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EKSAMEN i FY 2290 Energiressurser
Tirsdag 7. juni 2011
Varighet: 15:00-19:00

Antall sider: 12
Sensurfrist: 26. juni 2010

Tillatte hjelpemidler: Godkjent kalkulator, HP30S eller Citizen SR-270X.

Fysiske parametrer, konverteringstabell og likningslist, etc finnes på side 6-12.

Du må svare på alle spørsmålene. Vekten til hvert spørsmål er gitt i små tall først i hver deloppgave.

I beregningsoppgavene må du ise hvordan du har gått fram, og tallsvar må gis med riktig enhet (benevning)

For the calculations, you must show your work to get credit, and units must be included (and appropriate).

SECTION I
Short answers (50 points)

1)$_4$ List two reasons for the increase in global energy use, and give a perspective on how the situation is likely to change for one of these in a) 20 years and b) 200 years
population increase --The UN predicts that world population will stabilize around 10 billion by 2100. As the planet has limited capability to produce food, it is sure to stabilize at some point, but in the short term, it will continue to grow. 20 years - continued fast growth; 200 years, stability
industrialization - as nations become industrialized, the per capita use of energy increases manyfold. Although societies are becoming more efficient in their use of energy, this factor will continue to drive the need for more energy, quite possibly beyond the point where the world population stabilizes. Fast growth over the next 20 years, continued growth for at least 200 years.

2)$_4$ Explain the difference between an energy resource and an energy vector, and give examples of each. *An energy resource is a reservoir of stored energy, such as coal or natural gas or oil or a water-filled dam.*
An energy vector transports energy from one location to another - electricity is the prime example, but radiation and wind are others.

3)$_4$ List three types of potential energy, identify one that is often used for short term energy storage, and give an example of the device that stores energy in this form.
Gravitational - most common for energy storage (i.e. a dam)
Electrical - batteries
"chemical" - really electrical
Nuclear- stored in radioisotopes

4)$_4$ Give approximate values for the efficiencies of *four* of the energy conversions below.
Automobile (fuel-> motion) 20-25%
Gas turbine (fuel -> electricity) 40%
Coal-fired power plant (coal to electricity) 30%
Gas heater (natural gas -> heat) 75-85%
Electrical heater (panel ovn) (electricity -> heat) 100%

5)$_4$ Give the equation for the coefficient of performance and define the variables. Give an example of a device that would be characterized by this metric.
$COP = \frac{Q_H}{Q_H - Q_L} = \frac{T_H}{T_H - T_L}$; T_H is the temperature of the hot zone, T_L is the temperature of the cold zone. A heat pump is an example.

6)$_4$ What are the first and second laws of thermodynamics? State them in terms that relate to this course, and explain what they mean for the use of energy resources.
The first law of thermodynamics is that total energy is conserved. We may change the form, but it is not created or destroyed. This means that there is a limit to the use of energy on earth, set by the existing reservoirs of energy and the solar radiation received.
The second law of thermodynamics tells us that entropy increases in any process that occurs in a finite amount of time or at a temperature above absolute zero (or alternatively that the efficiency

is less than one). This means that any energy conversions we perform will decrease the useable exergy of the system and leave us with more random kinetic energy(heat)

7)$_3$ How will the system entropy change during the following processes (increase, decrease, remain the same)

a) absorption of sunlight and conversion of water and CO_2 to carbohydrates in a plant
increase

b) burning of gasoline at 800 ºC in a car engine
increase

c) mixing of the exhaust gases from the car engine with cooler air
increase

8)$_4$ Explain what fractional distillation is, and give examples of two products of the process.
fractional distillation is the separation of different molecular weight compounds of petrochemicals (oil) by heating, vaporization and recondensation. The lighter molecules boil at the lowest temperatures. Examples include gasoline and asphalt.

9)$_6$ Describe the costs and environmental and safety hazards associated with the extraction, transport and use of a fossil fuel of your choosing.
Example: Natural gas is associated with oil wells, and has the associated recovery costs and environmental impact. The major environmental impact on extraction is the release of methane, which is a powerful greenhouse gas. Transportation occurs either through pipelines, which can disturb habitat, or through liquification and ship transport. LNG can present an explosion hazard.

10)$_6$ What is the "greenhouse effect" and how can it be
a) a positive thing in house construction
b) a negative thing in earth's climate.
The greenhouse effect refers to a system which admits visible light through some layer or window, converts some fraction of that energy to heat/infrared radiation, which is then trapped by the overlayer or window.
In houses, winter sunlight can both illuminate a room and be absorbed to heat the surfaces it hits. Properly chosen glass can be made to reflect the resulting IR radiation back into the house.
In the earth's climate, CO2 and other gases can trap heat in the earth's atmosphere, leading to destabilization of the climate and melting of the polar icecaps

11a)$_2$ What is the source for sulfuric acid in rain?
b)$_3$Why has it been easier to reduce emissions of sulfur from cars, than to remove emissions of NO_x gases ?
Sulfur in the atmosphere comes primarily from the burning of hydrocarbon fuels such as oil and coal. It can be removed from gasoline during refining. NOx comes from the combustion process whenever the temperature exceeds about 1200C, and is thus an inherent pollutant from internal combustion processes. It is worse from diesel engines, where the temperature is higher.

12)$_2$ Why is the "half-life" of radioactive elements a concern in relation to nuclear power?
The half-life of the radioactive waste products tells us how long they will emit dangerous radiation.

SECTION II (50 points)

13) Solar and Wind(20 points)

The theoretical conversion efficiency of solar energy into wind energy has an upper limit of 1,2% [Vos & Wel, Theoretical and Applied Climatology **46**, 193].

a)$_{15}$ Compare the ultimate efficiency of the conversion from solar energy to electricity in the home using the following data:

Trondheim annual solar energy received 950 kWh/m^2

Average wind velocity 10 m/sec
Windmill size 20 m^2
conversion to electricity 90%
transmission loss 10%
40% of power in wind → mechanical power

Photovoltaic cell efficiency 15%
DC-AC conversion 85%
transmission loss 10%

the conversion of solar to electricity via wind is thus
.012 x .4 x .9 x .9= 0.0038 --> 0.38%

And solar photovoltaics
.15 x .85 x 0.9 = .115 = 11.5 %

b)$_5$ Calculate the ratio of the electricity delivered (including transmission losses as mentioned in a) above) of a 20m^2 solar panel per year in Trondheim compared to the 20m^2 windmill above

The power available in the wind is
kW/m^2 = 6.1 x 10^{-4} (10)^3
windmill, per m^2/yr = .4.9*.9*6.1 x 10^{-4} (10)^{3}m^3/sec^3* 24hrs/day*365days =1731 kWh/m^2/yr*
*1731kWh/m^2*20m^2=34600kWhr/yr*
note that we remove the factor of .012 from the efficiency calculation because we are now dealing with the actual wind at the site.

from the solar panel, per m^2
950kWh/yr.115=109 kWh/yr*
*20m^2*109 kWh/yr/m^2=2180 kW/yr*
Note that the collection area to drive the wind at that velocity is a) not known and b) large That is why we can get more energy per year even with a lower efficiency

14) Heat pumps (8 points)

a)$_2$ Sketch the thermodynamic diagram for both a heat pump and a heat engine.

b)$_2$ What is the maximum theoretical efficiency of a heat engine operating with a burner at 1200C and cooling water at 45 C?

efficiency is $(1-T_{cold}/T_{hot})$ = 1-(318/1473)=78%

c)$_4$ Give an example of a commonly used heat engine, sketch the components, and describe the operation.

e.g. a gasoline engine
4 “strokes” intake, compression, expansion (ignition/power), exhaust

has a spark plug to initiate combustion

15) Tides (12 points)

The height of the tides in the Bay of Fundy in Canada is as much as 7 meters in the Minas basin. The mean tidal height change over the basin is 5.5 meters, and the area is approximately 40x50 km(the basin gets 5.5 m deeper each cycle).

a)$_8$ Estimate the electrical energy available per tidal cycle if all of the water were captured by a dam, released through turbines and converted to electricity with an efficiency of 70%.

this is like a slab of water 5.5 m thick being raised above the dam. The average potential energy should be calculated with h=2.75m, since some of the water is higher, and some is lower.

*potential energy = M*g*h = Volume*10^3kg/m^3* 9.8 m/sec*2.75=*

*2000x$10^6$$m^2$*5.5m *2.75*$10^3$*9.8=3 x 10^{14} joules*

electricity produced w/70% efficiency --> 2.1x 10^{14} Joules

b)$_4$ An alternative way of tapping this energy source is to have underwater turbines in a region where the tidal flow is strong. How would you need to alter the equation for the power of a windmill to use it to calculate the power delivered by such an underwater turbine?

You would have to multiply the equation by the ratio of the densities of water and air, and there are probably differences on the basis of the larger viscosity of water.

16) BP report (10 points)

a)$_3$ Use the appended data to determine the per capita use of natural gas in Russia and Iran.

Russia 2730 m^3/person/yr

Iran 1756 m^3/person/yr

b)$_3$ What is the R/P ratio for natural gas in Canada? And in Norway?

10.9 years, 19.8 years

c)$_4$ If Kuwait decided to keep and use all of their natural gas themselves, at current usage levels, how long would the supply last?

133 years