



DEVIL PHYSICS
THE BADDEST CLASS ON CAMPUS

IB PHYSICS

LSN 8-1: ENERGY SOURCES

Questions From Reading
Activity?

Essential Idea:

- The constant need for new energy sources implies decisions that may have a serious effect on the environment. The finite quantity of fossil fuels and their implication in global warming has led to the development of alternative sources of energy. This continues to be an area of rapidly changing technological innovation.

Nature Of Science:

- Risks and problem-solving: Since early times mankind understood the vital role of harnessing energy and large-scale production of electricity has impacted all levels of society. Processes where energy is transformed require holistic approaches that involve many areas of knowledge. Research and development of alternative energy sources has lacked support in some countries for economic and political reasons. Scientists, however, have continued to collaborate and share new technologies that can reduce our dependence on non-renewable energy sources.

International-Mindedness:

- The production of energy from fossil fuels has a clear impact on the world we live in and therefore involves global thinking. The geographic concentrations of fossil fuels have led to political conflict and economic inequalities. The production of energy through alternative energy resources demands new levels of international collaboration.

Theory Of Knowledge:

- The use of nuclear energy inspires a range of emotional responses from scientists and society.
- How can accurate scientific risk assessment be undertaken in emotionally charged areas?

Understandings:

- Specific energy and energy density of fuel sources
- Sankey diagrams
- Primary energy sources
- Electricity as a secondary and versatile form of energy
- Renewable and non-renewable energy sources

Applications And Skills:

- Solving specific energy and energy density problems
- Sketching and interpreting Sankey diagrams
- Describing the basic features of fossil fuel power stations, nuclear power stations, wind generators, pumped storage hydroelectric systems and solar power cells

Applications And Skills:

- Solving problems relevant to energy transformations in the context of these generating systems
- Discussing safety issues and risks associated with the production of nuclear power
- Describing the differences between photovoltaic cells and solar heating panels

Guidance:

- Specific energy has units of J kg^{-1} ; energy density has units of J m^{-3}
- The description of the basic features of nuclear power stations must include the use of control rods, moderators and heat exchangers

Guidance:

- Derivation of the wind generator equation is not required but an awareness of relevant assumptions and limitations is required
- Students are expected to be aware of new and developing technologies which may become important during the life of this guide

Data Booklet Reference:

$$power = \frac{energy}{time}$$

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

Utilization:

- Generators for electrical production and engines for motion have revolutionized the world (see Physics sub-topics 5.4 and 11.2)
- The engineering behind alternative energy sources is influenced by different areas of physics (see Physics sub-topics 3.2, 5.4 and B.2)
- Energy density (see Chemistry sub-topic C.1)
- Carbon recycling (see Biology sub-topic 4.3)

Aims:

- Aim 4: the production of power involves many different scientific disciplines and requires the evaluation and synthesis of scientific information
- Aim 8: the production of energy has wide economic, environmental, moral and ethical dimensions

Definitions

- Primary Energy
 - Energy found in nature that has not been subject to processing of any kind
 - Energy stored in fuels: oil, coal, natural gas, solar, wind, tidal, etc
- Secondary Energy
 - Primarily electrical energy
 - Mechanical energy (transportation)

Primary to Secondary Energy Generation

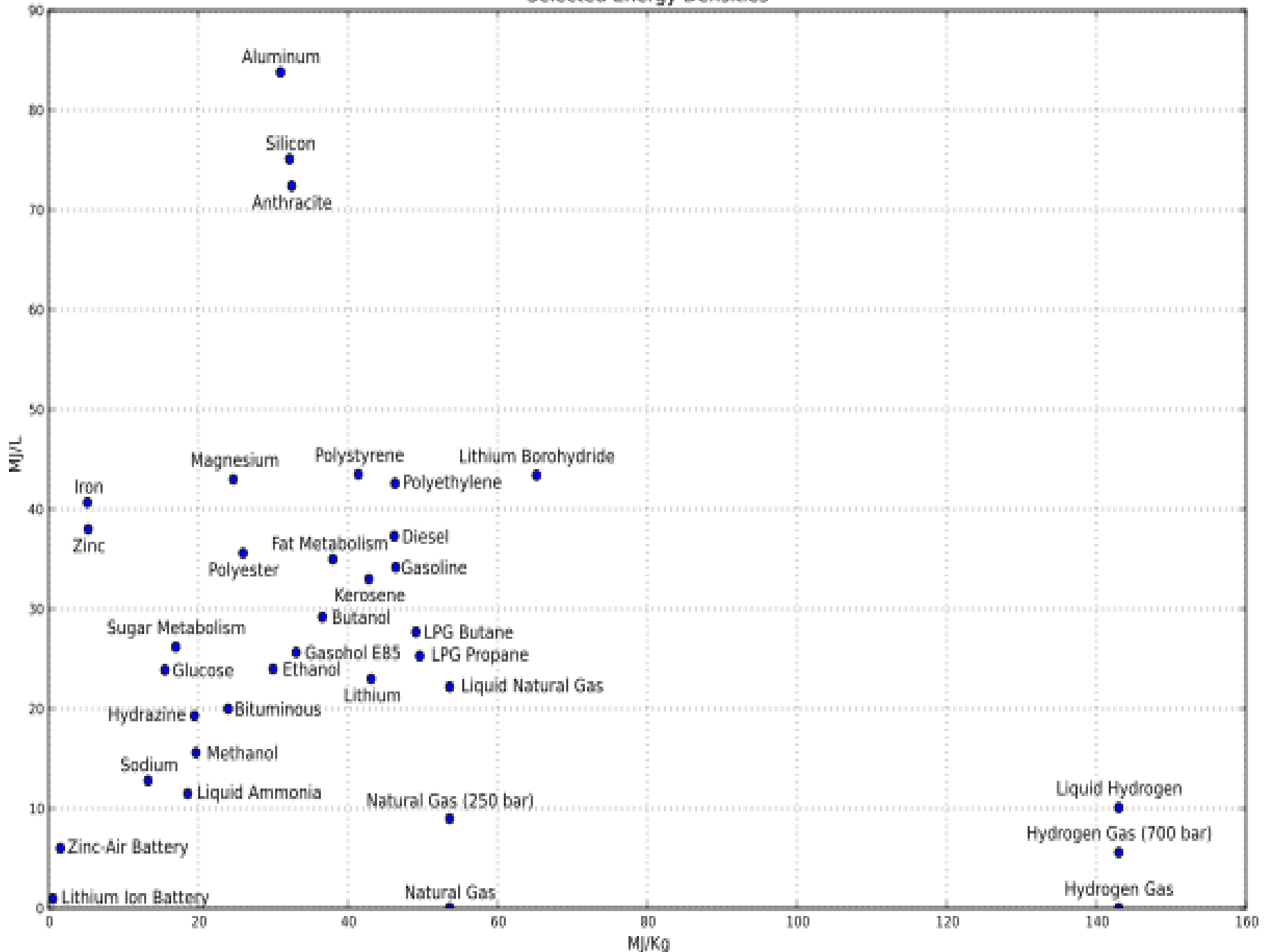


Electricity Generation: Non Renewables. Learn360. Films Media Group, 2015. Web. 12 Feb. 2016.

Definitions

- Specific Energy
 - Amount of energy extracted per unit mass of fuel
 - J/kg
- Energy Density
 - Amount of energy extracted per unit volume
 - J/kg
- Which is more important?

Selected Energy Densities



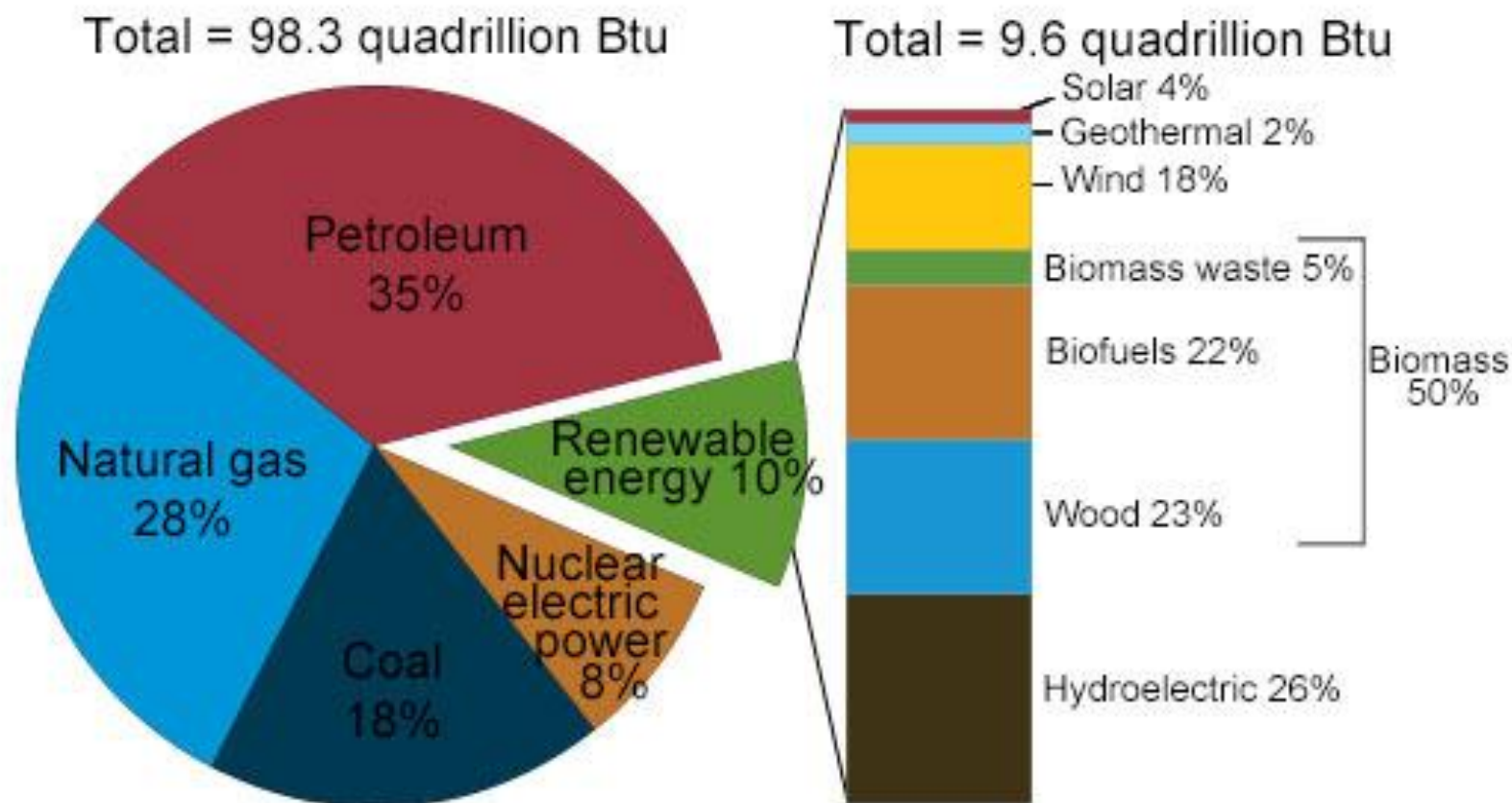
Definitions

- Non-renewable source
 - Finite sources that are being depleted faster than they are being produced
 - Fossil fuels and nuclear fuels
- Renewable sources
 - Sources essentially available as long as the sun, earth, and moon exist
 - Solar, wind, wave, tidal, geothermal

Considerations in Choice

- Cost of transportation
- Transportation safety considerations
- Storage facilities
- Environmental impact/risk

U.S. energy consumption by energy source, 2014



Note: Sum of components may not equal 100% as a result of independent rounding.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1 (March 2015), preliminary data



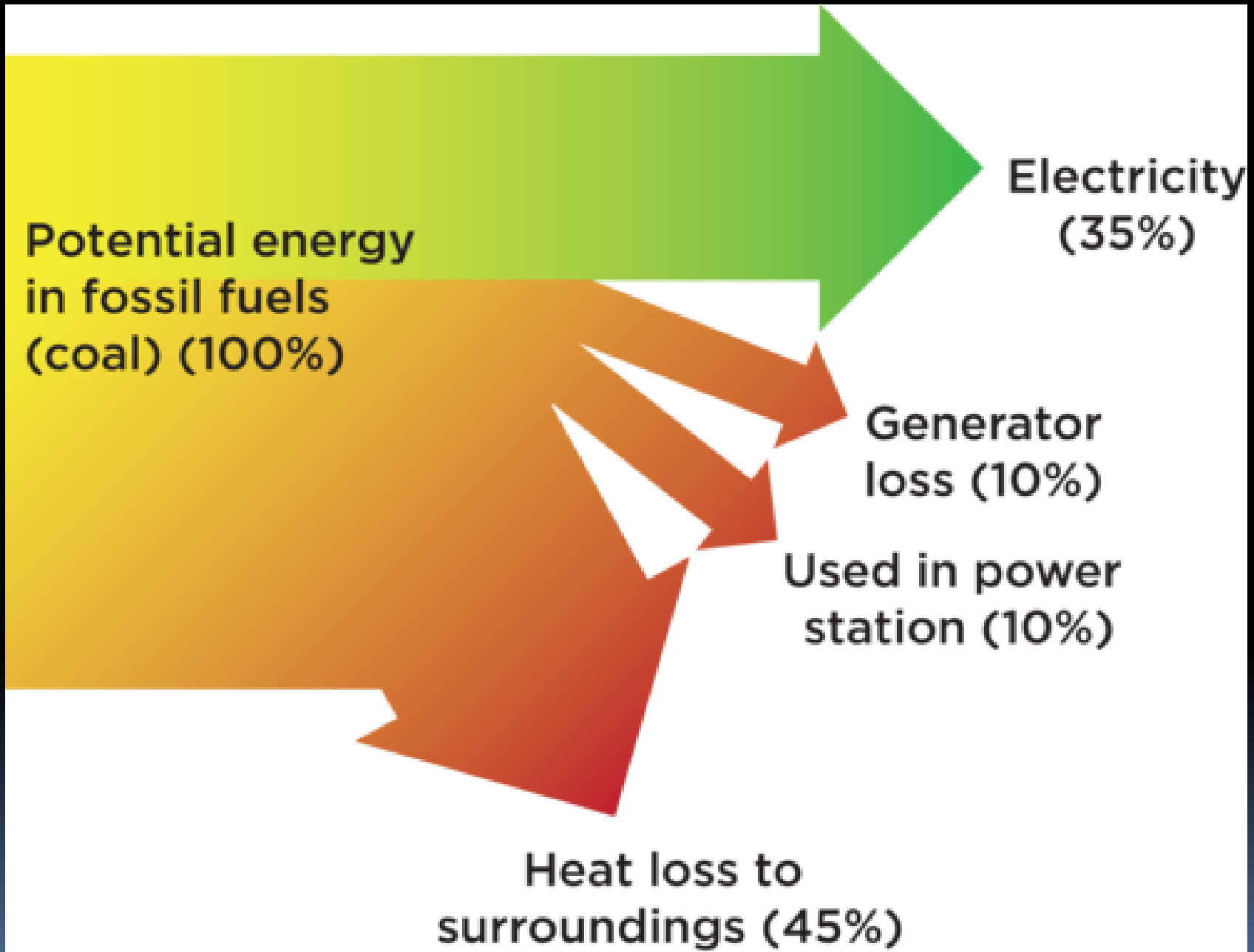
Non-Renewable Fossil Fuels

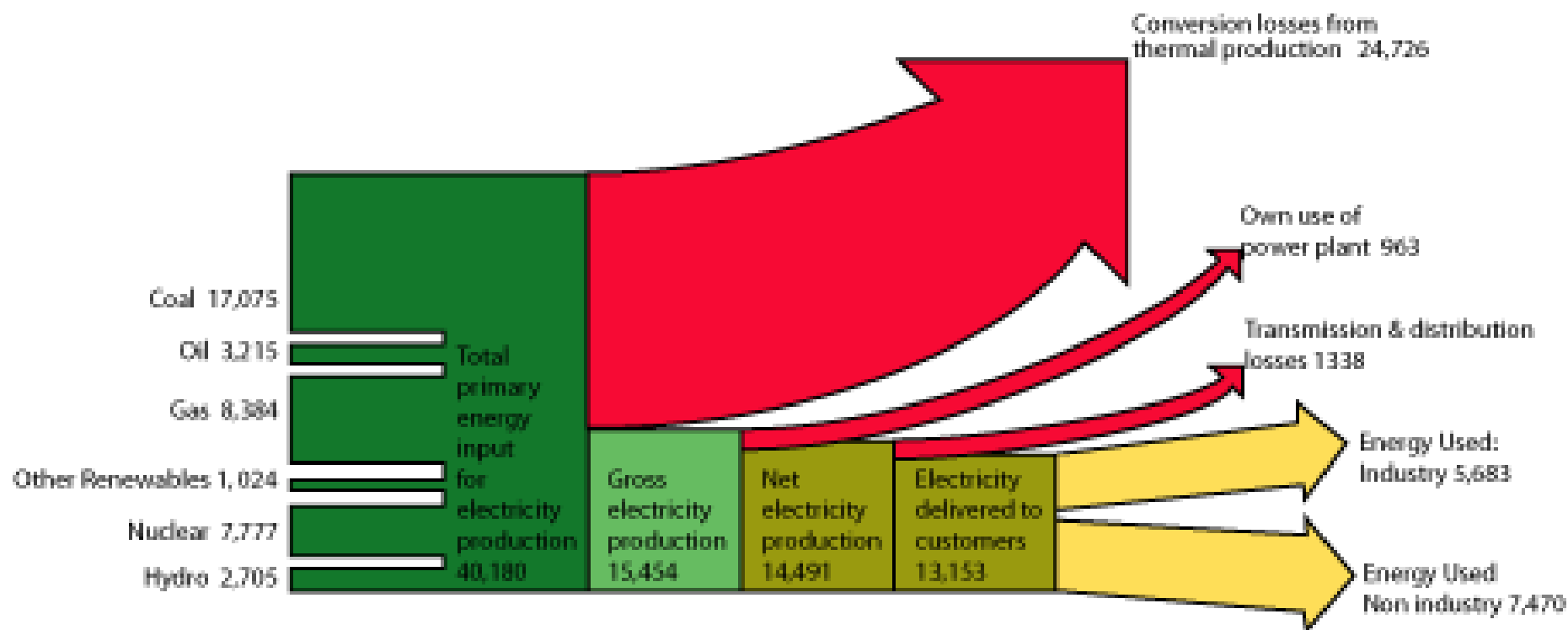


Electricity Generation: Non Renewables. Learn360. Films Media Group, 2015. Web. 12 Feb. 2016.

Fossil Fuels

- Primary resource for transportation, electricity production, and industry





The Pros and Cons of Coal and Oil

Electricity Generation: Non Renewables. Learn360. Films Media Group, 2015. Web. 12 Feb. 2016.

The Pros and Cons of Gas



Electricity Generation: Non Renewables. Learn360. Films Media Group, 2015. Web. 12 Feb. 2016.



Fossil Fuels

Advantages

- Relatively cheap and currently abundant
- High energy density
- Variety of engines and devices use them directly and easily
- Extensive distribution network in place

Disadvantages

- Will run out
- Pollutes the environment
- Contributes to greenhouse effect by releasing greenhouse gases in the atmosphere

The Pros and Cons of Nuclear

ELECTRICITY GENERATION: NON RENEWABLES

THE PROS & CONS OF NUCLEAR

Electricity Generation: Non Renewables. Learn360. Films Media Group, 2015. Web. 12 Feb. 2016.

Introduction to Nuclear Power

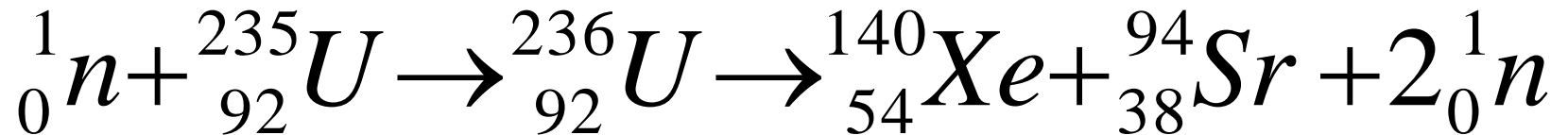
Generating Nuclear Power



**GENERATING
POWER**

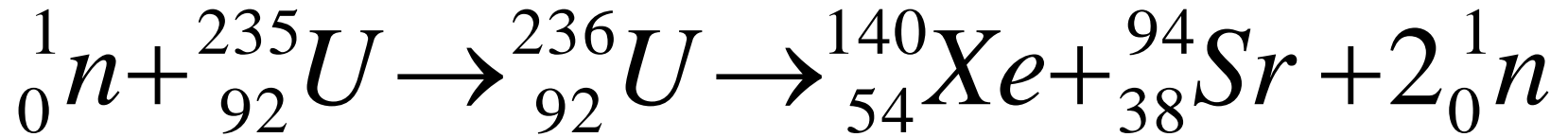
Nuclear Power

- *Induced* fission reaction



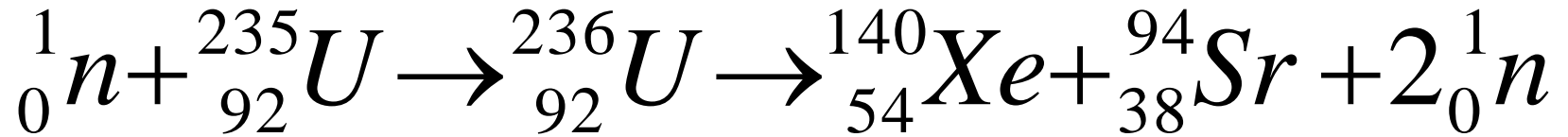
- Neutrons must be propelled into the material to start the reaction
- Two released neutrons have enough energy to initiate reactions in other atoms

Nuclear Power



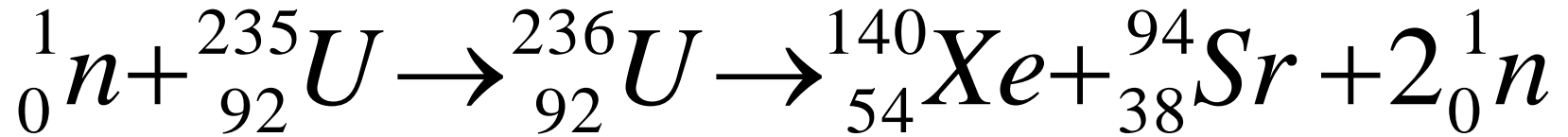
- The number of reactions increases exponentially -- a *chain reaction*
- Left unchecked, you have a nuclear meltdown and/or explosion
- We try to avoid that

Nuclear Power



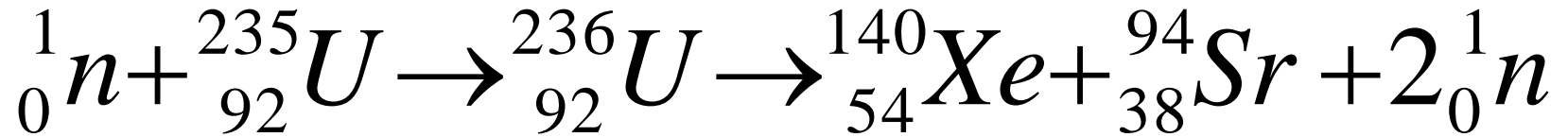
- ***Control rods*** absorb neutrons to limit the number available to start reactions
 - Raised or lowered to change the amount of surface area available for absorption

Nuclear Power

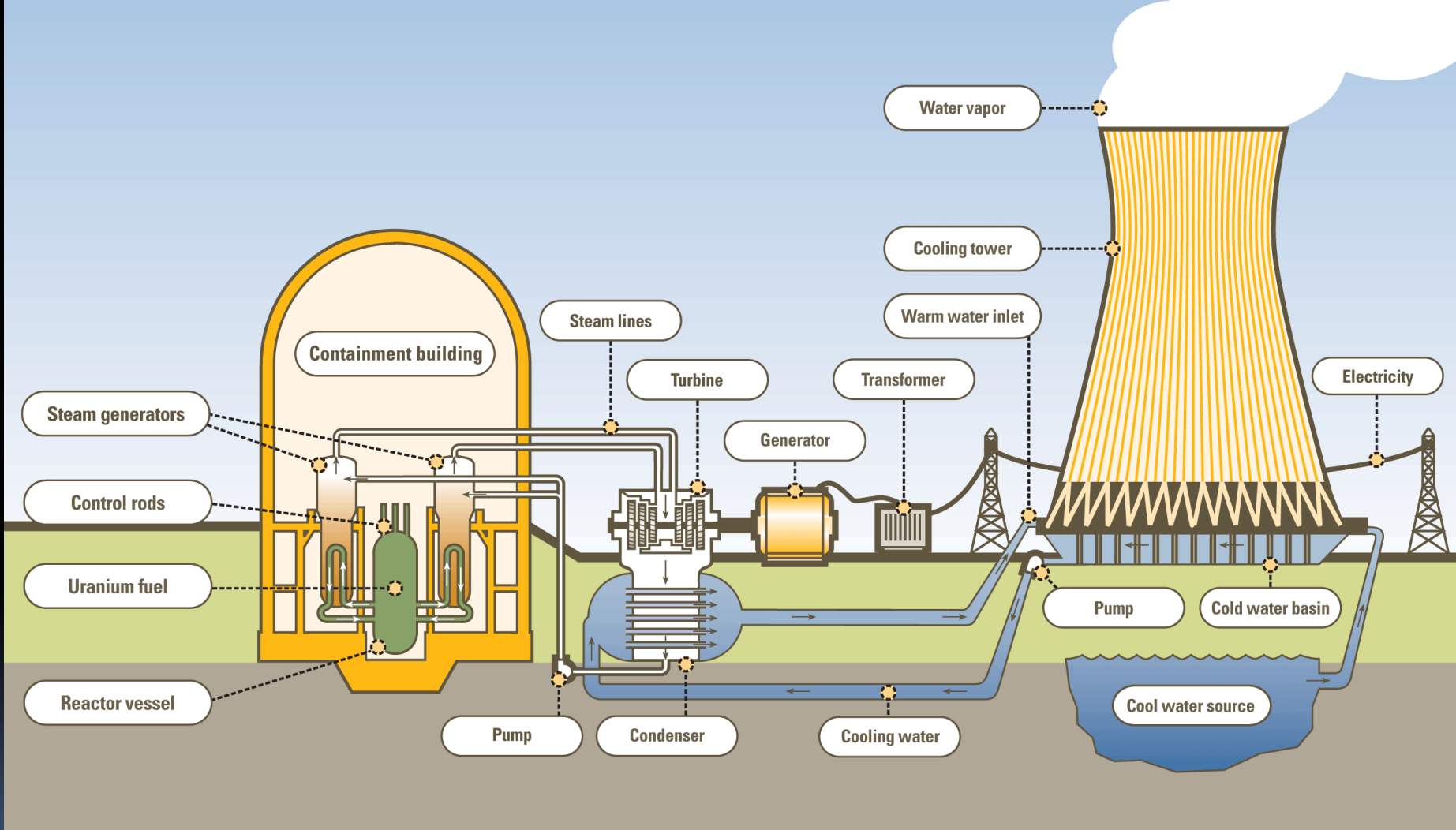


- Uranium will not react if the neutrons are going too fast
- The neutrons in the above reaction are going too fast
- **Moderators** (graphite or water) surround the control rods and slow the neutrons down by providing a collision surface

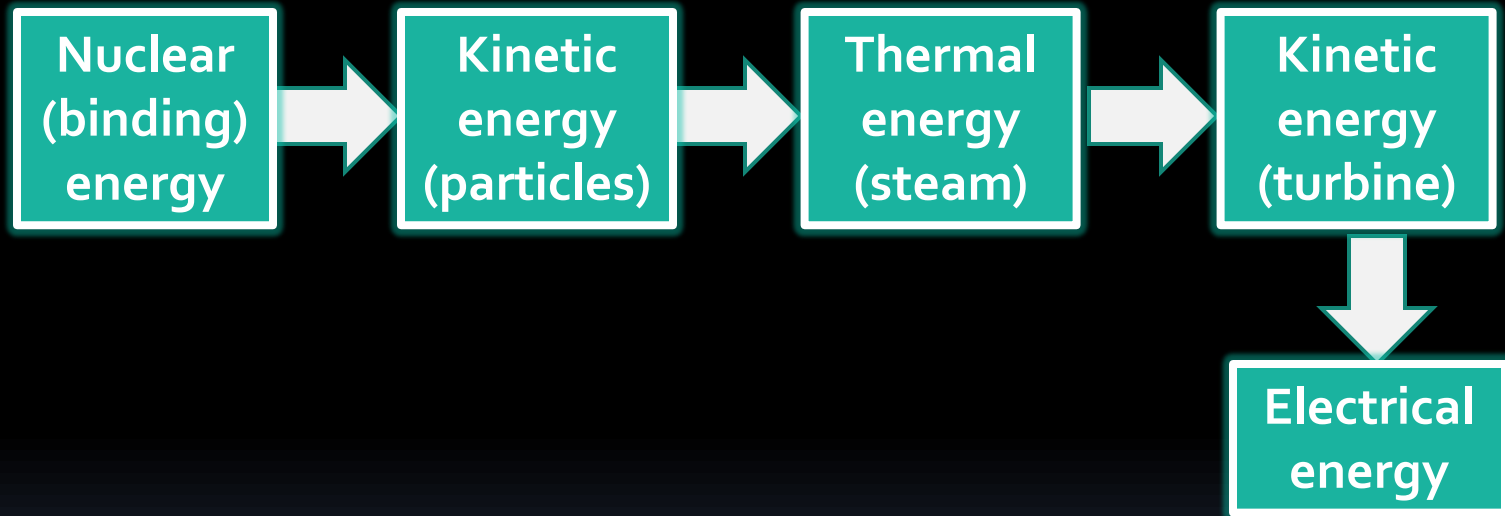
Nuclear Power

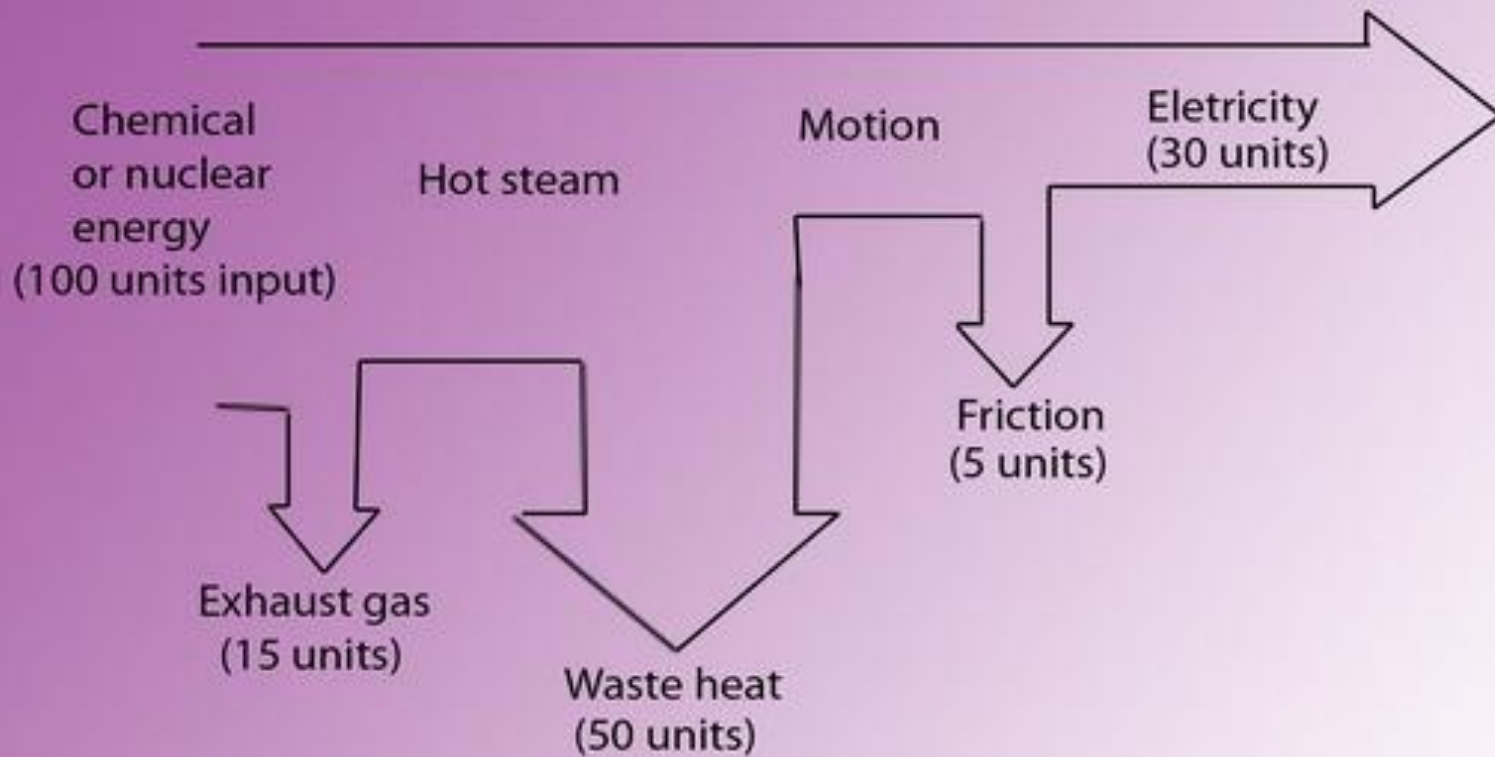


- Uranium must have a minimum mass based on its container that will allow reactions to continue without the neutrons escaping
- This mass value is call *critical mass*



Energy from Nuclear Power



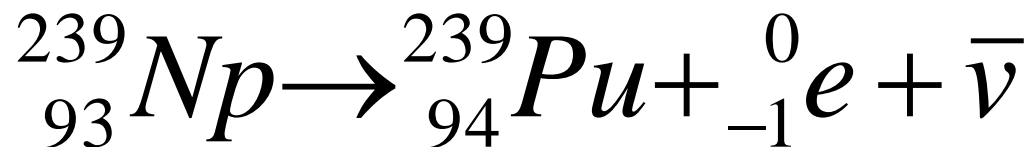
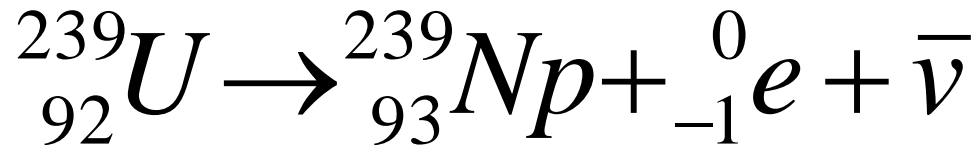
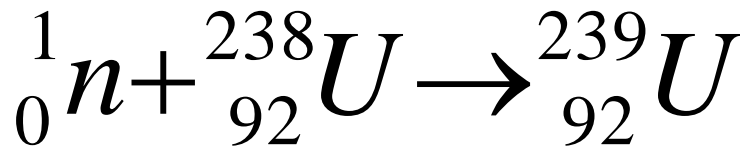


Other Uses of Nuclear Power



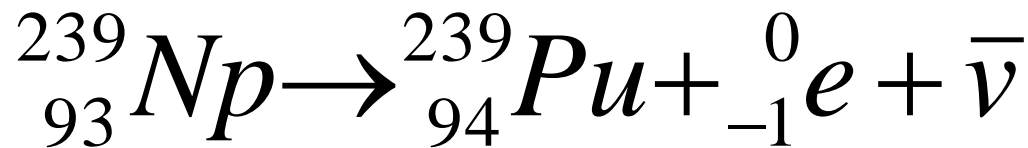
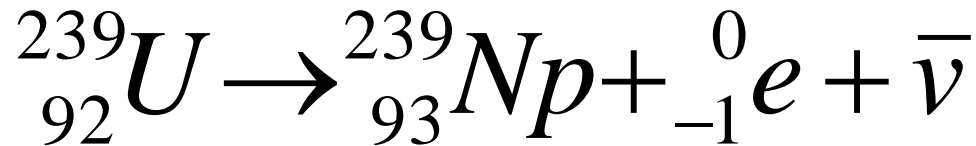
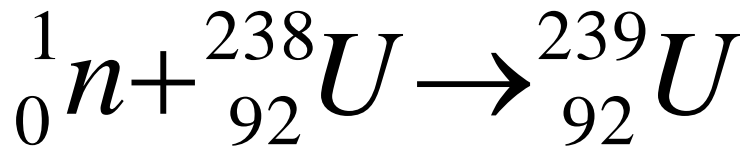
Other Uses of Nuclear Power

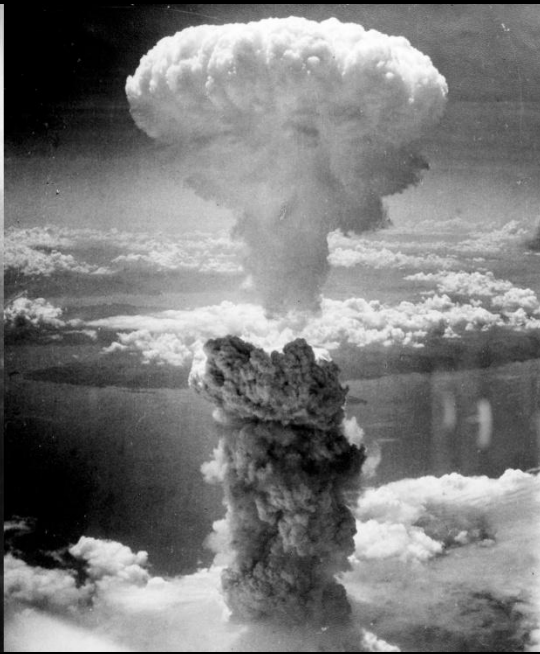
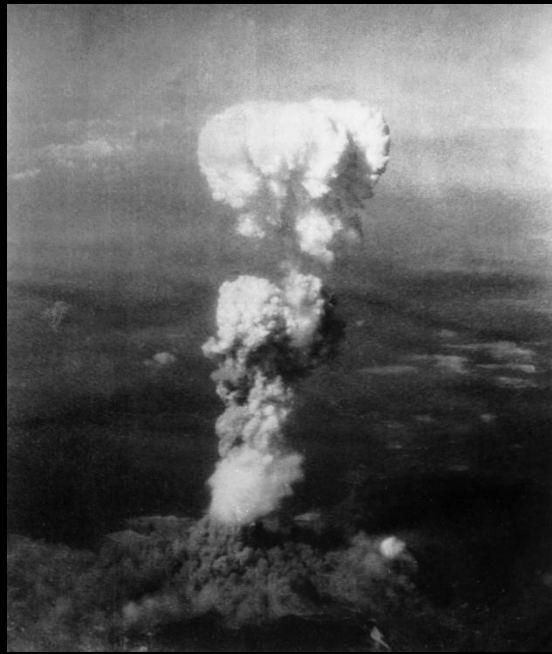
- Neutrons from a fission reaction can produce plutonium-239 (does not occur naturally) from uranium-238



Other Uses of Nuclear Power

- Process turns non-fissionable material (uranium-238) into fissionable material (plutonium-239) that can be used as reactor fuel or nuclear weapons











Nuclear Power

Advantages

- High power output
- Large reserves of nuclear fuels
- Nuclear power does not produce greenhouse gases

Disadvantages

- Radioactive waste products difficult to dispose of
- Major public health hazard in accidents
- Problems associated with uranium mining
- Potential for producing materials for nuclear weapons

More Information

- **Podcast On The Environmentalist Debate Over Nuclear Power**
- <http://www.kqed.org/a/forum/R201104010900>
- **Radiation Exposure Chart**
- <http://imgs.xkcd.com/blag/radiation.png>

From Petroleum Age to Alternative Energy Sources

The Pros and Cons of Solar

WORLD TIDAL "HOTSPOTS"



Electricity Generation: Renewables. Learn360. Films Media Group, 2015.
Web. 12 Feb. 2016.

Solar Power

- Active solar devices – used to directly heat water or air
- Photovoltaic cells convert sunlight to electricity
 - Low power output
 - About 30-45% efficient



Solar Power

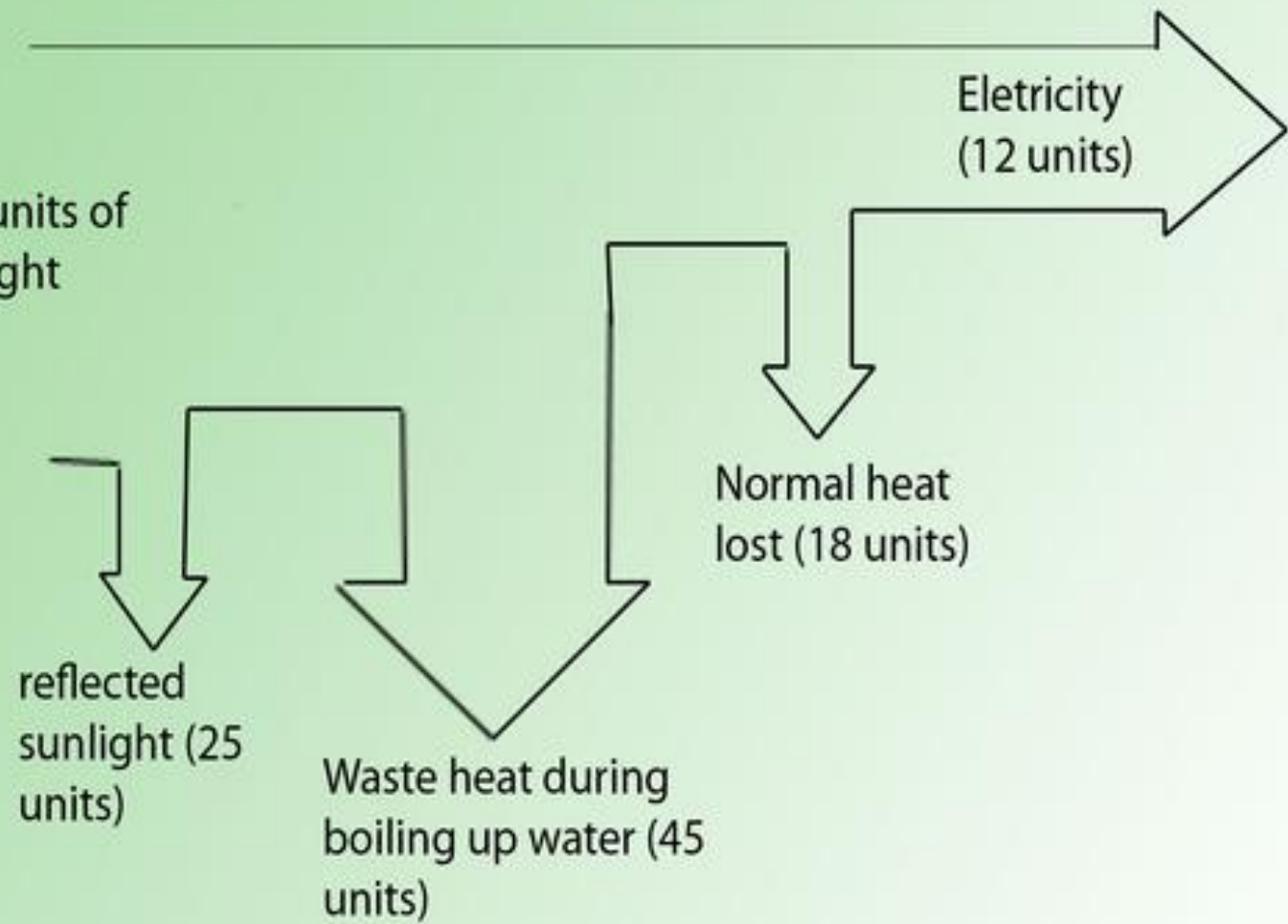
Advantages

- Free 'fuel'
- Inexhaustible
- Clean

Disadvantages

- Daylight only operation
- Affected by cloudy weather
- Low power output
- Requires large areas
- Initial costs high

100 units of
sunlight



reflected
sunlight (25
units)

Waste heat during
boiling up water (45
units)

Normal heat
lost (18 units)

Electricity
(12 units)

The Pros and Cons of Hydro-Electric Power



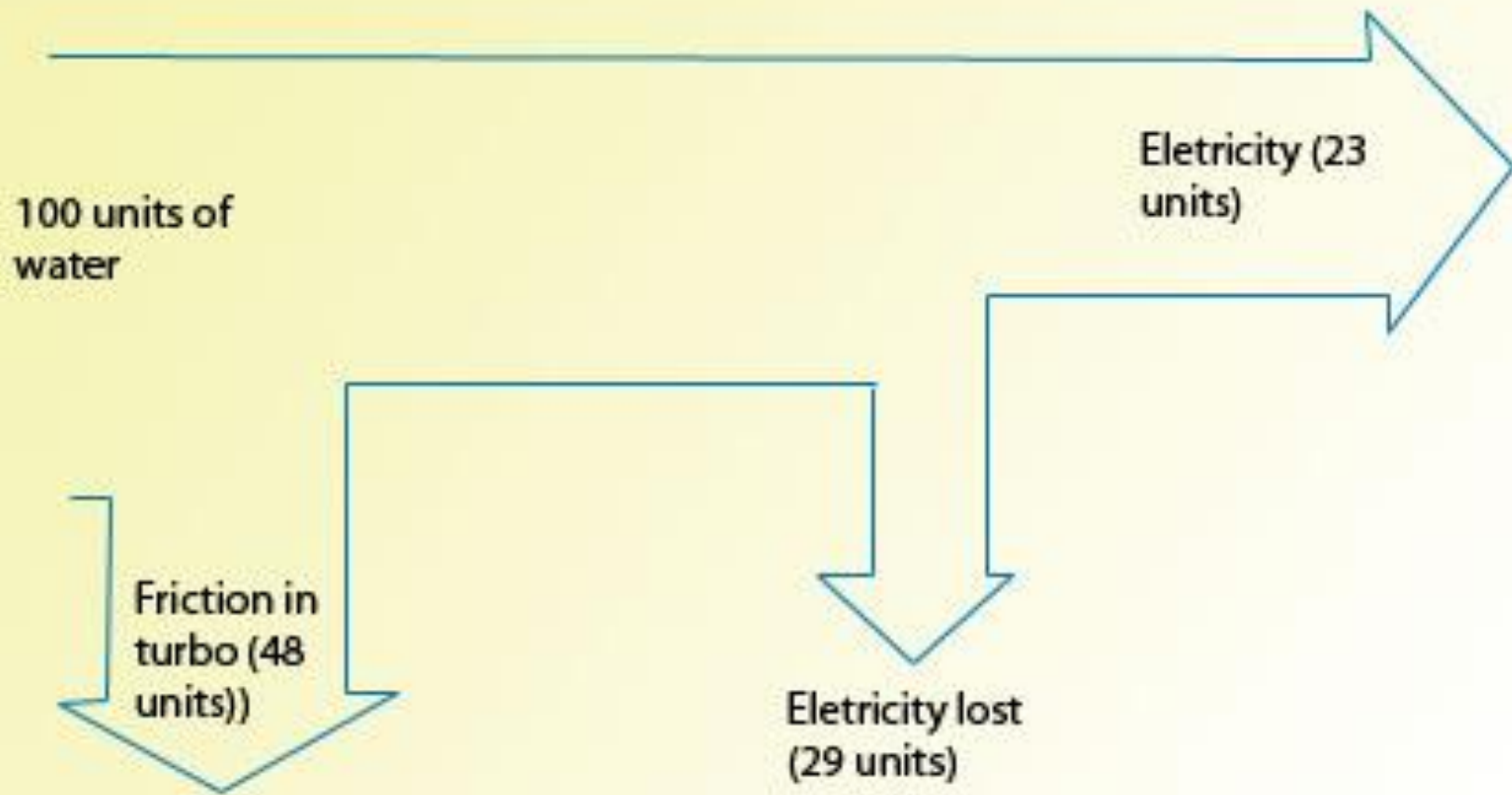
Electricity Generation: Renewables. Learn360. Films Media Group, 2015.
Web. 12 Feb. 2016.

Hydroelectric Power

- Requires a river with a large area that can be flooded
- Uses the potential energy of stored water

$$P = \rho Qgh$$

- ρ = density
- Q = volume flow rate of the water
- Pumped storage system



Hydroelectric Power

- Pumped storage system
 - Water pumped to an upper reservoir
 - Allowed to drain through a turbine
- Requires more energy to pump water to reservoir than can be effectively retrieved
- *Why would you want to do this?*

Hydroelectric Power

- Pumped storage system
 - Water pumped to an upper reservoir
 - Allowed to drain through a turbine
- Requires more energy to pump water to reservoir than can be effectively retrieved
- *Why would you want to do this?*
 - *Pump the water using excess solar or wind power to 'store' energy for nighttime or adverse weather usage*



Hydroelectric Power

Advantages

- Free 'fuel'
- Inexhaustible
- Clean

Disadvantages

- Very dependent on location
- Requires drastic changes to environment
- Initial costs high

Hydroelectric Power Rocks!



The Pros and Cons of Wind

Electricity Generation: Renewables. Learn360. Films Media Group, 2015.
Web. 12 Feb. 2016.

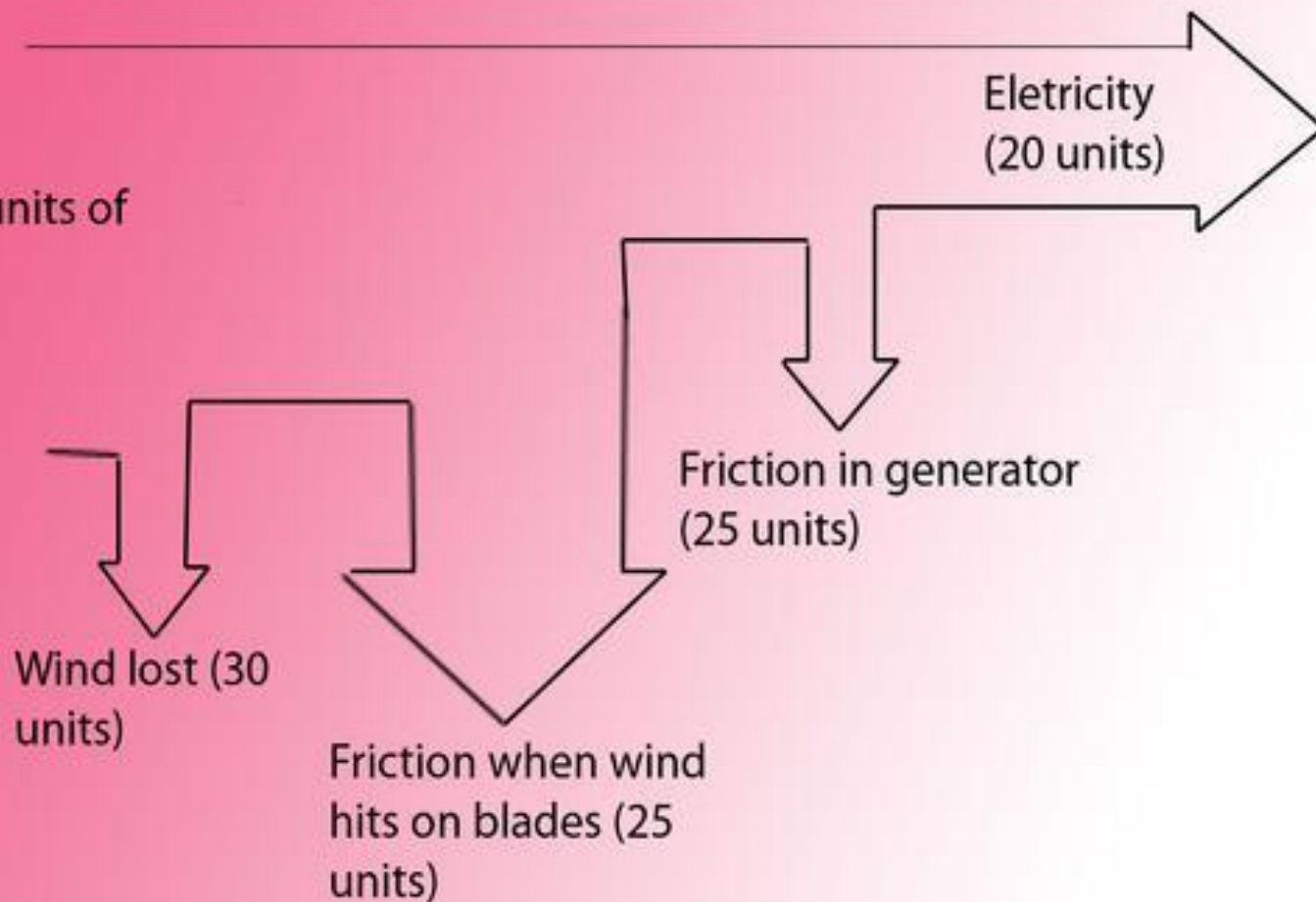
Wind Power

- Dutch windmills
- Modern wind turbine farms
- Transfers kinetic energy of wind to turning electrical generators

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

- Theoretical maximum assuming the wind velocity can be brought to zero

100 units of
wind





Wind Power

Advantages

- Free 'fuel'
- Inexhaustible
- Clean

Disadvantages

- Dependent on local wind conditions
- Aesthetic problems
- Noise problems
- Requires large open area

**JUST TO BE SMARTER THAN
EVERYONE ELSE . . .**

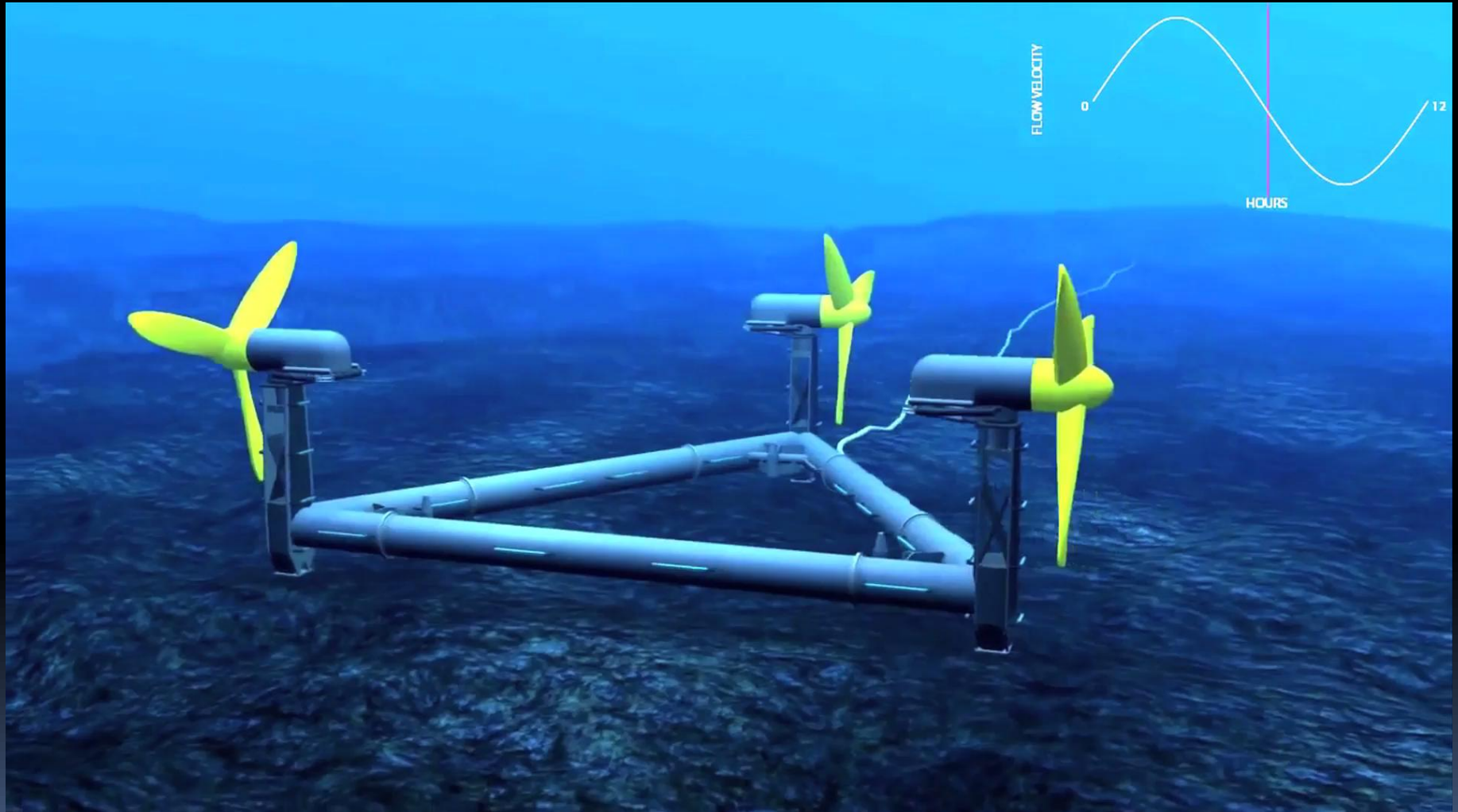
The Pros and Cons of Geothermal Power



Electricity Generation: Renewables. Learn360. Films Media Group, 2015.
Web. 12 Feb. 2016.



Tidal Energy Pros and Cons



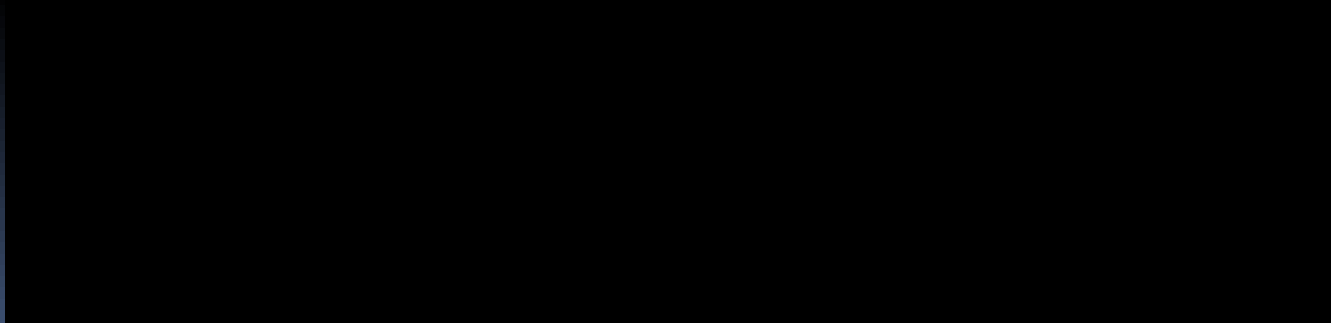
The Greening of Energy. Learn360. Films Media Group, 2014. Web. 12 Feb. 2016.

Wave Energy



Waves, Tides and the Coastal Environment. Learn360. Films Media Group, 2009. Web. 12 Feb. 2016.

Hydrogen Power



Alternative Energy Sources. Learn360. Films Media Group, 2003. Web. 12 Feb. 2016.

Study the Following On Your Own

***Know The
Advantages and
Disadvantages of
Each Type of Power
Source!!!!!!***

Understandings:

- Specific energy and energy density of fuel sources
- Sankey diagrams
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QUESTIONS?



Homework

#1-25

The Rest of the Nuclear
Power Video (32 min total)