**Day 9: Issues in Generating Electricity** **12.5, 12.8** **Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

This lesson assumes that students have already learnt about climate change and about the various ways of generating electricity. This lesson is designed to have them consider which methods should be used.

The electricity that comes from outlets can be generated by a variety of means. It can be generated by turbines that are rotated by water (hydro, tidal), steam (nuclear, coal, natural gas, geothermal) or wind. It can also come from solar cells. What methods should be used to supply the growing need?

This lesson came out of my frustration with what a poor job our textbook did on this incredibly important topic. Students need to know how important and difficult this problem is. They need to know that it is a global problem and getting increasingly more serious. They also need to know that there are solutions, but they aren’t simple. This lesson has students learn how to use a variety of graphical sources of information.

1. Look at page 536 -537 Science Perspectives 9 (Nelson).

This first question deals with information in the textbook and could be skipped or altered to use a better resource. Do coal as an example to speed up and improve the group work that follows.

1. Figure 1: What % of **Ontario’s** electrical energy comes from **coal**? (0%, 5%, 10%, 15%, 20%, 25%)
15%: Look at Figure 1 on page 536 and estimate.
2. Table 1: What % of **Canada’s** electrical energy comes from **coal**? (0%, 5%, 10%, 15%, 20%, 25%)
20%, look at Table 1 on page 536 and estimate.
3. Table 2: Increased carbon dioxide causes climate change. Does this method produce CO2? (Yes, No) Yes.

This next question has been removed because of new understanding.

Is this a non- renewable resource? (Yes, No) Yes, about 100 years left.

<http://www.worldcoal.org/coal/where-is-coal-found/>

Whether or not the various fuels are renewable is just be a distraction because we will destroy ourselves through runaway climate change, well-before we run out of fossil fuels. The reserves of natural gas are actually increasing because we are looking harder and improving technologies for its extraction. <http://energyeducation.ca/encyclopedia/Natural_gas_reserve>

1. Some energy sources are variable and need to be stored. There are large energy losses when energy is transferred from one form to another for storage. Does this energy require storage? (Yes, No) No

Note: Energy that needs storing can be stored in batteries, capacitors or pumped water behind a hydro dam. If energy sources are attached to a large smart grid, there is less need for storage. In this case energy that needs storage is used first and distributed where needed.

1. Should this method increase, continue or decrease? Why? (decrease) CO2, supplies running out and it produces air + water pollution (mercury, SO2, NO2). Information can be found in 12.5 (521, 523)
2. Answer the above questions for the type of electricity generation that your group is assigned and fill in the table with the results for each energy type.

After researching, each group presents their results or enters it into a large table that all can see. Students record the results of all groups in the table below. The reasons for the future choice may need teacher help. Go over the results as a class. Nuclear should be done by teacher afterwards.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Ont | Can | CO2 | Store | Future |
| coal | 15 | 20 | **yes** | no | **Decrease**: CO2 and air and water pollution |
| gas | 10 | 5, 10 | **yes** | no | **Decrease**: CO2 (flammable, toxic) |
| oil | 0 | 0 | **yes** | no | **Decrease**, CO2, (oil spills) |
| biomass | 0 | 0 | no | no | **Increase** but limited yearly supplies |
| tidal | 0 | 0 | no | no | **Increase** but very limited sites |
| hydro | 25 | 70 | no | no | **Increase** but limited sites |
| wind | 0 | 0 | no | **yes** | **Increase** but expensive, limited sites |
| solar | 0 | 0 | no | **yes** | **Increase** but expensive, needs large area |
| geothermal | 0 | 0 | no | no | **Increase** but very limited sites |
| nuclear | 50 | 20 | no | no | ???? danger from radioactivity ??????  |

1. The use of nuclear energy is very controversial. This method needs much more teacher guidance. At the end of this class they should have a sense that nuclear energy is problematic but may be necessary.

**The discussion of how long supplies will last has been removed. It is a distraction from the much more important considerations.**

How long will supplies last? <http://www.scientificamerican.com/article/how-long-will-global-uranium-deposits-last/> <http://phys.org/news/2011-05-nuclear-power-world-energy.html>

A recent Scientific American article argues that present types of fuel could last **500 years** with enrichment and fuel from sea water and breeder reactors would extend this to **100, 000 years** which means we should classify it as ‘renewable’. <http://www.scientificamerican.com/article/how-long-will-global-uranium-deposits-last/>

1. Is nuclear power dangerous under normal operations?

No. The waste is safer than the waste from coal. This article points out that ash emitted from **coal plants results in 50 to 100 times more radiation** ingested by nearby populations. However, even this is just a few percent of normal background radiation, less than an x-ray. <http://www.scientificamerican.com/article/coal-ash-is-more-radioactive-than-nuclear-waste/>

No. The waste is dangerous, but a coal plant produces **300, 000 tons of toxic waste vs. a nuclear plant’s 20 tons** of long-lasting radioactive waste. <http://homeguides.sfgate.com/one-better-environment-coal-nuclear-78760.html>

No. This NASA article says that nuclear power prevented 1.8 **billion** deaths between 1971 and 2009 vs. the **thousands** it caused. (This was due to reduced pollution.) It says that if nuclear were replaced with natural gas in the future (much cleaner than coal) this would still result in **40 times** more deaths per energy unit than nuclear because of climate change. <http://climate.nasa.gov/news/903/>

1. What about natural disasters or war?

Fukushima (2011) is an example of why nuclear plants should only be built in stable environments. However, it is also worth noting that this natural disaster caused **hundreds of thousands** of deaths and the nuclear problem will ultimately result in only **hundreds** of deaths.

Chernobyl (1986) was a disaster that could have been prevented. The deaths at the time and later are in the **thousands**.

It may be possible to make nuclear plants reasonably safe from natural disasters but it is still hard to know how to factor in danger from military conflicts – either from diverting the nuclear power into weapons or bombing a nuclear plant.

1. The textbook information stops in 2005 and doesn’t consider the whole world. This graph provides more up-to-date information. <http://energyeducation.ca/encyclopedia/Electricity>

Go to the bottom of the page. Select bar graph and press the play button to animate the graph to show changes from 1965 to 2013. This graph is easier for students to understand than the more abstract line graphs. Later, you might want to switch to the line graph to show a frozen picture of the time changes.

1. Choose ‘bar graph’ and look at the regions of the world. When you push the play button, you can see how the numbers have changed from 1965 to 2013. What was the biggest change?

Asia’s consumption grew rapidly (quadrupled) while every other region only grew slightly. This is partially because of the greater rate of population growth but it is mainly due to economic growth.

Students might interpret this graph to mean that people in Asia are being energy gluttons. This is not the case. Canadians use ten times as much energy **per person** as people in third world countries.

The world population is presently at 7 billion and expected to level off at 10 billion. <http://www.ted.com/talks/hans_rosling_religions_and_babies?language=en> However, this does not mean that energy consumption will also level off. It will continue to increase as more people improve their economic condition.

Each of the following questions has the students ‘predict’ (post-dict?) what a specific energy source was like in the past. They use their knowledge rather than just learning a bunch of facts. Afterwards, they could try making predictions for the future.

1. **Coal**: **Predict** what you will see when the play button is pushed. **Observe**.

The change for coal is even more dramatic than that of overall electrical energy consumption. Asia’s consumption increased ten times. Europe decreased and N. America stayed level. Coal generation of electricity is one of the easiest methods to implement. The problem of CO2 emissions is a world-wide problem that is getting worse.

1. **Natural Gas**: **Predict** what you will see when the play button is pushed. **Observe**.

There was growth everywhere but leveling off in Europe. Natural gas results in cleaner air and water than coal, however it still produces CO2. In the short term, the CO2 is harmless, but its long term effects are disastrous. Why isn’t Europe’s consumption increasing? What is Europe switching to?

1. **Hydro**: **Predict** what you will see when the play button is pushed. **Observe**.

There was lots of growth but it levelled off in N. Am. and Europe. Their best sites are already used.

1. **Nuclear**: **Predict** what you will see when the play button is pushed. **Observe**.

Large growth until 1985 and then it levelled off because public perception of dangers.

1. **Solar**: **Predict** what you will see when the play button is pushed. **Observe**.

There was huge growth, but only since 2010. This is a result of environmental/economic pressures driving technological development and political will.

1. **Wind**: **Predict** what you will see when the play button is pushed. **Observe**.

Huge growth since 2005. Very similar to solar.

1. It is extremely important that we produce electrical energy without producing CO2. <http://energyeducation.ca/encyclopedia/Electricity_generation>
2. What is the % of energy generated in the world by the non-CO2 sources?

The previous bar graphs may make it look like non-CO2 energy sources are significant sources of energy because of the different scales used. This second set of graphs clears up this misconception Hydro and nuclear are the only significant non-CO2 sources (16% and 11%). The other ‘green’ energy sources are so small that you can hardly see them. You need to hold your mouse over the section of the pie to see that solar/wind is 3%, Bio is 2% and tidal is not there at all.

1. Select North America and then Canada. Why is there such a big difference with the world average?

Canada uses 60+15+2+1 = 74% non-CO2 electrical energy generation. Why are we doing so well? This is not because we are more environmentally conscious. We happen to have some great hydro sites – like Niagara Falls.

1. **Contest**: Not every country has access to waterfalls for hydro generation or . Predict which country has the highest non-hydro, non-CO2 electrical energy production.

Each group discusses and then writes down one name. Most will realize that European countries are the best bet from the investigation 4c). Eastern Europe is not a good choice – this shows the difference that politics can make. It is not Norway (100%) or Switzerland (56%) because they happen to have so much hydro. It is also not Iceland which has 70% hydro and 30% geothermal.

The winner is France, which has invested heavily in nuclear (74%) starting in 1980. Other countries with significant nuclear investment are Belgium (49%) and Switzer land (37%). All three countries have not increased their nuclear for the past two decades.

Which country does the best without investing heavily in nuclear power? The winner is **Denmark**, at 51%! Look at the pie charts for earlier years. Ten years earlier Denmark was 19 % and ten years before that, it was only 5%. This shows what is possible with political will and emerging technologies.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Solar/wind | Bio/waste | geothermal | total |
| **Denmark** | **34** | **17** | **0** | **51** |
| Portugal | 25 | 7 | 0 | 32 |
| Iceland | 0 | 0 | 30 | 30 |
| Spain | 25 | 2 | 0 | 27 |
| Germany | 14 | 9 | 0 | 23 |
| Italy | 13 | 5 | 0 | 18 |
| Finland | 1 | 16 | 0 | 17 |
| Ireland | 15 | 2 | 0 | 17 |
| Lithuania | 12 | 5 |   0 | 17 |
| Belgium | 8 | 7 | 0 | 15 |
| Netherland | 8 | 6 | 0 | 14 |
| Austria | 6 | 8 | 0 | 14 |
| England | 8 | 6 | 0 | 14 |
| Netherlands | 5 | 9 | 0 | 14 |
| Sweden | 6 | 7 | 0 | 13 |

Note: Peat should be classified as a fossil fuel as it takes too long a long time to create – unlike biofuels.

Denmark’s energy production is the result of a strong political push, emerging technologies and a good location for wind energy. It now supplies 90% of off-shore wind generators around the world. As another example, take a look at the scale of this wind project for Holland. Gemini Windpark animation <https://www.youtube.com/watch?v=Q65mgPeygC8>.

1. How much of the world’s electrical energy do you think can come from ‘green’ sources in the next twenty years? (Green energy sources do not produce CO2 or nuclear waste.) Explain. Where should the rest of the energy come from? Explain.
2. 30% B) 50 % C) 70% D) 90%
* The world in 2013 was at 21%. How much higher can it go in twelve years?
* The previous graph showed huge growth in solar and especially wind in the past decade.
* Europe shows the possibilities. Denmark was able to go from 5% to 50% in twenty years.
* All countries can increase biofuels/waste.
* Dry and low latitude countries can especially increase solar.
* Oceanic countries can greatly increase wind and maybe tidal.
* Developing countries can increase hydro.

30% is pretty certain. That is just a 9% increase in 12 years. Technology will improve and get cheaper.

50% is possible if there is a strong political push and if change happens in India and China.

* If 70% and 90% are not realistic, then we need to encourage nuclear as a solution, at least temporarily.
* The purpose of this lesson was to help students recognize the scale of the problem; it is global and increasingly serious. Later lessons should look at reducing the growth in electrical energy consumption through conservation efforts and more efficient machinery. Students should also look at the various large-scale plans for sequestering C02. There are no simple solutions – but there are solutions. We don’t want to leave the students feeling powerless.

 **Textbook reinforcement: Read pages 518 - 528**

1. The textbook gives each source of energy about the same importance.
2. It makes hydro and tidal generation look equally important. Are they? Explain.

No! Hydro is 16% world-wide and 60% of Canada’s. Tidal is so small that it doesn’t even show up.

1. On pages 521-522, 524-525 it makes geo and bio look equally important. Are they? Explain.

No! Only Iceland has a significant source of geothermal energy. Europe shows that all countries could have 15-20% bio/waste generation.

1. On pages 521 and 523 – 524 it compares coal, oil, natural gas and nuclear fuels for thermal generation. They seem equally good and bad. Are they? Explain

No! Coal is the worse than oil and gas because of air and water pollution. However, this is just a short term consideration. Over the long term, all three are equally bad because of their CO2 emissions. The facts that natural gas is ‘clean’, convenient and that sources are growing is preventing the world from dealing with the more important long-term problem.

Nuclear power is a safer short-term solution. The worst case scenarios for nuclear waste are less devastating and more localized.

Interesting graphic:



Note: The renewable show per year and the non-renewables show remaining reserves. OTEC is ocean thermal energy conversion.

<http://c1cleantechnicacom.wpengine.netdna-cdn.com/files/2013/02/renewable-energy-reserves.png>