Energy Efficiency in APEC
A Focus on the Power Sector

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Study Background

- Needs for Energy Efficiency Improvement
  - Rising energy prices
    - Resource issue
  - Increasing energy import dependency
  - Global and local environmental concerns

- Needs for the Power Sector’s Energy Efficiency Improvement
  - The fastest growing energy source in final energy
  - Ease of policy implementation
    - Limited number of stakeholders
  - Substantial and long-term energy saving potential
Energy Prices in Recent Years

Weather and demand surge as the biggest contributors to the current increase in oil price

Widening price gap among oil, natural gas and coal

Steady increase in oil prices since the fourth quarter of 2003

(Source) APERC Analysis (2006)
# Energy Efficiency Policies in APEC Economies

## Australia
- Energy Efficiency Opportunities Act 2006 and Regulation 2006 to encourage large energy users to take a more rigorous approach to energy management.

## China
- Ten key projects for energy launched
  - Target to save 240 million tonnes of coal equivalent
- Top-1000 Enterprise Energy Conservation Action Plan launched
  - Target to save 100 million tce by 2010

## Hong Kong, China
- Issue of labels for 2,960 appliances.

## Indonesia
- Biofuels programme initiated.

## Japan
- New Energy Strategy calls for another 30 percent improvement of energy intensity by 2030.

## Korea
- Implementation of mandatory energy management audit
- Implementation of no driving days for employees of public offices

## Malaysia
- Implementation of demonstration projects for energy efficiency improvement in industry and commercial sectors.

## New Zealand
- Under the NZ Energy Strategy maximise the efficient use of energy to safeguard affordability, economic productivity and the environment.

## USA
- Implementation and plan for various measures for energy efficiency improvement
  - Energy efficiency standards for appliances
  - Tax incentives for the purchase of efficient appliances and vehicles
  - Promote energy efficiency and saving at federal agencies
  - Establish renewable fuel standards

## Viet Nam
- UNDP and the Vietnam Ministry of Science and Technology will implement a project to raise the effectiveness of energy use at small and medium enterprises (SMEs)
## APEC Final Energy Demand Outlook by Source (2002-2030)

Electricity demand to grow at the fastest rate of 3.1 percent per year

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<thead>
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<tbody>
<tr>
<td>Total Final Energy Demand</td>
<td>2 336.2</td>
<td>3 818.6</td>
<td>4 661.2</td>
<td>5 648.1</td>
<td>6 759.2</td>
<td>2.3</td>
<td>2.5</td>
<td>1.9</td>
<td>1.8</td>
<td>2.1</td>
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<td>Coal</td>
<td>310.5</td>
<td>336.7</td>
<td>466.8</td>
<td>515.1</td>
<td>560.2</td>
<td>0.4</td>
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<td>Oil</td>
<td>1 039.8</td>
<td>1 680.0</td>
<td>2 040.2</td>
<td>2 491.8</td>
<td>2 972.8</td>
<td>2.2</td>
<td>2.5</td>
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<td>Gas</td>
<td>396.3</td>
<td>565.6</td>
<td>674.5</td>
<td>832.7</td>
<td>1 010.8</td>
<td>1.6</td>
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<td>340.4</td>
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<td>-0.4</td>
<td>-0.2</td>
<td>-0.3</td>
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<tr>
<td>Electricity</td>
<td>290.4</td>
<td>693.3</td>
<td>935.9</td>
<td>1 254.2</td>
<td>1 640.3</td>
<td>4</td>
<td>3.8</td>
<td>3</td>
<td>2.7</td>
<td>3.1</td>
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<td>Heat</td>
<td>8.5</td>
<td>169.1</td>
<td>182.3</td>
<td>207.9</td>
<td>234.8</td>
<td>14.6</td>
<td>0.9</td>
<td>1.3</td>
<td>1.2</td>
<td>1.2</td>
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</table>

(Source) APERC Analysis (2006)
Utilization of coal-fired power generation technology
Weighted average fossil fuel thermal efficiency

Developed economies

Developing economies

[Graph showing weighted average thermal efficiency for developed and developing economies over years 1985 to 2005]

APEC
Asia-Pacific Economic Cooperation
Asia Pacific Energy Research Centre
Tokyo
Averaged thermal efficiency of coal-fired power generation

**Developed economies**

<table>
<thead>
<tr>
<th>Year</th>
<th>Thermal Efficiency (%)</th>
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<tbody>
<tr>
<td>1985</td>
<td>10%</td>
</tr>
<tr>
<td>1987</td>
<td>15%</td>
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<tr>
<td>1989</td>
<td>20%</td>
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<tr>
<td>1991</td>
<td>25%</td>
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<tr>
<td>1993</td>
<td>30%</td>
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<tr>
<td>1995</td>
<td>35%</td>
</tr>
<tr>
<td>1997</td>
<td>40%</td>
</tr>
<tr>
<td>1999</td>
<td>45%</td>
</tr>
<tr>
<td>2001</td>
<td>50%</td>
</tr>
<tr>
<td>2003</td>
<td>55%</td>
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</table>

**Developing economies**

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<th>Thermal Efficiency (%)</th>
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<td>40%</td>
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<td>1995</td>
<td>45%</td>
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<tr>
<td>1997</td>
<td>50%</td>
</tr>
<tr>
<td>1999</td>
<td>55%</td>
</tr>
</tbody>
</table>

AUS - Australia, CDA - Canada, CT - China, HKC - Hong Kong, JPN - Japan, ROK - Korea, NZ - New Zealand, USA - United States, AUS - Australia, CDA - Canada, CT - China, HKC - Hong Kong, JPN - Japan, ROK - Korea, NZ - New Zealand, USA - United States.
Averaged thermal efficiency of gas-fired power generation

Developed economies

Developing economies

[Graph showing averaged thermal efficiency of gas-fired power generation for developed and developing economies over years 1985 to 2005.]

Transmission Losses

Power Plant Own Use

(Source) APERC Analysis (2007)
Economics of Energy Efficiency Improvement

Marginal Cost (MC): Technology, and Scale Economy

Marginal Benefit (MB): Environment (local pollution), Carbon-offset, and Energy Price

Improvement in Efficiency
### Performance Characteristics of Power Generation Technologies

<table>
<thead>
<tr>
<th>Past Practice (Pulverized coal plant)</th>
<th>Modern Plant (Pulverized coal super critical with FGD and SCR)</th>
<th>Modern Plant (IGCC)</th>
<th>Future Plant (IGCC with zero emissions technologies)</th>
<th>Natural Gas Combined Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2 (mg/Mm3)</td>
<td>1500-7500</td>
<td>150</td>
<td>10 or less</td>
<td>0</td>
</tr>
<tr>
<td>Nox (mg/Mm3)</td>
<td>500-1000</td>
<td>100</td>
<td>50 or less</td>
<td>50 or less</td>
</tr>
<tr>
<td>Particulates (mg/Mm3)</td>
<td>200-350</td>
<td>50</td>
<td>10 or less</td>
<td>0</td>
</tr>
<tr>
<td>Thermal Efficiency (%)</td>
<td>25-35</td>
<td>37-44</td>
<td>45</td>
<td>43</td>
</tr>
<tr>
<td>CO2 (g/kWh)</td>
<td>900-1300</td>
<td>770-880</td>
<td>750</td>
<td>Near zero</td>
</tr>
<tr>
<td>Current Capital Costs ($/kW)</td>
<td>500-700</td>
<td>900-1200</td>
<td>1200-1500</td>
<td>1500 &lt;</td>
</tr>
</tbody>
</table>

Higher firing temperature enables higher thermal efficiency

Gas Turbine Technology Evolution (GE)

(Source) GE Homepage (2007)
China’s savings for coal consumption through 5% thermal efficiency improvement = 2.6x10^8 ton (24% savings)

(Source) APERC Analysis (2007)
US/CDA’s natural gas savings thru 4% thermal efficiency improvement = 16 BCM (10% savings)

(Source) APERC Analysis (2007)
Cost and Benefit of Power Generation Efficiency Improvement – A Case Study of Turbine Retrofitting in China

Project Description

– Retrofitting turbines of two units in the Pucheng coal-fired power plant in Shaanxi Province, China

– Capacity and commissioning date
  ● Unit 1 (330 MW): March 1996
  ● Unit 2 (330 MW): December 1997

– Thermal efficiency
  ● Current: 34.5%
  ● New: 38.4%

– Turbine Manufacture
  ● Current Turbine: General Turbine (Romania)
  ● New Turbine: Dongfong Turbine (China)

Project Assessment

– Approximately 10% reduction of CO2, NOx, and SOx emissions

– Capital investment for turbine
  ● 29.57 million USD
  ➢ 7.6 million USD/1% improvement of thermal efficiency

– Net revenue increase from reduced coal consumption
  ● 4.428 million USD/year

– Project life
  ● 30 years

– Expenses
  ● No O&M costs assumed (as it is reflected in the baseline case)

– IRR
  ● 8.1%
Barriers for Technology/Know-how Transfer for Power Generation

- Economic barriers
  - High transaction costs
  - Lack of full cost pricing
  - Low rate of return

- Lack of local infrastructure

- Lack of understanding of local needs

- Institutional limitations

- Inadequate environmental codes and standards
**CDM Projects under Validation**

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### Project Types

- **Energy conservation, 1%**
- **Non-CO2 reduction, 3%**
- **Fuel switching, 5%**
- **Wind power, 4%**
- **Biomass utilisation, 29%**
- **Hydroelectric power, 27%**
- **Methane recovery, 31%**

### Emissions Reduction Potential

- **2004**
- **2005**
- **2006**
- **2007**
- **2008**
- **2009**
- **2010**
- **2011**
- **2012**

- **Others**
- **Biomass utilisation**
- **Hydro and wind**
- **Methane recovery**
- **Non-CO2 reduction**

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JBIC’s Proposed Financial Support for Renovation of Coal-fired Power Generation in China

- China Electricity Council
- JBIC
- J-Coal
- Power Grids
- Coal Suppliers
- Power Generation
- Japanese Technology Suppliers
- Carbon Credits Buyers
- Payment
- Tech. Supply
- Carbon Credits
- Energy Saving CO2 Emissions Reduction

(Source) J-Coal (2007)
Scenario Analysis - Technology and Market Road Map

Efficiency and Enviro-centric Combination Scenario

- Bilateral public/private partnerships sought
- EWG Demand-side management declaration endorsed
- APEC-wide environmental declaration endorsed
- Regional power grid interconnection
- Peripheral industrial capacity in developing economies enhanced

Local/regional air quality declines - economic slowdown

Sydney Declaration - 25% energy intensity improvement by 2030

2005
- Price hike on fuels
- UN framework on forest/land change endorsed
- Monju fast breeder reactor re-commissioned
- G8 Summit endorses declaration for the environment
- EWG Peer Review on Energy Efficiency enacted

2010
- Oil companies become major players in CCS
- Global Carbon market
- Tax revenue used for technology transfer

2015
- APEC-wide mandatory air quality standards
- CCS Technologies are commercialised

2020
- APEC-wide DSM tax implemented

2025
- Yucca Mountain repository opens
- CO2 leakage from storage repositories

2030
- APEC-wide DSM tax implemented
- Oil companies become major players in CCS
- Global Carbon market
- Tax revenue used for technology transfer

(Source) APERC Analysis (2007)
Technology and Market Road Map - The Future of CCS

Carbon Capture and Sequestration (CCS)

- ZeroGen, Australia (100MW)
- Progressive, United Kingdom (800 MW)
- CCS Technologies are commercialised
- RWE-n Power, United Kingdom (1,000 MW)
- CO2 leakage from storage repositories

- RWE, Germany (400-450 MW)
- SaskPower, Canada (300 MW)
- FutureGen, United States (275 MW)
- PowerFuels, United Kingdom (900 MW)
- E.On, United Kingdom (450 MW)

- Global Carbon market
- Oil companies become major players in CCS
- Vattenfall, Germany (250 MW)

(Source) APERC Analysis (2007)
Energy Savings Potential through Thermal Efficiency Improvement

2030 - Savings in Coal Power Generation (million TOE)

Coal Consumption - 2005
- PRC: 1,122.1 million TOE
- USA: 555.5 million TOE
- Russia: 103.3 million TOE

Coal Consumption percentages:
- PRC: 13.3%
- USA: 16.6%
- Russia: 40.3%
- Other APEC: 20.0%
- AUS: 19.5%
- CT: 27.3%
- INA: 15.2%
- ROK: 8.8%
- JPN: 12.8%
- Total APEC: 100%
Energy Savings Potential through Thermal Efficiency Improvement

2030 - Savings in Gas Power Generation
(million TOE)

Gas Consumption - 2005
- Russia: 349.6 million TOE
- USA: 507.7 million TOE
- Japan: 70.5 million TOE

RUS | USA | THA | JPN | MEX | AUS | VN | CDA | Other | Total
---|---|---|---|---|---|---|---|---|---
| 28.2% | 9.7% | 11.0% | 12.3% | 13.7% | 34.3% | 16.2% | 19.0% | 3.4% | 100%

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Tokyo
Tentative Conclusions

- How to mobilise financial sources is the key for implementing the power sector energy efficiency projects.

- Incentives need to be provided to increase project viability.
  - Carbon price
  - Scale-economy through bundling projects

- Institutional arrangements are necessary to create framework conducive of financial flows.
  - ESCOs
  - Government commitment between host and investing economies
Way Forward

- Fixing all the numbers
- Complete the scenario exercise (to be included in the outlook)
- Identify economy-specific barriers & policy implications
- Extend the study to incorporate the end-use sector (next phase, 2009-2010)
APERC

www.ieej.or.jp/aperc