal

The claim that forest biomass replaces coal is fundamentally flawed. The world has already reached a consensus on prioritizing the phase-down of coal to mitigate climate change. Major advanced economies are shutting down their coal power fleet by the 2030s at the latest. Coal is already being phased out independently of the transition to biomass, and the growth of biomass power in South Korea does not show a meaningful correlation or causation with reduced coal consumption.

Instead, REC weightings available for biomass makes it compete with other renewable energy sources, such as solar and wind. As RECs supplied to the market are anonymous with untraceable energy sources, intense competition ensues among all types of energy. Consumers are as a result prevented from choosing their preferred sources. What biomass is replacing is not coal but rather clean renewable energy whose economic viability has been diminished due to an oversupply of RECs. The decline in the competitiveness of low-carbon energy inevitably hampers the country's energy transition efforts at large.⁴⁷

3.1.3.2. Carbon Stock Loss through Logging

The argument that biomass emissions can be offset by forests reabsorbing all the carbon released in the atmosphere is invalid. If logging for the purpose of burning does not occur in the first place, the carbon sequestered in the tree will remain entirely in the trees. Even if logging is conducted under the principles of "forest management" or restricted to "sustainable" levels, the carbon stocks in the logged forests are inevitably bound to be smaller than those in remaining intact areas.

Moreover, forests grow independently of anthropogenic biomass consumption. Claiming forests absorbing carbon solely for offsetting biomass combustion is unreasonable, and attributing the sequestration solely to human efforts is challenging, even with sustainable forest management (SFM). The carbon benefits of forest biomass must be compared with the scenarios where biomass is not used and where other renewable sources are employed. I

47 Kim, S. & Kim, J. (2019). *Can biomass qualify as renewable energy? The state of biomass policy in South Korea*. Solutions for Our Climate.

n both cases, carbon stocks in the forest decline, while CO₂ released into the atmosphere increases.⁴⁸

3.1.3.3. Unproven Effects of Replanting

The assertion that replanting trees, mandatory under South Korean forestry regulations, can absorb the released CO₂ is not universally applicable. As of 2022, 27.5% of forest residues for biomass were supplied through land conversion (Figure 14).⁴⁹ In the literal sense, reforestation cannot occur on land deforested for other use purposes, resulting in zero future carbon reabsorption.

Even if replanting takes place, it is unlikely that these saplings will grow intact for decades. Forest lands in South Korea continue to decrease due to urban development and road construction, among many other factors. Natural disasters such as large wildfires, pests, storms, and floods, exacerbated by worsening climate change, are putting the adaptability and survival of many tree species to the test. Reforesting efforts focused predominantly on pine trees, despite the increasingly uninhabitable conditions for conifers in the domestic climate zone, raise concerns about their long-term survival. Saplings replanted in areas cleared for biomass are not separately monitored by any means, leaving the carbon restocking effect reliant on mere hopes.

3.1.3.4. Carbon Neutrality that Takes Decades

Even under the unrealistic assumption that reforested trees grow mature in an ideal condition, achieving carbon neutrality through biomass is greatly far-fetched, given the impending timeline for climate action. Since tree growth takes decades, reaching a carbon-neutral state by absorbing all the CO₂ emitted at once takes a minimum of several decades. The initial carbon emitted during this time is referred to as “carbon debt,” and the time required

48 Stermann, J., Moomaw, W., Rooney-Varga, J. N., & Siegel, L. (2022). Does wood bioenergy help or harm the climate? *Bulletin of the Atomic Scientists*, 78(3), 128–138. <https://doi.org/10.1080/00963402.2022.2062933>

49 Korea Forest Service. (n.d.). 벌채목적별 미이용 산림바이오매스 증명서 확인 현황. https://www.forest.go.kr/kfswweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_11_07_03&cmsId=FC_003565

to reach carbon neutrality is termed the “payback period.” From achieving the initial carbon neutrality onward, “carbon benefits” would be incurred, a comparative advantage over burning fossil fuels in terms of emissions reduction.

In 2015, the Natural Resources Defense Council (NRDC)⁵⁰ estimated that burning wood pellets with 40% hardwood content would take approximately 70 years to become carbon-neutral. Particularly in the first half-century, it emits more CO₂ than coal power generation, resulting in significant cumulative emissions. Considering that roughly 40% of wood pellets produced in South Korea are made from roundwood as well and that coal power plant lifespans are usually around 30 years, yielding carbon benefits through biomass combustion is implausible.

In 2017, scientists from Natural Resources Canada announced that burning biomass instead of coal would take on average of 30 years for residues to generate carbon benefits and 100 years for burning salvaged or harvested wood. Substituting for oil would require about 70 years for residues, and there would be no carbon benefits in any scenario replacing gas.⁵¹

In 2018, a research team from the Massachusetts Institute of Technology (MIT) estimated the payback period to be between 44 and 104 years⁵² and extended it to 115 years in a subsequent study in 2022.⁵³

The payback period for carbon debt depends on various factors. The use of roundwood, older trees, slower forest growth, and lower power plant efficiency all prolong the payback period. In 2021, the EU Joint Research Centre (JRC) evaluated the payback period, biodiversity, and ecosystem impacts for various pathways of forest residues for biomass. According to the research, biomass fuels made from coarse debris and low stumps exhibited higher carbon emissions than fossil fuels for at least 50 years. Only the fine debris harvested while

50 Natural Resources Defense Council. (2015). *Think Wood Pellets are Green? Think Again*. <https://www.nrdc.org/sites/default/files/bioenergy-modelling-IB.pdf>

51 Laganière, J., Paré, D., Thiffault, E., & Bernier, P. Y. (2017). Range and uncertainties in estimating delays in greenhouse gas mitigation potential of forest bioenergy sourced from Canadian forests. *Global Change Biology Bioenergy*, 9(2), 378–369. <https://doi.org/10.1111/gcbb.12327>

52 Serman, J. D., Siegel, L., & Rooney-Varga, J. N. (2018). Does replacing coal with wood lower CO₂ emissions? Dynamic lifecycle analysis of wood bioenergy. *Environmental Research Letters*, 13(1), <https://doi.org/10.1088/1748-9326/aaa512>

53 Serman, J., Moomaw, W., Rooney-Varga, J. N., & Siegel, L. (2022). Does wood bioenergy help or harm the climate? *Bulletin of the Atomic Scientists*, 78(3), 128–138. <https://doi.org/10.1080/00963402.2022.2062933>

respecting landscape thresholds was found to both provide a climate change mitigation effect and maintain ecosystem conditions.⁵⁴ Biomass meeting such criteria is not only extremely limited in nature but also prohibitively expensive to collect.

When it comes to research conducted in South Korea, a 2021 Jeonbuk National University study estimated 70 years for biomass to pay back its carbon debt and predicted that atmospheric CO₂ could increase by more than 50% in the interim. The author concluded that his finding was only a theoretical best-case scenario and that the real-world implications would be even worse. “Biomass is not truly carbon-neutral and is not a suitable alternative to fossil fuels,” concluded the author.⁵⁵ In the same year, over 500 scholars from around the world issued a joint statement to the leaders of the US, the EU, Japan, and South Korea, claiming that biomass cannot replace fossil fuels.⁵⁶

In conclusion, the scientific community is skeptical of achieving carbon neutrality through industrial-scale forest biomass power within a meaningful timeframe. Even forest residues under strict criteria entail a payback period of at least several decades. During this period, biomass continues to accelerate the irreversible and catastrophic consequences of climate change. In the context of the IPCC AR6 predicting a 1.5° C rise by the 2030s, biomass only burns up the remaining global carbon budget and contributes nothing to mitigation efforts.

3.2. Acceleration of Preventable Forest Loss

Since the definition of forest biomass entails burning wood from forests to acquire energy, it inevitably involves logging of standing trees. Despite forests providing a wide range of ecological benefits and values to the public, the government’s ambitious targets and aggressive policy for biomass continue to ever-enlarge the industry, downplaying the imminent priority of forest conservation.

54 Camia, A., Giuntoli, J., Jonsson, K., Robert, N., Cazzaniga, N., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo Cano, J. I., & Mubareka, S. (2020). *The use of woody biomass for energy production in the EU*. Publications Office of the European Union. <https://doi.org/10.2760/428400>

55 Choi, S. (2021). A mathematical programming method for minimization of carbon debt of bioenergy. *Clean Technology*, 27(3), 269–274. <https://doi.org/10.7464/ksct.2021.27.3.269>

56 Frost, R. (2021, December 12). Stop burning trees for energy, hundreds of scientists tell EU leaders. *Euronews*. <https://www.euronews.com/green/2021/02/12/stop-burning-trees-for-energy-hundreds-of-scientists-tell-eu-leaders>

Consequently, the imports of wood pellets associated with severe forest loss and human rights violations have increased, and a significant portion of forest resources in South Korea has been diverted to biomass production. Alongside the inherent limitations of biomass failing to replace fossil fuels or reduce GHG emissions, the state of forest loss at both home and abroad makes the ideal promise of “sustainable biomass” ring hollow.

3.2.1. Importing of Unsustainable Biomass

The production of imported wood pellets, accounting for 84% of South Korea’s pellet consumption, takes place outside the jurisdiction of the government. Because these pellets are mostly sourced from opaque supply chains in emerging economies, ensuring their climate and environmental sustainability is extremely challenging. In 2022, South Korea imported 3.9 million tons of wood pellets, with 56.2% from Vietnam, 11.6% from Russia, 10.6% from Indonesia, 10.2% from Malaysia, and 8.8% from Canada (Table 6).⁵⁷

Table 6. Wood pellet imports to South Korea, 2012–2022

Thousand metric ton

	Vietnam	Russia	Indonesia	Malaysia	Canada	Other	Sum
'12	30	42	90	31	3	8	122
'13	157	77	34	78	80	59	485
'14	743	35	63	168	344	497	1,850
'15	1,023	84	60	154	88	62	1,471
'16	1,255	126	76	199	35	25	1,717
'17	1,516	128	120	405	152	111	2,431
'18	2,187	70	222	586	41	340	3,445
'19	1,941	99	239	520	11	191	3,002
'20	1,912	165	303	508	52	64	3,004
'21	2,102	167	315	406	329	39	3,357
'22	2,201	453	416	400	346	102	3,917

Source: Korea Customs Service.

57 Korea Customs Service. (n.d.). 수출입무역통계 [Data set]. <https://unipass.customs.go.kr/ets>

Recent trends include a sustained heavy reliance on Vietnamese imports, a significant increase in Russian imports since the Russo-Ukrainian war, steady growth in Indonesian imports surpassing Malaysian, and a six-fold increase in Canadian imports from 2021. The surge in imports raises criticisms for the *Regulation to Promote Legal Timber Trade*'s inability to examine the sustainability of biomass and "importing the deforestation" while contributing to environmental issues widespread in producer countries.⁵⁸

3.2.1.1. Regulation to Promote Timber Trade

Under the *Regulation to Promote Timber Trade*, which came into effect in 2019 for seven and now 12 wood products, including wood pellets, importers must prove legality based on the producer country's laws or submit voluntary certifications like the FSC or Programme for the Endorsement of Forest Certification (PEFC). The introduction of the South Korean timber legality scheme was long-overdue compared to not only other advanced economies, such as the US (2008), Australia (2012), the EU (2013), and Japan (2017), but also Indonesia (2016) and Malaysia (2017).⁵⁹ Consequently, the 11.5 million tons of wood pellets imported in the first seven years of industrial-scale biomass power were not even checked for lawfulness, let alone sustainability.

While implementing the Regulation, though belated, is considered a positive progress, the relevant procedures rely entirely on the discretion of the exporting country. Therefore, its effectiveness is highly susceptible to and limited by the producer country's vague or inadequate definitions of illegal logging and the questionable levels of enforcement. The low societal transparency in many emerging economies often results in document forgery and bribery, casting doubt on the legitimacy of certifications.

The customs clearance in South Korea also depends entirely on superficial document checks rather than the due diligence of importers. This approach provides no mechanism

58 Kim, S., Kim, H., Song, H., Chung, S., & Cho, J. (2022). *Importing deforestation: Forest-risk commodity supply chains and due diligence legislation in South Korea*. Advocates for Public Interest Law, Solutions for Our Climate, & Korea Federation for Environmental Movements. <https://forourclimate.org/en/sub/data/view.htmlidx74>

59 Ahn, H. (2021). 국가별 목재합법성 위험 평가. *세계농업*, 240. <https://repository.krei.re.kr/bitstream/2018.oak/26186/1/E03-2021-03-03.pdf>

for recognizing risks, even when products are widely known to be associated with environmental degradation or human rights violations.⁶⁰

Furthermore, the current system focuses solely on discerning legality, rather than comprehensively considering sustainability from the climate and human rights standpoints, rendering it unfit for determining the overall impact on the environment and society. These limitations of the South Korean timber legal framework are further substantiated by its inability to address any of the issues prevalent in Vietnam, Russia, Indonesia, and Canada, as detailed below.

3.2.1.2. Vietnamese Wood Pellets

Vietnam, the world's second-largest wood pellet exporter after the US, has long been categorized as a high-risk country due to illegal logging and conversion of natural forests to plantations. Low awareness regarding legality and complexity of land rights structure contribute to inaccuracies and opaqueness in the Vietnamese timber supply chains.⁶¹

The risk is further exacerbated by the approximately 2 million tons of wood imported from over 20 countries, including high-risk countries such as Cameroon, Papua New Guinea, Suriname, Nigeria, and the Democratic Republic of the Congo. Such high-risk timber accounted for 34% of all wood imports to Vietnam in 2020.⁶² Despite the growing concern that the booming pellet industry is indiscriminately sourcing timber from fast-growing monocultures and imported illegal wood, information is rarely available outside the country due to the severely reduced domestic civic space.

Some scandals with Vietnamese wood pellets fueled such far-reaching controversies that they garnered international media attention. A notable case is the FSC's expulsion of An Viet

60 Kim, S., Kim, H., Song, H., Chung, S., & Cho, J. (2022). *Importing deforestation: Forest-risk commodity supply chains and due diligence legislation in South Korea*. Advocates for Public Interest Law, Solutions for Our Climate, & Korea Federation for Environmental Movements. <https://forourclimate.org/en/sub/data/view.htmlidx74>

61 Vo, B. U. K. (2023, November 19). A thorny dilemma: Acacia plantations in Vietnam may not be all that green. *Mekong Eye*. <https://www.mekongeye.com/2023/11/19/acacia-not-green/>

62 Phuc, T. X., Cam, C. T., & Huy, T. L. (2021). *Vietnamese imports of high-risk timber: Current status and control mechanisms*. Forest Policy Trade and Finance Initiative. <https://www.forest-trends.org/publications/vietnamese-imports-of-high-risk-timber/>

Phat (AVP), one of Vietnam's largest wood pellet manufacturers. AVP operates wood pellet factories across the country and supplies millions of tons every year to South Korean power and logistics companies, such as SGC Energy, Hyundai Livart, OCI, GS Global, and Samsung C&T.⁶³

However, in 2021, FSC's audits revealed that AVP falsely certified a significantly larger quantity of wood pellets with FSC labels than the eligible volume. FSC ultimately revoked AVP's certification in January 2023⁶⁴ and initiated additional investigations on Vietnamese wood pellets in the following May.⁶⁵

Despite the FSC investigations being in full swing from 2021, AVP products have never ceased to make its way into South Korea. Both domestic trading partners and the relevant organizations, including the KFS and Korea Customs Service, did not take any action to restrict the imports. Their failure to respond can be attributed to the fact that the Regulation to Promote Legal Timber Trade allows alternate certifications, such as the PEFC or national timber legality documents, to substitute the FSC label.⁶⁶ AVP wood pellets are confirmed to be continuously supplied to South Korean biomass plants, including the five subsidiaries of KEPCO.⁶⁷

3.2.1.3. Russian Wood Pellets

The imports of Russian wood pellets sharply increased in 2022, also due to the limitations of the current legal system that cannot prevent the influx of internationally condemned timber. Originally, Russia exported pellets primarily to Europe. However, following its invasion

63 Kim, S., Kim, H., Song, H., Chung, S., & Cho, J. (2022). *Importing deforestation: Forest-risk commodity supply chains and due diligence legislation in South Korea*. Advocates for Public Interest Law, Solutions for Our Climate, & Korea Federation for Environmental Movements. <https://forourclimate.org/en/sub/data/view.htmlidx74>

64 Forest Stewardship Council. (2023, January 13). *Integrity of wood pellets supply chains at risk*. <https://fsc.org/en/newscentre/integrity-and-disputes/integrity-of-wood-pellets-supply-chains-at-risk>

65 Forest Stewardship Council. (2023, May 15). *Launch of transaction verification loop in Vietnam*. <https://fsc.org/en/newscentre/integrity-and-disputes/launch-of-transaction-verification-loop-in-vietnam>

66 Vo, B. U. K. (2023, November 19). Smoke, mirrors, wood pellets: Vietnam clears native forest to supply 'clean' energy to Asia. *Mekong Eye*. <https://www.mekongeye.com/2023/11/19/acacia-not-green/>

67 Kim, J., Kang, H., & Lee, M. (2023, March 2). [삼림파괴 주식회사@]친환경 연료 만든다며 동남아 환경 파괴..공급망 추적. Newstapa. <https://newstapa.org/article/kWTke>

of Ukraine in February 2022, both the FSC and PEFC designated Russian wood as “conflict timber” and revoked certification.^{68, 69} In May of the same year, the EU imposed sanctions against Russia, including a ban on all timber imports.⁷⁰ Meanwhile, independent investigations revealed that Russian timber oligarchs involved in illegal logging and deforestation had close connections with President Vladimir Putin.⁷¹

Despite fewer countries legally importing Russian wood pellets, South Korea, as seen in the AVP case, found a way to secure quantities that could not be sold to Europe. The monthly imports increased more than fivefold, reaching a record-high of 75 thousand tons by the end of 2022.⁷² Other countries that have seen a similar increase in the import volume following Europe’s sanctions are the neighboring Türkiye, Kazakhstan, and Kyrgyzstan, allegedly laundering the origin of Russian pellets to penetrate the EU border.⁷³ Apart from such illicit trade, South Korea stands out as the only country boldly importing large quantities of Russian conflict timber.

3.2.1.4. Indonesian Wood Pellets

Indonesia faces challenges in ensuring its legality of timber, similar to the cases in Vietnam.⁷⁴ In addition, Indonesia’s biomass demand is expected to surge in the coming years due to the government’s and state-owned power utility’s (Perusahaan Listrik Negara, PLN) plans to mandate biomass co-firing in all coal power plants. The government has also allowed existing plantation owners to switch business plans to biomass production without having to receive additional permits.

68 Forest Stewardship Council. (2022, March 8). *No FSC material from Russia and Belarus until the invasion ends*. <https://fsc.org/en/newscentre/general-news/no-fsc-material-from-russia-and-belarus-until-the-invasion-ends>

69 Programme for the Endorsement of Forest Certification. (2022, March 4). *Timber from Russia and Belarus considered ‘conflict timber’*. <https://pefc.org/news/timber-from-russia-and-belarus-considered-conflict-timber>

70 European Council. (2022, April 4). *EU adopts fifth round of sanctions against Russia over its military aggression against Ukraine*. <https://www.consilium.europa.eu/en/press/press-releases/2022/04/08/eu-adopts-fifth-round-of-sanctions-against-russia-over-its-military-aggression-against-ukraine/>

71 Earthsight. (2022, November 3). *Russia’s timber oligarchs*. <https://www.earthsight.org.uk/news/analysis/russias-timber-oligarchs>

72 Korea Customs Service. (n.d.). 수출입무역통계 [Data set]. <https://unipass.customs.go.kr/ets/>

73 Catanoso, J. (2023, January 24). The EU banned Russian wood pellet imports; South Korea took them all. *Mongabay*. <https://news.mongabay.com/2023/01/the-eu-banned-russian-wood-pellet-imports-south-korea-took-them-all/>

74 Jong, H. N. (2021, September 29). Monitoring reveals Indonesia’s ‘legal timber’ scheme riddled with violations. *Mongabay*. <https://news.mongabay.com/2021/09/monitoring-reveals-indonesias-legal-timber-scheme-riddled-with-violations/>

Independent analyses estimate that meeting the biomass fuel demand of 9 million tons for co-firing expansion would require energy forest plantations (Hutan Tanaman Energi, HTE) covering at least 2.3 million ha, 394 times the size of Manhattan. Given that 38% of existing industrial timber plantations (Hutan Tanaman Industri, HTI) have been converted from natural forests, the likelihood of substantial deforestation within Indonesia solely to meet domestic biomass demand remains high.⁷⁵

South Korea, importing over 416 thousand tons annually and accounting for 90% of Indonesia's total wood pellet exports,⁷⁶ is a significant contributor to deforestation in the tropical country. Even if such exports are found not to be directly associated with forest loss, South Korea's "indirect deforestation," disrupting one of the last-remaining biodiversity hotspots of the world, is clearly undeniable. If scaled continuously at the current rate, the external demands would lead to displacing the already high wood demand originating within Indonesia to other vulnerable areas.

The country has already experienced severe indirect land-use change effects with oilseed crops for biofuels production. Both the domestic and South Korean demands are likely to cause a similar wave of deforestation, this time for biomass.

3.2.1.5. Canadian Wood Pellets

In Canada, the controversy over deforestation for wood pellet production has not died down for several years. Particularly noteworthy is the global attention on the destructive clear-cutting by Drax in the lush temperate rainforests of BC.

While the exports of Canadian wood pellets to South Korea were relatively insignificant until 2020, the following year witnessed an increase of more than sixfold, exceeding 346 thousand tons.⁷⁷ This surge is believed to be linked to offtake contracts with Drax, which com-

75 Trend Asia. (2022). *Battle on Emission Reduction Claims*. <https://trendasia.org/wp-content/uploads/2022/11/Battle-on-Emission-Reduction-Claims.pdf>

76 United Nations. (n.d.). *UN Comtrade Database* [Data set]. <https://comtradeplus.un.org/>

77 Korea Customs Service. (n.d.). 수출입무역통계 [Data set]. <https://unipass.customs.go.kr/ets/>

mitted to supplying 320 thousand tons per annum to the CGN Daesan power plant⁷⁸ and an additional 100 thousand tons per annum to GS Global, a trading firm that shares the same parent company with the GS EPS power plant.⁷⁹

Initially, Drax denied the use of whole trees in its wood pellets. However, investigations by the international media and environmental organizations have revealed that the company had been bulldozing the primary forests of BC,⁸⁰ a region that serves as a habitat for the threatened Woodland caribou and where the Tsilhqot'in First Nations hold their federally recognized land rights.⁸¹ The area impacted by Drax's logging and milling operations covers over 840 thousand hectares, 142 times the size of Manhattan.⁸² Canadian pellets, like wood pellets imported from other countries, face no legal repercussions under the South Korean regulations.

3.2.2. Domestic Production of Unsustainable Biomass

Domestically produced biomass heavily relies on roundwood that could have had more valuable uses. The industry asserts that some of the feedstocks are bound to come from roundwood because the low wood quality of forestry by-products makes fuel production technologically challenging. The fact remains that the current practice was made possible only because the government incentive ensures the profitability of fuel manufacturers even when they source relatively expensive high-quality timber. Given the high REC weightings assigned to biomass, power plants can procure wood pellets and chips at higher prices, and biomass producers in turn, can secure the feedstocks at higher costs.

78 Pinnacle Renewable Holdings Inc. (2018, June 27). Pinnacle Renewable Holdings announces new off-take contracts in South Korea and Japan. *Cision*. <https://www.newswire.ca/news-releases/pinnacle-renewable-holdings-announces-new-off-take-contracts-in-south-korea-and-japan-686668701.html>

79 Kang, H. (2022, August 1). 영국의 세계 최대 바이오매스 발전소가 그린워싱 논란? *The Kyunghyang Shinmun*. <https://www.khan.co.kr/environment/environment-general/article/202208011606001>

80 Crowley, J. & Robinson, T. (2022, October 3). Drax: UK power station owner cuts down primary forests in Canada. *BBC*. <https://www.bbc.com/news/science-environment-63089348>

81 Stand.earth. (2020). *Canada's growing wood pellet export industry threatens forests, wildlife and our climate*. <https://stand.earth/wp-content/uploads/2022/10/report-canada-wood-pellet-industry.pdf>

82 Stand.earth. (2021). *Risk map: Pellet facility threatens primary forest and caribou habitat*. <https://stand.earth/resources/risk-map-pellet-facility-threatens-primary-forest-and-caribou-habitat/>

The same market dynamics is also fueling the excessive extraction of what is considered forest residues, or the misleadingly termed “unused forest biomass.” Because selective logging and sorting the fine debris, such as tops and limbs, are costly, loggers opt for large-scale clear-cutting and lump together all the harvests as forest residues. This regularly occurring practice in the name of forest management contributes to a significant loss of ecological values and functions; yet no regulation is in place to alleviate the adverse impacts.

3.2.2.1. Domestic Biomass Produced from Roundwood

Roundwood in South Korea is a limited resource that could be better employed as long-living and high-value products capable of storing carbon over an extended period in other wood industries. Using roundwood as fuel contradicts the cascading principles of wood use and represents a wasteful exploitation of forest resources. Specifically, the influx of roundwood into forest residues fuels may be seen as an illicit practice resulting from vague standards and insufficient enforcement failing to address the expansion of intensive logging.

However, both the KFS and MOTIE appear to either lack a precise understanding of the reality of roundwood biomass or choose to ignore it altogether. Concerns arise that illegal activities prevalent across the stages of harvest, manufacture, and distribution may ultimately compromise the integrity of RECs granted to electricity generated using these fuels.

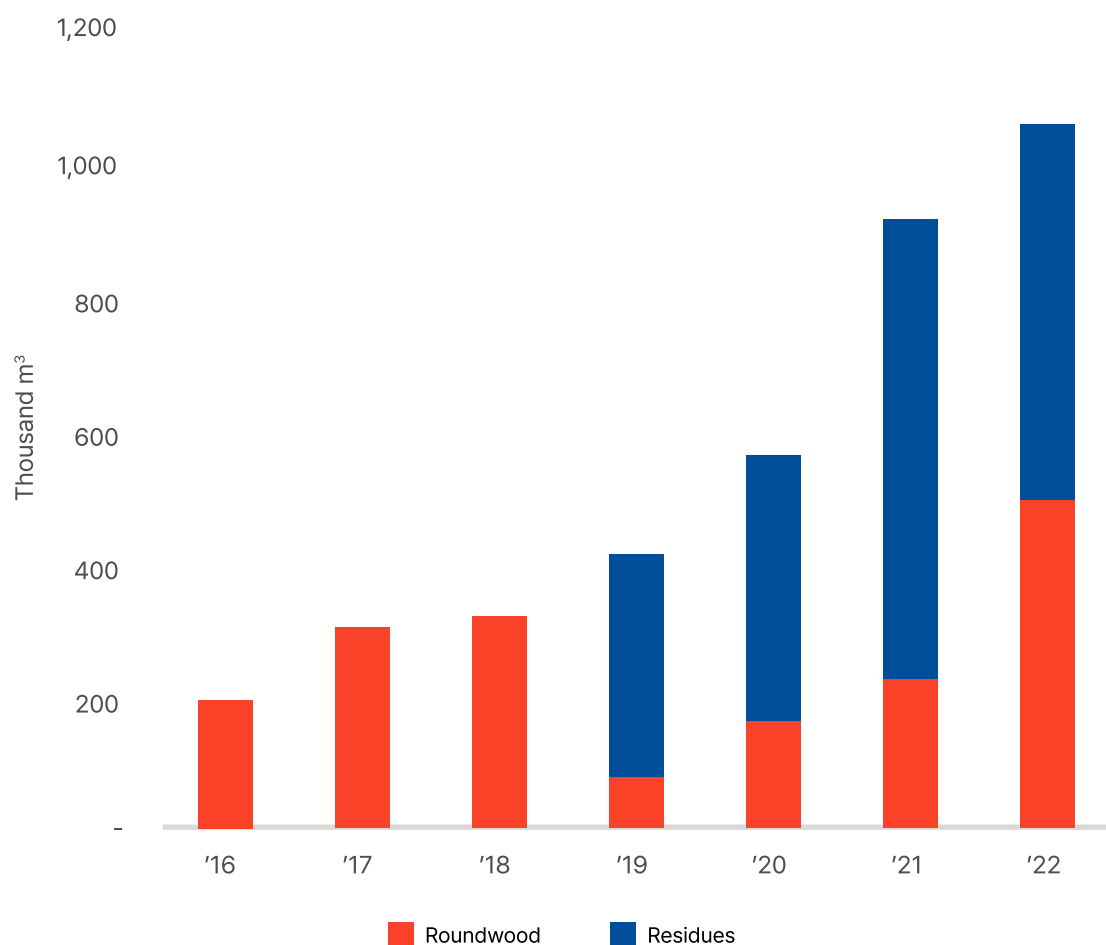
3.2.2.2. Mixing of Roundwood in Forest Residues

The overt use of roundwood for fuel is apparent even in government data. According to the KFS’s⁸³ timber supply records, among the 1.1 million m³ of domestic wood used for biomass in 2022, 46.5% turned out to be roundwood (Figure 13). Another annual survey by the KFS⁸⁴ specifies that 37.4% out of the 871 thousand m³ of wood used for wood pellets in 2021 was identified as roundwood. These records show an increase of over five times compared to five years ago.

83 Korea Forest Service. (2013–2023). 목재수급실적. https://www.forest.go.kr/kfsweb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_04_03_02&cm-sld=FC_003649

84 Korea Forest Service. (2022). 2021년 기준 목재이용실태조사.

° Figure 13. Wood used for biomass fuels in South Korea by wood type, 2016–2022



Source: Korea Forest Service, 2013–2023.

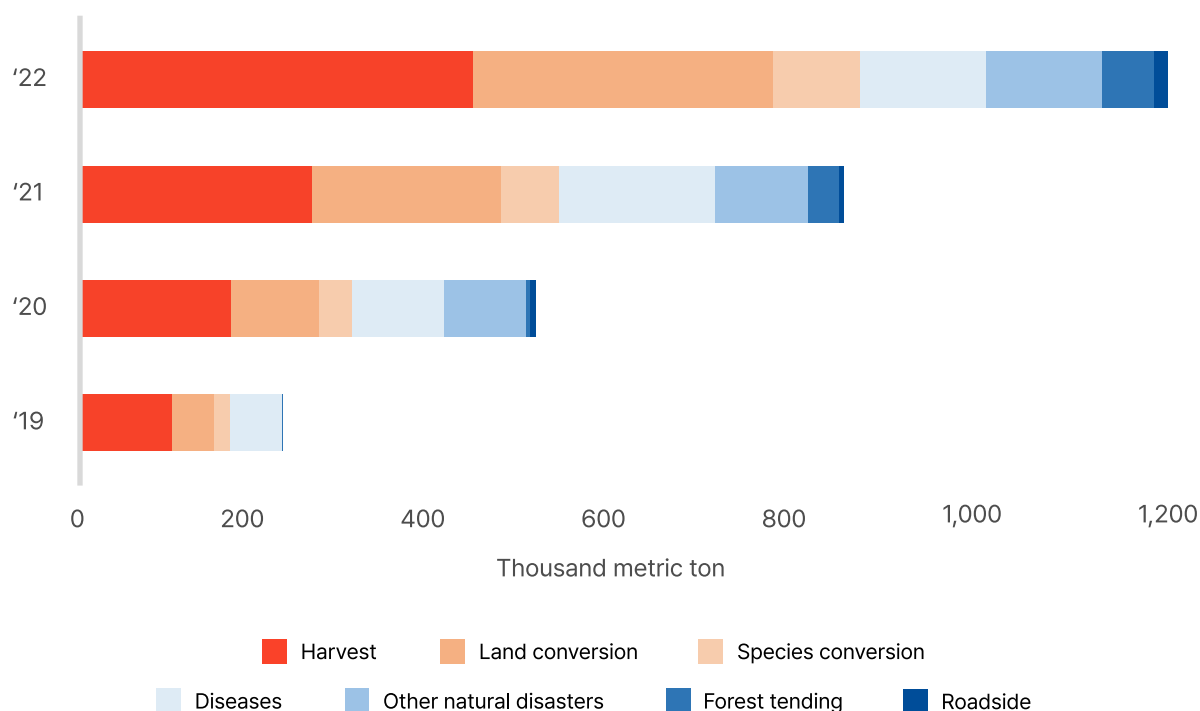
The actual amount of roundwood for energy production appears to surpass the official statistics the KFS chose to disclose. Since the support measures for forest residues came into effect in 2019, a substantial portion of the previously classified roundwood has begun to be categorized as residues. Considering that no measures have been taken during this period to reduce the use of roundwood, it can be inferred that a significant amount of it has been disguised as forest residues.

A 2022 study by researchers from the NIFoS also estimated that around 350 thousand m³ of roundwood is being blended into forest residues annually.⁸⁵ Given that this study limited the

85 Yang, J., Lee, J., Jeong, H., Sang, H., & Lee, S. (2022). Estimation of the amount of round wood in unused forest biomass reporting in forest clearing. *New & Renewable Energy*, 18(4), 70–78. <https://doi.org/10.7849/ksnre.2022.0038>

means of harvest to final cutting, which accounts for only 31–46% of total certified forest residues (Figure 14),⁸⁶ and that a significant portion of forest residues is produced through clear-cutting across all types of logging operations (Figure 15),⁸⁷ the total extent of roundwood mixing is likely to go beyond the study’s conservative estimates.

° Figure 14. Forest residues supplied for biomass fuels in South Korea by purpose of logging, 2019–2022



Source: Korea Forest Service.

The MOTIE’s fuel input records collected from power plants further raise suspicions of illegally issuing forest residues RECs to roundwood pellets. According to the KFS,⁸⁸ 94.4% of the 690 thousand tons of wood pellets sold in 2021 were intended for power generation. However, data from the MOTIE⁸⁹ indicate that biomass power plants across the country did not use any roundwood pellet from 2019 to 2021 (Table 3).

86 Korea Forest Service. (n.d.). 별채목적별 미이용 산림바이오매스 증명서 확인 현황. https://www.forest.go.kr/kfswb/kfi/kfs/cms/cmsView.do?mn=NKFS_02_01_11_07_03&cmsId=FC_003565

87 Korea Forest Service. (2023). *Details of applications and certifications for unused forest biomass* [Data set submitted to National Assembly].

88 Korea Forest Service. (2022). 2021년 기준 목재이용실태조사.

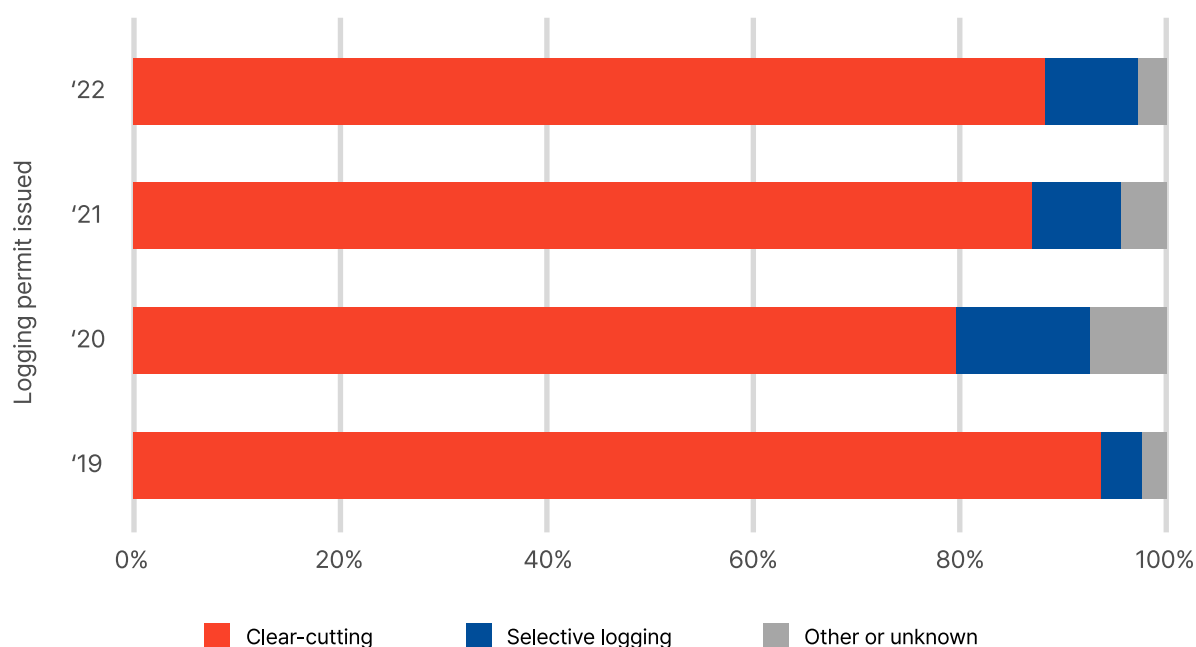
89 Ministry of Trade, Industry and Energy. (2023). *National statistics on biomass power fuel input* [Data set submitted to National Assembly].

The stark contrast between the MOTIE's data that all domestic wood pellets were forest residues and the KFS's acknowledgment that a significant portion of them were made of roundwood highlights both legality and sustainability concerns. This further amplifies the existing concern that pellets made from roundwood are being falsely labeled as residues, enabling them to receive higher REC weightings.

3.2.2.3. Intensive Logging for Biomass Production

Contrary to the common understanding that forest residues are by-products generated during usual logging activities, the very notion of "residues" in South Korea has become so derogated to the point it serves as a logging premium. In many regions, biomass fuel production has become the primary driver for logging, almost always resulting in the devastation of the local ecosystems. In fact, an average of 87% of all the certified collections of forest residues between 2019 and 2022 resulted from clear-cutting (Figure 15).⁹⁰

° Figure 15. Certified forest residues in South Korea by means of logging, 2019–2022

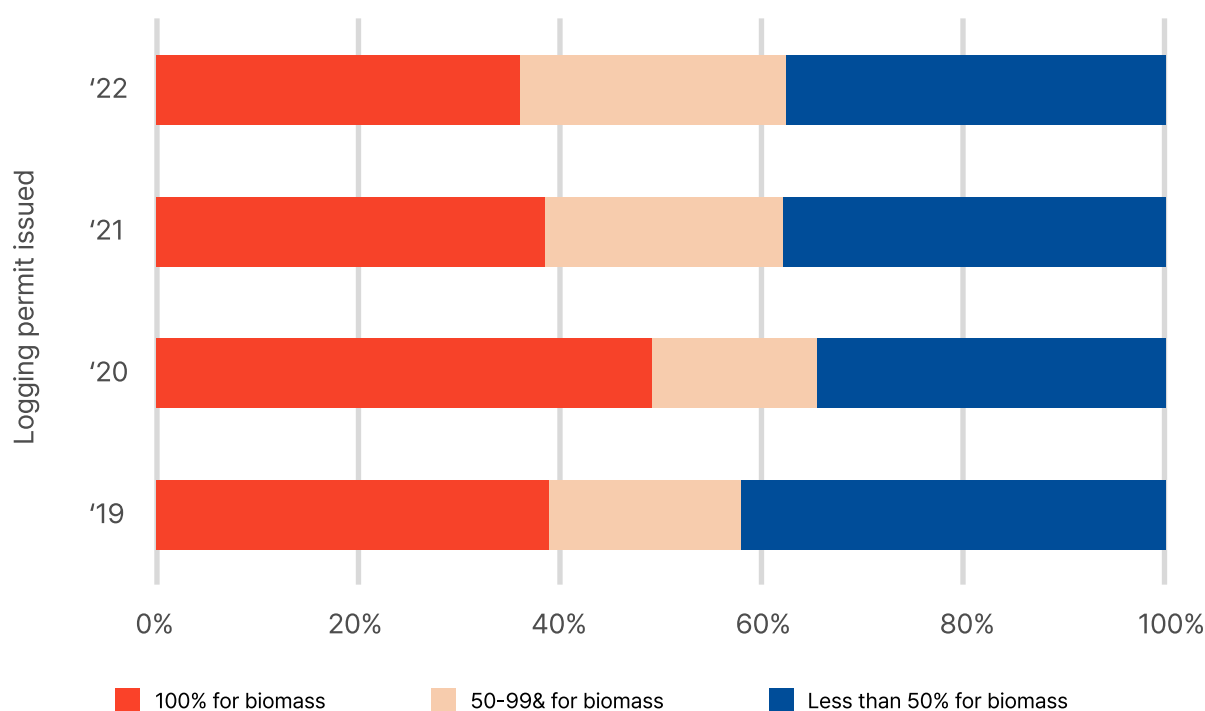


Source: Korea Forest Service, 2023; compiled by author.

90 Korea Forest Service. (2023). *Details of applications and certifications for unused forest biomass* [Data set submitted to National Assembly].

Of all the logging licenses that permitted the collection of forest residues, 40% were exclusively granted for biomass extraction, and an additional 22% contained more residues than harvested timber (Figure 16). During the same period, cases where the volumes of forest residues collected exceeded the initially permitted quantity averaged at 28%, and 12 % exceeded the planned quantity by 30%, subjected to a revision of forest residues permit application (Figure 17).⁹¹ Forest residues are no longer by-products in South Korea.

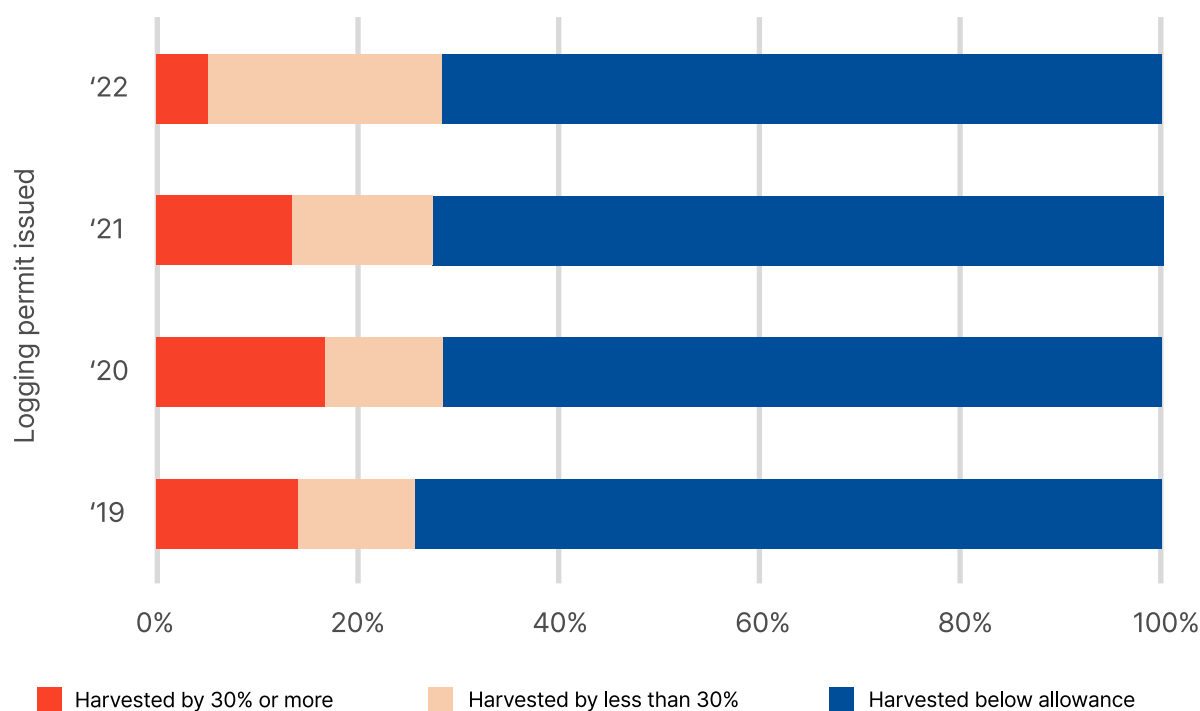
° Figure 16. Ratio of forest residues to logging allowance in South Korea, 2019–2022



Source: Korea Forest Service, 2023; compiled by author.

91 Korea Forest Service. (2023). *Details of applications and certifications for unused forest biomass* [Data set submitted to National Assembly].

° Figure 17. Quantity of forest residues harvested relative to collection allowance in South Korea, 2019–2022



Source: Korea Forest Service, 2023; compiled by author.

The NIFoS researchers also observed that the combined collected amount of forest residues often surpasses that of timber production, particularly in cases of harvest, logging of damaged trees, and land conversion. The researchers stated that “the timber produced after logging has been gradually decreasing since its peak in 2017... Considering the introduction of the forest residues system in 2018 and the commencement of supplying residues wood pellets to power plants in 2019, there could be an influence.”⁹² Such a misuse of the biomass system, substantiated by large amounts of forest residues containing roundwood, makes it imperative for the MOTIE and the KFS to investigate illicit or fraudulent issuance of RECs.

92 Yang, J., Lee, J., Jeong, H., Sang, H., & Lee, S. (2022). Estimation of the amount of round wood in unused forest biomass reporting in forest clearing. *New & Renewable Energy*, 18(4), 70–78. <https://doi.org/10.7849/ksnre.2022.0038>

4. Government Policies that Drive Forest Loss

The fundamental issue with South Korea's forest biomass policies, as highlighted in this report, is the failure to consider the numerous climate and environmental impacts associated with biomass as an energy source. For the past decade, the government has maintained the blanket assumption that all biomass is sustainable on par with genuinely clean renewables.

On one hand, the MOTIE has granted generous renewable subsidies in the form of REC weightings so high that solar and wind were dwarfed by biomass in the market. On the other hand, the KFS has not only insisted on the green myth of biomass but also actively advocated ever-increasing the RECs for forestry industry interests. The product of the two is the current governance lacking mechanisms to improve the sustainability of forest biomass. This deficiency is evident at both the legislative level and in key policies of both ministries.

4.1. Excessive Renewable Energy Certificate Weightings

Forest biomass, among the various types of renewable energy, is a particularly costly one. Globally, biomass power is not profitable and therefore unable to sustain its economic viability without some form of government support.

From affordable to expensive, the global weighted average levelized cost of electricity (LCOE) in 2022 ranked onshore wind, solar photovoltaic, geothermal, and biomass at 0.033 USD/kWh, 0.049 USD/kWh, 0.056 USD/kWh, and 0.061 kWh/USD, with only offshore wind at 0.081 USD/kWh costing more than biomass.⁹³ Likewise in South Korea, dedicated forest residues and dedicated regular wood pellets and chips exhibit higher LCOEs at 213 KRW/kWh (0.188 USD/kWh) and 159 KRW/kWh (0.141 USD/kWh) compared to solar at 138–165 KRW/kWh (0.122–0.146 USD/kWh) and onshore wind at 151 KRW/kWh (0.134 USD/kWh).

⁹³ International Renewable Energy Agency. (2023). *Renewable power generation in 2022*. <https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022>

Notably, the cost of new facilities burning forest residues, which are at the forefront of biomass expansion, reaches a maximum of 386 KRW/kWh (0.342 USD/kWh), even surpassing offshore wind at 326 KRW/kWh (0.288 USD/kWh) (Table 7).⁹⁴ The high cost is mainly attributed to the continuous demand of wood as fuel, alongside capital investment and operational expenditure associated with large combustion facilities, costs from which solar and wind are exempt.

94 Foreign exchange rates used in this context are based on the average of 1 USD = 1130 KRW from Aug 2020 to Aug 2021, the research period of the cited study. Korea Energy Economics Institute. (2021). RPS 신재생에너지원별 기술경제성 분석 및 제도 개선 연구.

Table 7. Average LCOE of renewable energy in South Korea by source

	Type		Initial LCOE (KRW/kWh)	LCOE at 2 nd revision of REC weightings (KRW/kWh)
Solar	Small scale (general site)		164.24	164.76 (small scale)
	Mid-scale (general site)		147.40	152.01 (mid-scale)
	Large scale (general site)		134.16	137.82 (large scale)
	Mid-scale (building)		140.31	
	Mid-scale (on water)		169.25	209.49 (on water)
	Mid-scale (forest land)		147.40	
	Residential		164.24	
Wind	Onshore		166.25	151.00 (onshore)
	Offshore		275.59	325.88 (Offshore)
	Offshore coastal		259.07	
Biomass (dedicated)	Regular wood chip	30 MW	205.20	159.03 (dedicated burning of regular wood pellet/chip)
		100 MW	126.75	
	Regular Wood pellet	30 MW	246.10	
		100 MW	167.15	
	Bio-SRF		154.31	123.09
	Residues Wood chip	30 MW	245.11	212.58 (dedicated burning of residues pellet/chip)
		100 MW	179.83	
	Residues wood pellet	30 MW	385.70	
		100 MW	306.75	
	Biomass (co-firing)	Regular wood chip	30 MW	30.81
100 MW			83.40	
Regular Wood pellet		30 MW	121.38	
		100 MW	116.06	
Bio-SRF		74.49		
Residues Wood chip		30 MW	141.32	
		100 MW	136.49	
Residues wood pellet		30 MW	260.56	
		100 MW	254.63	

Source: Korea Energy Economics Institute, 2021.

Therefore, biomass power in South Korea would not have grown into the current scale if it had not been for the subsidy market artificially created and facilitated by the government. While renewable sources benefited from government assistance during the initial phase and achieved a significant global cost reduction to as little as 11% (e.g., solar photovoltaic) of what it was in 2010, the costs of biomass electricity have largely remained steady at 74%.⁹⁵

The decreasing cost-competitiveness shows the innate limitations of combustion-based power generation, as it has very little room for advancement in terms of technological development. Biomass fuels also cost increasingly more as sourcing quality wood, a finite and protected resource, becomes more difficult. For instance, Enviva, the world's largest wood pellet producer, has seen its stock price plummet from \$88 to less than \$1 in just over 18 months.⁹⁶ Compared to other clean renewables, biomass is very unlikely to become financially self-sufficient without government subsidies.

4.1.1. Problems of Renewable Energy Certificate Weightings Based on Profitability

REC weightings, the South Korean renewable subsidy scheme, are intended to promote competition among different power sources by considering not only economic factors but also policy objectives. The reality is that REC weightings are the single most direct government intervention tool in the renewable energy market, wielding a significant influence over the profitability of power operators. While the government holds the key to choosing which renewable energy to subsidize, factors such as environmental impact, community acceptance, and climate change response, are often sidelined in designing the weightings.

The latest regular revision of the REC program took place in 2021 but maintained the high weightings for forest biomass. While the MOTIE's final decision was made against the political backdrops of that time, its rationale was based on an economic and policy analysis it commissioned to the Korea Energy Economics Institute (KEEI).⁹⁷

95 International Renewable Energy Agency. (2023). *Renewable power generation in 2022*. <https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022>

96 Berendt, C. (2023, November 15). Enviva reports massive losses. *The Sampson Independent*. <https://www.clintonnc.com/news/92569/enviva-reports-massive-losses>

97 Korea Energy Economics Institute. (2021). RPS 신재생에너지원별 기술경제성 분석 및 제도 개선 연구.

In the making of the REC weighting framework, the KEEI had 11 evaluators assigned a weight of 62.4% to economic feasibility and 37.6% to policy objectives, with 70.5% of the latter rubric further allocated to economic and industrial aspects. In contrast, environmental aspects, comprised of GHG reduction, local environmental impact, and community acceptance, were collectively assigned only 11.1% of the total consideration. GHG reduction for climate change mitigation received less than 5% consideration (Table 8).

Table 8. Analytic hierarchy process used for the 2021 revision of REC weightings in South Korea

Level 1		Level 2		
Factor	Weight	Factor 1	Factor 2	Weight
Economic feasibility	62.4%	-	Requested REC	62.4%
Policy objectives	37.6%	Economics and Industry	Activation of technology and industry	26.5%
			Stable power supply	
			Resource availability	
		Environment	GHG emissions reduction	11.1%
			Local environmental impact	
			Community acceptance	

Source: Korea Energy Economics Institute, 2021.

Biomass ended up scoring marginally lower in environmental rubrics compared to solar and wind, but even that seems overstated considering its reputation. The KEEI failed to factor in the pronounced negative environmental aspects and practically non-existent community acceptance of biomass. Instead, the Institute merely relied on its evaluators, whose composition lacked fair representation to comprehensively consider all aspects of every energy source. The KEEI stated it selected the experts based on their understanding of the REC

market without conflicts of interest with specific power sources; nevertheless, it is worth noting that no environmental experts were included in the panel.⁹⁸

4.1.2. History of Past Renewable Energy Certificate Weighting Revisions

The long-standing industrial and economic bias of REC weightings that led to the overcompensation for biomass dates back to 2012 when the RPS was adopted. Since then, the high incentives for biomass have not only persisted for over a decade but were also expanded to subsidize forest residues. The initial weightings of 1.5 and 1.0 applied to dedicated combustion and coal co-firing continued for six years.

In the second triennial revision in 2018, the weighting for bio-SRFs was reduced to 0.25, and that for the dedicated burning of regular wood pellets and chips to 0.5. While eliminating the weightings for new co-firing, the revision instead introduced a new bracket for forest residues, assigning the weightings of record-high 2.0 and 1.5 for dedicated combustion and co-firing.

Criticisms persisted, alleging that KEPCO subsidiaries operating large coal power plants were single-handedly fulfilling their RPS obligations by resorting to biomass instead of making substantial investments in clean renewable energy.⁹⁹ In response, the MOTIE halved the weighting for existing co-firing by SOUs from 1.0 to 0.5 in 2020.¹⁰⁰ Acknowledging the heightened controversy around biomass, the government maintained the previous weightings at the third triennial revision in 2021, which continue to this date.

98 Korea Energy Economics Institute. (2021). RPS 신재생에너지원별 기술경제성 분석 및 제도 개선 연구.

99 Byun, K. (2020, October 15). "바이오매스 혼소발전 REC 가중치 더욱 축소해야 한다". *Energy Daily*. <http://www.energydaily.co.kr/news/articleView.html?idxno=112633>

100 Jin, K. (2020, June 11). 발전공기업 바이오혼소 REC가중치 반토막. *Energy & Environment News*. <https://www.e2news.com/news/articleView.html?idxno=223208>

4.1.3. Biomass Renewable Energy Certificate Weightings Higher than Solar or Wind

The REC weightings reaching up to 2.0 do not only guarantee the profitability of otherwise economically unviable biomass power but are also excessively high compared to other renewable energy sources. For instance, solar receives the weightings of 0.5 for installations on forest land, 0.8–1.2 on general sites, 1.0–1.5 for utilizing existing facilities, and 1.2–1.6 on water. Biomass, on the other hand, is always granted higher weightings when burning forest residues and is eligible for those higher than most types of solar even when co-fired with coal.

Similarly, the weighting for onshore wind remains at merely 1.2, which is negligible compared to most forest biomass (Table 9).¹⁰¹ This institutional favoritism propelled bioenergy to rise as the no. 1 renewable power source until 2018, surpassing solar. Even to this day, electricity generated from biomass still exceeds that from wind by nearly three times.¹⁰²

Table 9. REC weightings in South Korea by major energy source

	Type	REC weightings
Solar	Forest land	0.5
	General site	0.8–1.2
	Residential	1.0
	Using existing facility	1.0–1.5
	On water	1.2–1.6
Wind	Onshore	1.2
	Offshore	2.0–2.5
Biomass	Regular biomass	0.25–1.5
	Forest residues	1.5–2.0

Source: Ministry of Trade, Industry and Energy, 2023.

101 신·재생에너지 공급의무화제도 및 연료 혼합의무화제도 관리·운영지침. Ministry of Trade, Industry and Energy Public Notice No. 2023-158. (2023).

102 Korea Energy Agency. (2022). 2021년 신재생에너지 보급통계 [Data set]. New and Renewable Energy Center. <https://www.knrec.or.kr/biz/pds/statistic/view.do?no=170>

4.1.4. Loophole Ensuring Previous Renewable Energy Certificate Weightings

The 2018 weighting revision significantly reduced and eliminated the weightings for regular wood pellets, chips, and bio-SRFs while introducing a new segment for forest residues. However, the MOTIE refused to apply the revised weightings to the existing facilities, citing the protection of industry profits as the reason, which ended up diluting the intended benefits of the revision.

Hence, power plants that commenced operations before June 2018 and those that received construction approval by July 2019 were allowed to enjoy the original high weightings regardless of policy changes. As there are no sunset provisions for the legacy weightings, these old power plants will remain eligible to receive the disproportionately high subsidies of the past until retirement (Table 10).

Table 10. REC weightings for biomass in South Korea

Feedstock	Type	Ownership	Year of operation		
			Before Jun '18	After Jun '18	
Residues pellet/chip	Dedicated		2.0		
	Co-firing		1.5		
Regular pellet/chip	Dedicated		1.5	0.5	
	Co-firing		Private	1.0	-
			Public	0.5	-
Bio-SRF	Dedicated		1.5	0.25	
	Co-firing		1.0	-	

Currently, most large biomass power plants are benefitting from this regulatory loophole. Some plants, having granted construction approval in advance and secured high weightings, are yet to even commence operations. For instance, Gwangyang Green Energy initially planned to start construction in 2017, but with local resistance pushing it back to 2022, operations are now delayed to 2025. Despite five years of no progress, the facility is still expected to receive a weighting of 1.5 for burning imported wood pellets because it received

the construction approval in 2018.¹⁰³

Since other new plants can obtain even higher levels of incentive through burning forest residues, the MOTIE's lowering of REC weightings only ironically ended up extending the life of existing power plants while having more plants added to the fleet.

4.2. Policy Goals that Promote Forest Loss

South Korea's forest policies that aim to combat climate change should incorporate the international climate and biodiversity initiatives that the country has signed. However, current laws and regulations, such as the *Act on the Management and Improvement of Carbon Sink*, *Forest Resources Act*, and *Timber Use Act*, as well as government strategies with the purpose of contributing to achieving net-zero emissions, seem to run counter to the country's commitment to halt and reverse forest loss.

Contrary to their ambitious titles, major policies prioritize intensive exploitation of forest resources while failing to indicate a legally binding or a clearly defined provision to ensure the sustainability of biomass. Even the *Forest Biomass Guidelines*, which provide operational guidance for the use of forest residues, are managed solely based on the KFS's arbitrary rules without legal grounds. Initiative to reassess the climate and environmental impacts of biomass from the ground up is nowhere to be found.

4.2.1. Problems of Carbon Neutrality Forest Sector Strategy

It is ironic that the KFS's recent attention on climate change lets its policies to overtly focus on expanding the production of forest biomass and fostering its industry. The *6th National Forest Plan* of 2018, announced before the country's net-zero commitment, aimed for an annual pellet production of moderate 200 thousand tons by 2030. The *Carbon Neutrality Forest Sector Strategy* proposal of January 2021, however, substantially increased the target for forest residues to 3 million tons by 2030 and 5 million tons by 2050.

103 Lee, S. (2019, January 14). '골리앗' 바이오매스 발전소들의 역습. *Energy & Environment News*. <http://www.e2news.com/news/articleView.html?idxno=206400>

The proposal not only described forest biomass as a carbon-neutral energy source but also attempted to double-count the questionable coal replacement effect as a definite emissions reduction in the forest sector, erroneously treating biomass-burning as a negative-emission activity. The controversy led to the convening of a public-private consultation committee in July of the same year and ultimately to the revision of the Strategy in December.¹⁰⁴

The finalized Strategy removed the claim that forest biomass is carbon-neutral. Also, it downgraded the target for forest residues in 2050 to 3 million tons, emphasized the use of timber for long-living products and a transition to less detrimental decentralized use of biomass, and included the implementation of sustainability criteria and GHG LCAs. Plans aimed at relaxing the age for final cutting, a radical logging policy initially framed as “planting 3 billion trees” and “carbon cycle forests,” were revised to prioritize SFM to consider ecosystem health. Additionally, corrections were made to the negative-counting of biomass emissions, adjusting the 2050 forest sector emissions target from -34 million tons to -23.6 million tons.¹⁰⁵

4.2.2. Half of All Domestic Timber to Become Biomass

Unfortunately, the revised Strategy still overlooks the carbon emissions from biomass burning, maintaining the misguided assumption that biomass contributes to GHG reduction as a renewable energy source. Particularly concerning are the annual production targets for forest residues that remain at exceedingly high levels. The persistent fixation on forest biomass is so strong that the Strategy even contradicts its own policy directive of the “sustainable use of timber through planting, nurturing, and harvesting.”¹⁰⁶

For instance, the KFS ambitiously plans to expand annual timber production from 460 million m³ in 2020 to 800 million m³ by 2050. Simultaneously, the 3 million tons of forest residues production by 2050 would increase the conversion of domestic timber use into biomass

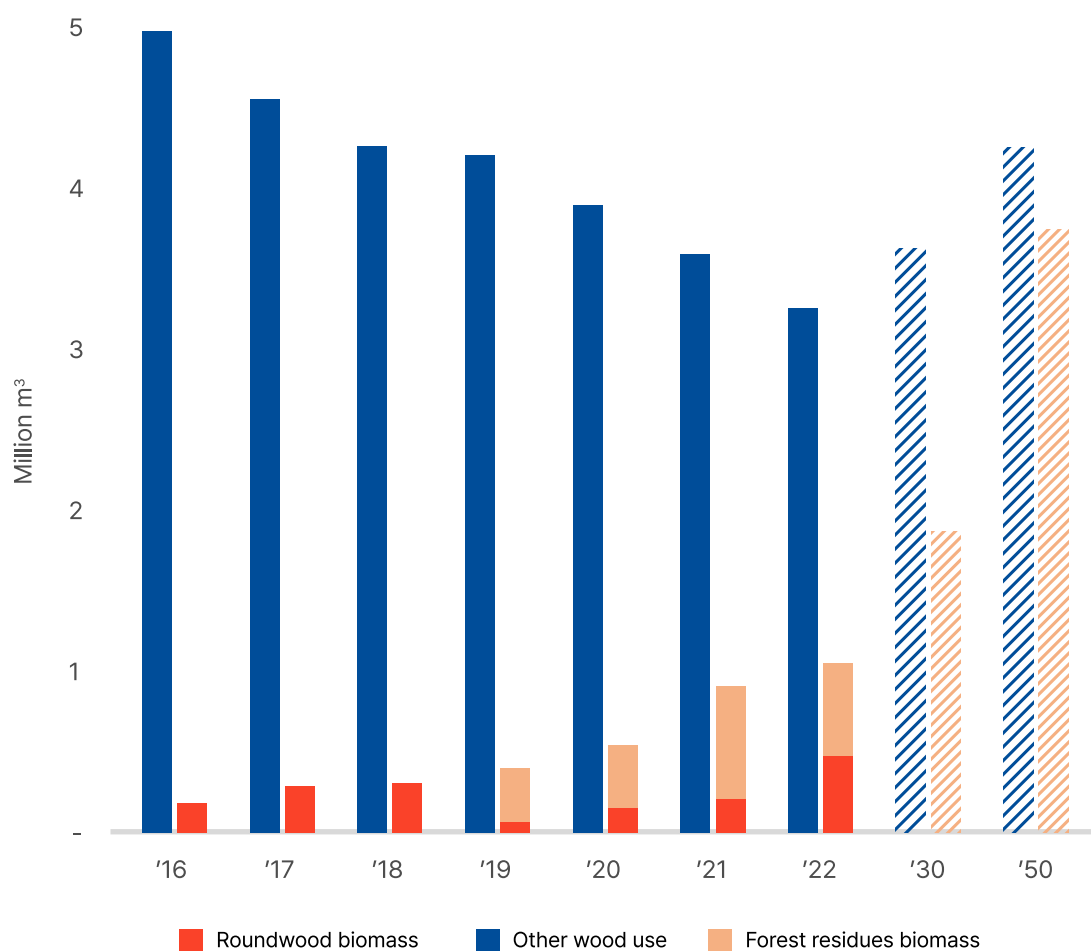
104 Ministry of Culture, Sports and Tourism. (2021, October 27). 산림부문 탄소중립 민관협의회 결과. 대한민국 정책브리핑. <https://www.korea.kr/briefing/policyBriefingView.do?newsId=156477407>

105 Korea Forest Service. (2021). 2050 탄소중립 달성을 위한 산림부문 추진전략.

106 Korea Forest Service. (2021). 2050 탄소중립 달성을 위한 산림부문 추진전략.

from the current 24% to at least 47% (Figure 18). Since the Strategy did not mention the usage of roundwood biomass, the actual quantity of biomass fuels produced is estimated to exceed half of all domestic timber supply by large margins.

° Figure 18. KFS domestic production targets for forest biomass



Source: Korea Forest Service, 2021; compiled by author.

The additional wood combustion would lead to a substantial increase in GHG emissions, with those from burning forest residues alone projected to release 5.0 million tCO₂ annually by 2050. The cumulative emissions over 30 years, starting from 2020, are projected to reach 93.8 million tCO₂. Since this estimation does not include imported wood pellets, bio-SRFs, and domestically sourced roundwood biomass, collectively making up most of the fuel mix, total yearly emissions could be in the tens of millions of tons and accumulate to billions of tons over time.

4.2.3. Problems of Forest Renaissance Strategy and 3rd Carbon Sink Plan

Policies that favor forest biomass persist, even under the conservative Yoon Suk-yeol administration inaugurated in May 2022. The *Forest Renaissance Strategy* announced in November 2022 placed the production target for forest residues at 1.3 million tons per year by 2027, aligning with the linear path to the 1.5 million tons target for 2030 set by the previous Moon Jae-in administration.

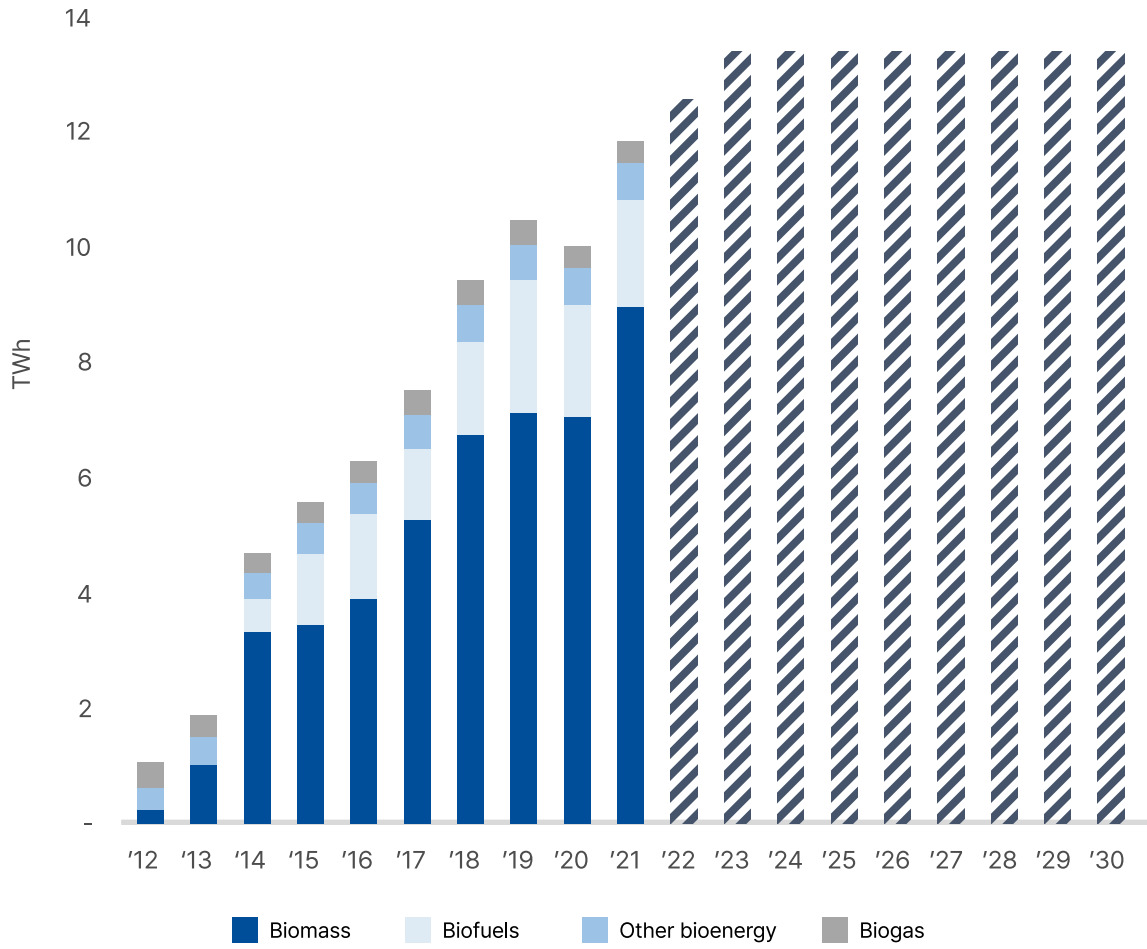
Regretfully, the KFS chose to revert the details of the 3rd Carbon Sink Plan, announced in June 2023, regressing to the previous government's retracted proposal rather than the revision reached through the public-private consultation. The Plan attempts to deflect criticism by describing forest biomass as "renewable energy source replacing fossil fuels" and "sustainable renewable energy that absorbs carbon from the atmosphere and releases it back," deviating from its original purpose of enhancing carbon sinks.¹⁰⁷

The KFS's persistent attempts to expand forest residues also conflicts with the energy plans of the MOTIE. The 10th Electricity Basic Plan of 2023 explicitly freezes the outlook for bioenergy generation, including biomass, biofuel, and biogas, at 13,329 GWh from 2023, with a cap on dedicated burning capacity of 1,800 MW from 2022. With bioenergy production in 2022 already achieving 86.9% of the 2023 target (Figure 19),¹⁰⁸ the freeze on supply capacity implies that adding new power plants is unnecessary. The KFS's plan to scale forest biomass by six times from the 2020 levels is thus incongruent with the energy ministry's lack of expectation for any significant deployment in the future, undermining the rationale for continued support.

107 Korea Forest Service. (2023). 제3차 탄소흡수원 증진 종합계획.

108 Ministry of Trade, Industry and Energy. (2023). 제10차 전력수급기본계획.

° Figure 19. MOTIE outlook on bioelectricity generation



Source: Ministry of Trade, Industry and Energy, 2023; compiled by author.

5. Policy Recommendations

Over the past decade, forest biomass power in South Korea has undergone rapid growth, fueled by the misconception of being a green energy source. In reality, biomass emits more GHGs than fossil fuels and exacerbates the climate crisis by contributing to deforestation and forest degradation both domestically and internationally. The steady increase in wood pellet imports, coupled with the introduction of domestic forest residues for biomass fuels, only compounds the negative climate and environmental impacts.

The rise of this false climate solution to become South Korea's second-largest renewable energy source can be attributed to government policies that prioritize industry profit while turning a blind eye to the environmental degradation. The MOTIE has been allocating higher REC weightings to biomass than clean renewables, while the KFS has set a goal to burn half of the harvested wood as forest residues fuels.

South Korea still has a way to correct the misguided forest and energy policies of the past decade. The scientific community has reached a consensus that burning forests for fuels cannot be a viable option to replace fossil fuels or tackle climate change. The distortion of renewable and forestry markets is propelling industry stakeholders to advocate for reduced subsidies for biomass. Repeated media coverage on intensive logging in the name of fuel production has sparked public outrage.

Underscored by the need for fundamental changes in energy and forest policies, South Korea should eliminate all existing policy support for biomass in 2024, when the fourth triennial revision of REC weightings is scheduled. If successful, South Korea will be one of the first countries to start phasing out the most detrimental form of false solutions to climate change and seize the chance to advance climate action across Asia.

This report hence proposes a complete overhaul of the premises and directions of energy and forest policy as the following:

A. Resetting of Policy Direction and Withdrawal of Production Targets

Recognizing that biomass cannot be considered equal to genuine renewables due to its carbon-emitting nature, the government should undertake a comprehensive overhaul of energy and forest policies. To mitigate climate change and achieve net-zero goals, it is crucial to shift the policy emphasis from quantitative targets to an immediate halt to coal co-firing and a time-bound phase-out of industrial scale biomass.

Specifically, the MOTIE should reduce the projected capacity for bioenergy in its electricity plans. The objective should be to phase out biomass power in the early 2030s, in line with the coal phase-out schedule compatible with the 1.5° C mitigation goal. The KFS should retract the production targets for forest residues specified in its forestry plans.

B. Prohibition on Use of Domestic Roundwood and Imported Biomass

Recognizing that forest biomass intrinsically leads to deforestation and forest degradation, the government should ensure transparency and traceability throughout the biomass supply chains.

The MOTIE and the KFS should investigate the use of roundwood, from logging to mills, power plants, and REC-issuing practices. The use of timber for biomass above the grade of fuelwood should be strictly prohibited, with pellet and chip production allowed only on an exceptional basis when it is proven to have no other uses.

Imported biomass, which emits GHGs during transportation and has unverifiable sustainability status, should be disqualified for REC weightings and subject to a time-bound phase-down.

C. Limit on Forest Residues Use to Small-Scale and Decentralized Plants

Recognizing that the current definition and scope of forest residues for biomass are overly broad and vague that this institutional gray area is allowing for intensive logging for large power utilities, the government should introduce feedstock restrictions to prevent such exploitation.

The primary purpose of using forest residues lies in the resource circulation of low-value by-products derived from conventional forestry activities. The KFS should exclude wood from large-scale land conversion, wood harvest, species conversion, and precautionary logging from natural disasters from the scope of eligible forest residues.

Priority use of these residues should be granted to small-scale and decentralized heating facilities located in the same region where the forest residues are collected. In parallel, the MOTIE should prohibit their burning in large power plants with high GHG emissions.

D. Cancellation of Renewable Energy Certificates for Biomass

To effectively phase out biomass power in South Korea, the MOTIE should abolish the REC weightings for biomass, which have been propping up this inefficient and expensive power source.

The earliest opportunity for this will be the 4th triennial revision of the weighting scheme scheduled for 2024. The REC weightings for regular wood pellets and chips, forest residues, and bio-SRFs for future facilities should be immediately removed, irrespective of the country of origin or combustion type.

The legacy REC weightings given to facilities that began operations prior to 2018 and have been subject to interim measures should be phased out by 2025. The current REC weightings given to facilities that commenced operations between 2018 and 2023 should be phased out by 2028. As an exception, small-scale and decentralized combined heat and power facilities using locally sourced forest residues can maintain their current weightings.

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