

Fuel for Flight: Which Biomass Should Become Jet Fuel?

Investigation question: A regional airline wants 30 million litres of jet fuel a year to come from biomass within five years. Which of five sources of biomass should it choose, judged by a systematic process against stated criteria and constraints?

Data-driven decision

Groups of 4

1 session

Setup 5 · Activity 40 · Cleanup 5 min

MS-ETS1-2 · assesses

MS-ETS1-1 · practice

MS-LS1-6 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Facilitator:** Reads the brief aloud, keeps the group on the step order (define, screen, score, test, recommend), and makes sure every weight is agreed before scoring begins.
- ☐ **Data checker:** Reads values from the dataset to the calculator, checks every number copied onto the sheet, and flags any candidate whose data break a constraint.
- ☐ **Calculator:** Computes fuel per year and feedstock cost per litre for each candidate, fills the matrix totals, and reruns the totals for the sensitivity test.
- ☐ **Reporter:** Writes the group's criteria and constraints, drafts the recommendation and trade-off, and presents the decision to another group.

Safety

- No physical hazards; this is a paper-and-calculator investigation.
- If students look up real sustainable-aviation-fuel figures to compare, have them record the source and date; real values change yearly and differ from the teaching dataset by design.

Procedure

1. Define: read the brief. The airline needs 30 million litres of jet fuel a year from biomass within five years. Its requirement list says: as much fuel per tonne of feedstock as possible; feedstock cost under \$0.40 per litre of fuel; the source must regrow within 5 years; it must not take food or farmland from food; it must be able to supply at least the 30 million litres; and it should cause as little other harm as possible. Write each requirement on a sticky note and sort it as a criterion (a goal to do as well as possible) or a constraint (a line that cannot be crossed). Record the sort and how each one will be measured.
2. Compute: for each of the five candidates, calculate the fuel it could supply per year (litres per tonne × tonnes available per year) and its feedstock cost per litre of fuel (dollars per tonne ÷ litres per tonne). Record both in the calculation table.
3. Screen: for each candidate, check every constraint and write pass or fail with the number that decides it. A candidate that fails any constraint is out, no matter how well it scores elsewhere. Highlight the

survivors.

4. Weight: as a group, give each criterion a weight of 1, 2 or 3 (3 = matters most). Write a one-line reason for each weight. Do this before scoring any candidate.
5. Score: for each survivor, score each criterion from 1 (worst of the survivors) to 4 (best), using the data. Multiply each score by its weight and add the weighted scores to get a total. Record the matrix.
6. Test: change one weight (for example, raise 'fuel per tonne' from 1 to 3) and recompute the totals. Record whether the winner changed. This is a sensitivity test: a decision that flips with a small change in weights is a close call and should be reported as one.
7. Recommend: write the group's recommendation in three sentences: the choice, the strongest reason from the data, and the main weakness or trade-off the airline should plan for.
8. Compare: present your decision and your weights to another group. If they chose differently, find the weight or score that explains the difference and record it.
9. Answer the analysis questions individually.

Record your observations

Lab 3 recording sheet: Fuel for flight

Work in the order Define, Screen, Score, Test, Recommend. Do not look at the totals until the weights are agreed. Every number you write must come from the dataset or from a calculation you show.

Define: the airline's requirements

Requirement from the brief	Criterion or constraint?	How we will measure it (number and unit)
As much fuel per tonne of feedstock as possible		
Feedstock cost under \$0.40 per litre of fuel		
Source regrows within 5 years		
Does not take food or farmland from food		
Can supply at least 30 million litres per year		
As little other harm as possible		

Candidate biomass sources (teaching dataset: rounded, invented values chosen to show the trade-offs; not real market data)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Candidate	Litres of jet fuel per tonne of feedstock	Feedstock available within 200 km (tonnes per year)	Feedstock cost (\$ per tonne)	Years for the source to regrow	Takes food or farmland from food?	Other impacts
City yard and food waste	120	400000	20	0 (continuous supply)	No	Mixed and messy; needs sorting; otherwise goes to landfill
Used cooking oil	900	20000	600	0 (continuous supply)	No	Small supply already wanted by other buyers
Corn grain	400	300000	200	1	Yes	Fertilizer and irrigation water; raises food prices
Fast-growing grass on marginal land	250	150000	80	1	No, if kept off farmland	Needs land and water; some habitat lost; harvest is seasonal
Forest timber (pine)	230	500000	60	30 to 40	No	Forest habitat lost; soil erosion after cutting

All five finished fuels have about the same energy per litre (roughly 35 MJ) and release about the same carbon dioxide per litre when burned, because they are refined into nearly the same hydrocarbons. The differences are in the source.

Compute: two numbers for each candidate

Candidate	Fuel per year (litres per tonne × tonnes per year)	Enough for 30,000,000 L? (yes/no)	Feedstock cost per litre (\$ per tonne ÷ litres per tonne)
City yard and food waste			
Used cooking oil			
Corn grain			
Fast-growing grass			
Forest timber			

Screen: pass or fail on each constraint

Candidate	Cost under \$0.40/L?	Regrows within 5 years?	No food competition?	Supplies 30 million L?	Survivor?
City yard and food waste					
Used cooking oil					
Corn grain					
Fast-growing grass					
Forest timber					

Score: weighted decision matrix for the survivors (score 1 to 4, times weight)

Criterion	Weight (1-3) and reason	Survivor 1: score × weight	Survivor 2: score × weight	Survivor 3 (if any): score × weight
Fuel per tonne of feedstock				
Lowest cost per litre				
Supply margin above 30 million L				
Least other harm				
Reliability of supply through the year				
TOTAL				

Test: change one weight and recompute

Weight changed (criterion, old → new)	New total, survivor 1	New total, survivor 2	Did the winner change?

1. Show the calculation of fuel per year for the fast-growing grass and for the used cooking oil. Which one could supply the airline's 30 million litres on its own?

2. Show the calculation of feedstock cost per litre for corn grain and for city waste. Which passes the \$0.40 constraint?

Analysis questions

3. List each candidate that failed the screen and the single constraint (with its number) that removed it. Why is it fair to remove forest timber even though it could make the second-largest amount of fuel per year and has the largest supply?

4. State your group's recommendation, the strongest piece of data behind it, and the main trade-off the airline should plan for.

5. In your sensitivity test, did changing one weight change the winner? What does that tell the airline about how confident it should be in the decision?

6. Every candidate on the list is biomass. Trace the energy in a litre of grass-based jet fuel back to its original source, naming each step.

7. A classmate says, 'Biofuel is carbon-free, so the airline can stop worrying about carbon dioxide.' Use the dataset note and what you know about photosynthesis to correct the claim.

8. A sixth candidate is proposed: algae grown in open ponds on desert land. Name the three numbers from the dataset columns you would need before you could screen and score it, and predict which constraint it is most likely to fail.
