

1 Project work for “Physics of Energy and the Environment ”

Write a 6-10 A4-page report on one a topic such as one

Your report should include some of the underlying physics, with basic equations and applications with concrete typical numbers.

1.1 Climate

global warming

- Consequences : Projected rises in temperature. Cost to the city of London and other major cities in flood protection. Use warming of the oceans (based on IPCC scenarios) and melting of polar ice caps.
- Statistical analysis of temperature record

Milankovitch cycles

The derivation of

$$\cos(\Theta) = \sin(\phi) \sin(\delta) + \cos(\phi) \cos(\delta) \cos(h)$$

using spherical law of cosines. How this is used to derive formula for average sunlight per day ? How orbit parameters affect the amount of sunlight falling on specified latitudes ? How this calculation is used in Milankovitch theory ?

Periodic changes in the properties of the Earth’s orbit over long time scales. How it affects the amount of yearly solar energy receive in arctic regions. As a theory of ice ages. Successes and problems. Wikipedia article on “Insolation” is a good place to start.

Global Climate models

What equations go in these models ? How are the equations dealt with ? What are the challenges ? See IPCC web-site. Wiki article on “global climate models” and follow up further references there.

Analytic models

Extensions of the simple radiative balance model we discussed in class ; Models including positive and negative feedback ?? Our model was 0-dimensional. You could pick a paper which develops a one-dimensional model.

For example papers such as [9]. YOU can find papers on the topic of your choice by searching in Google-Scholar.

1.2 Solar

Efficiency of Solar cells

Theoretical Aspects : The Shockley-Queisser paper [1] on detailed balance and efficiency. Generalization to multiple junctions [2]. The book by Nelson on “Physics of solar cells” (available from library) would be useful here.

Experimental : What kinds of efficiencies have been achieved experimentally ?

Areas of research in improving efficiency. See Wikipedia article on “solar cell research” and web-sites of research groups doing research in this area
e.g Durham <http://www.dur.ac.uk/renewable.energy/>
Caltech <http://daedalus.caltech.edu/research/thinfilmpv.php>

Solar energy : Devices and economics

Types of commercial solar cells.

Energy payback time. Estimates for different types of solar cells. (Some literature search to find relevant refs.) Present some calculations for these estimated payback times.

Solar energy : Prospects

What fraction of UK energy demand can realistically come from solar ? See relevant chapters of Mc Kay book.

Estimates of the size of the world solar PV market.

How much solar power will we be using in 5 , 10 , 50 years time ?

See reports on solar energy at [4] and elsewhere.

The web-site

<http://www.martinot.info/futures.htm>

has reports on future scenarios for use of renewable energy sources.

1.3 WIND

Wind Energy – The London Array ; Research areas

The London Array [3] is a proposed 1 GW offshore wind farm. Relate this expected power output to estimated wind speeds, wind turbine efficiencies etc. Issues of environmental impact are also discussed in the web-site and in the links.

The Durham web-site <http://www.dur.ac.uk/renewable.energy/> also has info on research areas in Wind Energy.

1.4 waste to heat

Waste to Heat systems

Anaerobic digestion.



This summarises a 4-step chain of chemical/biological processes. See more in Wikipedia article on Anaerobic digestion.

See bbc news article

<http://www.bbc.co.uk/news/uk-11433162>

about operating system in Didcot, Oxford.

Other methods for converting waste to energy include gasification, incineration. In *gasification*, the useful fuel produced is hydrogen. In *incineration*, burning of carbon-rich material produces heat, which drives a steam power plant.

London prospects .. A gasification bid for London
<http://www.renewableenergyfocus.com/view/967/waste2tricity-bids-for-london-waste-to-energy-contract/>

Consultation on waste in London
<http://www.london.gov.uk/consultation/waste-strategy/public-consultation/realising-value>

Inauguration of a waste to energy (gasification) plant in London
<http://www.newenergyworldnetwork.com/renewable-energy-news/by-technology/energy-efficiency/london-mayor-inaugurates-80m-uk-waste-to-energy-plant.html>

1.5 NUCLEAR

Nuclear Fusion

Some theory – cross-sections, Lawson criterion. Key challenges, raw materials, design of palladium reactors. ITER. Web-site of ITER

<http://www.iter.org/>

ITER is designed to demonstrate fusion reactions producing more power than put in.

UK research centre for fusion - Culham
<http://www.ccf.ac.uk/>

Nuclear Fission and Nuclear Waste

The physics of fission reactors – cross-sections, moderators – will be discussed in class. The project would use some of this physics, and discuss issues of nuclear waste disposal.

There is a Diamond University consortium doing research related to fission, waste disposal
<http://www.diamondconsortium.org/diamond10.pub.htm>

1.6 Other topics

Fuel Cells ; Wave/Tidal energy; Proposals on Hybrid Fusion-Fission reactors. The Andrews-Jelley book is a good place to start reading, then follow up some of the references to develop your project plan.

Geothermal Energy : Chapter 4 of the book by Fanchi [8] and Wikipedia article on this topic.

1.7 what an acceptable project is not

A collection of paragraphs from different sources merged together in a word document. This is plagiarism and unacceptable.

1.8 Practicalities

If your project write-up contains plenty of equations, it maybe better to do it in LaTeX. A lot of projects in the past have been in Microsoft Word, which is fine.

1.9 Schedule

- Week 7 (reading week) : Think about potential project topics.
- Week 8 : You start working on it and let me know your choice (by email)
- Week 10 : You continue working on it and we have a meeting discussing progress.
- Week 12 : YOu give 5-8 mins. presentation.

Meanwhile lectures will cover :

- Wks 8,9 : Wind
- Wk 10 : Nuclear fission
- Wk 11 : Nuclear fusion

References

- [1] W. Shockley and H. J. Queisser, “ Detailed balance limit of efficiency of p-n junction solar cells,” J. Appl. Phys. 32, 510-519 (1961)
- [2] C.H. Henry “ Limiting efficiencies of ideal single and multiple energy gap terrestrial solar cells,” J. Appl. Phys. 51, 4494-4499 (1980)
- [3] <http://www.londonarray.com/about/>
- [4] <http://www.epia.org/index.php?id=18>
- [5] <http://data.giss.nasa.gov/gistemp/>
- [6] http://www.msnbc.msn.com/id/33482750/ns/us_news-environment/t/statisticians-reject-global-cooling/
- [7] <http://www.dailymail.co.uk/sciencetech/article-2051723/Climate-change-New-analysis-1-6bn-weather-records-concludes-globe-IS-warming.html>
- [8] J. R. Fanchi, “Energy : technology and directions for the future,” (Elsevier, 2004) (available in Library)
- [9] Wei-Chyung Wang , Peter H. Stone, “Effect of Ice-Albedo Feedback on Global Sensitivity in a One-Dimensional Radiative-Convective Climate Model,” published by American Meterological society.