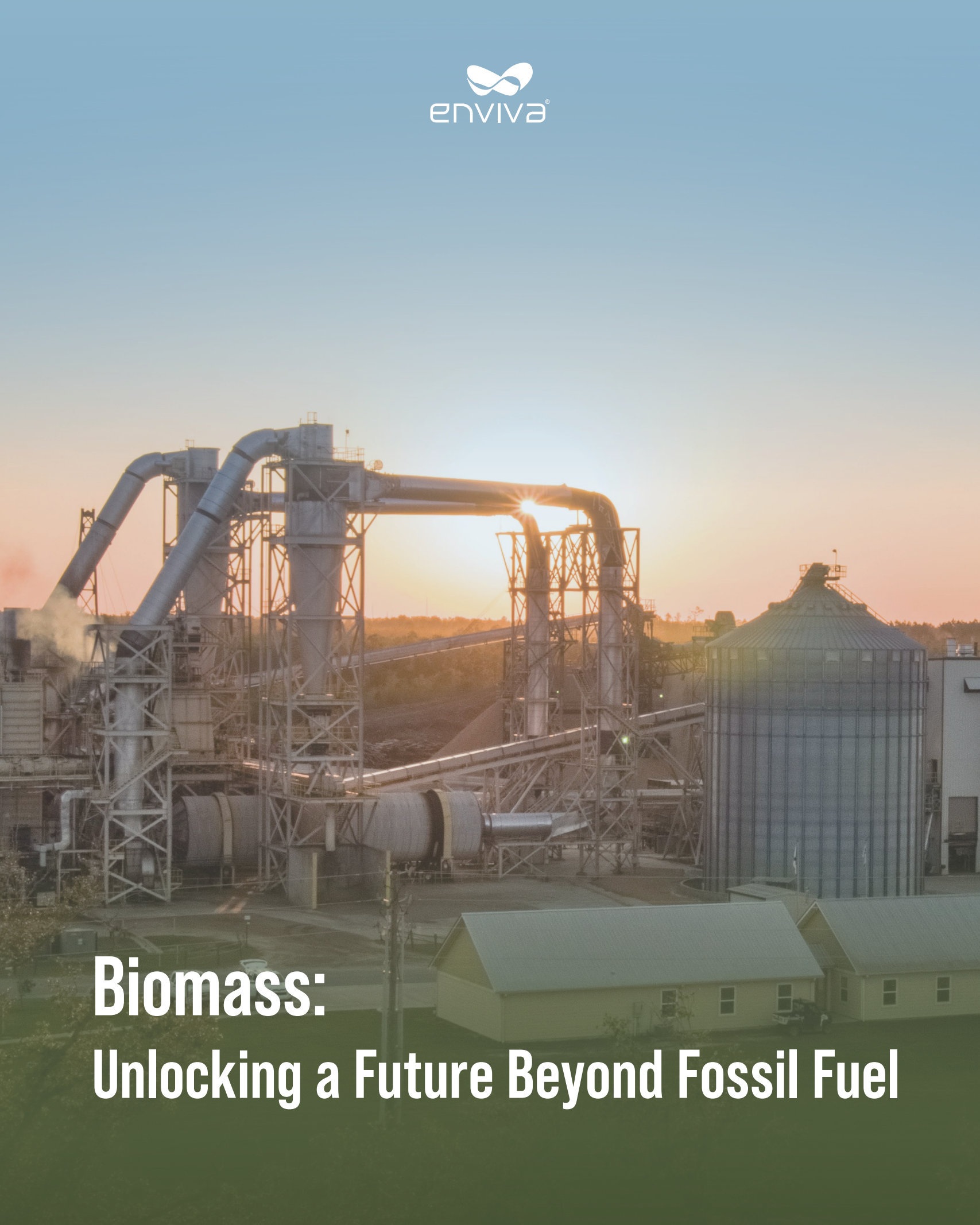

# Biomass:
## Unlocking a Future Beyond Fossil Fuel

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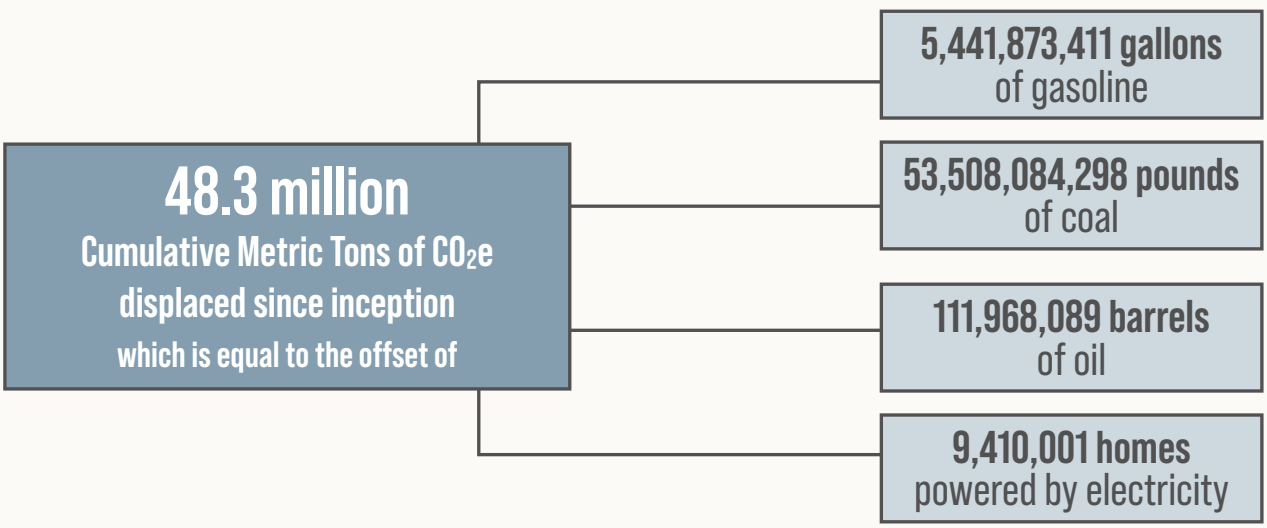
This paper draws on multiple publicly available sources. It also includes independent research, some of which was commissioned by Enviva, from universities in the U.S., Europe, and Asia, and environmental non-governmental organizations, to demonstrate the critical role wood-based bioenergy must play in mitigating the climate crisis.

# Biomass: Unlocking a Future Beyond Fossil Fuel

Dear Valued Stakeholder:

Enviva was founded in 2004 as an entrepreneurial start-up with a mission to displace coal, grow more trees, and fight climate change. Eighteen years later, we are the world's largest producer of sustainable wood biomass, having built a global supply chain based in the U.S. Southeast to export to energy customers around the world. Our wood biomass provides a low-carbon, drop-in alternative to fossil fuels for power and heat generation and is part of an all-in renewables strategy to reduce carbon emissions and limit global dependence on fossil fuels. Since its inception, Enviva has displaced more than 48.3 million cumulative metric tons of $CO_2e$ to the atmosphere.




Sustainable biomass is the only renewable energy source that currently provides vital dispatchable power and heat. Today, biomass represents nearly 60% of renewable energy consumption in Europe and is a critical component of growing renewable energy markets in Asia and other regions globally.[1]

While biomass is predominately used to decarbonize power and heat generation, there are also numerous other applications that will drive further growth as governments and industry endeavor to mitigate their climate change impacts through net-zero emissions goals and other exercises. Of all global emitters, energy-intensive industries represent the hardest sectors to abate for net zero. The use of biomass feedstocks in these sectors creates new opportunities for decarbonization where urgent solutions are needed to reach climate targets.

***Recognizing this opportunity, Enviva is expanding its focus to include four dynamic market opportunities, in addition to our core business of supplying the energy sector with a renewable alternative to coal:***

1. ***Sustainable Aviation Fuel (SAF)***
2. ***Green Lime***
3. ***Green Steel***
4. ***Green Cement***

***The opportunities for biomass continue to expand rapidly in our carbon-limited world, and these four sectors offer specific, immediate, and significant growth potential.***

The wood biomass industry is poised to play a pivotal role in carbon removal for the future, while also unlocking new value chains for hard-to-abate industries. Enviva is at the forefront of this movement, offering a realistic solution that is available at scale today, building a global bio-based economy, from power and heat to new green industrial applications. Serving as a trusted, sustainably sourced biomass producer to meet our growing global energy demands is what we do.

What we started almost 20 years ago has become the honor of a lifetime. Now is the time for action and I personally want to engage you in our vision for a climate positive future.

**Thomas Meth**
Co-founder, President of Enviva Inc.

# Biomass and the Urgency of Mitigating Climate Change

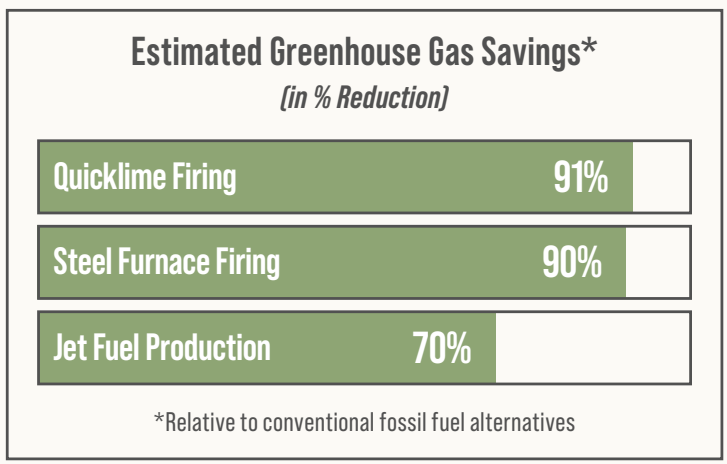
## Biomass is critical in fighting the climate crisis

In April 2022, the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, issued its Sixth Assessment Report, Climate Change 2022: Impacts, Adaptation and Vulnerability. The report further cemented what we already know: **"the impacts of climate change are increasingly evident in every region of our world…[and] are causing severe and widespread disruption in nature and in society"**.[2] Without adaptation and mitigation solutions, UN Secretary-General António Guterres said, "[we] are on a pathway to global warming of more than double the 1.5-degree [Celsius] limit" that was agreed in Paris in 2015.[3]

*In the new market opportunities for biomass applications, Enviva's biomass can deliver an estimated greenhouse gas savings of 91% for quicklime firing, 90% for steel furnace firing, and 70% for SAF,[7] as compared to conventional fossil fuel on a lifecycle basis.*

Sustainably sourced bioenergy offers a recognized and essential solution for fighting climate change now. In fact, every IPCC pathway to limiting global warming to 1.5°C above pre-industrial levels includes wood biomass.[4] And International Energy Agency (IEA) modeling indicates that modern bioenergy is an essential component of the future low-carbon global energy system, if global climate change commitments are to be met.[5]

A global energy transition is underway, and wood biomass plays an ever-critical role in phasing out coal and decarbonizing emissions from power and heat generation. Today, Enviva's sustainably sourced wood biomass offers greenhouse gas (GHG) savings of more than 85% when displacing coal and more than 70% when displacing natural gas.[6]




Most importantly, wood biomass is at the cusp of unlocking a future beyond fossil fuel in other industrial applications. All sectors – including the energy industry, construction, transportation, aviation, and food systems – need to rapidly decarbonize to support climate targets. Production of a wide range of liquid and gaseous fuels and industrial chemicals, which are now largely derived from fossil fuels, is possible via wood biomass conversion. GHG reduction potential from biomass-derived fuels and many types of industrial chemicals is substantial, translating to significant market advantages over the long term as societal costs of carbon emissions become more broadly recognized.

net-zero pledge

*Enviva's net-zero promise: In addition to the climate mitigation opportunities associated with Enviva's sustainable wood biomass, we are also committed to dramatically reducing the climate impact of our own operations.*

*On February 17, 2021, Enviva announced a goal of achieving net-zero greenhouse gas emissions from our operations by 2030. This commitment to climate action reinforces our core purpose to displace fossil fuels, grow more trees, and fight climate change.*

# Biomass in the Clean Economy

***The push towards a low-carbon economy is gaining momentum because of global policy developments necessitating the use of fossil fuel alternatives.***

## European Policy

The European Union (EU) has long recognized that sustainable biomass is a renewable, low-carbon, baseload, and dispatchable heat and power source. Today, bioenergy accounts for almost 60% of renewable energy used in Europe. EU policymakers are currently updating the Renewable Energy Directive (RED), which was put in place in 2009 and revised in 2018 (RED II), to establish common rules and targets for the development of renewable energy across all sectors of the economy to help the EU reach its ambitious energy and climate goals. These were increased by the European Green Deal with the goal of reducing net GHG emissions by 55% by 2030. Meeting these targets will require the expanded implementation of clean solutions, like biomass energy.

RED III is part of a package to increase and accelerate climate mitigation, which includes reviewing existing criteria for renewable sustainable biomass. The EU Parliament finalized its proposal on RED III in fall 2022, when it once again voted to recognize primary woody biomass as a renewable energy source, consistent with its prior classification under both the first RED and RED II. Both the EU Council of Ministers ("Council") and the EU Commission have published their proposals and positions on RED III that continue their steadfast support for woody biomass and for its increased utilization to deliver climate change benefits and security of energy supply. The EU Parliament's vote brings its position considerably closer to those of the Council and EU Commission by recognizing primary woody biomass as renewable, ensuring its continued zero-carbon rating in the EU Emissions Trading Scheme, and allowing its use to increase in volume. The final RED III law will be a negotiated piece of legislation reflecting a compromise reached in the trilogue negotiations among the EU Parliament, the Council, and the EU Commission, which is anticipated to be completed in mid-year 2023.

## U.S. Policy

In the U.S., the Biden administration continues to prioritize climate policy and economy-wide net-zero GHG emissions by 2050, as encapsulated in The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050. The Administration has cited biomass as "a key component of efforts to decarbonize the energy sector, as studies have shown that higher levels of biomass availability and use can offer lower-cost mitigation than decarbonization strategies without biomass." Biomass energy's potential in deep decarbonization scenarios is also recognized as a pivotal pathway for reducing emissions in multiple sectors, particularly when combined with carbon capture and sequestration (CCS) to yield negative emissions solutions.

In September 2022, U.S. President Joe Biden, signed an Executive Order and the White House released a fact sheet on "biotechnology and biomanufacturing innovation for a sustainable, safe, and secure American bioeconomy." The Executive Order specifically states it is the policy of the Biden Administration to boost sustainable biomass production and create climate-smart incentives for American agricultural producers and forest landowners; expand market opportunities for bioenergy and biobased products and services; promote standards, establish metrics, and develop systems to grow and assess the state of the bioeconomy; to better inform policy, decision-making, and investments in the bioeconomy; and to ensure equitable and ethical development of the bioeconomy. The Executive Order defines biomass as any material of biological origin that is available on a renewable or recurring basis. Examples of biomass

include plants, trees, algae, and waste material such as crop residue, wood waste, animal waste and byproducts, food waste, and yard waste.

The Inflation Reduction Act (IRA), passed and signed into law in August 2022, represents a historic action by the U.S. to support the global clean energy transition and to promote pathways for additional investments in American clean energy manufacturing. The IRA directs $370 billion for energy security and climate change resources - utilizing investments and tax credits to incentivize wind, solar and other renewable power sources, such as sustainably sourced biomass - while helping consumers purchase electric vehicles and install energy-efficient heating and cooling systems in their homes. Specific to bioenergy, the IRA doubles down on the U.S. commitment to SAF by providing tax credits for every gallon produced based on lifecycle greenhouse gas emission reduction percentages. Further, the IRA extends and modifies the tax credit for the production of renewable energy from biomass and other technologies. The law also enhances tax credits for CCS at both industrial facilities and power plants in the U.S.

The incentives and tax credits built into the IRA will provide certainty for the future of U.S. biofuels and investment in the industry's ability to provide clean and affordable domestic fuel options. Historically, Enviva's business has been export-driven and is not reliant on a domestic customer base. However, actions by Congress and the White House have created the potential for a significant domestic market that Enviva will continue to evaluate and explore as one of the next big emerging opportunities. Recently, we signed our first contract with Alder Fuels, a U.S. based SAF producer, to further scale and commercialize SAF supply chains.

## Geopolitical Tensions

Russia's invasion of Ukraine in February 2022 has further exacerbated the global urgency of mitigating climate change and de-carbonizing the energy system. The ongoing geopolitical crisis is creating energy security issues in Europe and other regions and raising fuel costs for the energy industry, for the average consumer at the gas pump and for home heating.[8] Since March 2022, the price per megawatt hour for manufacturers in Germany has risen by 65%; UK analysts are anticipating a cost increase of 65% this year for home gas and electricity bills.[9] To reduce dependence on Russian fossil fuels, the U.S. and its allies recognize the need for more rapid deployment of clean energy solutions, like biomass energy. U.S. Energy Secretary Jennifer Granholm has called a move to clean energy "the greatest peace plan of all. We want and need to move to clean."

## Looking Ahead

The energy trilemma – the need for decarbonization, security of supply, and affordability – creates a difficult situation for governments and companies. Ensuring clean energy, on an urgent timeline, with an affordable price tag is a global challenge.

Biomass has already enabled several leading economies to decarbonize their power and heat sectors – and the ability for biomass to aid in further decarbonization of other sectors and industries has the potential to greatly accelerate a scalable transition to a future beyond fossil fuel. Even with rising demand, biomass has not experienced the price volatility and supply shortages seen in the natural gas market.

Today, bioenergy is the most regulated energy sector when it comes to environmental protection under the EU's RED policies and its stakeholders are proactive leaders in reducing the GHG emissions of bioenergy while expanding its contribution to Europe's energy system. With smart policies in place in other developed nations, biomass will continue to add a sustainable, secure, and affordable energy source to the global market.

## The Future State of Biomass: Applications in Hard-to-Abate Industries

Highly carbon intensive industrial processes provide an additional opportunity for biomass to deliver on its promise of phasing out coal and achieving emissions reductions. Enviva has chosen to focus on sectors of the economy with significant global emissions and where technologically advanced, scalable, and market-ready products are poised to substantially mitigate climate change – sustainable aviation fuel (SAF), green lime, green steel, and green cement. To meet existing commercial momentum with power and heat generators and new demand from industrials in hard-to-abate sectors, Enviva plans to double production capacity over the next five years.[10]

***Steel, aviation, aluminum, cement, and chemical sectors are responsible for about 30% of global emissions, but that figure is expected to rise to about 50% of emissions by mid century without intervening actions and clean alternatives.***

### Sustainable aviation fuel (SAF)

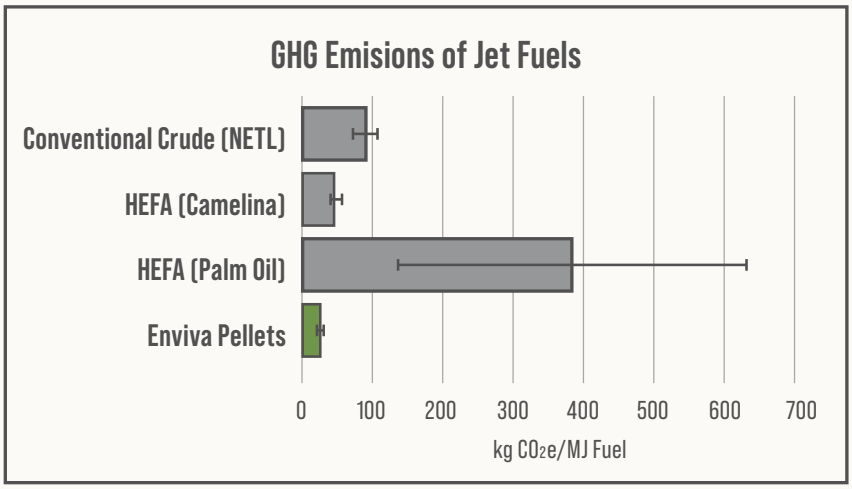
The global aviation industry is responsible for around 2.1% of all annual $CO_2$ emissions. In 2019, airplanes produced approximately 915 million metric tons of $CO_2$, and the demand for jet fuel is only expected to grow.[11] Initial estimates on demand indicate more than a 2x increase in air travel from 2018 to 2050.[12]

**Price and cost estimates for traditional jet fuel and SAF (USD/MT)**


Wood biomass derived SAF is on par with current Jet fuel prices and well below the prices for the vegetable oil derived version (Hydrogenated ethers and Fatty acids)

Airlines, fuel producers, and governments across the globe recognize the need to decarbonize the sector in order to make progress against climate and net-zero emissions goals, while meeting demand. Airlines are already facing a deadline for measurable emissions reductions in a number of countries – notably, Sweden and France have already instituted per-passenger flight taxes and Germany and the Netherlands have signaled interest in similar levies. And other proposals from the UN and elsewhere have called for the mandatory purchase of emissions offset credits and air miles reductions taxes.

The development and large-scale deployment of SAF is key to finding a solution to meet the aviation industry's emissions reduction targets and could account for 65% of emissions reductions in the sector, according to the International Air Transport Association.[13] As a result, the SAF market is projected to grow from US $219 million in 2021 to US $15.716 billion by 2030.[14]

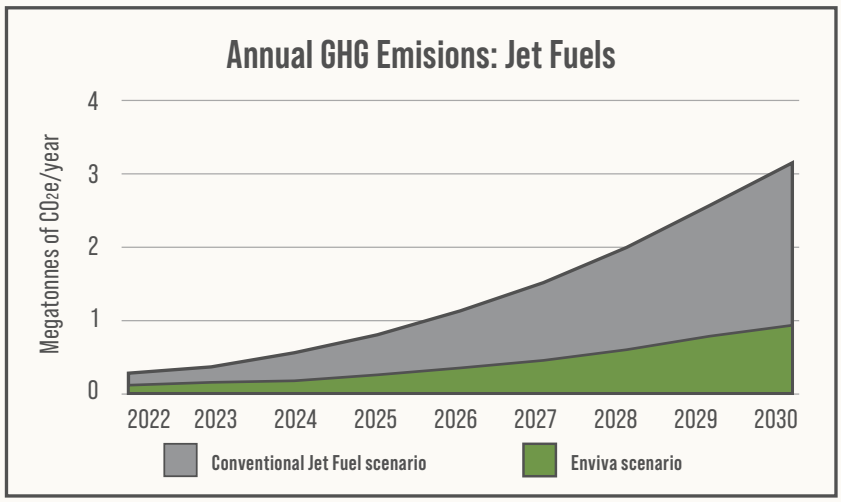



Cost-competitive, environmentally sustainable SAFs are a critical part of decoupling carbon growth from market growth,[15] making biofuels one of the most important pathways for decarbonizing the aviation sector.[16] IEA sustainable development scenarios anticipate biofuels making up 15% of the aviation fuel market by 2030 and 40% by 2050.[17] While there are several bio-based feedstock options for producing SAF, wood biomass and other low-ash biomass residuals are the only near term scalable and affordable solutions available to producers today. The cost of wood biomass-derived SAF is already on par with current jet fuel prices and well below the prices for SAF derived from vegetable oils.

In addition to cost-competitiveness with current fossil-based jet fuels and vegetable oil-based SAF, wood biomass-derived SAF offers significant emissions savings. Enviva's sustainable wood biomass, when used to make SAF, could provide 70% GHG savings when compared to conventional jet fuel, and have a smaller GHG footprint than vegetable oil-based SAF versions. If Enviva's wood biomass were to replace conventional petroleum jet fuel in Europe in the near term (2022–2030), global emissions would be lowered by 8.5 million metric tons of $CO_2e$ – or the equivalent of all of the emissions from EU member country Latvia in 2019.

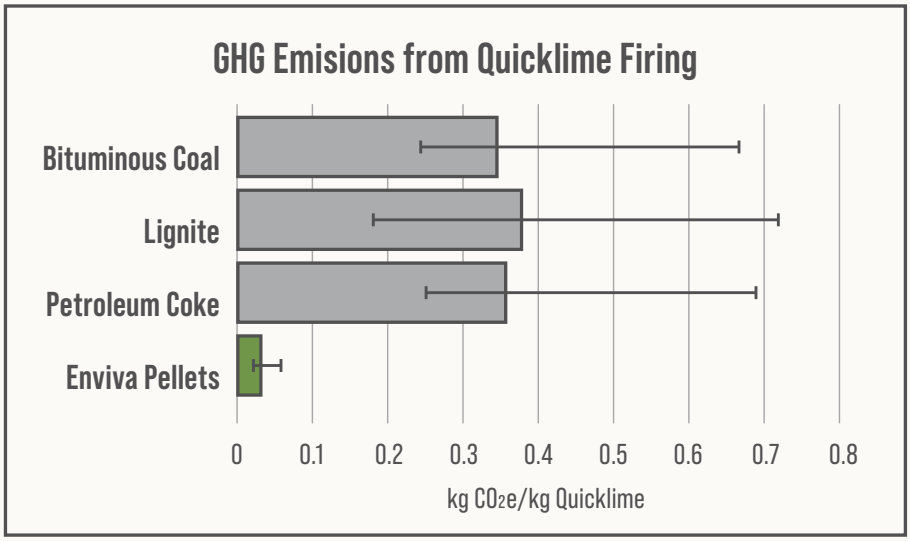
In November 2021, Enviva announced the signing of a 10-year contract with an industrial customer in Europe for 60,000 metric tons per year of wood biomass to be used as feedstock for the production of SAF and other biofuels. Deliveries under the initial traunche of the contract are scheduled to commence in 2023, with volumes potentially increasing to approximately 1.2 million metric tons per year by 2027.[18]

In January 2022, Enviva announced its first MOU with a U.S.-based customer for the long-term, large-scale supply of wood biomass for the production of SAF to be used nationwide by U.S. airline industry partners, such as Boeing and United Airlines. In September 2022, Enviva announced the progression of this MOU into a partnership with this same customer, Alder Energy, LLC (Alder Fuels). Enviva is the exclusive supplier of up to 750,000 metric tons per year of wood biomass feedstock for Alder Fuels' proprietary biocrude process, which will be shipped to Alder Fuels' refining partner in the Gulf region. Enviva is expected to start providing the supply of wood biomass feedstock in 2024 at a jointly developed pilot facility. After the initial supply has been provided as per the contract, Enviva has the right of first offer to be the wood biomass supplier for future Alder Fuels' plants in the U.S. Southeast and California.



## Green lime

Lime is one of the most common chemicals consumed globally. In 2021, the global lime market size was valued at US $40.07 billion, with projected growth to US $49.17 billion by 2029.[19] Lime is used as key input for a myriad of industrial, chemical, and environmental applications – many of the processes associated with these applications are extremely hard to decarbonize.




When making lime, the production process is highly energy- and heat-intensive, and the chemical reactions and fossil fuels commonly used in calcination result in substantial emissions of carbon dioxide. In 2019, in the United States alone, lime production accounted for 12.1 million metric tons of $CO_2e$[20], a number that will only grow as demand increases.

Around 70% of the emissions from lime production are inherent process emissions and are difficult to mitigate; however, the remaining 30% are related to the fuel required to produce the high temperatures needed to complete calcination – more than 1200°C. Electrification is not an option in the lime production process because of the high temperature required. But sustainable biomass can address the fuel emissions association with production and provide the green process heat needed to reach calcination temperatures, helping to de-fossilize the industry.

In addition to directly replacing fossil fuels in the lime production process, sustainable biomass provides the $CO_2$ abatement urgently needed across all sectors. In quicklime firing, Enviva's wood biomass is forecasted to reduce process emissions by 91% as compared to petroleum coke and coal in kiln combustion. Technologies for carbon capture can also be applied in lime production to reduce emissions and make the process carbon negative.

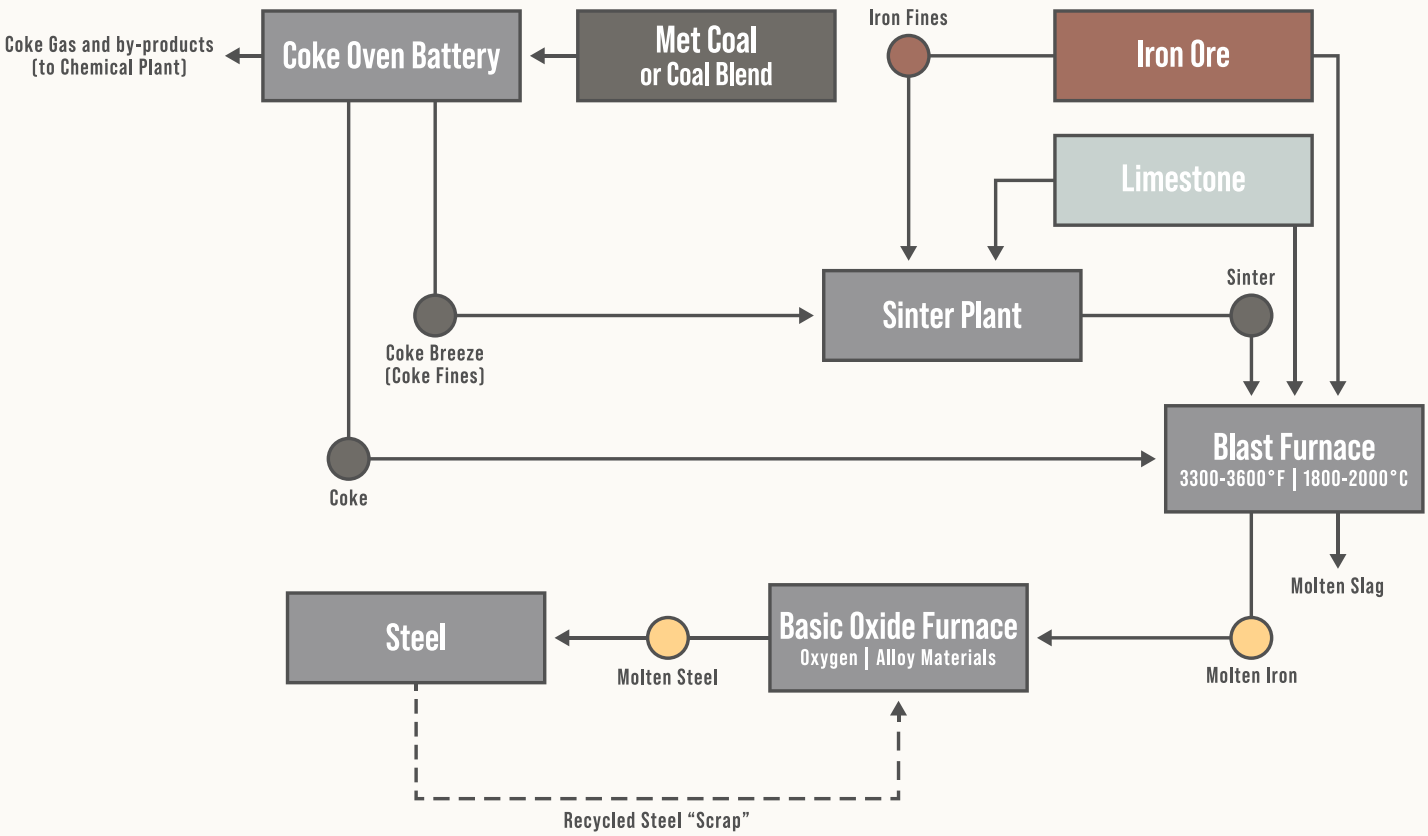
## Green steel

Steel is one of the most essential engineering materials for daily life as we know it – it is the foundation for modern buildings and infrastructure, automobiles, transport, energy, and many other applications. While steel is a bedrock for today's economy, steel production currently contributes 7%–9% of all global $CO_2$ emissions, releasing more than 3 billion metric tons of $CO_2$ each year.[21] With the steel market anticipated to grow from US $837 billion in 2018[22] to US $1.43 trillion by 2028, the urgency for deploying low-carbon solutions in the production process becomes even more immediate.[23]

Because of the high temperatures needed to transform iron ore into steel, it is difficult to replace carbon-based energy carriers, like fossil fuels, in production. Standard practice today relies on coke, a fuel derived from coal. On average, steel production emits about 1.85 metric tons of $CO_2$ per ton produced.[24] In 2026, the global market for steel is projected to reach 2.2 billion metric tons.[25] The industry has acknowledged that efficiency

improvements will not have enough impact to sufficiently reduce process emissions by mid-century and are instead looking towards new inputs and technologies and close-to-zero emissions production sites.[26]

Biomass is an immediate substitute for the coal and coke used in blast furnaces for steelmaking, once torrefied.[27] Sustainable wood biomass provides a carbon-based, renewable heat source that can withstand process temperatures up to 1600°C. The use of biomass in steelmaking can also reduce the carbon intensity of the production process by up to 89%, rising to 144% in reductions if bioenergy with carbon capture and sequestration (BECCS) is included.




***To meet the International Renewable Energy Agency's (IRENA) 1.5°C climate change scenario, the use of bio-based carbon for steel production needs to increase to 4.3 exajoules (EJ) by 2030, with CCS playing a significant role in driving emissions reductions.[29] From 2030 onwards CCS and BECCS deployment should increase ambitiously to around 3.5 gigatons per year and 5 gigatons per year in 2050.***

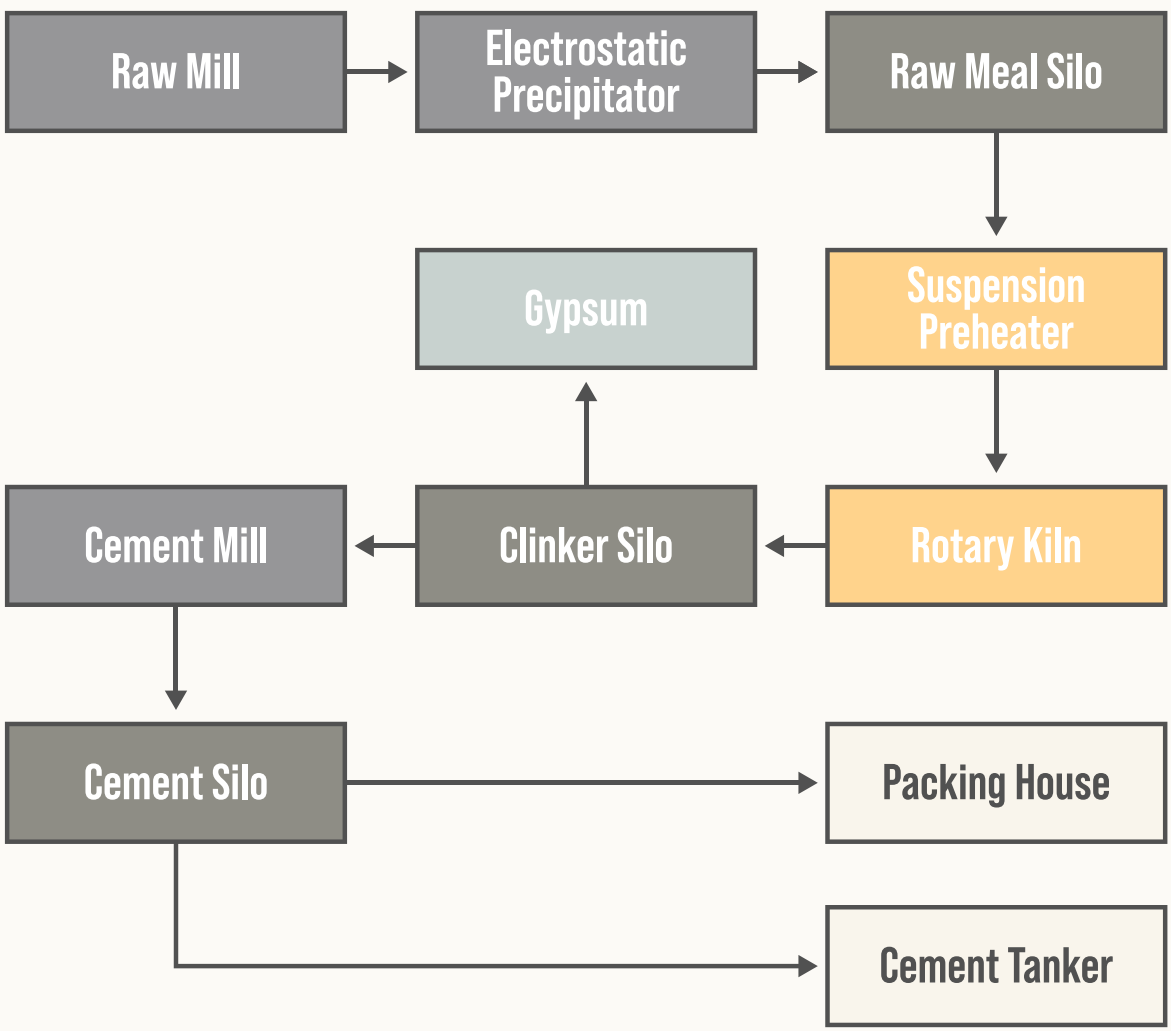
In recognition of the current and future climate impacts of steel, global efforts are underway to change processes and produce green steel using bioenergy.

This kind of innovation is driving the sector and picking up international momentum. In May 2022, more than 50 corporations joined a global "buyers' club," pledging to purchase green versions of aluminum, steel, and other commodities.[28] In recognition of the market urgency to drive down emissions in steel production, Enviva is already working with technology providers and steel producers to produce test volumes and build a business case for investing in torrefaction facilities.

## Green cement

Cement is another energy intensive commodity with a footprint that can be reduced by using bioenergy. Currently, cement production consumes 7% of the world's energy and contributes 8% of all global $CO_2$ emissions, making it the second-largest single industrial emitter in the world, behind only the iron and steel industry. The scale of the market – more than US $326.8 billion in 2021 – is driving significant demand for more sustainable alternatives to today's materials. From 2020–2021 alone, more than $100 million in venture funding went towards start-ups trying to reduce the emissions associated with cement production.[30]

The process of making "clinker," the key binder for cement, is what releases the most $CO_2$ during the cement-making process – accounting for nearly 90% of the sector's emissions.[31] Clinker is made when limestone is calcinated along with silica, aluminum, and iron oxides. Clinker production requires high heat for calcination, typically achieved by using coal, and the production process itself releases large amounts of $CO_2$.




For example, substituting biomass fly ash in place of cement or aggregate content in concrete can have good emissions results, as can providing process heat with biomass instead of fossil fuels. In a lifecycle comparison of steel furnace firing between coal, petroleum coke, and Enviva's wood biomass, it was estimated that Enviva's biomass could offer 90% GHG savings when used as a replacement feedstock for the production process.[32]

***Over the past two decades the cement industry has already cut emissions by more than a fifth, but many efficiency-based solutions have already been employed, leaving a significant remaining gap to achieve international climate goals.[36] Sustainably sourced biomass can change the way that cement is being produced in the near-term, making it more beneficial to the environment, reducing emissions and replacing the use of fossil fuels.***

Another promising pathway for green cement manufacturing involves indirectly heating the steel kiln with biomass heat and using CCS for the $CO_2$ produced from the kiln and from combustion, creating a carbon negative, renewable process. With the incorporation of biomass heat and process improvements, cement production emissions could be reduced by 92%[33] with a moderate cost per ton for abated $CO_2$.

Research and pilot projects are ongoing to further incorporate biomass into cement production and reduce its carbon footprint. As increasingly innovative solutions are brought to market, the role of biomass will increase in the face of demands to meet climate change targets.

Currently, in the EU, cement production costs – excluding $CO_2$ costs – are estimated at 46 to 58 euros per ton. With projected increased carbon prices in the EU's Emissions Trading System – which more than doubled from 2021 to 2022 and plateaued in 2022 at around 90 euros per ton of $CO_2$ – the $CO_2$ cost component of producing cement has doubled since 2021, amounting to 15% of the total cost of cement.[34] The incorporation of biomass into the cement production process could help to reduce $CO_2$-price exposure in the industry and increase the marketability of green cement, potentially even incurring a green premium.

Already, biomass offers a critical contribution to the cement sector's 2050 ambitions. The industry is targeting the incorporation of 60% alternative fuels by 2030, with biomass making up 30% of that goal. By 2050, the industry is targeting the use of 90% alternative fuels with at least 50% biomass by 2050.[35]

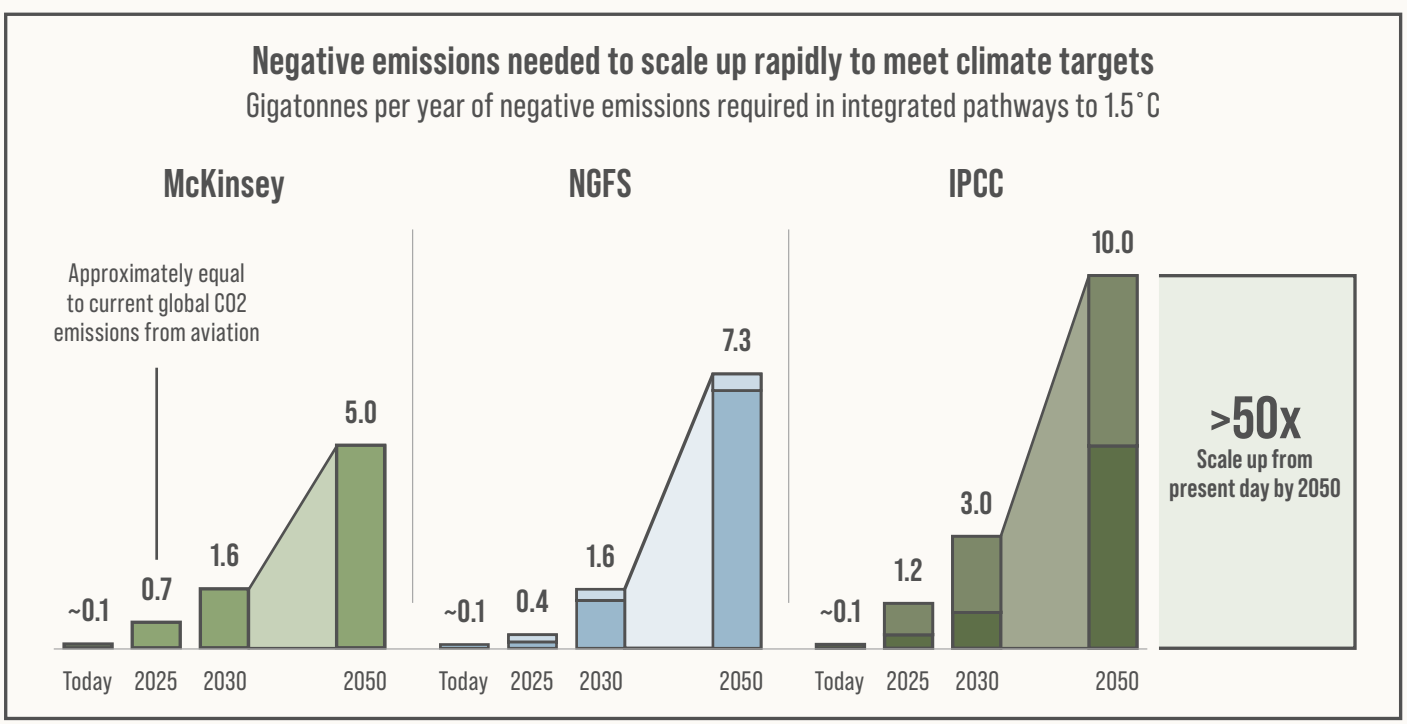
| Pathway | Carbon Intensity (t CO2/t cement) | % Reduction | Cost ($/tonne CO2 abated) |
|---|---|---|---|
| **Reference Cement** | 0.78 | | |
| **50% biomass heat** | 0.68 | 13% | $101 |
| **50% biomass and CCS (MEA)** | 0.13 | 83% | $134 |
| **Biomass, oxyfuel combustion** | 0.4 | 49% | $41 |
| **Biomass, with IHCaL** | 0.06 | 92% | $60 |

## Additional opportunities

The sustainable biomass industry will continue to expand into new applications such as decarbonizing heavy industry, but it will also supply much-needed negative emissions technology through BECCS. BECCS is the process of capturing and permanently storing $CO_2$ from biomass power generation. BECCS and other negative emissions technologies are recognized today as crucial and scalable tools for meeting international long-term climate goals – in fact, BECCS can provide up to 40% of the removals needed to limit global warming to 1.5°C.[37]

Today, the BECCS industry is ramping up, with nearly 20 operational BECCS projects globally. Enviva has developed partnerships with two of the companies already working on BECCS, Drax and Ørsted, and will continue to monitor the pace of technology developments for carbon dioxide removal.

There is also the potential to use biomass to produce green hydrogen, batteries, and other grid-scale storage mechanisms, but scaled production of these applications is not yet feasible, and the economics remain questionable. Batteries and hydrogen offer hope in the medium- and long-term, but we are only a few years away from the deadline to decrease EU emissions by 55%. We simply do not have the time to wait for these solutions to become cost-competitive at scale.



# Biomass – A Scalable Climate Solution

Enviva's wood biomass offers a turnkey solution for decarbonization based on a reliable, sustainable economy of scale with a robust supply chain across multiple continents. Enviva brings global expertise and best practices to de-risk investments, ensure security of supply, and offer affordable long-term fixed prices for renewable energy products.

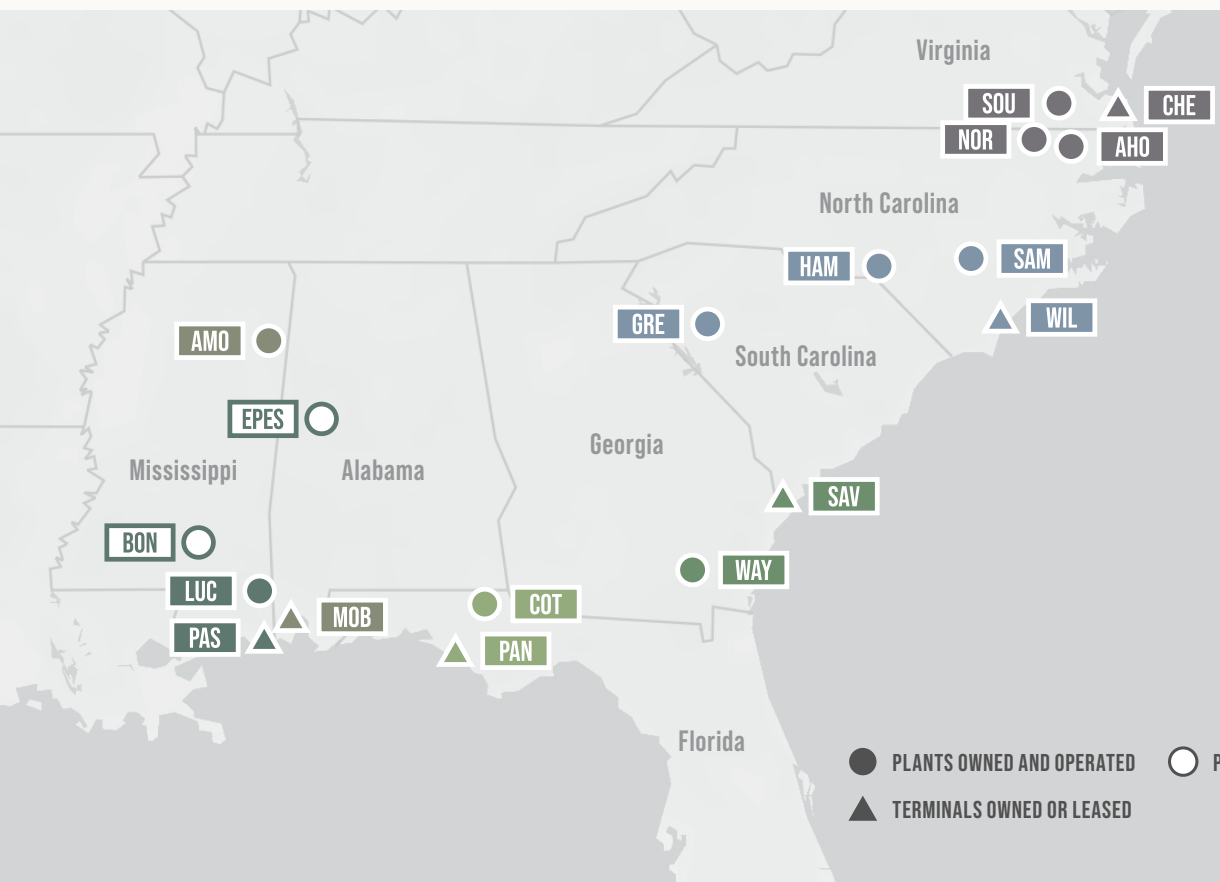
## A fully developed and well-established sustainable supply chain

Enviva is well-poised to meet the demand of its traditional heat and power customers, as well as explore additional market applications. Today, Enviva operates 10 pellet plants and six deep-water marine terminals in the U.S. Southeast, where robust natural resource growth drives a sustainable, stable low-cost supply. On an annual basis, Enviva has more than 6.2 million metric tons of production capacity serving customers all over the world, with plans to double that number by 2026, including bringing forward plans for a third plant in the Pascagoula, Mississippi cluster as well as additional plants around Savannah, Georgia and in the mid-Atlantic regions.

> **Protecting our environment and our forests for current and future generations is a shared goal. Wood energy is a sustainable, responsible, renewable, and economically viable way to achieve it.**
>
> **U.S. Senator Susan Collins**

The vast majority of wood pellets that Enviva sells are produced in our own mills in the Southeast U.S. However, we also purchase wood pellets from third-party suppliers. Due diligence on these third-party suppliers forms an integral part of our Responsible Sourcing Policy. Our due diligence process ensures that the suppliers we work with are meeting the same high standards we would expect of our own production. This requires that all our third-party suppliers are also committed to sustainable and responsible sourcing within their own operations and supply chains and that all suppliers can meet, or have plans in place to meet, our requirements for responsible sourcing.

## Enviva's Facilities




| CHESAPEAKE CLUSTER | |
|---|---|
| Southampton VA (SOU) | 760,000 MTPY |
| Ahoskie, NC (AHO) | 410,000 MTPY |
| Northampton, NC (NOR) | 750,000 MTPY |
| Port of Chesapeake, VA (CHE)* | 2,500,000 MTPY |

| WILMINGTON CLUSTER | |
|---|---|
| Hamlet, NC (HAM) | 600,000 MTPY |
| Sampson, NC (SAM) | 600,000 MTPY |
| Greenwood, SC (GRE) | 600,000 MTPY |
| Port of Wilmington, NC (WIL)* | 3,000,000 MTPY |

| SAVANNAH CLUSTER | |
|---|---|
| Waycross, GA (WAY) | 800,000 MTPY |
| Port of Savannah, GA (SAV)* | 1,500,000 MTPY |
| Cottondale, FL (COT) | 780,000 MTPY |
| Port of Panama City, FL (PAN)* | 780,000 MTPY |
| Amory, MS (AMO) | 115,000 MTPY |
| Port of Mobile, AL (MOB)* | 115,000 MTPY |

| PASCAGOULA CLUSTER | |
|---|---|
| Lucedale, MS (LUC) | 750,000 MTPY |
| Epes, AL (EPES) | 1,100,000 MTPY |
| Port of Pascagoula, MS (PAS)* | 3,000,000 MTPY |

● PLANTS OWNED AND OPERATED ○ PLANTS UNDER DEVELOPMENT / CONSTRUCTION

▲ TERMINALS OWNED OR LEASED

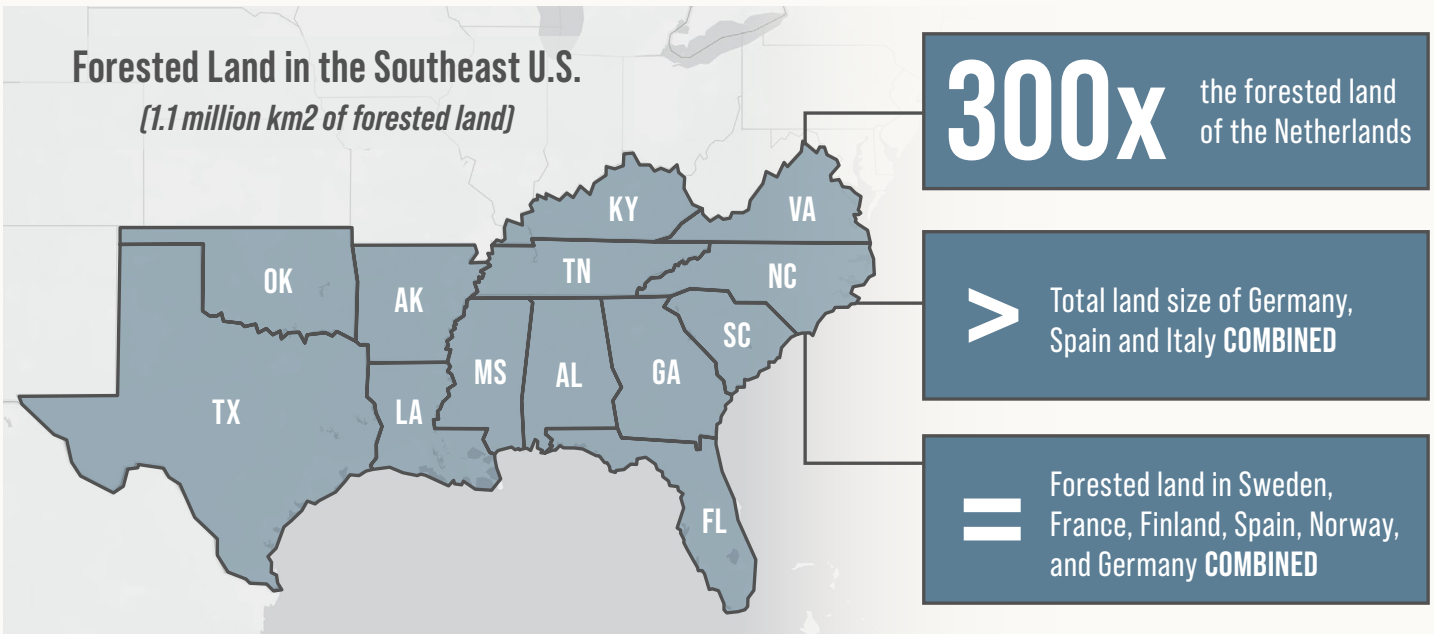
*throughput capacity

## Sustainability and scalability of the U.S. Southeast supply

Enviva's business model is based on sustainable forestry practices. Our sourcing region, the U.S. Southeast, is one of the world's most important timber baskets, producing about 20% of the wood that is used worldwide every year. Increased demand for forest products in the region has resulted in more forest inventory, which has more than doubled since 1953.[38] In fact, according to data from the U.S. Department of Agriculture's Forest Inventory and Analysis Program, the growth-to-drain ratio in the U.S. Southeast is about 2.0 – meaning that for every ton of wood that is harvested each year, two tons grows back.

Biomass markets support thriving, healthy forests. In the U.S. Southeast, forest landowners consistently respond to robust forest products markets by further investing in their forests, which creates a virtuous cycle. As more trees are planted than harvested each year, more carbon is pulled out of the atmosphere year after year. Today, private forest owners in the U.S. are growing 43% more wood than they harvest.[39] And Enviva plays a small, but important, role in this cycle by creating an additional market for private forest landowners to sell their low-value wood in, providing incentives to replant and keep their land as forests.

Because of that growth, an estimated 1 billion dry tons of biomass can be collected sustainably each year in the United States.[40] While some estimates of new market demand for wood biomass approach 10 billion metric dry tons by 2050, that number represents less than 3% of the world's current forest biomass – 391 billion metric tons, according to the UN Food and Agriculture's Global Forest Resources Assessment 2020.




The availability of wood biomass is not without limits, and projections of increased use must take these limitations into account. However, while wood biomass cannot by itself take the place of fossil fuels domestically or globally, it will play an important role in fossil fuel replacement in many or most of the product areas identified above and in concert with other decarbonization strategies.

Fundamental to our business are responsible sourcing practices that keep forests thriving, healthy, and growing. And in 2019, Enviva launched an enhanced and expanded global Responsible Sourcing Policy (RSP), clarifying Enviva's

commitment to forest stewardship in three critical areas: 1) at the tract level, with strict standards for forest sourcing; 2) throughout our supply chain, with provisions for verification, transparency, and reporting; and 3) in pledges for conservation leadership on landscape-level challenges and opportunities. Enviva's RSP is supported by Track & Trace®, an industry-leading sustainable sourcing program that provides transparent, publicly available supply chain data. Track & Trace® enables Enviva to track all of the in-scope volume that we receive directly from the forest to its harvest origin, ensuring that our feedstock meets Enviva's strict sourcing requirements.

## Reliability and security of supply

A global energy transition is underway, and wood biomass plays an important role in stabilizing and decarbonizing power and heat generation. Dubbed the "overlooked giant" of the renewable energy field by the IEA, bioenergy contributes as much energy as hydro, wind, solar, and all other renewables combined.[41]

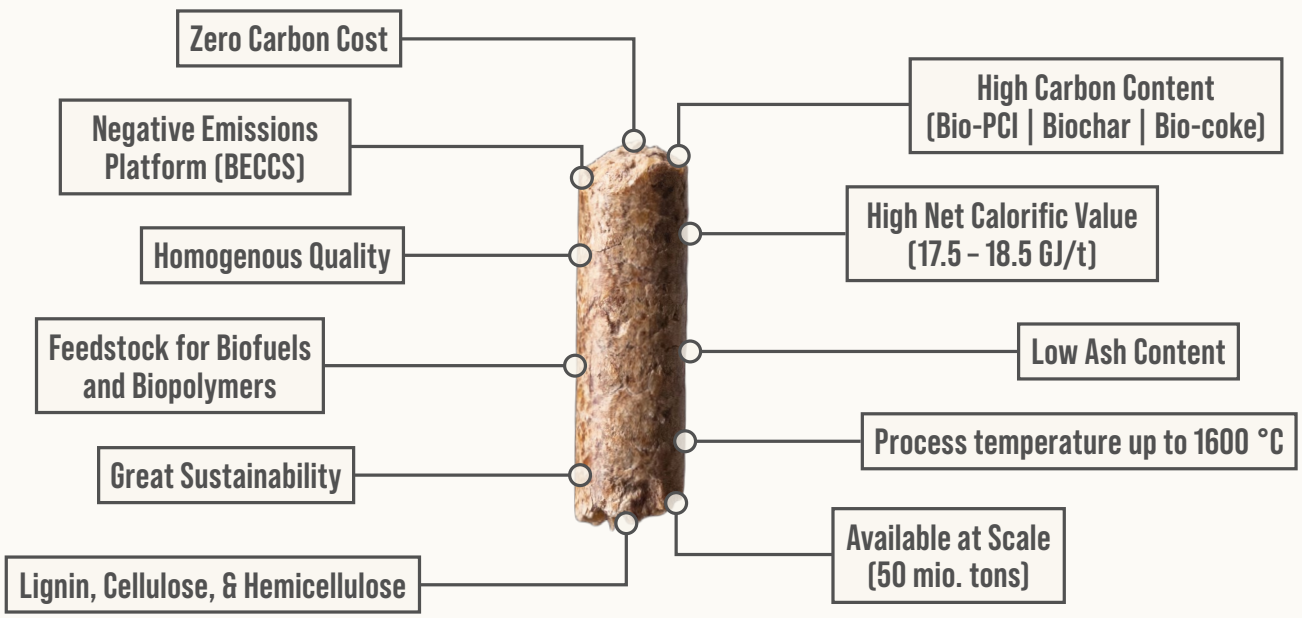
As a renewable energy alternative to fossil fuels, Enviva's industrial wood biomass is designed to provide consistent, reliable results for a wide range of heat- and power-generating customers. Wood bioenergy provides uninterrupted power at any time, at large scale, and at comparatively low cost, which means power generation using sustainably sourced biomass provides a reliable, affordable, cleaner source of renewable energy that complements the intermittency of other renewables, including wind and solar energy.

Sustainably sourced biomass also provides energy security and independence in the face of geopolitical conflict, enabling a clean and consistent pathway for decarbonizing the industrial sector.

## Quality specifications of wood pellets needed for advanced processes that are not easily replicated

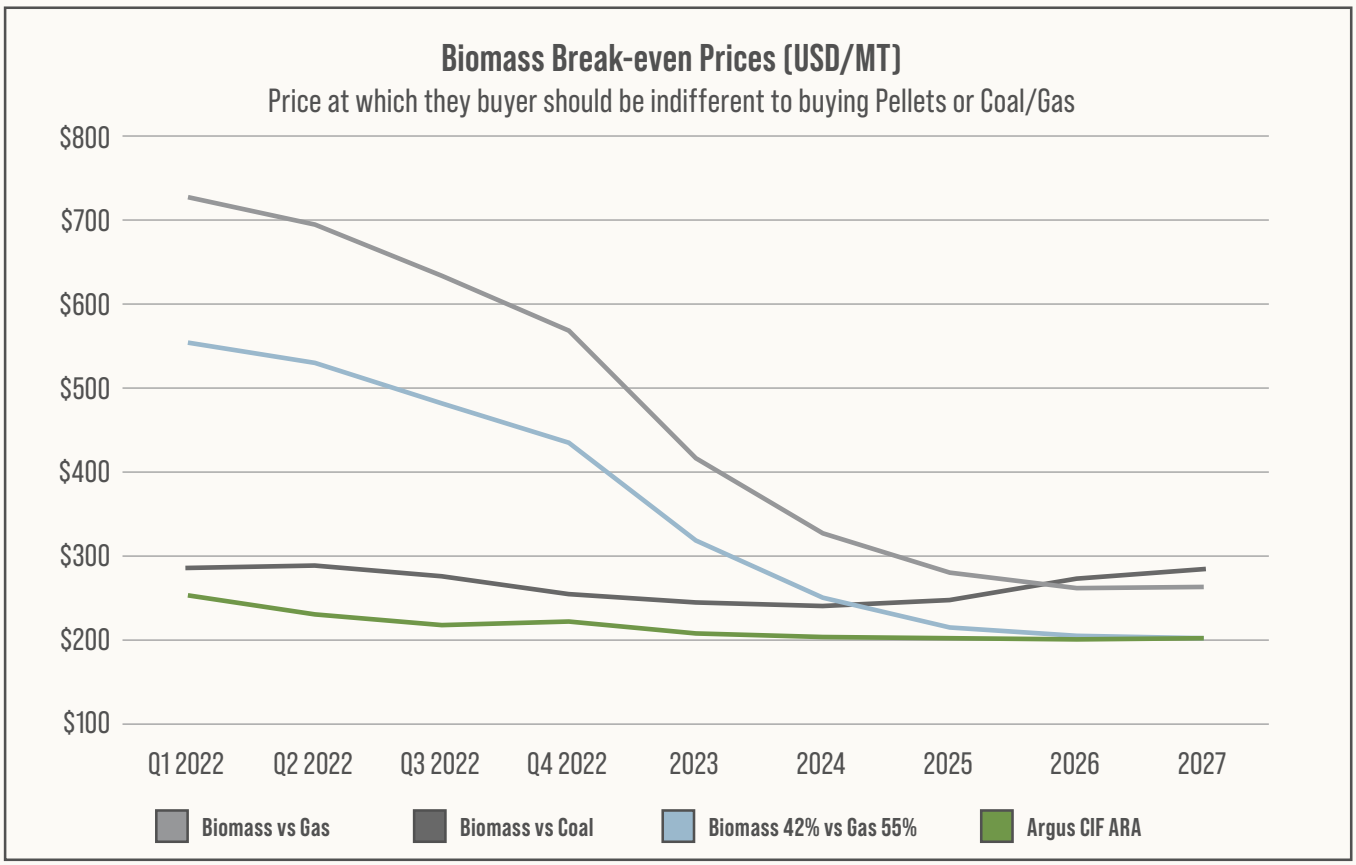
Enviva provides a standardized wood pellet to the market that is produced to meet the quality specifications of various applications. Enviva's pellets have a high carbon content and can withstand process temperatures up to 1600°C, making them a drop-in feedstock readily able to replace things like coal and coke in current industrial processes.

## Enviva's Wood Pellets



## Biomass already offers price advantages over fossil fuel

When compared to gas and coal, biomass already offers a cost advantage in the current market. With coal, gas, and carbon prices rising, the competitiveness of wood biomass is expected to be maintained over the next 5 years. This cost advantage only increases as biomass allows for the production of green-based materials like SAF, green steel, lime, and cement that have high-premium margins.



## Enviva's is Unlocking the Power of People and Forests

Bioenergy is part of an all-in strategy to reduce carbon emissions and limit dependence on fossil fuels. Wood biomass directly replaces coal, providing customers around the world with a renewable fuel source from sustainably managed forests that improves the environmental profile of energy generation. Ongoing research has also demonstrated a new suite of industrial applications for wood biomass. Many of the process temperatures, chemicals, and feedstocks currently derived from fossil fuels can be produced more cleanly and at a lower cost with sustainably sourced biomass.

Because of the current and future climate mitigation potential of biomass, Enviva's purpose has never been more important. We are unlocking the power of people and forests in the fight against climate change, and the renewable fuels we deliver to customers in countries around the world provide an essential, safe, secure supply of renewable energy for power, and heat, and true independence from coal, natural gas, and crude oil.

Enviva is looking to the future and the climate positive impacts that biomass can have not only for the energy sector, but also in the production of critical industrial materials and biofuels. Sustainable aviation fuel, green lime, green steel, and green cement offer opportunities today that will only grow in the future as our climate-constrained world looks for sustainable solutions.

Enviva Inc. is proud to carry on and grow in its core mission of maintaining and improving the health of our forests while reducing greenhouse gas emissions on a lifecycle basis around the world through new and expanded opportunities. We look forward to unlocking a renewable society together.

**To learn more about Enviva please visit www.envivabiomass.com or reach out to futureofbiomass@envivabiomass.com.**

**connect with us on social @enviva**

# Endnotes


1 https://www.canadianbiomassmagazine.ca/why-europe-also-needs-to-count-on-sustainable-bioenergy-iea-bioenergy/#:~:text=In%20Europe%2C%20bioenergy%20represents%20about,also%20of%20European%20energy%20security
2 https://www.ipcc.ch/report/ar6/wg2/about/frequently-asked-questions/keyfaq1/
3 https://news.un.org/en/story/2022/04/1115452
4 https://www.ipcc.ch/sr15/
5 https://www.iea.org/reports/technology-roadmap-delivering-sustainable-bioenergy
6 https://iopscience.iop.org/article/10.1088/1748-9326/10/11/114019
7 Boundless Impact Research and Analysis, Enviva Inc. Biomass Energy Industry, Environmental Impact Report, March 2022
8 https://www.bloomberg.com/news/articles/2022-07-12/worst-of-global-energy-crisis-may-be-ahead-iea-s-birol-warns
9 https://www.bloomberg.com/opinion/articles/2022-07-11/europe-s-natural-gas-crisis-is-worse-than-it-looks
10 https://ir.envivabiomass.com/news/news-details/2022/Enviva-Announces-MOU-With-U.S.-Customer-Provides-Updates-to-Business-and-Sales-Pipeline-and-Accelerates-Capacity-Expansions/default.aspx
11 https://www.atag.org/facts-figures.html
12 https://www.mckinsey.com/~/media/mckinsey/industries/travel%20transport%20and%20logistics/our%20insights/scaling%20sustainable%20aviation%20fuel%20today%20for%20clean%20skies%20tomorrow/clean-skies-for-tomorrow.pdf
13 https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/
14 https://www.researchandmarkets.com/reports/5178303/global-sustainable-aviation-fuel-market-by-fuel?utm_source=CI&utm_medium=PressRelease&utm_code=r4v99z&utm_campaign=1660395+--+The+Worldwide+Sustainable+Aviation+Fuel+Industry+is+Expected+to+Reach+%2415.7+Billion+by+2030+&utm_exec=jamu273prd
15 https://www.energy.gov/sites/prod/files/2020/09/f78/beto-sust-aviation-fuel-sep-2020.pdf
16 https://www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022
17 https://www.iea.org/reports/world-energy-outlook-2021
18 https://www.envivabiomass.com/wp-content/uploads/Enviva_GHG_Final_Report_03172022.pdf
19 https://www.fortunebusinessinsights.com/lime-market-104548
20 https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-chapter-4-industrial-processes-and-product-use.pdf
21 https://cen.acs.org/environment/green-chemistry/steel-hydrogen-low-co2-startups/99/i22
22 https://www.marketresearchfuture.com/sample_request/5465
23 https://www.globenewswire.com/news-release/2021/10/18/2315415/0/en/Steel-Market-worth-USD-1-43-Trillion-by-2028-registering-a-CAGR-of-3-47-Report-by-Market-Research-Future-MRFR.html
24 https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel
25 https://www.prnewswire.com/news-releases/global-steel-market-to-reach-2-2-billion-metric-tons-by-2026--301493681.html
26 https://www.ft.com/content/46d4727c-761d-43ee-8084-ee46edba491a
27 https://www.sciencedirect.com/science/article/pii/S2405844020303765
28 https://www.nytimes.com/2022/05/25/climate/corporate-climate-pledges-davos.html
29 https://irena.org/publications/2022/mar/world-energy-transitions-outlook-2022
30 https://www.ft.com/content/24d610a0-fb65-45bb-b747-e015e1f10c1a
31 https://www.bbc.com/news/science-environment-46455844
32 https://www.envivabiomass.com/wp-content/uploads/Enviva_GHG_Final_Report_03172022.pdf
33 https://publications.tno.nl/publication/34638722/5FN2HP/yang-2021-carbon.pdf
34 https://cembureau.eu/media/jpthbmva/co2-costs-in-eu-cement-production-december-2021.pdf
35 https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf
36 https://www.ft.com/content/24d610a0-fb65-45bb-b747-e015e1f10c1a
37 https://energyfuturesinitiative.org/wp-content/uploads/sites/2/2022/03/Surveying-the-BECCS-Landscape_BECCS_Factsheet_Jan2022.pdf
38 https://www.globenewswire.com/news-release/2017/07/27/1063553/0/en/Forest2Market-Report-Shows-Increased-Demand-for-Wood-Fiber-Leads-to-Forest-Growth.html
39 https://nafoalliance.org/private-forest-owners-grow-43-more-wood-than-they-harvest/
40 https://www.energy.gov/eere/bioenergy/2016-billion-ton-report
41 https://www.teriin.org/press-release/modern-bioenergy-overlooked-giant-renewable-energy-field-says-iea