Chm 286/486: Today's Agenda

Introduction and Overview

Initial Info,

Purpose, goals

Course web site

Reference materials

Grading

Page with Lecture Notes

Topical outline, lecture plan

Research projects

Example of statistical energy data

0&1: *Sustainability* (of Human Civilization) *in the Anthropocene*

Energy: Science, Technology & Civilization Society (Chm 268/468 Phy285)

Hot Discussion Points

- Does coal have a black outlook?
- Is fracking freaking you out?
- Is natural gas too volatile?
- Does solar have a sunny future?
- Are wind farms overblown?
- Is biofuel foolish?
- Can we bet on batteries?
- Is lithium limitless?
- Are new nukes a No-No?
- Tritium troubles in fusion?
- Too many waves on hydropower?
- Geothermal only for Icelanders?
- Fearing geo-engineering?
- Is NIMBY an option?

Plenty of advocates, as well as opponents, for any course of action!

Goal of course:
Develop critical understanding of scientific issues, technical principles and potential of sustainable energy "generation," distribution and management.

https://www.sas.rochester.edu/chm/courses/chm286_486/index.html

Energy: Science, Technology and Society W. Udo Schröder

CHM 286/486 Introduction to energy issues

HOME ANNOUNCEMENTS LECTURE NOTES ASSIGNMENTS CONTACT WUS

Links

Course Syllabus
Class Venue/Times

Links on this page:

- Lectures
- Office Hours
- Prerequisites
- Synopsis
- Reference Materials
- Assignmenta

General Info

Goals of the course are to help students develop a sophisticated and critical understanding of scientific principles, tasks, and technological realizations of modern energy conversion. The course aims, as well, to provide an appreciation of the impact of energy consumption on the development of civilization, the finite recoverable resources, and the climate of our planet.

Lectures:

Professor W. Udo Schröder
Lectures on Mondays/Wednesdays 12:30 - 13:45h,
Hylan, Room 102.
First Lecture : Wednesday, August 26, 2024
12:30-13:45, Hylan, Room 102.

This course is intended to be conducted in terms of 2 per week in-person meetings.However, as Campus health concerns may arise this fall, it may have to be given in a virtual format, with 2 per week on-line lectures on the ZOOM platform. **As per current UR protocol, classes are held in person, but wearing a properly fitted face mask is required for all.**

This course follows the UR College Credit Hour Policy for 4-credit courses. The class meets two times per week, each for 1.5 academic hours. The course also includes regular out-of-class reading and preparatory assignments. Students are encouraged to use regular office hours held by instructor and TA, which are meant to answer questions and/or help students with reading, homework and projects. Additionally, students are also expected to complete an additional 8 hours of supplementary work per week on sets of homework and research for 2 research papers.

Office Hours

W. Udo Schröder:
Tuesdays, 12:00 - 1:30 p.m.,
Hutchison Hall (HH) 466 or, by appointment (275-8263), schroeder@chem.rochester.edu

Teaching Assistant, TBA
Hutchison Hall, Wednesdays, TBA, or by appointment.

Prerequisites

Familiarity with basic calculus, principles of modern physics and chemistry, or by special permission

https://www.sas.rochester.edu/chm/courses/chm286_486/index.html

Energy: Science, Technology and Society

W. Udo Schröder

CHM 286/486 Introduction to energy issues

HOME ANNOUNCEMENTS LECTURE NOTES ASSIGNMENTS CONTACT WUS

General Info

This is the web site for the science course Chm286/486. Additional pages are accessible via the navigation bar on top..

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Reference Materials

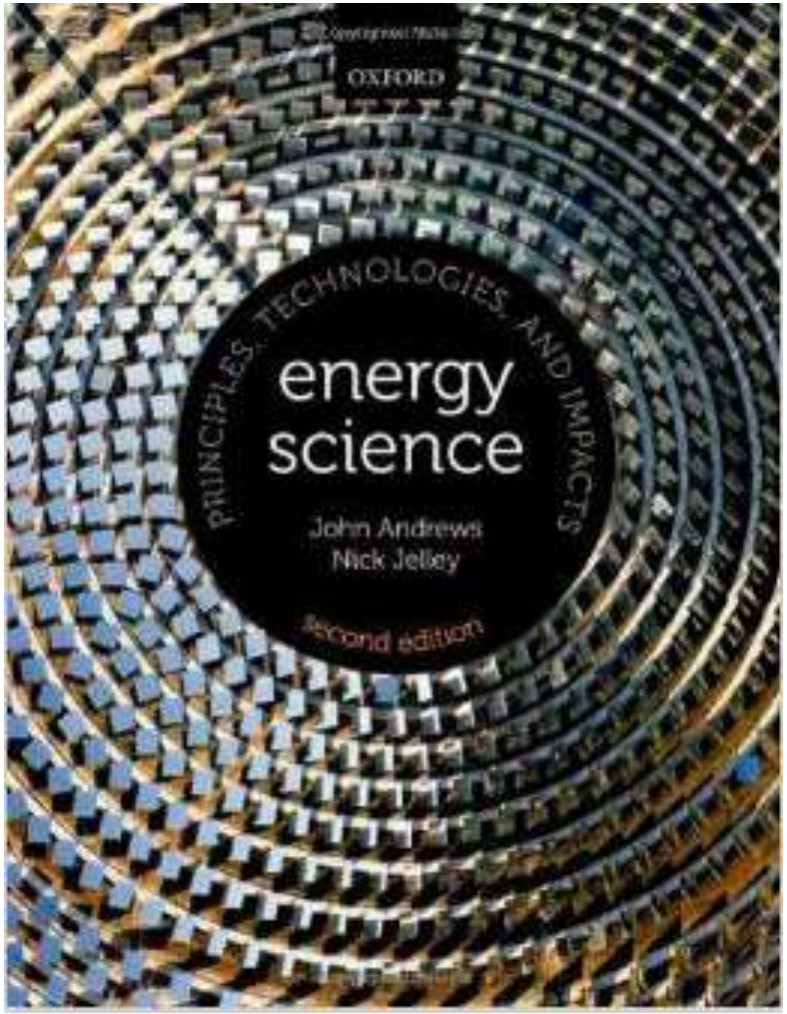
For a review of technical topics covered in the course use the text
"*Energy Science. Principles, Technologies, and Impacts.*" by John Andrews & Nick Jelley (required)
and, as an auxiliary reference the freely available (recommended)
"*Sustainable Energy - Without the Hot Air,*" by David J.C. MacKay,
The latter is available as e-book for free download (www.withouthotair.com)
Several copies of reference books are on 2-hr Reserve in Carlson Library.

Assignments/Grades

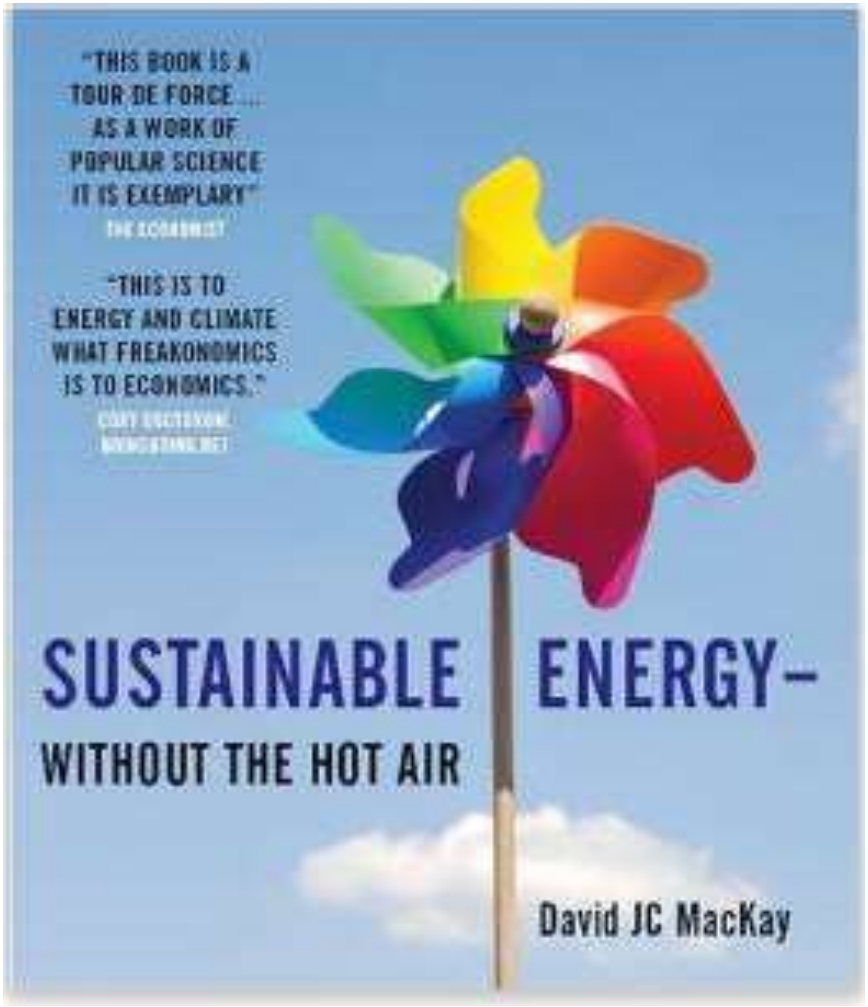
Asignment include regular weekly homework problem sets and 2-3 research papers.
The grades will be computed from homework (25%) and 2 research project reports (70%).
For graduate students, project scopes are extensive and include classroom presentations with Q&A on one project. >>>> There are **no written exams**.

Assignments (fractional grade): Homework sets (25%), 2 research papers (70%), Misc. (5%)

Technical Reference Texts



Andrew & Jelley (2nd edition):
Main reference textbook



Free e-copy down loadable at
http://www.withouthotair.com/

Plus resources on specific topics, e.g., IPCC, NAS or IEA reports, statistics.

Topical Outline

The Big Picture: Human Energy Utilization and Environmental Consequences
Sustainability, managing finite resources/policies(US), external costs of energy management (Illustrations)
Climate factor: Atmospheric chemistry and physics, greenhouse effect, pollution and climate change

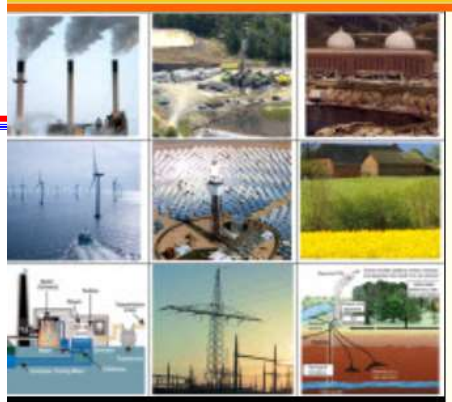
Energy Demand/Uses, Past and Outlook
History of energy technologies, current energy demand, outlook to 2050, fuel reserves, resource estimates

Energy Conversion/Harvesting, Science and Technology
Equivalent forms of work, energy, energy units , basic mechanics and thermodynamics, electro-chemistry
Heat engines, power plants, batteries and fuel cells, electricity, motors and generators, AC/DC
Geothermal energy harvesting, prospects
Basic hydrodynamics, wind and hydro-power generation
Physics and chemistry of solar cells, PV and thermos-solar generation
Energy from biomass,
Nuclear fission power, small 4S generators, radio-thermal generators; Nuclear fusion technology

Energy Distribution and Storage Infrastructure
Fuel transport, electrical grid (dumb and smart), cyber security, energy storage technologies,

Energy Strategies: Potential and Risks
Risk factors for environment, health and climate, hydrocarbon fuel technologies (clean coal, CCS, shale, synfuels)
Nuclear power (new nukes, fusion), development of renewable energy sources, energy efficiency, conservation

Energy Policies vs. Public Attitudes
Diversification of energy technologies, electrification of transport, residential, industrial sectors,
Selective subsidies of energy technologies, energy conservation strategies
Changing public attitudes through education.



Links

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lass Venue/Times

Links on this page:

- Disclaimer
- Energy & Sustainability
- Work & Energy
- Renewables
- Demand & Resources
- Conventional Technologies
- Fuel & Energy Grids
- External Costs
- Realistic Policies
- Smart Use/Grids

Lecture Notes

0. Introduction/Survey (pdf)

1. The Big Picture:Sustainability in the Anthropocene

1. Human habitat and resources (pdf1)(pdf2)
Tools and fuels in human history (pdf1, pdf2)

2. Civil organization and environmental footprint (pdf)(pdf).
Resources and their allocation
Environmental footprint, pollution, climate (pdf1, pdf2)
Earth climate variations and trends (pdf3)
Atmospheric greenhouse model

3. Public policies: mitigation vs.adaptation to changing climate (pdf).
Stated policies, transition to renwable resources,
carbon capture & sequestration, geoengineering

.....**Tutorial:** Interactions of radiation w. matter **/ (pdf)**
.....**Auxiliary Materials**
.....**NAS Climate Report 2010 (web, loc)**
..... IPCC AR6 Executive Summary 2023 **(pdf)**, long,
..... NAS Policy GHG Mitigation report (web)

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2. Work and Energy: The Basic Science

1. Work and energy forms (pdf)
..... Potential and kinetic energy, pV work, heat, equilibration (pdf)
..... Molecular binding and rearrangement energies

2. Thermodynamic principles (pdf1, pdf2)
..... Laws of Thermodynamics, state functions, reversible processes (pdf1)
..... Electro-chemistry, batteries, hydrolyzers & fuel cells (**pdf**)
..... Carnot and other TD cycles, steam engines, gas turbines,(**pdf2**)

3. Electricity basics
..... Electronic circuits, reactance in AC transmission (pdf)
..... Electric motors, generators, transformers (pdf)

3. Generation Technology: Renewable Energy

1. Solar power, concentrated and photo-voltaic
. ....Solar concentrated (thermal) power (pdf),
.....Solar photo-voltaic energy conversion (pdf1)(pdf2)

Lecture Plan

The Big Picture: Energy and the Environment
Sustainability, external costs of energy management,
History of energy use and technologies in illustrations

Work and Energy, the Basic Science
Equivalent forms of work, energy, power, energy units,
Energy balance in material transformations,
Fundamentals of thermal engines, electricity

Renewable Energy Technologies and their Scientific Foundation
Solar concentrated (thermal), geothermal energy conversion,
Physics and chemistry of photovoltaic solar cells,
Basic hydrodynamics of working media
Wind power generation, hydro-powerplants
Hydropower resource development

P1

P1 Research Project #1, 2.5-3 weeks

P2 Research Project #2, 2.5-3 weeks

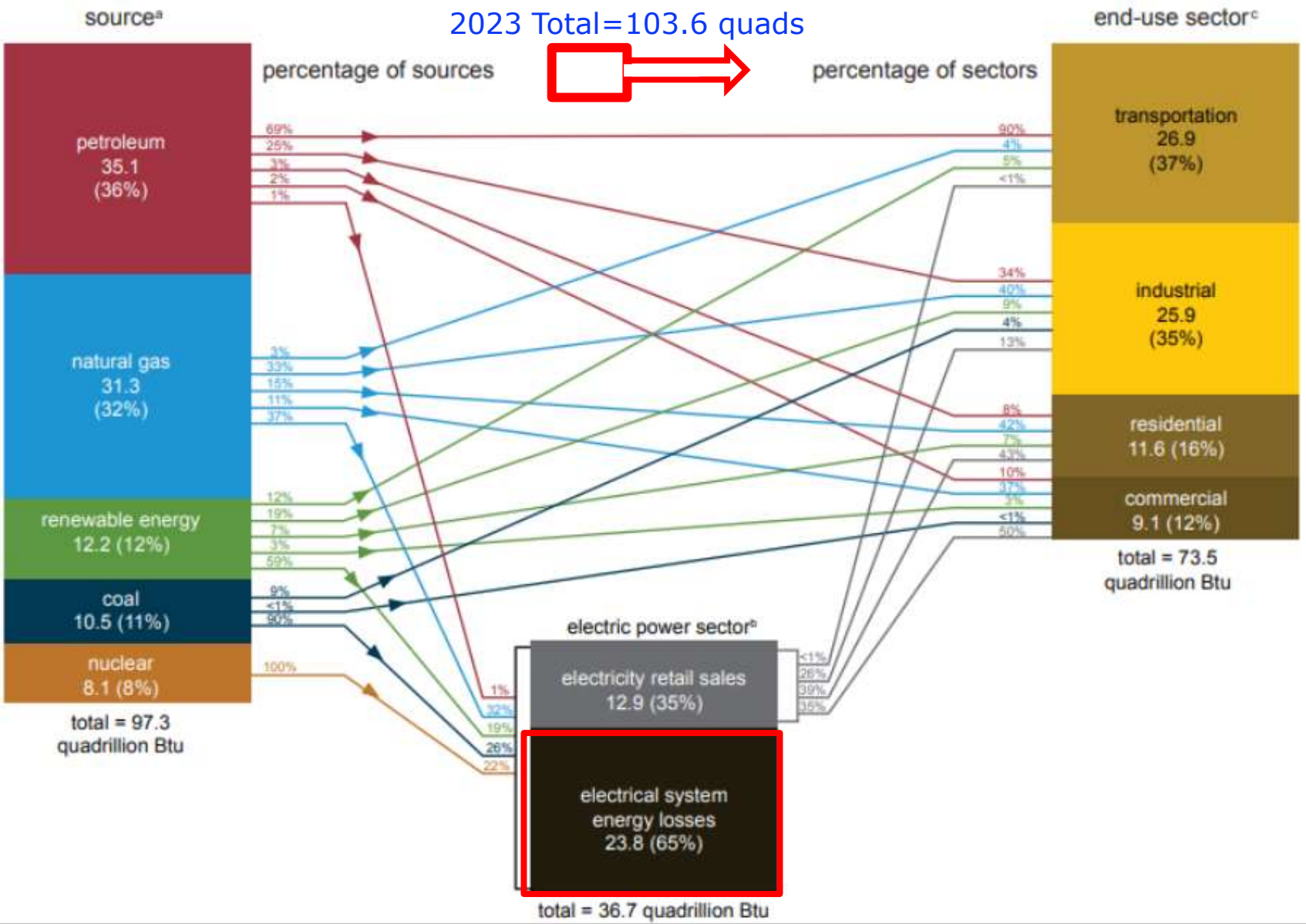
Conventional Energy Technologies, Use and Outlook
Energy from Biomass and synthetic fuels
Fossil fuel demand and resources
Thermal power plants, reciprocal engines, internal combustion
Steam turbines and thermal power plants, efficiencies

P2

Power from Nuclear Transmutation
Basic nuclear energetics of fission and fusion of atomic nuclei
Radiation hazards
Nuclear fission power plants, new generation plants
Prospects of nuclear fusion power

Fuel and Energy Distribution Infrastructure
Fuel transport, electrical grid (dumb and smart), cyber security,
energy storage technologies,

US Energy Consumption 2021 (quads Btu)



Useful Links

International Energy Agency
https://iea.blob.core.windows.net/assets/d0031107-401d-4a2f-a48b-9eed19457335/GlobalEnergyReview2021.pdf

US Energy Information Administration
https://www.eia.gov/environment/emissions/carbon/archive/2014/index.php

US Environmental Protection Agency

https://www.epa.gov/web-policies-and-procedures/free-viewers-and-readers-read-and-print-epa-information

National Oceanic and Atmospheric Administration
https://www.ncdc.noaa.gov/cag/national/time-series/110/tavg/1/11/1895-2021?base_prd=true&begbaseyear=1901&endbaseyear=2000&filter=true&filterType=binomial

Carbon cycle GHG data (Global Monitoring Laboratory - Carbon Cycle Greenhouse Gases (noaa.gov))

Climate Data: "Copernicus" Applications and Tools

https://cds.climate.copernicus.eu/toolbox/doc/gallery/index.html

US energy information:

https://www.eia.gov/energyexplained/us-energy-facts/

Useful statistical data:
International Monetary Fund

https://www.imf.org/external/datamapper/NGDPDPC@WEO/OEMDC/ADVEC/WEOWORLD

Energy Units
(https://www.aps.org/policy/reports/popa-reports/energy/units.cfm)

Energy Unit Converters

https://www.eia.org/energyexplained/units-and-calculators/energy-conversion-calculators.php

https://www.iea.org/data-and-statistics/data-tools/unit-converter

Common Energy Units

		Joules	BTU	Quads	kcal	mtce	boe	mtoe	m3 gas	ft3 gas	kWh	TWy
1 J	=		9.479 E-4	9.479 E-19	2.39 E-3	3.414 E-11	1.634 E-12	2.234 E-11	2.684 E-8	9.48 E-7	2.78E-7	3.171 E-20
1 BTU	=	1055		1 E-15	0.2522	3.602 E-8	1.724 E-7	2.357 E-8	2.832 E-5	0.001	2.93E-4	3.345 E-17
1 QUAD	=	1.055 E+18	1 E+15		252 E+12	3.602 E+7	1.724 E+8	2.357 E+7	2.832 E+10	1 E+12	2.93E+11	0.03345
1 kcal	=	4184	3.966	3.966 E-15		1.429 E-9	6.838 E-7	9.347 E-8	1.123 E-4	3.966 E-3	1.16E-3	1.327 E-16
1 mtce	=	29.29 E+9	27.76 E+6	27.76 E-9	7 E+6		4.786	0.6543	786.1	2.776 E+4	8,135	9.287 E-10
1 boe	=	6.119 E+9	5.8 E+6	5.8 E-9	1.462 E+6	0.2089		0.1367	164.2	5800	1,699	1.94 E-10
1 mtoe	=	44.76 E+9	42.43 E+6	42.43 E-9	1.07 E+7	1.528	7.315		1201	42,430	12,430	1.94 E-4
1 m3 gas	=	37.26 E+6	35.31 E+3	35.31 E-12	8905	1.272 E-3	6.089 E-3	8.323 E-4		35.31	10.35	1.181 E-12
1 ft3 gas	=	1.055 E+6	1000	1 E-12	252.2	3.6 E-5	1.724 E-4	2.357 E-5	0.02832		0.2930	3.345 E-14
1 kWh	=	3.60E+6	3.41E+3	3.41E-12	860.39	1.228 E-4	5.88E-4	8.042E-05	0.096621	3.412		1.142E-13
1 TWy	=	3.154 E+19	2.989 E+16	29.89	7.537 E+15	1.076 E+9	5.154 E+9	7.045 E+8	8.464 E+11	2.989 E+13	8.76E+12	