Approaches for biomass projects

November 2023

Regional and Urban Policy

Approaches for biomass projects

Contents

Aim and scope

The aim of this toolkit is to provide an overview of useful tools and aspects as well as challenges when considering investments in biomass and bioenergy opportunities in former coal+ regions.[1] The toolkit focuses on the opportunities for planting biomass and using it as bioenergy for coal+ regions in their transformation to become climate neutral.

Who is this toolkit for?

The toolkit is aimed at local governments and landowners in coal, oil, peat, and shale regions.

Background information

Policy context

In recent centuries, we have largely relied on fossil fuels to power our energy system. However, profound transformation of the global energy landscape is essential to realise the EU's climate ambitions to reduce greenhouse gas emissions by at least 55% by 2030 and be climate-neutral by 2050.[2] The EU Renewable Energy Directive (RED) sets a target for at least 42.5% renewable energy across Europe by 2030, striving for 45%. With a share of 60%, bioenergy is currently the most widely used renewable energy source[3]. Biomass can be used for materials or energy in the form heating, electricity generation, or the production of transport fuels. Under the RED, different forms of energy from biomass can count towards renewable energy targets under the condition that bioenergy use adheres to specific sustainability and greenhouse gas savings criteria. These specific sustainability criteria are set out for biofuels, bioliquids and biomass fuels and include a greenhouse gas saving threshold. They guarantee that agricultural land used to plant biomass for biofuel production is not highly biodiverse land or land with high-carbon stock, such as forested areas, ensuring that the contribution of bioenergy is sustainable. The RED also provides additional incentives for biomass produced on land that has been unused, abandoned or severely degraded, and for the use of recycled woody biomass.[4,5]

Sustainability criteria for bioenergy

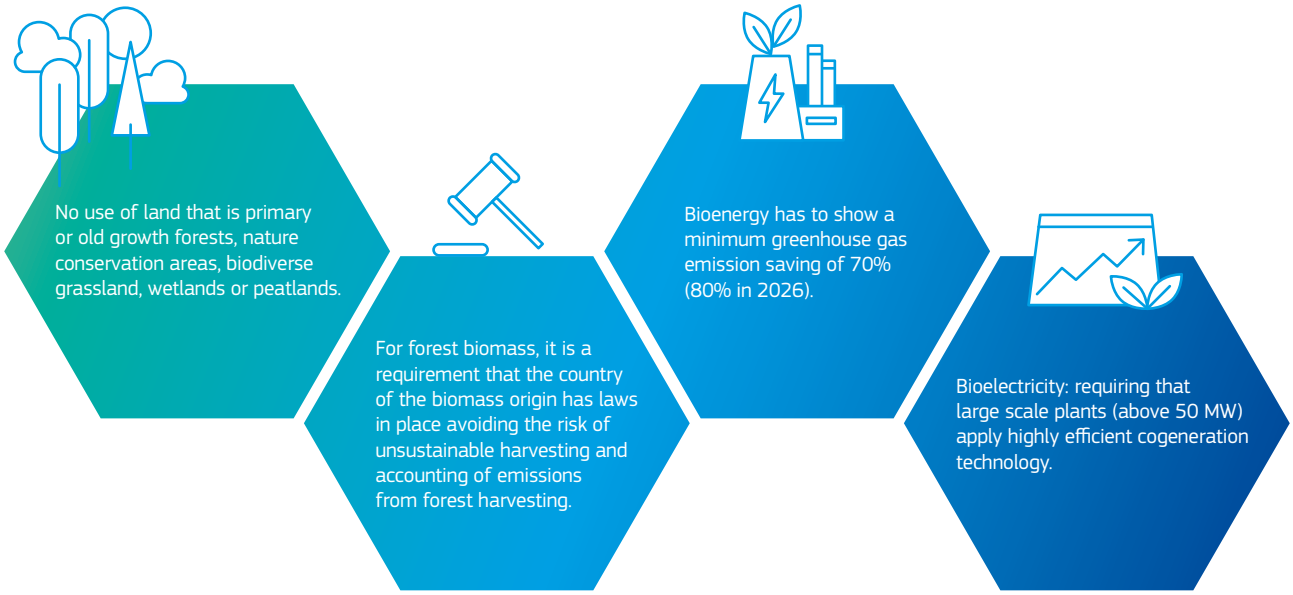


Figure 1 - Sustainability criteria for bioenergy. Source: RED II. Design, Guidehouse/Simpelplus

Clean energy opportunities for coal+ regions

Coal-fired power generation is a major contributor to greenhouse gas emissions and pollution. Countries across Europe have set coal phase-out targets, resulting in the closure of coal mines and plants and creating an opportunity to find new uses for abandoned coal mining areas. Surface and underground coal mining has changed the natural landscape of many regions across Europe. In undergoing this major and challenging restructuring process, EU policies are supporting regions, many of which are coal+ regions, in their just transition process[6] through funding and capacity building via the Just Transition Fund (JTF).

JTF regions have or are currently implementing projects that actively assist the recovery of ecosystems around coal mining areas (nature restoration) or repurpose the land for tourism. Common projects include creating historical museums to preserve and showcase underground mines and mining culture, or creating recreational areas e.g., lakes or green spaces on surface mines. Nine EU member states allocated around EUR 300 million for projects to restore former coal mines.[7] Former surface mines can also be used for renewable energy generation. Clean energy is one focus area of the JTF and concentrates on solar, wind, biomass, and other innovative renewable energy technologies. Figure 2 shows the JTF funding allocated by EU Member States to develop renewable energy projects.

Cultivating biomass on abandoned or degraded land from coal mining actives can be one key form of renewable energy projects.

The use of biomass and its conversion into heat or electricity has the potential to reduce greenhouse gas emissions compared to fossil counterparts, as biomass captures emissions from the atmosphere in the form of forests or crops. Currently, the emission factor for biomass under the EU Emissions Trading System (ETS) is zero, with exception of liquid biomass. However, the sustainability and greenhouse gas emissions savings of biomass depend on the feedstock type, how it is grown and used, and the supply chain set up. If sustainability considerations are ensured, biomass and its resulting bioenergy can offer an effective alternative to coal energy and a possible use case for former mining sites.

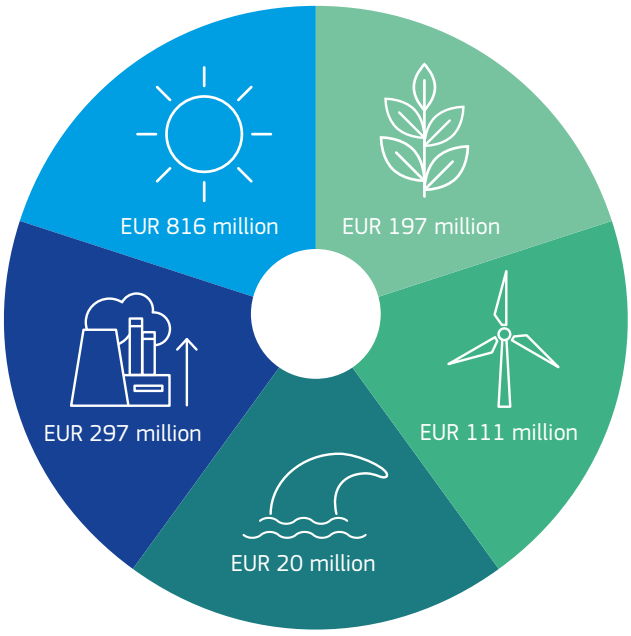


Figure 2 - JTF funding allocated to renewable energy projects. Source: Visual, Guidehouse/Simpelplus. Data, European Commission (2023e)

What is biomass - Definitions of the most important terms

Bioenergy: Bioenergy is a broad term to refer to any form of renewable energy generated from any plant-based or organic waste-based materials (biomass).

Biomass: Biomass refers to a wide range of organic resources that can be used to produce bioenergy in a variety of forms. Biomass includes starch, oil or sugar crops, fibre or wood process residues from the industrial sector; dedicated energy grasses or short-rotation crops or agricultural wastes and residues such as straw or manure; or forest and agroforestry residues and dedicated energy plantations from the forestry sector.

Biogas: Biogas is a mixture of mainly methane and carbon dioxide produced by anaerobic digestion of organic matter (such as food waste or manure) in an oxygen-free environment.

Biomethane: Biomethane is the purified form of raw biogas (the carbon dioxide is removed) and it can be used as a natural gas substitute. In the future, biomethane is expected to make up an important part of the renewable gases to decarbonise the EU's energy system.

Biofuel: Biofuels are usually used to refer to liquid fuels for transport, produced by conversion of biomass such as rapeseed, corn or sugarcane into biodiesel or bioethanol, which can either directly replace or be blended into fossil diesel or petrol. Biofuels can be distinguished between conventional biofuels that are commonly produced from food crops and advanced biofuels made from non-food sources like agricultural waste etc. Advanced biofuels are more sustainable since they do not compete with food and feed production on land requirements but currently still face some technical production challenges.

Feedstock: A feedstock is an alternative term to biomass. It is defined as any renewable, biological material that can be used directly as a fuel or converted to another form of fuel or energy product. In the context of biofuels, a feedstock is any biomass destined for conversion to energy or biofuel. For example, corn is a feedstock for ethanol production and rapeseed oil is a feedstock for biodiesel. Agricultural residues like straw and manure are often used as feedstocks to produce biogas.

Figure 2 - Overview of biomass and possible end uses
Source: Guidehouse, 2023

Biomass cultivation on degraded coal mining land

There are two types of mining activities we will distinguish in the following practical examples and opportunities: open pit mining and closed pit mining. Open pit mining offers the most opportunities to grow biomass, as it offers the most available land surface. The amount of biomass that can be successfully cultivated and harvested is dependent on several factors, such as climate regions, depth of topsoil, degree of soil degradation, type of soil contamination and general soil health.

Open pit mining

During and after a coal phase-out, vast areas of surface mines become available that are often still contaminated and thus not suited to grow food or feed crops. For open pit mines, the cultivation of biomass for material or energy use on this unused, abandoned, degraded, or contaminated land could be one option for coal+ regions to still make use of the land, as it does not compete with the land for food or feed crops. While biomass still releases carbon when burned or decomposed, certain plants are not only resistant to contaminated soils, but can even take up the pollutants and thereby improve the soil. This process is called phytoremediation. These metals can be recovered through phytomining after biomass processing (either incineration or anaerobic digestion). Other positive aspects resulting from biomass cultivation, such as carbon sequestration, biodiversity support and provision of other ecosystem services partly outweigh these carbon emissions.

A wide range of crops could be grown on such land, depending on the status of the land and any contaminants that might impact the growth of crops. It is important to consider a range of factors when deciding which crop to grow for bioenergy purposes. The yield and lifetime of the crop is important, but it is also important to consider whether the crop can meet other aims such as promoting nature restoration and biodiversity.

HORIZON-2020 Projects

The HORIZON-2020 project GOLD has conducted seven trials in total to research the opportunities to use contaminated land for bioenergy purposes. High-yielding lignocellulosic (energy grasses and fibre) crops, such as miscanthus, industrial hemp, switch grass and sorghum are excellent to grow on metal-contaminated soils. The HORIZON-2020 project FORTE cultivated flax, industrial hemp and kenaf in former-mining regions in Greece, in their project they reported that hemp was the best plant to remove excess copper and lead from the soil and kenaf was best to remove cadmium, nickel, and zinc. All of the before mentioned crops are suitable for bio-energy purposes, mainly for biogas.

Agri-PV

Another way to increase the energy yield from the land and reduce the risk of erosion and draught, is to have a combination of solar panels and agriculture, so-called Agri-PV or Agrivoltaics. This type of mixed-agriculture is most suitable for crops that require (partly) shade, such as leafy greens (lettuce, cabbage and spinach), root crops (potatoes, radishes, beets, and carrots) and fiber-rich crops (hemp, miscanthus and hops). Hemp and miscanthus are more suitable for contaminated land, as these are mostly resistant to the metals in the soil and can even take up metals from the soil. Though not JTF projects, there are examples of planned agri-PV projects in two German JTF regions. In the Rhenishe Revier, RWE and the research center Jülich have plans for agri-PVs on recultivated land at the edge of Garzweiler in North Rhine-Westphalia. Similarly, Research Institute for Post-Mining Landscapes (FIB) is currently investigating opportunities for agri-PV on reclaimed coal mining land in Lusatia.

Closed pit mining

There are a few more innovative methods to re-purpose closed pit mines to cultivate additional biomass. Even though cultivating biomass in mine shafts provides a challenge regarding sunlight, it also comes with an opportunity as ground water could easily be used and it is a controlled environment with no influences of fluctuating weather conditions or natural disaster risks. Biomass could be grown using the 'vertical farming' principle, often used in 'urban farming' applications. This system uses LED lights and a hydroponic system, where the plants are grown directly in a water-nutrient solution instead of in soil[8]. The biomass grown in these closed pit mines could then be used for energy purposed in surrounding power plants.

Retrofitting of coal power plants into biomass plants

Another option for coal+ regions to make use of existing infrastructure is the transformation of coal power plants into biomass plants. This can help to preserve jobs in the local economy, as coal plant workers can be easily re-trained both at the power station, through biomass production and along the supply chain. When evaluating the transition of a coal power plant to biomass use, it is essential to consider both technical challenges[9] and environmental impacts. Local availability of biomass offers higher energy security, lower costs, and less GHG emissions to transport the biomass to where it is used. On the other hand, it may still lead to air pollution and a resulting negative impact on local populations.

For areas where biomass resources are easily accessible, switching from coal to biomass energy using an existing power plant could be a feasible alternative. Realizing this switch might require changes to existing equipment, such as the boiler and fuel delivery systems, but in some cases the main components could remain from the original plant. The project BIOFIT, funded by the Horizon 2020 Program, has shown that that the conversion from a pulverized fuel coal boiler of to a multi-fuel biomass (which includes different sources of biomass, such as saw dust or wood chips from forest residues or wood waste) are relatively small. The website of the BIOFIT project is a useful resource where further information can be found, including their digital support tools.

Example – The case of the La Pereda coal power plant in Asturias

Another example is "La Pereda", Hunosa´s power station, a 50-megawatt (MW) Circulating Fluidised Bed Combustion power plant located in the Asturias region (Spain). After more than three decades of burning coal, it will be retrofitted during 2023 to biomass firing. The decision to retrofit the coal power plant for biomass uses was influenced by the vast land availability around the power plant, owned by the mining company, which is mainly forest land and thus offers a viable source for forest biomass. Option studies, investigating the potential uses of the power plant showed that retrofitting for biomass use is a viable option. Particularly because many parts of the power plant can be easily fitted for the biomass use. The main modifications include the adaptation of the circulating fluidized bed boiler, which will be able to work with 100% forest biomass. Modifying the boiler is not always possible and must be explored through option studies before the retrofitting. The plan is to use solid forest residues and the energy production from biomass is expected to start in 2025 (2 years to-date). The retrofitting is in line with the objective to boost renewable energy supply chains, particularly biomass, laid out in the Asturias chapter of the Spanish TJTP.

To realize this project, Hunosa followed the following steps:

1. Options studies to produce bioenergy in the coal power plant which showed in this case that the boiler is suitable for converting biomass into energy
2. Analysis of the available biomass streams and their suitability for the boiler
3. Permitting and impact assessments

Ensuring the sustainable production and use of biomass

Biomass offers many benefits, but attention needs to be paid to ensure the feedstock is sourced sustainably and does not trigger demand for additional land. Biomass should first always be used according to its highest economic and environmental added value, prioritizing it first for material products, before being recycled, burned for energy, or disposed of. If used for energetic purposes, agricultural and forest residues and (municipal) waste that are not suitable (anymore) for material use should be prioritised. When combusting biomass for energy use, local air pollution needs to be avoided to not compromise the health of communities.

In addition, the EU RED sets out mandatory sustainability criteria that must be met for biomass to be counted towards renewable energy targets.[10] These need to be fulfilled in any bioenergy use case:

Sustainbility criteria to consider:

Are the sustainability criteria for agricultural biomass adhered to?

→ Include the protection of highly biodiverse grasslands, peatlands and protected areas, avoidance of soil carbon and soil quality impacts.

Are the sustainability criteria for forest biomass adhered to?

→ Include the protection of primary, old growth and highly biodiverse forest, minimising unsustainable harvesting, minimising negative impacts on soil quality, and maintaining or improving long-term forest production capacity.

→ No financial support for use of logs, industrial grade roundwood, roots and stumps.

Are the GHG emission saving criteria adhered to?

→ Requirements depend on the fuel type/end-use and date that an installation started operating and range from 50 % GHG savings for fuels produced in installations on or before October 2015 to 65 % GHG for installations starting operation from 1 January 2021.

To ensure and demonstrate the sustainability criteria set out in the RED, voluntary certification schemes recognized by the European Commission certify compliance of biomass use with these sustainability criteria. The schemes can be found on the Bioenergy voluntary schemes webpage from the European Commission.

Financial, regulatory, and logistical steps

If biomass cultivation or retrofitting of a coal power plant seem like viable and sustainable options in a coal+ region, financial, regulatory, and logistical steps need to be considered.

Financial aspects

The first step in defining the specific biomass or bioenergy project refers to identifying the related costs and revenues for the project. The potential costs depend on local, technical, and additional conditions. The financial aspects may differ considerably based on whether biomass cultivation on former coal mines or a repurposing strategy of a coal fired power plant is planned. Answering the questions below may be helpful in this regard to decide which option to choose:

Financial aspects to consider:

Are the capital costs for land restoration considered and calculated?

→ Includes pre-operation costs such as, seeds, agricultural equipment, as well as planning costs and permits.

Are the operations and maintenance costs planned?

→ These include for example energy, water and material costs as well as labour costs.

To calculate revenues from biomass it should be calculated what selling prices from feedstock (e.g. for different crops or woody products) are expected.

In total: What are the financial parameters associated with the project?

→ Such as debt terms and applicable taxes.

For the implementation of a biomass project, different types of financial support may be available. For example, on the EU website on "EU funding possibilities in the energy sector" information can be found on whether EU funding is available.

In addition, some European Member States provide further support. These include, for example, subsidies on electricity prices. In this case, it is worth contacting your local government.

Regulatory aspects

In addition to the financial aspects, there are other questions to be addressed when investing in former coal regions, such as the legal aspects. Different permits are required in the process depending on the biomass strategy that is pursued in the region. When considering repurposing a coal power plant into a biomass plant, a variety of permits are needed. At the same time, the restoration of previous coal mining land is associated with less bureaucratic barriers. The list of permits varies from country-to-country and depending on the scope and size of the project. Therefore, not all projects will experience the same issues relating to their planning and development. To provide some guidance as to the kind of permits that may be required, the box below lists the relevant permitting procedures in the European Union.

Main permitting procedures to consider

Planning permit	In some European countries, a planning permit is required by the regional authorities. This planning permit generally lists all the permits that are obligatory before operating the production plant: • The applicable authorities • The crucial technical documentation • A basic planning of the various steps of the project • A timeline of the activities etc.
Environmental permit	The environmental permit controls the emissions to the environment, primarily to the atmosphere. An environmental permit may include an environmental impact assessment (EIA), an integrated pollution prevention and control procedure or some other country specific procedure. Since this step is very important and dependent on the region, this should be taken care of at an early stage and professional advice should be sought.
Construction permit	The environmental permit is followed by the construction (building) permit, granting the right to build the facility. It is possible in some cased that the environmental and the construction permit are integrated.
Operational permit	After construction, in some countries an operational permit is required to license the project developer to exploit the facility.
Production permit	In some countries, a production permit to license electricity and/or heat production is required.
Grid access	A permit or license to access the grid may be required.
Other permits	Depending on the region and project type some more permits may be required as e.g. for water abstraction or abduction for biogas plants. Plus, safety permits, and waste management plans are most likely obligatory.

Logistical aspects

Finally, answering the following questions can help in the planning phase of the land transformation phase:

Ownership & Skills

→ Can a suitable land ownership structure be found?

→ Is the necessary expertise available?

Existing Feedstock

→ Does biomass cultivation already exist in the region with the corresponding infrastructure?

→ Can a local agricultural research centre or university who can advise on feedstock options and potentials be identified?

→ Is there sufficient feedstock available for the operation of a bioenergy plant?

Logistical

→ Is there already infrastructure existing and could be repurposed? – E.g. is there a suitable coal plant or suitable infrastructure to connect a biogas plant to the grid?

→ Is there a supplier readily available with appropriate technology?

→ Is there a purchaser?

→ Is the distribution of feedstock amenable to the project?

→ Is there a need for feedstock storage?

Practical steps towards realizing biomass opportunities in coal+ regions

The implementation of growing biomass on former coal mines as well as exploring bioenergy opportunities in coal power plants involves several key steps. It is important to note that the following aspects, steps and considerations may vary depending on the region's characteristics, resources and priorities. The following provides a general outline of the process:

1) To start a biomass project in your region, **collaboration** with research institutions, local organisations or local engineering companies may be helpful to get started. There are various options here, depending on the region. One option is to contact the local university, which is usually well connected with other (research) organisations in the area. Another possibility is to contact specific networks, for example Bioenergy EUROPE.

2) Supportive **political and legal frameworks** to ensure sustainable biomass cultivation and/or retrofitting of coal power plants form the basis and the implementation of projects must be in line with the regional political agenda. In addition, legal approvals must be obtained as well as compliance with environmental and sustainability standards must be ensured. This applies to EU-wide standards, such as those presented in the EU sustainability criteria for biomass, but also to local permits.

3) Assess the biomass resources and potential: Carry out an assessment of biomass resources available or that have potential in the region. Especially areas that are no longer suitable for the traditional cultivation of food or feed crops are of particular interest. Identify suitable areas for cultivation, based on the local context and assess the potential yield and sustainability of different biomass feedstocks. In addition, agricultural, forest or municipal waste and residues that occur in the region can also play a role.

4) Establish a **financing mechanism** to support farmers and in the biomass feedstock production. This includes affordable loans, grants, and subsidies - find out which support is available.

5) Develop appropriate and necessary **infrastructure** for bioenergy production, such as production facilities, processing plants, storage facilities and distribution networks. For this step, partnerships with private investors or public-private partnerships can be useful to ensure sufficient capital.

6) In addition to logistical infrastructure, **market infrastructure** must also be created. This includes facilitating the development of a market for bioenergy by creating demand through blending obligations, fiscal incentives, or government procurement programmes, encouraging partnerships with fuel traders, transport companies and other stakeholders to promote the use of bioenergy or biomass materials.

7) Farmer support and training: Provide training and technical assistance to farmers to help them adopt biomass cultivation techniques and the technical skills for serving a biomass instead of a coal power plant. This can for example include trainings in sustainable agricultural practices, crop management and efficient use of resources.

8) Monitoring and evaluation: Establish monitoring and evaluation mechanisms to assess the progress, impact and sustainability of biomass production and use. Regularly review and update policies and practices based on the results.

9) Cooperation: Participate in international cooperation and knowledge sharing to learn from the experiences of other regions and keep up to date on best practices.

Conclusion – Key messages

This toolkit provided useful tools and guidelines when investing in biomass on former coalfields or the retrofitting of coal power plants. Biomass can offer a sustainable and renewable solution for energy production and material use. Local biomass cultivation on degraded or abandoned coal mining land can be a sustainable way to restore land and to contribute to energy security after a coal phase-out. Successful implementation requires careful planning, resource assessment, stakeholder engagement as well as adherence to sustainability criteria and legal frameworks. With the right strategies, that are displayed in this toolkit, biomass can unfold its benefits and play a crucial role in supporting the transformation of coal+ regions towards a sustainable and economically successful future.

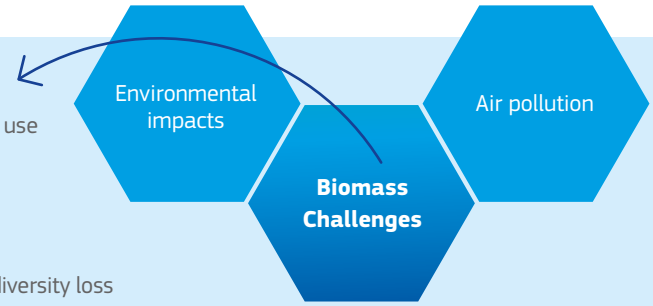
Sustainability criteria and targeted use

Biomass challenges

→ Air pollution: Combusting of biomass for energy use releases carbon emissions and other gases

→ Potential negative environmental impacts through direct and indirect land-use change

- Deforestation, Land degradation, Water pollution, Biodiversity loss



Biomass Benefits

→ Environmental: Use of degraded land from mining activities

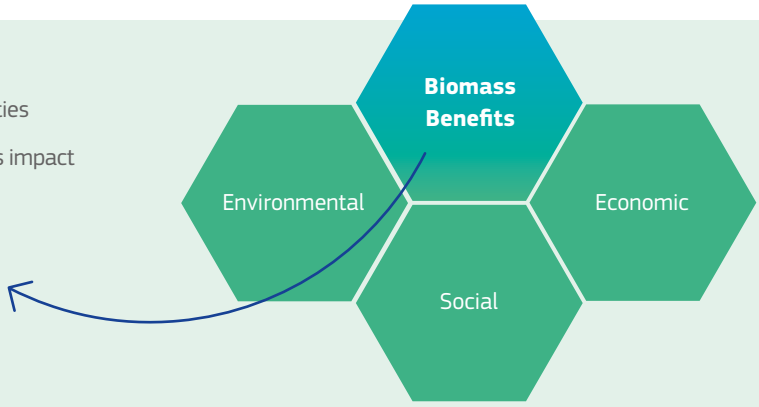
- Land restoration & ecosystem services, greenhouse gas impact

→ Social: Repurposing of former coal regions

- Job opportunities

→ Economic: Repurposing existing infrastructure

- Opportunities for local agriculture, energy security & local energy supply



List of useful sources for further information

- BIOFIT (2023): Digital Support tools
- BIOFIT (2023): Factsheet about Coal Conversion
- European Biomass Industry Association
- European Commission (2023): Funding possibilities in the energy sector
- Netherlands Enterprise Agency (2014): Tools for Sustainable Biobased Projects

Overarching references

- ECN, TBR Consulting, The Green House, SVN Netherlands Development Organization (2014): Biomass Waste-to-Energy Toolkit for Development Practitioners
- ENVIA (2023): Coal-to-Biomass Conversion
- European Commission (2023a): 2030 Target Plan
- European Commission (2023b): Biomass
- European Commission (2023c). Renewable Energy Directive. Available online: Renewable Energy Directive
- European Commission (2023d): Supporting policy with scientific evidence
- European Commission (2023e): A new fund in the Cohesion Policy family
- European Commission (2023f): Biofuels
- Gurunathan, B., & Sahadevan, R. (2022): Biofuels and Bioenergy: A Techno-Economic Approach
- International Energy Agency (2017): Biomass for Power Generation and CHP
- International Energy Agency (2023): An introduction to biogas and biomethane
- Merzić et al. (2022): Towards just transition of coal regions - Cultivation of short rotation copies and dedicated energy crops for biomass co-firing vs photo voltaic power plants
- Nunes et al. (2023): Coal to Biomass Transition as the Path to Sustainable Energy Production: A Hypothetical Case Scenario with the Conversion of Pego Power Plant (Portugal)
- Nunes et al. (2014): A review on torrefied biomass pellets as a sustainable alternative to coal in power generation
- Preshanthan (2021): Sustainable biofuels: opportunities and challenges.
- Process Barron (2016): Converting from Coal to Biomass: A Case Study
- Sánchez et al. (2019): Biomass Resources
- U.S. Office of ENERGY EFFICIENCY & RENEWABLE ENERGY (2023): Bioenergy Basics
- UK Department for Environment Food & Rural Affairs (2021): Section 2: Plant biomass: miscanthus, short rotation coppice and straw
- United States Department of Agriculture (2014): Estimating Cover Crop Biomass

This document is part of a series presenting information and lessons learned on policy approaches at national, regional or local level supporting a just transition to a climate-neutral economy. The Just Transition Platform (JTP) assists EU Member States and regions to unlock the support in this transition. Visit the JTP website.

Endnotes

1 Coal+ regions are defined by the extraction of solid fossil fuels – including lignite, hard coal, peat, and oil shale – and their subsequent use in energy production, while carbon-intensive regions rely heavily on the usage of (fossil-fuel based) energy to produce metals, chemicals, cement, or fertiliser.

2 European Commission (2023a)

3 European Commission (2023b)

4 European Commission (2023c)

5 European Commission (2023d)

6 Just transition describes the transition to a climate-neutral economy while addressing the social, economic and environmental consequences, making sure to leave no one behind.

7 European Commission (2023e)

8 See here for more information.

9 BIOFIT (2023).

10 European Commission (2023f)

Authors: Lena Knab (Guidehouse), Larissa Nöthel (Guidehouse), Shanon Peeters (Guidehouse)
Reviewers: Gemma Toop (Guidehouse), Emma Krause (Guidehouse), Sander Happaerts (European Commission)