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| **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

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| **Energy Production** | Shelving Guide |

# Global Energy Usage

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

# Efficiency

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| --- | --- |
| $$Efficiency=\frac{useful work out}{total work in}=\frac{useful power out}{total power in}$$ |  |
| Sankey Diagram Rules: |

# Energy Density

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| --- | --- | --- |
|  | Definition | Units |
| Specific Energy |  |  |
| Energy Density  |  |  |

# Primary and Secondary Sources

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| --- | --- |
| Primary Energy Sources | Secondary Energy Sources |
|  |  |

# Nuclear Power

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| --- | --- | --- | --- |
|  | Describe | Examples | Challenges |
| Fission |  |  |  |
| Fusion |  |  |  |

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|  | % of U-235 |  | Why is the concentration of U-235 important? |
| Uranium Ore |  |  |
| Fuel-Grade |  |  | What is done with the nuclear waste? |
| Weapons-Grade |  |  |

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| Moderator | Control Rods |
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# Renewable Energy

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| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Power |  |  |  | $$Power=\frac{1}{2}Aρv^{3}$$ |
| Cross-Sectional Area |  |  |  |
| Air Density |  |  |  | $$A=πr^{2}$$ |
| Air Speed |  |  |  |

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| Photovoltaic Cells | Solar Concentrator | Solar Heating Panel |
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|  | Biomass | Coal | Geothermal | Hydropower | Natural Gas | Nuclear | Petroleum | Solar | Wind |
| Renewable |  |  |  |  |  |  |  |  |  |
| Produces CO2 |  |  |  |  |  |  |  |  |  |

# Thermal Energy Transfer

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| --- | --- | --- |
| Conduction | Convection | Radiation |
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|  | Emissivity |  | Black Body Radiation |  |
| Sun |  |  |  |
| Earth |  |  |
| Black-Body |  |  |

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| --- | --- | --- | --- | --- |
| Power Emissivity | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Power |  |  |  | $$P=eσAT^{4}$$ |
| Emissivity |  | --- |  |
| Surface Area |  |  |  | $$λ\_{max}=\frac{2.90×10^{-3}}{T}$$ |
| Temperature |  |  |  |
| Max Wavelength |  |  |  | $$σ=5.67×10^{-8} W m^{-2} K^{-4}$$ |

# Solar Radiation and Climate Change

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| --- | --- | --- | --- | --- |
| Intensity | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Intensity |  |  |  | $$I=\frac{power}{A}$$ |
| Power |  |  |  |
| Area |  |  |  | $$A\_{sphere}=4πr^{2}$$ |

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| Greenhouse Gases |  | Positive Feedback Loop | Negative Feedback Loop |
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