How do we access chemical energy?

Why do combustion reactions give off energy?

Order wood, Coal, Natural Gas (methane), gasoline (C_8H_{18}), and ethanol in terms of energy content (per gram) using Table 4.3

Table 4.3 Energy Content of Fuels

Source	kJ/g
Hydrogen	140
Methane	56
Propane	51
Gasoline	48
Coal (hard)	31
Ethanol	30
Wood (oak)	14

What are the major energy-related issues/challenges facing us today?

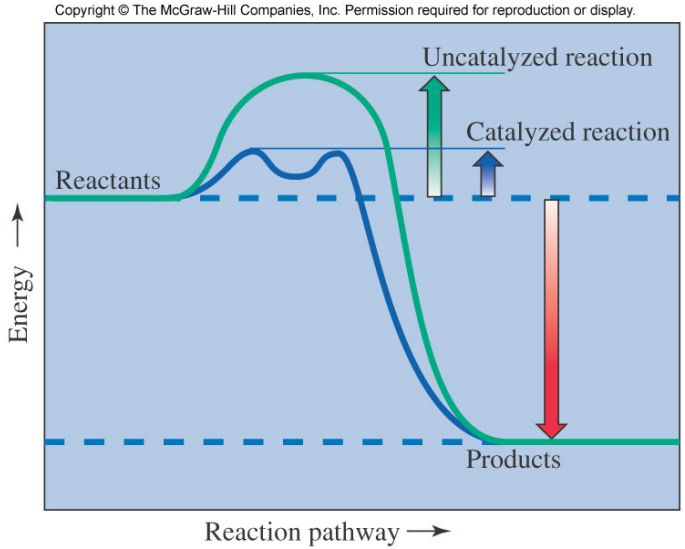
What are the pluses & minuses of coal?

What are the pluses & minuses of natural gas?

What are the pluses & minuses of oil/petroleum?

What's involved in refining crude oil to gasoline?

What's a catalyst?



What are the pluses & minuses of wind power?

What goes into a lifecycle cost analysis?

Biofuels

What are the two major biofuels?

How do we/do we want to produce ethanol?

What are the three major macronutrients?

Of the three major macronutrients (fats, carbohydrates & proteins)
Which has the higher energy content?

How is biodiesel made?

When comparing a renewable energy source such as corn ethanol
What factors need to be considered on the biofuel side?

When comparing a renewable energy source such as corn ethanol
What factors need to be considered on the petroleum side?

How much energy can reasonably be recovered from biofuels?

What is in wood?

Is lignin a better energy source than cellulose?

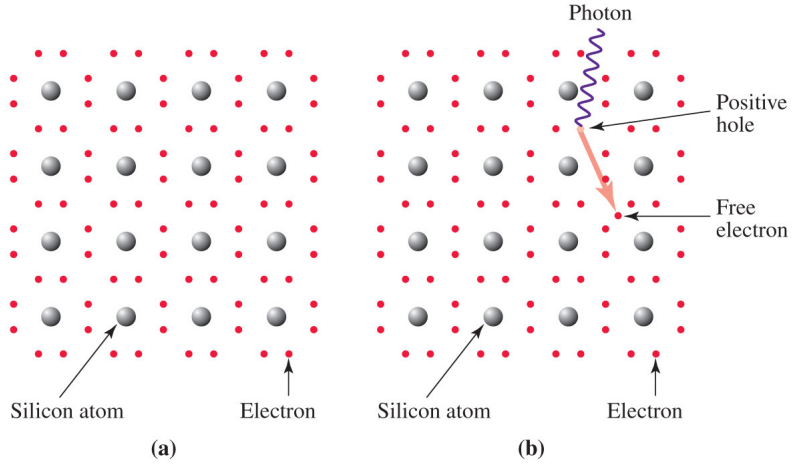
Why can’t “we” eat cellulose?

What are the pluses & minuses of Solar Thermal & PV?

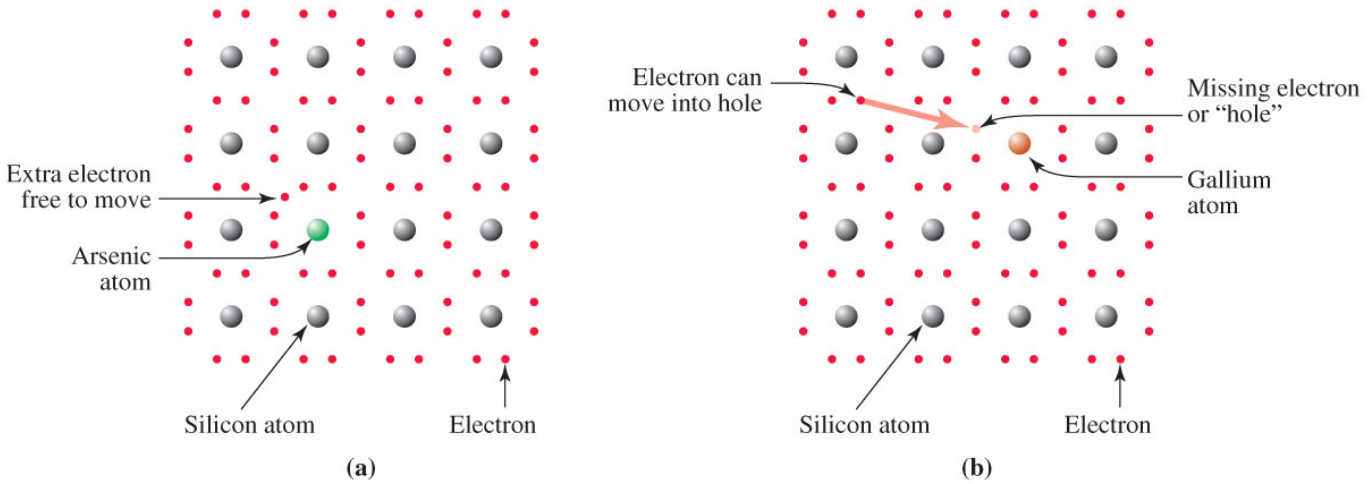
Chemically, what do you need for a PV device?

In a Si solar photovoltaic device, what types of elements can serve as dopants?

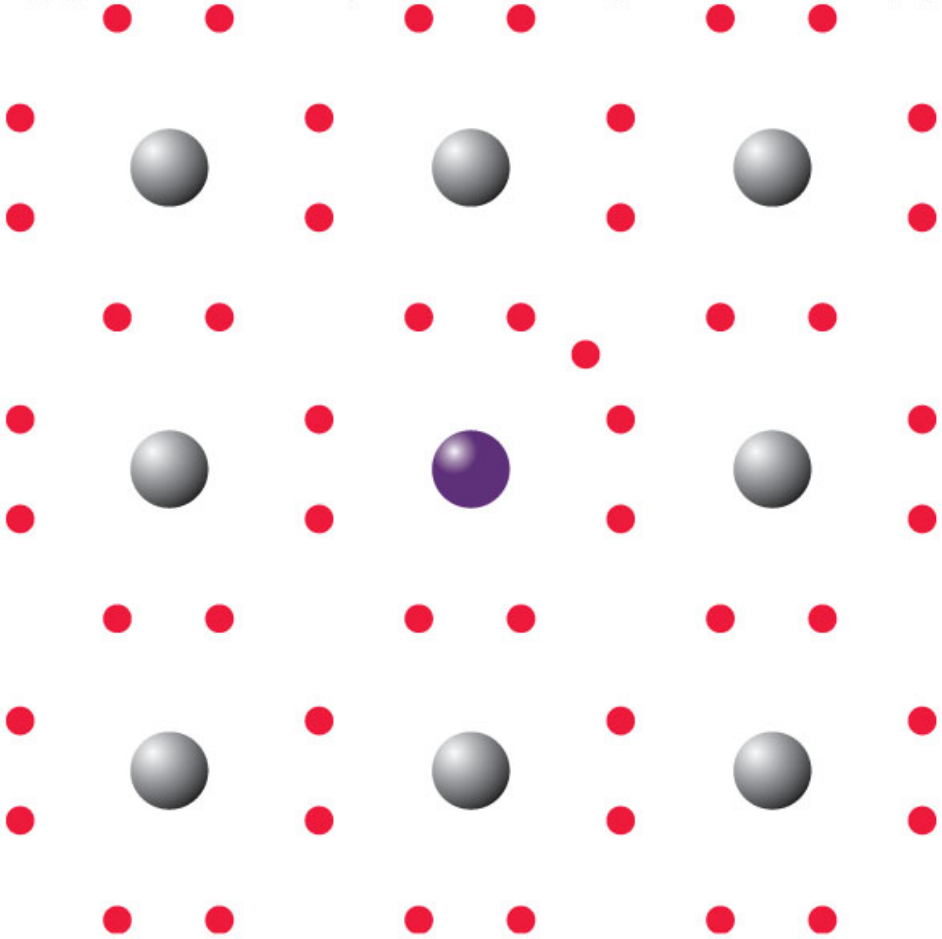
Group 5A and Group 3A



Energy from Electron Transfer



Is the purple atom in the following diagram a group 3A or group 5A element?



CO_2 emissions

kJ fuel→Grams fuel→moles fuel→moles CO_2→grams CO_2

1 kJ of energy derived from ethanol would release how many grams of CO_2?

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Nuclear

How much mass is converted to energy in the following nuclear decay process?

$$^{218}_{84}\text{Po} \rightarrow {}^{214}_{82}\text{Pb} + {}^{4}_{2}\text{He}$$

$^{218}_{84}$Po: 218.009

$^{214}_{82}$Pb: 214.000

$^{4}_{2}$He: 4.003

Fill in the blank in the following nuclear decay process

$$^{239}_{94}\text{Pu} + {}^{4}_{2}\text{He} \rightarrow {}^{\quad}_{96}\text{Cm} + {}^{1}_{0}\text{n}$$

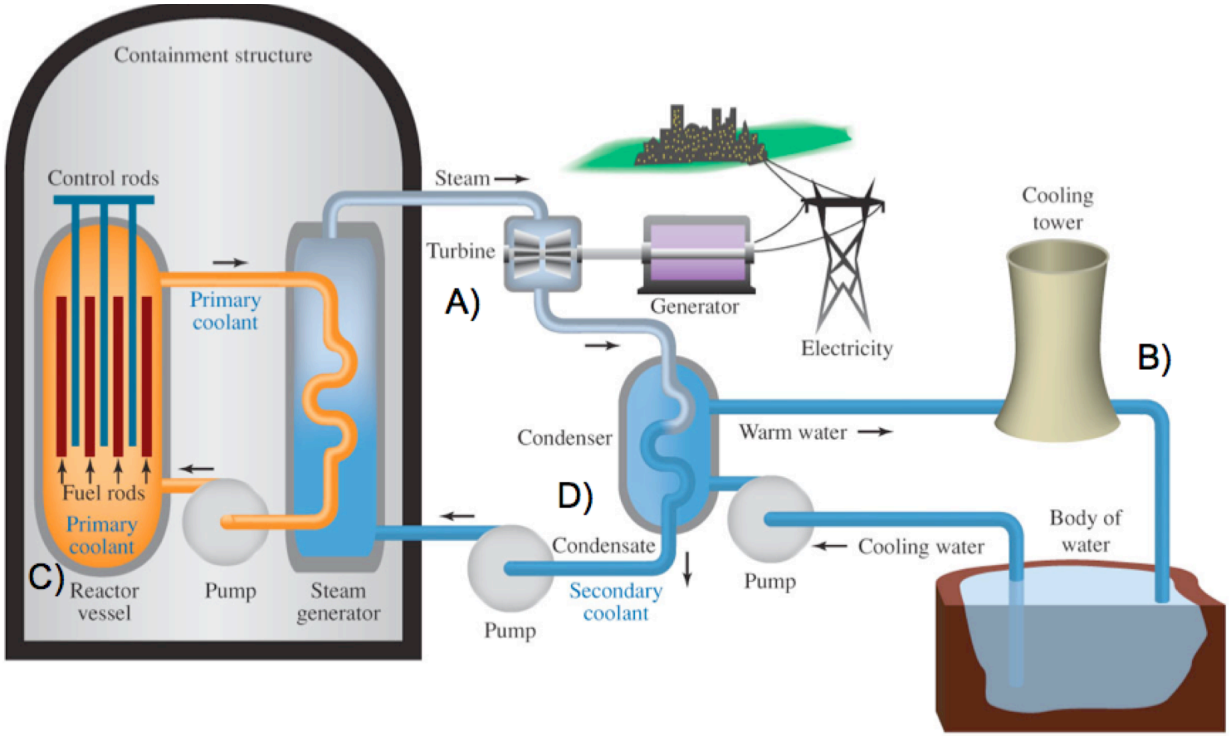
How does radioactivity impact us and other living matter?

What types of cells are most impacted by radioactivity?

How long do we have to worry about radioactive decay?

Energy Loss

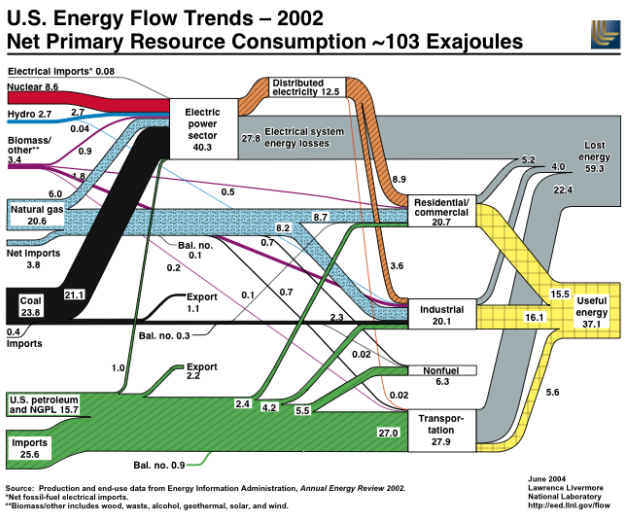
In the following diagram, which labeled step in a nuclear fission power plant is only 30% efficient?

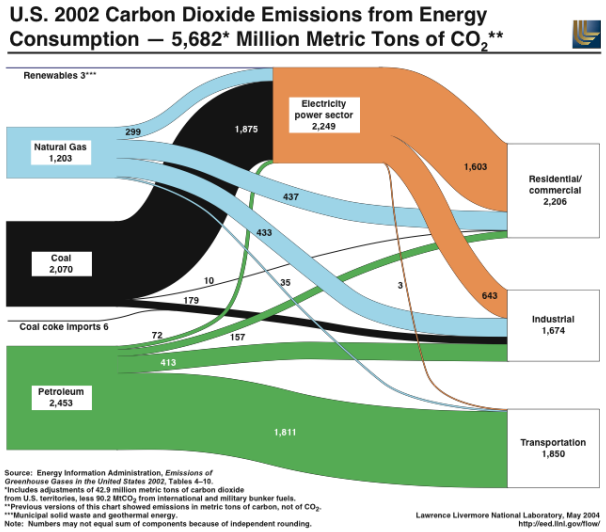


How much of our energy usage is wasted?

What can we do to burn less gas?

If the fleet-average MPG increases from 18 MPG to 39 MPG what would this do for our annual usage of petroleum in EJ (the figure below will tell you what fraction of petroleum is used in transportation)? How does this number compare to the other “renewable” energy options?





28% of our energy use is transportation

32.6% of our CO_2 emissions come from transportation

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1 calorie=4.184 J
1000 calories=1 Calorie
1 Calorie=1kcal
1 kcal=1.16 watt-hr
1 barrel (42 gallons) of crude oil=6.12×10^9J
1 gallon gasoline=1.31×10^8J
1 cubic ft natural gas=1.08×10^6J
1 short ton coal=2.13×10^{10}J
1 kilowatt-hour of electricity=3.60×10^6J
1 EJ=1×10^{18} J
1 Quad=1.055 EJ (a quadrillion BTU)
Gt=gigatonne (a billion metric tons (10^9), 2200 billion pounds (2.2×10^{12} lbs))

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World Reserves	
Coal	20,200 EJ
Natural Gas	7,170 EJ
Oil	10,200 EJ
US use:	
Coal	20.8 EJ
Natural Gas	26.3 EJ
Oil	37.2 EJ
Nuclear	8.7 EJ
Biofuels	16.7 EJ
Wind	36 EJ
Solar	38 EJ
MPG	17.8

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Table 4.3 Energy Content of Fuels

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Average Energy Content of Macronutrients

Fats	38 kJ/g
Carbohydrates	17 kJ/g
Proteins	17 kJ/g

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Table 4.2 Bond Energies (in kJ/mol)

	H	C	N	O	S	F	Cl	Br	I
Single Bonds									
H	436								
C	416	356							
N	391	285	160						
O	467	336	201	146					
S	347	272	—	—	226				
F	566	485	272	190	326	158			
Cl	431	327	193	205	255	255	242		
Br	366	285	—	234	213	—	217	193	
I	299	213	—	201	—	—	209	180	151
Multiple Bonds									
C=C	598			C=N	616		C=O	803 in CO_2	
C≡C	813			C≡N	866		C≡O	1073	
N=N	418			O=O	498				
N≡N	946								

Source: Data from Darrell D. Ebbing, *General Chemistry,* Fourth Edition, 1993 Houghton Mifflin Co. Data originally from *Inorganic Chemistry: Principles of Structure and Reactivity,* Third Edition, by James E. Huheey, 1983, Addison Wesley Longman.

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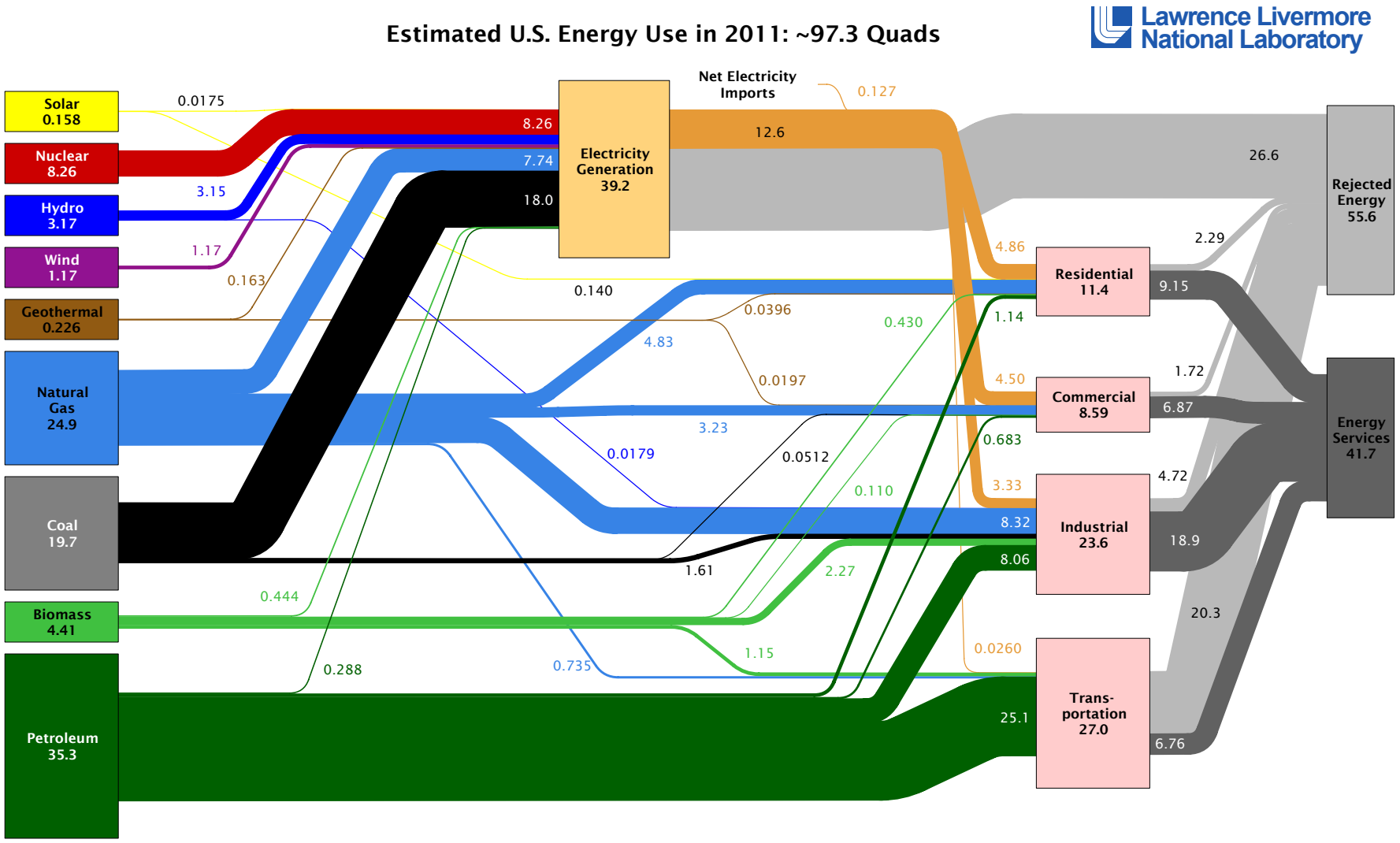

Source: LLNL 2012. Data is based on DOE/EIA-0384(2011), October, 2012. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527