

Renewable Energy & Sustainability



Miguel Prado

The Netherlands, April 2009

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- 3 – How does Life gets its energy?
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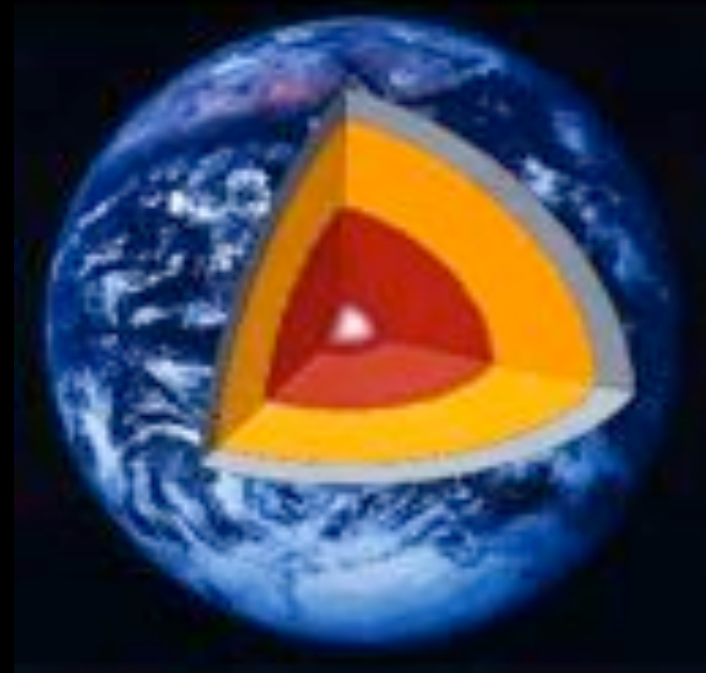
Click on desired chapter

What renewable sources
does our planet have?





Tidal



Geothermal

Solar



Tidal Energy



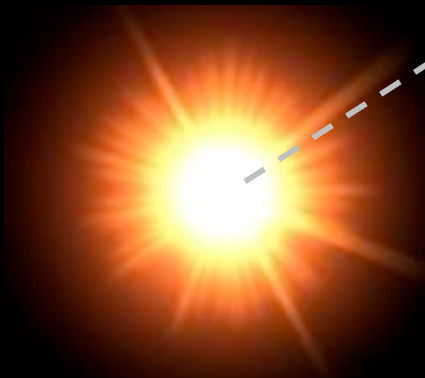
3.2 TW

(20% of WEC)



0.5 TW

(3% of WEC)



Geothermal Energy

30-44 TW

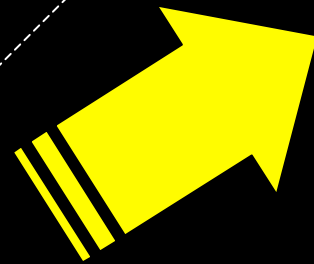
(2-3 x WEC)



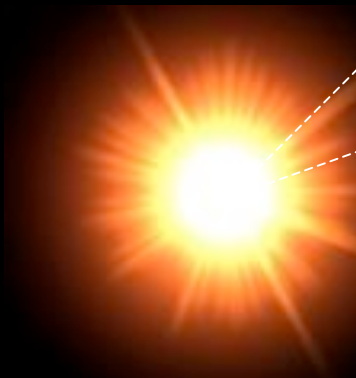
Solar Energy

174000 TW

(11000 x WEC)



1366 W/m²

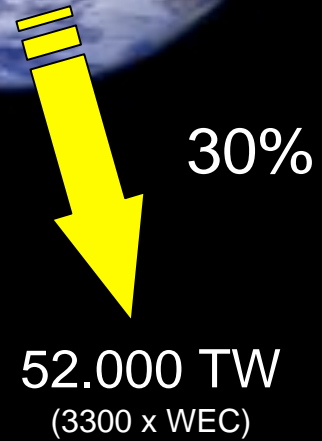
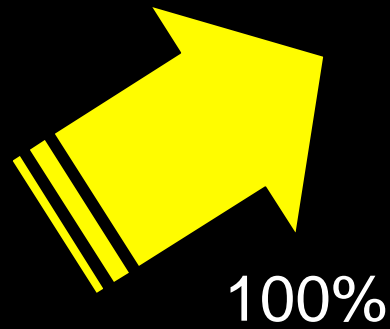


63 MW/m²

What happens to all this
Solar Energy ?

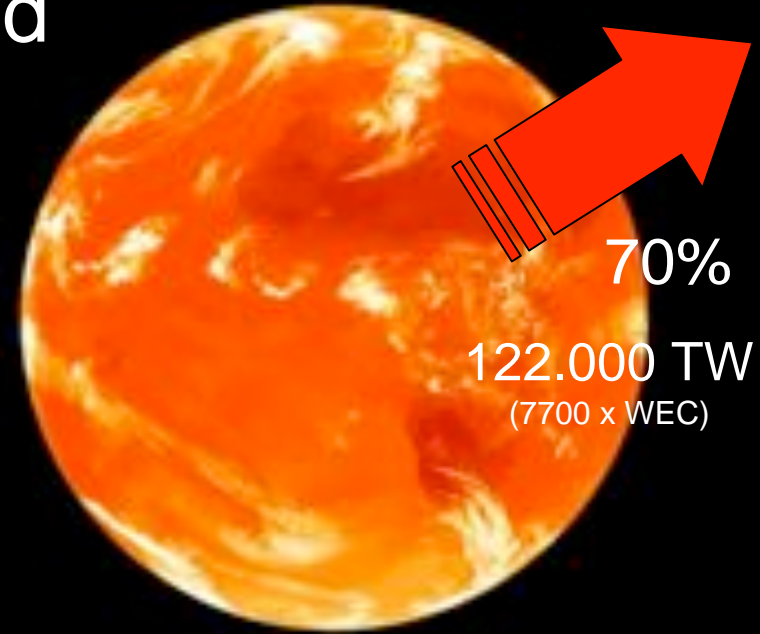


30% is reflected ...



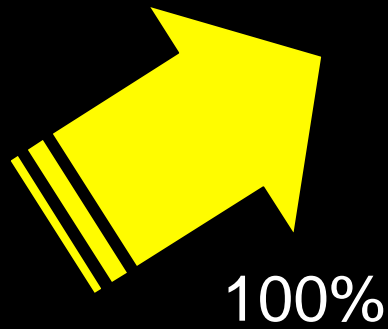
70% absorbed and reradiated
back to space...

Infrared



70%

122.000 TW
(7700 x WEC)

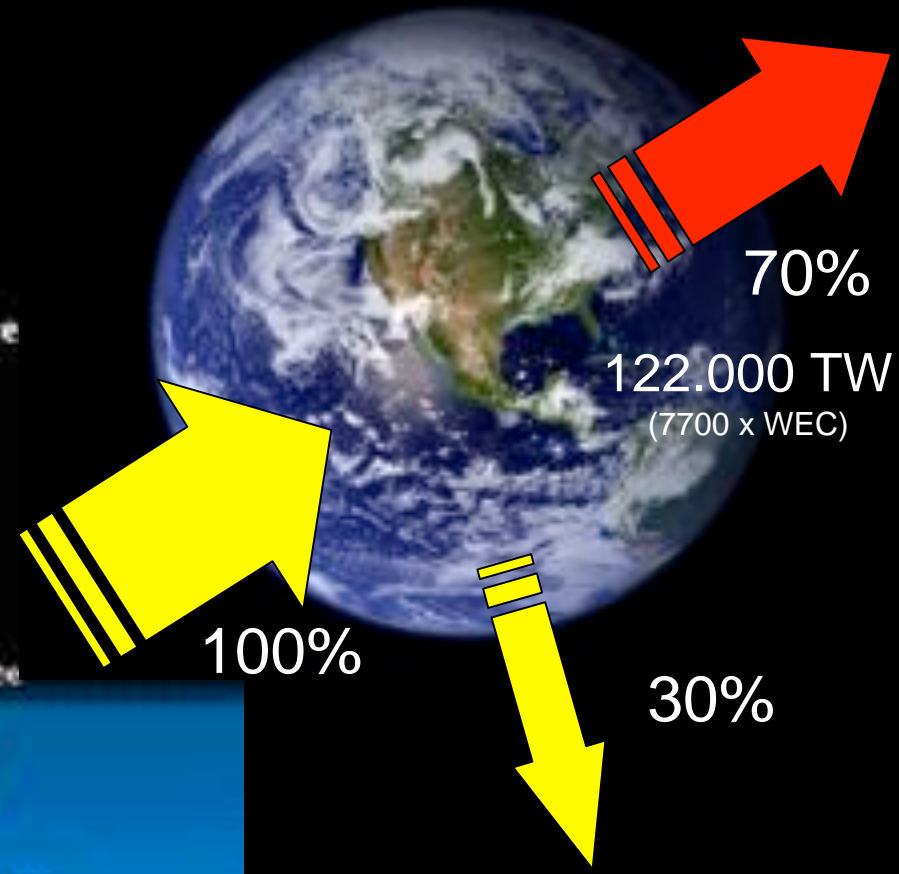
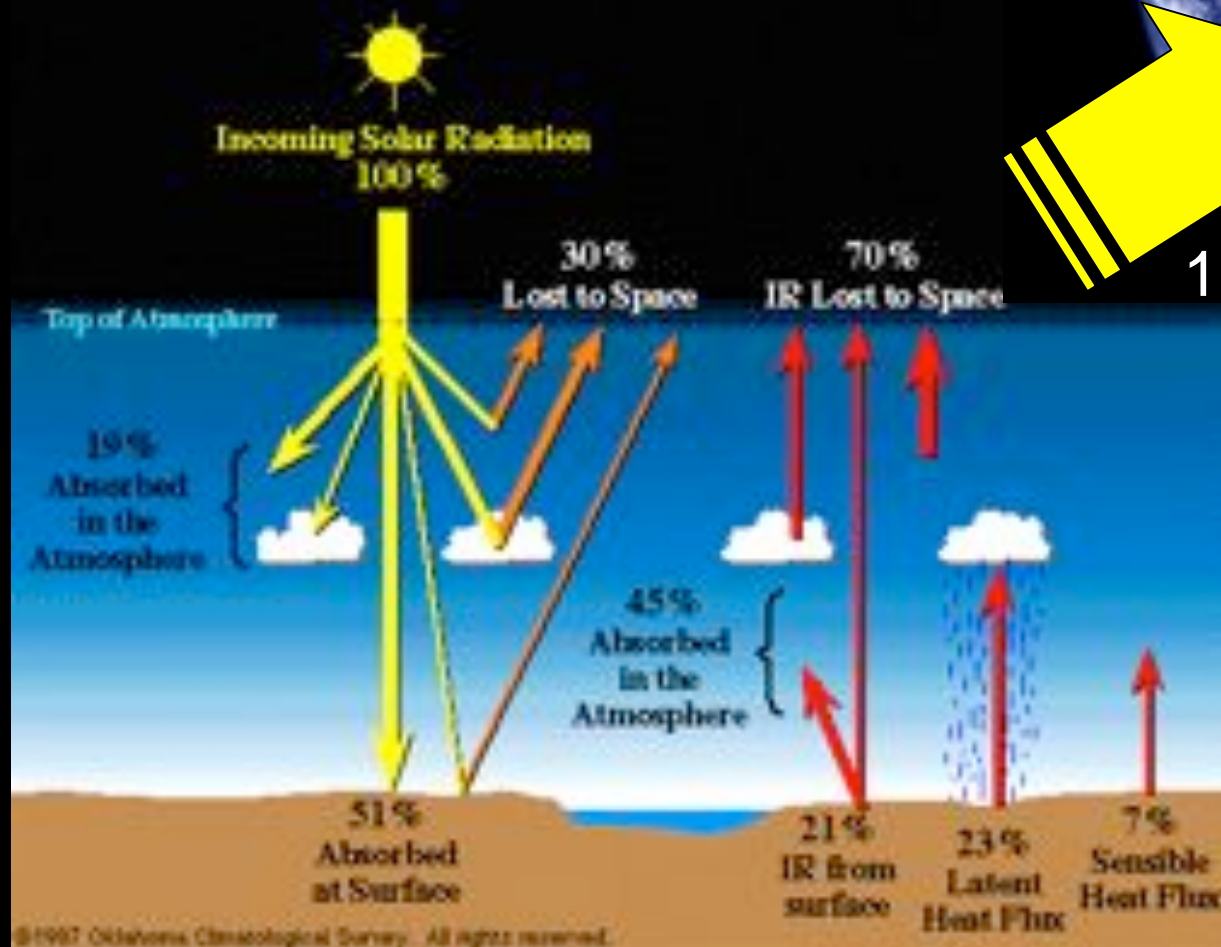


100%



The balance of the solar energy flux ...

The Annual Mean Global Energy Balance



The absorbed Solar Energy before leaving ...

Wind



Ocean Waves
and Currents



Hydropower



Oceanic Biomass



Terrestrial Biomass



In old civilizations, the Sun
meant “Source of life” ...



Inti

(Inca)



Aten

(Egyptian)

Today it seems to mean only
“good weather” ...



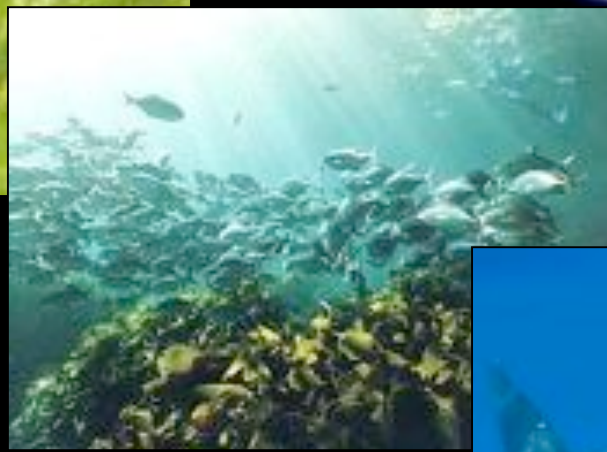
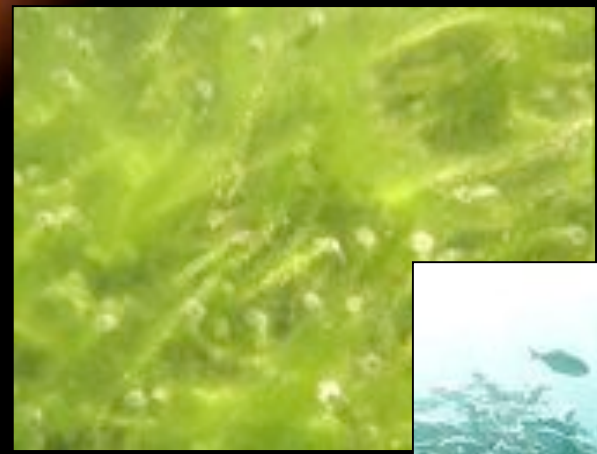
How does Life gets its energy ?



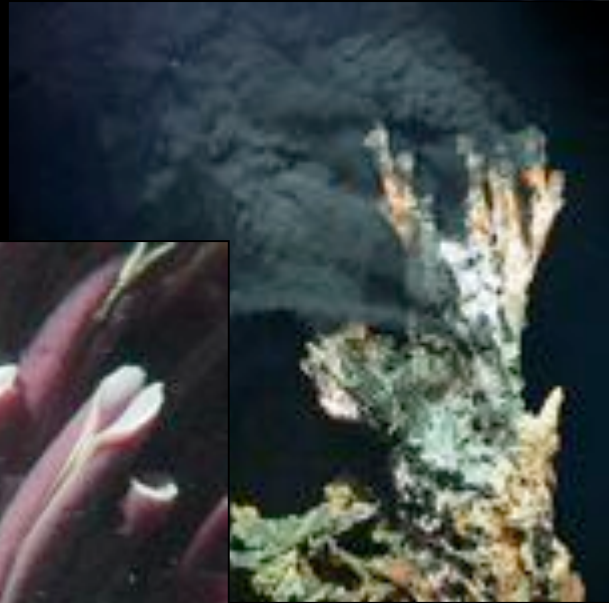
At the Land ...



In the Ocean ...



And deep in the Ocean ?



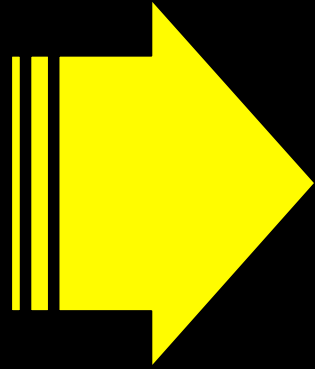
Life also uses energy for heating ...



How humans get 87% of their energy ?



In one word ...



122000 TW



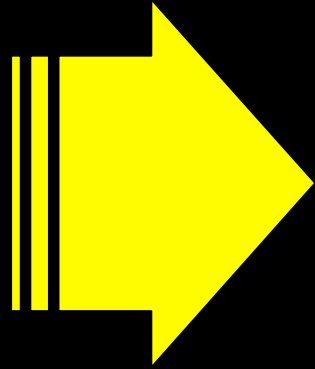
2 TW



14 TW



Are we able to join our planet ?



122000 TW



We have intelligence for
this ...



TSAR Bomb = 10 x WW II



CERN LHC – proton at 99.999999% c

Maybe it's time for us to
change ...



Maybe ...



Maybe ...



Maybe ...



Maybe ...



Maybe ...



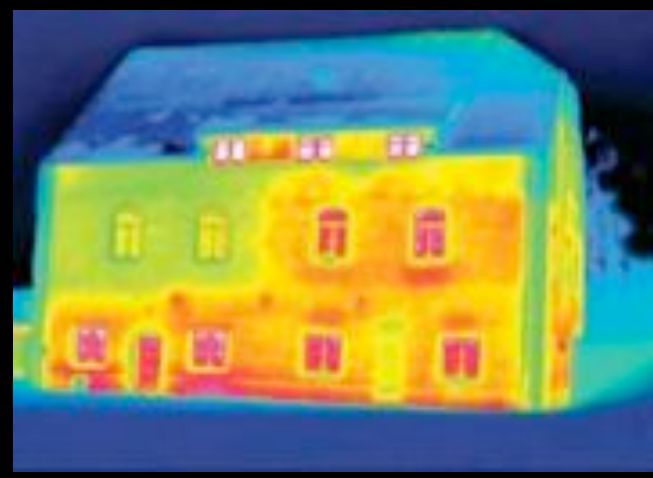
Maybe ...



Maybe we could also be
more energy efficient...



At home ...



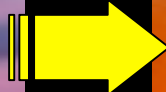
With our transportation ...



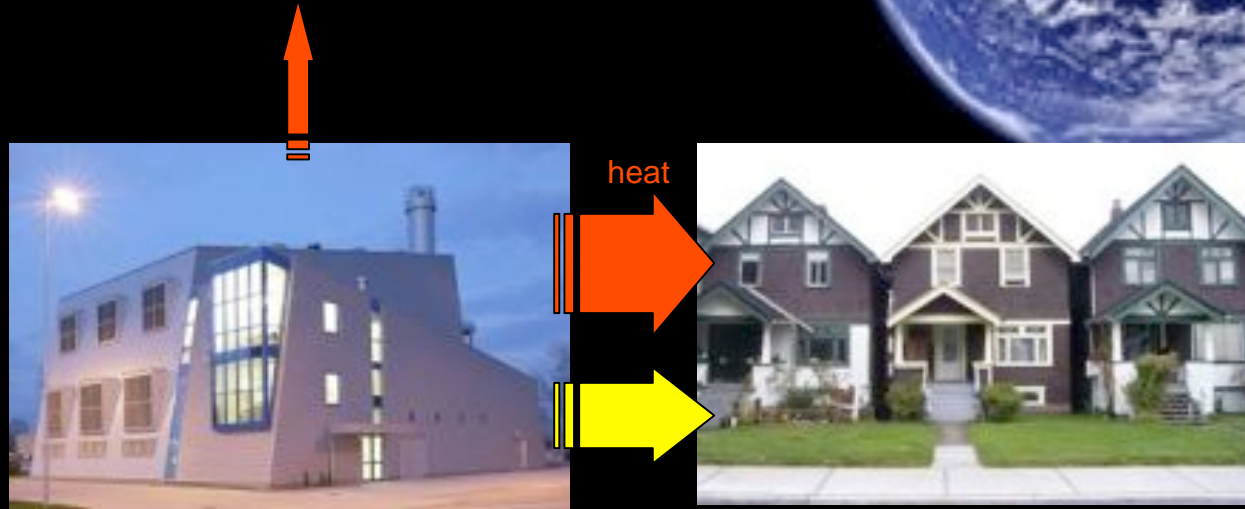
Not throwing food away ...



Maybe instead of centralized energy production...

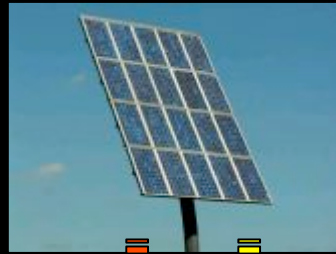


Decentralized cogeneration of heat & power (CHP)...



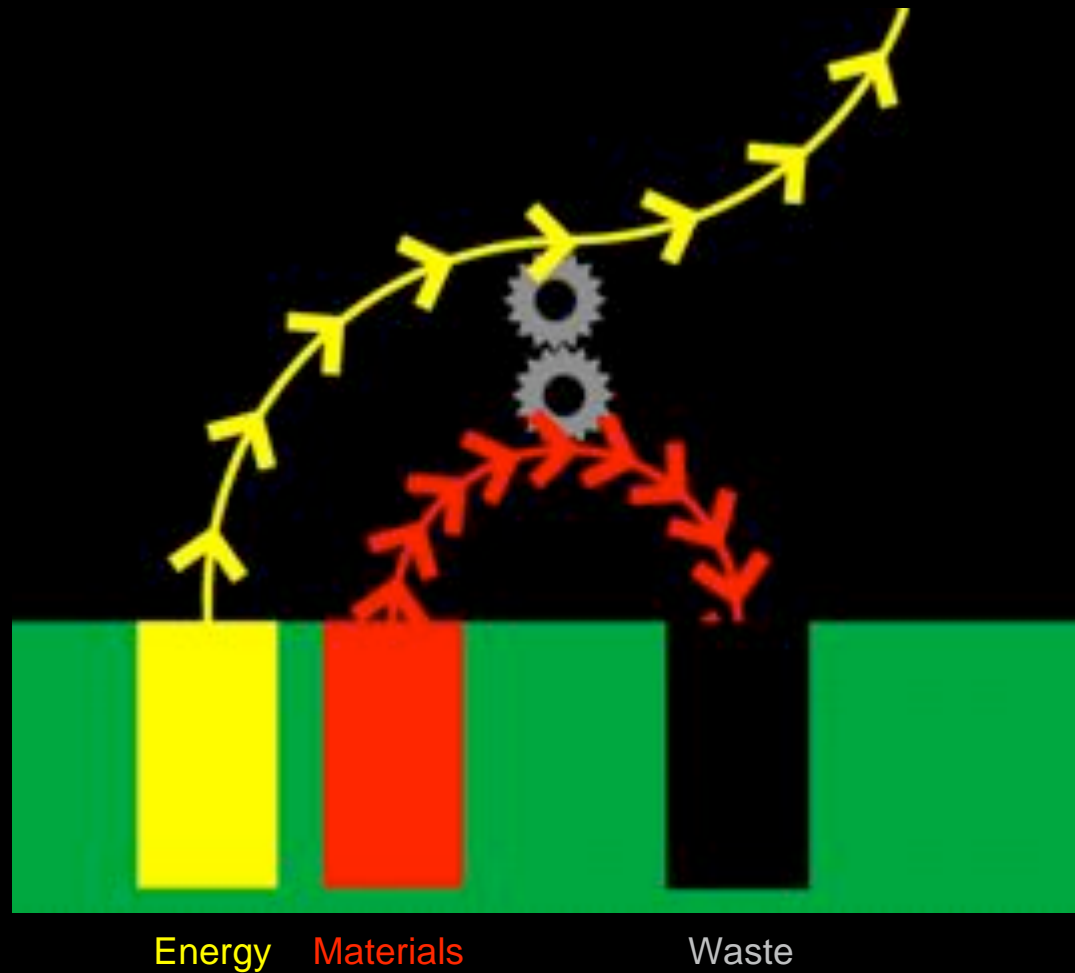
CHP

Each house producing energy ...



Maybe instead of doing this

...



We could do like Nature ...



Maybe then our planet would
say ...





Thank you !

More information ...



Renewable Energy and Saving ...



Intelligent Energy Europe (ec.europa.eu/energy/intelligent)

YOURIS (www.youris.com/Energy)

Wikipedia - Renewable Energy (en.wikipedia.org/wiki/Renewable_energy)

Renewable Energy Policy Network for the 21st century (www.ren21.net)

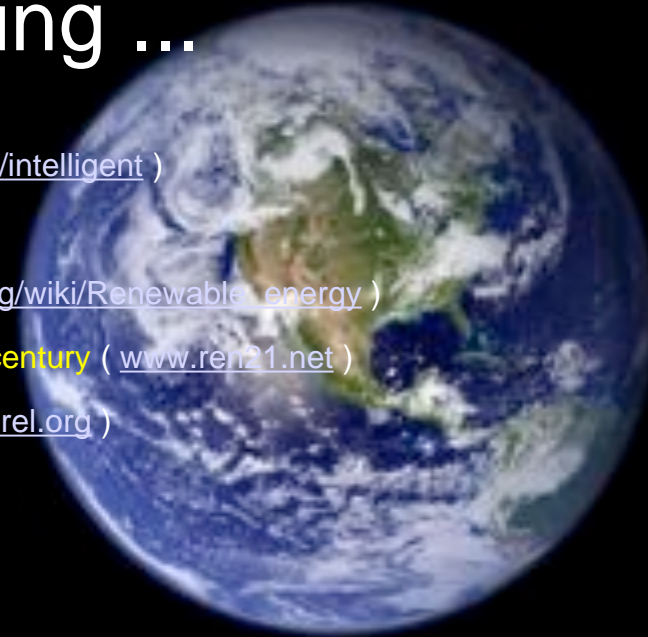
National Renewable Energy Laboratory (www.nrel.org)

Sustainable Energy for All (www.sealnet.org)

OLINO (www.olino.org)

RE-Energy (www.re-energy.ca)

Environmental Literacy Council (www.enviroliteracy.org)



“Energy Use in Buildings: Use it better, use it less”

1/1 (ec.europa.eu/dgs/energy_transport/video/energy_buildings/energy_buildings_en)
European Commission, 2005

Renewable Energy and Saving ...



“Intelligent Shopping: Energy Efficient Appliances”

1/1 (greenenergytv.com/Watch.aspx?v=900497045)

Sustainable Energy Europe, European Commission, 2006



“20% Renewable Energy by 2020”

1/1 (www.youtube.com/watch?v=1cysaOnlv_E)

European Commission, 2008



“BELIEF project”

1/1 (www.youtube.com/watch?v=pv89-e6dC7s)

European Commission, 2008

Renewable Energy and Saving ...



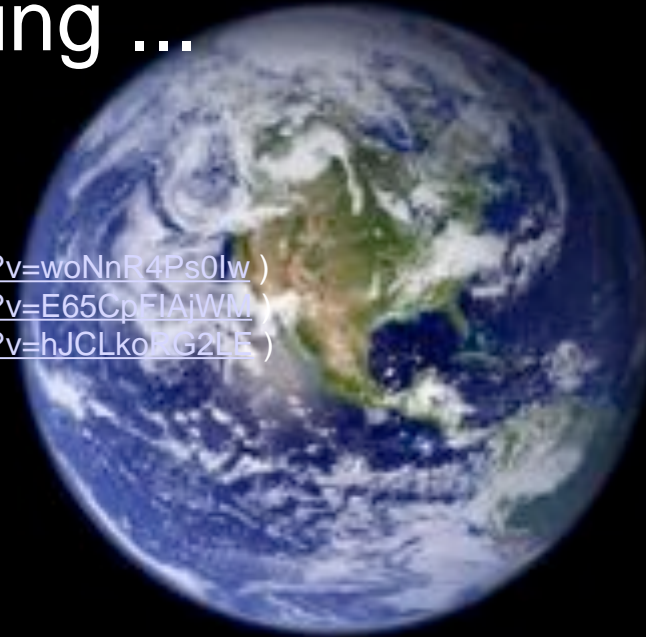
"The Search for Ultimate Energy"

1/3 (www.youtube.com/watch?v=woNnR4Ps0lw)

2/3 (www.youtube.com/watch?v=E65CpF1A1WM)

3/3 (www.youtube.com/watch?v=hJCLkoK2LE)

Discovery Channel, 2007



"Renewable Energy"

1/1 (www.youtube.com/watch?v=tSBACzRE3Gw)

History Channel, US, 2008



"Sweden Gotland Island Energy"

1/1 (www.youtube.com/watch?v=7Grl-L9iur4)

France 24, Oct. 2007

Renewable Energy and Saving ...



“Islanders get 24-hour green power”

1/1 (news.bbc.co.uk/1/hi/scotland/highlands_and_islands/7219658.stm)

BBC News, Feb. 2008



“Energy, Let’s save it!”

1/1 (www.youtube.com/watch?v=1-g73ty9v04)

European Commission, 2008



“Energy Efficient Penguin”

1/1 (www.youtube.com/watch?v=kocZ-j-o3I)

Animal Planet TV, UK, 2008

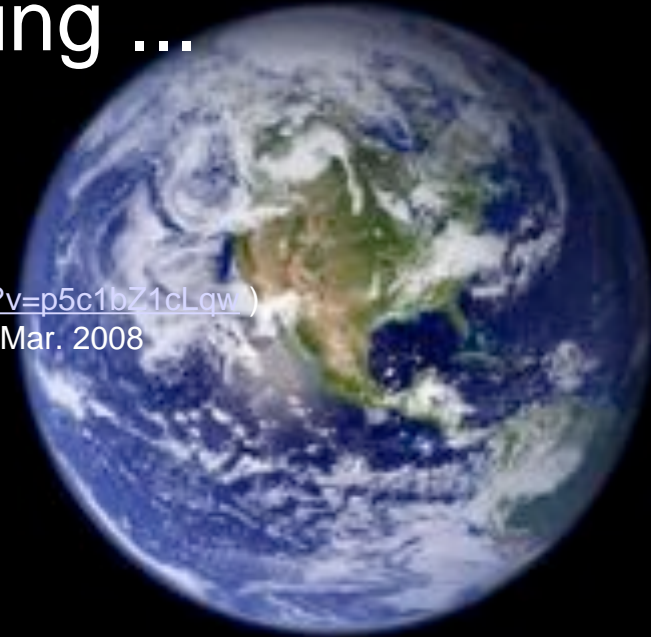
Renewable Energy and Saving ...



“Saving Power at Peak Hours”

1/1 (www.youtube.com/watch?v=p5c1bZ1cLqw)

Dr. Mary Ann Piette, Berkeley, Mar. 2008



“ECO driving”

1/1 (www.youtube.com/watch?v=1RB461IQR8Y)

European Commission, 2008



“Efficient Car”

1/1 (www.youtube.com/watch?v=1a8TTmOj-vg)

EcoTech, 2008

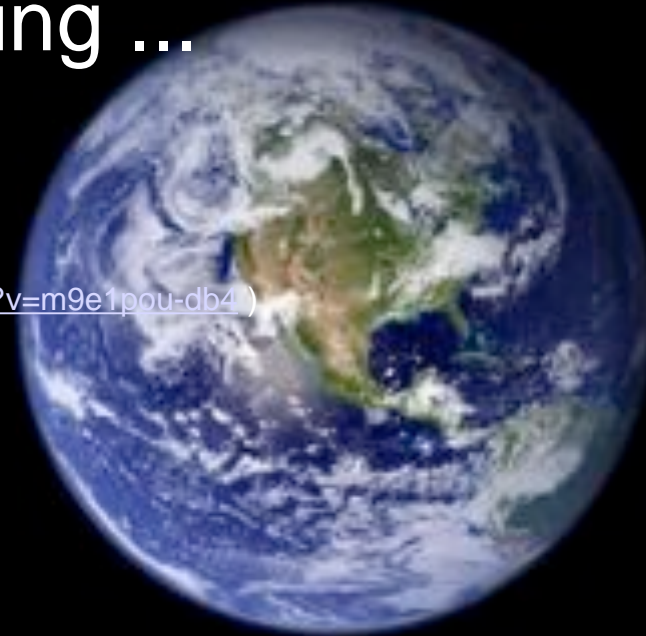
Renewable Energy and Saving ...



“The case of Malmö in Sweden”

1/1 (www.youtube.com/watch?v=m9e1pou-db4)

EcoTech, Powering Up, 2008



“Climate Change Special: The renewable energy revolution is underway”

1/1 (www.europartv.europa.eu/yourparliament.aspx)

EuroparlTV, EU, Jan. 2009



“How many light bulbs?”

1/1 (www.youtube.com/watch?v=oRQB2YXUxvY)

David Mackay, Cambridge Ideas, April 2009

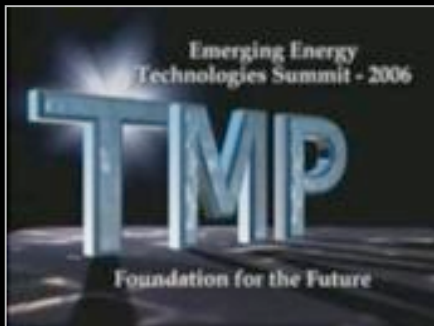
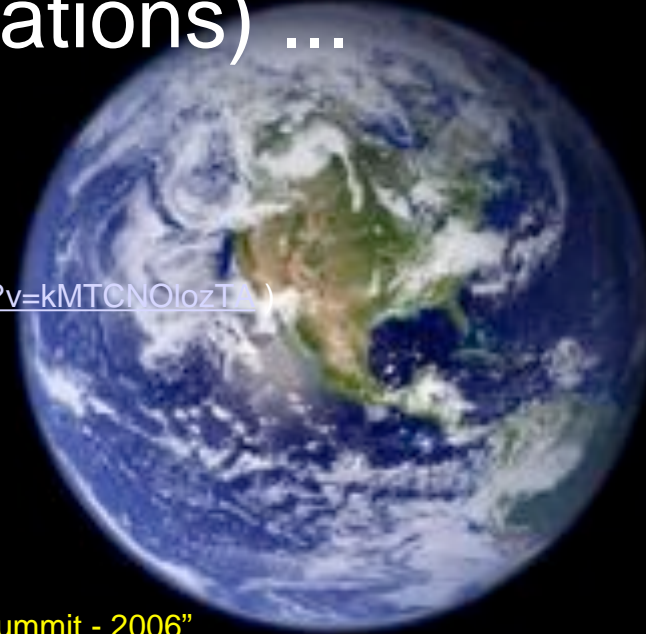
Renewable Energy (Presentations) ...



“We must win the oil end game”

1/1 (www.youtube.com/watch?v=kMTCNOlozT)

Amory Lovins, TED, Feb. 2005



“Emerging Energy Technologies Summit - 2006”

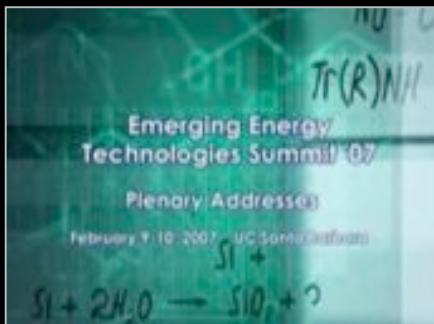
1/4 (www.youtube.com/watch?v=b4tJ5z4yF5E)

2/4 (www.youtube.com/watch?v=Scu1_bVhu8c)

3/4 (www.youtube.com/watch?v=ZpiLUtKha-4)

4/4 (www.youtube.com/watch?v=23R2ObFIZRk)

Technology Management Program, UCSB, USA, Feb. 2006



“Emerging Energy Technologies Summit - 2007”

1/3 (www.youtube.com/watch?v=gQH9vo4Rp1M)

2/3 (www.youtube.com/watch?v=sFUzabcfno4)

3/3 (www.youtube.com/watch?v=r-fiOkPlobE)

Technology Management Program, UCSB, USA, Feb. 2007

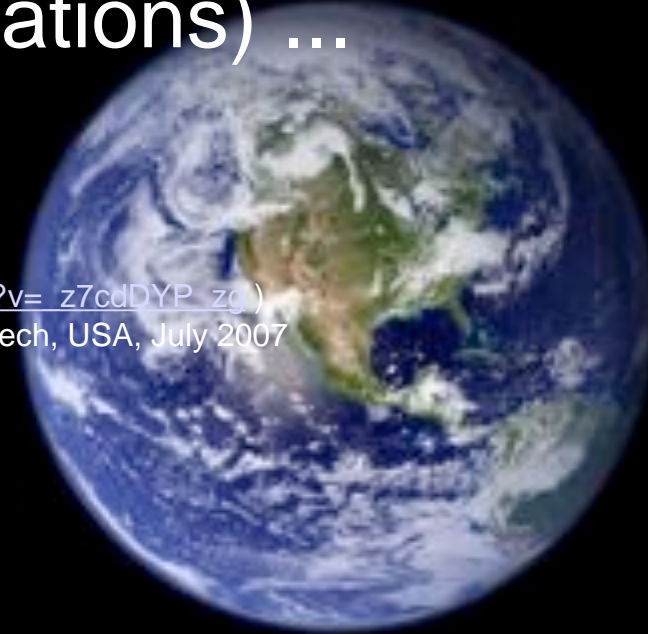
Renewable Energy (Presentations) ...



“Energy Crisis and Clean Energy”

1/1 (www.youtube.com/watch?v=z7cdDYP_zg)

Hermann Scheer, MIT Clean Tech, USA, July 2007



“Sustainable Energy Consumption”

1/1 (www.youtube.com/watch?v=n8xFHCru9ok)

Davos Open Forum, July 2007



“UC Berkeley Energy Symposium” (min 18:15 to 55:43)

1/1 (www.youtube.com/watch?v=EMouRbje-js)

David Sandalow, UC Berkeley, March 2008

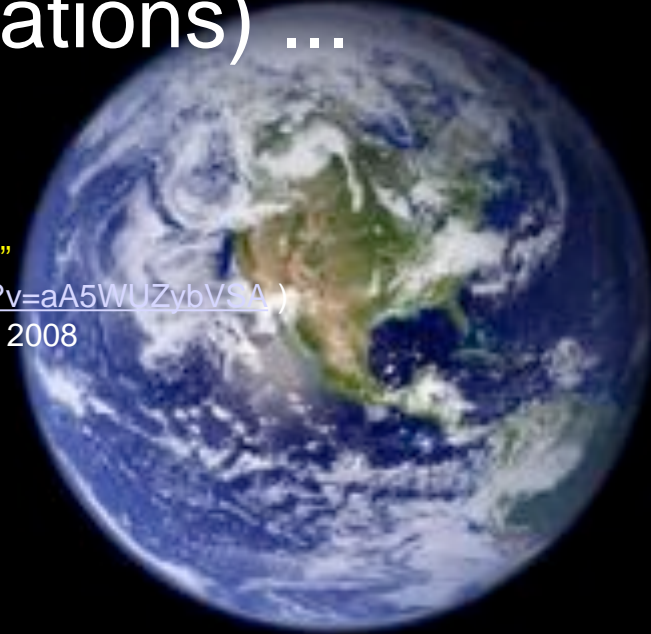
Renewable Energy (Presentations) ...



“Competing in the Green Economy”

1/1 (www.youtube.com/watch?v=aA5WUZYbVSA)

New America Foundation, May 2008



Tidal Energy ...



"Lunar Laser Ranging: a Continuing Legacy of the Apollo Program"

Jean O. Dickey et al.
Science, Vol. 265, pp. 482-490, 1994



"Dissipation of tidal energy, paleotides and the evolution of the Earth-Moon system"

B. A. Kagan, J. Suendermann
Advances in Geophysics, Vol. 38, pp. 179-266, 1996



"Once again: once again – tidal friction"

W. Munk
Progress in Oceanography, Vol. 40, pp. 7-35, 1997



"Abyssal recipes II: Energetics of tidal wind mixing"

W. Munk, C. Wunsch
Deep-Sea Research, Part I, Vol. 45, pp. 1977-2010, 1998



"Tide distribution and tapping into tidal energy"

Z. Kowalik
Oceanologia, Vol. 46, 3, pp. 291-331 (www.iopan.gda.pl/oceanologia), 2004



Geothermal Energy ...



International Geothermal Association (www.geothermal-energy.org)

Geothermal Energy Association (www.geo-energy.org)

Wikipedia – Geothermal Power (en.wikipedia.org/wiki/Geothermal_power)



“Heat flow from the Earth’s interior: Analysis of the global data set”

H. N. Pollack, S. J. Hurter, J.R. Johnson

Reviews of Geophysics, Vol. 31, 3, pp. 267-280, 1993



“What is Geothermal Energy ?”

M. H. Dickson, M. Fanelli

International Geothermal Association, 2004

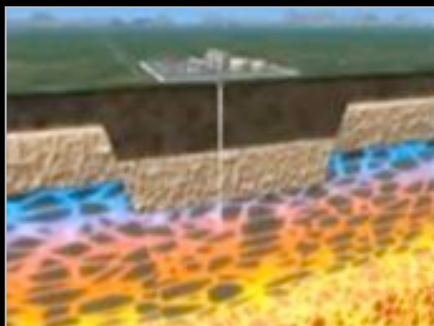
(www.geothermal-energy.org)



“Earth’s Heat flux revisited and linked to chemistry”

A. M. Hofmeister, R. E. Criss

Tectonophysics, Vol. 395, pp. 159-177, 2005



“How a Geothermal Plant works?”

1/1 (nl.youtube.com/watch?v=kjpp2MQffnw)

Oct. 2007



Geothermal Energy ...



“Geothermal Energy in Iceland”

1/1 (nl.youtube.com/watch?v=XRAQrDducU0)

Schreiner Productions, Feb. 2008



“Geothermal Energy: Harnessing the Heat Beneath your Feet (DUTCH)”

1/2 (collegerama.tudelft.nl/mediasite/Viewer/?peid=7baf5583-277e-4292-8b41-b1e4e)

2/2 (collegerama.tudelft.nl/mediasite/Viewer/?peid=7565bac6-622e-4755-b1a4-3273)

Andries Wever, Studium Generale, TU Delft, Mar. 2008



“Geothermal Energy: Harnessing the Heat Beneath your Feet”

1/1 (nl.youtube.com/watch?v=pA27aEamWzY)

UCTV, Sept. 2008

Solar Energy ...



Wikipedia – Solar Power (en.wikipedia.org/wiki/Solar_power)

Wikipedia – Earth's Energy Budget (en.wikipedia.org/wiki/Earth's_energy_budget)

Wikipedia – Solar Radiation (en.wikipedia.org/wiki/Solar_radiation)

DESERTEC (www.desertec.org)

“Power from the Sun: Its Future“

P. E. Glaser

Science, Vol. 162, N. 3856, 1968



“The Solar Economy – Renewable Energy for a Sustainable Global Future“

Hermann Scheer

Earthscan Publications Ltd., London, 2002



“Clean Power from Deserts“

DESERTEC Foundation, 2009

(www.desertec.org/fileadmin/downloads/DESERTEC-WhiteBook_en_small.pdf)



“Solar Energy and a New Future“

1/1 (www.youtube.com/watch?v=eR9uHR7uAX4)

Rick Smalley, Nobility Project, 2008



Solar Energy ...



“The Universe: Secrets of the Sun”

1/1 (nl.youtube.com/watch?v=gdLaPhNEOcU)

History Channel, 2007



“Solar Fields - Africa”

1/1 (nl.youtube.com/watch?v=dUdaf97almk)

Journeyman.tv, Jan. 2009



“Here comes the Sun”

1/1 (www.youtube.com/watch?v=mLHBFyfvK8A)

Backlight, VPRO International, The Netherlands, Oct. 2008

Solar Energy ...



“Solar Thermal Energy”

1/1 (www.youtube.com/watch?v=w9Oy3VOPEqs)
Sustainable Energy Europe Campaign, EU, 2007



“46MW Photovoltaic Solar Power Plant”

1/1 (www.youtube.com/watch?v=Gg-CgsQnUAU)
France 24 TV Channel, 2009



“Solar Stirling Engine”

1/1 (www.ted.com/index.php/talks/bill_gross_on_new_energy.html)
Bill Gross, TED, USA, Feb. 2003

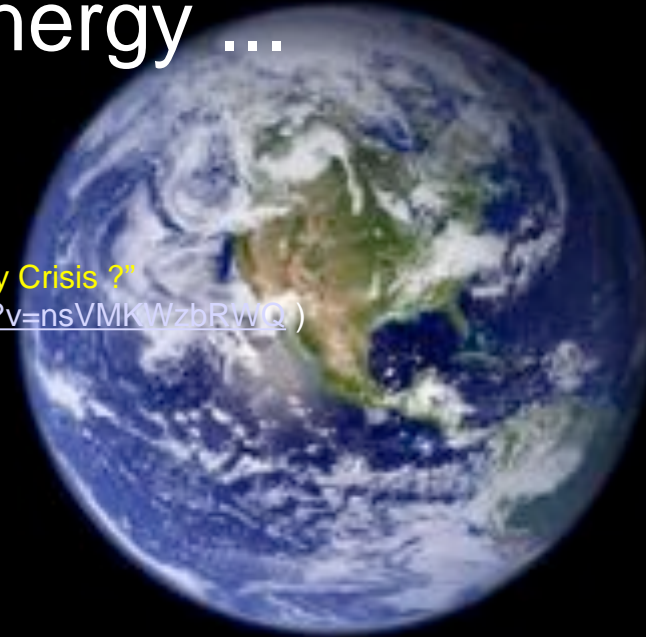
Biotechnology & Biomass Energy ...



“A Biological Solution to the Energy Crisis ?”

1/1 (www.youtube.com/watch?v=nsVMKWzbRwQ)

Dr. Steven Chu, Aug. 2005



“Renewable Energy from Synthetic Biology”

1/1 (www.youtube.com/watch?v=GZge1v7GDq0)

Dr. Jay Keasling, June 2007



“Forest Products: Part of Sustainable Future”

1/1 (www.youtube.com/watch?v=BqzPuA8R8Ws)

Ian de la Roche, UC Berkeley, Oct. 2007

Biotechnology & Biomass Energy ...



“Jamtland County Example in Sweden”

1/1 (ec.europa.eu/dgs/energy_transport/video/biofuels/biocarburants_en.mpg)
EC, 2005



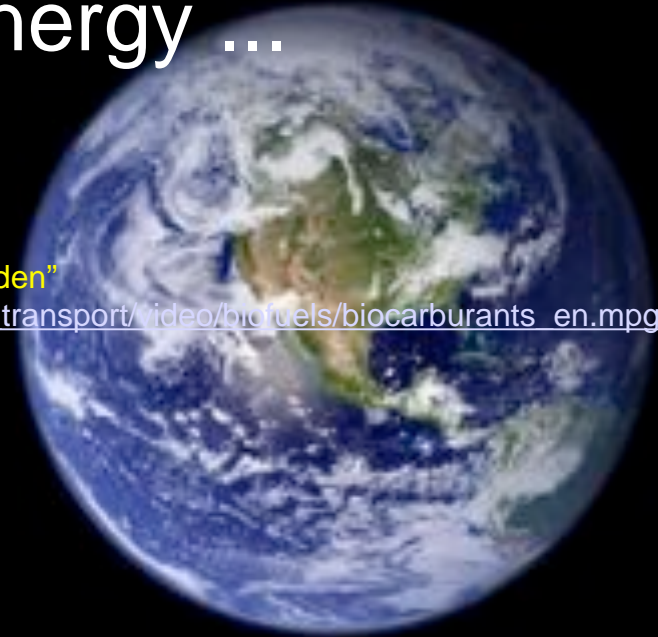
“Biofuels to replace Oil”

1/1 (ec.europa.eu/dgs/energy_transport/video/biofuels/biocarburants_en.mpg)
EC, 2006



“Better and Cleaner urban transport for Europe”

1/1 (ec.europa.eu/dgs/energy_transport/video/cleaner_urban_transport/cleaner_urban_transport_en.mpg)
EC, 2006



Biotechnology & Biomass Energy ...



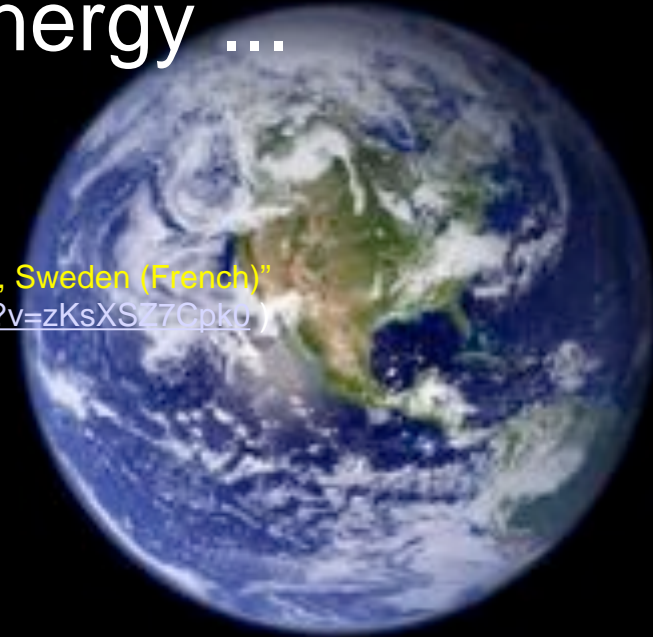
“Biomass Power Plant in Varnamo, Sweden (French)”
1/1 (www.youtube.com/watch?v=zKsXSZ7Cpku)
EU DG, 2007



“MIT Algae Photobioreactor”
1/1 (www.youtube.com/watch?v=EnOSnJJSP5c)
MIT, USA, May 2007



“The Biology and Business of Biofuels: Algae as Biofuel”
1/1 (www.youtube.com/watch?v=0FrbMMwDccY)
S. Kay, B. G. Mitchell, S. Mayfield, USA, Jan. 2008



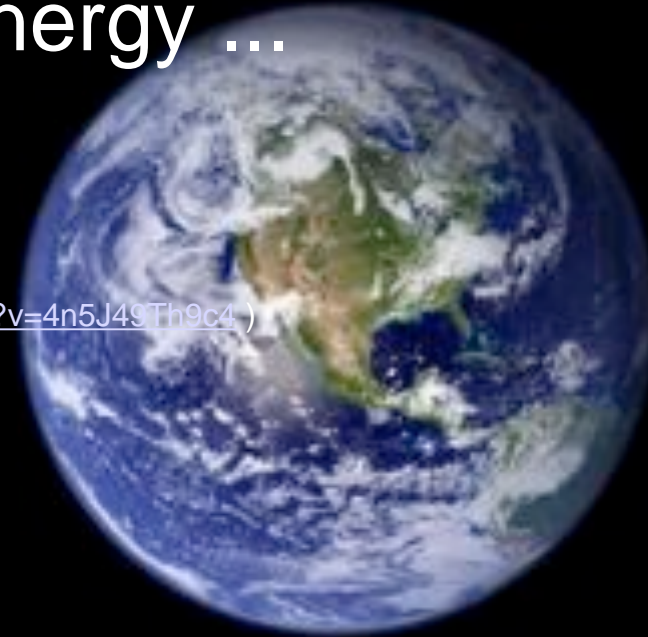
Biotechnology & Biomass Energy ...



"Hydrogen from Algae"

1/1 (www.youtube.com/watch?v=4n5J49Th9c4)

USDA, USA, Jan. 2008



"Future Fuels"

1/2 (www.youtube.com/watch?v=jFhaTN7QkT8)

2/2 (www.youtube.com/watch?v=ySLDCt5MmTc)

EcoTech, USA, 2008



"Fuel from Scum"

1/1 (www.youtube.com/watch?v=m-GpX3oJFTU)

CNN, USA, Feb. 2008

Ocean Energy ...



EMEC (www.emec.org.uk)

Wave Energy Center (www.wavec.org)

European Ocean Energy Association (www.eu-oea.com)

Edinburgh University - Wave Power Group (www.mech.ed.ac.uk/research/wavepower)

NTNU – Wave Energy Research (folk.ntnu.no/falnes/w_e)

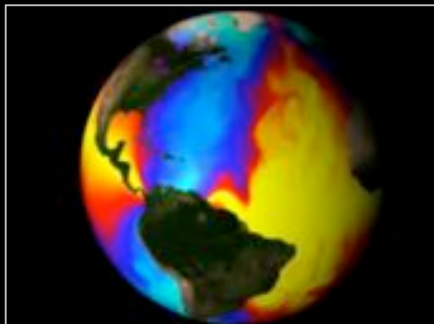


“Ocean Energy Launch”

1/2 (www.youtube.com/watch?v=8aQXg5M5DiM)

2/2 (www.youtube.com/watch?v=9yRWNQ4OJDo)

Macdonald Productions, USA, 1981



“Renewable Energy from the Deep Ocean”

1/1 (www.youtube.com/watch?v=x59MptHscxY)

USA, Jan. 2007

Ocean Energy ...



"Tidal Power"

1/1 (www.youtube.com/watch?v=TrhfFLNah24)
Channel 4 News, UK, 2008



"Tidal Energy"

1/1 (www.youtube.com/watch?v=BdWK2SskMda)
CBC News, Canada, Jul. 2008



"A new renewable energy concept"

1/2 (www.youtube.com/watch?v=jcyM3c5yISU)
University of Michigan, USA, 2008

Ocean Energy ...



“The Wave Dragon wave energy converter”

1/1 (www.youtube.com/watch?v=r7-EPR8Ss6M)

Energy Program, EC, June 2007



“Wave Power Energy”

1/1 (www.youtube.com/watch?v=5v23_5dvgWM)

Beyond Tomorrow, Science, TV Australia, Sept. 2008



“Ocean Wave Energy”

1/1 (www.youtube.com/watch?v=ovw-pHqyP7E)

Max Carcas, OPD, USA, Nov. 2006

Decentralized Generation & CHP ...



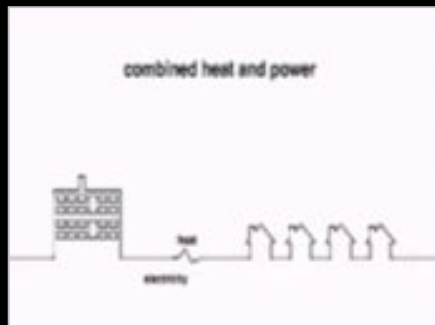
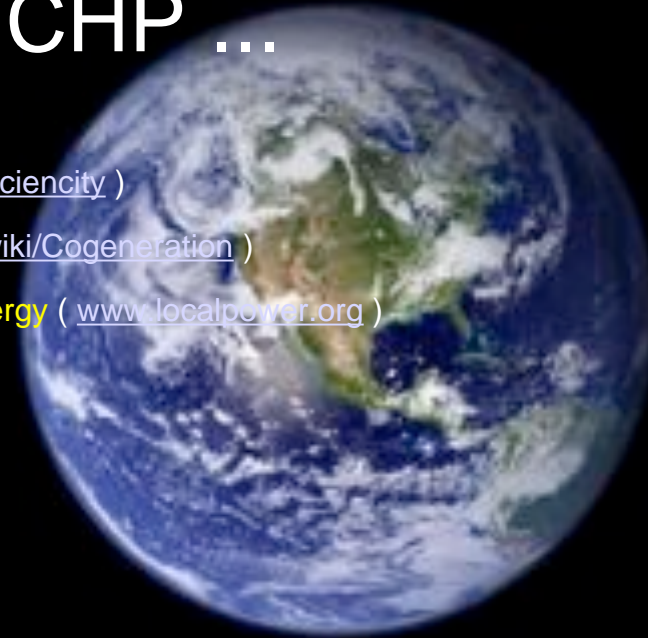
Greenpeace UK (www.greenpeace.org.uk/efficiency)

Wikipedia – Cogeneration (en.wikipedia.org/wiki/Cogeneration)

WADE – World Alliance for Decentralized Energy (www.localpower.org)

COGEN EUROPE (www.cogen-europe.eu)

US-CHPA (www.uschpa.org)



“What are we waiting for?”

1/1 (nl.youtube.com/watch?v=klooRS-Jjyo)

GreenpeaceUK, June 2006



“Electricity from Biomass in India”

1/1 (www.youtube.com/watch?v=K79tX7I2Y98)

Future in our hands, 2007

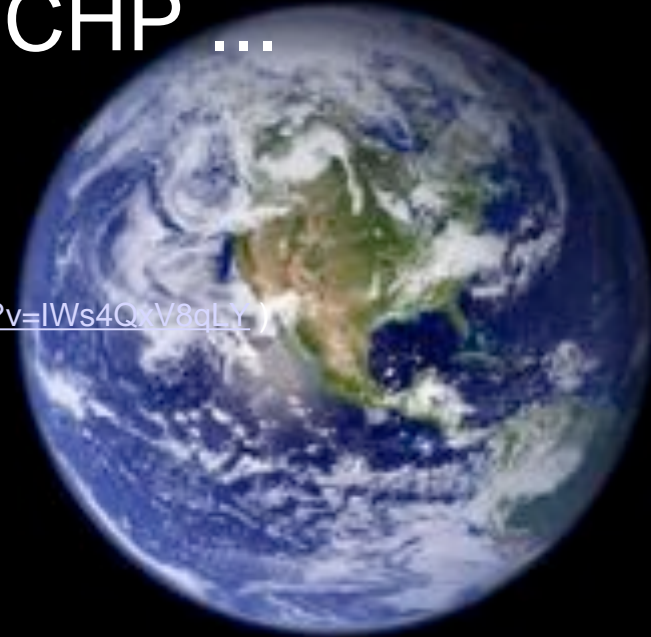
Decentralized Generation & CHP ...



“CHP and Biomass in Denmark”

1/1 (www.youtube.com/watch?v=IW54QxV8qLY)

GreenPeaceUK, 2008



Sustainability ...



Worldwatch Institute (www.worldwatch.org)

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Acknowledgments ...



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The End

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