Energy Production IB Physics Content Guide

Big Ideas

- Most energy sources can be traced back the sun, our ultimate primary source
- No energy source can be converted to electricity with 100% efficiency
- All energy sources have advantages and drawbacks and it important to understand the complete picture
- Every object with a temperature above 0 K emits thermal radiation
- Radiation intensity is related to separation distance by the inverse square law (similar to force fields)
- The Earth's climate relies on a delicate thermal energy balance where total energy in equals total energy out

Content Objectives

1 – Energy Sources Overview

I can list the top 6 most common sources in the global energy supply and general % of total			
I can distinguish between primary and secondary energy sources			
I can define power as a rate of energy usage in terms of watts			
I can calculate the efficiency as the percentage of useful energy of the total			
I can interpret energy flow from a Sankey Diagram			
I can define specific energy and energy density with proper units			
I can use specific energy to calculate the amount of fuel needed for a given amount of power			

2– Nuclear Power

I can describe the chain reaction that occurs to support a self-sustaining fission reactor			
I can describe the concentration of U-235 as a sample is enriched into fuel-grade uranium			
I can outline the process of enriching uranium			
I can explain how a nuclear reactor transforms the energy of a fission reaction into electricity			
I can describe the role of the moderator and control rods in a nuclear reactor			
I can discuss the challenges of disposing of nuclear waste			

3 – The Renewables

I can list examples of energy sources that are considered renewable			
I can list examples of energy sources that are known carbon dioxide emitters			
I can calculate the power produced by a wind turbine			
I can compare the different styles of solar power and what each is used for			
I can calculate the power from a solar panel from the panel area and solar intensity			
I can describe the factors that affect the solar intensity in different locations on Earth			
I can outline the operation of a hydropower generator			
I can explain how a hydropower plant can incorporate pumped storage to store energy			
I can list challenges that are facing a future of renewable energy			

4 – Thermal Energy Transfer

I can provide examples of conduction, convection, and radiation			
I can define black-body radiation in terms of absorption and emission of light			
I can describe an object based on its emissivity			
I can calculate the power emitted by a black body radiation using the Stefan-Boltzmann Law			
I can describe the shape of the emission spectra in terms of radiation wavelength			
I can mathematically relate peak wavelength and temperature using Wien's displacement law			

5 – Radiation from the Sun

I can define intensity with proper units			
I can describe how intensity changes according to the surface area of a sphere			
I can derive the Solar Constant from the sun's power and distance from earth			
I can calculate the average solar intensity on earth from the solar constant and earth's radius			
I can compare the properties of albedo and emissivity			
I can list the gases that have the largest impact on the greenhouse effect			

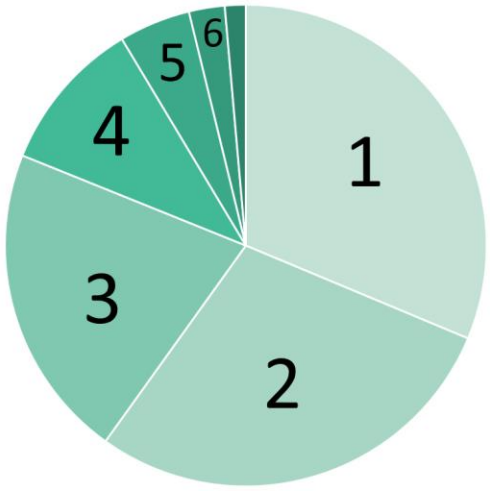
6 – Climate Change

I can describe the greenhouse effect as absorption and re-emission of thermal energy			
I can describe the concept of thermal equilibrium and how it pertains to earth			
I can recognize trends in the climate model based on different factors			
I can describe the long term and seasonal trends in the carbon dioxide concentration			
I can list examples of positive and negative feedback loops in terms of the climate discussion			
I can engage in an evidence-based conversation about climate change			

Energy Production Shelving Guide

Global Energy Usage

Rank	Energy Source	%
1		31%
2		27%
3		23%
4		9%
5		5%
6		2.5%



Efficiency

$$Efficiency = \frac{useful\ work\ out}{total\ work\ in} = \frac{useful\ power\ out}{total\ power\ in}$$

Sankey Diagram Rules:

Energy Density

	Definition	Units
Specific Energy		
Energy Density		

Primary and Secondary Sources

Primary Energy Sources	Secondary Energy Sources

Nuclear Power

	Describe	Examples	Challenges
Fission			
Fusion			

	% of U-235
Uranium Ore	
Fuel-Grade	
Weapons-Grade	

Why is the concentration of U-235 important?
What is done with the nuclear waste?

Moderator	Control Rods

Renewable Energy

	Variable Symbol	Unit
Power		
Cross-Sectional Area		
Air Density		
Air Speed		

Data Booklet Equations:

$$\text{Power} = \frac{1}{2}A\rho v^3$$

$$\text{A} = \pi r^2$$

Photovoltaic Cells	Solar Concentrator	Solar Heating Panel

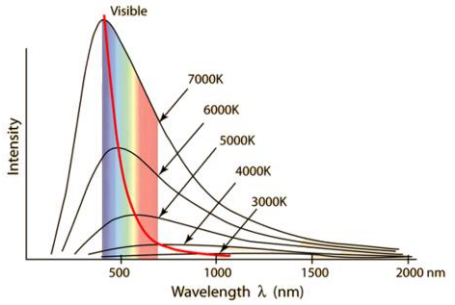
	Biomass	Coal	Geothermal	Hydropower	Natural Gas	Nuclear	Petroleum	Solar	Wind
Renewable									
Produces CO_2									

Thermal Energy Transfer

Conduction	Convection	Radiation

	Emissivity
Sun	
Earth	
Black-Body	

Black Body Radiation



Power Emissivity

	Variable Symbol	Unit
Power		
Emissivity		---
Surface Area		
Temperature		
Max Wavelength		

Data Booklet Equations:

$$P = e\sigma AT^4$$

$$\lambda_{max} = \frac{2.90 \times 10^{-3}}{T}$$

$$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$$

Solar Radiation and Climate Change

Intensity

	Variable Symbol	Unit
Intensity		
Power		
Area		

Data Booklet Equations:

$$I = \frac{\text{power}}{A}$$

$$A_{sphere} = 4\pi r^2$$

Greenhouse Gases

Positive Feedback Loop	Negative Feedback Loop