Sustainable development for aerospace engineers (lecture notes)
AE3-T11

Lecture 2

Methods to investigate the past

ICE cones from the poles core

- Isotopes (O^- variant) with the mass-spectrometer (*)
  - $^{18}0^-$ (0.21%) against $^{16}0^-$
  - $^{18}0^-$ has a lower tendency to evaporate
    - higher concentration mean higher global temperatures in that period on a global scale and vice versa
      - evaporation cycles which start on the equator and end at the poles
    - concentration is called the ice signature
- air bubbles ⇒ possibility to investigate the gas in these bubbles

oceanic sediment

- has the advantage of being more or less globally the same
- sediment consists mainly of carbon (C)
  - mainly C^{12} but also the unstable C^{14}
- measurement of the ratio C^{14}/C^{12} ⇒using the decay time of the C^{14}

(*) Mass-spectrometer

- Ionises the H_20 in OH^{-1} and H^+ ions
- $^{18}0^-$ is heavier then $^{16}0^-$⇒ $mass\left(^{18}OH^-\right) > mass\left(^{16}OH^-\right)$
  - Energy equation results in a different speed vector for the different ions

    $$E = eV = \frac{1}{2} m_{ion} V^2$$

- Uses a magnetic field ⇒ $\bar{F} = q \times \bar{B} \times \bar{V}$
  - Weight is measured by its position in the magnetic field

Lecture 3

Feed in system (ex photo voltaic cells)

- System first used in Germany to enlarge the market for a new technology ⇒results in lower (acceptable) production costs for new and expensive technologies.
- Concept (using the example)
  - 1995: government ensures 1euro/kWh for 20 year
    - Tariff just enough to make it possible for the user to make a little profit in the long run
    - Costs payed by the non-users⇒cost neutral
    - Still small market⇒ high costs for the hardware
  - 2005: government ensures 0.65euro/kWh for 20 year
    - Cost of the solar cells are all ready lower and the market will grow⇒lower hardware costs
  - Etc until the cost of solar energy is actually as expensive as the normally produced energy
    - Large market⇒many users

Cradle 2 cradle

- A system to make our environmental footprint smaller or even negative
- Eco-effectiveness Vs eco-efficiency: we don't have to reduce our production and use of the nature we just have to do it better (win-win situation) and in cooperation with the earth
- Concept (2 cycles)
    - Bio-cycle: all our waste should be ready to use as food for something else
        - Ex: easy decomposition of textile, shoes, protection material, etc
    - Techno-cycle: recycling the things that cannot be put back into nature
        - Product returns to the producer who has to recycle it
            - Profit and the risk for the producer ⇔ risk for the consumer
            - Will push producers to use less hazardous, hard to recycle products (plastics)

Amount of polar ice

The decline in the amount of polar ice is measured by NASA (20 year study) to be around 1% per year, which would mean the all the ice will be disappeared in the year 2100. But, satellite measurements by ESA (2005 and 2007) show a 10% decrease per year⇒no more ice around 2015.

⇒ Means that the disappearance of the ice sheets is accelerating

Lecture 4

Methods of producing/storing renewable energy

- Wind energy
    - Windmills (1-3 MW)
    - Ladder mill: system with multiple kites that pull a cable which makes the energy
        - $P = V_{\text{climb}} \cdot F_{up}$
        - Low cost +/- 30 euro for 500 hours ⇒0.02 euro per kWh
        - Higher wind speeds at high altitudes (highest 9km ⇒5kWh/m^2)
        - Use of kite-planes go up easy and also come down easy (kites don't come down easy)
        - Can be used as propulsion (ex. Boats) positive: no negative vertical component
- Photovoltaic cells
- Aqua fire: hole in the ground under some layers (100m) to store heat
    - Excess heat in the summer put in storage by circulating water
    - Winter time the stored energy is used

fossile storage

- Use of renewable energy is dependent on weather ⇒very variable ⇔ energy demand is less variable
- Safe fossile fuel by only using it when renewables can't fit the demand ⇔ quickly variable production

Energy neutral houses

- Houses that on average totally produce their own energy (electricity and heating)
- Of 450000euros only 75000 euro is used to make the house energy neutral
- This is an interesting investment because
    - These houses would have an average cost of around 5000 euro per year for their energy
    - Energy prices are rising quickly

Lecture 5

Wubbo ockel's boat

- 13000 kg of lead batteries 30 Wh/kg
  - 30 Wh/kg⇒350 kWh⇒ 350h on the boat 1kW/hr (double average usage 0.5kW/hr)
  - Can be charged in +/- 50 hr ⇒7kW charging due to sailing (300 m^2, wind 10 m/s)
  - Cost electricity due to the sail=€0.1/ kWh
    - Cost €10000 for 15years⇒2years actual usage (50/350)⇒16000hr⇒0.6€/hr

Solar challenge

- Darwin –Adelaide (3000km in from 8am-5pm) average speeds 90-103 km/hr
- 9m^2 GaAr solar cells: €150/piece, 24%-32% efficiency 2000-2008, space technology
  - TJ: triple junction⇒different layer (3) each absorb a part of the spectrum(IR to UV)
- Strategy: **generic algorithm:** optimising using the principle of Darwin (survival of the fittest)
  - Create a population of possibilities (speeds over the trajectory in this case)
  - Let different possibilities make children⇒make errors ⇒mutations and X-chromosomes
  - Kill the slowest and start over (diversity)

Lecture 6

Vehicle to grid

- Electrical or hybrid cars can be used to store energy and on failure they can deliver the needed energy
- 20kWh/kg for lead acid (200kWh/kg for lithium polymer)
- 7 million cars⇒140GWh
- Conventional energy storage⇒pump up water 15e^8 m^3 1m $\frac{1}{2}mg\Delta h$ = 2 GWh⇒pump up to 70m

Hydrogen

- 75% of the universe is built out of H_2
- Made by reformation of natural gas (ng) (ex CH_4), electrolyse, sunlight, plasma discharge
- High energy density due to stronger chemical bondings (8X that of CH_4)
- Higher efficiency (gas to electricity) then gasoline (50-70% instead of 25%)
- Less exploding power then gasoline (22 times)
- Doesn't burn when it diffuses (needs a 1/8 mix with O_2)
- 60% of the produced H_2 is used for the production of gasoline

Knowable

Causes of climate change

- Volcanic eruptions results in stratospheric dirt
  - Gets spread around the world due to currents
  - Block the sun and cool it down
- Large scale weather systems like El Niño
- Growing Radiative imbalance due to green house gasses: energy going in Vs energy going out
  - Mismatch of 1-2 W/m² (less outgoing energy)

Oil

- Production happens when there is no more ice (hot and much green material) in between ice ages
- Problem: we use 100 years what took the earth 100 million years to produce
- Amount of oil found is following the function $e^{-t/T}$
  - Mathematical the total amount to be found is $\int^{t_0} e^{-t/T} = 1 - e^{-t_0/T}$
  - Results in high prices (and crisis) due to speculation (buying of put options by countries)
- The Netherlands use 3000 PJ/year of energy

Capacity factor: percentage of the total capacity that is available on average (wind direction, weather etc) (25% for the Netherlands)

The moon stabilises the earth's rotation axis

Average sun energy flux that reaches the earth surface is 1000 W/m²⇒this gives an average per square meter over the entire earth surface of 250 W/m² because only ¼ of the earth receives sunlight

Apollo project

- Relatively young people realised it in a very short period
- Rest of the mission used to take the first X-ray picture of the sun (SKY-LAB)

Environmental footprint: amount of space each person needs to live (sustainable) according to one's lifestyle

- Consist of water surface, woods(carbon oxygen cycle), agricultural land, etc needed
- Everybody the American lifestyle ⇒4.3 times the earth is needed for 6 billion people

Photovoltaic cells:

- Produce the energy needed to make them in 3 years
- Lifetime >20 years
- In 2008 the global amount of used solar cells doubled (+100%) (+62% in 2007)
- $1m^2 = 100\frac{kWh}{year} \Rightarrow$15% efficiency
- Officially 31% of the Netherlands needs to be covered to provide 100%
  - Can be reduced to +/- 3% when houses are heated by another source (heating is the largest fraction)
- 1 car for 20000 km with 20m²⇒average car $100\frac{km}{hr} \Rightarrow \frac{1}{15}\frac{Liter_{fuel}}{km} = \frac{1.5kWh}{15} = 0.1\frac{kWh}{km}$

Challenger

- Disaster caused by a leakage in the solid rocket boosters (wrong direction)
  - Made of different parts due to transport problems in Ohio
  - There were 8 leakages in 24 flights
- Not the H_2 caused the explosion but the fact that the shuttle is less strong then an average plane