Introduction to Sustainable and Renewable Energy Sources

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Primary energy overview
Global energy sources

Global Energy Use by Source 2011

- Oil: 33.07%
- Coal: 30.34%
- NG: 23.67%
- Nuclear: 4.88%
- Hydro: 6.45%
- Renew: 1.59%

chart: www.gregor.us  |  data: bp statistical review

Global energy sources

Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2008

- Fossil fuels: 78%
- Renewables: 19%
- Nuclear: 2.8%
- Wind/solar/biomass/geothermal power generation: 0.7%
- Biofuels: 0.6%
- Biomass/solar/geothermal hot water/heating: 1.4%
- Hydropower: 3.2%
- Traditional biomass: 13%
Global energy sources

Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2009

- Fossil fuels: 81%
- Renewables: 16%
- Nuclear: 2.8%
- Wind/solar/biomass/geothermal power generation: 0.7%
- Biofuels: 0.6%
- Biomass/solar/geothermal hot water/heating: 1.5%
- Hydropower: 3.4%
- Traditional biomass: 10%
World primary energy consumption

World consumption
Million tonnes oil equivalent

Regional primary consumption 2012

Regional consumption pattern 2012
Percentage

North America
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific
Fossil fuel R/P ratios – 2012

Primary energy consumed per capita

Consumption per capita 2012
Tonnes oil equivalent

Oil & Gas production forecasts

Oil Overview
Oil consumption by area

Consumption by region
Million barrels daily

- Asia Pacific
- Africa
- Middle East
- Europe & Eurasia
- S. & Cent. America
- North America

World oil consumption fell by 1.2 million b/d, a second consecutive decline and, like oil production, the largest decline since 1982. OECD consumption fell by 2 million b/d, a fourth consecutive annual decline. Consumption outside the OECD increased by 860,000b/d. Consumption declined in North America, South and Central America and Europe and Eurasia, outweighing modest increases in the Middle East, Africa and Asia-Pacific regions.
Oil consumption per capita

[Map showing oil consumption per capita worldwide with different color codes for different tonnage ranges.]
Oil production/consumption by area

Production by region
Million barrels daily

Consumption by region
Million barrels daily
Major oil trade movements

Trade flows worldwide (million tonnes)

USA
Canada
Mexico
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific

BP website (BP.com)
Proved Oil Reserves at end 2011

Figure 1.26
Proven oil reserves at end 2011

Proved reserves of crude oil by country, 2012

Source: Oil & Gas Journal
Oil reserves-to-production ratios

2012 by region

World proved oil reserves at the end of 2012 reached 1668.9 billion barrels, sufficient to meet 52.9 years of global production. An increase in official Iraqi reserves was the single largest addition, adding 6.9 billion barrels. OPEC members continue to dominate, holding 72.6% of the global total. South & Central America continues to hold the highest R/P ratio. Global proved reserves have increased by 26%, or nearly 350 billion barrels, over the past decade.
Coal Overview
Proved coal reserves at end 2011

Figure 1.10
Coal: proven reserves at end 2011

Coal production - Coal consumption

Global coal production grew by 2%. The Asia Pacific region accounted for all of the net increase, offsetting a large decline in the US. The Asia Pacific region now accounts for more than two-thirds of global output. Coal consumption increased by a below-average 2.5%. The Asia Pacific region was also responsible for all of the net growth in global consumption. A second consecutive large decline in North America (-11.3%) more than offset growth in other regions; EU consumption grew for a third consecutive year.
Reserves-to-production (R/P) ratios

2012 by region

History

World proved reserves of coal in 2012 were sufficient to meet 109 years of global production, by far the largest R/P ratio for any fossil fuel. Europe & Eurasia holds the largest regional reserves while North America has the highest R/P ratio. The US holds the largest individual reserves, followed by Russia and China.
Natural Gas Overview
Proved natural gas reserves 2011

Figure 1.9
Natural gas: proven reserves at end 2011

15 countries hold 87% of the world's proved reserves. 2012 natural gas consumption worldwide was 114 tcf.
Natural gas production by area

World natural gas production increased by 1.9% in 2012. The US once again recorded the largest national increase. Production grew in every region except Europe & Eurasia, where declines in Russia and the UK offset a gain in Norway. Natural gas consumption increased by a below-average 2.2%. As was the case with production, the US recorded the largest national increase and consumption rose in every region except Europe & Eurasia. EU consumption fell to the lowest level since 2000.
Natural gas R/P ratios

Reserves-to-production (R/P) ratios

2012 by region

History

World proved natural gas reserves at end-2012 stood at 187.3 trillion cubic metres, sufficient to meet 55.7 years of global production. Proved reserves declined by 0.3% relative to end-2011 data, the first annual decline in our data set. Revisions were made to the earlier published estimates for proved reserves in the Former Soviet Union (FSU) countries, which lowered the FSU R/P ratio to 71 years, from 98.3 years at end-2011 in last year’s edition.
Natural gas consumption per capita
Major natural gas trade movements

Trade flows worldwide (billion cubic metres)

USA
Canada
Mexico
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific

Natural gas
LNG

BP website (BP.com)
Nuclear Energy Overview
Nuclear energy consumption by area

Nuclear energy consumption by region
Million tonnes oil equivalent

- Rest of World
- Asia Pacific
- Europe & Eurasia
- North America
Sources of new energy

Exajoule (EJ): 1 EJ = 10^{18} J
Renewable and Sustainable Energy
Reasons for Renewable Energy

- Declining Fossil Fuel Supplies
- Environmental Concerns
  - Global warming
- Political Concerns
- Increasing Cost of Fossil Fuels
- Business Opportunities
- Other Reasons
Global Warming

1995-2004 Mean Temperatures

Temperature Anomaly (°C)

Versus 1940-1980 Norms

Wikipedia.org, Climate Change, Global Warming articles
World Population Growth

Historic Population Growth

Total Population

from 10000BC to AD 2000

Wikipedia.org, Climate Change, Global Warming articles
Carbon Dioxide Concentrations

The Industrial Revolution Has Caused A Dramatic Rise in CO₂

Ice Age Cycles

Wikipedia.org, Climate Change, Global Warming articles
Global Fossil Carbon Emissions

Wikipedia.org, Climate Change, Global Warming articles
Annual Carbon Emissions by Region

Wikipedia.org, Climate Change, Global Warming articles
CO\textsubscript{2} Emissions by Country (1995)

Emissions of CO\textsubscript{2} - selected countries (1995)

- **Tonnes per capita**
  - USA: 19.6
  - Canada: 10.4
  - Russia: 9.7
  - UK: 9.2
  - Japan: 8.7
  - Poland: 7.8
  - Iceland: 7.7
  - South Africa: 3.9
  - World: 2.5
  - China: 1.8
  - Brazil: 0.9
  - India: 0.6

- **Total million tonnes**
  - World: 2,214.9
  - USA: 5,228.5
  - China: 3,006.8
  - Russia: 1,547.9
  - Japan: 1,150.9
  - India: 803
  - UK: 564.8
  - Canada: 470.8
  - Poland: 336.1
  - South Africa: 320.9
  - Brazil: 287.5
  - Nicaragua: 2.6
  - Iceland: 2.3

Figure 1.6 (a) Atmospheric concentrations of carbon dioxide (CO$_2$), 1854–2000. Carbon dioxide data from 1958 were measured at Mauna Loa, Hawaii; pre-1958 data are estimated from ice cores (b) estimated global mean temperature variations, 1860–2000 (source: Intergovernmental Panel on Climate Change, 2001)
Global Temperatures

![Graph showing global temperatures over time with anomalies and average temperatures.](Image)

Wikipedia.org, Climate Change, Global Warming articles
A chlorofluorocarbon (CFC) is an organic compound that contains only carbon, chlorine, hydrogen, and fluorine, produced as a volatile derivative of methane and ethane.
The **Kyoto Protocol** is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), aimed at fighting global warming. The UNFCCC is an international environmental treaty with the goal of achieving the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The Protocol was initially adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005. As of September 2011, 191 states have signed and ratified the protocol. The only remaining signatory not to have ratified the protocol is the United States. Other United Nations member states which did not ratify the protocol are Afghanistan, Andorra and South Sudan. In December 2011, Canada renounced the Protocol.

Volatile Oil Prices (Rotterdam)

US dollars per tonne

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<th>Year</th>
<th>Gasoline</th>
<th>Gas oil</th>
<th>Heavy fuel oil</th>
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<td>2004</td>
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</table>

Source: Platts.

From 2nd quarter 1992: unleaded gasoline.

BP website (BP.com)
Crude oil prices since 1861

US dollars per barrel

World events

Growth of Venezuelan production
Discovery of Spindletop, Texas
East Texas field discovered
Netback pricing introduced
Iranian revolution
Suez crisis
Iraq invaded Kuwait
Asian financial crisis

Penn-sylvanian oil boom
Sumatra production begins
Russian oil exports begin
Loss of Iranian supplies
Post-war reconstruction
Yom Kippur war
Invasion of Iraq

$ money of the day
$ 2004

1861-1944 US average.
1945-1983 Arabian Light posted at Ras Tanura.
1984-2004 Brent dated.

BP website (BP.com)
Sustainable Energy

- **Renewable**
  - Hydro Power
  - Wind Energy
  - Oceanic Energy
  - Solar Power
  - Geothermal
  - Biomass

- **Sustainable**
  - Hydrogen
  - Nuclear
  - Fossil Fuel Innovation
  - Exotic Technologies
  - Integration
    - Distributed Generation
1. Solar

The Sun releases an amazing amount of energy due to the nuclear fusion of hydrogen taking place within its core. Solar panels, called photovoltaic cells are used to convert the Sun’s energy into electricity. The Sun can also be used to heat water passing through special solar collectors.

**Advantages**
- The energy from the Sun is free.
- The sun does not produce greenhouse gases.
- The sun will always be there during our lifetime.

**Disadvantages**
- It is relatively expensive to build solar power stations.
- When it is cloudy or at night there is not enough light so no electricity can be made.
- Some people don’t like the look of solar panels.
2. Wind

Wind is made when the Sun heats the Earth and the area above land gets hotter than the area above water. The hot air above land rises upwards leaving an area of low pressure. Cooler air moves into this area of low pressure making wind which we use to turn wind turbines and make electricity. Wind used to turn windmills to grind wheat into flour.

**Advantages**
- Wind is free and will not run out so the cost is in building the wind turbine.
- Wind power generation does not create greenhouse gases.
- There are very few safety risks with wind turbines.

**Disadvantages**
- We can only use windmills in areas where there is a lot of wind. Sometimes there may be days where there is little wind.
- We need a lot of turbines to make a lot of electricity.
- Some people don't like the way wind turbines look, they think they spoil the countryside.
3. Biomass

Biomass uses the energy from plants and waste materials to make electricity. For example, wood or animal droppings can be burnt to make steam that turns turbines to make electricity.

**Advantages**
- The fuel is cheap and can use things that we might otherwise throw away.
- We can find waste everywhere and should not run out.

**Disadvantages**
- When the fuel is burned greenhouse gases are made which pollute the environment.
- Sometimes people grow biomass crops where we could grow food.
- We may not have enough space to grow enough biomass fuel.
4. Geothermal

Geothermal power uses the heat that comes from deep rocks under the surface of the Earth. The temperature of the Earth increases towards its centre. The hot water or steam that comes from deep within our planet can be used to make electricity.

**Advantages**
- Geothermal energy does not produce greenhouse gases.
- The energy source is free and will not run out.

**Disadvantages**
- There are not many places where we can build geothermal power stations.
- Harmful gases and minerals may occasionally come up from the ground below. These can be difficult to control.
5. Hydro-electric

Hydro-electricity is generated from running water. Dams are built across a lake or river in a valley to trap water. The water flows through tunnels and turns turbines to make electricity.

**Advantages**
- When the electricity is generated, no greenhouse gases are made.
- The water used is free.
- It is a renewable energy resource.

**Disadvantages**
- The dam is expensive to build.
- By building a dam, the nearby area has to be flooded and this could affect nearby wildlife and plants.
- If it does not rain much we may not have enough water to turn the turbines.
Hydroelectricity consumption by region

- Asia Pacific
- Africa
- Middle East
- Europe & Eurasia
- S. & Cent. America
- North America
6. Wave

Waves are created by the wind blowing across the sea and by the gravitational force of the moon. Wave power uses the energy of the waves to turn turbines that make electricity.

**Advantages**
- Waves are free and will not run out so the cost is in building the power station.
- Wave power does not produce greenhouse gases.
- There are very few safety risks with wave power generation.

**Disadvantages**
- Waves can be big or small so you may not always be able to generate electricity.
- You need to find a way of transporting the electricity from the sea onto the land.
- Not many people have tried to generate electricity this way yet so the equipment is expensive.
7. Tidal

Tidal energy comes from the movement of water in the sea by the tides. These tides happen twice a day. The flow of water that is created by the tides is used to turn generators that make electricity.

**Advantages**
- Tides are free once the power station has been built and will not run out.
- No greenhouse gases are produced when we make the electricity.
- We know exactly when the tides happen so we know when electricity will be made.

**Disadvantages**
- You may need to build a large wall called a dam to make the water flow through the generators.
- This may not be good for plants and animals that live nearby.
- The tides only happen twice a day, so can only produce electricity for that time.
Potential of Renewable Energy Sources

Solar Energy
2850 times

Hydropower
1 times

ENERGY RESOURCES OF THE WORLD
All renewable energy sources provide 3078 times the current global energy needs.

Biomass
20 times

Geothermal energy
5 times

Wave-tidal energy
2 times
Available renewable energy:
The volume of the cubes represent the amount of available geothermal, hydropower, wind and solar energy in TW, although only a small portion is recoverable. The small red cube shows the proportional global energy consumption.

One million million (\(10^{12}\)) watts, abbreviated as TW.
Energy Resources and Consumption in Palestine

- Fossil fuel
- Solar
- Geothermal
- Biomass
- Wind
Fossil energy

Fig. 2: Total final energy consumption by fuel and sector, 2007

B. Yaseen, Renewable Energy Applications in Palestine. pp. 52-65
Conventional energy sources in the Gaza Strip

1- Petroleum Products

Petroleum products (gas, kerosene, gasoline, diesel, oil, and liquefied petroleum gas (LPG) are imported.

The annual amount of Petroleum products consumed and needed in Gaza Strip in 2009

<table>
<thead>
<tr>
<th>Type of Product</th>
<th>Consumed (m³/ year)</th>
<th>Needed (m³/ year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>325</td>
<td>30,000</td>
</tr>
<tr>
<td>Diesel</td>
<td>371</td>
<td>120,000</td>
</tr>
<tr>
<td>Gas</td>
<td>34,783,000 Ton</td>
<td>60,000,000 Ton</td>
</tr>
<tr>
<td>Industrial diesel</td>
<td>107,710</td>
<td>120,000</td>
</tr>
</tbody>
</table>

Source: (The Palestinian General Petroleum Corporation, 2009)
2- Natural Gas

- Two natural gas fields were discovered in the territorial water of Gaza Strip in 2000 at commercial quantities.
- One of these fields is entirely within the regional boarders of Gaza Strip, while (67%) of the second field is located within them.
- This has not been invested yet due to the unstable political situation.

The US Geological Survey estimated a mean of 1.7 billion barrels of recoverable oil and a mean of 122 trillion cubic feet of a recoverable gas in Levant Basin Province.
Energy Shortage in Gaza Strip

• According to Gaza Electricity Distribution Company (GEDC) 2007 statistics, it is likely to conclude that about 70% of the total electricity consumption in Gaza Strip, which was 244MW at that time, is consumed by domestic sector.
• However, there is a significant shortage in electricity supply to Gaza. According to GEDC (2011), statistics show that Gaza Strip needs 300MW of electricity.
• The available quantity is 197MW, coming from the Israeli Electricity Company 120MW (60%), Gaza Power Plant 60MW (32%), and the Egyptian source of 17MW (8%).
THE GAZA POWER STRIP

Gaza's power plant was supposed to lessen the territory's dependence on Israel. But after seven years, the plant provides only 25 percent of what Gaza needs to survive.

1993 The Oslo Accords give Palestinians greater authority over municipal services like the electricity grid.

1994 The Gaza power plant is commissioned as part of a larger blueprint to lessen dependence on Israel.

1999 Construction begins on the US $140 million project. Total demand to be met: 24.4 megawatts.

2002 The plant begins initial operations; Enron, a major U.S.-based investor, collapses.

2005 Israel pulls military forces from Gaza in a strategy known as disengagement.

2006 Israel bombs the plant in retaliation for the kidnapping of an Israeli soldier.

2007 Israel begins rationing fuel to 2.2 million liters per week. The plant needs 4.9 million liters per week to meet demand.

DECEMBER 2008 Fuel cutoffs in the wake of Israel's military strikes damage the plant's transformers, and the plant shuts down completely.

2009 Even when the power plant is online, Gaza only gets at most 60 MW from the plant itself. The rest must be imported from Egypt and Israel.
• Electricity energy demand increases by about 10–15MW annually, as a result of the natural population growth.
Solar energy

1. Photovoltaic electricity (PV)
   • Atouf village was provided by PV centralized power system. The village includes 25 houses, school, and clinic with power capacity about 24 kWp.
   • Street lighting and electrification of public sites at Jib Aldeeb community.

2. Solar water heating (SWH)
   • SWH are extensively used in the residential sector (more than 70% of households use solar family systems).
   • Solar thermal energy has the share of 8.5% of the total energy supply.
JERICHO GOVERNMENTAL HOSPITAL

- Covers the needs of hot water for cleaning, washing and the patients' needs (55 beds).
- A closed loop type with tilt angle 43°
- 69 solar panels
- Total area around 100 m²
Birzeit University collective solar water heating

- a collector area of 148 m²
- a 15 m³ storage tanks
- covers the demand of hot water needed for the cafeteria of the University
- Palestinian pilot project for studying the tele-monitoring protocol and GSR.
Solar thermal plant at Beit Jala School
Geothermal energy

Etihad residential subdivision in Ramallah

- Geothermal has installed a **25kW** heating and cooling system in the Etihad residential subdivision
- 10 holes were drilled at a depth of 70m
  - **23kW** Cooling Load
  - **21kW** Heating Load
- The cost was $48,000
UCI Headquarters Building in Ramallah

Geothermal technology was implemented in the UCI Building, which considered the largest geothermal heating and cooling project in the Middle East and North Africa.

System Features
• 260 kW Cooling Load
• 230 kW Heating Load
• Vertical Closed Loop at 150m deep
• 2 Geothermal Reversible Chillers
• Fan Coil Distribution
• Expected Savings: $30,000 per year
Biomass energy

- The Biogas potential in Palestine is over than 33 million m$^3$. Biomass (wood and agricultural waste) is traditionally used for cooking and heating in rural areas.
- Palestine is an olive oil producing country, the interest now is directed to utilize the olive mill solid waste (OMSW) to be used as clean source of energy. The olive harvest season is all year round and also constantly available. The annual average amount of OMSW is around 76,000 tons.
- The municipal solid waste in Palestine could be used as a source of energy, a new developing proposal projects were released by PEC to generate electricity from burning the wastes. The proposal project is for constructing an 18 MW waste to energy power plant in the northern provinces of the west bank.
Wind energy

The proposed and the required wind turbine(s) to be installed at Al–Ahli Hospital (south-western part of Hebron at 1,000m above sea level) is expected to be around 700kW total power production capacity.

The following is the general outline of the tentative specifications:
• Annual wind average 7-10 m/s
• Hub Height 45 m- 55 m
• Nominal Power 750 kW
Solar Power – Next