Renewable Energy - Solar Farms

A solar farm is a large-scale installation that generates electricity from sunlight. There are two main types of solar farms.

Photovoltaic (PV) Solar farms use large arrays of solar panels to generate electricity directly through the photovoltaic effect. This energy is then sent to the power grid, or can be stored in batteries until it is needed.

Click here to learn how PV panels generate electricity.

The Kidston Solar Project (KS1):

- has 540,000 solar panels
- powers up to 26,000 homes
- generates up to 145GWh/yr
- offsets 120,000 tonnes of CO2/yr
- has a 30yr lifespan
- cost $115M
- is situated in the highest radiation zone in Australia.

Concentrated Solar Thermal Power (CST or CSP) Farms use mirrors or lenses to concentrate sunlight on a receiver, creating high temperatures. This heat is captured using a fluid (such as oil, or molten sodium), which is then used to heat water, create steam, and power a turbine. CST is used widely in Spain, but is a newer technology for Australia. Compared to PV Solar, it has a higher set up cost, however it can store the energy as heat, without the need for batteries with very little energy loss. This technology has been proto-typed in **Goodna, Queensland**.

These two types of solar farms can work together, with the PV Farms providing energy during daylight hours, and the CST farms collecting heat energy during the day, and converting it to electricity at night.

If you want to learn more about solar energy check out the '**Discover Solar**' course from the Clean Energy Council.

Solar - Case Studies

Helping build solar farms has taken Jamie Lyon across the country.

His work as a **quality assurance and quality control engineer** has seen him involved in projects from Wyalong in New South Wales to Kingaroy and Munna Creek in Queensland. Read more here.

A blue sea of solar panels sits atop a Mackay Isaac Whitsunday landscape, close to Collinsville. It's here that 830 sheep can be found, grazing happily between the rows of panels.

This is **Hamilton Solar Farm** where partners Edify and Gentari are working with the landowner to find **sustainable collaborations between agriculture and renewable energy**. Read more here.

Melinee Leather and her family have become champions of sustainable agriculture, running 5,000 head of cattle while nurturing the health of the land and climate.

As well as enhancing their soil carbon storage they use **agrivoltaics** - placing solar panels on their farmland to ensure renewable energy developments can coexist with agriculture. Read more here.

COOL .ORG

Renewable Energy - Small-scale Solar

Small-scale solar is often called rooftop solar, and is installed at the point of demand - where people live and work. This has the added benefit of not needing to transfer electricity over long distances. There are three types of small scale systems:

Grid-connected solar	Grid-connected with battery back-up	Stand-alone solar system
Electricity is made by solar panels and either used by the household, or transferred to the grid. When the panels are not generating enough electricity it is drawn from the grid.	In this system, excess electricity is first put into a battery, before being put into the grid. When insufficient electricity is being generated the battery is used first, before drawing from the grid.	Stand-alone systems are not connected to the grid and require batteries or a generator (usually petrol or diesel) to provide electricity at night.

Click here to learn how the Feed-in Tariff (FiT)scheme works!

Challenges of small scale solar include:

- **Grid congestion:** when increased solar is fed into the grid this ‘traffic jam’ needs to be managed.
- **Voltage instability:** old inverters weren’t able to manage voltage increases caused by solar however inverters have had this capability since 2015
- **Weather events:** extreme weather can impact solar output and increase customer load on the grid.
- **Battery storage:** low rates of solar with battery storage means there's less control over when energy is sent back to the grid

If you want to learn more about solar energy check out the ‘Discover Solar’ course from the Clean Energy Council.

Small-scale Solar - Case Studies

Becoming an Accredited Installer was a smart career choice for Naomi Bourke.

“With renewable electricity, it’s ever-changing and evolving,” says the **electrician** from Townsville, Queensland, who is accredited to install home battery storage systems as well as rooftop solar panels. Read more here.

When Mark McClurg paddles out for a surf and looks back at solar panels dotted on roofs, he sees more than the work of his small business.

Mark is the **Managing Director** of a company with a staff of 15, and they have installed over 2700 solar systems. Given his affinity for nature, working in clean energy “just made sense,” he says. Read more here.

A record number of Queensland schools have had solar panels installed to help **slash electricity costs** and **cut carbon emissions**.

Former Education Minister Grace Grace said the Advancing Clean Energy Schools (ACES) program was expanded in February 2022 and had exceeded targets to deliver more panels at more schools than originally planned. Read more here.

Renewable Energy - Wind

Harnessing wind energy isn't a new concept! In the Neolithic period, humans developed **winnowing**, where wind energy is used to separate grain from chaff. Boats with **sails** to take advantage of wind energy first appeared in Ancient Egypt in 3,200 BCE. **Vertical axis windmills** were developed in Persia (Iran) in the 7th century and used to grind grain and pump water. In the 12th century **horizontal axis windmills** were widely implemented in Europe. In 1987 **wind turbines** were first used to generate electricity, with the modern wind energy industry taking off in the 1980s.





Click here to learn how wind turbines generate electricity.

Wind Power in Australia

- in 2023, 13.7% of electricity was generated by wind power.

Benefits of wind farms include:

- low operating costs
- able to co-exist with current farm practices
- renewable energy source that does not release emissions or pollution
- suitable for remote areas

Challenges include:

- misconceptions about wind turbines
- recycling of parts at end-of-life
- require strong winds and 'smooth air' (low turbulence)
- inconsistent wind supply

If you want to learn more about wind energy check out the 'Discover Wind Power' course from the Clean Energy Council.

Wind - Case Studies

Tracy, of the Western Wakka Wakka people, is the **Cultural Heritage Manager** at Wambo Wind Farm, working with her team to recover and preserve Indigenous artefacts on the construction grounds. Watch her story here.

Alice is a **site engineer** at ACCIONA Energía's MacIntyre Wind Farm Project, near Warwick in Queensland.

“I feel like I’m making history. I’m really passionate about sustainability and the environment, so getting to work on such an influential project in the renewables industry is a big tick,” she says. Watch her story here.

For those who are happy at heights and like the idea of a job that can take you around the world, **blade technicians** get a truly unique view of the energy transition.“I love what I do, and you’ll get a job anywhere with these skills.”

Darren Smith is a renewable energy veteran, someone with huge experience in and around wind energy across the globe. Read more here.

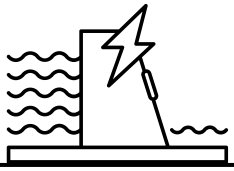
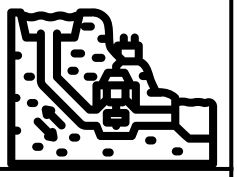
Traditionally host to agriculture, forestry and tourism, the Mt Gellibrand wind farm has brought economic diversity to Victoria’s Western District. Alex McKenzie, Vice President of the Colac Chamber of Commerce, says that large renewable projects bring **multiple benefits to regional economies**. Read more here.

Renewable Energy - Hydropower

Hydropower has been a key element of the Australian power system for more than 100 years. There are more than 100 hydroelectric power stations in Australia with a total installed capacity of about 7800 megawatts (MW).

Click here to learn how hydropower generates electricity.

There are three types of hydropower plants that use both the **potential energy** and the **kinetic energy** of water.

Impoundment 	**Diversion** 	**Pumped Storage** 
When water is held in a reservoir such as a dam and slowly released through a canal to run a turbine.	When a portion of a river is diverted to run through the turbine.	When water is pumped uphill to a reservoir when extra energy is available, and released through a turbine when energy is needed.
Barron Gorge, QLD Hydroelectric Powerstation	**Poatina Power Station, Tas**	**Kidston, QLD Pumped Storage Hydro**

Genex Kidston Pumped Hydro

The Kidston Project, located 270kms north of Townsville, is the first pumped hydro energy storage scheme in the world to be developed in an abandoned gold mine. The project is co-located with solar energy projects.

This projects buys power from the National Electricity Market when it is cheap and plentiful in off-peak periods. It is the third largest energy storage device in the county at 250MW.

If you want to learn more about hydro energy check out the '**Discover Hydropower**' course from the Clean Energy Council.

Hydropower - Case Studies

Meet Alyssa, a **cadet hydrographer** with **Hydro Tasmania**.

As a Cadet Hydrographer, Alyssa travels around Tasmania **taking water readings at our rivers and lakes, reporting the data** back to head office. Find out more here.

Kyle is one of the **Jumbo Operators** working at the **Kidston Hydro Project.**

At Kidston he **helps out with the drill and blast projects and operating different machinery**. Coming from an underground mining background he is loving the diversity of opportunities the job is providing.
Find out more here.

Stephen Burt's **drilling business** grew almost overnight thanks to the the geotechnical contract for early exploratory works for the proposed **Pioneer-Burdekin Pumped Hydro Project**.

Prior to this contract, Stephen's business had been 100% focussed on the coal industry for the past 17 years. Now, 50% of his fleet are dedicated to working in the renewable energy sector. Read more here.

Gurpinger Mand, or G as she's called at work is a **site engineer** for **Genex Power's Kidston underground team.**

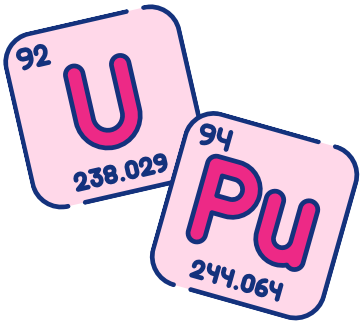
She is one of many dedicated workers that are busy building the underground infrastructure and tunnels crucial for water transfer.
Find out more here.

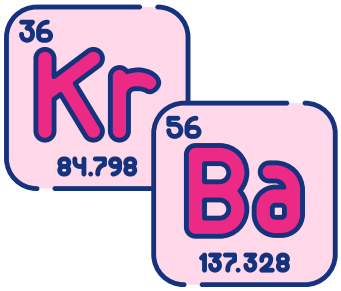
COOL.ORG

Non-renewable Energy - Nuclear

Like many forms of energy, nuclear energy involves making steam to turn a turbine. The heat to turn water into steam is made through a process called **nuclear fission**, where atoms are split and release energy.

To start fission, a **neutron** is fired at a large unstable atom like **uranium**, or **plutonium**. When the **nucleus** of these atoms absorb the neutron they rapidly break up into **fission fragments**, releasing a large amount of energy in the form of **heat and radiation**.

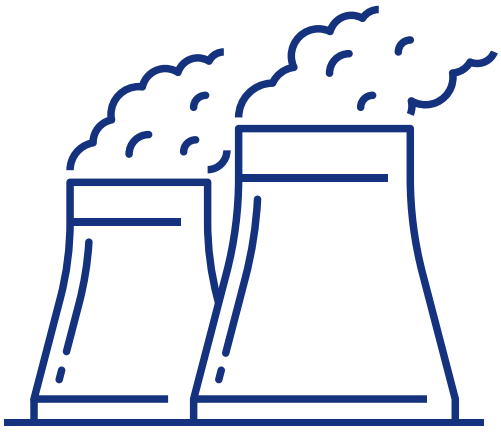




These fission fragments are typically smaller elements such as **barium** and **krypton**. The reaction also releases two or three more neutrons, which trigger further fission reactions in the surrounding elements, and creates a self-sustaining reaction.

Control rods, made of materials like **boron** or **cadmium** can be lowered to absorb neutrons and slow down the reaction process, or raised to let more neutrons collide with the fuel. **Moderators**, usually **graphite** or **water** are used to slow down the neutrons and help sustain the reaction.

Water is used as a **coolant**, to absorb the heat and turn into **steam**. This steam turns the turbine to generate electricity. After the steam has passed through the turbine, it is cooled in large **cooling towers**, and is either released into the environment, or recirculated to create more energy. The coolant water is not radioactive and is kept in a separate system to the water used as a moderator. The radiation itself is not used to generate electricity but is a by-product.



The **fuel rods** are usable for 12 - 24 months, after which it is **spent** and can no longer sustain a reaction. The spent fuel rods will remain radioactive for millions of years, and sustain levels of radioactivity that are dangerous to humans for between 10 000 and 24 000 years.
That's between 400 and 800 generations of people.

Non-renewable Energy Nuclear

Spent fuel rods are difficult and dangerous to store. The current options for storing spent fuel are in Cooling pools or Dry Cask Storage.

Cooling pools: For the first 5-10 years, the rods are stored in large deep pools of water. This water absorbs heat from the rods as well as providing radiation shielding. Cooling pools are not a long term storage option. They rely on an active cooling system, as well as continual filtering and monitoring to make sure the water remains at a low level of radioactivity. If the water were to leak or evaporate the rods would be exposed, releasing radiation. This was an issue in Fukushima, Japan in 2011, when an earthquake and the following tsunami compromised the cooling systems.

Dry Cask Storage: Once the material has cooled sufficiently it is moved into dry casks for long term storage. These are a canister of thick steel where the spent fuel is stored, surround by an inert gas such as helium, and the canister is welded or bolted shut. An outer cask made of steel and concrete provides additional radiation shielding. Dry casks are intended to last a minimum of 60 years, meaning they will need to be replaced at least 160 times before the fuel is no longer radioactive.

Due to their comparatively short life spans, both of these storage methods are described as temporary, however there are not currently any long-term storage solutions.

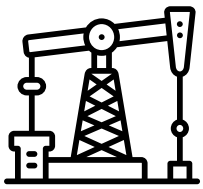
Despite having the world's largest deposits of uranium, and being the world's 4th largest supplier of uranium, Australia has no nuclear energy plants. On a federal level the Australian Radiation Protection and Nuclear Safety Act 1998 and the Environment Protection and Biodiversity Conservation Act 1999 both prohibit nuclear power. Every state and territory also has their own regulations banning nuclear energy.

Non-renewable Energy - Natural Gas

Natural gas is formed when organic matter is buried and exposed to heat and pressure, much like coal. In fact, one of the sources of natural gas is coal seam gas (CSG), which is the primary source of natural gas in Queensland.

Elsewhere in Australia, natural gas is primarily found in **conventional gas reserves.** These are underground pockets of natural gas, often co-existing with oil reserves. 70% of Australia's natural gas is found in conventional reserves, with 93% of these being off-shore.

Natural gas can be extracted in a number of ways.

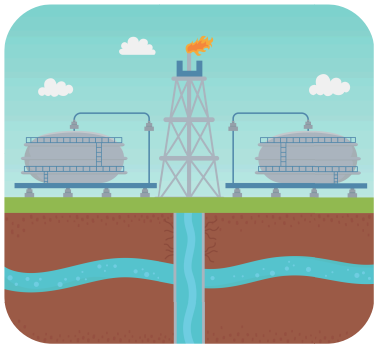


Drilling: used for conventional gas reserves, both on land and at sea, a well is drilled through porous rock such as sandstone or limestone. While underground the gas is under high pressure, so when the drill reaches the reserve, this pressure forces it up the well.

Gas-Lift: when the pressure in a conventional reservoir declines, compressed air can be injected to force the natural gas to the surface.

Dewatering: CSG is often trapped in coal seams under water. Wells are drilled into the seams, and the water is pumped out, allowing the gas to flow up the well.

Hydraulic Fracturing (Fracking): is most commonly used outside of conventional and CSG reserves. When the gas is difficult to extract from the rock, this process forces water, sand and chemicals under ground to fracture the rock and release the gas to flow up the wells.

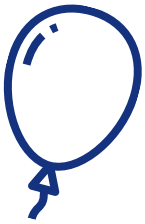


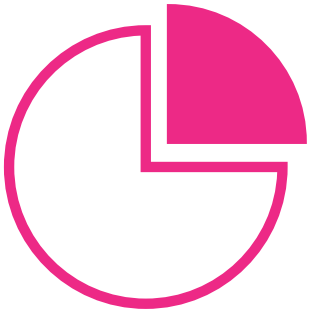
Underground Coal Gasification (UCG): is a process where a coal seam is ignited underground, and oxygen and steam are injected into the seam to produce a gas mixture. While trials began in Queensland in 2009, in 2017 UCG was banned in Queensland following significant environmental impacts from the trials including groundwater contamination, and uncontrolled gas leaks.

COOL.ORG

Non-renewable Energy - Natural Gas

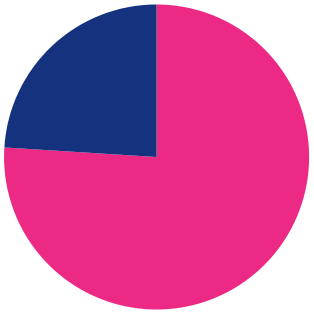
In 2023, Australia extracted approximately 151.7 billion cubic meters (bcm) of natural gas(energy.gov.au).
That's enough to fill 10 trillion balloons!





Currently, natural gas supplies a quarter of Australia's energy needs. While only a small amount is used for electricity generation, it is heavily used as a fuel source for commercial and residential applications.

In 2023 Australia exported about 76% of the natural gas extracted as Liquid Natural Gas (LNG), with the biggest markets being China, Japan and South Korea. Australia is the 7th largest global gas producer, and the 2nd largest exporter. (Geoscience Australia, ga.gov.au)



Converting natural gas to LNG requires a lot of energy as it needs to be cooled to -160° to become a liquid. The gas export industry uses more gas to process its product than is used by the entire manufacturing industry of Australia. (climatecouncil.org.au)

Similarly to coal, natural gas is considered a non-renewable energy source. Natural gas continues to be extracted while the plant's climate and situation are not currently creating more reserves.

Based on 2022 production rates, the estimated life for Australia's conventional gas reserves is 16 years, while the estimated life for coal seam gas is 20 years (ga.gov.au). As conventional reserves are depleted, more resources intensive and environmentally impactful extraction methods would need to be adopted to meet supply and demand.

COOL.ORG

Nonrenewable Energy - Coal

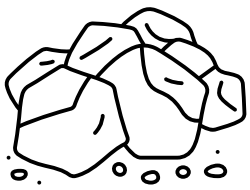
Coal is a sedimentary rock found in seams or beds. Coal starts life as **plant matter**, such as algae growing in shallow seas, or dense forests, which is covered in mud and debris by shifting landscapes.

This plant matter is buried and compressed, preventing contact with oxygen, in turn preventing decomposition. As the plant matter moved deeper under the Earth's surface it encounters heat and pressure creating a process called **carbonisation**.

Coal is ranked depending on how much carbon it contains. The longer coal is subjected to this heat and pressure, the more it carbonises and the higher rank of coal is produced.

Lignite	Sub-bituminous Coal	Bituminouse Coal	Anthracite Coal

Younger (<100my)
Less carbon (60-70%)
More moisture
Lowest rank
Less energy dense
Emits more pollutants)



Older (300 - 400 my)
More carbon (87-97%)
Low moisture
Highest rank
More energy
Less pollutants

COOL.ORG

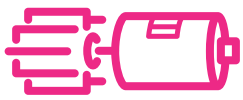
Nonrenewable Energy - Coal

Coal is considered a '**nonrenewable**' energy source. It takes many millions of years to form and cannot be replenished faster than it is used.

The process of forming coal still takes place today. The precursor to coal is a material called peat, which is partially decayed plant matter, however peat is formed incredibly slowly. The geological conditions of Earth are very different to those 100 - 400 million years ago and this also means much less is being formed.

Additionally, while **lignite** is often called 'brown coal' and is considered a low rank of fuel, it is still being used to create energy. This means it won't be underground for the next 200 million years it would need to become **Anthracite Coal**.

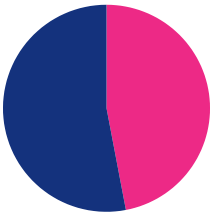
To generate electricity, coal is first mined, either through surface or underground mining.



It is then burned to heat water and generate steam. This steam is used to turn a **turbine** and generate electricity.

Coal power plants have distinctive tall chimneys called **stacks**. By releasing the exhaust gases at a height, the pollutants are dispersed over a wider area in order to minimise their impact.

Coal generated electricity accounted for 47% of Australia's electricity in 2022, down from 83% in 2000.



COOL.ORG

Transitioning from Coal - Case Studies

Steve is a proud Kingaroy local and his story goes right back to 1987 when he joined public energy provider Stanwell as a young apprentice.

More than 30 years later, this **energy sector journeyman** transitioned his decades of experience to the Wambo Wind Farm, located near Jandowae in the Darling Downs South West region. Read more here.

Peter Woodall began his career as an apprentice at the Tarong Power Station over 30 years ago. Since then, Peter's journey has seen him transition his skillset across to the renewable energy sector. A move he's glad he made.

Peter is now the **Future Pathways Manager** for public energy provider Stanwell. Here he helps prepare the next generation of Queenslanders for the transition to a renewable future.
Read more here.

Australia's mining and heavy industry sectors are on the cusp of a revolution as the world shifts to net-zero. Demand for traditional industrial commodities – coal, oil, and gas – is set to slide. What will be the impact on **regional towns** reliant on the coal industry? Read more here.

The next industrial revolution: Transforming Australia to flourish in a net-zero world. (Grattan Institute, 2022)