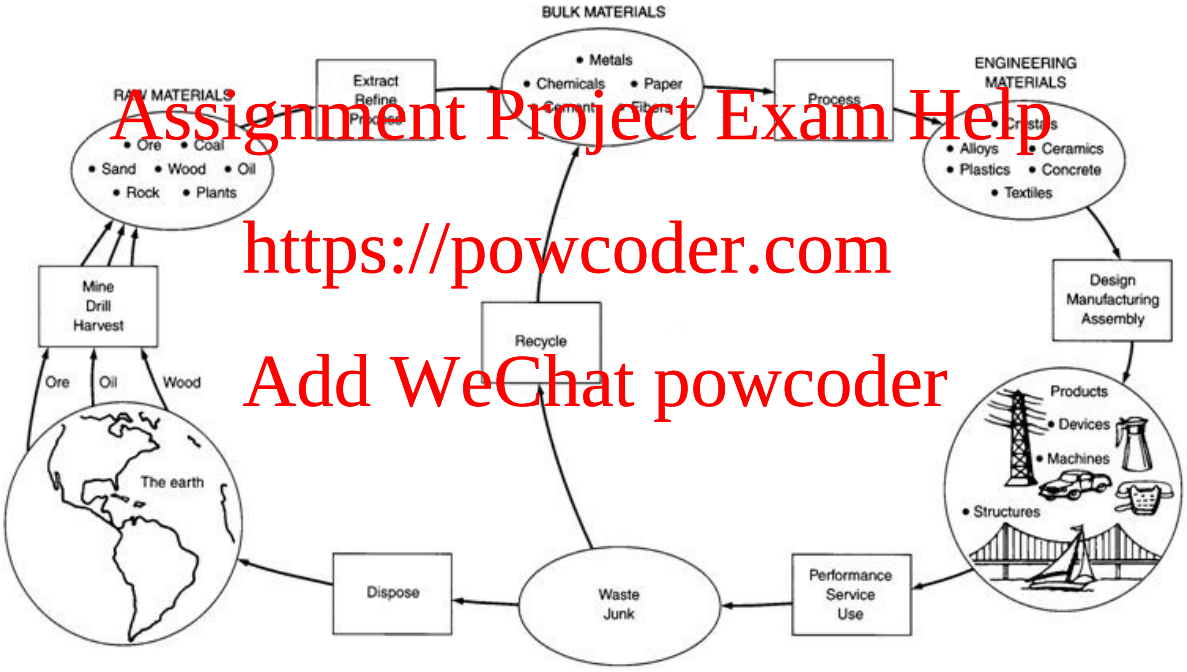
Workshop R1: Classification of Materials

LEARNING OUTCOMES

- Explore the various ways in which material can be classified into Natural Resources, Raw Materials, and Bulk/Engineering Materials
- Identify the processes required to produce an end product
- Identify the impacts from a life cycle analysis, for producing ethylene from a natural resource, and translate them into material/energy costs of the process

INTRODUCTION

Everything we use in daily life may be considered to be an End Product, which is designed, manufactured or assembled from Engineering Materials, or even directly from Bulk Materials in some cases.



Natural Resources often need to be mined, drilled or harvested before they form the Raw Materials, which often need different levels of extraction, refining or processing to form Bulk or Basic Materials, from which most of the world's products are made.

ACTIVITIES

Each group will be given one End Product, which they will work with through the session.

Activity 1: Identifying the Materials that form the End Product (30 minutes)

Working as a group, list 3-5 separate *bulk/engineering materials* used to make up different identifiable parts of your End Product. The Figure on page 1 may help you to differentiate between materials as *resources*, *raw materials*, *bulk/engineering materials* and *product*. Do some research on the internet if you are not sure of how these products are made.

For each material identified, identify the *raw material*, and *resource*, used to produce it.

For example, an umbrella (see table below) is made up of different materials.

End Product: earphone

	Example (umbrella)	1	2	3	4	5
Part of Product	handle	speakers	earbuds	Wire covering	wire/cable	casing
Identified Material	wood	Magnets	silicon	rubber	metal	plastic
Raw Material	chopped wood	Iron ore	silica	latex	Copper ore	Oil/natural gas
Natural Resource	trees	Ore reverses	Silica stone	Rubber trees	Mines/rock	Crude oil/natural gas

Each group will be selected to present their summary to the class.

Activity 2: Identifying Key Processes (15 minutes)

Australia is currently the highest producer of lithium precursor in the world[1]. The production of battery-grade lithium is crucial to the value chain of electric batteries (EV), electronics and energy storage technology[2,4]. The flow diagrams below show how battery grade lithium carbonate (Li_2CO_3) is produced from ore containing lithium minerals.

Figure 1 shows a generic block diagram, to depict a series of processes that convert a Raw Material to a Bulk Material.

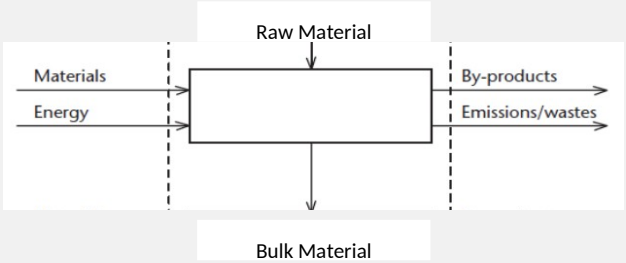


Figure 1: block diagram for conversion of Raw Material to Bulk Material.

Figure 2 shows a schematic diagram to produce Bulk Material (battery-grade Li_2CO_3) used to make the *final end product*, the lithium-containing cathode.

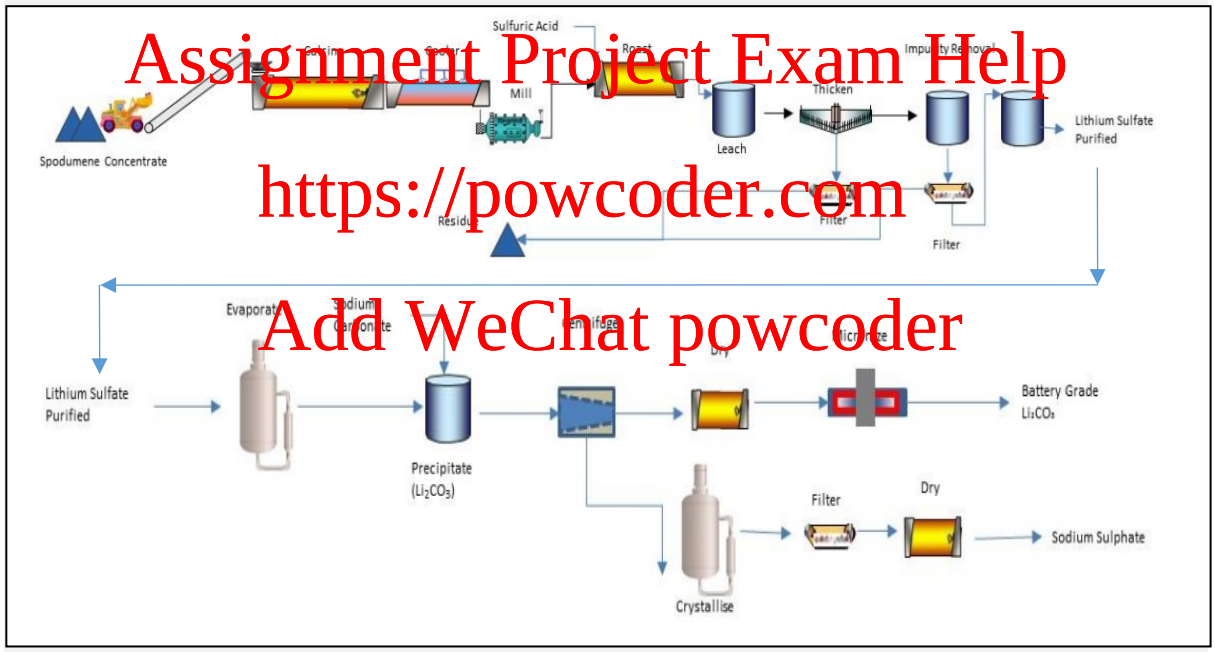
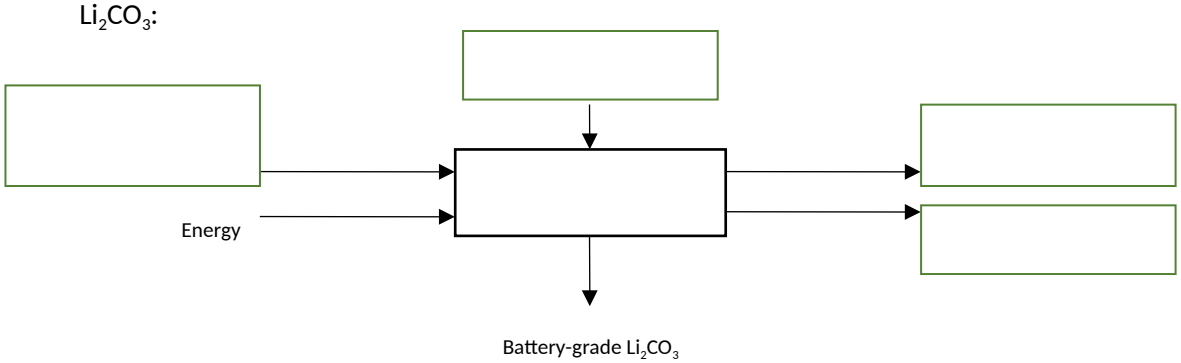


Figure 2: A conventional process route[3] for the production of battery-grade lithium carbonate (Li_2CO_3).

a) Fill in the following textboxes, using Figures 1 and 2 above, for Bulk Material battery-grade Li_2CO_3:



Roaster,Calciner,Dryer,Miller,Evaporator

b) Referring to Figure 2 above, list the 5 most energy intensive processes:

[1]https://www.visualcapitalist.com/charted-lithium-production-by-country-1995-2020/
[2]https://www.ga.gov.au/scientific-topics/minerals/mineral-resources-and-advice/australian-resource-reviews/lithium
[3] Extracted from: https://www.asx.com.au/asxpdf/20170830/pdf/43lw4l1drpkmh8.pdf
[4]https://www.nanoone.ca/technology/cathodes-infographic/

Activity 3: Which Process is "Better"? (40 minutes)

Ethylene is a bulk chemical produced on very large scales globally, as it is the starting chemical to produce many plastics. The Figure below shows alternative routes to produce ethylene from biomass. Using the data in the paper, and Lecture R1, answer the following questions:

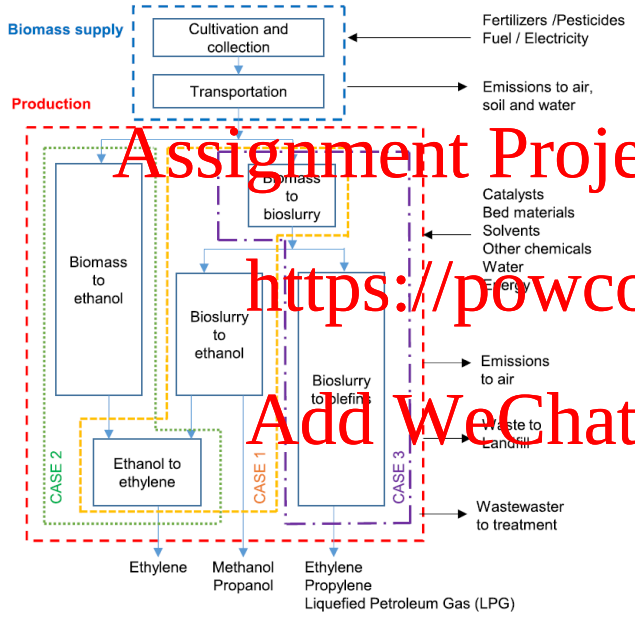


Figure: Systems boundaries considered for 3 thermo-chemical routes to produce ethylene from the same biomass supply. Case 1: direct ethanol dehydration; Case 2: indirect ethanol dehydration; and Case 3: dimethyl ether to ethylene.
https://doi.org/10.1016/j.jclepro.2018.08.147

(a) What are the different routes for producing ethylene that are considered in this paper?

Route	Cases 1,2,3	Bio-chemical ethylene	Fossil-fuel based ethylene
Feedstock	biomass	sugarbeet	Fossil fuel(crude oil,natural gas)

(b) Which case is the least energy intensive, in MWh (Table 2)? Show your full working, taking energy units of 1 Nm^3 = 10.655 kWh.

Case1: 1.7Mkh+10.655kwh*84=2.59502Mkh=2.595Mkh

Case2: 0.39Mkh+10.655kwh*84=1.285Mkh

Case3: 2.120Mkh

The case 2 is the least energy intensive

*Nm^3 = normal meter cubed, refers to the volume of a gas measured under Normal conditions (not Standard conditions)

Identify within your group what 11 environmental imapct indicators are used to assess each thermo-chemial route. *Hint: see section 2.4 in the paper.*

Ethylene has historically been produced using fossil fuels (via steam cracking of hydrocarbons), and also sugar beet (via bio-ethanol). To decide which route is best for producing ethylene, the relative environmental impacts of each route must be considered.

(c) Fill in the Table below, by placing a "Y" when ethylene produced via Cases 1,2 or 3, ***is better than*** bio-ethylene from sugar beets, and ethylene from fossil fuels (*sections 3.3 and 3.4*).

Route better than bio-ethylene	**ADP_e**	**ADP_f**	**GWP**	**ODP**	**HTP**	**FAETP**	**MAETP**	**TETP**	**POCP**	**AP**	**EP**
Case 1		Y	Y		Y	Y	Y	Y	Y		
Case 2		Y	Y		Y	Y		Y			
Case 3		Y		Y	Y	Y	Y	Y	Y		

Y

Route better than fossil fuel	**ADP_e**	**ADP_f**	**GWP**	**ODP**	**HTP**	**FAETP**	**MAETP**	**TETP**	**POCP**	**AP**	**EP**
Case 1	Y			Y	Y	Y	Y	Y	Y		Y
Case 2	Y			Y	Y	Y	Y	Y			Y
Case 3	Y				Y	Y	Y	Y	Y	Y	Y

(d) Discussing the *significance* of the impacts in the Tables above, make a decision about whether ethylene should be produced from fossil fuels, from sugar beets, or from biomass via thermo-chemical route (Cases 1 or 2 or 3). Justify your answer by identify the largest materal/energy consumption/production that should be reduced in your chosen route.

Case 2 is a more effective method of using biomass when compared to using sugar beets and biomass. However, as compared to the biomass via thermo-chemical pathway, the fossil fuel route appears to be the superior choice. The fossil fuel method thus appears to be preferable to the other routes, provided that all consequences are equal.
Fossil fuel, however, is a non-renewable resource, therefore using it would not be sustainable. Therefore, among all Cases, Biomass via the thermochemical route's Case 2 would be more appropriate in terms of sustainability.
Case 2 has the lowest values in 8 out of 11 impact indicators when compared with using sugar beets,