GEOSCIENCE FOR LEAVING CERTIFICATE GEOGRAPHY

Continuing Professional Development Course 2023

HUMAN INTERACTION WITH THE ROCK CYCLE ADDITIONAL RESOURCES

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An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

Additional Resources: Human Interaction with the Rock Cycle

Contents

Fact sheet

Case Study: Ireland

Geothermal energy use

What? Using geothermal heat is an example of human interaction with the rock cycle.
Why? It is a cost-effective and environmentally friendly way of meeting basic human needs.
Where? Ireland! Geothermal heat is available everywhere, only needing different methods to use it.
When? Now! Projects using geothermal heat are already running in Ireland, and more and more
Causes:

Geothermal Gradient

- The geothermal gradient is the rate of increase of temperature with depth into the ground.
- The effects of weather, the Sun and the season only affect the top 10-20m of the earth and the temperature below that is controlled by heat already in the centre of the planet.
- Away from plate tectonic boundaries this rate is 30 °C/km.
- The gradient is much higher nearer to plate boundaries.

Extracting the heat

- Hot water can be extracted directly from the earth, if the rocks are *porous* and *permeable.* In an open loop system, cold water can be pumped into the earth through one hole, while hot water will be pumped out from another hole
- If the rock is not *permeable*, a closed loop can be used where water can be pumped into the earth to be heated up and taken back out through another hole. This is how central heating systems work, except we would use the earth instead of a boiler.

Using the heat

- The hot water can be pumped directly into *district-heating systems* which will feed the radiators of houses, large public buildings, warehouses, factories, offices – all manner of places that need to be warm.

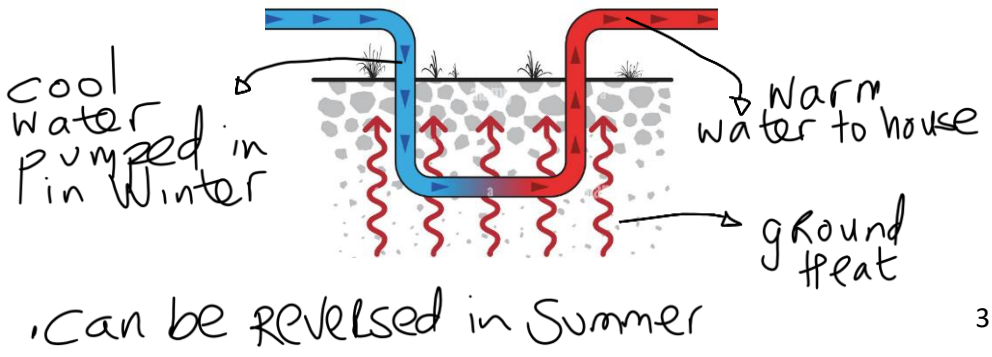
Effects:

- 30% of energy used in Ireland is used directly for heating
- This energy currently mostly comes from fossil-fuel sources
- Geothermal energy is:
    - Always on
    - Renewable
    - Clean and carbon neutral
    - Cheap!

Examples: Examples of small geothermal projects can be found in over 9,500 homes in Ireland for heating, using ground source heat pumps. Larger geothermal projects include:

- IKEA in Ballymun for heating the large retail space
- Mallow swimming pool harnessing a hot spring (warm maybe) to heat the pool
- Cliffs of Moher: to heat and cool the visitor centre

Diagram:



Sample Answer

Humans interact with the rock cycle in a number of ways. Describe and explain how this interaction with the rock cycle takes place, with reference to one of the following:

· Mining · Extracting Building Materials · Oil/Gas Exploitation · Geothermal Energy Production.

30marks

Humans interact with the rock cycle in many different ways, I will explain this process by examining Geothermal Energy in Ireland. Yes, Ireland ! It is not a spelling mistake. Although Iceland is the poster boy of Geothermal energy, Ireland still can harness the energy from within.

Geothermal energy uses heat from rocks (igneous rocks mostly) to heat water, turning it into steam and resulting in the creation of energy. This type of energy is produced in Iceland due to the endless amounts of volcanic activity there. And many other volcanic areas too ie Italy, Philippines and America.

ICeland sits on the middle of the Mid-Atlantic Ridge, a constructive plate boundary with many active volcanoes. The Mid-Atlantic Ridge is a huge opening in the ocean floor created as the North American and Eurasian plates separate. Iceland was created when magma rose through this opening and cooled and hardened on the earth's surface, over time it built up creating an island called Iceland.

Over 90% of houses in Iceland are heated naturally by geothermal energy, this type of energy is one of the cheapest and cleanest forms of energy that exists today. The magma rises from the mantle and heats the rock close to the surface to around 200 degrees Celsius, this heats the water around the rocks.

But that's Iceland, now to Ireland. While we are distant from a plate boundary and have no active volcanoes and yes also our igneous rocks (granites in Leinster and basalt in Antrim) cooled millions of years ago, we still have potential. Despite all that, Ireland has excellent shallow geothermal energy reserves all over the country.

Our shallow groundwaters provide a stable resource of thermal energy that can be used to provide heating at a very high efficiency rate. Ground Source Heat Pumps (GSHPs) are becoming more and more popular and with sufficient insulation these can be a very efficient method of heating and cooling our homes and businesses.

We can look more to countries like Denmark and France to see that shallow Geothermal energy can provide heating, not electricity generation. To drill down 1km would generate water at 26^{o}c approx. This is called the geothermal gradient. This would indeed be sufficient to heat district heating systems, swimming pools, schools and hospital and businesses. The geothermal gradient varies from place to place, but is estimated that in Ireland that gradient might be higher in the northeast of the country (Northern Ireland)

In Paris, since the late 1960's investment in geothermal energy has seen them now heat 250,000 homes by drilling 1,500m and 2000m deep to access the water in underground aquifers. The water accessed is between 60^{o} and 80^{0}c. The bedrock is limestone and other sedimentaries.

This is significant to Ireland as we are really at the start of our geothermal journey. Geologists are looking for the optimal locations to drill. Indeed there has been some success stories in Ireland already, for example:

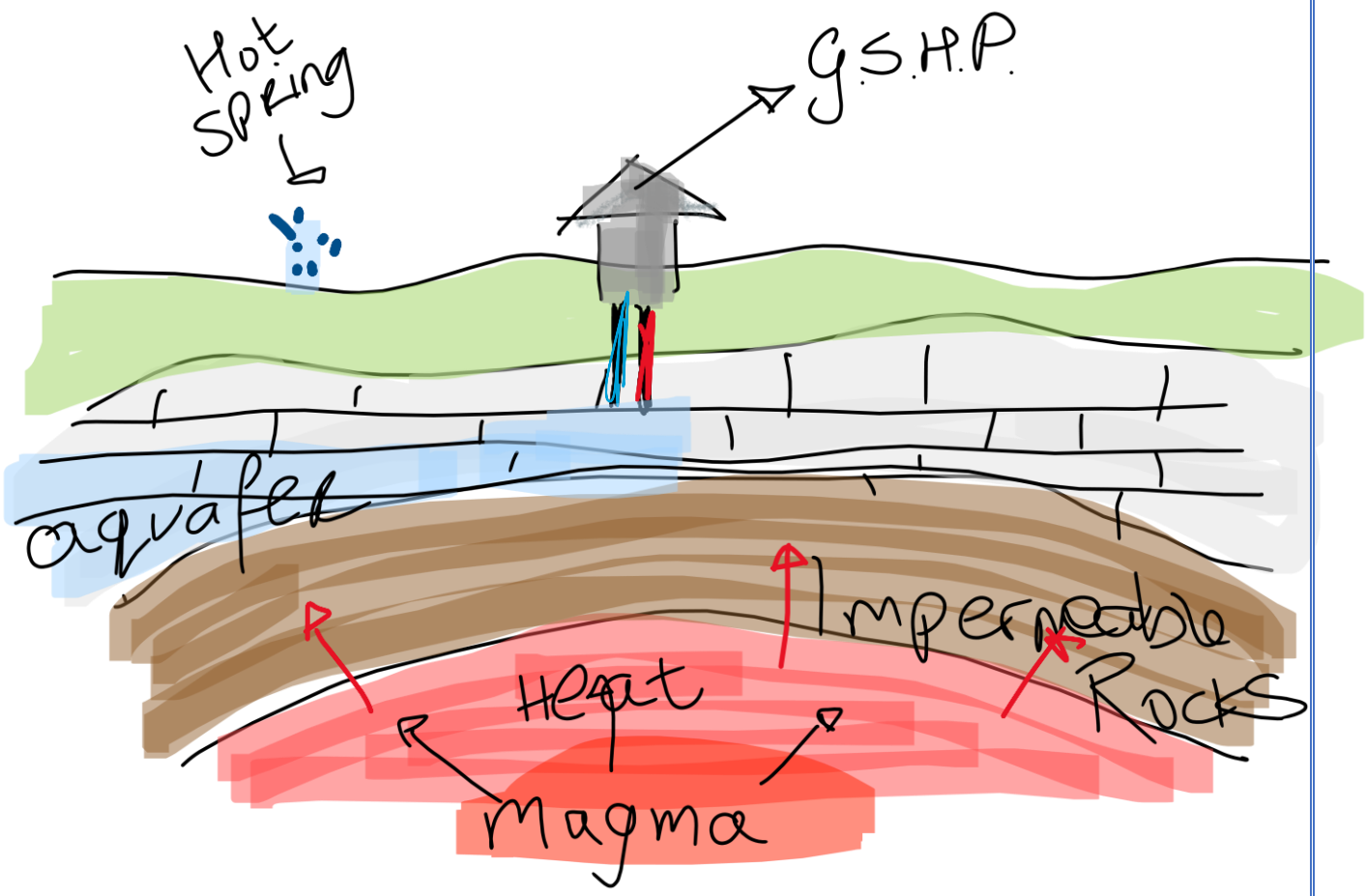
- Cliffs of Moher & Ikea in Ballymun: both uses ground source heats pumps for heating and cooling the buildings. Ikea drilled over 150 boreholes to generate almost half its heating requirements.
- Mallow swimming pool is heated by an underground thermal spring. Four 500m deep wells heat the pool to almost 20^{0}c. There are over 40 of these springs documented in Ireland so the potential to exploit this shallow geothermal energy is vast.
- The Athlone Town Shopping centre & Sheraton Hotel.

All these projects use shallow geothermal energy (< 400m) for heating with a heat pump to circulate the water.

The best places to harness this hidden heat are where the rocks are both porous and permeable. The porosity of a rock is a measure of its ability to hold a fluid. This is the open spaces available in a rock (as a %). Permeability is a measure of the ease of flow of a fluid through a porous solid. Rocks that commonly have high permeability are conglomerates, sandstones, basalt, and certain limestones – although Irish limestone is not very permeable. Permeability in sandstones and conglomerates is high because of the relatively large, interconnected pore spaces between the grains.

The advantages of Ireland exploiting our geothermal potential are endless: the move away from fossil fuel fired heating systems to ground sourced thermal heating would allow for major reductions in CO2. It would make us less dependent on global imports of fossil fuels and the uncertainty this brings. Also it brings down the costs to the business/homes. It is not reliant on weather conditions unlike solar, wind or hydro. In short, geothermal is a reliable constant source or energy for heating in Ireland.
The limitations so far in Ireland have been : - Investment: Drilling is expensive and public investment in green technologies is vital if we are to meet our climate goals by 2030. Private investment also needs to be encouraged by policy and tax incentives. Currently there is a grant of €3500 to install geothermal heat pump in your home.
Indeed, the first urban, deep test hole in Dublin (1km down) is showing temperatures of over 38.5^{0}c. So Ireland like many countries, centrally placed on a tectonic plate can indeed drill down and release the radioactive heat from with the earth.

Diagram (see next page)

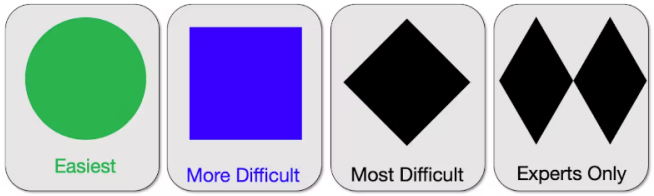


How Geothermal Works.

Geothermal Energy in Ireland: Tic – Tac – Toe Board

Rules: You must choose a minimum of 2 tasks but 3 in a line is a winner!

Ski Slope Colour Guide



1. Word Search 	**2. Crossword**	**3. Draw a labelled diagram of a shallow, vertical, closed loop geothermal solution.**
4. Reading comprehension Iceland & Questions	**5.Comparison Table of Geothermal, Hydroelectric & Nuclear energy**	**6. Definition unscramble** 
7.Complete the Quiz Worksheet 	**8. Cloze test**	**9.Reading Comprehension on Ireland** 

Tasks Selected No.	Colour

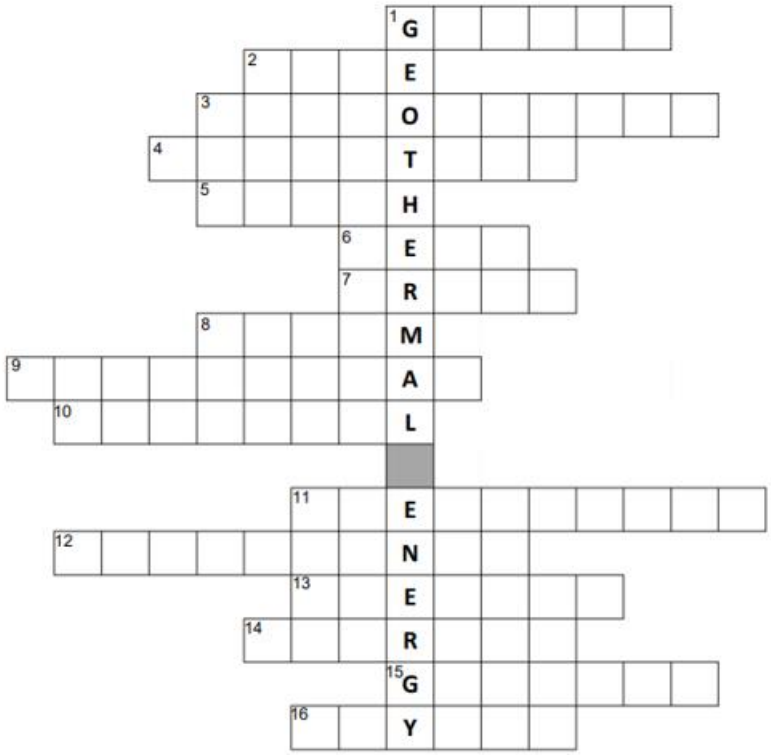
1. *Wordsearch*

Geothermal Energy Ireland

electricity generation		decarbonise
ground source heat pump		permeable
hot spring	renewable	potential
reliable	bedrock	Eurasia
heating	potential	cooling
porous	mantle	magma

A H P E R M E A B L E G H C S A G U W N S C N V N
P W O Z G F B U C H T V I P P U L L A J D X M F Y
P U P K R C Q W D I B V S Z O C E J P F G F K Q W
R J Y J O U W M H T V B T O R N L H A C B P T T K
W C K Y U V D C N F X F L R O O E G B S N M E R G
U D J B N S J X I R D Z G J U R C A W O N E R E G
U B I D D L C W Y S V U Q I S M T G T Z Q C M L T
B C X V S E T P F J E T R F W X R S R W Q R M I I
B V X X O L G L U Y U P N E Y N I D X D G E C A E
Y P I A U N H M A K A Q M X B F C R B T P B Q B I
Z H O N R J W H C P W E V E E M I Z K S M T Q L L
C X V T C O Z Q E O O F A T D A T X T R A A C E C
N Y T F E E S W I A O Q M G R G Y W H Y N C J L A
C R X X H N P A B F T L W H O M G M M I T C O P N
B D I L E P T H E N F I I R C A E F T D L F S E V
O F S A A Y U I O G A J N N K M N O Y F E M F U K
G P R C T C T L A T F G P G G X E S Y H L E S R H
D I E B P W E F R L S F F A D H R Y A V O Z J A J
U N N K U A V L E V Q P Q D I Z A C F W Q Y A S G
D Q E E M V T Y J T W C R E S F T G Q L S T B I U
F H W I P Y J L E V C U Q I E X I U I O A U I A A
V F A X C L K P W I T G B A N C O Q N N P Q F G C
C O B W C G P C U F D O Z K O G N M H L G M M L X
V W L G S D E C A R B O N I S E M G G A O Y P O L
V Y E O F S M N V L X J F P O T E N T I A

2. *Crossword*



1. The earth beneath our feet,
2. The innermost part of the earth which generates heat.
3. Type of decay that contributes to geothermal energy.
4. Pumping fluids deep underground.
5. A type of tank used to convert hot water into steam.
6. A deep hole in the ground used to obtain water.
7. Outermost layer of the earth.
8. Vapour obtained from boiling water.
9. A type of loop installation for ground-source heat pumps.
10. A space saving version of the previous answer.
11. Energy created from Geothermal power plants.
12. Geothermal technology is said to be high in.....
13. Country with the largest geothermal market.
14. Renewable energy from the core of the earth.
15. The study of the earth's structure and substance.
16. A hot spring that produces hot water and steam.

The USA is the leading geothermal power market in the world.

3. *Draw a labelled diagram of a shallow, vertical, closed loop geothermal solution*
   Include a title and the following labels

- **Home**
- **Heat pump**
- **Vertical loop**
- **Fluid in loop absorbs heat from ground**
- **i.e. Underfloor heating**
- **Inlet**
- **Outlet**

4. Reading comprehension on Iceland

Irish Independent

LATEST | Iceland prepares to shield geothermal plant from risk of volcanic eruption

A road is damaged in the village of Grindavik, which was evacuated due to volcanic activity, in Iceland November 14, 2023. REUTERS/Ben Makori

Nov 14th 2023

Iceland is expecting a major volcanic eruption within days or even hours, as the pressure of lava beneath the ground accumulates at "an unprecedented rate".
A river of molten rock is now just 2,500ft beneath the south-western town of Grindavik, about 40km from the capital, Reykjavik.

The eruption could cause major damage to the town which was evacuated over the weekend as magma shifting beneath the Earth's crust caused hundreds of earthquakes.

Located between the Eurasian and the North American tectonic plates, among the largest on the planet, Iceland is a seismic and volcanic hot spot as the two plates move in opposite directions.

Iceland, which has 33 active volcanic systems, has declared a state of emergency as experts say an eruption is imminent as the magma forces its way upwards on the Reykjanes peninsula. It is likely to happen at some point along a 16km-long fissure that has opened up near Grindavik, damaging buildings, causing cracks in roads and subsidence at a golf course.

The fissure continues into the sea so the eruption could take place on the ocean floor – an event which would send up a giant ash cloud as super-heated rock comes into contact with cold water. It is close to the Svartsengi geothermal plant, the main supplier of electricity and water to 30,000 residents as well as a freshwater reservoir. Grindavik, which has a population of 4,000, is also near the Blue Lagoon geothermal spa resort, one of Iceland's main tourist attractions, which has been closed due to the uptick in seismic activity.

"We are really concerned about all the houses and the infrastructure in the area," Vidir Reynisson, the head of Iceland's civil protection agency said.

A tunnel of magma was at a depth of 5,000ft early on Saturday but is now rising towards the surface.

Icelandic authorities were on Tuesday preparing to build defence walls around a geothermal power plant in the southwestern part of the country that they hope will protect it from lava flows amid concerns of an imminent volcanic eruption.
Seismic activity and underground lava flows intensified on the Reykjanes peninsula near the capital Reykjavik over the weekend, prompting authorities to evacuate nearly 4,000 people from the fishing town of Grindavik on Saturday.

The probability of an eruption remained high despite a decrease in seismic activity, the Icelandic Meteorological Institute said in a statement on Tuesday.

Nearly 800 earthquakes were recorded in the area between midnight and noon on Tuesday, fewer than the two previous days, it said.

"Less seismic activity typically precedes an eruption, because you have come so close to the surface that you cannot build up a lot of tension to trigger large earthquakes," said Rikke Pedersen, who heads the Nordic Volcanological Centre based in Reykjavik.

"It should never be taken as a sign that an outbreak is not on the way," she said.

Authorities said they were preparing to construct a large dyke designed to divert lava flows around the Svartsengi geothermal power plant, located just over six kilometres from Grindavik.

Iceland's Justice Minister Gudrun Hafsteinsdottir told state broadcaster RUV that equipment and materials that could fill 20,000 trucks were being moved to the plant.

Construction of the protective dyke around the power station was awaiting formal approval from the government.

A spokesperson for HS Orka, operator of the power plant, said the plant supplies power to the entire country, although a disruption would not effect power supply to the capital Reykjavik.

Almost all of Grindavik's 3,800 inhabitants, who were evacuated over the weekend, were briefly allowed back in on Monday and Tuesday to collect their belongings, the Icelandic department of civil protection and emergency management said.

Grindavik resident Kristin Maria Birgisdottir, who works for the town municipality, told Reuters on Tuesday she only had the clothes she had worn for work on the day the town was evacuated.

Streetworks continue after cracks emerged on a road due to volcanic activity near Grindavik, Iceland obtained by Reuters on November 14, 2023. Road Administration of Iceland via Facebook/ Handout via Reuters. TPX images of the day

"I'm getting prepared in case I get a chance to visit my house and get some of my belongings," said Birgisdottir, who has moved to a summer house with her family.

Some residents had to be driven into Grindavik in emergency responders' cars, while most inhabitants were allowed to drive into Grindavik in their private cars accompanied by emergency personnel.

Most pets and farm animals had been rescued from Grindavik by Monday night, according to charity Dyrfinna.

Answer the following questions based on the article:

1. What is expected to happen in Iceland in the very near future? _____
2. What is the name of the town that has been evacuated? _____
3. What 2 tectonic plates is Iceland located on _____ & _____
4. What direction are they moving in? _____
5. What type of eruption is expected to occur? _____
6. How many people were evacuated over the weekend? _____
7. What is the capital of Iceland? _____
8. How far from the capital is the eruption expected to occur ? _____
9. How many earthquakes were recorded in the previous 2 days ? _____
10. Why did authorities construct a dyke ? _____
11. Why were residents of the town briefly allowed back to their homes?_____

5. *Comparison: Geothermal v other energy sources*

Give one reason for choosing Geothermal over the following energy sources.

(a) Fossil Fuels: ----------

(b) Hydropower: ----------

(c) Nuclear: ----------

Look for positives of Geothermal in Ireland as opposed to investments in the other energy options.

Give one reason for choosing to invest in geothermal in your home, rather than in solar panels**.**

_____

_____

_____

6. *Definition unscramble*

Geothermal Vocab Matching - Match the Word with the definition

	WORD	Ans	Definition
A	**Closed loop**		-it is a massive, irregularly shaped slab of solid rock, generally composed of both continental and oceanic lithosphere. Size can vary greatly, from a few hundred to thousands of kilometers across.
B	**Decarbonisation**		-it is defined as the increase in temperature with depth in the Earth. In normal continental crust it is approx. 26°C/km.
C	**Deep Geothermal Systems**		The amount of space in a rock in which fluids may be stored.
D	**District heating**		The supply of heat or hot water from one source to a district or a group of buildings.
E	**Eurasia**		-these are non-renewable, this means that their supply is limited and they will eventually run out. They formed from the decomposition of plants and animals from millions of years ago this is why they are called fossil fuels. Examples such as Coal, peat, Oil and Gas are some of the most important natural resources that we use every day.
F	**Fault Lines**		-these are an energy source that cannot be depleted and are able to supply a continuous source of clean energy. For example geothermal, wind, hydro, solar power
G	**Fossil Fuels**		-this involves continuously circulates the same fluid. The loop is filled just once. The same solution is used again and again in a closed loop!
H	**Ground Source Heat Pump**		-this is a geothermal system that pipes clean ground water directly from a nearby aquifer to an indoor geothermal heat pump. After the water leaves the home, it's expelled back through a discharge well, located a suitable distance from the first.
I	**Hot Spring**		-this is a heating/cooling system for buildings that uses a type of heat pump to transfer heat to or from the ground, taking advantage of the relative constancy of temperatures of the earth through the seasons. These systems transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer.
J	**Open loop**		-this is a measure of the ability of water to move through a rock.
K	**Permeability**		-this is a plate tectonic boundary consisting of most of Europe, Russia, and China.
L	**Porosity**		-this is essentially the warmth of the Earth's crust – from 1.5 meters deep all the way down to 300 or 400 meters deep. The heat originates from the earth's core and is therefore the cleanest and practically inexhaustible source of energy.
M	**Renewable Energy**		-this is the term used for removal or reduction of carbon dioxide (CO_2) output into the atmosphere by human activities. This is achieved by switching to low carbon energy sources.
N	**Shallow Geothermal Systems**		-this is *a crack in the Earth's lithosphere that occurs between two pieces of rock.*
O	**Tectonic Plate**		-this is a spring that is produced when geothermally heated groundwater emerges from the Earth's crust. Some have waters that are cool enough for bathing, but in volcanic areas water may come into contact with rock that has been heated by magma.
P	**Thermal Gradient**		-this involves deep drilling more than 400 m below the earth's surface.

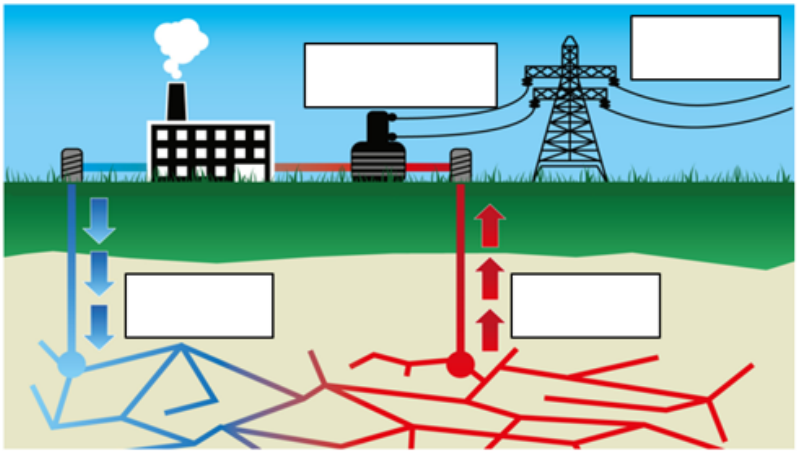
7. *Quiz – 21 questions to show you know your Geothermal !!*

1.	**Name the two tectonic plates on which Iceland lies.** (a) _____ (b) _____
2.	**What types of plate boundary does Iceland lie on?**
3.	**On what ocean ridge does Iceland lie ?**
4.	**At what rate do these plates diverge ?**
5.	**What is the most common rock type in Iceland?**
6.	**What characteristic of this rock makes it suitable for the geothermal process?**
7.	**At 1,000 to 2,000 metres below the surface, what is the temperature of the bedrock ?**
8.	**Briefly explain how geothermal electricity is generated in Iceland ?**
9.	**What are the remaining hot fluids used for after electricity generation in Iceland ?**
10.	**Are there any disadvantages to geothermal energy? Explain**
11.	**Name 4 other places in the world where geothermal energy is generated.** 1. 2. 3. 4.
12.	**List 5 advantages to harnessing Geothermal Energy** 1. 2. 3. 4. 5.
13.	**What is rock permeability ?**
14.	**Describe 2 characteristics of rock required for geothermal Energy to be viable.** **1._____ & 2._____**

15. **True or False**: Geothermal energy produces no pollutants or greenhouse gasses.

16. **Label the geothermal diagram below by outing the steps in correctly:**

- **Electricity generated**
- **Water pumped into wells**
- **Turbine rotates**
- **Heated water returns as steam**



17. **Tick the box: True or False**

		True	False
a	The deeper underground, the higher the temperature.		
b	Geothermal energy is non-renewable.		
c	Ground source heat pumps are used to create light.		
d	Geothermal plants can be constructed almost anywhere.		
e	Steam is the gaseous form of water.		
f	Geothermal reservoirs replenish naturally in a few days.		
g	Geothermal electricity production is very efficient.		

18 **List three Geothermal Projects that are operational in Ireland :**

1.
2.
3.

19. **Compare and contrast Ireland & Iceland's Geologic Locations:**

1._____
2._____
3._____

20. **What type of geothermal Energy is most suited to Ireland ?** _____
_____
_____.

21. **Explain briefly 2 reasons why are countries becoming more interested in Geothermal Energy now, even though its been used for centuries. ?**

1. _____
_____

2._____
_____

8. *Cloze test – Fill in the blanks from the word bank.*

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30marks

Fill in the blanks using the word bank:

Heating	**island**	**Geothermal Energy**	**CO2**	**Ground Source**	**solar**	**Eurasian**		
Northern	**heat**	**Italy**	**active**	**200**	**Geologists**	**Shopping**	**permeable**	
Ireland	**sandstones**	**Mid-Atlantic Ridge**	**heated**	**volcanic**	**cooled**			
geothermal gradient	**fossil fuel**	**magma**	**drilling**	**electricity**	**porous**	**grant**		

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In Paris, since the late 1960's investment in geothermal energy has seen them now heat 250,000 homes by drilling 1,500m and 2000m deep to access the water in underground aquifers. The water accessed is between 60° and 80°c. The bedrock is limestone and other sedimentary.

This is significant to Ireland as we are really at the start of our geothermal journey. _____ are looking for the optimal locations to drill. Indeed there has been some success stories in Ireland already, for example:

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The advantages of Ireland exploiting our geothermal potential are endless: the move away from f____ _____ fired heating systems to ground sourced thermal heating would allow for major reductions in ____. It would make us less dependent on global imports of fossil fuels and the uncertainty this brings. Also it brings down the costs to the business/homes. It is not reliant on weather conditions unlike _____, wind or hydro. In short, geothermal is a reliable constant source or energy for heating in Ireland.

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Draw a labelled diagram to accompany any part of this question:

9. Reading comprehension on Geothermal in Ireland.

What's the potential of geothermal energy for Irish agriculture?

Could the required energy come from under our feet?

Geysir sometimes known as The Great Geysir, is a geyser in southwestern Iceland.

WED, 12 JAN, 2022 - 18:29

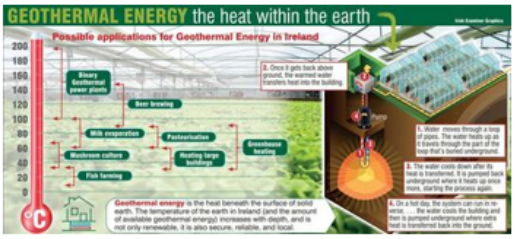
KATHLEEN O'SULLIVAN

It's more commonly associated with Iceland, the land of fire and ice, but advances in technology mean that geothermal energy can now be used in non-volcanic regions, such as Ireland.

A new Government report suggests geothermal could have significant potential for Irish farms, in processes such as heating and cooling buildings, and possibly even to produce electricity.

"Geothermal energy" is the term used to describe the heat beneath the surface of solid earth. It can be stored heat from the sun, or heat from the earth's core. This type of energy has been used for a long time in volcanic regions, such as Iceland, Italy, and New Zealand. However, recent developments have opened up the possibility for the technology to also be used in non-volcanic parts of the world, for example, its application for horticultural growing in the Netherlands. The technology could be revolutionary for sectors such as dairy, which uses large amounts of energy to heat and cool milk through the production process, and also horticulture.

The geothermal potential of Ireland is not yet fully understood, with the Government's draft policy statement on geothermal energy for a circular economy saying more research is needed. However, it could have significant environmental gains for Irish farming and the agri-food sector should it be found to be viable here. Minister for the Environment, Climate and Communications Eamon Ryan said geothermal energy is not only renewable, it is also secure, reliable, and local and has the potential to play a "significant" role in Ireland's transition to a carbon-neutral and circular economy.



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Dairy processing: Overseas, shallow geothermal resources have been used for aquaculture, such as in Huka Prawn Park, Taupo, New Zealand, and for soil warming. Low geothermal heating can be used effectively in traditionally energy-intensive horticultural operations, such as heating greenhouses to grow fruit, vegetables, and flowers, like in Slovenia and the Netherlands.

Low and mid geothermal resources can also be used to dry agricultural products, such as tomatoes, chillies, rice, cotton, and timber. The draft policy statement on geothermal energy for a circular economy

proposes that Irish geothermal resources could be used to increase the proportion of energy coming from renewable sources in agriculture, in particular, increasing the share of renewable heat in dairy farming.

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The last two decades have seen Ireland shift from an oil dominance for heating to near parity between oil and gas for heat supply. The largest and most consistent reduction in oil use for heat has come from the industry sector, with the agriculture and services sectors seeing smaller reductions. According to Teagasc, farm businesses are under "increasing pressure" to become more energy efficient. Barry Caslin, Teagasc energy and rural development specialist, said that, for these units, both air and ground-source heat pumps can be a good source of heat, and also for some horticultural operations.

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In Ireland, the geological features are very different from New Zealand, Italy or Iceland. However, more than 25% of the EU population lives in areas directly suitable for geothermal district heating. Luca Guglielmetti, senior researcher at the University of Geneva and part-time associate to the International Geothermal Association explained that there has been "a wave of geothermal developments" focusing on heating and cooling in non-volcanic regions in the last 10 years or so.

"There is a lot of potential for geothermal development because non-volcanic regions are the areas where there are the highest population densities and therefore, energy demand," he explained. "Where you have lots of people, you also have lots of people eating, and food production is responsible for about 30% of global emissions and this is huge.

"One of the main demands in agri-business is heating and cooling; you can see that there is a match between the configuration of the global energy system and what the food sector needs." Mr Guglielmetti emphasised geothermal is ***"not the solution, it is part of the solution".*** "To decarbonise the sector, specifically in areas where it's tricky or too expensive to produce electricity with geothermal, you should focus on the heating and cooling, and combine it with other renewables.

"In the agriculture sector, biomass can play a big role in producing power. It's great to integrate geothermal in agriculture but at the same time you have to combine it with other renewables to make it fully sustainable." Mr Guglielmetti said that there is a "lack of education about geothermal", and that one of the blockers to integrating it is that capital expenditures are relatively high.

"A farmer who already has an entire production framework implemented, and that works, and its cost fluctuates only because of the oil and gas, to integrate geothermal and other renewables they have to make also a technical transition," he said. "This is not something that you do overnight, it costs a lot, it's difficult. "To boost this in countries that don't have geothermal in the agri-business, we need pilots. "And pilots mean small-scale installations, different types of food products, and projects that cover the entire process from the resource assessment to the fork."

In its 2015 report on the use of geothermal energy in agriculture, the Food and Agriculture Organization (FAO) of the UN noted that start-up costs remain the main barrier to developing geothermal energy uses on a larger scale, especially in developing countries. This makes it "more necessary for governments to take a leading role in attracting investment and creating policy environments that support the sector", according to the FAO.

Read the Article from The Examiner. Answer the following questions.

1. Which sector does the government think could benefit from geothermal ?

2. What would geothermal be used for mostly to do ?

   _____ and _____.
3. What % of global greenhouse emission is food production responsible for ? _____.

4. Complete the sentence below:

"_____ cooling is the biggest driver of energy consumption on dairy farms, using ___% of the total amount, followed by water heating at 23% and the _____ machine at 20%."

5. According to the Sustainable Energy Authority of Ireland, What % of all energy consumption in Ireland is used for heat. _____.

6. According to the UN, what is the main barrier to developing geothermal energy on a large scale, especially in developing countries ? _____.

7. In your opinion, what is needed now in Ireland to promote development of geothermal energy ? _____
   _____.

8.According to the article, where would geothermal development have the biggest benefit. ?
_____.

Activities

Geothermal Energy

★ **Homework Activities** ★ **Retrieval Exercises**

★ **Revision Materials** ★ **Study Aids**

Geothermal Energy Ireland

electricity generation
ground source heat pump
hot spring
reliable
heating
porous
renewable
bedrock
potential
mantle
decarbonise
permeable
potential
Eurasia
cooling

Geothermal Energy Production in Iceland & Ireland

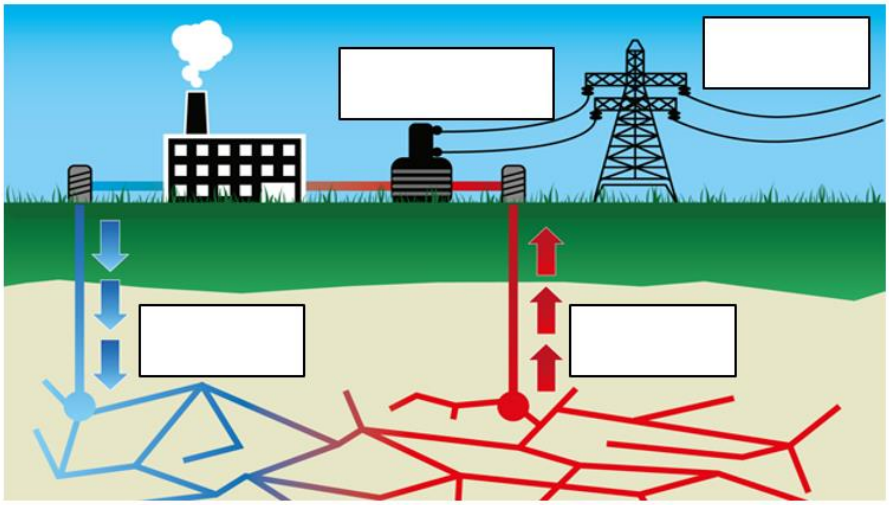
WORKSHEET

1.	**Name the two tectonic plates on which Iceland lies.** (a) _____ (b) _____
2.	**What types of plate boundary does Iceland lie on?**
3.	**On what ocean ridge does Iceland lie ?**
4.	**At what rate do these plates diverge ?**
5.	**What is the most common rock type in Iceland?**
6.	**What characteristic of this rock makes it suitable for the geothermal process?**
7.	**At 1,000 to 2,000 metres below the surface, what is the temperature of the bedrock ?**
8.	**Briefly explain how geothermal electricity is generated in Iceland ?**
9.	**What are the remaining hot fluids used for after electricity generation in Iceland ?**
10.	**Are there any disadvantages to geothermal energy? Explain**
11.	**Name 4 other places in the world where geothermal energy is generated.** 1. 2. 3. 4.
12.	**List 5 advantages to harnessing Geothermal Energy** 1. 2. 3. 4. 5.
13.	**What is rock permeability ?**
14.	**Describe 2 characteristics of rock required for geothermal Energy to be viable.** **1._____ & 2._____**

15. **True or False**: Geothermal energy produces no pollutants or greenhouse gasses.

16. **Label the geothermal diagram below by outing the steps in correctly:**

- **Electricity generated**
- **Water pumped into wells**
- **Turbine rotates**
- **Heated water returns as steam**



17. **Tick the box: True or False**

		True	False
a	The deeper underground, the higher the temperature.		
b	Geothermal energy is non-renewable.		
c	Ground source heat pumps are used to create light.		
d	Geothermal plants can be constructed almost anywhere.		
e	Steam is the gaseous form of water.		
f	Geothermal reservoirs replenish naturally in a few days.		
g	Geothermal electricity production is very efficient.		

18 **List three Geothermal Projects that are operational in Ireland :**

1.
2.
3.

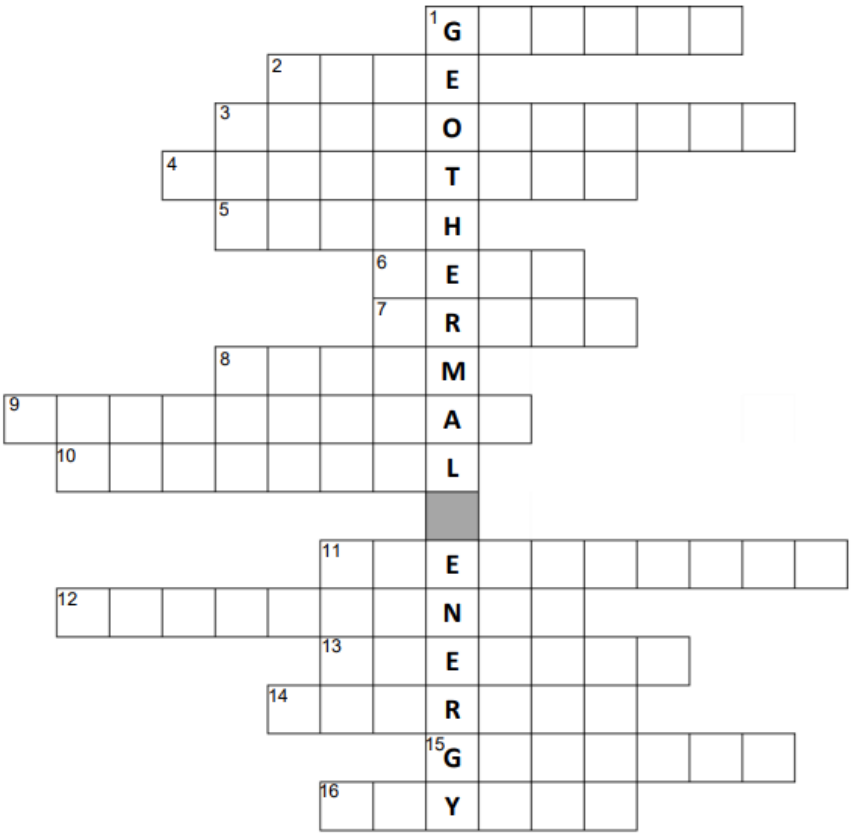
19. **Compare and contrast Ireland & Iceland's Geologic Locations:**

1._____
2._____
3._____

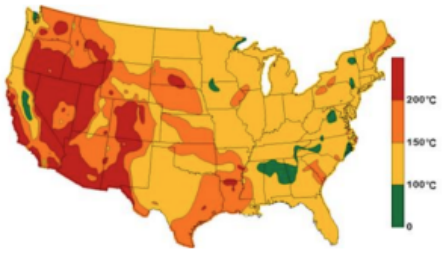
20. **What type of geothermal Energy is most suited to Ireland ?** _____
_____
_____.

21. **Explain briefly 2 reasons why are countries becoming more interested in Geothermal Energy now, even though its been used for centuries.** ?

1. _____
_____
2._____
_____



1. The earth beneath our feet,
2. The innermost part of the earth which generates heat.
3. Type of decay that contributes to geothermal energy.
4. Pumping fluids deep underground.
5. A type of tank used to convert hot water into steam.
6. A deep hole in the ground used to obtain water.
7. Outermost layer of the earth.
8. Vapour obtained from boiling water.
9. A type of loop installation for ground-source heat pumps.
10. A space saving version of the previous answer.
11. Energy created from Geothermal power plants.
12. Geothermal technology is said to be high in.....
13. Country with the largest geothermal market.
14. Renewable energy from the core of the earth.
15. The study of the earth's structure and substance.
16. A hot spring that produces hot water and steam.



The USA is the leading geothermal power market in the world.

Key Word Learning Grid

Igneous	Vertical/ horizontal	basalt	Plate tectonics	turbine	mantle
aquifer	deep	shallow	Mallow	Geothermal gradient	reliable
steam	granite	Domestic heating	Hot spring	drill	Closed loop
decarbonise	cooling	Ikea	Cliffs of Moher	investment	turbine
Heat pumps	permeable	porous	Paris Basin District Heating	fault	potential

Irish Independent Nov 14th 2023

LATEST | Iceland prepares to shield geothermal plant from risk of volcanic eruption

A road is damaged in the village of Grindavik, which was evacuated due to volcanic activity, in Iceland November 14, 2023. REUTERS/Ben Makori

Iceland is expecting a major volcanic eruption within days or even hours, as the pressure of lava beneath the ground accumulates at “an unprecedented rate”.

A river of molten rock is now just 2,500ft beneath the south-western town of Grindavik, about 40km from the capital, Reykjavik.

The eruption could cause major damage to the town, which was evacuated over the weekend as magma shifting beneath the Earth’s crust caused hundreds of earthquakes.

Located between the Eurasian and the North American tectonic plates, among the largest on the planet, Iceland is a seismic and volcanic hot spot as the two plates move in opposite directions.

Iceland, which has 33 active volcanic systems, has declared a state of emergency as experts say an eruption is imminent as the magma forces its way upwards on the Reykjanes peninsula. It is likely to happen at some point along a 16km-long fissure that has opened up near Grindavik, damaging buildings, causing cracks in roads and subsidence at a golf course.

The fissure continues into the sea so the eruption could take place on the ocean floor – an event which would send up a giant ash cloud as super-heated rock comes into contact with cold water. It is close to the Svartsengi geothermal plant, the main supplier of electricity and water to 30,000 residents as well as a freshwater reservoir. Grindavik, which has a population of 4,000, is also near the Blue Lagoon geothermal spa resort, one of Iceland’s main tourist attractions, which has been closed due to the uptick in seismic activity.

“We are really concerned about all the houses and the infrastructure in the area,” Vidir Reynisson, the head of Iceland’s civil protection agency said.

A tunnel of magma was at a depth of 5,000ft early on Saturday but is now rising towards the surface.

Icelandic authorities were on Tuesday preparing to build defence walls around a geothermal power plant in the southwestern part of the country that they hope will protect it from lava flows amid concerns of an imminent volcanic eruption.
Seismic activity and underground lava flows intensified on the Reykjanes peninsula near the capital Reykjavik over the weekend, prompting authorities to evacuate nearly 4,000 people from the fishing town of Grindavik on Saturday.

The probability of an eruption remained high despite a decrease in seismic activity, the Icelandic Meteorological Institute said in a statement on Tuesday.

Nearly 800 earthquakes were recorded in the area between midnight and noon on Tuesday, fewer than the two previous days, it said.

"Less seismic activity typically precedes an eruption, because you have come so close to the surface that you cannot build up a lot of tension to trigger large earthquakes," said Rikke Pedersen, who heads the Nordic Volcanological Centre based in Reykjavik.

"It should never be taken as a sign that an outbreak is not on the way," she said.

Authorities said they were preparing to construct a large dyke designed to divert lava flows around the Svartsengi geothermal power plant, located just over six kilometres from Grindavik.

Iceland's Justice Minister Gudrun Hafsteinsdottir told state broadcaster RUV that equipment and materials that could fill 20,000 trucks were being moved to the plant.

Construction of the protective dyke around the power station was awaiting formal approval from the government.

A spokesperson for HS Orka, operator of the power plant, said the plant supplies power to the entire country, although a disruption would not affect power supply to the capital Reykjavik.

Almost all of Grindavik's 3,800 inhabitants, who were evacuated over the weekend, were briefly allowed back in on Monday and Tuesday to collect their belongings, the Icelandic department of civil protection and emergency management said.

Grindavik resident Kristin Maria Birgisdottir, who works for the town municipality, told Reuters on Tuesday she only had the clothes she had worn for work on the day the town was evacuated.

Streetworks continue after cracks emerged on a road due to volcanic activity near Grindavik, Iceland obtained by Reuters on November 14, 2023. Road Administration of Iceland via Facebook/ Handout via Reuters. TPX images of the day

"I'm getting prepared in case I get a chance to visit my house and get some of my belongings," said Birgisdottir, who has moved to a summer house with her family.

Some residents had to be driven into Grindavik in emergency responders' cars, while most inhabitants were allowed to drive into Grindavik in their private cars accompanied by emergency personnel.

Most pets and farm animals had been rescued from Grindavik by Monday night, according to charity Dyrfinna.

Answer the following questions based on the article:

1. **What is expected to happen in Iceland in the very near future?** _____
2. **What is the name of the town that has been evacuated?** _____
3. **What 2 tectonic plates is Iceland located on** _____ **&** _____
4. **What direction are they moving in?** _____
5. **What type of eruption is expected to occur ?** _____
6. **How many people were evacuated over the weekend?** _____
7. **What is the capital of Iceland?** _____
8. **How far from the capital is the eruption expected to occur?** _____
9. **How many earthquakes were recorded in the previous 2 days?** _____
10. **Why did authorities construct a dyke?** _____
11. **Why were residents of the town briefly allowed back to their homes?**_____

Geothermal Vocab Matching - Match the Word with the definition

	WORD	Ans	Definition
A	**Closed loop**		-it is a massive, irregularly shaped slab of solid rock, generally composed of both continental and oceanic lithosphere. Size can vary greatly, from a few hundred to thousands of kilometers across.
B	**Decarbonisation**		-it is defined as the increase in temperature with depth in the Earth. In normal continental crust it is approx. 26°C/km.
C	**Deep Geothermal Systems**		The amount of space in a rock in which fluids may be stored.
D	**District heating**		The supply of heat or hot water from one source to a district or a group of buildings.
E	**Eurasia**		-these are non-renewable, this means that their supply is limited and they will eventually run out. They formed from the decomposition of plants and animals from millions of years ago this is why they are called fossil fuels. Examples such as Coal, peat, Oil and Gas are some of the most important natural resources that we use every day.
F	**Fault Lines**		-these are an energy source that cannot be depleted and are able to supply a continuous source of clean energy. For example geothermal, wind, hydro, solar power
G	**Fossil Fuels**		-this involves continuously circulates the same fluid. The loop is filled just once. The same solution is used again and again in a closed loop!
H	**Ground Source Heat Pump**		-this is a geothermal system that pipes clean ground water directly from a nearby aquifer to an indoor geothermal heat pump. After the water leaves the home, it's expelled back through a discharge well, located a suitable distance from the first.
I	**Hot Spring**		-this is a heating/cooling system for buildings that uses a type of heat pump to transfer heat to or from the ground, taking advantage of the relative constancy of temperatures of the earth through the seasons. These systems transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer.
J	**Open loop**		-this is a measure of the ability of water to move through a rock.
K	**Permeability**		-this is a plate tectonic boundary consisting of most of Europe, Russia, and China.
L	**Porosity**		-this is essentially the warmth of the Earth's crust – from 1.5 meters deep all the way down to 300 or 400 meters deep. The heat originates from the earth's core and is therefore the cleanest and practically inexhaustible source of energy.
M	**Renewable Energy**		-this is the term used for removal or reduction of carbon dioxide (CO2) output into the atmosphere by human activities. This is achieved by switching to low carbon energy sources.
N	**Shallow Geothermal Systems**		-this is *a crack in the Earth's lithosphere that occurs between two pieces of rock.*
O	**Tectonic Plate**		-this is a spring that is produced when geothermally heated groundwater emerges from the Earth's crust. Some have waters that are cool enough for bathing, but in volcanic areas water may come into contact with rock that has been heated by magma.
P	**Thermal Gradient**		-this involves deep drilling more than 400 m below the earth's surface.

What's the potential of geothermal energy for Irish agriculture?

Could the required energy come from under our feet?

Geysir sometimes known as The Great Geysir, is a geyser in southwestern Iceland.

WED, 12 JAN, 2022 - 18:29

KATHLEEN O'SULLIVAN

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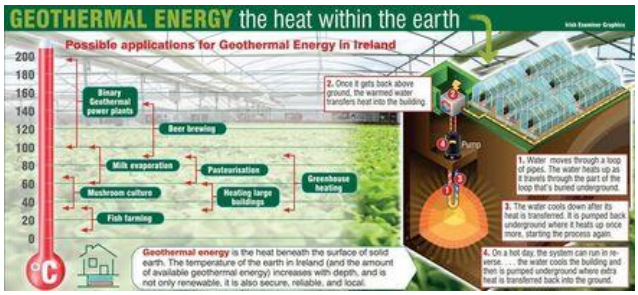

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5. According to the Sustainable Energy Authority of Ireland, What % of all energy consumption in Ireland is used for heat. _____.

6. According to the UN, what is the main barrier to developing geothermal energy on a large scale, especially in developing countries ? _____.

7. In your opinion, what is needed now in Ireland to promote development of geothermal energy ? _____
   _____.

8.According to the article, where would geothermal development have the biggest benefit. ?

_____.

Humans interact with the rock cycle in a number of ways. Describe and explain how this interaction with the rock cycle takes place, with reference to one of the following:

· Mining · Extracting Building Materials · Oil/Gas Exploitation · Geothermal Energy Production.

30marks

Fill in the blanks using the word bank:

Heating	**island**	**Geothermal Energy**	**CO2**	**Ground Source**	**solar**	**Eurasian**	**Northern**	**heat**	**Italy**
active	**200**	**Geologists**	**Shopping**	**permeable**	**Ireland**	**sandstones**	**Mid-Atlantic Ridge**	**heated**	**volcanic**
cooled	**geothermal gradient**	**fossil fuel**	**magma**	**drilling**	**electricity**	**porous**	**grant**		

Humans interact with the rock cycle in many different ways, I will explain this process by examining _____ _____ in _____. Yes, Ireland ! It is not a spelling mistake. Although Iceland is the poster boy of Geothermal energy, Ireland still can harness the energy from within.

Geothermal energy uses _____ from rocks (igneous rocks mostly) to heat water, turning it into steam and resulting in the creation of energy. This type of energy is produced in Iceland due to the endless amounts of _____ activity there. And many other volcanic areas too ie _____, Philippines and America.

Iceland sits on the middle of the __ - _____ _____, a constructive plate boundary with many active volcanoes. The Mid-Atlantic Ridge is a huge opening in the ocean floor created as the North American and _____ plates separate. Iceland was created when magma rose through this opening and cooled and hardened on the earth's surface, over time it built up creating an _____ called Iceland.

Over 90% of houses in Iceland are _____ naturally by geothermal energy, this type of energy is one of the cheapest and cleanest forms of energy that exists today. The _____ rises from the mantle and heats the rock close to the surface to around _____ degrees Celsius, this heats the water around the rocks.

But that's Iceland, now to Ireland. While we are distant from a plate boundary and have no _____ volcanoes and yes also our igneous rocks (granites in Leinster and basalt in Antrim) _____ millions of years ago, we still have potential. Despite all that, Ireland has excellent _____ geothermal energy reserves all over the country.

Our shallow groundwaters provide a stable resource of thermal energy that can be used to provide heating at a very high efficiency rate. _____ _____ Heat Pumps (GSHPs) are becoming more and more popular and with sufficient insulation these can be a very efficient method of _____ and cooling our homes and businesses.

We can look more to countries like Denmark and France to see that shallow Geothermal energy can provide heating, not _____ generation. To drill down 1km would generate water at 26°c approx. This is called the _____ _____. This would indeed be sufficient to heat district heating systems, swimming pools, schools and hospital and businesses. The geothermal gradient varies from place to place, but is estimated that in Ireland that gradient might be higher in the north east of the country (_____ Ireland)

In Paris, since the late 1960's investment in geothermal energy has seen them now heat 250,000 homes by drilling 1,500m and 2000m deep to access the water in underground aquifers. The water accessed is between 60° and 80°c. The bedrock is limestone and other sedimentary.

This is significant to Ireland as we are really at the start of our geothermal journey. _____ are looking for the optimal locations to drill. Indeed there has been some success stories in Ireland already, for example:

- Cliffs of Moher & Ikea in Ballymun: both uses ground source heats pumps for heating and cooling the buildings. Ikea drilled over 150 boreholes to generate almost half its heating requirements.

- Mallow swimming pool is heated by an underground thermal spring. Four 500m deep wells heat the pool to almost 20^{0}c. There are over 40 of these springs documented in Ireland so the potential to exploit this shallow geothermal energy is vast.
- The Athlone Town _____ centre & Sheraton Hotel.

All these projects use shallow geothermal energy (< 400m) for heating with a heat pump to circulate the water.

The best places to harness this hidden heat are where the rocks are both p_____ and _____. The porosity of a rock is a measure of its ability to hold a fluid. This is the open spaces available in a rock (as a %). Permeability is a measure of the ease of flow of a fluid through a porous solid. Rocks that commonly have high permeability are conglomerates, s_____, basalt, and certain (few) limestones – although Irish limestone is not very permeable. Permeability in sandstones and conglomerates is high because of the relatively large, interconnected pore spaces between the grains.

The advantages of Ireland exploiting our geothermal potential are endless: the move away from f____ _____ fired heating systems to ground sourced thermal heating would allow for major reductions in ____. It would make us less dependent on global imports of fossil fuels and the uncertainty this brings. Also it brings down the costs to the business/homes. It is not reliant on weather conditions unlike _____, wind or hydro. In short, geothermal is a reliable constant source or energy for heating in Ireland.

The limitations so far in Ireland have been : - Investment: _____ is expensive and public investment in green technologies is vital if we are to meet our climate goals by 2030. Private investment also needs to be encouraged by policy and tax incentives. Currently there is a _____ of €3500 to install geothermal heat pump in your home.

Indeed, the first urban, deep test hole in Dublin (1km down) is showing temperatures of over 38.5^{0}c. So Ireland like many countries, centrally placed on a tectonic plate can indeed drill down and release the radioactive heat from with the earth

Draw a labelled diagram to accompany any part of this question:

Iceland V Ireland

Compare and contrast the settings, suitability and usage of geothermal energy in these two countries.

Characteristics	Ireland	Iceland
		
Location		
Tectonic Plates		
Rock Types		
Main source of energy		
Geothermal Gradient		
Geothermal Uses		
Potential		
Disadvantages		