# 12 | Energy Production IB Physics Content Guide

## Big Ideas

- Most energy sources can be traced back the sun, our ultimate primary source
- Energy sources must be compared based on many factors including energy density, cost, availability, politics, safety, and environmental impact
- 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

### 12.1 – Energy Sources Overview

 p. 332-338

| | | | |
|---|---|---|---|
| I can list the top 6 most common sources in the global energy supply and general % of total | | | |
| I can describe the different ways (sectors) that energy is used for | | | |
| 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 | | | |

### 12.2 – Fossil Fuels

 p. 338-341

| | | | |
|---|---|---|---|
| I can give an approximate number of years left in proved fossil fuel reserves | | | |
| I can explain the Hubbert Peak and why it is important | | | |
| I can discuss where the United States' oil supply comes from | | | |
| I can describe the process of fracking and how it is used to extract oil and natural gas | | | |
| I can identify the primary uses for each of the primary fossil fuels | | | |
| I can compare the transportation methods for the different fossil fuels | | | |

### 12.3 – Nuclear Power

 p. 341-348

| | | | |
|---|---|---|---|
| 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 | | | |

## 12.4 – The Renewables

 p. 349-357

| | | | |
|---|---|---|---|
| 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 | | | |

## 12.5 – Thermal Energy Transfer

 p.360-365

| | | | |
|---|---|---|---|
| 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 | | | |

## 12.6 – Radiation from the Sun

 p. 366-371

| | | | |
|---|---|---|---|
| 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 | | | |

## 12.7 – Climate Change

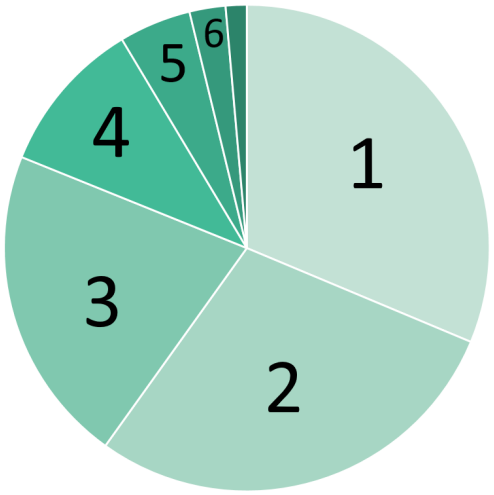
 p. 371-377

| | | | |
|---|---|---|---|
| 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 | | | |

# 12 | Energy Production Shelving Guide

## Global Energy Usage

| Rank | Energy Source | % |
|---|---|---|
| 1 | | 32% |
| 2 | | 28% |
| 3 | | 22% |
| 4 | | 10% |
| 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 |
|---|---|
| | |

## Fossil Fuels

| Number of years left in global reserves | |
|---|---|
| Coal | |
| Oil | |
| Natural Gas | |

| Describe the process of **Fracking**: |
|---|
| |

## Nuclear Power

| | % 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:*

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

$$A = \pi r^2$$

| Photovoltaic Cells | Solar Concentrator | Solar Heating Panel |
|---|---|---|
| | | |

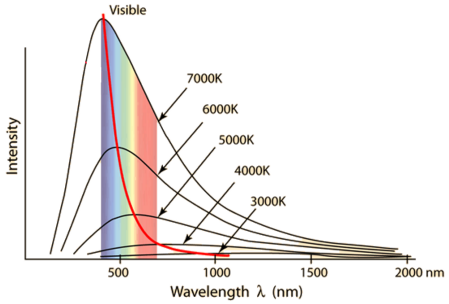
| | Biomass | Coal | Geothermal | Hydropower | Natural Gas | Nuclear | Petroleum | Solar | Wind |
|---|---|---|---|---|---|---|---|---|---|
| Renewable | | | | | | | | | |
| Produces $CO_2$ | | | | | | | | | |

# 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:*

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

$$\lambda_{max} = \frac{2.90\times10^{-3}}{T}$$

$$\sigma = 5.67\times10^{-8}\ W\ m^{-2}\ K^{-4}$$

# Solar Radiation and Climate Change

## Intensity

| | Variable Symbol | Unit |
|---|---|---|
| Intensity | | |
| Power | | |
| Area | | |

*Data Booklet Equations:*

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

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

| Greenhouse Gases |
|---|
| |
| |
| |

| Positive Feedback Loop | Negative Feedback Loop |
|---|---|
| | |
| | |
| | |