Task 5.1.1:

Estimating the amount of energy in different polymers and determining which polymer embodies the least energy during its manufacture when a Young's modulus value of at least 0.8 GPa is required involves several considerations. First, we make the chart map at level 2, where all materails are polymers. Then we use the filter to limit the Young's modulus value of at least 0.8 GPa and at this position, we noticed Thermoplastic Starch (TPS) is the polymer which embodies the least energy during its manufacture.

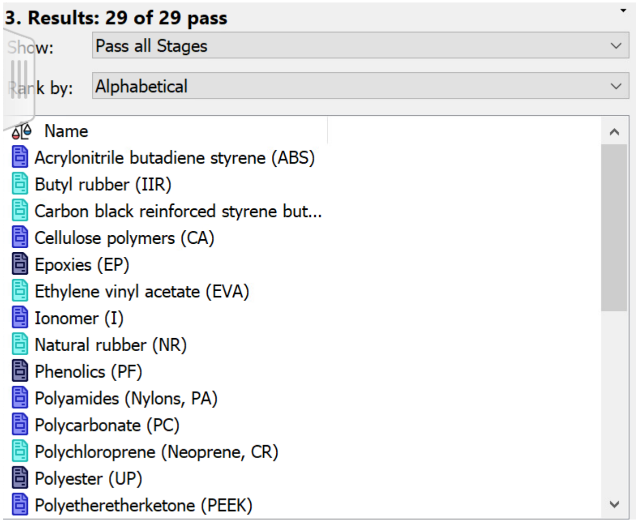


Figure 1. Amount of energy in different polymers (total 29)

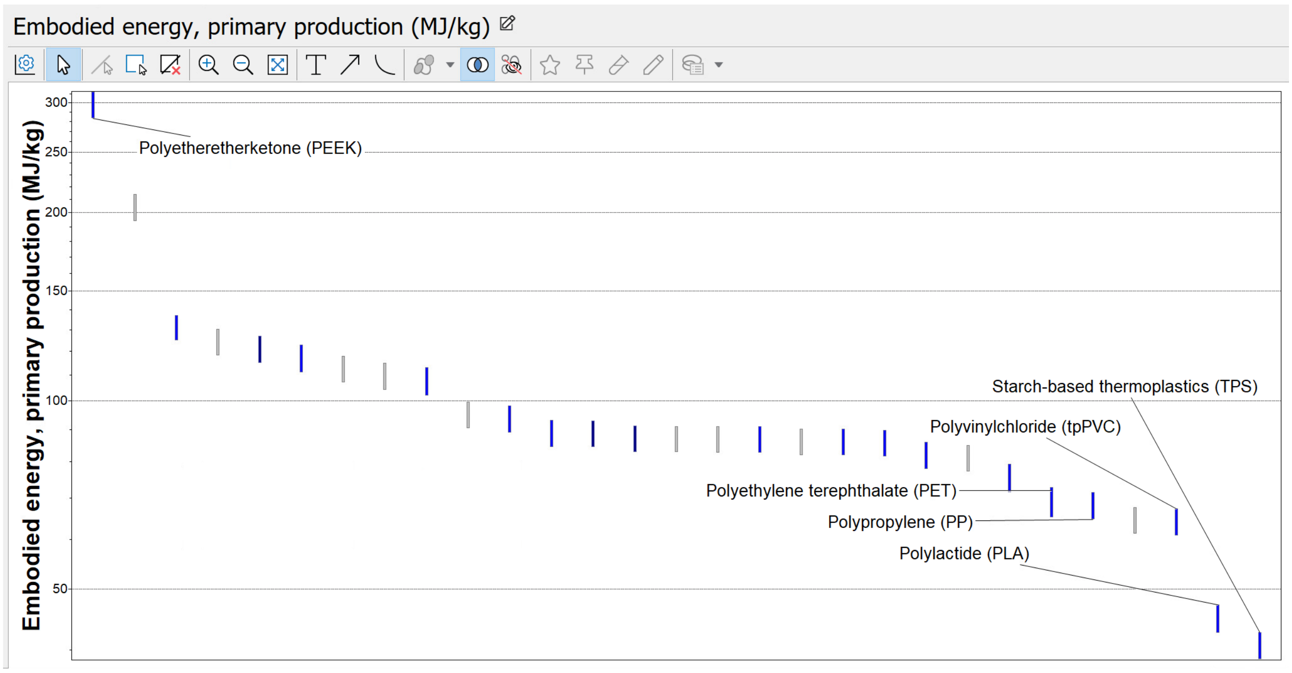


Figure 2. Polymer that has least embodies energy during its manufacture, TPS

Task 5.1.2:

First, we draw the map at level 2 and choose Yield strength and CO2 footprint * Density as references. As the textbook provides the function:

$$M_3 = \frac{\sigma_f^{2/3}}{H_p \rho}$$

We can use the slope value as 1,5 and draw the index line:

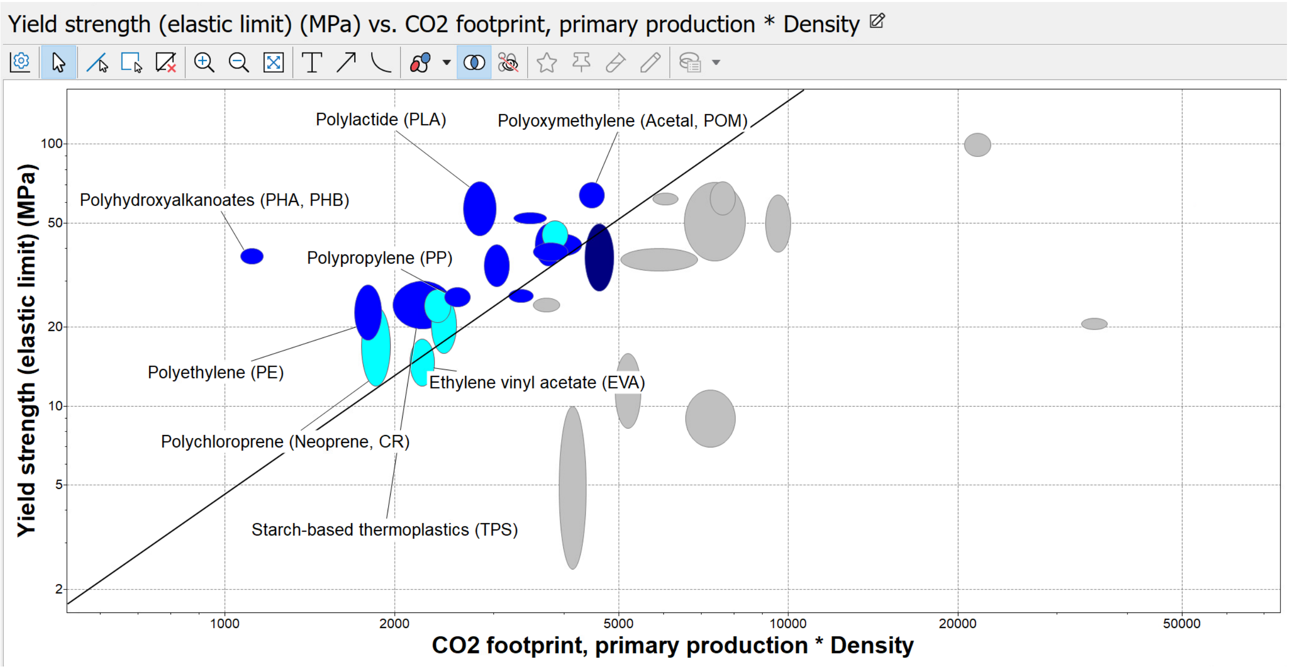


Figure 3. compare different materials regarding beam strength versus CO2 emissions.

We noticed that the Polyhydroxyalkanoates (PHA, PHB) are smallest carbon footprint possesses compared to strength, when there no other special conditions require.
Next, based on this map, we can set the limit that the materials must be recyclable, and we get this kind of results:

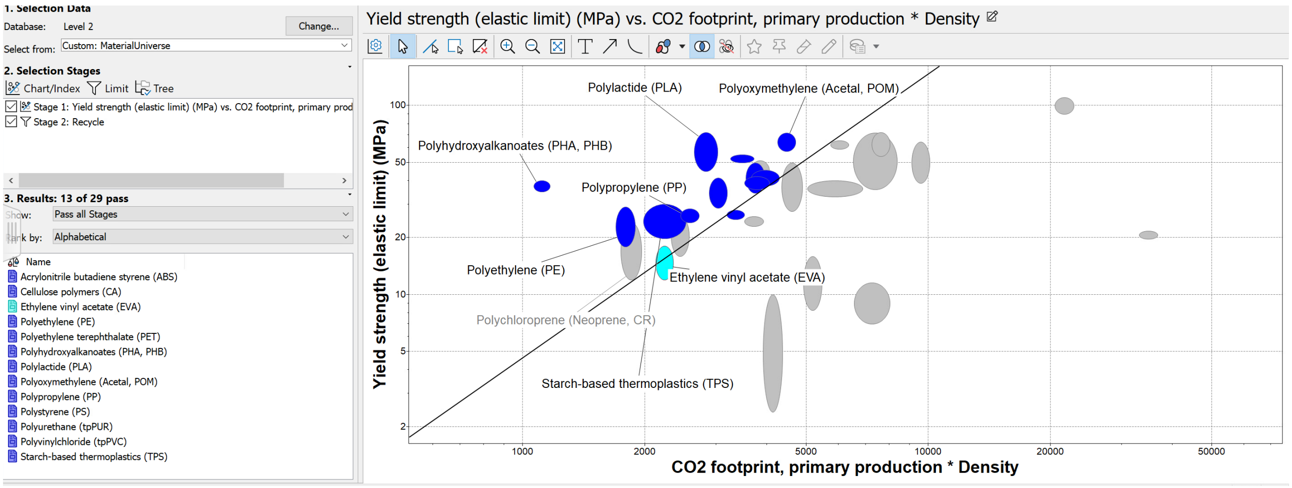


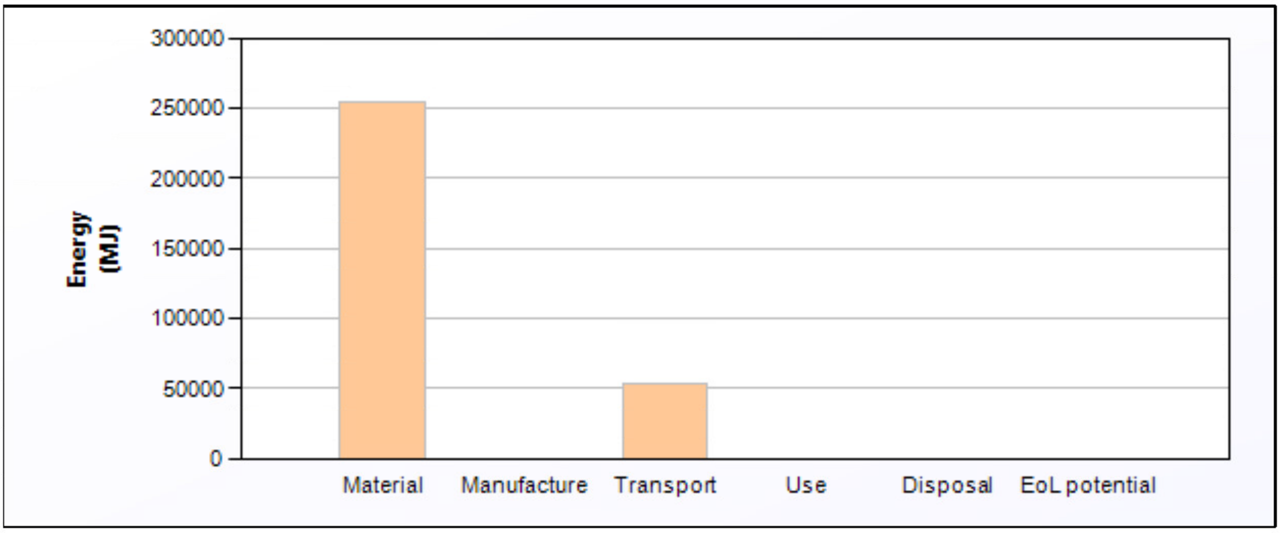
Figure 4. compare different materials regarding beam strength versus CO2 emissions, when the materials must be recyclable.

The Polyhydroxyalkanoates (PHA, PHB) are still smallest carbon footprint possesses compared to strength, even we set the materials must be recyclable. But we also can see that all Elastomers can’t fit the requirements, which means these are not available to recycle.

Task 5.1.3:

Energy Analysis

Summary



	Energy (MJ/year)
Equivalent annual environmental burden (averaged over 1 year product life):	3,09e+05

Material:

Summary

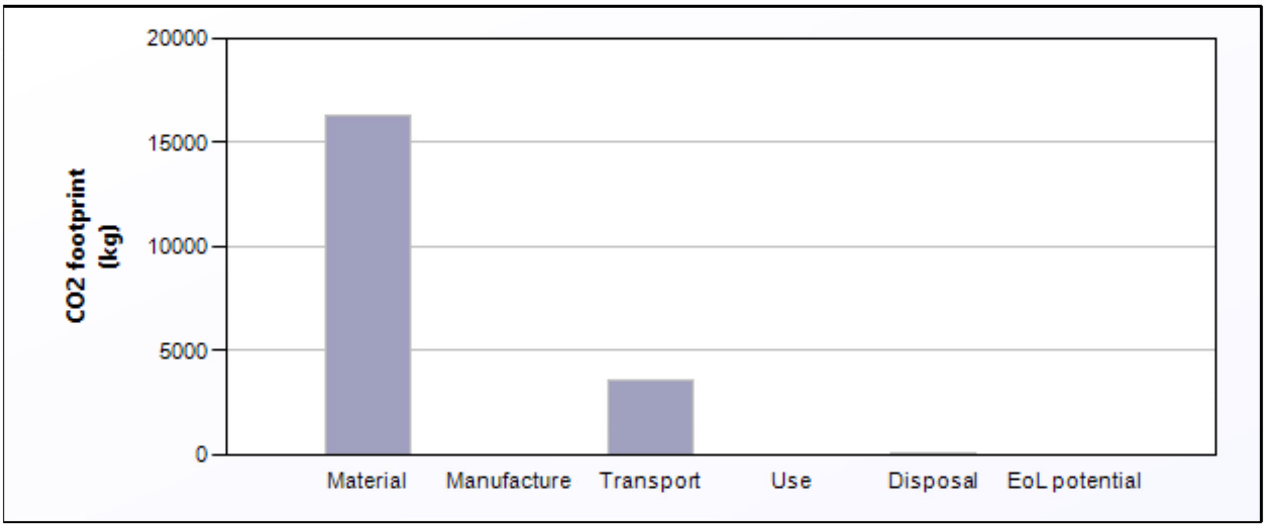
Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	Energy (MJ)	%
GRP	GFRP, epoxy matrix (isotropic)	Virgin (0%)	2,4e+03	1	2,4e+03	2,5e+05	100,0
Total				**1**	**2,4e+03**	**2,5e+05**	**100**

*Typical: Includes 'recycle fraction in current supply'

***User-defined material

CO2 Footprint Analysis

Summary



	CO2 (kg/year)
Equivalent annual environmental burden (averaged over 1 year product life):	2e+04

Detailed breakdown of individual life phases

Material:

Summary

Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	CO2 footprint (kg)	%
GRP	GFRP, epoxy matrix (isotropic)	Virgin (0%)	2,4e+03	1	2,4e+03	1,6e+04	100,0
Total				**1**	**2,4e+03**	**1,6e+04**	**100**

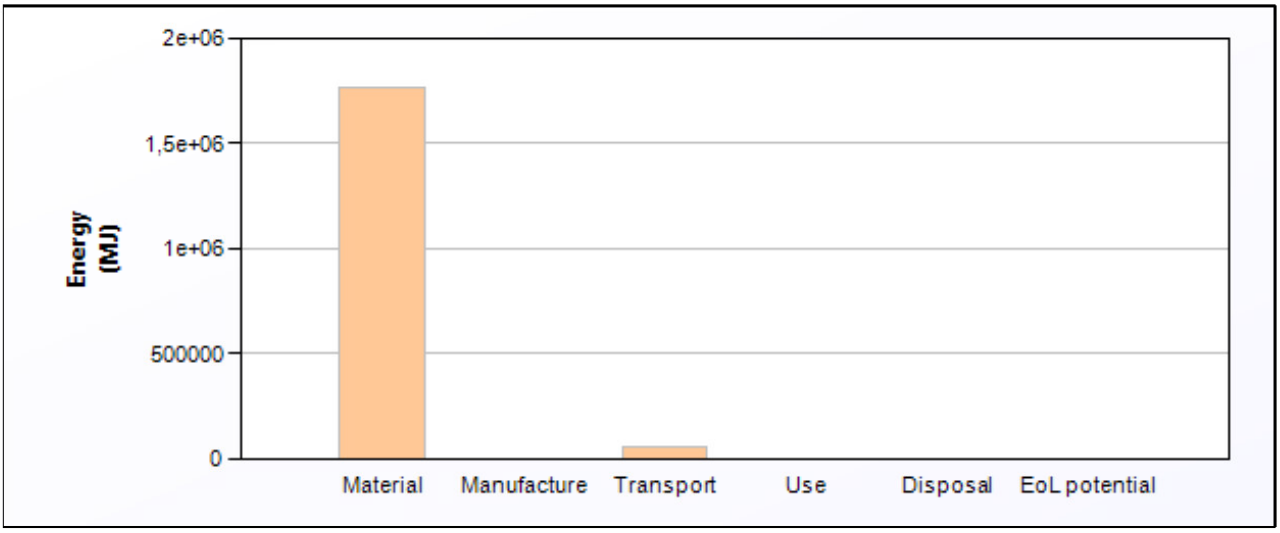
*Typical: Includes 'recycle fraction in current supply'

***User-defined material

Figure 5-8 energy consumption and CO_2 emissions of wind turbine blades that made from GRP.

Energy Analysis

Summary



	Energy (MJ/year)
Equivalent annual environmental burden (averaged over 1 year product life):	1,82e+06

Detailed breakdown of individual life phases

Material:

Summary

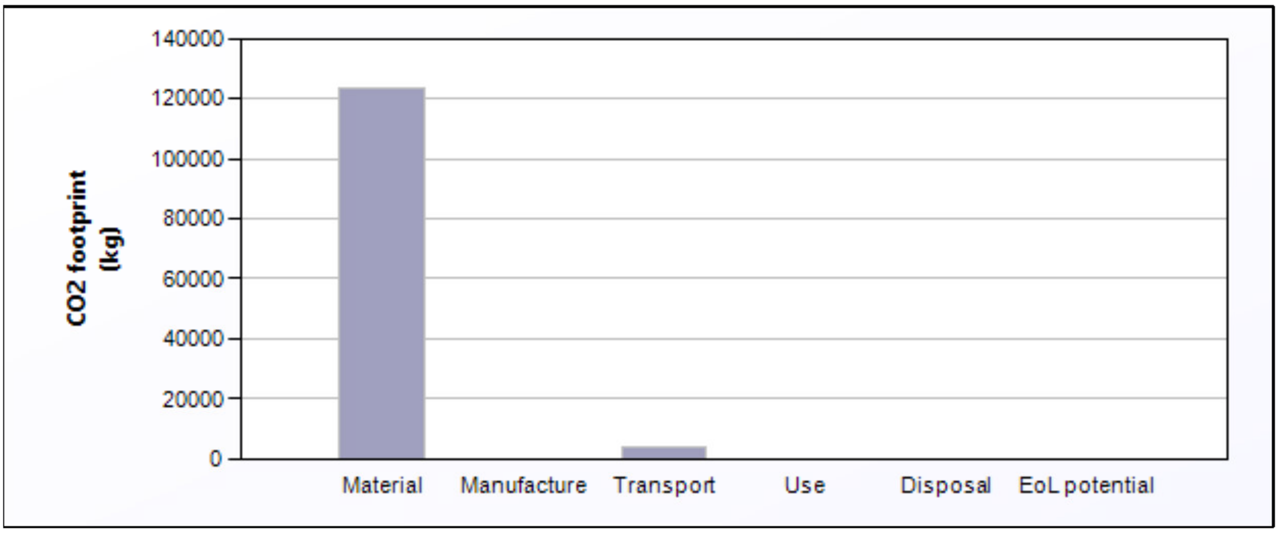
Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	Energy (MJ)	%
CFRP	CFRP, epoxy matrix (isotropic)	Virgin (0%)	2,4e+03	1	2,4e+03	1,8e+06	100,0
Total				**1**	**2,4e+03**	**1,8e+06**	**100**

*Typical: Includes 'recycle fraction in current supply'

***User-defined material

CO2 Footprint Analysis

Summary



	CO2 (kg/year)
Equivalent annual environmental burden (averaged over 1 year product life):	1,27e+05

Detailed breakdown of individual life phases

Material:

Summary

Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	CO2 footprint (kg)	%
CFRP	CFRP, epoxy matrix (isotropic)	Virgin (0%)	2,4e+03	1	2,4e+03	1,2e+05	100,0
Total				**1**	**2,4e+03**	**1,2e+05**	**100**

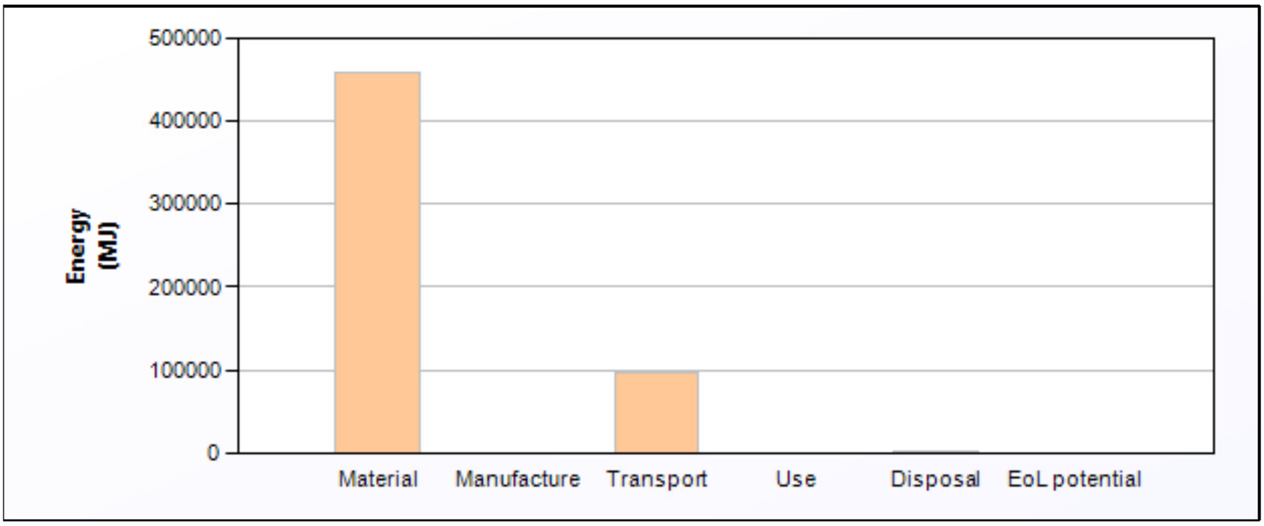
*Typical: Includes 'recycle fraction in current supply'

***User-defined material

Figure 9-12 energy consumption and CO_2 emissions of wind turbine blades that made from CFRP.

Energy Analysis

Summary



	Energy (MJ/year)
Equivalent annual environmental burden (averaged over 1 year product life):	5,57e+05

Detailed breakdown of individual life phases

Material:

Summary

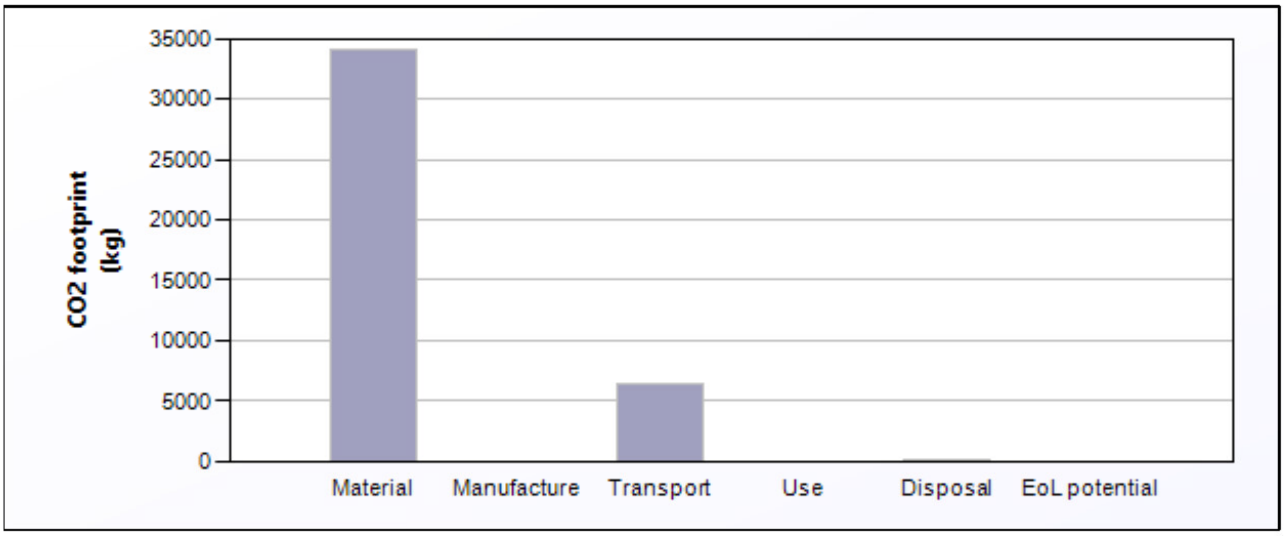
Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	Energy (MJ)	%
Al	Cast Al-alloys	Virgin (0%)	4,3e+03	1	4,3e+03	4,6e+05	100,0
Total				**1**	**4,3e+03**	**4,6e+05**	**100**

*Typical: Includes 'recycle fraction in current supply'

***User-defined material

CO2 Footprint Analysis

Summary



	CO2 (kg/year)
Equivalent annual environmental burden (averaged over 1 year product life):	4,06e+04

Detailed breakdown of individual life phases

Material:

Summary

Component	Material	Recycled content* (%)	Part mass (kg)	Qty.	Total mass (kg)	CO2 footprint (kg)	%
Al	Cast Al-alloys	Virgin (0%)	4,3e+03	1	4,3e+03	3,4e+04	100,0
Total				**1**	**4,3e+03**	**3,4e+04**	**100**

*Typical: Includes 'recycle fraction in current supply'

***User-defined material

Figure 13-16 energy consumption and CO2 emissions of wind turbine blades that made from Al.

Task 5.1.4:

Environmental Impact of GRP Wind Turbine Blade can be:
The production of GRP involves energy-intensive processes, including resin and fiberglass production. This results in carbon emissions and energy consumption. Also, GRP are durable and have a long service life. The end-of-life phase for GRP has a significant negative impact on their environmental profile due to the lack of recycling options.

Environmental Impact of Aluminum Wind Turbine Blade can be:
Aluminum production is energy-intensive and generates greenhouse gas emissions. Also, Aluminum is known for their longevity and durability, like GRP. Aluminum is highly recyclable. Recycling aluminum at the end of their life cycle significantly reduces their environmental impact. The energy saved by recycling offsets the initial energy-intensive production.

The situation changes significantly when using aluminum that are recycled at the end of their life cycle. The key differences are Aluminum can be easily and efficiently recycled, resulting in lower energy consumption and greenhouse gas emissions compared to producing new aluminum. This greatly reduces the end-of-life environmental impact. Also, Aluminum avoids the waste issue associated with GRP, which can have detrimental environmental effects. Choosing aluminum for wind turbines and recycling them at the end of their life cycle is a more environmentally sustainable option than using GRP. The lack of recycling options for GRP blades and their disposal in landfills or incineration contribute significantly to their negative environmental impact.

Task 5.2.2:

Process Type	Process	Steel	Aluminum	Plastic
Joining Processes	Welding	Suitable	Suitable	Less Suitable
	Adhesive Bonding	Less Suitable	Suitable	Suitable
	Mechanical Fastening	Suitable	Suitable	Suitable
Shaping Processes	Machining	Suitable	Suitable	Less Suitable
	Injection Molding	Less Suitable	Suitable	Less Suitable
	Sheet Metal Stamping	Suitable	Suitable	Less Suitable
Surface Treatment	Painting	Suitable	Suitable	Suitable
	Anodizing	Less Suitable	Suitable	Less Suitable
	Electroplating	Suitable	Suitable	Less Suitable

Task 5.2.3:

Composite materials are engineered materials that are made by combining two or more different constituent materials to achieve specific performance characteristics that are superior to those of the individual materials alone. These composites are widely used in various industries, including aerospace, automotive, construction, and sports equipment. The process of making composites typically involves several key steps:

1. Material Selection:
The first step in making composites is selecting the constituent materials. Typically, one material is chosen as the matrix, which is a continuous phase, and the other is the reinforcement, which is dispersed within the matrix. Common matrix materials include polymers, metals, or ceramics, while reinforcement materials can be fibers, particles, or other structures.

2. Fabrication Methods:
Composite materials can be fabricated using various methods, such as Lamination, Casting, Injection Molding, Powder Metallurgy and Filament Winding:

3. Curing or Solidification:
Once the matrix material is combined with the reinforcement, it must be cured or solidified. This can involve heat, pressure, or chemical reactions, depending on the specific composite and matrix material used.

4. Post-processing:
After the composite material has solidified, it may undergo additional processes such as machining, polishing, or coating to meet specific dimensional and surface finish requirements.

5. Quality Control:
Throughout the manufacturing process, quality control measures are critical to ensuring that the composite meets the desired specifications and performance standards.

Composite materials offer a wide range of advantages, including high strength-to-weight ratios, corrosion resistance, and tailored mechanical properties. The choice of constituent materials, fabrication methods, and curing processes depends on the specific application and performance requirements of the composite product. These factors make composites a versatile and valuable class of materials in modern engineering and manufacturing.