Tomorrow's energy scenarios

One of EirGrid's roles is to make sure that Ireland's electricity ***transmission grid*** is appropriate to meet future needs. How it does this will depend on what path we choose to meet our national energy demand while complying with our international commitments.

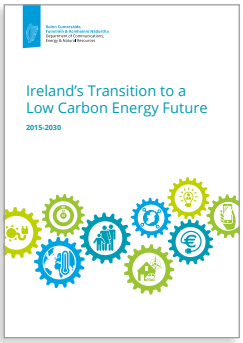
Ireland's energy

Following the economic downturn in 2008, Ireland's ***primary energy*** use dropped about 20%. Then in 2015 there was a significant increase in energy use. Economic activity increased by 4.8% and there was a corresponding increase in energy use (4.9%) and in carbon dioxide emissions (5.8%). About 88% of the energy was derived from ***fossil fuels***.

Renewable energy accounted for about 25% of the country's total electricity needs or about 9% of our total energy requirement. This is more than half way towards meeting the 2020 target of producing 16% of our total energy from renewable sources. (SEAI 2016 Report: *Renewable Electricity in Ireland 2015*.)

Ireland's energy and emissions targets

In 2015, the Irish government released a white paper entitled '***Ireland's Transition to a Low Carbon Future 2015 – 2030***'.
It outlined further steps towards reducing dependence on fossil fuels over the coming years so that we can meet both the energy and ***emissions targets*** for 2020, 2030 and 2050 to which we are committed. These are described below.



The 2020 target
The EU has set a target that 16% of Ireland's energy consumption must come from renewable sources by 2020.
In order to achieve this, the government split the renewable energy target into three sectors – 40% from electricity, 12% from heat, and 10% from transport.Based on the progress made to date, it is likely that Ireland will meet its electricity target by 2020 or very shortly afterwards.

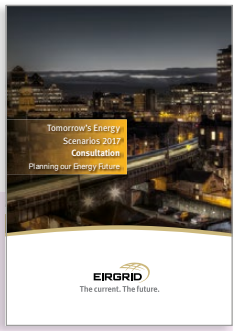
The 2030 target
The EU has set a target of reducing ***greenhouse gas*** emissions by 40% in 2030 compared to 1990 levels. In order to achieve this, EU-wide targets have been set for power generation, large industrial plants and aviation while each EU member state has been given individual targets in the areas of agriculture, heating and transport. Ireland has been allowed some flexibility with regard to some of these targets and so there is some uncertainty as to what the final target will be. We may see up to 65% of electricity coming from ***low carbon generation*** by 2030.

Between 1990 and 2015 our greenhouse gas emissions actually increased by almost 25%.

The 2050 target
The EU ambition is to reduce greenhouse gas emissions by 80-95% by 2050, compared to 1990 levels. The targets for 2020 and 2030 are milestones along that path. It is likely further energy and emissions targets will be set in the future.

Four scenarios

In order to help plan and operate the future transmission system, EirGrid have developed four different 'future possibilities' or ***scenarios*** to help plan the system with future uncertainties. These are presented here.



Scenario 1: Steady Evolution
Renewable electricity generation grows at a steady pace with economic growth and improved technologies for electricity generation. New technologies raise awareness of the need to make more efficient use of energy. There is growing use of electric vehicles and ***heat pumps***. This means that, over time, electricity powers a larger proportion of transportation and heating.

Highlights
- Onshore wind generation increases to approximately 5,200 ***MW*** by 2030
- A new 700 MW ***interconnector*** to Europe is in place by 2025
- Ireland's 2030 emissions targets are met.

Scenario 2: Low Carbon Living

The economy enjoys high economic growth. This encourages the development of new technologies for low carbon electricity generation. There is strong public demand to reduce greenhouse gas emissions. There is growth in ***renewables*** driven by incentives and high carbon taxes. This clean energy then combines with improvements to ***broadband*** and transport to drive growth in large data centres.

Highlights
- The total demand for electricity increases by 60% by 2030 compared to today
- ***Data centre*** demand increases from about 300 MW (2017) to almost 2000 in 2030 — and most of these are based in Dublin
- Coal generation is ***repowered*** to gas and peat generation is repowered to ***biomass*** by 2025.

Scenario 3: Slow Change

The economy experiences very slow growth and so there is little investment in novel renewable electricity generation. There is also little growth in domestic and industrial renewable energy systems. Therefore there is little change in the way electricity is generated when compared to today. The only source of demand growth is the connection of new data centres but the level of investment slows down significantly after 2025.

Highlights
- Coal generation remains on the power system beyond 2030
- The total demand for electricity increases by 28% by 2030 compared to 2017
- Ireland's 2030 emissions targets are missed.

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Scenario 4: Consumer Action

A strong economy leads to high levels of consumer spending. The public want to reduce greenhouse gas emissions. Electricity consumers enthusiastically limit their energy use and generate their own energy. This results in a large number of community led energy projects and a rapid adoption of electric vehicles and heat pumps in the home.

Highlights

- There are almost 300,000 electric vehicles on the road by 2030
- 17% of residential houses are heated through heat pumps by 2030
- Household batteries and solar PV help to increase self-consumption of electricity.

Solar thermal and photovoltaics (PV)

There are two main kinds of solar panels. Solar thermal panels typically heat water which is then stored in a hot water cylinder. Photovoltaic panels convert light energy to electrical energy which can then be stored in batteries.

Heat pumps

Currently over 80% of the country's energy supply is derived from imported fossil fuels. About one third of this energy is used for heating. The use of heat pumps could reduce this significantly. A refrigerator moves heat from the inside to the outside (usually via a grill or radiator at the back). A heat pump works in a similar way; it moves heat energy from one place to another. It can extract heat from the air or from the ground (and so cool it) and release that heat inside a building.

In the case of an electric heater every ***kWh*** (kilowatt-hour) of electrical energy produces one kWh of thermal energy. In the case of a heat pump every kWh of electrical energy produces one kWh of thermal energy but also moves another two or three kWh of thermal energy, typically from the ground, to a building. (1 kWh equals 3.6 million ***joules***)

In each of the scenarios outlined above much greater use of heat pumps is envisaged.

Summary of expected effects

According to each of the four scenarios outlined above there would be an increased electricity requirement of between 30% and 60%. However, they also indicate a decrease in fossil fuel capacity of between 20% and 30% as well as a very substantial increase in renewable energy sources.

Expected growth in the particular energy sources from 2016 to 2030	Steady Evolution	Low Carbon Living	Slow Change	Consumer Action
Electricity Requirement	32%	60%	28%	55%
Fossil Fuels	-22%	-31%	-21%	-24%
Gas Capacity	12%	1.4%	-9%	12%
Renewable Generation	108%	230%	70%	150%
Heat Pump Capacity	900%	1270%	400%	1600%

EIRGRID

EirGrid is responsible for a safe, secure and reliable supply of electricity: Now and in the future.

We develop, manage and operate the electricity transmission grid. This brings power from where it is generated to where it is needed – throughout Ireland. We use our grid to supply power to industry and businesses that use large amounts of electricity.

Our grid also powers the distribution network. This supplies the electricity you use everyday in your homes, businesses, schools, hospitals, and farms.

We develop new electricity infrastructure only when required. EirGrid is a state-owned company. We answer to government and to regulators. We work for the benefit and safety of every citizen in Ireland; we abide by strict laws and safety standards.

You can find out more about the work of EirGrid at **www.EirGrid.com**

The EirGrid National Control Centre

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Syllabus References

The main syllabus references for the lesson are:

Leaving Certificate Physics

- Electric current as a flow of charge. 1 A = 1 C s^{-1}
- Sources of emf and electric current.
  Potential difference (voltage) … measured in volts. (p.35)
- Structure and principle of operation of simple a.c. generator.
- Conversion of a.c. to d.c. Practical applications. (p.44)

Leaving Certificate Technology

- Electricity as a form of energy distribution. Basic electrical concepts: electric current, voltage, resistance, power and the relationship between them. The units in which electric current, voltage, resistance, power and frequency are measured (p.22)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- Explain why decisions regarding future energy supplies have implications for the development of the transmission grid.
- Outline Ireland's 2020, 2030 and 2050 energy targets.
- Explain what is meant by 'emissions targets' and how they relate to the energy targets.
- Outline the 'four scenarios' presented in the lesson, discuss the differences between and describe the extent to which they address the energy and emissions targets.

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- Ireland is committed to energy targets for 2020, 2030 and 2050. These all involve reduction in dependence on fossil fuels and growth in renewable sources of energy such as solar, heat pumps and biomass.
- Ireland also has corresponding commitments to reduce greenhouse gas emissions to 40% less than 1990 levels by 2030.
- The ambitious goal is to reduce greenhouse gas emissions to 80-95% less than 1990 levels by 2050.
- Four different scenarios have been presented in which the effects of various actions can be compared.
- These scenarios all forecast an increased demand for electricity by up to 60%. However, they also indicate a decrease in fossil fuel use of 20% or more.

Student Activities

The table (right) shows the amount of energy used per person per annum in a number of countries. The unit used is the 'kilogram-of-oil-equivalent per annum' (kgoe/a). 1 kgoe ≈ 42 MJ = 0.042 GJ.

	kgoe/a
Bangladesh	209
Pakistan	487
India	566
Zambia	628
North Korea	761
Brazil	1363
Ireland	3218
UK	3254
France	4031
South Korea	5060
Sweden	5468
Australia	5593
USA	7165
Canada	7380
UAE	8272

1. Draw a barchart to represent the data. Compare Bangladesh and Ireland in terms of energy per capita.
2. Show that the number of seconds in a year is 31,557,600.
3. Convert the numbers in the table to the equivalent in **GJ/a** (gigajoules per annum) and write them in another column. (The figure for Bangladesh should be 8.77 GJ/a per capita.)
4. Add another column labelled **W** (watt per person). The required data can be found by dividing the GJ/a by the number of seconds in a year.
   (Don't forget to multiply by 10^9 to convert gigajoules to joules.)
5. What steps can individuals or families take to reduce their total demand for energy under the headings: Transport, Heating and Electricity.

True/False Questions

a) Following the economic downturn in 2008 Ireland's primary energy use dropped about 2%. **T F**

b) In the future the percentage of primary energy going to electricity generation is expected to fall. **T F**

c) Primary energy is energy coming directly from the Sun. **T F**

d) About 50% of Ireland's energy supplies come from renewable sources. **T F**

e) Half of our imported fuel is used for transport and half for electricity generation. **T F**

f) By 2020 40% of our electricity supply should be generated from renewable sources. **T F**

g) By 2030 our greenhouse gas emissions should be down to 1990 levels. **T F**

h) By 2050 the demand for electricity is forecast to drop by 28%. **T F**

i) By 2030 there will be a 200% increase in the use of heat pumps. **T F**

Check your answers to these questions on www.sta.ie.

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Examination Questions

Leaving Certificate Physics (HL) 2016, Q. 7 (part)
At a lecture in Cork in 1843, James Joule, while describing his work on heat and temperature, suggested the principle of conservation of energy. Later in the nineteenth century, the work of Joule and Lord Kelvin led to the invention of the heat pump.

In a heat pump, a fluid is used to transfer energy from a cold body to a warmer body. Describe the operation of a heat pump and explain how a heat pump can be used to reduce the temperature of a cold region, for example the interior of a refrigerator.

State two desirable physical properties of the fluid used in a heat pump. The fluid in the heat pump of a refrigerator has a specific latent heat of vaporisation of 4.6 MJ kg^{-1}. The internal volume of the refrigerator is 0.6 m^3. The heat pump removes 12 kJ of energy from the air in the refrigerator as the fluid evaporates.

Calculate the mass of fluid that has evaporated and the fall in temperature of the air in the refrigerator.
(*specific heat capacity of water* = 4200 J kg^{-1} K^{-1}; *acceleration due to gravity* = 9.8 m s^{-2}; *density of air* = 1.23 kg m^{-3}; *specific heat capacity of air* = 1005 J kg^{-1} K^{-1})

Leaving Certificate Physics (HL) 2013, Q. 8 b
Electricity generating companies transmit electricity over large distances at high voltage. Explain why high voltage is used.
A 3 km length of aluminium wire is used to carry a current of 250 A. The wire has a circular cross-section of diameter 18 mm.

(i) Calculate the resistance of the aluminium wire.

(ii) Calculate how much electrical energy is converted to heat energy in the wire in ten minutes.
(*resistivity of aluminium* = 2.8×10^{-8} Ω m)

Leaving Certificate Physics (OL) 2015, Q. 9

(a) A glass bottle is filled with 0.75 kg of water at a temperature of 20° C. The bottle is then placed in a freezer, which freezes the water and cools it to −15° C. Calculate the energy removed from the water.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of fusion of water = 3.3×10^5 J kg^{-1}
specific heat capacity of ice = 2200 J kg^{-1} K^{-1}.

(b) The power rating of the freezer is 300 W. How long will it take for the freezer to remove 9000 J of energy from the water?

(c) The freezer is an example of a heat pump. Outline the operation of a heat pump.

Leaving Certificate Geography (OL) 2007, Q. 9 B
The Stern Report predicts that global warming could shrink the world's economy by 20% unless action is taken now.

(i) Describe two effects of global warming.

(ii) Describe two actions that could be taken to reduce these effects.

Did You Know?

Provision of electricity in Ireland

- EirGrid Group (including EirGrid and SONI), a state-owned company, has an all-island remit to plan and operate the electricity transmission system.
- EirGrid operates and develops the national high voltage electricity grid in Ireland and SONI is the electricity System Operator for Northern Ireland.
- The grid moves wholesale power around the island of Ireland. It brings energy from generation stations to heavy industry and high-tech users. It also supplies the distribution network operated by ESB Networks and NIE Networks that powers every electricity customer on the island.
- To make sure the lights stay on throughout the island, a team of staff operate the grid from National Control Centres (NCCs) in Dublin and Belfast. The NCCs carry out the intricate task of matching electricity production to customer demand.
- EirGrid is independent from ESB. EirGrid operates the flow of power on the grid and plans for its future, while ESB Networks is responsible for carrying out maintenance, repairs and construction on the grid. Northern Ireland Electricity (NIE) operates the electricity network in Northern Ireland. (Power is provided by a number of generators.)

Historical Notes

Heat pumps

Refrigerators, air conditioners and heat pumps all work on the same principle. When a gas is compressed it gets hot and can act as a source of heat. If the pressure is then removed, the gas expands and cools.

The Scottish scientist **William Cullen** is usually identified as the inventor of the refrigerator. His was manually operated. Lord Kelvin developed the idea further in 1852. Around 1856 Peter von Rittinger built a working heat pump system driven by a water wheel. **Robert C. Webber** built the first ground source heat pump during the late 1940s. Having burned his hand on the outlet pipes of his freezer he decided to reverse the system and extract heat from the ground. It worked so well that he modified it in order to heat his entire house.

Heat pumps provide efficient and cost effective heating in the market place. Unlike solar thermal panels, heat pumps can operate 24 hours a day.

Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

biomass, broadband, data centre, emissions targets, fossil fuels, greenhouse gas, heat pump, interconnector, joule, kWh (kilowatt-hour), low carbon generation, MW, primary energy, renewables, repowered, scenario, transmission grid.

Check the Glossary of terms for this lesson on www.sta.ie