Hong Kong Academy of Engineering Sciences Forum

WORLD ENERGY DEMAND
AND
ENERGY SECURITY FOR HONG KONG

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Myth


Truth

There has never been an energy crisis in the history of the human race.
There was an oil crisis in 1973.

Why should we be concerned with energy demand and energy security?

- Environmental security
- Economic security
- National security
Outline

- Overview of World Energy Demand
- Technology Options for Generating Electric Power
- Energy Security for Hong Kong

Overview of World Energy Demand
World Total Energy Consumption (2007-2035)

(1 quad = 172 million barrels of oil)

Average Annual Growth in Delivered Energy Consumption by Region and End-Use Sector

Source: Energy Information Administration / International Energy Outlook 2010, Figure 1, pg. 1
## World Total Energy Consumption

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Quad (1 quad ≈ 172 million barrels of oil)</th>
<th>2007</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquids (Oil)</td>
<td></td>
<td>174.7</td>
<td>223.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(35.3%)</td>
<td>(30.3%)</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td>112.1</td>
<td>162.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(22.6%)</td>
<td>(21.9%)</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td>132.4</td>
<td>206.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(26.7%)</td>
<td>(27.9%)</td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td>27.1</td>
<td>47.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.5%)</td>
<td>(6.4%)</td>
</tr>
<tr>
<td>Hydro &amp; other renewables</td>
<td></td>
<td>48.8</td>
<td>99.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9.9%)</td>
<td>(13.5%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>495.2</td>
<td>738.7</td>
</tr>
</tbody>
</table>


## World Fossil Fuel Use & Reserves

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2005</th>
<th>2007</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (million barrels per day)</td>
<td>66.5</td>
<td>86.2</td>
<td>88.1</td>
<td>110.6</td>
</tr>
<tr>
<td>Natural Gas (trillion cubic feet)</td>
<td>73.4</td>
<td>104.6</td>
<td>108.5</td>
<td>156.3</td>
</tr>
<tr>
<td>Coal (million short tons)</td>
<td>4,307.6</td>
<td>6,090.3</td>
<td>6,379.4</td>
<td>9,940.2</td>
</tr>
</tbody>
</table>

### Proven reserves:
- **Oil and natural gas as of 1 Jan 2010**
- **Coal as of 1 Jan 2008**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Reserves available at present</th>
<th>Estimated # of years remaining @ 2007 consumption rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (million barrels)</td>
<td>1,353,700</td>
<td>43.1</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>6,609</td>
<td>80.9</td>
</tr>
<tr>
<td>Coal (million short tons)</td>
<td>909,400</td>
<td>142.6</td>
</tr>
</tbody>
</table>

Source: Energy Information Administration / International Energy Outlook 2010, table 5, pg. 37; table 7, pg. 57; table 10, pg. 73.
World Total Energy Consumption and Carbon Emissions

World Total Energy Use by Fuel Type (1990 – 2035)

World Energy-related Carbon Dioxide Emissions by Region (2007 – 2035)


Technology Options for Generating Electric Power
World Electric Power Generation by Source (2007)

- Oil-fired power plants (5%)
- Gas-fired power plants (21%)
- Coal-fired power plants (42%)
- Nuclear (14%)
- Renewables (18%)
  - Hydro
  - Wind
  - Solar PV
  - Biomass
  - Geothermal

Wind Energy

- Conversion of wind to mechanical energy and then into electric energy
- Global wind power capacity has grown at an average cumulative rate of over 30% from 1998 to 2008
- Total worldwide installed capacity of nearly 200,000 megawatts at the end of 2010
- The cost of electricity generated from wind is now at record lows, with several projects in US Brazil, Sweden, Mexico display a cost of energy below $68/MWh
- China is now the world’s leading wind power country, accounted for nearly half of the new global installations in 2010

Image: Global Wind Report 2010
Worldwide Installed Wind Capacity (2006-2010)

China’s Wind Capacity (2000-2010)
China's Wind Capacity

- Current installed wind capacity by province 2009 (MW)

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Solar PV- Installed Capacity

**2005**
(0.09% of total electricity capacity)

1,422MW 38%
479MW 13%
375MW 10%

**2008**
(0.3% of total electricity capacity)

5,300MW 38%
3,400MW 25%
2,100MW 15%
1,100MW 8%
2,000MW 14%

- Germany
- Spain
- Japan
- USA
- Rest of world

Nuclear Power

- Over 440 commercial nuclear power reactors operating in some 30 countries
- Providing about 14% of the world’s electricity
- As of end of 2010, more than 60 International Atomic Energy Agency member states were considering introducing nuclear power programmes. Almost all of the 29 countries which already had such programmes planned to expand them
- China has six nuclear power plants, with 13 nuclear power reactors in operation, and more than 25 reactors under construction

Next Generation Nuclear Power Plants
NGNP- Very High Temperature Reactor (VHTR)

- Countries working together

![Diagram showing electricity and hydrogen production with different reactor types and temperature levels.](source: Idaho National Engineering and Environmental Laboratory, DOE, Office of Nuclear Energy)
NGNP- Mission Objectives

- Demonstrate a full-scale prototype NGNP by year 2017
- Demonstrate high temperature Brayton cycle electric power production at or near full scale
- Demonstrate hydrogen production
- Demonstrate by test the exceptional safety capabilities

High Temperature Reactor

- China has built a small (10MW) advanced high-temperature gas-cooled demonstration reactor with pebble bed fuel, which successfully generated electric power since 2003.
- A commercial prototype high-temperature reactor is expected to start up in 2013.

China Energy Policy

  - Increase nuclear generating capacity to 40 Gwe by 2020
  - Meet 4% of China's electricity demand

- 12th Five-Year Plan (2011-2015)
  - Non-fossil fuel to account for 11.4% of primary energy consumption
  - Energy consumption per unit of GDP to be cut by 16%
  - Carbon dioxide emission per unit of GDP to be cut by 17%

- China's nuclear energy policy has the following key elements:
  - Pressurised Water Reactors will be the mainstream but not sole reactor type
  - Nuclear fuel assemblies are fabricated and supplied indigenously
  - Domestic manufacturing of plant and equipment will be maximised, with self-reliance in design and project management
  - International cooperation is encouraged

- State Council suspended the approval process for new nuclear power stations so as to revise safety standards after the Fukushima crisis

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Nuclear Power

Benefits:
- No carbon dioxide or other greenhouse gas emissions
- Produces clean electricity on a global scale

Public concerns:
- Radioactive waste disposal
- Plant safety
- Disaster preparedness
- Nuclear material proliferation
- Public outcry against use of nuclear power after Fukushima crisis
  - Germany to scrap nuclear power by 2022

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Sources: World Nuclear Association, IEA
Energy Security for Hong Kong

Hong Kong Electricity End-uses (2008)

Source: Hong Kong Energy End-use Data 2008, Electrical & Mechanical Services Department, HESAR
Hong Kong Proposed Fuel Mix Revamp

(2009)  
- Nuclear (23%)
- Natural gas (23%)
- Coal (54%)

(2020)  
- Nuclear (50%)
- Natural gas (40%)
- Renewables (3-4%)
- Coal (<10%)

Total electricity consumption:
162,799 TJ (0.15 quad) in 2009 and 200,399 TJ (0.19 quad) in 2020

Source: Hong Kong's Climate Change Strategy and Action Agenda, HK SAR Government

What Is the Future Environment That We Want?

- Clean environment
  - minimize use of fossil fuels
- Same level of living standard
  - convenient
  - comfortable
  - efficient

How Do We Meet These Requirements?

- Coal power is on the way out
- Nuclear power is not welcome
- Choices available:
  - reduce electricity consumption
  - increase use of renewable energy
Vision for 2050

- Reduce electricity consumption by 50%
- Increase use of renewable energy to 80%

Germany's targets

Energy Experts at PolyU

<table>
<thead>
<tr>
<th>Department</th>
<th>Name</th>
<th>Expertise</th>
</tr>
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<tbody>
<tr>
<td>Department of Applied Biology and Chemical Technology</td>
<td>Prof. WT Wong</td>
<td>Biofuel production from Algae</td>
</tr>
<tr>
<td></td>
<td>Prof. Sam Lo</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Joseph Yung</td>
<td></td>
</tr>
<tr>
<td>Department of Building Services Engineering</td>
<td>Prof. YANG Hongxing</td>
<td>Renewable energy (solar energy and wind energy)</td>
</tr>
<tr>
<td></td>
<td>Dr. LU Lin, Vivien</td>
<td>Renewable energy (solar energy and wind energy)</td>
</tr>
<tr>
<td></td>
<td>Prof. NIU Jianlei</td>
<td>Energy consumption/demand modelling and simulation in the building sector</td>
</tr>
<tr>
<td></td>
<td>Dr. CHEN Ting-yao</td>
<td>Building energy analysis and conservation</td>
</tr>
<tr>
<td></td>
<td>Prof. WANG Shengwei</td>
<td>Energy efficiency in building through optimized controls</td>
</tr>
<tr>
<td></td>
<td>Prof. DENG Shi-Ming</td>
<td>Air Conditioning and Refrigeration System energy consumption, Building Energy Audit</td>
</tr>
<tr>
<td>Department of Electrical Engineering</td>
<td>Dr. NGAN Hon-wing</td>
<td>Power market reform, Energy Policy</td>
</tr>
<tr>
<td>Department of Electronic &amp; Information Engineering</td>
<td>Prof. WOO Chung-ho</td>
<td>Nuclear energy</td>
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