



Pembroke POWER STATION



Everything you ever wanted to know
about Pembroke Power Station





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Welcome to Pembroke

This brochure provides a summary of who we are and what we do here at Pembroke Power Station. If you have any questions please do not hesitate to ask a member of our team for further information.

RWE Generation UK

RWE is one of Europe's leading electricity and gas companies. Through our expertise in oil, gas and lignite production; electricity generation from gas, coal, nuclear and renewables; energy trading as well as electricity and gas distribution and sales; we are active at all stages of the energy value chain.

In the UK our generating fleet is predominantly made up of combined cycle gas turbine (CCGT) power stations.

Our Power Station

Pembroke Power Station is a 2200MW CCGT power station which officially opened in 2012. Pembroke Power Station burns natural gas and is capable of meeting the electricity demands of 3.5 million homes. Our five 440MW CCGTs have a thermal efficiency of around 60% making Pembroke one of the most efficient CCGT power stations in Europe.

Who We Are

At Pembroke we employ a close-knit team of around 100 highly-skilled people. Our team can be divided into four departments who work closely together in order to keep the lights on:

Engineering

Mechanical (Rotating Plant & Balance of Plant), Electrical, Controls & Instrumentation and DCS.

Regulations

Environment, Safety, Chemistry, Performance, Commercial, Learning & Development and Business Support.

Operations

Made up of 5 shift teams (A-E). Each team has five Operators and one Shift Team Leader.

Maintenance

Mechanical, Electrical and Controls & Instrumentation Technicians and Craft Teams.

DECISIVENESS
DRIVE
HUMOUR
CHALLENGE
RESPONSIBILITY
COMMITMENT
LOYALTY
INTEGRITY
RESPECT

Our Station Values

Our station values represent the qualities and characteristics we expect from every member of our team here at Pembroke. The values were established to act as a guide in selecting our team during the initial recruitment process in 2010. Our aim was - and remains today - to recruit competent and talented individuals. Whilst we put great value on the technical competency of an individual - we also look for individuals who we feel align with our values and culture at the station. Through a day-long interview process involving technical interviews, group problem solving, presentations and testing we observe and measure the 'whole' person. By approaching our selection process with our values at its centre, we continue to build a highly-performing and motivated team and aspire to create a great place to work.

A local stonemason was commissioned to carve our station values into rocks that were excavated from the old power station. These pieces of our station history are found along the walkway to our office buildings, providing daily inspiration as we walk into work each day.



Health & Safety

We aim to sustain a culture where Health & Safety is embedded in the behaviours and activities of everyone on site.

Like most major industrial sites, hazards such as high pressures, temperatures and voltages are all present at Pembroke Power Station. Our team of engineers and operators as well as our sophisticated control systems ensure that the process operates safely, but some hazards will always remain. It is imperative that Health & Safety is taken seriously to ensure that everyone gets home safely at the end of the working day.

We employ a common-sense practical approach to Health & Safety at Pembroke. Our staff are encouraged to be pro-active and to test our procedures in the interests of Health & Safety. Everyone on site is empowered to challenge unsafe working practices.

Our Health & Safety culture is centred very much around our people. Protecting them from ill health and harm is an integral part of what we do. We are all responsible for not just our own personal safety, but also the safety of each other and our

working environment. We work closely with our contractors and site visitors, enabling them to take an active role in making Pembroke a safe site.

Station Overview

Data Sheet

Design output XL-mode (m-mode)	440MW (452MW) per unit
Firing temperature XL-mode (m-mode)	1295°C (1315°C)
Stack height	75m
Shaft rotational speed (frequency)	3000rpm (50Hz)
Gas Turbine Exhaust Temperature	650°C
Gross efficiency	~60%
Natural gas requirement	8,000,000m ³ /day
Total length of pipework	80km



The History of Pembroke

Pembroke A Power Station

Pembroke A Power Station was an oil-fired power station operated by the Central Electricity Generating Board. Construction of the station, comprised of four 500MW units, began in 1965, with the station officially opening for generation in 1968. At 2000MW, it was one of the largest oil-fired power stations in Europe. The station operated for almost 30 years and employed as many as 400 people at its peak, before closing in 1997. Demolition of the station was completed by 2003.

Pembroke B Power Station

Pembroke Power Station is a 2200MW combined cycle gas turbine (CCGT) power station which officially opened in 2012. Built on the site of the former CEGB oil-fired power station, Pembroke Power Station is capable of meeting the electricity demands of 3.5 million homes.

The prospect of building a gas-fired power station on the site was first discussed after planning permission was granted for the construction of two LNG terminals on the Milford Haven waterway. The LNG terminals brought to the area a high pressure gas pipeline which could support the power station. The site was favourable due to the nearby access to a natural gas supply, its coastal location allowed for direct cooling to maximise plant efficiency, whilst the existing 400kV substation provided access to the National Grid.

In 2005, a planning application was submitted for the construction of a direct-cooled power station on the site of the former CEGB station. The necessary environmental impact assessments and environmental permit applications were subsequently launched. An abstraction license for the direct cooling water was granted in December 2008 and planning permission for the power station was granted in February 2009. Construction commenced in April 2009 and the environmental permit was agreed in November 2011, allowing for the plant to operate. Plant commissioning took place in late 2011, with station handover completed by September 2012.



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Pembroke Facts

Pembroke Power Station is supplied by a 4.5 kilometre gas pipeline from across the Haven. At the time of construction the 3005 metre-long section under the estuary was the world's longest ever horizontal drill.

A Timeline of Our History

MXL upgrade, April-December 2015

2015



2012

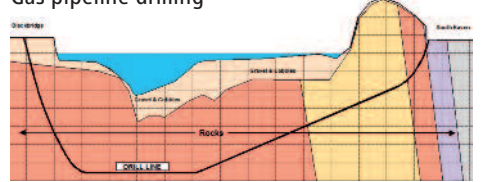
Station handover, September 2012
1st Unit handover, May 2012

100% staff on site, Q4 2011
Commissioning, Q3 2011

2011

2010

Gas pipeline drilling



Construction begins April 2009
Planning permission granted January 2009

2009

2008

Abstraction licence granted December 2008

Planning application submitted

2005

2004

Opportunity identified

Planning permission for two
LNG import terminals granted

2003



1997

'A' Station demolished, 2000-2003



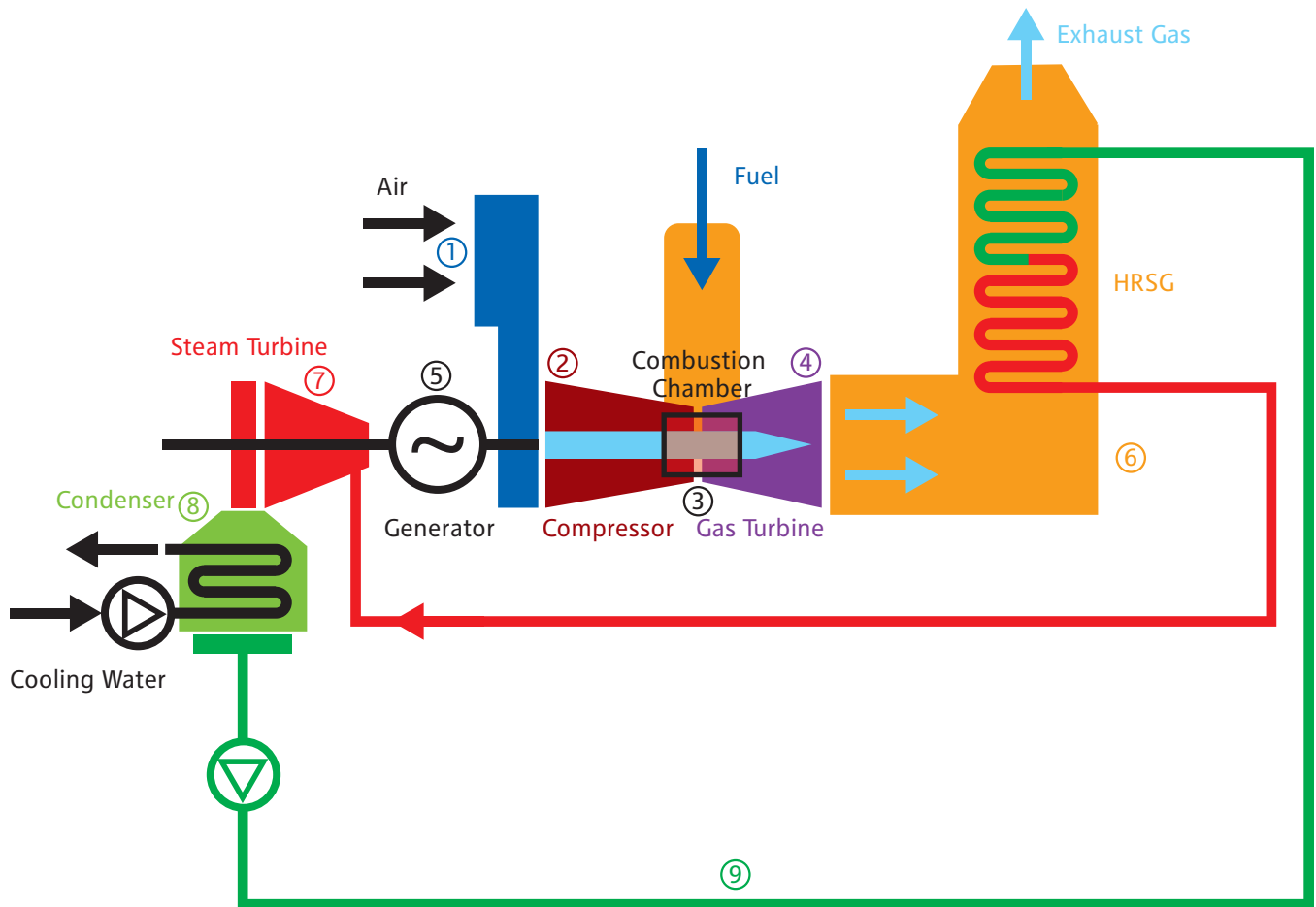
'A' Station in operation, 1968-1997

1968



1965

Oil-fired 'A' Station construction



Combined-Cycle Gas Turbines

How a CCGT Works

A combined-cycle gas turbine power station generates electricity by burning natural gas in order to drive a gas turbine. Exhaust gases from the gas turbine are then used to produce steam in order to drive a steam turbine, generating additional power. It is the recovery of heat energy from the waste exhaust gases which makes combined-cycle gas turbines one of the most efficient types of conventional power plant.

Air from the atmosphere is drawn in through multi-stage air filters (1) by a compressor (2). The air is compressed and mixed with fuel gas (predominantly methane) in a combustion chamber (3). The fuel-air mixture is ignited, producing carbon dioxide, water and vast amounts of heat. The hot combustion gases expand through a gas turbine (4), causing the turbine to rotate at 3000rpm. The rotation of the gas turbine (GT) drives a generator shaft to produce electricity (5). The hot GT exhaust gases are passed through a heat recovery steam generator (HRSG) containing a large number of tubes, filled with demineralised water (6). The heat energy from the exhaust gases is transferred to the water in the HRSG, generating steam. The steam produced in the HRSG is used to drive a steam turbine (ST) (7). Both the ST and GT are coupled to a generator on a single shaft, capable of producing >440MW per unit. After the steam has expanded through the ST it is condensed using cooling water from the Haven (8). The steam passes over hundreds of cooling-water-filled tubes in the condenser, and is converted back to water. The condensate is then re-turned to the HRSG to be reheated (9).



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Pembroke Facts

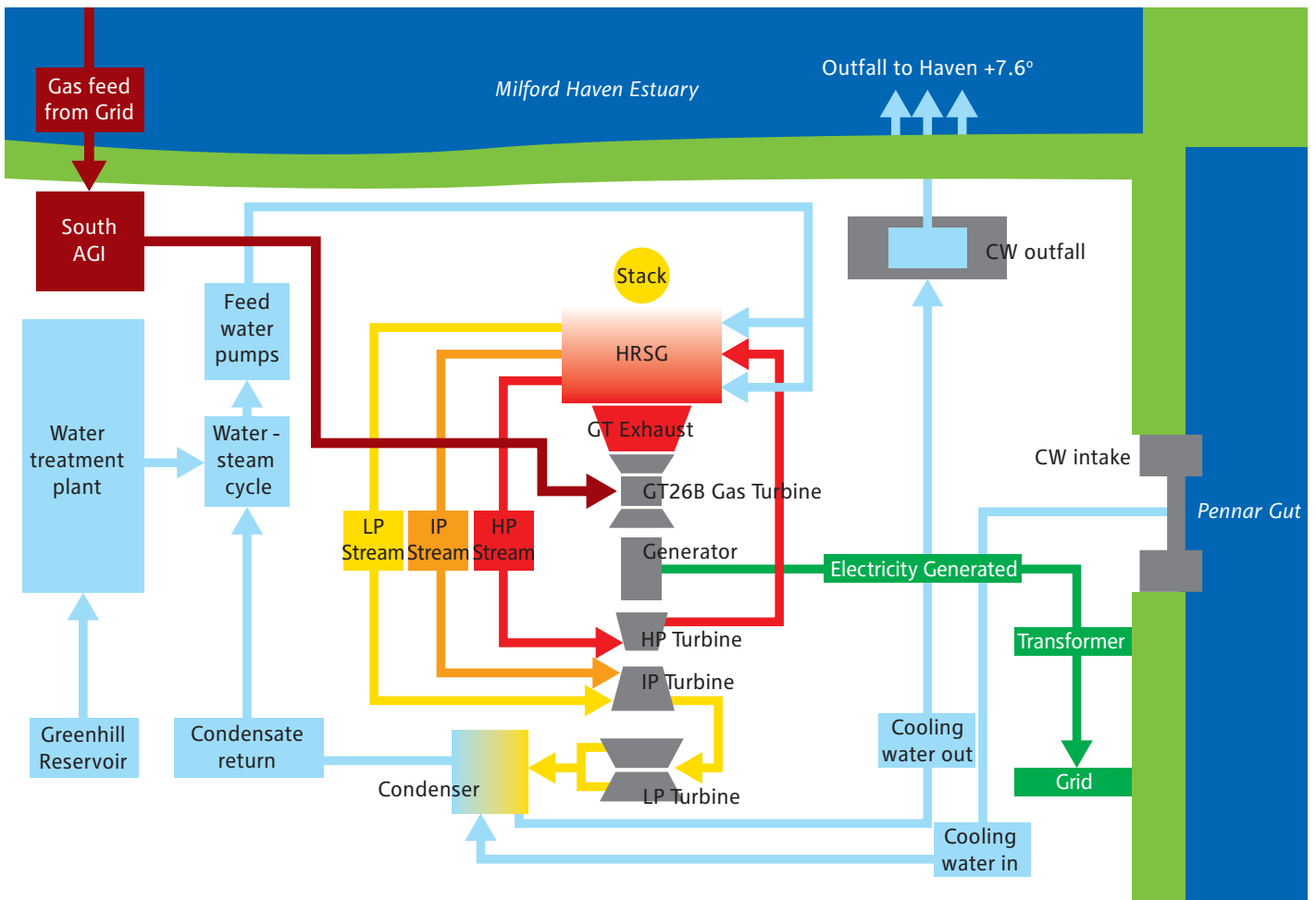
- Over a three-year period, one of Pembroke's Gas Turbines will rotate 4.5 billion times, equivalent to the number of times the Earth has orbited the Sun in its lifetime.
- On a typical day, Pembroke burns 8,000,000 m³ of natural gas.



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Pembroke Facts

- The HRSG recovers 87% of the heat energy from the GT exhaust gas.
- Pembroke uses 40 cubic metres of cooling water per second – around 40% less than the previous oil-fired station.
- Pembroke uses sequential combustion in its gas turbines to reduce NO_x emissions.
- Blade tip speed in the LP steam turbine is approximately 580mph, the same as the cruising speed of an Airbus A380.
- Our demineralised water tank at Pembroke is 10,000 cubic metres, large enough for the plant to continue generating power for 14 days in the absence of a water supply.



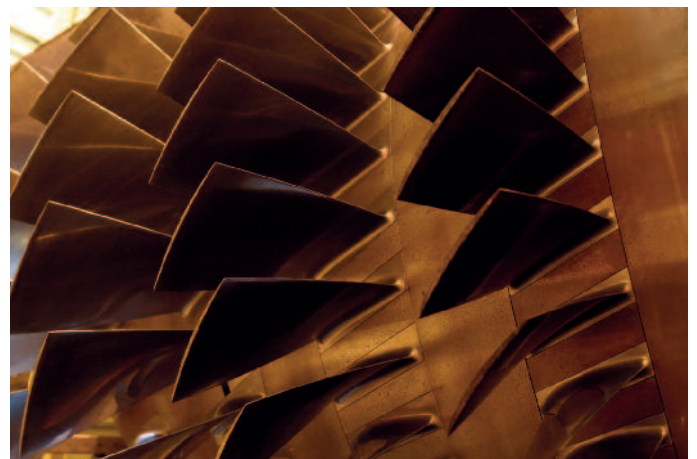
Gas Supply

At Pembroke we use natural gas as our primary fuel. One of the major pull factors for building Pembroke Power Station in its current location was the availability of a fuel source. Our natural gas is supplied from the main National Grid pipeline on the other side of the Haven, near to the liquefied natural gas (LNG) import terminals. During the construction process, a 4.5km gas pipeline was drilled under the Haven estuary to facilitate our fuel supply. The drilling process itself involved a 3005 metre-long horizontal drill which, at the time of construction, was the longest horizontal ever undertaken worldwide.

Gas Turbine (GT26B)

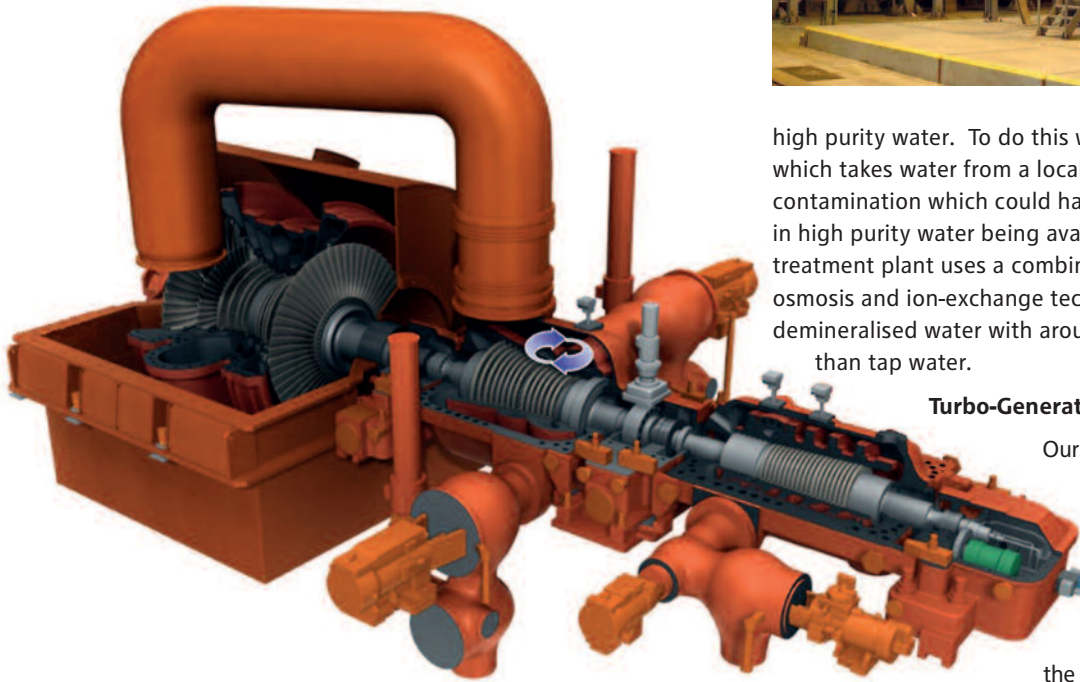
The GT can be split into three distinct stages: compression, ignition, and expansion. The compressor increases the pressure and temperature of air received from the air intake system before delivering it to the combustion chamber. The GT26B has a 22-stage compressor which takes 600 kilograms of atmospheric air per second and raises it to around 32 bar. Our GTs have two combustion stages; sequential combustion allows for lower combustion temperatures (reducing NO_x emissions) whilst the second ignition stage reduces incomplete combustion (lowering CO emissions). In the first stage the air-fuel mixture is ignited at 1140°C, before expanding through the high pressure turbine, driving the generator shaft. In the second stage the ignition temperature is 1295°C. Following ignition, the combustion gases expand through the low pressure turbine before entering the HRSG.

Our gas turbines have the capability of firing at an elevated temperature of 1315°C, known as m-mode, in order to generate an extra 12MW of electricity above the standard 440MW output.



Heat Recovery Steam Generator (HRSG)

The HRSG is essentially a large heat exchanger which converts demineralised water into superheated steam. Our HRSG is a triple pressure system comprised of high pressure (HP), intermediate pressure (IP) and low pressure (LP) circuits which operate at 140, 32 and 4 bar respectively. Each circuit is made up of a drum and a series of tubes which allow for heat transfer between the hot exhaust gases and the water contained within the tubes. The exhaust gas enters the HRSG at around 615°C, passes over the tubes, generating steam, and exits the stack at 80°C. Within the HRSG, the HP system sits closest to the GT exhaust where the exhaust gases have the greatest energy.



Steam Turbine

Our steam turbine is made up of HP, IP and LP turbines. HP steam feeds the HP turbine and expands, driving the shaft. The HP exhaust, known as cold reheat, returns to the HRSG and combines with the IP steam. IP steam is fed to the IP turbine, expands, combining with LP steam before entering the LP turbine without any reheating. The LP steam drives the LP turbine and the exhaust steam enters the condenser to be converted back to water. In order to protect the steam turbines, during a unit start-up steam will bypass the turbines until the steam conditions are correct; wet steam can cause impact damage to turbine blades.

Condenser

The location of our site allows us to use direct cooling as a means of condensing our steam. The use of direct cooling water avoids the need for unsightly cooling towers and increases the overall plant efficiency. Our condensers are each supplied with 8 cubic metres of cooling water per second. Steam passes over the condenser tubes, forming condensate which drops to the base of the condenser. Condensate is returned to the feed-water tank ready to start the cycle again.

Water Treatment

Whilst our boilers, steam turbines and condenser form a water-steam cycle in which water is mostly recycled, there are minor losses of water and steam in our system. As such we need to continually top-up our water-steam cycle with small amounts of

high purity water. To do this we have a water treatment plant which takes water from a local reservoir and removes contamination which could harm our boilers or turbines, resulting in high purity water being available for top-ups. The water treatment plant uses a combination of ultrafiltration, reverse osmosis and ion-exchange technologies to do this, producing demineralised water with around 4000 times fewer impurities than tap water.

Turbo-Generator & Step-up Transformer

Our turbo-generators are connected to both the gas turbine and steam turbine in a single-shaft arrangement. The connection between the generator and the steam turbine is via the SSS-clutch, allowing the ST to disengage from the shaft. The SSS-clutch allows for us to

begin generating power using the only the GT during a start-up while we wait for the desired steam conditions. Electricity is generated at 21,100 volts. 21,100 volt busbars connect the generator to the step-up transformer via the generator circuit breaker. The oil-filled step-up transformers transform the voltage up to 400,000 volts. Underground cables carry the power to the National Grid substation.

National Grid Substation

The underground cables from the Generator Transformer enter the substation and terminate at the HV Circuit Breaker. The HV Circuit Breaker is a gas insulated circuit breaker that uses Sulphur Hexafluoride (SF_6) gas to insulate the 400kV busbar. This then connects to air insulated busbars which are then used to distribute the power to the overhead lines which transmit power to the various distribution centres in South Wales and the West of England.



The Environment

Pembrokeshire is a special place and here at Pembroke Power Station we value our uniquely stunning natural surroundings.

The station is located adjacent to a Marine Special Area of Conservation and has large areas of wood-land, grassland and wetland with a great amount of biodiversity around it. We take our responsibilities towards the environment very seriously and are committed to continual improvement. We liaise regularly with Natural Resources Wales and the local community regarding plant operation.

Plant Design

The plant has been designed to minimise its impact on the environment. For example, Pembroke boasts a state-of-the-art main cooling water (MCW) intake system; the design featuring a wide intake channel, low approach velocities, fish deterrents and a fish return system. The ability to utilise direct cooling makes Pembroke one of the most efficient CCGTs in Europe, reducing our carbon emissions to the atmosphere. Thanks to our sophisticated sequential combustion technology, our NO_x emissions are very low when compared to other power plants.

Continuous Monitoring

Since we started operating we have carried out an extensive and ongoing environmental monitoring program to identify any potential impacts our activities may have on the local environment.

Biodiversity at Pembroke

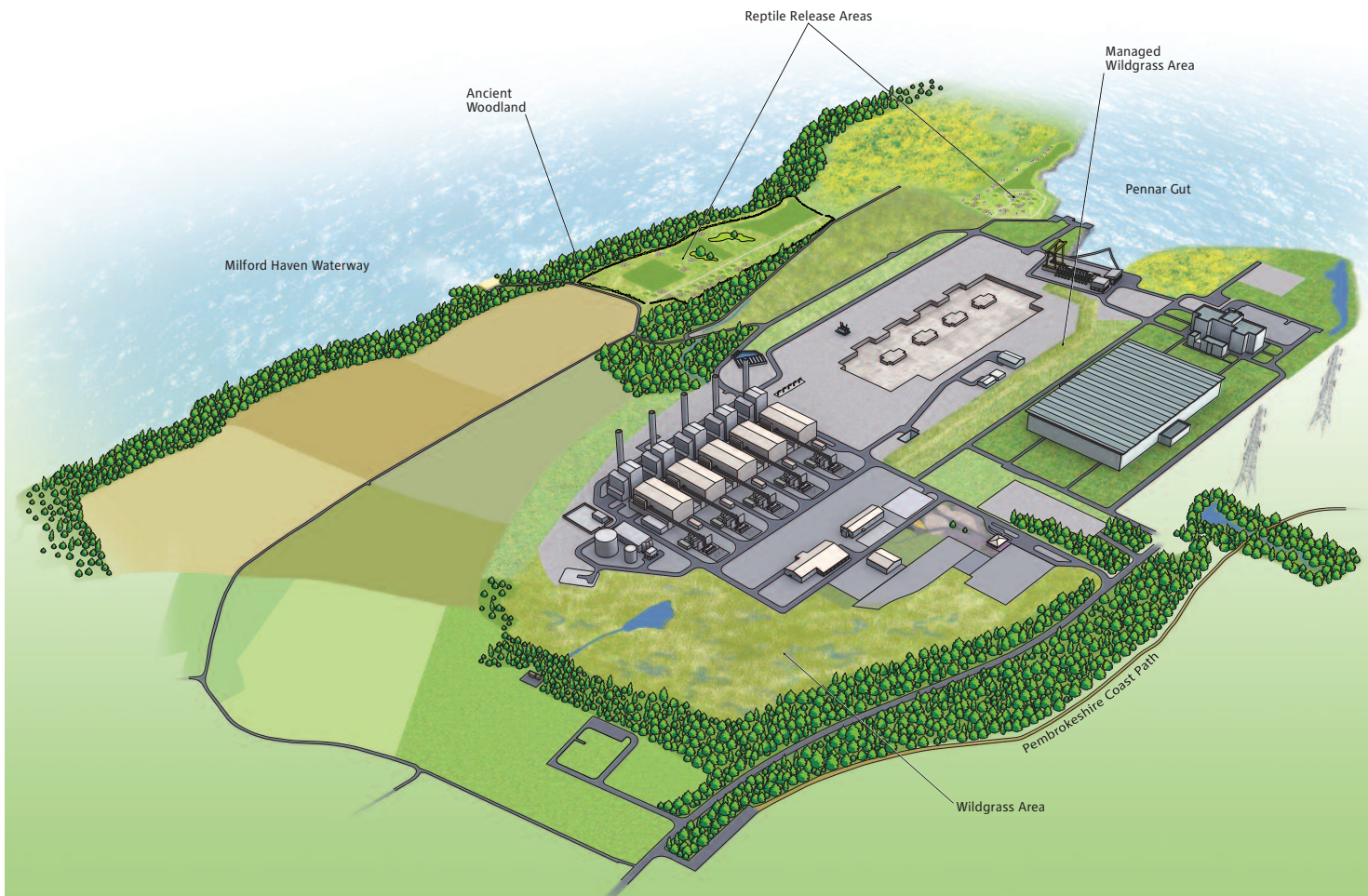
The Pembroke site has a long history of being integrated within a landscape that is important for a large variety of species. Some of these are rare due to their specific requirements and also as a result of habitat loss elsewhere. Wildlife living near to the site has been preserved and, where possible, enhanced through continual management. The result of this is a location which now supports a colourful and varied range of habitats, enriching the biodiversity of the area.

As well as the plant and insect life that can be seen around the site there are also many other species that can be observed. These include protected species such as bats, reptiles, badgers and various birds which share the site with us.

Biodiversity has been enhanced through the planting of new hedges and woodland with species indigenous to the local area. These have now established and provide important wildlife corridors on the headland.

Our site also contains an area of semi-natural ancient woodland bordering the Milford Haven Waterway which is managed to encourage wildlife to flourish.

Pembroke Power Station is located within a key nature conservation area. The site already supports a range of interesting and protected species and continues to provide further opportunities to enhance the biodiversity of the site and its immediate surroundings.



Reptile Release Area


During construction, two Reptile Release areas were created to provide suitable habitat for the reptiles which were removed from the area where the power station was being built. These areas have developed and have become home to populations of common lizard, slow worm and grass snake, which are protected by law. We have created areas where reptiles can bask in the sun and hibernate in the winter. The areas are managed and inspected to ensure they continue to provide the habitat needed by these reptiles.

Badger Setts

In common with much of Pembrokeshire, the site and surrounding area is well used by badgers. There are currently several badger setts located around the site. Work is carefully planned to ensure these areas are left undisturbed.

Wildflower Grassland

Several areas spread across the site are managed to encourage wildflower grasslands. These grasslands support a diverse range of flora and fauna, particularly small mammals, butterflies and other pollinating insects.



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Pembroke Facts

- Our 440MW CCGTs are around 60% efficient, making Pembroke Power Station one of the largest and most efficient power stations in Europe.
- Pembroke Power Station emits around half of the CO₂ emissions of a coal-fired power station with the same capacity.

The Role of CCGTs

The UK energy industry is dominated by the challenge of ensuring our future energy supply is clean, reliable and affordable.

We believe that to keep the balance between CO₂ emissions whilst maintaining a secure and affordable energy supply for customers, the UK needs a diverse mix of generating technologies and fuels. RWE has invested billions of pounds in cleaner generation including a vast renewable portfolio. Highly-efficient power stations like Pembroke will have a crucial role in maintaining a reliable energy supply in the UK for the coming years. With the capacity to provide enough power for 3.5 million homes on demand, Pembroke will play a major part in the UK's energy mix for years to come.

In 2015 we completed our MXL upgrades, investing £125 million. The result of these upgrades was an increase in efficiency to more than 60%, making Pembroke one of Europe's most efficient gas-fired power stations. It is predicted that this will cut our CO₂ emissions by an impressive 0.6 million tonnes over a ten-year period.



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Pembroke Facts

- Pembroke Power Station can generate 2200MW of electricity, approximately 5% of the UK demand.
- Each of Pembroke's five CCGTs can produce as much electricity as 180 onshore wind turbines.





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Pembroke Facts

- Pembroke is able to provide frequency response to the National Grid; in just 10 seconds Pembroke can offer a response equivalent to the switching on of 3 million televisions.

Plant Capability

On start-up, our CCGTs are able to reach full load (440MW) in under 45 minutes, whilst our units can ramp up from half-load to full load in just 12 minutes. Fast start-ups and rapid load changes make CCGTs like Pembroke vital for balancing the National Grid in response to fluctuations in renewable generation.

At Pembroke, our teams of skilled operators and engineers are continuously working hard to achieve new levels of flexibility for the plant. CCGTs were originally designed to be operating 24/7 at full load; however, with the recent emergence of renewables such as wind generation, CCGTs have to operate more flexibly. When wind generation is low, the demand for CCGT generation increases, and vice versa.

We are always looking for new innovative ways of improving station performance, ensuring that we can react even more rapidly to changes in consumer power demand. With the ability to reach its full output in under 45 minutes, Pembroke plays a vital role in balancing the National Grid. When the UK's energy system is under stress, the station can balance its output quickly against other energy supplies such as wind and solar, playing a key role in keeping the country's lights on. Based on current predictions the upgraded turbines are now expected to provide as much as 7% of the UK's flexible power each year – making a significant contribution to the UK's energy supply.

Plant Operation

A plant is only as capable as its people.

At Pembroke we employ a highly-skilled team of operators who work around the clock in order to keep the lights on for 3.5 million homes. The station is manned 24/7, every day of the year by our five shift teams, with each made up of five operators and a Shift Team Leader.



The Local Community

Pembroke Power Station actively contributes to our local community. We do this in a variety of different ways:

- Local Liaison Committee – this is a committee made up of local town and county councillors, representatives from regulatory bodies and, of course, RWE staff. The committee engages with local residents on issues connected with operations and to inform local communities of developments and opportunities at Pembroke Power Station and beyond.
- Support of local events such as the county show, town shows, community events, concerts, local awards ceremonies, local theatre productions and events designed to attract tourism.
- A Community Fund is operated to support local grass-roots organisations by means of a donation. Applications are considered throughout the year and donations are made to a wide variety of organisations from sports clubs to mother and toddler groups.
- Election of a Station Charity – Annually, the station team selects a local charity by means of a vote. Fund raising activities are then focussed on this selected charity for the year.
- Corporate charity – RWE also has a corporate charity which is supported on a national basis. Pembroke Power Station hosts events to support the corporate charity.
- Site Tours - The station has hosted a number of tours for both educational and community purposes. Groups hosted consist



Pembroke Facts

- Pembroke Power Station contributes over £20million/year to the local economy.

Extracted from Economic Impact Study, February 2015.

- of University students and local community organisations. The station also works with a local charity to provide educational tour opportunities for school groups.
- Support of village halls and other community spaces - The station hosts leadership meetings and staff events in village halls and other such spaces, making a donation each time for its use. Many local village halls have also benefitted from successful applications to the power station's community fund.
- Community Space - Greenhill Farm which is owned by RWE, neighbouring the power station, has been leased to a local charitable organisation for provision of community space.
- Match funding for sponsored events – the station is very supportive of employees' participation in sponsored events. There is match funding available for funds raised and, the station will sponsor registration fees for an event in order to encourage employees to get involved.
- Volunteering – many employees at the power station spend time volunteering with numerous local organisations from sports clubs to animal welfare. The station encourages this and ensures that employees are supported in their endeavours.



Join the Team!

We are a small team of dedicated people who work hard to keep the plant running safely, efficiently and flexibly.

Roles

The types of roles that we have on site include:

- Operations Technicians
- Shift Team Leaders
- Engineering (Mechanical, Electrical, C&I, DCS)
- Maintenance (Mechanical, Electrical, C&I)
- Planning
- Environmental
- Performance/Commercial
- Health & Safety
- Learning & Development
- Chemistry
- Administration
- Finance
- Procurement
- Section Heads
- Senior Management

We also have opportunities for individuals who would like to apply directly from education. We review our business need on an annual basis and advertise these opportunities accordingly:

- Apprenticeship
- Power Trainee Technician
- Year in Industry
- Graduate scheme

Recruitment

All job opportunities are advertised on our website. To view current opportunities please visit www.rweukjobs.com where you can sign up to job alerts within our area.

We also utilize the local/national press and job websites where appropriate.

Contractors

We also have a number of contractors on site who provide some of the essential services we require on site. Our contractors carry out their own recruitment in accordance with their company policies. The types of contractual roles you would expect to see include the following:

- Security
- Scaffolding & Lagging
- Plant Cleaning
- Office Cleaning
- Maintenance



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