

Hydrogen Use





Hydrogen Use – Teacher Resource

Powering Careers in Energy Link:

Unit 2: Outline the forms and sources of energy

Unit 2: Demonstrate an understanding of the importance of science in LNG operations

Background Information:

Most hydrogen is produced from natural gas and used in the manufacture of industrial chemicals such as ammonia. However, the use of hydrogen as an energy carrier is becoming more important and is expected to increase in the future.

When hydrogen is burned or used in a fuel cell, the emission is water. Hydrogen also carries approximately four times more energy per kilogram than petrol. Hydrogen-fuelled cars are available from Toyota (Mirai) and Hyundai (Nexo).

There are many infrastructure challenges to implementing hydrogen power. Metal becomes brittle in the presence of hydrogen, potentially damaging gas lines. Hydrogen is also highly flammable and ignites much more easily than petrol (1/10 ignition energy).

Aim

To design a hydrogen energy implementation plan for your local community, balancing infrastructure costs and benefits.

Materials

Per student

- Hydrogen Use Options table

Method

1. Fill in the infrastructure and population information for your area.

Teachers may wish to provide this to the class. The diagram of average solar radiation will help you to determine the score for solar potential. Using a larger area will lower costs (eg metropolitan Perth versus East Perth)

2. Work in a small group to choose appropriate ways to implement hydrogen power in your area.

Students may choose to add natural gas infrastructure to make more use of hydrogen, but this is only cost effective for a large population.

3. Calculate the benefits and infrastructure costs.

Results

Students should develop an overall score for their plan.

Discussion

1. How does the choice of local area (neighbourhood versus city) affect the calculations?

When infrastructure cost is shared among more people, it becomes relatively cheaper. This lowers the overall cost.

2. Some hydrogen uses may not be reasonable in your local area. Explain why you rejected some of the use options.

Areas without natural gas infrastructure cannot implement a hydrogen mix gas strategy. The high cost of hydrogen fuel cell heaters makes these too expensive in all but the coldest climates. Areas with a small population will struggle to make a hydrogen transition unless they have abundant renewable energy available.

Evaluation:

1. As renewable energy infrastructure is built, the cost of 'green' hydrogen for electricity generation will decrease (hydrogen generated through electrolysis of water, powered by renewable energy sources). How might this change the costs and benefits for your community?

As the cost of green hydrogen decreases, it will become a more cost-effective way to generate electricity. This will be a greater benefit in areas with high amounts of solar radiation for our model, but wind power could also be used to create hydrogen by electrolysis.

Extension:

- Carry out the exercise for your local area and a larger area or another location. Compare the results.
- Research the hydrogen airships of the 1920s and 1930s, along with the Hindenburg disaster that ended the airship era.

References:

Dawood F, Anda M, Shafiullah GM (2020). Hydrogen production for energy: An overview. *International Journal of Hydrogen Energy* 45(7): 3847-3869. <https://doi.org/10.1016/j.ijhydene.2019.12.059>



Worksheet: Hydrogen Use

Aim

To design a hydrogen energy implementation plan for your local community, balancing infrastructure costs and benefits.

Materials

Per student

- Hydrogen Use Options table

Method

1. Fill in the infrastructure and population information for your area.
2. Work in a small group to choose appropriate ways to implement hydrogen power in your area. Circle these on the hydrogen use options table.
3. Calculate the benefit points and infrastructure cost points.

Local Area Characteristics

Population _____

Natural gas available to houses _____

Solar points (see map) _____

Natural gas available to businesses _____



Discussion

1. How does the choice of local area (neighbourhood versus city) affect the calculations?

2. Some hydrogen uses may not be reasonable in your local area. Explain why you rejected some of the use options.

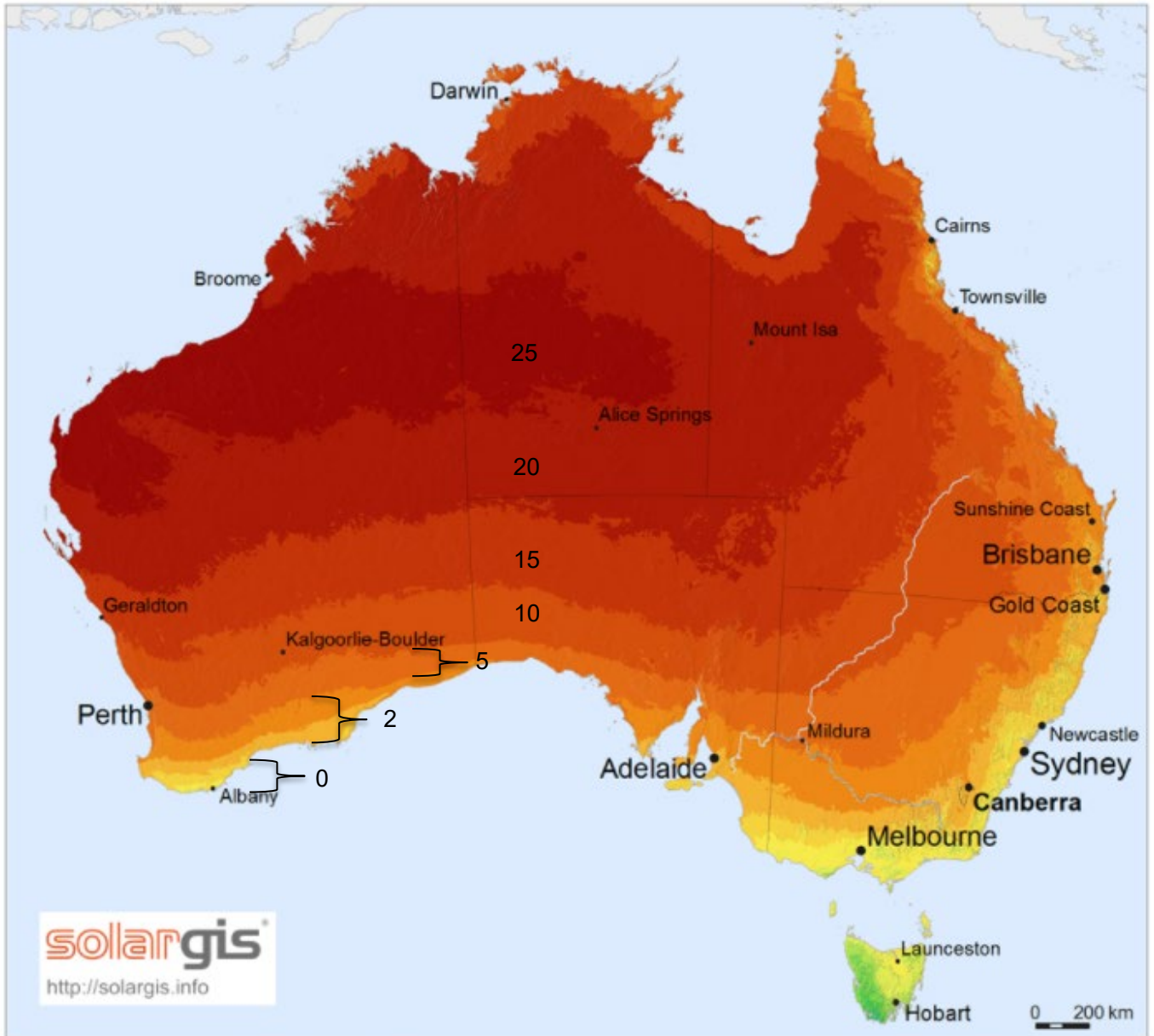
Evaluation

1. As renewable energy infrastructure is built, the cost of 'green' hydrogen for electricity generation will decrease (hydrogen generated through electrolysis of water, powered by renewable energy sources). How might this change the costs and benefits for your community?

Hydrogen Use Options

Use	Benefits	Benefit points	Infrastructure needed	Infrastructure cost points
Transport (cars)	Long travel range, quick refuelling (Water is only emission)	10	Hydrogen refuelling stations	1 000 000 / population
Home heating and cooking – WITH existing natural gas service	Mix 20% hydrogen + natural gas (Reduces CO ₂ emissions)	2	None	0
	100% hydrogen (No CO ₂ emissions)	5	New heaters and cooktops	1 000 000 / population
Business use – WITH existing natural gas service	Mix 20% hydrogen + natural gas (Reduces CO ₂ emissions)	2	None	0
	100% hydrogen (No CO ₂ emissions)	5	New boilers, heaters and stoves needed	1 000 000 / population
Electricity generation (grid)	Hydrogen stores energy from intermittent renewable sources to generate electricity when needed; (Water is only emission)	30 + solar points	Hydrogen electrolysis plant and fuel cell generators	3 000 000 / population
Option				
Add natural gas/ hydrogen pipe infrastructure to community	Allows home heating, cooking and business use with hydrogen and natural gas	0	Pipelines and supply stations	3 000 000 / population
TOTAL BENEFIT			TOTAL COST	

Average solar radiation in Australia with solar points added (from: <https://www.hotspotenergy.com/DC-air-conditioner/australia-solar-map.php> accessed 16/08/2021)



Average annual sum, period 2007-2012
 < 1100 1300 1500 1700 1900 2100 2300 > kWh/m²

SolarGIS © 2013 GeoModel Solar