



**Asia-Pacific
Economic Cooperation**

Overview of APEC Energy Working Group Projects

Stage 3: Project Outcomes

**Report: New and Renewable Energy
Technologies and Clean Fossil Energy**

APEC Energy Working Group

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EXECUTIVE SUMMARY

This report forms part of the third stage of a review of projects that were funded and implemented under the auspices of the APEC Energy Working Group (EWG).

The initial overview report from this review concentrated on identifying and categorising EWG projects and therefore did not focus on project outcomes. The purpose of the second and third stages of the review is to summarise the outcomes of each of the projects and thereby demonstrate to a wider global audience how the EWG's project activities contribute towards addressing energy security, climate change and clean development.

The report from the second stage of the review summarised the outcomes of EWG projects covering energy efficiency and conservation; energy data and analysis; and energy trade and investment.

This report from the third stage of the review summarises the outcomes of EWG projects covering the following areas:

- new and renewable energy, including alternate transportation fuels; and
- clean fossil energy.

New and Renewable Energy Projects

Between 1992 and 2001, eight annual seminars were held concerned with energy R&D and technology transfer in relation to new and renewable energy. These seminars covered a broad range of topics and seem to have functioned well in building networks in the APEC region on new and renewable energy.

Following the termination of the annual seminars, the development and implementation of projects on specific topics and issues about new and renewable energy has continued. Project work commenced in 1993 and since then new and renewable energy projects funded through the EWG cover a relatively large number of subject areas – nine in all. The ways in which the projects have addressed these subjects varies.

For some subjects, the work undertaken through EWG projects constitutes a carefully planned and successfully executed program of research and action that has achieved significant progress to date and is still ongoing. This is particularly the case for the work on renewable energy technologies and technology transfer, renewable energy resource and end-use assessment, and renewable energy training.

For other subjects, the project work has commenced only recently and is beginning to show some promise. This is the case for the work on alternative transport fuels and renewable energy standards.

For a third group of subjects, only a couple of projects have been undertaken and the work does not appear to have produced significant results. This includes work on electricity from renewable sources, renewable energy business development and renewable energy project management (the single project on this subject was actually abandoned).

Finally, there is the group of eight projects loosely categorised under the subject area Renewable Energy Policy, Regulation and Programs. This grouping largely consists of one-off projects, some of which show considerable promise for further work. Some of these projects should be revisited to determine whether further work should be carried out.

Clean Fossil Energy Projects

Since 1993, five series of annual seminars and workshops have been held on various topics relate to clean fossil energy. In fact, 24 of the 50 EWG projects implemented on clean fossil energy to the end of 2007 were seminars and workshops. These events seem to have functioned well in building networks in the APEC region on clean fossil energy.

The other 26 clean fossil energy projects are distributed among four subject areas: clean coal, electricity generation, natural gas and coal mine gas, and reducing CO₂ emissions. The work in each of these subject areas constitutes a carefully planned and successfully executed program of research and action that has achieved significant progress to date and is still ongoing. Further projects should be developed and implemented to build on this existing work. Investigations should also be carried out to determine whether projects should be developed and implemented in other clean fossil energy subject areas.

Conclusion

The initial overview report concluded that the EWG projects had developed an extensive and comprehensive collection of policy-targeted information that has been, and will continue to be, invaluable in achieving APEC's goal of maximising the energy sector's contribution to the region's economic and social well being while mitigating the environmental effects of energy supply and use. The more detailed review of project outcomes in this report has confirmed the initial conclusion while identifying a range of strengths and weaknesses in the coverage and results of the projects.

1. INTRODUCTION

Asia-Pacific Economic Cooperation (APEC) was established in 1989 to further enhance economic growth and prosperity for the region and to strengthen the Asia-Pacific community. APEC is the premier forum for facilitating economic growth, cooperation, trade and investment in the Asia-Pacific region.

APEC has 21 members - referred to as “member economies” - which account for approximately 40% of the world's population, approximately 56% of world GDP and about 48% of world trade.

APEC is the only inter-governmental grouping in the world operating on the basis of non-binding commitments, open dialogue and equal respect for the views of all participants. Unlike the World Trade Organisation or other multilateral trade bodies, APEC has no treaty obligations required of its participants. Decisions made within APEC are reached by consensus and commitments are undertaken on a voluntary basis.

The APEC Energy Working Group (EWG) was launched in 1990 and seeks to maximise the energy sector's contribution to the region's economic and social well being, while mitigating the environmental effects of energy supply and use. The EWG is one of 11 Working Groups currently operating under the APEC umbrella.

The EWG has a well established structure comprising representatives from APEC economy governments, research organisations and the business community, including five Expert Groups, two Task Forces, the Asia Pacific Energy Research Centre (APEREC) and the Energy Business Network (EBN). Australia has served as Lead Shepherd and Secretariat for the Energy Working Group since its formation.

One of the activities undertaken under the auspices of the EWG is the funding of research projects that study topics relevant to energy supply and use in the APEC region. Between 1992 and 2007, 250 projects were funded through the EWG.

A previous report¹ presented an overview of these projects. This initial overview report concluded that the EWG projects had developed an extensive and comprehensive collection of policy-targeted information that has been, and will continue to be, invaluable in achieving APEC's goal of maximising the energy sector's contribution to the region's economic and social well being while mitigating the environmental effects of energy supply and use.

In the Declaration from their meeting in Darwin in May 2007, APEC Energy Ministers recognised the need to respond to the challenges of meeting rapidly growing energy demands while minimising environmental effects. As well as emphasising the need to strengthen emergency preparedness and participate in measures to manage the risks and consequences of short-term energy supply disruptions, Energy Ministers also recognised the importance of pursuing policies and technologies to promote the development of cleaner energy and the improvement of energy efficiency and conservation.

¹ Energy Futures Australia Pty Ltd (2007). *Overview of APEC Energy Working Group Projects*. Canberra, Department of Industry, Tourism and Resources.

The Darwin Declaration provided an important input into the Sydney APEC Leaders' meeting in September 2007. In the Sydney Declaration on Climate Change, Energy Security and Clean Development, APEC Leaders agreed on cooperative actions, including actions on energy efficiency, low emissions technology development, alternative and low carbon energy uses and open trade and investment.

During the second and third stages of the review of EWG projects, the technical and/or policy outcomes of the projects are reviewed and analysed to demonstrate and assess how they have contributed towards achieving energy security in the context of APEC Ministers' and Leaders' broader considerations of energy security, climate change and clean development.

The report from the second stage of the review² summarised the outcomes of EWG projects covering energy efficiency and conservation; energy data and analysis; and energy trade and investment.

This report from the third stage of the review summarises the outcomes of EWG projects covering the following areas:

- new and renewable energy, including alternate transportation fuels; and
- clean fossil energy.

2. APEC ENERGY POLICY INITIATIVES PRIOR TO 2007

2.1 The Bogor Declaration

Since its inception, APEC has worked to reduce tariffs and other trade barriers across the Asia-Pacific region, creating efficient domestic economies and dramatically increasing exports. Key to achieving APEC's vision are the 'Bogor Goals' *of free and open trade and investment in the Asia-Pacific by 2010 for industrialised economies and 2020 for developing economies*. These goals were adopted by APEC Leaders at their November 1994 meeting in Bogor, Indonesia.

In the Declaration from their Bogor meeting, APEC Economic Leaders stated APEC's basic objectives as follows:

- to strengthen the open multilateral trading system;
- to enhance trade and investment liberalisation in Asia-Pacific; and
- to intensify Asia-Pacific development cooperation.

2.2 The 3Es Initiative

Also in November 1994, at the APEC Ministerial meeting held in Jakarta, a report was presented to the Ministers on the 3Es: economic growth, energy security and environmental protection. This paper, prepared by Japan, contained an assessment of current levels and patterns of energy supply and demand with a view to arriving at a

² Energy Futures Australia Pty Ltd (2008). *Overview of APEC Energy Working Group Projects. Stage 2: Project Outcomes. Report 1: Energy Efficiency and Conservation, Energy Data and Analysis and Promoting Energy Trade and Investment*. Canberra, Department of Resources, Energy and Tourism.

more balanced level and pattern in future. Ministers discussed the increasing demand for energy and the growing significance of environmental issues in the region, and noted the importance of the simultaneous achievement of the 3Es. Ministers also examined the future issue, as pointed out in the report, of improving the regional structure of energy demand-supply, and discussed APEC's vital role in information exchange, fostering common understanding and policy discussion. Ministers noted that the Japanese paper would prove helpful to the Energy Working Group in defining its future efforts.

2.3 EWG Action Program

At the eleventh meeting of the Energy Working Group held in Taipei in October 1995, agreement was reached on the full Action Program for the EWG which was to be incorporated into the Osaka Action Agenda (see section 2.4, page 5).

2.3.1 Goals

The activities embarked on and proposed in the EWG's Action Program aimed to contribute to the achievement of the objectives of the *Bogor Declaration* and address the elements embraced in the 3Es initiative by:

- improving the understanding by the governments and business sectors of member economies of regional energy markets, thus assisting policy making and business activities;
- reducing regulatory, institutional and procedural impediments to trade and investment in energy infrastructure, products and services;
- reducing the environmental impacts of energy production, delivery and consumption through improving access to technology, training, services and investment opportunities;
- reducing costs to both governments and business by the acceptance of equivalence in accreditation and the closer harmonisation of standards relating to energy products, appliance and services.

Achievement of these goals would enable the Energy Working Group to foster the development of APEC as a sustainable energy community.

2.3.2 Principles

Also included in the EWG's Action Program were 14 non-binding policy principles for rational energy consumption which were later endorsed by APEC Energy Ministers (see Table 1, page 4). EWG members agreed to develop and build upon these principles, including applying them into additional areas where consensus can be reached, leading to the development of a range of shared energy policy goals.

**Table 1. Non-Binding Energy Policy Principles
 Endorsed by APEC Energy Ministers in 1996**

1.	Emphasise the need to ensure energy issues are addressed in a manner which gives full consideration to harmonisation of economic development, security and environmental factors.
2.	Pursue policies for enhancing the efficient production, distribution and consumption of energy.
3.	Pursue open energy markets for achieving rational energy consumption, energy security and environmental objectives, recommending action in the appropriate forum of APEC to remove impediments to the achievement of these ends.
4.	Recognise that measures to facilitate the rational consumption of energy might involve a mix of market based and regulatory policies, with the relative components of the mix being a matter for the judgement of individual economies.
5.	Consider reducing energy subsidies progressively and promote implementation of pricing practices which reflect the economic cost of supplying and using energy across the full energy cycle, having regard to environmental costs.
6.	The regular exchange of experience on the various policies being used by member economies to achieve a more rational energy consumption.
7.	Ensure that a least cost approach to the provision of energy services is considered.
8.	Promote the adoption of policies to facilitate the transfer of efficient and environmentally sound energy technologies on a commercial and non-discriminatory basis.
9.	Encourage the establishment of arrangements for the development of human resource skills relevant to the application and operation of improved technology.
10.	Enhance energy information and management programs to assist more rational energy decision making.
11.	Encourage energy research, development and demonstration to pave the way for cost effective application of new, more efficient and environmentally sound energy technologies.
12.	Promote capital flows through the progressive removal of impediments to the funding of the transfer and adoption of more energy efficient and environmentally sound technologies and infrastructure.
13.	Promote cost effective measures which improve the efficiency with which energy is used but reduce greenhouse gases as part of a suggested regional response to greenhouse gas reductions.
14.	Cooperate, to the extent consistent with each economy's development needs, in the joint implementation of projects to reduce greenhouse gas emissions consistent with the Climate Change Convention.

2.3.3 Priorities

The EWG's Action Program did not attempt to include the full spectrum of the Group's activities. Rather it focussed on a limited number of key initiatives that would produce outcomes of direct relevance to the achievement of the objectives of the Bogor Declaration and the 3Es initiative.

The activities set out in the EWG Action Program consisted of four themes:

- fostering a common understanding on regional energy issues;
- facilitating investment in the energy sector;
- reducing environmental impacts in the energy sector; and
- acceptance of equivalence in accreditation and increasing harmonisation of energy standards.

2.4 The Osaka Action Agenda

At the request of APEC Economic Leaders, following the Bogor meeting the APEC Senior Officials began the task of developing an Action Agenda to implement the Bogor Declaration. The Action Agenda was subsequently endorsed by APEC Economic Leaders at their third meeting in Osaka in November 1995. The Action Agenda consisted of two parts: Part One concerning trade and investment liberalisation and facilitation; and Part Two concerning economic and technical co-operation. The Action Agenda included Action Programs in 12 specific areas, including the EWG Action Program in relation to energy.

2.5 APEC Energy Policy Principles

The APEC Energy Ministers held their first meeting in Sydney in August 1996. Ministers identified objectives of fundamental importance to the region's future prosperity. These included:

- improvement of regional energy security primarily through the enhancement of open efficient regional energy markets, and through supply capacity expansion and energy conservation;
- reforms to mobilise business investment in power sector infrastructure;
- a strategic approach to reduce environmental impacts;
- a framework to reduce business costs through cooperation on energy standards; and
- the adoption of energy policy principles which give impetus to regional initiatives to reform energy policies for incorporation into member economies' domestic energy policy deliberations.

The 14 non-binding energy policy principles endorsed by Ministers at this meeting and also included in the EWG Action Program for the *Osaka Action Agenda* are shown in Table 1 (page 4).

2.6 APEC Energy Security Initiative

At their meeting in Brunei in November 2000, APEC Economic Leaders (and Ministers) noted the risks to the world economy posed by volatility in the oil market and called for appropriate measures to promote stability in the mutual interests of consumers and producers. To help reduce vulnerability and promote market stability, APEC Leaders directed the EWG to implement an energy security initiative. Following a series of workshops the EWG developed the *APEC Energy Security Initiative*, which was endorsed by the EWG in September 2001, and by APEC Economic Leaders in October 2001.

The *Energy Security Initiative* (ESI) comprises a series of short-term measures to respond to temporary energy supply disruptions, and longer-term policy responses to address the broader challenges facing the region's energy supply that are practical in a policy context and politically acceptable.

In October 2003, APEC Economic Leaders endorsed an Implementation Plan and an APEC Action Plan as mechanisms to accelerate implementation and further enhance the ESI.

In June 2004, APEC Energy Ministers issued a Declaration which included a number of new ESI directions under the following themes:

- preparing for energy supply disruptions;
- facilitating energy investment;
- using energy more efficiently;
- expanding energy choices; and
- capitalising on technological innovation.

The ESI was further enhanced and expanded in November 2004, when APEC Economic Leaders endorsed the *Comprehensive Action Initiative Recognising the Need for Strengthening the APEC Energy Security Initiative* (CAIRNS Initiative) to strengthen the ESI under the following themes:

- energy security;
- sustainable development; and
- common prosperity.

Short-term ESI Measures

- Improving transparency of the global oil market through reporting timely and quality data under the Joint Oil Data Initiative.
- Monitoring efforts to strengthen maritime security.
- Participating in the Real-time Emergency Information Sharing system.
- Encouraging Member Economies to have emergency mechanisms and contingency plans in place, including the establishment and management of strategic oil stocks.

Longer-term ESI Policy Responses to Improve Regional Energy Security

- Removing market impediments to oil exploration and production.
- Facilitating investment in new downstream oil infrastructure.
- Facilitating more effective utilisation of existing downstream oil infrastructure.

- Attracting energy investment by creating conditions that facilitate energy infrastructure development.
- Promoting energy efficiency and conservation through sharing information on energy efficiency policies and programs.
- Participating in the Energy Standards and Labelling Cooperation Initiative and identifying best practices, benchmarks and indicators to assess efficiency improvements.
- Accelerating energy technology development by increasing cooperative activities to support the development and uptake of technologies for new and renewable energy, clean fossil energy including clean coal, carbon capture and storage, hydrogen and fuel cells and methane hydrates.
- Developing practical measures to enhance cooperation that supports the development of alternative transportation fuels.
- Sharing information on current measures to improve transport and vehicle efficiency.
- Facilitating the development and implementation of best practices in energy efficiency and renewable energy in buildings.
- Encouraging interested APEC economies to progress nuclear power while ensuring optimal safety, security, health and waste handling standards.
- Expanding cross-border energy trade by moving towards best practice in facilitating natural gas trade, improving the collection of natural gas data, implementing the LNG Public Education and Communication Information Sharing Initiative and supporting the APEC Gas Forum.
- Exploring new mechanisms for working more closely with international and local financial institutions to facilitate infrastructure development and investment in energy efficiency and renewable energy projects within the APEC region.
- Fostering collaboration with other international energy organisations, noting the ongoing cooperation between the EWG and the International Energy Agency and the recently-formed collaborative relationship with the Renewable Energy and Energy Efficiency Partnership.

2.7 EWG Future Directions Strategic Plan

In May 2001, the Energy Working Group approved the *Future Directions Strategic Plan* to operate over the five year period from 2001 to 2006.

2.7.1 Objectives

In the *Future Directions Strategic Plan*, the EWG agreed to work cooperatively over the five year period through voluntary agreements which took into account the individual circumstances of member economies. As part of its contribution to sustainable development within APEC, the EWG agreed to pursue the following objectives:

- strengthening the security and reliability of affordable energy to all within the APEC community;

- promotion of clean and efficient technologies, and the efficient use of energy to achieve both economic gains and environmental enhancement;
- achieving environmental improvement of energy production, use and mineral extraction within the APEC community;
- harnessing all expertise available to the Energy Working Group to give effect to the above objectives.

2.7.2 Themes

The Future Directions Strategic Plan stated that the EWG would promote policy approaches and initiatives and adopt work programs within the following strategic themes:

- fostering a common understanding on regional energy issues;
- improving the analytical, technical, operational and policy capacity within member economies;
- facilitating energy and minerals resource and infrastructure development in an environmentally and socially responsible manner;
- facilitating energy efficiency and conservation;
- facilitating improved reliability and stability in the provision of energy supply to meet demand;
- facilitating energy technology development, exchange, application and deployment;
- facilitating a diverse and efficient supply mix.

2.8 Energy for Sustainable Development

At the World Summit on Sustainable Development in September 2002, Australia and Mexico, on behalf of the EWG, submitted *Energy for Sustainable Development: The Contribution and Role of the APEC Energy Working Group* as a Type 2 Partnership Initiative. The Initiative had been agreed by APEC Energy Ministers at their sixth meeting earlier that year. It demonstrated to a global audience how voluntary regional partnerships can be effectively utilised to achieve sustainable development objectives.

Energy for Sustainable Development highlights the four main elements of the EWG's approach to furthering sustainable development objectives:

- strengthening the security and reliability of affordable energy to all within our APEC community;
- promoting clean and efficient technologies, and the efficient use of energy to achieve both economic gains and environmental enhancement;
- achieving environmental improvement of energy production, use and mineral extraction within our APEC community, and
- harnessing all expertise available to the EWG to give effect to the above objectives.

The EWG has been actively implementing its commitments under Energy for Sustainable Development through a range of projects and activities, and has agreed to incorporate sustainable development principles into the development and implementation of all EWG projects.

In recognising the link between sustainable development and energy security, the EWG has recognised that a number of EWG activities support the implementation of both the *APEC Energy Security Initiative* and *Energy for Sustainable Development*.

Australia and Mexico, on behalf of the EWG, have submitted a Revised Type 2 Partnership Initiative, *Energy for Sustainable Development: Fostering Regional Energy Cooperation in APEC 2007 – 2010*, to the United Nations Commission on Sustainable Development at CSD 15, 30 April to 11 May 2007.

2.9 EWG Operational Plan 2006

The seventh APEC Energy Ministers Meeting in Gyeongju, Republic of Korea, provided the framework for the *EWG Operational Plan 2006*. Under the theme, “Securing APEC’s Energy Future: Responding to Today’s Challenges for Energy Supply and Demand”, Ministers discussed and developed initiatives to respond to high oil prices and oil dependency, as well as the region’s broader energy supply and demand challenges. The meeting also continued the Energy Ministers’ previous broad-based approach to energy security, committing to continued development of response mechanisms for short-term disruptions while pursuing longer term security objectives.

Reflecting the Ministers Meeting, the *Operational Plan* categorised EWG initiatives into the following three themes and corresponding sub-themes.

- **Responding to the Impact of High Oil Prices and Oil Dependency**
Initiatives under this theme were classified into two sub-themes:
 - ▶ Removing Market Impediments to Oil Exploration and Production
 - ▶ Encouraging Fuel Efficiency in Transport and Diversification Away from Oil
- **Responding to the APEC Region’s Broader Energy Supply and Demand Challenges**
Initiatives under this theme were classified into four sub-themes:
 - ▶ Promoting Energy Efficiency and Conservation
 - ▶ Expanding Cross-Border Energy Trade
 - ▶ Attracting Energy Investment
 - ▶ Accelerating Energy Technology Development
- **Harnessing All Expertise Available to the EWG**

3. APEC ENERGY POLICY INITIATIVES DURING 2007

3.1 Introduction

During 2007, there were a series of APEC ministerial and leaders' meetings that significantly revised and updated APEC energy policies, goals and objectives. These were:

- the 8th meeting of APEC Energy Ministers, Darwin, Australia, 27-30 May 2007;
- the 19th APEC Ministerial Meeting, Sydney, Australia 5-6 September 2007; and
- the 15th APEC Economic Leaders' Meeting, Sydney, Australia, 9 September 2007.

3.2 Energy Ministers' Declaration

In their Darwin Declaration on Achieving Energy Security and Sustainable Development through Efficiency, Conservation and Diversity, APEC Energy Ministers agreed to a range of initiatives covering a number of energy policy areas, including:

- facilitating investment and trade in downstream and upstream oil markets;
- enhancing emergency preparedness;
- improving oil data sharing;
- promoting energy efficient transport and alternative transport fuels;
- improving energy efficiency;
- developing and deploying cleaner and more efficient energy technologies;
- attracting energy investment and facilitating cross-border trade; and
- promoting broader energy cooperation.

Policy initiatives announced in the Energy Ministers' Declaration and relevant to new and renewable energy technologies and clean fossil energy are detailed in sections 3.2.1 and 3.2.2 below.

3.2.1 *New and Renewable Energy Technologies*

Ministers agreed:

- to encourage the development of cleaner and more efficient power generation technologies, including renewables, clean coal, natural gas/LNG, and for interested economies, nuclear technologies;
- to recognise the importance of progress in the uptake of new and renewable energy through the APEC 21st Century Renewable Energy Development Initiative.

3.2.2 *Clean Fossil Energy*

Ministers agreed:

- to encourage the development of cleaner and more efficient power generation technologies, including renewables, clean coal, natural gas/LNG, and for interested economies, nuclear technologies;

- to direct the EWG to progress the development of clean fossil energy technologies, including carbon capture and storage.

3.3 APEC Ministers' Statement

In their statement, APEC Ministers welcomed the initiatives proposed by APEC Energy Ministers to address the challenges of rapidly growing energy demand while minimising environmental effects.

Policy initiatives supported by the APEC Ministers and relevant to new and renewable energy technologies and clean fossil energy are detailed in sections 3.3.1 and 3.3.2 below.

3.3.1 New and Renewable Energy Technologies

Ministers:

- encouraged efforts towards a diversified mix of energy sources to meet long-term development goals in the region, including the use of natural gas, biofuels from sustainably farmed crops and residues, renewable energy and nuclear energy for interested economies;
- welcomed the findings of the APEC Biofuels Task Force that biofuels from several crops are cost-competitive at current oil prices, that biofuels can lower greenhouse gas emissions, and that biofuels can displace a sizeable share of oil use over time.

3.3.2 Clean Fossil Energy

Ministers agreed:

- to progress the development of fossil energy technologies, particularly carbon capture and storage.

3.4 APEC Leaders' Declaration on Climate Change

In their Sydney Declaration on Climate Change, Energy Security and Clean development, APEC Leaders committed, through wide-ranging and ambitious actions, to ensuring the energy needs of the economies of the region while addressing the issue of environmental quality and contributing to the reduction of greenhouse gas emissions.

Policy initiatives supported by the APEC Leaders in relation to new and renewable energy technologies and clean fossil energy are detailed in sections 3.4.1 and 3.4.2 below.

3.4.1 New and Renewable Energy Technologies

APEC Leaders agreed:

- to enhance energy efficiency and diversify energy sources and supplies, including renewable energy;
- to support the development of criteria for performance-based biodiesel standards for the region through the work of the APEC Biofuels Task Force;
- to welcome work underway in international partnerships involving a wide range of economies, including on methane, hydrogen, renewable energies and carbon

sequestration, and the Asia Pacific Partnership on Clean Development and Climate, which are advancing key new clean technologies.

3.4.2 Clean Fossil Energy

APEC Leaders agreed:

- to promote policies that advance the deployment of low and zero emission energy uses, in particular in the field of clean coal use and carbon capture and storage, through co-operative work in the APEC Energy Working Group;
- to establish an Asia-Pacific Network for Energy Technology (APNet) to strengthen collaboration on energy research in our region particularly in areas such as clean fossil energy and renewable energy sources.

4. PROJECTS ON NEW AND RENEWABLE ENERGY

4.1 Policy Context

Goals in relation to new and renewable energy have been included in most major energy policy initiatives undertaken by APEC Ministers and leaders.

Three of the 14 Energy Policy Principles endorsed by APEC Energy Ministers in 1996 were concerned with promoting efficient and environmentally sound energy technologies:

- promote the adoption of policies to facilitate the transfer of efficient and environmentally sound energy technologies on a commercial and non-discriminatory basis;
- encourage energy research, development and demonstration to pave the way for cost effective application of new, more efficient and environmentally sound energy technologies;
- promote capital flows through the progressive removal of impediments to the funding of the transfer and adoption of more energy efficient and environmentally sound technologies and infrastructure.

The longer-term policy responses under the 2004 APEC Energy Security Initiative included three policy responses promoting new and renewable energy technologies:

- accelerating energy technology development by increasing cooperative activities to support the development and uptake of technologies for new and renewable energy, clean fossil energy including clean coal, carbon capture and storage, hydrogen and fuel cells and methane hydrates.
- developing practical measures to enhance cooperation that supports the development of alternative transportation fuels.
- facilitating the development and implementation of best practices in energy efficiency and renewable energy in buildings.

New and renewable energy technologies were particularly highlighted during 2007 in the APEC Energy Minister's Darwin Declaration and the APEC Leaders' Sydney Declaration on Climate Change. In the Darwin Declaration, Ministers agreed to

encourage the development of cleaner and more efficient power generation technologies, including renewables. In the Sydney Declaration, the Leaders agreed to enhance energy efficiency and diversify energy sources and supplies, including renewable energy, and to support the development of criteria for performance-based biodiesel standards for the region through the work of the APEC Biofuels Task Force.

4.2 The Projects

The initial project overview report identified 46 projects related to new and renewable energy that were funded through the EWG between 1992 and 2007. Table 2 (page 13) shows the subjects covered by these projects and the numbers of projects funded for each subject. Appendix A (page 25) provides details of each of the projects, including summaries of the project outcomes³.

Most new and renewable energy projects were initiated through the EWG Expert Group on New and Renewable Energy Technologies (EGNRET). This Expert Group was established in 1993 as the APEC Technology Cooperation Expert Group and adopted its current name in 1997. The mission of EGNRET is to facilitate an increase in the use of new and renewable energy technologies in the APEC region.

Table 2. Subjects Covered by New and Renewable Energy Projects	
Subject	No Projects
APEC Energy R&D and Technology Transfer Seminars	8
Renewable Energy Technologies and Technology Transfer	10
Electricity from Renewable Sources	2
Alternative Transport Fuels	4
Renewable Energy Standards	3
Renewable Energy Resource and End-use Assessment	4
Renewable Energy Policy, Regulation and Programs	8
Renewable Energy Business Development	2
Renewable Energy Training	4
Renewable Energy Project Management	1
Total	46

³ Project reports were not available for some projects and it was therefore not possible to prepare outcome summaries for these projects.

4.3 APEC Energy R&D and Technology Transfer Seminars

Between 1992 and 2001, eight seminars concerned with energy R&D and technology transfer were organised and held by EGNRET. Topics discussed during these seminars included:

- the introduction and diffusion of new energy technologies into the APEC region;
- transfer of technologies and fostering of human resources related to new energy and energy conservation;
- the introduction and popularisation of renewable energy and energy conservation technologies and efficient utilisation technologies for natural gas;
- financing new and renewable energy projects in rural areas;
- the utilisation of new and renewable energy technologies in remote areas such as islands;
- barriers restricting the acceleration of the dissemination of new and renewable energy;
- facilitating the increased utilisation of new and renewable energy technologies among APEC economies through sharing information about technology introduction enhancement.

4.4 Renewable Energy Technologies and Technology Transfer

Ten projects on renewable energy technologies and technology transfer have been funded for implementation by the end of 2007. Activities undertaken during these projects included:

- establishing the first directory of major energy R&D establishments within APEC economies;
- developing a Technology Cooperation Guide to improve information flows on the availability of renewable technologies within the APEC region and the needs of APEC economies for these technologies;
- identifying technology cooperation needs among APEC member economies;
- analysing technical, economic, social and environmental issues associated with retrofitting diesel mini-grids with renewable energy technologies and developing a systematic approach for evaluating various options;
- assessing the state of the renewable energy infrastructure in the APEC economies;
- reviewing recent advances in electricity storage as it supports the development of distributed renewable energy based systems;
- holding a renewable energy fair;
- assessing the medium and long term scenarios of future fuel technology development and developing technology roadmaps for those scenarios;

- establishing a web-based database of applied renewable energy products from APEC economies, such as solar refrigerators, wind-driven water pumps, solar lanterns, and solar radios, as well as integrated power production systems;
- reviewing recent advances in the best practices for energy efficiency and renewable energy in buildings.

4.5 Electricity from Renewable Sources

Two EWG projects studied electricity generation from renewable sources in the APEC region. These projects:

- investigated the penetration of new and renewable energy (NRE) technologies in the APEC region with the aim of providing some insights for other economies that have plans to promote the further use of NRE in their respective economies particularly for electricity generation;
- determined the real costs of electricity generation by accounting for the cost of externalities; and studied the benefits of internalising the cost of externalities in power generation to the economy as a whole.

4.6 Alternative Transport Fuels

Four EWG projects concerned with alternative transport fuels have been funded for implementation by the end of 2007. These projects

- provided APEC member economies with up to date information on natural gas vehicles as a first step towards introducing the economies to existing information exchange networks on this topic;
- analysed baseline data and information on the development of liquid biofuels and studied possible utilization of biofuels in the APEC economies, especially in the developing economies;
- established guidelines for the development of biodiesel standards in the APEC region to enhance the trade of biodiesel among APEC member economies;
- provided guidelines for the implementation of successful programs for the introduction of alternative transport fuels that will be both coherent throughout APEC economies and applicable to individual economies.

4.7 Renewable Energy Standards

Three EWG projects concerned with renewable energy standards have been funded for implementation by the end of 2007. These projects involved:

- developing a renewable energy standards Action Plan and Resource Guide to provide APEC economies with a framework for the consensus development, adoption, and harmonization of quality standards for renewable energy hardware, systems, and installer training based on the priority needs of the economies;
- updating a section of an existing *Sourcebook for Hydrogen Applications* on codes and standards;

- developing an action plan and an alternative action plan for the harmonisation of three prioritised standards: for solar water heaters, stand alone power systems (off-grid systems) and grid-connected PV systems.

4.8 Renewable Energy Resource and End-use Assessment

Four EWG were concerned with renewable energy resource and end-use assessment. These projects:

- held a workshop that provided the professionals responsible for the planning development and implementation of renewable energy programs with an overview of the tools and techniques available for assessing renewable energy resources;
- assessed renewable energy applications which had the highest opportunity value and which offered the greatest economic and social benefit to the member economies of China, Indonesia, Philippines and United States;
- summarised the published information about solar, wind, biomass, geothermal, and hydro resources in each of 18 APEC economies;
- catalogued current and planned biomass resource assessments throughout the APEC region, increasing awareness of the resource availability and identifying future needs.

4.9 Renewable Energy Policy, Regulation and Programs

Eight EWG projects concerned with renewable energy policy, regulation and programs have been funded for implementation by the end of 2007. These projects:

- published a compendium of renewable energy programs and projects in APEC member economies designed to facilitate an improved understanding of developments and opportunities available in the field of renewable energy;
- implemented a survey to assess the barriers to the increased use of renewables, with a view to developing strategies for overcoming those barriers;
- held a workshop that addressed the proposition that the increased use of renewable energy in the Asia-Pacific will ultimately depend on the contributions renewable energy can make toward the region's development goals and economic growth;
- identified, assessed and improved analytic methodologies to incorporate renewable energy options in an APEC economy's energy and economic planning;
- developed a series of renewable energy road maps that documented important information and necessary steps for identifying and implementing successful renewable energy projects;
- commissioned a survey that invited energy officials of APEC member economies to share information on current renewable applications relating to sustainable development and growth, and identified barriers, issues and priorities involving these applications;

- enhanced the energy-modelling capabilities in APEC member economies with respect to renewable energy technologies and carried out case studies regarding the effects of different penetration rates of renewable technologies;
- assessed the current status of energy technologies in the electricity and iron and steel sectors in APEC economies and analysed alternative scenarios of the future development and adoption of new technologies.

4.10 Renewable Energy Business Development

Two EWG projects were concerned with renewable energy business development. These projects:

- held a conference that was designed to serve as a catalyst for sustainable renewable energy and energy efficiency investments for grid connected and village/household power with member economy specific, regional and global benefits for APEC region economies;
- demonstrated the feasibility of operating a renewables-related energy-services company (RESCO) focussed on hydro-electricity.

4.11 Renewable Energy Training

Four EWG projects were concerned with energy efficiency indicators. These projects:

- held a prototype information visits program on photovoltaic technology in Australia designed to improve the understanding of photovoltaic applications and the environmental benefits of the technology, and reduce impediments to applications of the technology;
- organised a tour of major renewable energy demonstration sites in the United States;
- developed a system for accrediting renewable energy training within the APEC region and encouraged APEC economies to adopt training accreditation standards that are consistent throughout the region;
- recommended the adoption of the Institute for Sustainable Power's framework into the APEC region as the mechanism for accrediting renewable energy training.

4.12 Renewable Energy Project Management

One EWG project attempted to develop a software system for project managing and integrating APEC Renewable Energy Collaboratives projects. However, this project was eventually abandoned.

4.13 Review

Between 1992 and 2001, EGNRET held eight annual seminars concerned with energy R&D and technology transfer in relation to new and renewable energy. These seminars covered a broad range of topics and seem to have functioned well in building networks in the APEC region on new and renewable energy.

Following the termination of the annual seminars, EGNRET has continued to develop and implement projects on specific topics and issues about new and renewable energy. Project work commenced in 1993 and since then new and renewable energy projects funded through the EWG cover a relatively large number of subject areas – nine in all. The ways in which the projects have addressed these subjects varies.

For some subjects, the work undertaken through EWG projects constitutes a carefully planned and successfully executed program of research and action that has achieved significant progress to date and is still ongoing. This is particularly the case for the work on renewable energy technologies and technology transfer, renewable energy resource and end-use assessment, and renewable energy training.

For other subjects, the project work has commenced only recently and is beginning to show some promise. This is the case for the work on alternative transport fuels and renewable energy standards.

For a third group of subjects, only a couple of projects have been undertaken and the work does not appear to have produced significant results. This includes work on electricity from renewable sources, renewable energy business development and renewable energy project management (the single project on this subject was actually abandoned).

Finally, there is the group of eight projects loosely categorised under the subject area Renewable Energy Policy, Regulation and Programs. This grouping largely consists of one-off projects, some of which show considerable promise for further work. EGNRET would be well-advised to revisit some of these projects to determine whether further work should be carried out.

5. PROJECTS ON CLEAN FOSSIL ENERGY

5.1 Policy Context

The longer-term policy responses under the 2004 APEC Energy Security Initiative included one policy response promoting clean fossil energy:

- accelerating energy technology development by increasing cooperative activities to support the development and uptake of technologies for new and renewable energy, clean fossil energy including clean coal, carbon capture and storage, hydrogen and fuel cells and methane hydrates.

Clean fossil energy was particularly highlighted during 2007 in the APEC Energy Minister's Darwin Declaration and the APEC Leaders' Sydney Declaration on Climate Change. In the Darwin Declaration, Ministers agreed to encourage the development of cleaner and more efficient power generation technologies, including clean coal and to direct the EWG to progress the development of clean fossil energy technologies, including carbon capture and storage. In the Sydney Declaration, the Leaders agreed to promote policies that advance the deployment of low and zero emission energy uses, in particular in the field of clean coal use and carbon capture and storage, through co-operative work in the APEC Energy Working Group.

5.2 The Projects

The initial project overview report identified 50 projects related to clean fossil energy that were funded through the EWG between 1992 and 2007. Table 3 (page 19) shows the subjects covered by these projects and the numbers of projects funded for each subject. Appendix B (page 67) provides details of each of the projects, including summaries of the project outcomes⁴.

Most clean fossil energy projects were initiated through the EWG Expert Group on Clean Fossil Energy (EGCFE). This Expert Group was established in 1993 as the Expert Group on Clean Coal (EGCC). In 1996 and 1997, it was known as the Expert Group on Clean Fossil Fuels (EGCFF) before adopting its current name in 1998. The mission of the Expert Group is to encourage the use of clean fuels and energy technologies that will both contribute to sound economic performance and achieve high environmental standards.

Subject	No Projects
APEC Technical Seminars on Clean Fossil Energy	7
APEC Coal Flow Seminars	6
Joint APEC Coal Flow Seminars and APEC Technical Seminars on Clean Fossil Energy	3
Clean Fossil Energy Technical and Policy Seminars	4
APEC Coal Trade and Investment Liberalisation and Facilitation Workshops	4
Clean Coal	4
Electricity Generation	6
Natural Gas and Coal Mine Gas	8
Reducing CO2 Emissions	8
Total	50

5.3 APEC Technical Seminars on Clean Fossil Energy

Between 1993 and 2000, seven seminars concerned with clean fossil energy were organised and held by EGCFE. Topics discussed during these seminars included:

- practical issues associated with the introduction of clean coal technologies including their efficiencies, economics, environmental performance, financing and policy;

⁴ Project reports were not available for some projects and it was therefore not possible to prepare outcome summaries for these projects.

- commercial scale operations, addressing relevant policy issues, evaluating clean coal technologies relative to other energy options, and the promotion of means to facilitate deployment of clean coal technologies for existing and planned coal-fired facilities in the Asia-Pacific region;
- clean coal technologies in APEC member economies from the perspective of development, operating efficiencies, environmental performance and project financing;
- energy and environmental aspects of clean coal technologies;
- conventional and commercial state-of-the-art clean fossil fuels technologies, alternate energy options and policy issues relevant to deployment of clean fossil fuels technologies;
- promoting practical clean fossil technologies (for oil and gas as well as coal) to the developing economies in the APEC region;
- application and development of clean fossil energy for power generation and for industrial Sector applications, and the role of clean fossil energy in addressing global climate change.

5.4 APEC Coal Flow Seminars

Between 1994 and 2000, six seminars to facilitate a better understanding of the supply and demand for coal in the APEC region were organised and held by EGCFE. Topics discussed during these seminars included:

- strategies, cooperative arrangements and networks to facilitate the smooth expansion of coal trade and investment;
- the market outlook for coal and important issues impacting on coal investment and trade decisions;
- the implications of Kyoto greenhouse gas emission limits on the future energy mix in Asia, and the impacts of the Asian economic crisis on energy demand, with particular attention on coal.

5.5 Joint APEC Coal Flow Seminars and APEC Technical Seminars on Clean Fossil Energy

Between 2000 and 2003, three joint seminars on the supply and demand for coal in the APEC region, and on clean fossil energy were organised and held by EGCFE. Topics discussed during these seminars included:

- the clean and efficient use of fossil energy for power generation in Thailand;
- coal in sustainable development in the 21st century.

5.6 Clean Fossil Energy Technical and Policy Seminars

Between 2003 and 2007, four seminars on technical and policy issues in relation to clean fossil energy were organised and held by EGCFE. Topics discussed during these seminars included:

- technology – coal’s way forward;
- coal policies and the outlook for coal utilization, advanced clean coal technology development, coal mine methane technologies, and carbon capture and sequestration; plus natural gas expansion in the APEC area, including bringing new gas reserves to markets and utilization in new gas-fired combined cycle power generating plants;
- coal supply and demand developments and outlook in APEC economies, national coal strategies, existing and emerging clean coal technologies, zero-emission coal-fired power generation, and carbon capture and sequestration;
- coal supply and demand outlook in APEC economies, advanced coal mining technologies, and commercial and emerging clean coal technologies including zero-emission power plants and carbon capture and storage.

5.7 APEC Coal Trade and Investment Liberalisation and Facilitation Workshops

Between 1997 and 2000, four workshops on coal trade and investment liberalisation and facilitation were organised and held by EGCFE. These workshops focussed on the liberalisation and facilitation of trade and investment in the coal and coal-based energy sectors of developing member economies and supported the region’s rapidly expanding demand for clean and efficient energy. Participants at the workshops discussed issues related to facilitating trade and investment in the coal and electricity sectors in APEC economies with particular attention on the economies which hosted the workshops: Indonesia, the Philippines, Vietnam and Malaysia.

5.8 Clean Coal

Four EWG projects concerned with clean coal have been funded for implementation by the end of 2007. These projects:

- developed a better understanding of regional issues concerning environmental aspects of coal and coal technologies;
- held a training course to strengthen understanding of both the technical aspects of clean coal technologies and the techniques for evaluating technology options;
- held a training course to provide training on the technical, environmental and economic aspects of clean coal technologies;
- assessed experience to date in developed APEC economies regarding the interaction of environmental regulations with clean coal technology deployment and, based on this analysis, made recommendations on regulatory methods that promote investment in new commercial clean coal projects in developing APEC economies.

5.9 Electricity Generation

Six EWG projects concerned with electricity generation using clean fossil energy have been funded for implementation by the end of 2007. These projects:

- considered current and future electricity supply requirements in the Asia Pacific region within a framework of energy sustainability;
- assessed the costs and effectiveness of various power plants upgrades and operational and maintenance improvements to APEC developing economies' pulverised coal-fired power stations;
- assessed the role nuclear power can play in APEC by analysing its current status and the forces driving the technology in the region, and looking at the factors that will influence the development of nuclear power in the future;
- drew lessons from experience in upgrading and refurbishing older coal fired power plants that may serve to improve the prioritization and economic assessment methods proposed, and make usable information, tools, and best practice guidelines more widely available to APEC developing economies faced with decisions on how to obtain the best value for the limited funds they have available for upgrading;
- gathered, synthesized and assessed experience in Asian APEC economies with regard to environmental monitoring and reporting by individual coal-fired power generating plants and made recommendations regarding how monitoring should be applied and how it should interact with regulations for effective adoption of clean coal technologies;
- gathered, synthesized and assessed information on experience to date in APEC economies with regard to the status, performance, relative costs, and project development/financing risks for plants using advanced coal power generation technologies operating in different economies; made recommendations on policy measures and financial incentives needed to favour projects using clean coal technologies in APEC economies; and made recommendations for power generation sector capacity-building in developing economies through improved knowledge and access to information on constructing, operating and maintaining cleaner and more efficient new coal-fired plants.

5.10 Natural Gas and Coal Mine Gas

Eight EWG projects were concerned with natural gas and coal mine gas. These projects:

- undertook the development of a demonstration project for recovery and utilisation of coal mine gas;
- examined and summarised the status and potential role of coal and natural gas in each APEC economy;
- assessed the quality and quantity of the land fill gas resource at selected sites in Thailand, Indonesia and the Philippines;
- investigated the penetration of natural gas in the industrial sector for selected APEC economies, with the aim of providing some insights for other economies that have

plans to promote the use of natural gas in the industrial sector after successfully utilising the fuel in the power sector;

- developed a reference tool for policymakers in APEC economies who are considering, or wishing to expand, natural gas as a clean energy fuel to meet their respective economy's growing energy needs;
- held a workshop to progress the recommendations and best practice principles presented to APEC Energy Ministers in June 2004, regarding the facilitation of natural gas trade in the Asia-Pacific region;
- held a workshop to exchange information on public education campaigns related to LNG in APEC economies.

5.11 Reducing CO2 Emissions

Eight EWG projects were concerned with reducing CO2 emissions. These projects:

- correlated emission regulations within each of the 15 participating APEC economies and related actual emissions to control systems in each economy;
- examined the options for petroleum-based and alternative transportation fuels and the contribution they could make towards reducing emissions and air quality impacts associated with transportation in the APEC region;
- expanded the information available on methods for improving the efficiency of current technologies and on the performance of alternative and emerging technologies for electricity generation;
- provided broad insights into opportunities to improve electricity generation in APEC economies by reducing CO2 emissions;
- held a workshop focusing on issues that can affect the coal as a future energy source in developing APEC member economies, and in particular, how CO2 emission reduction issues may distort future trade and investment decisions;
- identified geological prospectivity for carbon dioxide subsurface storage in selected APEC member economies;
- developed training materials to enhance the capacity of APEC economies to conduct their own carbon dioxide and geo-sequestration technical site assessments and to build awareness and capacity of the potential for the capture and geo-sequestration of carbon dioxide;
- held two workshops to enable developing APEC economies to explore carbon capture and storage technologies currently available or in development, and increase their adoption.

5.12 Review

Since 1993, EGCFE has organised and held five series of annual seminars and workshops on various topics relate to clean fossil energy. In fact, 24 of the 50 EWG projects implemented on clean fossil energy to the end of 2007 were seminars and workshops. These events seem to have functioned well in building networks in the APEC region on clean fossil energy.

The other 26 clean fossil energy projects are distributed among four subject areas: clean coal, electricity generation, natural gas and coal mine gas, and reducing CO2 emissions. The work in each of these subject areas constitutes a carefully planned and successfully executed program of research and action that has achieved significant progress to date and is still ongoing. EGCFE should develop further projects to build on this existing work. EGCFE would also be well-advised to investigate whether projects should be developed and implemented in other clean fossil energy subject areas.

6. CONCLUSION

The initial overview report concluded that the EWG projects had developed an extensive and comprehensive collection of policy-targeted information that has been, and will continue to be, invaluable in achieving APEC's goal of maximising the energy sector's contribution to the region's economic and social well being while mitigating the environmental effects of energy supply and use. The more detailed review of project outcomes in this report has confirmed the initial conclusion while identifying a range of strengths and weaknesses in the coverage and results of the projects.

APPENDIX A: APEC EWG PROJECTS ON NEW AND RENEWABLE ENERGY, 1992-2007

Project Title	Year Funded	Funding Channel	Project Code
APEC ENERGY R&D AND TECHNOLOGY TRANSFER SEMINARS			
1992/93 APEC Energy R&D and Technology Transfer Seminar	1992	Japan	EWG SF92-1

Project Summary

Seminar held in Bali in November 1992 to promote the introduction and diffusion of new energy technologies into the APEC region.

Project Outcome

Project report not available.

1993/94 APEC Energy R&D and Technology Transfer Seminar	1993	Japan	EWG SF93-2
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Project Summary

Seminar held in Chinese Taipei in February 1994.

Project Outcome

Project report not available.

1994/95 APEC Energy R&D and Technology Transfer Seminar	1994	Japan	EWG SF94-3
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Project Summary

Seminar held in Seoul, Republic of Korea in February 1995 with the theme "Transfer of Technologies and Fostering of Human Resources Related to New Energy and Energy Conservation".

Project Outcome

Project report not available.

1995/96 APEC Energy R&D and Technology Transfer Seminar	1995	Japan	EWG SF95-3
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Project Summary

Seminar held in Beijing, China in February 1996.

Project Outcome

Project report not available.

Overview of APEC Energy Working Group Projects
Stage 3: Project Outcomes

1996/97 APEC Energy R&D and Technology Transfer Seminar	1996	Japan	EWG SF96-5
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Project Summary

Seminar held in Santiago, Chile in March 1997 to promote the introduction and popularisation of renewable energy and energy conservation technologies and efficient utilisation technologies for natural gas.

Project Outcome

Project report not available.

1998/99 APEC Energy R&D and Technology Transfer Seminar	1998	Japan	EWG SF98-2
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Project Summary

Seminar held in Okinawa, Japan in October 1998 and consisted of two parts: a half day workshop on financing new and renewable energy projects in rural areas; and a one-day symposium on the utilisation of new and renewable energy technologies in remote areas such as islands.

Project Outcome

Project report not available.

1999/2000 APEC Energy R&D and Technology Transfer Seminar	1999	Japan	EWG SF99-2
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Project Summary

Seminar held in Bangkok, Thailand in October 1999 to analyse the significant barriers restricting the acceleration of the dissemination of new and renewable energy.

Project Outcome

During the seminar, the various presenters identified a range of barriers restricting the acceleration of the dissemination of new and renewable energy, including:

- national policies and programs and policy-inherent constraints;
- national energy pricing/non-pricing policies;
- the high cost of renewable technologies;
- the poor financial performance of renewable resources and lack of price competitiveness with conventional fuels;
- the absence of 'net metering';
- inadequate information exchange, education, and training;
- lack of, or insufficient technological awareness;
- intellectual property rights (IPR) and standards;
- the unreliability of components of many PV systems
- lack of, or insufficient technological support;
- the prohibitively expensive importation of technology.

Presenters also identified measures that could contribute to overcoming these barriers, including:

- government and institutional policies,
- supportive infrastructure;
- confidence-building measures;
- increasing the availability of capital;
- accepting loans/grants from abroad;
- provision of incentives and rewards;
- strengthening technology exchange;
- technical cooperation.

During the panel discussion, the following points were made by the panellists:

- barriers were interlinked and that there is a lack of coordinated policy and planning, coupled with a lack of credit;
- market access was a significant barrier and that overall results could be improved through RESCOs, better access to the market, and the formulation of energy policies with a certain percentage attributable to new and renewable;
- subsidies and incentives were necessary to overcome the barriers faced in China;
- subsidies and incentives were unconditionally necessary and that funding mechanisms must be developed to persuade the private sector to invest;
- while APEC economies were making serious efforts in overcoming all the barriers, social consensus would lead to greater awareness of the situation and would deepen international cooperation;
- economic viability was a major barrier to be overcome and that there must be a coordinated commitment from the political, private and public sectors;
- all barriers, the most significant being policies and the lack thereof, could be surmounted; the best way to eliminate barriers was through coordinated government policies;
- price was the most significant barrier; mass production and the experience curve effect would collectively operate in bringing down the prices of renewable energy dissemination.

The majority of comments from the audience centred around two themes, namely, financial barriers and the importance of technical training. Several in the audience voiced their concerns about cost comparisons and both the audience and the panellists agreed that 'green accounting' is of utmost importance in gauging the long-term benefits of new and renewable energies.

Another topic of major concern was the speed at which technology was transferred from the donor economies to the recipient economies. The panellists concurred that the procedures for technology transfer under the United Nations Framework Convention on Climate Change don't go far enough.

Following are other significant conclusions that could be drawn from the interactions among the audience and the panellists:

- there is a large market potential for new and renewable energy in the region as many villages remain unelectrified;
 - appropriate financial mechanisms must be developed to mitigate the risks of
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project investment;

- the training of technicians and education of the end-users must be increased;
- project developers, investors, and donor economies must have ready access to accurate information;
- continuous development of new and renewable energy technologies must be conducted with the results promptly disseminated among APEC members.

2000/2001 APEC Energy R&D and Technology Transfer Seminar

2001

Japan

EWG SF01-5

Project Summary

Seminar held in Morelos, Mexico in October 2000 with the purpose of facilitating the increased utilisation of new and renewable energy technologies among APEC economies through sharing information about technology introduction enhancement.

Project Outcome

Presentations at this seminar included:

- NEDO's activities and cooperation with developing economies in the renewable energy sector;
 - keys to the success of renewable energy for rural development;
 - deployment of renewable energy technologies in Canadian remote communities;
 - investigation and evaluation of wind power development in Inner Mongolia autonomous region of China;
 - wind farm in Cheju island, Korea;
 - renewable energy in Mexico: experiences, actions and perspectives;
 - the development and utilisation of biogas generation in Chinese Taipei;
 - promotion of energy efficiency and renewable energy in Thailand;
 - photovoltaic rural electrification in Mexico;
 - a strategy for sustainable energy services in remote Australia;
 - income generation utilising renewable energy in Indonesia;
 - new and renewable energy for rural social and economic development: enterprise models for large scale sustainable applications.
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RENEWABLE ENERGY TECHNOLOGIES AND TECHNOLOGY TRANSFER

Energy R&D Data Bank	1993	EGNRET	EWG SF93-3
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Project Summary

The objectives of the Data Bank were to collate energy R&D expenditures within APEC economies by area of technology, and to establish the first directory of major R&D establishments.

Project Outcome

Project report not available.

Technology Cooperation Guide	1993	EGNRET	EWG07/1993
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Project Summary

The purpose of the Guide was to improve information flows on the availability of renewable technologies within the region and the needs of economies for these technologies.

Project Outcome

Project report not available.

Assessment and Development of Technology Transfer Cooperation Needs, Skills and Capabilities for Sustainable Area-based New and Renewable Energy Projects	1996	EGNRET	EWG06/1996
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Project Summary

The output of this project was a detailed study on technology co-operation needs among APEC member economies. Through the study, existing expertise and technical capabilities in the field of new and renewable energy as well as the level of needs for new and renewable technology sharing and technology transfer was established.

Project Outcome

A survey was conducted among the APEC member economies to identify existing expertise and technical capabilities in relation to new and renewable energy (NRE). Fifteen APEC member economies responded to the questionnaire. This number represented 83% of the total APEC membership. A total of 30 responses were received from the responding member economies.

There was high interest in solar energy technologies, particularly photovoltaic home systems, centralized photovoltaic systems, high efficiency PV systems, and solar water heater technologies. Biogas generation and biomass gasification for power generation were also of interest to the respondents.

All respondent member economies expressed their willingness to participate in technology cooperation in relation to new and renewable energy. Australia, Canada, Japan, and the United States of America were willing to share NRE technologies with other APEC members by providing training and technology transfer. Where expertise existed, other member economies also expressed interest in sharing technologies.

Chinese Taipei was willing to share in providing training and technology transfer in the area of solar water heating. The Philippines indicated willingness to participate as a technology provider in the area of biogas generation. The Republic of Korea also expressed willingness to act as trainer on high efficiency photovoltaic and fuel cell technologies. Korea also expressed interest in providing technology transfer in the areas of solar home systems, gasification (process heating), and fuel cells.

Analysis of Renewable Energy Retrofit Options to Existing Diesel Mini-Grids	1997	EGNRET	EWG05/1997
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Project Summary

The focus of this project was the technical, economic, social and environmental issues associated with retrofitting diesel mini-grids with renewable energy technologies and the development of a systematic approach for evaluating various options. To set the stage for this study, general considerations of renewable energy/diesel retrofits were presented, including the characteristics and costs of diesel mini-grids, the opportunities and benefits of retrofitting the diesels with renewable energy options; and the type of financing mechanisms and means to access to capital to foster rural energy development. The output of the project was a report that presented the technical, economic, social and environmental issues associated with retrofitting diesel mini-grids with renewable energy technologies. The report also developed a systematic approach for evaluating the various retrofit options.

Project Outcome

The project found that reliance on isolated diesel systems, combined with the renewable energy resource potential in rural areas of the APEC region, presents a large opportunity for retrofitting diesel mini-grids with renewable energy systems. These hybrid systems can be important in reducing operating costs and fuel usage with added benefits for the environment. In addition, the increased use of renewables will reduce reliance on imported fuels and help to create energy self-sufficiency.

Where governments are faced with increased fiscal austerity in their budgets, subsidies for rural energy development, specifically those allocated for fossil fuels, are more difficult to maintain. Therefore, APEC member economies are embracing the concept of self-sustaining projects that can recoup their costs. This means that subsidies will have to be reduced or eliminated, creating a level playing field for the entry of renewable energy equipment into a competitive market. This is being financed through a combination of multilateral, government, and private sector sources. By leveraging capital from different sources and using innovative financing mechanisms, it is possible to maximize the limited resources of each investor, while maintaining their rural development agenda.

The project concluded that the transition to renewable energy/diesel hybrid systems will require that there is a commitment to the following principles.

- **A policy and regulatory environment that is conducive to the adoption of renewable energy in the energy supply portfolio of a member economy.** By creating policies that create a level playing field where renewables can compete, member economies will help to open up and accelerate their renewable energy markets. Once subsidies and other price supports such as duties and tariffs are reduced or eliminated the transition to renewables can occur.

- **A rationalization of electricity generation and supply prices in rural areas.** Looking at the true costs of electric generating options and incorporating those costs into prices will help to rationalize the market. Alternatives to traditional grid extension from urban to rural areas, such as renewable energy/diesel hybrid systems, need to be considered in light of the lower costs, increased energy self-reliance, and fuel diversification, which will enhance rural energy development. The task of electrifying the rural areas will then become more affordable.
- **The operation of open financial markets and access to capital markets for renewable energy options.** Infusing capital into the rural areas will require that investors are comfortable risking their capital and that communities are willing to spend their capital on renewable energy/diesel hybrid systems. A smooth functioning of the general economy will facilitate this by creating transparent and enforceable regulations that will help promote better macroeconomic fundamentals and encourage private sector investment.
- **Financing mechanisms that are tailored to the people living in rural areas.** Access to capital and making energy services affordable to rural communities is critical to the implementation of renewable energy/diesel hybrid systems. Financing that is tailored to the income stream of the end-user, through mechanisms such as micro-credit, energy service companies, or credit through local cooperatives, can help communities pay for their energy systems and sustain projects. As more multilateral agencies and commercial banks develop dedicated programs to finance rural energy development, capital that is distributed through these more localized financing channels will increase.
- **Rural energy development linked to socio-economic development.** An important aspect of providing energy services to rural areas is the impact that it will have on the socio-economic development of the community. With renewable energy/diesel hybrid systems, the quality and service will be improved so that electric power can be provided over the course of the entire day, rather than just a few hours in the evening. This expansion of service will allow the community to pursue income-earning opportunities that will help create jobs and improve the overall economic condition of rural areas. Some of the income-earning operations that can have a significant impact on the rural areas are irrigation pumping, water supplies, crop processing, refrigeration and motive power.

APEC Renewable Energy Infrastructure Assessment	2001	EGNRET	EWG05/2001
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Project Summary

The purpose of this project was to assess the state of the renewable energy infrastructure in the APEC economies. Renewable energy infrastructure as defined in this study includes the availability of end user financing, presence of a domestic renewable energy industry and entrepreneurs, renewable energy policies, training, and information dissemination mechanisms. To assess the level of renewable energy infrastructure a survey instrument was developed and was sent out by the United States in December 2001. The responses to the survey were inconsistent among the economies surveyed. Many of the economies simply did not have the data to properly answer many of the questions. The responses to the survey were therefore supplemented with information gathered from other sources.

Project Outcome

Following is a brief summary of the results of the survey.

The actual factors that make up the renewable energy infrastructure in an economy - financing, policy, manufacturing base, communications, market demand, educational programs and professional associations and networks - are most likely more important than the actual technology itself. The methods by which an economy establishes itself in the renewable energy market and the ways it educates consumers create a more favourable market place for the technologies. Providing more economic incentives and easier access to the technologies enables the renewable energy industry to grow more rapidly.

The APEC economies that participated in this survey are all at different levels of deployment. Some, like Australia and the U.S., have strong commitments to marketing renewable energy systems and have established policies and provide economic incentives. Others, like Japan and Korea, are in the research and development stages of establishing their renewable energy infrastructure.

All APEC economies need to do more to encourage the growth of the renewable energy sector. More financing and consumer awareness need to be included in order to grow the renewable energy industry.

Australia, Canada, Korea and the U.S. lead the way in the production of basic technologies. Financing contributes to local production in all of these economies. However, even without a well developed finance structure, Korea is still strong in most of the categories except for importing and distributing.

Brunei, Chile, Fiji, Indonesia, Peru, Russia, Singapore, Thailand and Vietnam have virtually undeveloped markets for renewables. This is due, in the case of Brunei, Fiji and Singapore to a shortage of viable sources of wind, sun, biomass, and geothermal power. However, in the case of Chile and Peru, where there is a plentiful resource base, it is due to lack of government policies, incentives and financing mechanisms. In the case of Hong Kong, China, the underdevelopment of renewable energy is due to the sufficient and reliable electricity supply from the two power companies, so there has not been a real urgency to use renewable energy as an alternative energy source.

With the exception of Australia, Korea and the U.S., most of the economies do not have enough training programs or decision support tools to support the growth of the renewable energy industry in their economies. Government policies are fairly underdeveloped across the board with the exception of Australia and New Zealand. Information dissemination is most widespread in Australia, Canada, Korea, New Zealand and the U.S.

More information needs to be acquired to provide a complete picture of the renewable energy infrastructure in the APEC economies. This working paper just scratches the surface. It is important that the Expert Group on New and Renewable Energy Technologies continues to share information on the renewable energy infrastructure as it expands and changes in the various economies.

APEC 21 st Century Renewable Energy Development Initiative (Collaborative VI) : Workshop on Advances in Electricity Storage in Support of Distributed Renewable Energy Based Systems	2003	EGNRET	EWG07/2003
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Project Summary

The purpose of this Workshop, held in Honolulu, Hawaii in May 2004, was to present APEC representatives with a review of recent advances in electricity storage as it supports the development of distributed renewable energy based systems. This workshop directly addressed the growing need of energy planners to understand the costs and benefits of coupling advanced energy storage systems with distributed renewable energy systems.

Project Outcome

This workshop brought together approximately 30 people from 12 APEC economies. A wide range of topics were covered, including:

- recent advances in energy storage;
- pumped sea water energy storage in Japan;
- energy storage in California;
- demonstration of a supercapacitor/PV power generation system in China;
- renewable energy/fuel cell systems in Chinese Taipei;
- energy storage via finance in Mexico;
- distributed generation and energy storage in Indonesia;
- distributed generation and energy storage in the Philippines;
- energy storage and distributed generation in New Zealand;
- distributed generation and energy storage in Fiji;
- an electric utility perspective on applications of energy storage for distributed generation;
- distributed generation and ice energy storage.

On the final day of the workshop, attendees agreed that cost effective energy storage can benefit all energy systems, but understanding power vs energy is critical for project success.

APEC New and Renewable Energy Fair (Korea)	2003	EGNRET
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Project Summary

The Energy Fair was held in November 2002 by the Korea Institute of Energy Research. It was held in conjunction with the 2002 APEC Renewable Energy Exhibition.

Project Outcome

Project report not available.

Future Fuel Technology: An APEC-wide Foresight Study	2005	ISTWG/ EWG
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Project Summary

The purpose of this project was to assess the medium and long term scenarios of future fuel technology development and to develop technology roadmaps for those scenarios.

Project Outcome

This project was a unique cooperative exercise between ISTWG and EWG to provide strategic intelligence on future fuel technologies for the APEC region. The technologies selected for study were: hydrogen/fuel cells, conventional and unconventional hydrocarbons and biofuels within the time frame to 2030.

Scenario creation was used to provide a framework for understanding the role of emerging energy fuel technologies in energy futures. Technology roadmapping enabled identification of critical steps in development of these technologies. The aim was not to produce a set of detailed roadmaps for selected technologies but to develop a number of ambitious, but realistic, visions which would assist planning for future developments by industry, researchers and policy makers.

Following are the major conclusions of the study.

- There is no unique solution to the future fuel needs of APEC economies. To ensure energy security, an integrated approach is needed in which various energy technologies can make significant contributions. The roadmapping exercise developed technology roadmaps for three fuel areas and showed how they can be used in an integrated approach.
- While the study focused on only three fuel areas, it was clear that development and application of other energy technologies, e.g. photovoltaic arrays, wind turbines and advanced nuclear power systems are important components of an integrated energy approach.
- While there is current concern over security of oil supplies the current and projected developments of conventional oil production, together with the potential of hydrocarbon liquids from unconventional sources, e.g. tar sands and conversion of natural gas, have the potential to meet anticipated needs, particularly for transport fuels, for the foreseeable future.
- For some economies with available agricultural resources, liquid biofuels (ethanol and biodiesel) provide an opportunity to ensure a considerable degree of energy security. Such fuels can be readily incorporated into the existing transport fuel infrastructure. Biofuels in the form of biomass can be used in stationary applications for power production and heating.
- Fuel cells are likely to be applied first in stationary applications for distributed power generation using a variety of fuels. Reduction of cost and development of small efficient systems should lead to their later widespread application in vehicles. However hydrogen is likely to appear only as a minor component of the energy mix in the late 2020s to 2030.
- The impact of a strong push to a low carbon economy in response to concerns over climate change resulting from continued greenhouse gas emissions from fossil fuel combustion could speed up the rate of development of alternative

energy sources. A complementary driving force for more rapid change is pressure to reduce urban pollution and improve the health of urban dwellers.

- However, change will be incremental as there is considerable inertia in bringing about shifts in energy systems due to the very large investments involved and the long life of major infrastructure. Over a 50 year time horizon for a complete transition, there will be probably only one replacement of major electricity generating plant and perhaps two to three replacements of the motor vehicle fleet.
- Long term planning for overall energy infrastructure must take into account the anticipated changes in fuel technologies. Thus a steadily increasing share of electricity production from distributed sources is likely as a result of moves to energy security; this has considerable implications for grid operation and management.
- While oil prices more than doubled in 2005, similar price jumps occurred in the 70s and 80s followed by a decline in price. However the rapid and continuing economic growth in the APEC region suggests that prices will stabilize at a higher price of say US\$35 per barrel by 2010. Such a price favours both the continued development of hydrocarbon resources and the development of alternative energy sources.
- The emphasis on research and development of energy technologies will vary from one economy to another, depending on their resource bases and their R&D capabilities. There is a clear need for cooperation and exchange of research information and personnel in materials and energy R&D within APEC.
- Policymakers need to be conscious of community attitudes to new energy technologies and ensure that adequate steps are taken by their governments to communicate with the general public on issues of health and safety, and environmental impacts associated with such technologies, e.g. biofuels, hydrogen, nuclear power.

APEC 21 st Century Renewable Energy Development Initiative (Collaborative VI) Renewable Energy Products Database: Paving the Way for Deployment of Renewable Energy	2006	EGNRET	EWG02/2006
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Project Summary

This project supported development of a web-based database of applied renewable energy products from APEC economies, such as solar refrigerators, wind-driven water pumps, solar lanterns, and solar radios, as well as integrated power production systems. The database was organised by product and included performance, cost, and compatibility information.

Project Outcome

The project developed a web-based database of applied renewable energy products that will be an information source for consumers who are looking for renewable energy products that provide a specific energy service. The database was designed to make it easy for consumers to find specific renewable energy product information and to compare renewable energy products from different companies and in different economies. Each product in the database is listed in the same format to make the information consistent so consumers can compare products available

throughout the APEC region concurrently. The database will continue to be updated with additional renewable energy products and companies. The database is available at: <http://www.technologydevelopmentpartners.org/apecdb/default.htm>

APEC 21st Century Renewable Energy Development Initiative (Collaborative I): Workshop on Best Practices in Energy Efficiency & Renewable Energy in Buildings	2007	EGNRET	EWG04/2007
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Project Summary

The objective of this project is to provide APEC decision makers with recent advances in the best practices for energy efficiency and renewable energy in buildings. The project will bring together experts who have been involved in developing financial and technical schemes so that APEC planners and policy makers can benefit from their experiences in learning about opportunities and challenges in the energy consumption of buildings. The topics to be reviewed are expected to include insulation and construction materials, energy efficient design, analysis of positive externalities, financial mechanisms, regulations and construction codes and the application of renewable energy devices such as solar water heaters and others.

Project Outcome

Project report not available.

ELECTRICITY FROM RENEWABLE SOURCES

New and Renewable Energy in the APEC Region: Prospects for Electricity Generation	2004	APERC
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Project Summary

The objective of this project was to investigate the penetration of new and renewable energy (NRE) technologies in the APEC region with the aim of providing some insights for other economies that have plans to promote the further use of NRE in their respective economies particularly for electricity generation.

Project Outcome

The project found that generating electricity from new and renewable energy (NRE) sources could address four key issues related to electricity generation:

- environmental concern;
- energy security;
- rural electrification; and
- applications in niche markets where conventional electricity supply is not feasible.

When utilised for electricity generation, new and renewable energy can:

- provide environmental benefits by avoiding greenhouse gases and other pollutants like sulphur dioxide, nitrogen oxide and particulate matters;
- provide indigenous, safe and reliable energy supply;
- offer a cost-effective alternative to supply electricity to rural households; and

- serve as an alternative electricity supply option for niche markets where conventional electricity supply technology is not cost-competitive or practical.

The APEC region has an overall energy import dependency of about 10 percent and this is expected to increase to 19 percent in 2020. APEC Asia's dependency is even much higher, at 60 percent and 80 percent for the same period (1999-2020). Many of these economies are also the fastest growing in the region and the most vulnerable to oil price volatility and supply disruption.

Chinese Taipei, Hong Kong, China, Korea and Japan are economies that could strengthen their security of supply by increasing NRE utilisation in power generation. Although these economies also have a significant share of the region's nuclear capacity, eroding public acceptance and heightened terrorist threats could render nuclear as a non-option.

NRE has been widely utilised by developing economies for providing electricity to rural households. Most often, this is also the most cost-effective option for providing electricity in areas too remote for electricity grid extension. Without NRE, rural communities in most of these economies may never get the needed electricity supply for decades to come. China's rural electrification programme, utilising PV and wind technology, serves as a shining example for other developing economies.

Aside from direct power applications, NRE technologies also serve as the most cost-effective and practical solution in a wide range of niche market applications such as in telecommunication repeater stations, navigation buoys, lighthouses, vaccine refrigeration, etc. NRE is the most practical choice for these growing markets.

There is a current lack of comprehensive renewable energy resource data for wind and photovoltaics in the APEC region. In many economies where reasonably detailed data on renewable energy is available, the resources far exceed current energy demand. In some economies, certain NRE technologies were not even considered as a viable option until preliminary resource assessment has indicated otherwise. The Philippines, for example, which previously has not considered wind as an economically viable option (due to absence of resource data) is now developing three utility-scale wind farms of 40 MW each.

Many developing economies in the region still do not have renewable energy resource data and exclude NRE technologies such as wind and photovoltaics from their generation planning. In terms of NRE applications, developed economies are well ahead of developing economies in the region in all respects. Most of the current installed NRE capacities are in developed economies where the size of such facilities is relatively larger or utility-scale. These economies also have a well-established institutional and regulatory framework. In contrast, developing economies utilise NRE technologies almost exclusively for rural electrifications and other niche market applications.

The main hurdles that impede greater deployment of NRE technologies are high costs, inadequate regulatory and institutional framework and various market barriers. These hurdles could be cleared in part by employing the following policy options.

- **Demand-pull strategies** such as Renewable Portfolio Standards (RPS) have been successfully utilised to stimulate demand for electricity from NRE sources in several states in United States. The most compelling evidence for the successes of feed-in-tariff is Germany, where wind capacity grew from virtually zero in 1990s

to 14,000 MW in 2003.

- **Financial incentives** in the form of subsidies and rebates, tax credits and grants have provided a significant boost to the deployment of NRE technologies in developing economies. The Production Tax Credit (PTC) policy of the United States clearly illustrates the significant role for these incentives where investment in new wind capacity stopped altogether when the policy expired in 2001. Rebates offered by the Japanese government under its sunshine policy have turned Japan into a world leader in terms of installed PV capacity as well as PV module/cell manufacturer.
- **Market facilitation and investment policy** in the form of public benefit fund, carbon tax and government procurement have been very successful in stimulating demand for NRE in several states in the United States as well as other economies.
- **Rural electrification policy** such as energy service concession, micro credit and rural business development reveals positive gains in the development of new NRE capacity. One of the most successful cases for rural energy service concession is the World Bank/PERMER project in Argentina.
- **Distributed generation policies** such as real-time pricing and net-metering have successfully stimulated growth in NRE technologies. Japan and the United States present evidence of substantial gains resulting from these policies.

APEC economies would gain substantial environmental and economic benefits if the share of NRE in electricity generation were increased. Increasing the share of NRE in the generation fuel mix to 42 percent by 2050 would result in a total fuel cost savings of US\$4.4 to US\$5.8 trillion. Total carbon dioxide emissions of between 206 billion and 254 billion tons could also be avoided depending on the timeframe adopted. This should be examined more carefully, however, by comparing the costs of deploying NRE technologies in large-scale taking into consideration their technical limitations.

Renewable Electricity in the APEC Region	2005	APERC
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Project Summary

The competitiveness of new and renewable energy (NRE) is undermined by a host of barriers and constraints including technological limitations and costs. This project was undertaken: first to determine the real costs of electricity generation by accounting for the cost of externalities; and second to study the benefits of internalising the cost of externalities in power generation to the economy as a whole. Externalities have been constantly negated or ignored in most electricity cost estimations. When taken into account externalities would actually leverage NRE, thereby increasing its share in future power generation structures of most developing economies in the APEC region.

Project Outcome

One approach to address environmental problems caused by burning conventional fuels for power generation is to internalise externalities in electricity costs. This approach would not only reap substantial savings to economies, but would also create a fairly competitive institutional framework to promote renewable electricity.

In this project, a modelling approach was adopted and implemented to assess the

impact of internalising the cost of externalities in power generation on the share of new and renewable energy (NRE) in electricity production within the APEC region. The main idea was to compare the share of renewable energy in the power generation mix (for all 21 APEC member economies), against that of conventional fossil fuels, under a least-cost optimisation function.

Internalising externality costs in electricity production within the APEC region would:

- increase the share of renewable electricity in total electricity production of the APEC region by about 3 or 4 percent (or between 430 and 600 TWh);
- increase the average annual growth of renewable electricity production by about 3 to 4 percent from the business-as-usual case;
- increase the average generation cost of electricity to twice that of its current level.

Further analyses have shown that:

- varying degrees of avoided externality cost per KWh or “externality yield” exist among member economies;
- in renewable electricity projects, an externality yield of 2 to 3 times compared with conventional electricity generation could be expected;
- additional investments for renewable electricity will reach about US\$200 billion in the next 15 years;
- externality costs based on ExternE assessments are considered to be close to optimal for the purpose of renewable electricity promotion.

Infrastructure constraints and the cost of access to renewable energy resources are additional critical issues for renewable energy economics and development.

Externality accounting would make almost any type of renewable electricity (except solar) competitive with coal generation in any APEC member economy. Even with externalities internalised, solar technologies would have to be subsidised by up to 80 percent of investment cost to compete with traditional power generation technologies. Hydro will remain as one of the cheapest renewable energy options among power generation technologies.

The US, Japan, Korea and Chinese Taipei, as economies that are least sensitive to externality internalisation, could have economic and social benefits as a result of the consequential increase in equipment orders for renewable electricity generation.

The study confirms the importance of institutional framework and background studies for assessments of government subsidies for new and renewable energy. However to further promote renewable electricity within the APEC region, studies should be based on a fair market competition approach for different power generation technologies, comprehensive renewable energy resource data, power interconnection and grid development evaluations, and R&D efforts to decrease the per unit cost of renewable electricity.

ALTERNATIVE TRANSPORT FUELS

Information Exchange Network on Natural Gas Vehicles	1993	EGNRET	EWG08/1993
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Project Summary

The objective of this project was to provide APEC member economies with up to date information on natural gas vehicles as a first step towards introducing the economies to existing information exchange networks on this topic.

Project Outcome

Project report not available.

The Future of Liquid Biofuels for APEC Economies	2006	EGNRET	EWG01/2006A
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Project Summary

This project analyzed baseline data and information on the development of liquid biofuels and to study possible utilization of biofuels in the APEC economies, especially in the developing economies. Emphasis was given to capacity building in the APEC developing economies which depend heavily on imported oil and natural gas for energy. Relevant topics for the study included liquid biofuel technology, liquid fuel specifications, potential benefits to auto-manufacturers, national energy policies, and regional directives in supporting and promoting the use of liquid biofuels to lessen the over-dependence on fossil fuels and to cope with environmental issues resulting from the use of fossil fuels.

Project Outcome

Continued growth in the demand for transportation fuels and declining oil production within the APEC region had led member economies to consider alternative energy options, such as fuels made from biomass materials. In addition to energy security, other key drivers included improving air quality, tackling climate change, and revitalizing rural development. However, these drivers had different weights among the APEC members.

The biofuels industry in the APEC region consisted of two distinct sectors, ethanol and biodiesel. Fuel ethanol production within the region in 2007 was estimated at approximately 27,600 million liters, mainly produced in the United States; China; Canada; Australia; and Thailand. Biodiesel production in 2007 was approximately 4,400 million liters with the United States; Indonesia; Malaysia; China; Australia; and Canada as leading producers.

Ethanol was made from starches and sugars, but advanced conversion technologies under development would allow it to be made from more abundant “cellulosic” biomass sources such as forest and agricultural residues. Economies such as the United States; China; and Japan were heavily investing in the development of this advanced technology.

Biodiesel in the region was produced from vegetable oils, waste cooking oil, and animal fats. Some economies were considering alternative biodiesel feedstock such as jatropha and other non-edible oils. A long-term strategy pursued by few economies was the use of microalgae as a biodiesel feedstock; however, a considerable investment in R&D would be needed to make it a viable option.

Although biofuels trade was relatively minor within the APEC region, some member economies saw substantial opportunities for export. These included Malaysia; Thailand; Indonesia; and the Philippines, which would greatly benefit from their proximity to China; Korea; and Japan – the latter economies were projected to be significant importers if the biofuels industry develops in the region.

While governments in some economies had provided substantial support for biofuels development, enabling it to compete with conventional gasoline and diesel, others had just begun to consider policy measures. Some policy instruments applied in the region included mandatory blending, fuel tax exemptions, loan guarantees, reduced enterprise taxes and subsidies (direct and indirect) for biofuels production, and R&D investments.

Several factors influenced the continued growth of the biofuels industry and the long-term market potential for biofuels in the APEC region and around the world; but the fundamental one was production economics. The future development of sustainable biofuels also depended on a balanced scorecard to evaluate the performance of biofuels against the metrics of energy security, greenhouse gas (GHG) reduction, and the energy return on investment (EROI). For both first- and second-generation liquid biofuels, resolution of technical, economic, social, environmental, and regulatory issues remained critical to further development of biofuels in the APEC economies.

APEC 21st Century Renewable Energy Development Initiative (Collaborative IX): Establishment of the Guidelines for the Development of Biodiesel Standards in the APEC Region	2007	EGNRET	EWG02/2007A
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Project Summary

The objective of this project was to establish guidelines for the development of biodiesel standards in the APEC region to enhance trade of biodiesel among APEC member economies.

Project Outcome

The use of biodiesel for transportation can reduce air emissions, increase domestic supply of renewable fuel and create new markets for agricultural sectors. Biodiesel fuel can be produced from various animal fats and vegetable oils, but the quality of the product depends on the natural characteristics of the feedstocks used.

The current European biodiesel specification EN 14214 is based on biodiesel produced from rapeseed and combinations of oils that together provide similar characteristics to rapeseed oil, including sunflower, soy and palm. Most of the Asian APEC member economies have derived their biodiesel standards from the European standard, with elements from the U.S. ASTM D6751 biodiesel standard, which was developed to address biodiesel produced predominantly from soy and waste cooking oils. Although Europe is not an APEC economy, it has increasing requirements to reduce CO₂ emissions, coupled with a growing shortage of diesel fuel. Thus, Europe represents a large potential biodiesel export market for APEC producer economies.

Economies in the Asia Pacific have different climates, feedstocks and vehicle fleets, which may require a different biodiesel standard in order to ensure market acceptance and to maximize the opportunity for regional trade. This study

compared current biodiesel standards between APEC member economies, Europe, Brazil and India and outlines the key biodiesel quality parameters required to ensure the durability and performance of vehicles in the APEC region.

Experience has shown that biodiesel market problems often have less to do with the standards, and more to do with poor manufacturing practices and quality control. For this reason, effort should be focused on ensuring a standard that is workable for biodiesel producers, and this needs to be backed by a quality control and assurance program that supports high levels of compliance. A proper reporting and monitoring program is therefore key to successful national biodiesel programs.

In developing an APEC biodiesel standard, the approach followed included:

- agreeing on a minimum "fit for purpose" standard as soon as possible, perhaps even without all the answers;
- defining and conducting research programs to examine the chemically based parameters of the standard that restrict certain feedstocks and try to replace them with less restrictive performance based parameters accompanied by suitably defined test methods;
- providing quality assurance programs for both manufacturers and fuel blenders;
- providing field experience monitoring; and
- establishing a framework for adjustments and advancements as necessary.

At the first workshop to discuss the establishment of the guidelines for development of a biodiesel standard in the APEC region, held in Thailand on October 25 and 26th, 2007, it was agreed by those APEC member economies and experts present that:

- the standard should be based on first generation biodiesel;
 - it should be developed for B100 as a trading fuel, which is to be blended according to local vehicle conditions and fuel standards of APEC member economies. At present the U.S. has vehicles that require sophisticated emissions control systems to meet stringent tier 2 emissions regulations, whereas many of the APEC economies in Asia (excluding Japan, Australia and others) have vehicles that are not equipped with particulate traps and oxygen sensors as they do not as yet have emissions regulations that require them;
 - it should focus on the best way to facilitate the largest volume of trade, which translates to lower percentages of biodiesel sold to a greater number of vehicles. Therefore the standard should be developed for high speed vehicles;
 - largely due to initial availability of biodiesel and suitable logistics systems, the end use would likely be B5 during the early years, with the blended fuel meeting the existing local diesel standard;
 - the same biodiesel can be blended at higher levels, such as B10, B20 and B50. These higher blends may require waivers from the diesel specification, or may require special standards. In such cases, due to being tailored to specific user needs, for captive fleets, or where the higher blend, including B100, is sold to the public, this should include specific communication such as product labelling;
 - if biodiesel that did not meet the future APEC B100 standard was sold, then it would have to be a non-compliant blend component, with contractual waivers to the APEC specification that had been agreed between buyer and seller.
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A review of specific parameters in the APEC economies that have set biodiesel standards showed that there was already agreement on a number of critical parameters. No parameters were identified where it was considered impossible to reach an agreement. Further discussion and research is required to address those areas of difference.

Expert stakeholders from the APEC economies will also need to conduct an assessment of testing facilities and laboratories in member economies. The representative from Indonesia mentioned for example that there is no laboratory in Indonesia capable of testing all the biodiesel.

APEC 21st Century Renewable Energy Development Initiative (Collaborative IX): Alternative Transport Fuels— Implementation Guidelines	2007	EGNRET	EWG04/2007A
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The purpose of this project is to provide guidelines for the implementation of successful programs for the introduction of alternative transport fuels that will be both coherent throughout APEC economies and applicable to individual economies. The audience for the project will principally be governments and government agencies. The work will consist of reviewing both successful and unsuccessful alternative transport fuel programs in the APEC economies and elsewhere. Success factors and failure factors will be thus identified. From this analysis, guidelines for successful projects will be compiled. A resource database will be compiled for economies to refer to.

Project Outcome

Project report not available.

RENEWABLE ENERGY STANDARDS			
Adoption of Renewable Energy Standards Action Plan Resource Guide	2002	EGNRET	EWG01/2002T

Project Summary

This project developed a renewable energy standards Action Plan and Resource Guide to provide APEC economies with a framework for the consensus development, adoption, and harmonization of quality standards for renewable energy hardware, systems, and installer training based on the priority needs of the economies.

Project Outcome

The importance of developing and harmonizing renewable energy technical standards, both for hardware and for the content and process of training, lies in the value to the participating economies of international trade and domestic workforce development. By participating in regional and international standards development, the APEC member economies will be able to help shape the content of the standards; by agreeing on and adopting harmonized standards, APEC member economies will be able to trade more freely, expanding their markets, expanding their workforces, and validating the quality of their products and services.



The Action Plan provided APEC economies with a framework for the consensus development, adoption, and harmonization of quality standards for renewable energy hardware, systems, and installer training based on the priority needs of the economies of the region as identified by a representative Secretariat.

The Resource Guide identified whether:

- a technology was being applied in an APEC member economy;
- there were any in-economy incentives to encourage the technology(ies);
- if neither of the above, whether or not there was in-economy potential for the technology(ies).

The Resource Guide also included tables that indicated whether a particular APEC economy could have a need for standards in a particular technology. Where a need was identified, a table was developed that listed the economies and international organisations where standards in those technologies were available.

APEC 21 st Century Renewable Energy Development Initiative (Collaborative VI) : Development of A Sourcebook of Hydrogen Codes and Standards for APEC Member Economies	2004	EGNRET	EWG08/2004T
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Project Summary

This project updated a section of an existing *Sourcebook for Hydrogen Applications* on codes and standards. The purpose of the update was to include codes and standards information and demonstration activities within APEC member economies and to define the relevant government agencies involved in approval of codes and standards. As part of the contract, two workshops were held in November 2004 in Cuernavaca, Mexico focused on Western APEC economies and in May 2005 in Honolulu, Hawai'i, USA focused on Eastern hemisphere economies. A complete summary of the Workshops is included in the project report.

Project Outcome

With the emergence of hydrogen onto the international arena as an alternative energy form to fossil-based energy resources for transportation and power generation, it is becoming increasingly more important to facilitate information exchange on codes and standards and demonstration activities from one economy to another and from one economic community to another. The United States, Canada, and Japan have led many efforts to implement hydrogen and fuel cell research and demonstration activities. In the 21st century, many more national economies have joined the hydrogen effort and have begun the process of implementation of hydrogen and fuel cell technologies.

The implementation process is complex and varies from one economy to the next. The approach in each economy can be different in terms of the regulatory structure and process and the set of codes and standards that must be met in order for the technologies to be approved by their governments. In many cases for developing economies, codes and standards for hydrogen technologies have not yet been developed or adopted.

International codes and standards promote trade by assuring an agreed upon level of performance and safety for products covered. They assure manufacturers that products produced in one economy can be safely shipped and sold in another

economy. They assure buyers that the imported products that they purchase are safe and will perform to a certain agreed-to level. Without this confidence, manufacturers will be reluctant to ship to foreign markets and buyers reluctant to purchase foreign products. If done poorly, international standards can act as a barrier to trade. With global communications, an accident anywhere in the world will negatively affect hydrogen and related products everywhere. It is important with the emergence of hydrogen and fuel cell technologies that early in the process a baseline is established. There is a requirement for a reference baseline document to serve as the future basis for harmonization of codes and standards among economies, to promote trade and benchmark best practices to assure the safe use of hydrogen and related products.

The *Sourcebook for Hydrogen Applications* fills that need. The *Sourcebook* has served as a comprehensive peer-reviewed reference on hydrogen since the mid 1990's. This extensive reference is available in multimedia format on CD-ROM. Its content is contained on over 900 video pages that are several layers deep. It covers not only the technical aspects of hydrogen and engineering system design considerations, but also issues of public acceptance and guidelines for local and national public officials called upon to approve hydrogen projects. While the *Sourcebook* on CD is a resource whose extensive information is available through both directed and curiosity-driven searches, targeted versions can provide highly focused information to their intended audiences.

The codes and standards part of the *Sourcebook* has been developed to reconcile the different codes and standards and demonstration activities within the international community and serve as a reference for their development in those economies where they are yet to be deployed. It provides a one-stop, user-friendly program for code officials, government agencies, and research organizations to use as a reference for implementation of hydrogen projects within their own economies.

With the support of APEC, the Partnership for Advancing the Transition to Hydrogen (PATH) was able to bring together representatives from 10 different economies to discuss their governments' work in hydrogen and what is needed to steer the course towards implementation of hydrogen and fuel cell technologies in their economies. As part of PATH and TISEC's joint effort to update the codes and standards part of the *Sourcebook*, APEC member economies were asked to assist in data collection of all economies' hydrogen codes and standards and demonstration activities. The purpose was to expand the *Sourcebook* to cover important codes and standards information in each APEC economy to help advance the transition to a hydrogen economy on a global scale.

APEC 21 st Century Renewable Energy Development Initiative (Collaborative IV) : Adoption of Renewable Energy Standards Phase II –Final Groundwork	2005	EGNRET	EWG01/2005T
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Project Summary

This project developed an action plan and an alternative action plan for the harmonisation of three prioritised standards: for solar water heaters, stand alone power systems (off-grid systems) and grid-connected PV systems.

Project Outcome

This final report provides an overview of the activities undertaken in this project, summarizes the work undertaken in Phase 7, and includes the action plan and an



alternative action developed for harmonization of the three prioritized standards.

Phases 1 involved a review of the action plan developed in the previous project EWG/012002T. This recommended the development of an APEC Standards Secretariat to oversee the harmonization of renewable energy standards. The review was completed by September 2005.

Phase 2 required the prioritizing of the standards that required harmonization and selecting the top three. It was concluded that the three priority areas were:

- manufacture and installation of solar water heaters;
- installation of PV grid-connected systems; and
- installation of stand-alone power systems.

Phase 3 required the formation of three committees for each of the three priority areas. The committees were established by June 2006. This phase raised some questions from potential committee members about harmonizing standards only in APEC while a number of APEC member economies (e.g. Australia, Canada, China, Korea, Japan, Malaysia and USA) are active in the IEC process of harmonising renewable energy standards internationally.

Phase 4 involved establishing a technical secretariat to lead and support activities for each committee. Mr Yunfeng Huang commenced his duties in Beijing, China, as an ISP representative and standards technical secretariat in August 2006.

During Phase 5, the project manager identified and purchased copies of all the relevant standards (member economies, IEC, IEEE and ISO) for each of the three priority areas. These were forwarded to the respective committee leaders who then developed a summary of the standards and a harmonization review. These were distributed by the project to the respective committees for comments.

During Phase 6 the reviews and the recommendations for harmonizing the respective standards were finalized by the technical secretariat in co-operation with the project manager. This was completed in November 2006.

Phase 7 involved the distribution of the three harmonization reports throughout the APEC region and the development of the harmonization plan. The reports were sent to most of the standard organizations (those with identifiable e-mail addresses) within the APEC member economies with a request for contact information on any committees that would oversee the introduction of similar standards within that economy as well as requesting that the reports were forwarded to these committees.

In summary, the harmonization action plan developed in this phase recommended:

- contacting each of the standards association/organizations in each of the 21 APEC member economies and identifying the person who is responsible (if any) for renewable energy standards within that organization;
- determining which member economies would be interested in developing harmonized standards in all or any of the three priority areas;
- forming a committee to oversee the development of the harmonized standard;
- developing the harmonized standard following the typical process for developing standards.

This project did identify that only; 7 APEC member economies had existing solar water heating standards; 4 member economies had existing stand alone PV power

system standards and only 6 member economies had grid-connected PV standards. The previous project identified that many of the member economies are installing grid connected PV systems, stand alone PV and hybrid systems and solar hot water systems. Therefore they do have a need for good quality standards in the three priority areas.

From experience with the IEC process, the harmonization of standards is a difficult and expensive process and takes many years. It requires many face to face meetings of people representing the standard organization from the various economies and commitment from each economy to the harmonization process.

Though the objective of the project was to empower (or encourage) APEC member economies to begin the process of harmonization of these three standards, the project teams believed this will be very difficult to achieve across all member economies and anticipated reluctance from those member economies that have developed their own standards and/or are active in the IEC process. Therefore an alternative action plan was developed. This involved helping the member economies which currently do not have a standard or standards that relate to the three priority areas in developing a national standard based on the harmonizing reports.

In summary, the alternative harmonization action plan involved:

- notifying all standards organizations within member economies of this project and providing each with copies of the three reports that summarizes the existing standards and provides recommendations on harmonization;
- encouraging those member economies with existing standards to use these reports when they next review their standards and to adopt any of the recommendations if appropriate;
- encouraging those member economies without existing standards to either develop their standards based on the recommendations or at least adopt an existing standard of one of the other member economies incorporating some or all of the recommendations;
- using the established secretariat to support those member economies who want to develop a new national standard based on these reports.

RENEWABLE ENERGY RESOURCE AND END-USE ASSESSMENT			
Workshop on Renewable Energy Resource Assessment Techniques	1995	EGNRET	EWG07/1995

Project Summary

This workshop was held in Beijing, People's Republic of China in February 1996 and focused on renewable energy research and development and renewable energy resource assessment techniques. The workshop provided the professionals responsible for the planning development and implementation of renewable energy programs with an overview of the tools and techniques available for assessing renewable energy resources.

Project Outcome

Project report not available.

High Value Renewable Energy End-use Applications Analysis	1996	EGNRET	EWG07/1996
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Project Summary

This project carried out a qualitative assessment of renewable energy applications which had the highest opportunity value and which offered the greatest economic and social benefit to the member economies of China, Indonesia, Philippines and United States.

Project Outcome

The project report comprises summaries of the renewable resource potential and consumer demand for each of the four APEC member economies that were the focus of this work: China, Indonesia, Philippines and the United States. The summaries include an overall characterization of each member economy including the types, locales, and size of the renewable resource base; the amount of electricity produced from renewables as compared to conventional sources; current and forecasted electricity demands by sector; trends in consumer demand and economic growth; and amount and costs of fuel imports.

Renewable energy applications were evaluated in light of their match with the energy demand and appropriate end-use applications. Critical areas that required more attention were identified along with regions within an economy that have a high probability of success in getting systems installed. Barriers to increased deployment of renewable energy systems were identified in each member economy.

The overriding premise of energy development in the four member economies was that they were all experiencing growth in their energy demand and there was a need to consider alternative technologies such as renewable energy systems in order to achieve their economic and environmental goals. The member economies in Asia (China, Indonesia, and the Philippines) were experiencing large growth in their energy demand compared with the United States. In fact, the growth that these three member economies were experiencing was considerably higher than any other region in the world. These dramatic increases were attributed to high rates of economic growth, increasing energy intensities, the rapid pace of industrialization, growth in energy-intensive industries, electrification of industries and households, and increases in the number of motor vehicles.

The outlook for the member economies implied that there would have to be substantial increases in power generation capacity. It was expected that this capacity would continue to be dominated by fossil fuels, most likely coal and natural gas. However, due to environmental and financial considerations, renewable energy would be a more viable and practical option, especially in rural areas. All of the member economies recognized the importance of modifying their energy supply portfolio to include renewable energy technologies. However the importance that was placed on these technologies was variable.

The member economies of China, Indonesia, and the Philippines were all faced with a lack of access to modern energy services for large portions of their population, mainly in rural areas. With grid extension being too costly and not practical, they were all undertaking serious efforts for rural electrification using renewable energy systems.

To varying degrees, all of the member economies had programs in place that addressed the issue of decentralized power systems in places where total and/or

partial grid connections are not economically feasible. It was recognized that rural energy is the key to rural development and therefore small-scale power generation, small grids, or individual stand-alone systems based on sustainable energy technologies may be the preferred options because they are cost-effective, sustainable, and good for the environment. In addition, government policies and regulations were being put in place in these member economies to facilitate investment by the private sector and to enable access to appropriate credit and financing mechanisms. Given the large number of people living in rural areas and inadequate energy services, the potential to impact development in these member economies was substantial.

The most common programs that were being instituted in China, Indonesia, and the Philippines involved deployment of photovoltaic solar home systems, biogas, small hydropower, wind and hybrid systems. Typically these systems had been introduced through demonstration projects, government grants, or government-private sector partnerships. Photovoltaics for individual homes had been proven to be quite effective in providing electricity for lighting, televisions, and other household appliances in rural areas. These solar home systems are advantageous because they are easy to operate and maintain, they require no additional fuels to operate and they create no pollution or noise.

In addition to the improvement of rural communities by providing light and other energy services, there were new opportunities for economic growth related to the development of new industries for local manufacture and assembly of renewable energy systems. For photovoltaics, this could include developing capacity in the production of batteries and controllers and in system assembly and maintenance.

In addition to the solar home systems that had already been installed, all of the member economies had plans for future development that would encourage further use of solar home systems. Indonesia had just announced an ambitious program to install 50 MWp of photovoltaics to provide electricity to one million households in rural areas over the subsequent ten years. China had plans to install 200,000 solar home systems in northwest China, and photovoltaic power stations in nine counties. In the Philippines, over 500 solar home systems were installed in 1996 making for a total number of 1,800 installations for 2000 households. From 1998 to 2035, the Philippines was planning to install 67,900 units which is equivalent to 5.092 MWp. In addition, a Village Power Fund was being conceived to provide financing assistance to village/community organizations which may want to undertake renewable energy power projects for their communities. The Indonesian government had the most ambitious program for the installation of solar home systems, and there were also some successful private sector entities that were also selling and installing solar home systems in rural areas with no government funding.

One of the biggest barriers that the member economies cited was the difficulty faced by customers in paying the high up-front costs for renewable energy systems. This was being addressed through the use of innovative financing mechanism to convert the initial capital costs into operating costs so that payments could be aligned with the stream of benefits received. In addition micro-financing had been used effectively to provide households and small business with loans for purchase of solar systems under flexible and non-traditional terms. In rural areas, the local community was willing to pay for the systems and the key issue was the design of a credit or financing scheme that fitted the needs and ability to pay of that community.

Although governmental programs can play an important catalytic role, the success of

development strategies in the member economies depended on the creation and development of self-sustaining energy markets. Market reforms and liberalization of markets had increased consumption of energy and had enabled the adoption of sustainable energy systems in rural and urban areas. The elimination of subsidies for conventional fuel, adjusting import duties for renewable energy technologies, and revising the tax structure would be important in facilitating the deployment of cleaner energy systems. In addition, the ongoing changes in the member economies toward competition and choice would also benefit markets for sustainable energy.

Overview of the Quality and Completeness of Resource Assessment Data for the APEC Region	1998	EGNRET
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Project Summary

The availability of information and data on the renewable energy resources for renewable energy technologies is a critical element in the successful implementation of these technologies. The output of this project was a report that summarised the published information about solar, wind, biomass, geothermal, and hydro resources in each of 18 APEC economies. The report includes an extensive bibliography and reference system. Direct input from some economies regarding unpublished information was also included.

Project Outcome

Project report not available.

Survey of Biomass Resource Assessments and Assessment Capabilities in APEC Economies	2007	Biofuels Task Force	EWG01/2007A
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Project Summary

This survey catalogued current and planned biomass resource assessments throughout the APEC region, increasing awareness of the resource availability and identifying future needs. It also aimed to understand the capability of APEC economies to undertake such assessments. Particular attention was paid to assessments of the potential of various crops, crop residues, forest wastes and urban wastes to be utilized for production of bioethanol and biodiesel to displace oil use in the transport sector and thereby to grow oil exports or limit growing reliance on oil imports.

Project Outcome

The results of the survey revealed that most of the APEC economies had assessed their biomass resources at an economy-wide level. Many had completed biomass resource assessments by state/province, and few at a finer geographic level – county/district or local.

The survey also found that all APEC economies had what was necessary to conduct biomass resource assessments - scientific knowledge, tools, and data. However, not all of them had used their full capabilities in existing assessments. Some members had used their advanced capabilities, such as geospatial technologies and simulation modelling to develop detailed analyses of resource potential. For others, the survey identified products that were not direct examples of biomass resource assessments, but they indicated existing capabilities that could be applied to future resource assessment projects, thus enabling them to achieve fine geographic

presentation of resources and project potential.

A summary of findings is presented below.

Economies with Good Resource-Assessment Capabilities and Detailed Resource Assessments

Australia, Canada, Chile, Indonesia, Korea, Mexico, the Philippines, Thailand, United States

Economies with Good Resource-Assessment Capabilities and Medium Scale (state/province) Resource Assessments

China, New Zealand

Economies with Good Resource-Assessment Capabilities and Broad (Economy-Wide) Resource Assessments

Japan, Malaysia, Chinese Taipei, Viet Nam

Economies with Good Resource-Assessment Capabilities and Limited or No Resource Assessments

Papua New Guinea, Peru, Russia

Economies with Limited Biofuel Resources

Brunei Darussalam, Hong Kong, Singapore

With respect to resource potential for ethanol production in the APEC region, the study concluded that a significant amount of second generation feedstock (particularly crop and forest residues) was available. This feedstock could be utilized when the technology for conversion of this material to ethanol became cost-effective. The feedstock amounted to about 1,700 million tonnes (Mt), which would yield some 509 hm³ (1) of ethanol or 245 Mt gasoline equivalent. Such a volume would displace about two-fifths of the region's current gasoline consumption and one-fifth of its crude oil imports. Many economies could substitute a substantial volume of their current gasoline consumption with ethanol from second generation feedstock, while others such as China, Thailand, and Viet Nam could substitute their entire consumption.

Regarding first generation feedstock for ethanol production, the study evaluated the contribution of 20% of the economies' current starch and sugar crops production. The 20% figure was purely illustrative but would be consistent with trend-based hypotheses regarding the potential for increased agricultural yields to render a fifth of production surplus to food needs over time. If the equivalent of one-fifth of current agricultural production could actually be spared for biofuels production, the first-generation resource potential would amount to some 252 Mt of feedstock and 92 hm³ of ethanol or 44 Mt of gasoline equivalent. This would be sufficient to displace only 7% of current gasoline consumption and 3.5% of crude oil imports in the region.

With respect to resource potential for biodiesel production, only first generation feedstock was considered. Data on second generation feedstock (non-edible crops, such as Jatropha and Pongam, or from algae) was insufficient to provide meaningful results. If 20% of APEC economies' current vegetable oil supply could be spared for biofuel production and if all waste oils and fats could be practically gathered for such production, it would yield about 22 Mt of biodiesel. This would be sufficient to displace about 7% of current petroleum-based diesel consumption and 2% of crude

oil imports. Economies with the highest resource availability included China, Indonesia, Malaysia, and the United States. It was expected that the resource potential for biodiesel production in APEC economies would increase significantly over the next years with the development of second generation feedstock.

RENEWABLE ENERGY POLICY, REGULATION AND PROGRAMS

Compendium of Renewable Energy Programs and Projects in APEC Member Economies	1993	EGNRET	EWG09/1993
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Project Summary

The compendium was published in November 1995 and was designed to facilitate an improved understanding of developments and opportunities available in the field of renewable energy.

Project Outcome

The compendium provides a comprehensive picture of the various renewable energy programs and projects implemented in APEC member economies in 1995.

The information contained in the compendium was collected from a variety of sources. Each member economy was asked to provide the appropriate program and project information. In certain cases, this primary information was augmented by secondary sources, including The World Bank, the United Nations, and other multilateral organizations.

The compendium is divided into individual economy studies. Each economy chapter considers the energy overview, the regulatory/policy environment, the availability of renewable resources, current renewable energy programs, and representative renewable energy projects. A series of charts provides information on the distribution of the primary energy sources of the economies and the energy consumption by sector of the economies.

Survey of Impediments to the Use of New and Renewable Technologies	1994	EGNRET	EWG08/1994
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Project Summary

The goal of this project was to assess the barriers to the increased use of renewables, with a view to developing strategies for overcoming those barriers.

Project Outcome

Project report not available.

Workshop on Renewable Energy as it Relates to Sustainable Development	1995	EGNRET	EWG SF95-4
APEC Membership Survey of Economic and Social Development Priorities			
Workshop Report			

Project Summary

This workshop addressed the proposition that the increased use of renewable energy in the Asia-Pacific will ultimately depend on the contributions renewable energy can make toward the region's development goals and economic growth. Prior to the workshop, the APEC Expert Group on Technology Co-operation commissioned a survey of all the APEC member economies to determine which development priorities and sectors are of the highest importance in the region. The results of this survey helped develop the agenda of the workshop.

Project Outcome

The responses to the survey questions established the APEC member economies' priorities relative to sustainable economic development, and identified which sectors (e.g., health, education, etc.) were of the highest importance. Such information was useful in identifying the most appropriate renewable energy technologies that could be utilized in advancing the economic and social development priorities in the region.

Almost all of the economies identified "sustainable economic development" or "environmental protection" in their top development goals. The manner with which each economy expressed these ideas was very unique and specific to each economy, and these expressions provided insights on the distinctions of emphases among the different economies. The concepts of "improvement in quality of life" and "education" were also frequently expressed.

The replies to the questions on the sector questions did provide some concrete directions for the Renewable Energy for Sustainable Development Workshop.

Over 50 people from 13 APEC member economies attended the workshop. Speakers from China, Mexico, Malaysia, the Philippines, Thailand, and the United States discussed both the potential contributions that renewable energy technology could make to specific national development priorities, as well as detailed economy case studies exemplifying successful application in place. Following these presentations, the group split into small focus groups to discuss in detail the relevance of the material presented for their respective national development strategies, as well as to identify specific barriers and recommended actions for the increased use of renewable energy in the region. Detailed project recommendations were the result of these deliberations.

A total of 41 projects were suggested by the workshop breakout groups. These suggested projects were categorised into six broad areas.

Market Characterization/Identification

- Preparation of baseline economy specific minimum energy needs, i.e., indices at a central level accessible by different economies and by different information users within economies.
 - Analysis of renewable energy retrofit options and potential to existing diesel mini-
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grids.

- Comparative economic analysis of utilization of wastes for energy versus other uses.
- Identify municipal waste utilization opportunities.
- Economy assessment of renewable energy manufacturing capabilities.
- Determine the best way to integrate renewable energy as part of a national strategy.
- Identify opportunities for renewable energy within the grid-connected system.

Database Development/Technology Characterization

- Master list of each economy's decision-making organizations in the private section for renewable energy.
- Development of a technology status information base at the national level.
- Investigation of the use of telecommunications as a means of education and knowledge dissemination.
- Survey to access local manufacturing capabilities at the national level and to suggest means to enhance these capabilities.
- Development of technology-specific guidelines for social evaluation of renewable energy projects to enhance social acceptance.
- Develop methodologies for least-cost energy systems analysis which expands the boundaries to include broader social, economic, and environmental aspects.
- Compendium of existing examples of social and economic impacts of implementation of renewable energy systems.
- Renewable energy standards for APEC economies.
- Case studies of failed renewable energy applications (lessons learned).
- Assessment of economy renewable energy resources (including quality of existing data).
- Evaluation of institutional and business infrastructures for sustainable renewable energy applications.
- Make above information and databases available on-line over a World Wide Web (WWW) server or internet bulletin board.
- Examine applicability of advanced biomass derived fuels.
- Better define the role of renewable energy as a complement to conventional energy systems in both national and regional energy planning.

Training

- Identify entities which can provide renewable energy technology training at the local level.
 - Invite more private sector energy companies to APEC workshops for cross-training and networking.
 - Evaluation of training systems.
 - Training of Non-Government Organizations (NGOs), community-based
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organizations, and field personnel to equip them to improve user awareness and participation.

- "How to" workshop on financing private investment of renewable energy-based local power.
- Education for local populations by NGOs of applicable renewable energy (sharing of successful approaches).
- Moderated internet discussion forum on renewable energy issues/topics.
- Series of national dialogue forums to assess interest in private local investment.
- Identify and provide training to entities (often NGSs) which could act as ESCOs in support of renewable energy project identification, implementation, and maintenance.

Technology Transfer

- Conduct research on optimum production of energy from palm oil mills, municipal wastes and bagasse -- transfer of technology between other Asian economies.
- Conduct research on new technologies (hydrogen, banagrass, and offshore ocean thermal energy conversion or OTEC).
- Technology diffusion and mediation facilitation (NGOs/renewable energy industries).
- Examination of the effects of independent power producers on the transfer of renewable energy new technology.

Information Dissemination

- Educate government entities on how to prepare energy planning documents and compile a compendium of regional plans.
- Compile information on in-economy infrastructure projects using renewable energy -costs, availability, applicability, sources of funding.
- Conduct workshops on financing mechanisms and project financing for small and large scale infrastructure projects.
- Compile reference documents on appropriate renewable energy technology for agricultural applications.

Project Implementation

- Renewable energy-based hybrid systems for villages, including production use (cooperative analysis/training).
 - Decentralized renewable energy supply options for rural industries (analysis).
 - Local empowerment for the utilization of hydro for rural power.
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Development of Analytic Methodologies to Incorporate Renewable Energy in National Energy and Economic Planning	1998	EGNRET	EWG05/1998
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Project Summary

The objective of this project was to identify, assess and improve analytic methodologies to incorporate renewable energy options in an APEC economy's energy and economic planning.

Project Outcome

It was suspected that existing energy models were not adequate tools for evaluating the penetration of renewable energy technologies in an economy. Thus it was thought that the models could not show the currently cost-effective renewable energy technology options to policy makers. This would make renewable energy technologies not receive a fair evaluation in the economy's fuel mix when it came to energy planning. The project was initiated on the basis that the development of improved models to assess the potential of renewable energy technology would contribute to the provision of distributed energy services at both economy and regional levels.

This study contributed to three main areas.

First, the study examined three principal economy-level energy models with special emphasis on the characterization of renewable energy options. The three models were: the Energy and Power Evaluation Program (ENPEP), the Market Allocation Program (MARKAL), and the Long-Range Energy Alternatives Planning System (LEAP). These three models were selected because they are widely used in many APEC member economies as well as non-APEC member economies worldwide, for their own domestic economic planning and at the international level of energy analysis. In addition, they represent three different types of energy models. Each model takes a different overall approach to the analysis of energy and environmental systems, which will provide a broad understanding of how various energy models handle existing and potentially new renewable energy technologies in an economy. The comparison of these three models should help senior policy officials and modellers in selecting economy-level energy models for use in their own energy planning.

Second, the study revealed detailed information on assumptions and methodologies utilized by the selected economies, which could benefit other APEC member economies who are currently developing, or plan to develop, their own economy-level energy models.

Finally, the study discussed important factors and attributes of renewable energy resources that modellers should take into consideration when developing their economy-level energy models so as to have a fair evaluation of all energy supply options including renewable energy options.

Four APEC member economies—Thailand, Indonesia, the Philippines, and the People's Republic of China—were selected as case studies. They were selected based on the criteria that they were APEC member economies, they had participated in economy-wide-level energy system modelling, they provided examples of different energy models, they provided examples of various renewable energy resources to be included in the models, and they made available reports and data sets utilized in actual economy-level modelling projects. Thailand was used as

a case study for ENPEP, Indonesia and the Philippines were used as case studies for MARKAL, and the People's Republic of China (PRC) was utilized as a case study for LEAP.

Energy models could be classified into three categories—technology-level (such as HOMER, Hybrid 2, and ViPOR), sector-level (such as, MABS, MIDAS, and PROVIEW), and economy-level energy models (such as ENPEP, MARKAL, and LEAP). These three levels of models have different objectives. The technology-level model is used to select individual components of a single system. The sector-level model, such as an electric utility model, is adopted to define the least-cost fuel mix for electricity generation to meet an economy's future electricity demand. In comparison, the economy-level model is utilized to simulate the decisions needed to define the necessary energy supplies to satisfy the future economy-wide energy demand at the least cost by taking into consideration other issues such as energy security or environmental related problems. Information required and factors influencing the decisions in the planning process are thus different among these three model levels.

The overall conclusion of the study was that the existing economy-level models like ENPEP and MARKAL have high capabilities for capturing most of the important factors and attributes of renewable energy and can present a reasonable picture of renewable energy potential in an economy, if the necessary information is made available and the models are utilized to their full potential.

Economy-Level Renewable Energy Roadmap	1999	EGNRET	EWG05/1999
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Project Summary

This project developed a series of renewable energy road maps that documented important information and necessary steps for identifying and implementing successful renewable energy projects.

Project Outcome

Five APEC member economies with six principal project examples in the areas of wind energy, photovoltaics, bioenergy, and landfill gas for on-grid and / or off-grid projects were selected as case studies in this project. The selected economies were: the United States, the Philippines, Thailand, Japan, and China. The selected technologies and associated APEC economies were:

- Off-grid wind energy applications (China) *program*;
- Grid-connected photovoltaics (Japan) *program*;
- Off-grid photovoltaics (Philippines) *project / business initiative*;
- Grid-connected and free-standing biomass cogeneration (Thailand) *project*;
- Grid-connected landfill gas recovery and conversion (United States) *project*;
- Grid-connected wind energy development (United States) *project*.

A review and analysis of the selected renewable energy projects was carried out to describe the "road maps" for successful project development. The principal steps in the project development and implementation process were described for the selected case examples.

Three of the projects selected were commercial single technology initiatives, and their development roadmaps were quite similar. The technologies are large -scale

grid-connected wind electric power, industrial biomass cogeneration, and landfill methane recovery and conversion. Generic roadmaps could be developed for each of these, but there were important differences in the roadmaps among these technologies. There was no single roadmap that fitted all commercial renewable energy projects.

For the other three case studies in the project, it was even more complex.

The small wind turbine program in China was not a project, but a national program with regional support. While it could serve to some extent as a model for similar programs elsewhere, the roadmap for this program bore little resemblance to those for the single technology commercial projects.

The development of the Rural Energy Services Company (RESICO) project / business initiative in the Philippines was an important example of new trails being blazed. This project was one of several being developed under a new business initiative by Shell International. It created its own unique roadmap, although the lessons learned appear to be widely applicable to initiatives designed to use clean energy technologies to bring priority energy services to off-grid communities.

The Japan PV rooftop program was an example of a national initiative designed to reduce the cost of a specific set of technologies and to stimulate the market demand for these. Again, there were important lessons to be drawn from this experience that can be applied by other APEC economies with similar goals, but the roadmap was different from all the other case studies in the project.

Several of the case studies demonstrated, technically and financially successful projects tend to occur in substantial numbers, gradually penetrating a potential market. It is unusual to find isolated examples of highly successful projects. Successful projects reflect attractive market environments, often shaped by deliberate policy incentives. In such environments it is natural to find many similar projects. Also, through the development of many successful projects the relevant industries and government agencies learn how to improve the process and increase the economic and technical effectiveness of such projects. Professional practices become established, together with standards and appropriate regulatory initiatives, as an industry grows. This in turn usually makes it increasingly easy to develop the next project in this environment.

APEC 21 st Century Renewable Energy Development Initiative: Synthesis of the Survey of APEC Member Economies' Renewable-Energy-Based Priority Needs and Issues Relating to Sustainable Development	2000	EGNRET
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Project Summary

This project comprised a survey sent out by the United States in November 2000 as the first major activity of the APEC 21st Century Renewable Energy Development Initiative. The survey invited energy officials of APEC member economies to share information on current renewable applications relating to sustainable development and growth, and to identify barriers, issues and priorities involving these applications.

Project Outcome

Fifteen of the 21 APEC economies responded to the survey. Following were the

main results of the survey.

Sustainable Development Priorities and Goals

Transportation and air pollution reduction was the most common sustainable development priority and goal among the APEC member economies; six member economies selected this goal. Rural development and electrification was mentioned by four member economies. The other areas that most member economies identified in their top three sustainable development priorities and goals were poverty alleviation and education.

The development and use of bioenergy were at different stages among the member economies. In general, the developed economies used more advanced technology applications such as biomass gasification, landfill gas and biofuels for transportation while in developing economies, these technologies are either not being adopted, still in a demonstration stage, or used only in small-scale operations.

Wind-related technology applications were at a demonstration stage in the developing economies. The wind energy technologies utilized by developed economies were more advanced and larger in scale. For example, developed economies focused on grid-connected wind farms and large turbine manufacturing. On the other hand, the developing economies employed wind technologies in small off-grid connected applications.

Off-grid PV was more widely used than grid connected PV in both developed and developing economies because of its cost effectiveness. While PV was much more expensive than conventional power available on the grid, off-grid PV is more price competitive against grid extension or conventional stand-alone power systems.

Besides biomass, wind and solar technologies, diesel/solar/wind hybrid systems were the most identified technology being used in APEC economies to address development needs, followed by small hydro (mini- and micro-hydro) systems. The utilization of electric vehicles for transportation was still at a small scale and fuel cell technology was mainly still under R&D.

Particular measures in member economies' future plans to apply renewable energy technologies to sustainable development goals and priorities included encouraging the private sector to develop renewable energy technologies (Indonesia), establishing a performance certification center for renewable energy technology (Korea), teaching the new generations to conserve energy and use renewable energy more efficiently, productive and environmental friendly (Mexico), emphasizing transport policies that contribute to energy efficiency and the reduction of CO₂ from vehicles (Singapore) and continuing improvements in energy efficiency and a progressive transitions to renewable energy (New Zealand).

Major Issues, Needs and Barriers

The availability of technology was not the most significant technical barrier associated with the use of renewable energy technologies in APEC. More advanced technologies such as fuel cells, biofuels or hybrid electric systems might not be available in all economies. However, simple and/or commercialized technologies were available in most economies or could be imported. The most common technical barrier associated with the use of renewable energy was lack of in-economy personnel to operate and maintain the technologies.

The key competition to the use of new and renewable technologies for addressing sustainable development needs was fossil fuels. The cost-effectiveness of new and

renewable technologies as compared to fossil fuels was not identified by each member economy.

Standards and certification programs did not widely exist in APEC economies. Only Canada and the U.S. claimed that standards and certification programs exist or are underway in their economies for all renewable energy technologies.

Legislative, policy and business-related barriers to the use of renewable energy technologies include both lack of policies that support the use of renewable energy and the existence of policies that are counterproductive to the promotion of renewable energy utilization. Uncertainties associated with the development of renewable energy for power generation, such as the lack of long-term contracts to buy electricity generated from renewable energy, were also mentioned as a barrier.

The main financial barrier to the use of renewable energy technologies was their high up-front costs. Because of the high investment costs, and the unfavorable views of loan officers on the profitability and reliability of renewable energy businesses, receiving a loan from a commercial bank for a renewable energy project was difficult.

The member economies used various financing arrangements to promote renewable technology deployment. The financing arrangements adopted included tax incentives (such as tax write-offs, tax reductions and tax exemptions on machinery and equipment), loans and financial support (such as in R&D or on pilot projects). Other financing arrangements included government subsidies and micro-enterprise credits. Korea had an arrangement that mandates the purchase of renewable-based electricity. Some states in the U.S. required that electricity suppliers provide a minimum percentage of their supply from renewables. In addition, in some states in the U.S., a standard fee was collected from all electricity consumers and the money used to fund renewable investment. The green pricing option, where consumers could voluntarily increase their payment to buy power from renewable sources, has also been adopted in Australia, New Zealand and the U.S.

Private institutions did not seem to play a major role in supporting renewable energy development in APEC economies. Most economies mentioned government agencies as the main institutions that supported renewable energy deployment, followed by government laboratories, public research centers/agencies, and local universities.

The economies support enterprises and business development for new and renewable energy technologies in several ways. These included, for example, providing government funds, grants, and loans to support new businesses, providing financial assistance from commercial banks, forming an agency to work closely with industry in developing and implementing marketing strategies and institutionalising renewable energy into the national government. In the U.S, although some special subsidy programs existed, renewable energy systems were generally financed through commercial lending programs.

Six member economies mentioned issues related to financing as a barrier to providing adequate delivery mechanisms for renewables use. Other barriers included lack of supporting policies from the government, high cost of renewable energy technologies, lack of information/knowledge about technologies, lack of human capacity (i.e., lack of local expertise, manufacturers and maintenance), and lack of physical infrastructure.

Knowledge of financing and fee collection requirements was identified as a key

information barrier that prevented delivery mechanisms from being put in place. Knowledge of the in-economy capacity to service and maintain renewable technologies was also identified as a key information barrier. Knowledge of the technology and its characteristics, lack of capacity of in-economy institutions to provide technology and information assistance and lack of knowledge of technology sources were also mentioned.

Collaborative Activities within APEC

Collaboration among the member economies was mainly in the form of aid and assistance from the developed economies to developing economies.

The majority of the member economies agreed on the benefits of sharing experiences from other economies. Australia, Canada, Japan and the U.S were most mentioned as having technologies or experiences relevant to meeting sustainable-energy priorities in other member economies.

Collaborative R&D was the most preferred among the member economies. Some economies preferred collaboration on the presentation of case study experiences. The benefit of collaboration with planning tools, collaboration on joint project development and training programs and business development forums were also mentioned.

Including New and Renewable Energy Technologies in Economy Level Energy Models	2001	EGNRET	EWG04/2001
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Project Summary

The objective of this project was to enhance the energy-modelling capabilities in APEC member economies with respect to renewable energy technologies and to carry out case studies regarding the effects of different penetration rates of renewable technologies.

Project Outcome

MARKAL modelling teams from Australia, China, Japan, and the United States agreed to participate in the study.

The first step in the work involved reviewing each economy model to assess its suitability in regard to the study's objectives. All four member economy models were found to be suitable for inclusion in the assessment.

A generic database of renewable technology characterizations (technical performance and costs) was built. This enhanced the detail on renewable and energy efficient technologies in the MARKAL framework and enabled testing of various hypotheses about the effects of different penetration rates of renewable and energy efficient technologies on energy supply mix and energy consumption patterns in APEC member economies. The database could be used by other APEC member economies, as well as non-member economies.

In the next step, the characterizations of renewable electric-generating technologies currently used in the participating member economy MARKAL models were examined. The most recent information was compiled on the prospects for a host of renewable electric technologies available from the United States Department of Energy (US DOE). The DOE characterizations fell toward the optimistic end but were generally within the range of what was found in the various member economy models. The renewable technology characterizations to be used in the assessment

were then assembled into a database (APECR), refined for local conditions in each of the member economies, and structured for being conveniently incorporated into the existing member economy MARKAL models.

A series of scenarios looking to establish increasing percentages of electric generation from renewables were run, with and without modest reductions in future carbon dioxide (CO₂) emissions. Owing to the cost effectiveness of the APECR technologies (especially after 2020), some level of adoption of these technologies was seen even without imposing any renewable portfolio goals. Over the entire model period, the overall impact on the energy system of modest renewable targets was an initial increase in costs, but the cost impact was surprisingly small. In addition, MARKAL results with the APECR technology characterizations showed the following benefits to each of the economies:

- improvement in long-term energy security, as characterized by lower energy imports;
- slight change in economic conditions, as characterized by modest increases in total system cost over the modelling horizon;
- a lower cost of meeting any CO₂ reduction targets; and
- reduced environmental pollution—both in CO₂ and in local air pollutants.

This assessment highlighted the potential role of renewable resources and energy technologies within selected APEC economies and demonstrated the merits of using a common framework to examine APEC member economy issues.

The APECR technology characterizations are available for other APEC member economies to utilize. The potential benefits to APEC from leveraging the extensive coverage provided by the MARKAL models for analysis of possible policy options for APEC member economies deserve serious consideration.

New Energy Technologies: Measuring Potential Impacts in APEC	2002	EGNRET	EWG03/2002T
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Project Summary

The objectives of this project were to assess the current status of energy technologies in the electricity and iron and steel sectors in APEC economies and to analyse alternative scenarios of the future development and adoption of new technologies.

Project Outcome

The study found that total primary energy consumption in APEC economies under 'business as usual' assumptions is projected to grow at 2.1 per cent a year between 2002 and 2030. Much of this growth will be driven by energy intensive industries such as electricity generation and iron and steel production.

The electricity and steel industries in the region are characterised by plant of mixed vintage, with corresponding variation in operational and environmental performance. However, the scale of required capacity additions over the next three decades, particularly in electricity generation, provides considerable potential to improve the overall efficiency of the power generation and steel making sectors in APEC economies by adopting more advanced technologies.

Accelerated development and adoption in APEC of more advanced technologies could reduce growth in energy consumption in the electricity generation sector by 40

per cent by 2030, and halve the growth in energy consumption in the steel making sector. This could lead to energy savings of more than 500 million tonnes of oil equivalent (Mtoe) each year in these industries by 2030.

The extent to which this potential can be realised is dependent on two key factors: research to develop more advanced technologies; and appropriate institutional settings within each economy to facilitate uptake of new technologies.

The study concluded that accelerating the development and uptake of advanced technology in the energy sector has the capacity to reduce the growth in energy consumption and greenhouse gas emissions in the APEC region.

RENEWABLE ENERGY BUSINESS DEVELOPMENT

Asia Pacific Renewable Energy and Energy Efficiency Business Development Conference	1996	EGNRET	EWG04/1996
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Project Summary

This conference, held in Denver, USA in June 1996, was designed to serve as a catalyst for sustainable renewable energy and energy efficiency investments for grid connected and village/household power with member economy specific, regional and global benefits for APEC region economies.

Project Outcome

Project report not available.

APEC 21 st Century Renewable Energy Development Initiative (Collaborative VIII): Demonstration of the Feasibility of Operating a Renewables-related Energy-service Company (RESCO) in the Hydro-electric Field	2002	EGNRET	
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Project Summary

This project aimed to demonstrate the feasibility of operating a renewables-related energy-services company (RESCO) focussed on hydro-electricity. Specifically, the project identified and prioritised hydro-power generation facilities possessing optimization project opportunities in APEC-member economies. Optimization projects achieve the modification of, or addition to, power generating equipment in existing facilities to provide additional power in a given locale with a lower cost and environmental impact per megawatt of capacity.

Project Outcome

Project report not available.

RENEWABLE ENERGY TRAINING

Solar Energy Training Program	1993	EGNRET	EWG06/1993
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Project Summary

This project was a prototype information visits program on photovoltaic technology held in Australia in July/ August 1993. The project was designed to improve the understanding of photovoltaic applications and the environmental benefits of the technology, and reduce impediments to applications of the technology.

Project Outcome

Project report not available.

Renewable Energy Tour 1996	1996	United States	EWG SF96-4
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Project Summary

This tour of major renewable energy demonstration sites in the United States was held in June 1996.

Project Outcome

Project report not available.

APEC 21 st Century Renewable Energy Initiative: Training and Accreditation Needs and Capabilities Study (Stage 1)	2002	EGNRET	EWG04/2002
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Project Summary

This project responded to a recommendation from a previous EWG project to develop and implement a system for accrediting renewable energy training within the APEC region. The project encouraged APEC economies to adopt training accreditation standards that are consistent throughout the region.

Project Outcome

The skill level required for the many renewable energy technologies is dependent on the actual application of the technology. A person only trained to install and maintain a solar home system using one or two PV modules in rural areas would not have the skills required to install a large hybrid system using PV, wind and a diesel genset. However, an engineer and/or senior technician who is trained in the advanced theory, installation and maintenance practices of a number of technologies (eg PV, Wind and micro-hydro) can generally adapt their skills into many new applications of that technology with either no additional training or with suitable further training.

Therefore the level and amount of training required within an APEC member economy is dependent on the identified needs for that member, the renewable energy resources available and the actual technology chosen to meet the needs. Whether that economy is required to build capacity, so that they can provide the training internally, or whether the training could be provided by another member economy, is dependent on the total long term market for that particular application within the economy.

This study only investigated the need for technical training. The success of any

renewable energy program or project within any economy is dependent on the acceptance by and support of the technology by the various government departments (eg Dept of Energy, Department of Finance etc) and also the final beneficiaries - that is the people in villages and the cities.

The study was principally undertaken using a survey of APEC member economies and desk-top research. Intensive research of the web was used to identify

- institutions that were offering renewable energy training;
- organisations that could be contacted to provide information on institutions that were offering courses.

The level of training available within the member economies varied with no training being identified in Brunei; Hong Kong, China; Singapore, Chinese Taipei. Australia was the most advanced in renewable energy training with courses available within both technical colleges and universities and a long established formalised technician training program (started in 1993).

Though the study was not exhaustive, the following conclusions were reached.

- Within the APEC member economies either renewable energy training already existed or the skills existed to develop training for all technical levels of all renewable energy technologies.
- The majority of vocational training has been undertaken by industry within most of the economies. This has generally been undertaken to meet a market need such as installation of particular projects or to provide renewable energy equipment on a commercial basis.
- An institutionalised framework for providing vocational training is required or, where a national vocational exists, renewables training should be integrated within that framework
- Research-level training was active in many of the member economies

APEC 21 st Century Renewable Energy Development Initiative (Collaborative III): Development and Implementation of a System for Accrediting Renewable Energy Training	2003	Australia
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Project Summary

This report recommended the adoption of the Institute for Sustainable Power's framework into the APEC region as the mechanism for accrediting renewable energy training.

Project Outcome

The Institute for Sustainable Power Inc (ISP) had already established an internationally recognised accreditation program for renewable energy training courses, institutions, and certification of trainers. Within the APEC region, China had adopted the ISP standards for renewable energy training; a number of institutes within the USA were already accredited; the Canadian industry was investigating whether to adopt ISP accreditation; and Australia had completed a study into the adoption of ISP accreditation for training institutes and certification of trainers. There was also a project in ASEAN economies (seven of which were member

economies of APEC) to implement ISP accreditation in the region.

Therefore, it was important that APEC built on the work already undertaken and complemented any proposed work in the region. This would help fast-track the introduction of a renewable energy training accreditation program across the APEC region.

Recommendation 1: It was therefore recommended that APEC adopt ISP accreditation throughout the region and not develop its own program. This would remove the need to either duplicate an already existing entity or develop similar guidelines and procedures.

Recommendation 2: It was recommended that EGNRET work with ISP to introduce ISP accreditation of training to the region.

RENEWABLE ENERGY PROJECT MANAGEMENT

APEC 21 st Century Renewable Energy Development Initiative (Collaborative VIII) : Building and Developing an APEC Renewable-Energy Collaboratives Projects Integrator (APEC-CPI)	2003	EGNRET	EWG02/2003T
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Project Summary

This project attempted to develop a software system for project managing and integrating APEC Renewable Energy Collaboratives projects. APECC-CPI was intended to be a dynamic economic network bringing together for the first time in a seamless online environment the public and private sectors whose core focus is in new and renewable energy technologies. The system consisted of robust channels that integrated with each other or could be utilised on their own.

Project Outcome

This project was eventually abandoned.

APPENDIX B: APEC EWG PROJECTS ON CLEAN FOSSIL ENERGY, 1992-2007

Project Title	Year Funded	Funding Channel	Project Code
APEC TECHNICAL SEMINARS ON CLEAN FOSSIL ENERGY			
First APEC Technical Seminar on Clean Coal Technology	1993	EGCC	EWG02/1993

Project Summary

Seminar held in Chiang Mai, Thailand in September 1993 provided a forum to facilitate in depth discussion of practical issues associated with the introduction of clean coal technologies including their efficiencies, economics, environmental performance, financing and policy.

Project Outcome

Project report not available.

Second APEC Technical Seminar on Utilisation of Clean Coal Technologies	1994	EGCC	EWG02/1994
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Project Summary

Seminar held in Jakarta, Indonesia in October 1994, provided the opportunity to share information about actual commercial scale operations, addressing relevant policy issues, evaluating clean coal technologies relative to other energy options, and the promotion of means to facilitate deployment of clean coal technologies for existing and planned coal-fired facilities in the Asia-Pacific region.

Project Outcome

Project report not available.

Third APEC Technical Seminar on Utilisation of Clean Coal Technologies	1995	EGCC	EWG03/1995
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Project Summary

Seminar held in Taejon, Republic of Korea in August 1995 provided an opportunity for experts to examine clean coal technologies in APEC member economies from the perspective of development, operating efficiencies, environmental performance and project financing.

Project Outcome

Project report not available.

Overview of APEC Energy Working Group Projects
Stage 3: Project Outcomes

Fourth APEC Technical Seminar on Clean Fossil Fuels Technology	1996	EGCFF	EWG02/1996
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Project Summary

Seminar held in Beijing in October 1996. The theme of the seminar was “Clean coal technologies: energy and environmental aspects of clean coal technologies”.

Project Outcome

Project report not available.

Fifth APEC Technical Seminar on Clean Fossil Fuels Technology	1997	EGCFF	EWG04/1997
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Project Summary

Seminar held in Reno Nevada USA; in October 1997. Subjects covered by the seminar included: 1) current conventional clean fossil fuels technologies; 2) current commercial state-of-the-art technologies; 3) specific clean fossil fuels technology applications suitable for the Asia Pacific region; 4) performance characteristics and physical performance efficiency, environmental performance, and economic costs; 5) alternate energy options; and, 6) policy issues relevant to deployment of clean fossil fuels technologies.

Project Outcome

Project report not available.

Sixth APEC Technical Seminar on Clean Fossil Energy	1998	Japan	EWG SF98-1
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Project Summary

Seminar held in Okinawa, Japan in October 1998 focussed on promoting practical clean fossil technologies (for oil and gas as well as coal) to the developing economies in the APEC region.

Project Outcome

Project report not available.

Seventh APEC Technical Seminar on Clean Fossil Energy	1999	Chinese Taipei	EWG SF99-4
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Project Summary

Seminar hosted by Chinese Taipei and held in Taipei in March 2000 and included a tour of one of Asia’s largest coal-fired power plants, and a full review of the advanced environmental technologies in use and the economics and efficiency of the plant.

Project Outcome

The seminar included the following five technical session:

- Application and Development of Clean Fossil Fuels;
- Application and Development of Clean Fossil Energy for Power Generation;
- Clean Fossil Energy Application and Development in the Industrial Sectors;

- Market Opportunities for Clean Fossil Energy in the APEC Region;
- The Role of Clean Fossil Energy in Addressing Global Climate Change.

APEC COAL FLOW SEMINARS

First APEC Coal Flow Seminar	1994	Japan	EWG SF94-1
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Project Summary

The seminar was held in Tokyo, Japan in October 1994.

Project Outcome

Project report not available.

Second APEC Coal Flow Seminar	1995	China	EWG SF95-1
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Project Summary

The seminar was held in Shanghai, People's Republic of China in December 1995.

Project Outcome

Project report not available.

Third APEC Coal Flow Seminar	1996	Australia	EWG SF96-1
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Project Summary

The desired outcome of the seminar was to develop strategies, cooperative arrangements and networks to facilitate the smooth expansion of coal trade and investment. The seminar was held in Terrigal, Australia in November 1996.

Project Outcome

The seminar examined the investment and financial issues impacting on the outlook for coal in the APEC region.

To provide successful regional strategies for coal, power infrastructure and technology transfer in APEC member economies it would be necessary to mobilise business investment to finance \$2 trillion in power infrastructure and invest \$180 billion in expanding the APEC coal supply by 900 million tonnes out to 2010.

The seminar found that there is a distinct need to examine all the issues as a whole across the coal power cycle to achieve these goals.

Barriers to Investment

Some of the major barriers to mobilising business were identified as:

- Competition from governments of member economies with IPPs for capital for development and access to stable coal supplies
- Long lead times to generate suitable investment returns
- Conservative approach to investment impacting on continuity of stable coal supply
- No long-term pricing strategy to attract investment
- Security of tenure
- Right to repatriate profits
- Management and equity control

- Fixed tax regimes
- Stable laws controlling mining
- Lack of supporting infrastructure for coal chain development
- Lack of transparency in the coal market

Main Points Drawn from Seminar

- Investors will consider clean coal technologies when the economic circumstances are acceptable.
- Consistent treatment of market reforms across APEC and a greater transparency of actions and proposals would encourage confidence in the processes.
- Governments might consider playing a larger role in creating the regulatory circumstances for the freeing up and development of a transparent trading arrangement.
- Security of energy supply with stable prices is high priority of most member economies.
- Greater facilitation of trade and investment generally in the region will mean greater energy security.
- Environmental concerns can have a major impact on the cost and availability of investment finance for coal-power projects.
- There is a real need to develop and implement cost effective solutions for addressing coal's environmental impacts.
- The value of communicating to the public the positive benefits of CCT.
- The value of APEC to the communication process between economies, particularly to address issues relating to the coal and energy industries.

Conclusions

The next challenge facing APEC economies was the establishment of a collaborative regional action plan for an open trading framework for primary energy. This was strategically important if thermal coal capacity was to be expanded without price shocks and if inefficient allocation of energy resources was to be avoided.

A transition to an open regional market must be carefully managed, requiring clear unambiguous support at ministerial level from all APEC member economies. Identified structures and processes for advancing regional coal production and consumption consistent with regional economic growth plans must also be identified.

A central issue was the need to promote investment for coal mine development. In order to achieve this, there must be communication and mutual understanding among the related parties, power producers, coal developers and governments across the APEC region.

The ability to achieve large growth targets for coal fired power in the APEC economies would only be achieved if there was reduced business risk and barriers to entry for foreign investors.

All participants in the fuel supply/electricity generation chain would need to make acceptable returns for their investor and owners if there was to be a stable and predictable market.

Members of the Asia Pacific region should adopt a development and investment

strategy which simultaneously achieved sustainable economic growth, stabilised energy demand and protected the environment. An essential factor in this was to facilitate investment in the complete coal chain from development to consumption based on satisfactory environmental policies.

Fourth APEC Coal Flow Seminar	1997	United States	EWG SF97-1
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Project Summary

The goals of the seminar were to examine the market outlook for coal and important issues impacting on coal investment and trade decisions, including:

- the emergence of new markets and coal trade opportunities in APEC;
- managing the greenhouse challenge; and
- the status and outlook for new coal pricing arrangements.

The seminar was held in Honolulu, USA in November 1997.

Project Outcome

The challenges facing coal in meeting possible future constraints on greenhouse-gas (GHG) emissions were an important element of a number of presentations. It was clear that APEC coal-consuming economies were seriously evaluating options for meeting the GHG challenge. A number of speakers discussed the critical importance of continuing to develop advanced coal conversion technologies that can substantially increase efficiencies and reduce GHG and other emissions.

The shift among APEC economies to more open and transport markets for coal was resulting in greater competition and an erosion of the traditional benchmark pricing system for international coal pricing in Asia. Positive and negative aspects of the move away from benchmark pricing were reviewed, and concerns about possible increased risks to a stable coal supply system were raised.

The decline in government and industry support for the development and dissemination of advanced coal conversion technologies, and a shift in the utility industry to shorter-term goals for low-cost, fully proven conventional technologies, might result in delays in the development of new critically needed technologies and their introduction, particularly to developing APEC economies.

Because of the above concerns, there was growing importance for APEC energy groups concerned with stable coal supplies, and environmentally sound coal use, to cooperate to ensure that governments of APEC member economies understood the need for long-term stable coal supplies, and for continued support for the development and introduction of advanced coal-conversion technologies to all APEC-member coal-using economies.

The research results and discussions at this seminar will be helpful to member economy governments in the development of energy and environmental policies and strategies that will ensure stable, low cost, environmentally sound energy systems among all APEC economies in the long-term.

Fifth APEC Coal Flow Seminar	1999	Japan	EWG SF99-1
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Project Summary

The first goal of the seminar was to examine the implications of Kyoto greenhouse gas emission limits on the future energy mix in Asia, with emphasis on the implications on the future demand for coal.

The second goal of the seminar was to examine the impacts of the Asian economic crisis on energy demand, with particular attention on coal.

The seminar was held in Yokohama, Japan in February 1999.

Project Outcome

The seminar technical sessions included:

- energy choices resulting from the Kyoto agreements;
- impacts of global warming issues on coal demand;
- impacts of the Asian economic crisis on coal demand;
- securing a stable coal future in an environment of uncertainty; and
- the outlook for supply and demand for coal in Asia.

These topics were broadly discussed under two major headings: impacts on coal markets resulting from the Kyoto agreements and the Asian economic crisis.

The first goal of the seminar was to examine the implications of Kyoto greenhouse gas emission limits on the future energy mix in Asia, with emphasis on the implications on the future demand for coal. Discussions were primarily quantitative, with speakers presenting estimates for both specific economies and the Asian region. The modelling results suggested that rigorous implementation of the Kyoto agreements would result in substantial negative impacts on economic growth rates and coal demand. One speaker suggested that government strategies to achieve greenhouse gas reductions should be guided by careful analysis of the benefits and costs of various options. The high-growth electricity sector appeared to present the most difficult challenge in reducing greenhouse gas emissions, while the steel sector in mature economies, such as Japan, could achieve substantial reductions through technology and process innovations. The key challenge facing coal is the cost of compliance with tighter emissions restrictions, most importantly in the area of reduced greenhouse gas emissions.

The second goal of the seminar was to examine the impacts of the Asian economic crisis on energy demand, with particular attention on coal. Most speakers indicated stagnation in energy consumption due to the economic crisis, with excess coal-mine capacity in the region, and falling coal prices. The representative from the P.R. China reported that large coal stockpiles exist in the P.R. China, and major reforms are under way to close illegal and inefficient mines and to promote efficiency in the coal mining sector. Representatives from the three economies most impacted by the economic crisis (Indonesia, the Republic of Korea, and Thailand) presented revised projections for coal consumption, indicating slower longer-term growth rates. Overall, however, almost all speakers indicated that substantial growth in coal consumption is anticipated after their economies recover from their present economic difficulties. One analyst showed that the present slowdown in energy growth was unlikely to change the long-term outlook of a doubling in Asian coal consumption by 2020.

On the supply side, lower coal prices and increased spot-market coal sales were

changing the competitive position among coal suppliers. One senior market analyst suggested that North American coal exporters could no longer effectively compete in Asian thermal coal markets with lower-cost Australian, Indonesian, and Chinese coal supplies. A representative from the Australian coal industry reviewed the large gains in mine productivity in Australia. There was limited debate on the future of coal prices, with most speakers anticipating that low coal prices would continue for a number of years into the future. One speaker suggested that coal prices in constant U.S. dollars could continue to decline gradually over the next two decades.

The critical issues of attracting financing for coal developments was addressed by one speaker, and two speakers addressed advanced coal-fired power plants. One speaker suggested that "advanced technology insurance" would facilitate the introduction of advanced coal conversion technologies, such as integrated gasification combined-cycle power plants. In addition, government-private-sector partnerships were suggested as a possible commercial structure for high-risk new energy technology projects that can reduce environmental pollution.

The majority of representatives from Asian economies referred to efforts under way to deregulate and privatize portions of their energy sector, with priority generally going to deregulation of the power generation sector. Speakers noted the competitive nature of the international coal trade, the high level of stability in coal supplies, and the lack of significant political risks of coal supply disruptions.

A number of speakers referred to the problem of improving coal's image. They made suggestions that greater dissemination of information is needed, to show how the coal sector is meeting high environmental standards and to demonstrate the important economic benefits to both coal-supplying and coal-consuming economies.

Overall, the seminar was timely in addressing two key problems facing Asian APEC economies: the impacts on coal demand arising from the Kyoto greenhouse gas targets and from the Asian economic crisis. There was general agreement that, after the present economic crisis, renewed growth in coal consumption will take place, but at lower rates in some economies. One speaker suggested that, given the uncertainty about future energy and environmental constraints and opportunities, prudent energy strategies should foster robust competition in the energy sector, backed by sound no-regrets energy and environmental policies.

Sixth APEC Coal Flow Seminar	2000	Korea
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Project Summary

The seminar was held in Kyungju, Korea in March 2000.

Project Outcome

Project report not available.

JOINT APEC COAL FLOW SEMINARS AND APEC TECHNICAL SEMINARS ON CLEAN FOSSIL ENERGY

Joint Seventh APEC Coal Flow Seminar & Eighth APEC Technical Seminar on Clean Fossil Energy	2000	Thailand	EWG SF00-2
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Project Summary

The conference theme was “The Clean and Efficient Use of Fossil Energy for Power Generation in Thailand”. The objective of the seminar was to discuss the technologies currently available to use fossil fuels in power generation plants and, in particular, to address a range of important technical, economic and policy issues facing coal utilization in power generation in APEC economies. The seminar was held in Bangkok, Thailand in October 2000.

Project Outcome

This was the first seminar that brought together two previously successful seminar series into one joint seminar. The eighth APEC Clean Fossil Energy Technical Seminar was combined with the Seventh APEC Coal Flow Seminar.

The seminar was organized in response to the request of the host government for the need for a group of experts to share technical, economic, environmental and policy information related to the use of clean energy. Emphasis was placed on the experiences of various APEC economies in dealing with coal-related pollution.

The seminar opened with a session on broader APEC wide issues of sustainable development, environmental impacts on fossil fuel use, and implications of deregulation of the electricity sector and fossil fuels use. Numerous case studies were presented, and included Australia, Canada, PR China, Chinese Taipei, Hong Kong (China), Indonesia, Japan, Republic of Korea, Malaysia, Philippines, Thailand, United States, and Vietnam.

The specific energy environmental situation in Thailand was reviewed, and papers were presented that showed the low emissions and high efficiencies being achieved with recently commissioned power plants using advanced technologies. Speakers addressed pollutants having local and regional impacts, primarily particulates, SO₂ and NO_x, plus CO₂ emissions having global greenhouse gas impacts. Considerable attention was given to R&D underway into options to reduce CO₂ emissions, and included papers on both benefits increased energy efficiencies and the capture and sequestration of CO₂. Two speakers suggested that zero greenhouse gas emissions technologies should be among the long-term research areas.

Numerous speakers emphasized the need to do a better job in seeking public participation in energy and environmental planning. In addition, most government and industry speakers suggested the need for the fossil fuels industry to continue its efforts to achieve higher environmental standards.

The ambitious plans in the United States to develop very high efficiency technologies with very low emissions were presented (Vision 21 program), indicating the large potential gains from ongoing research. The comments of one senior speaker from Japan's coal sector reflected the changing attitude of the coal sector toward environmental issues in his statement that we must "be friendly to the earth".

The importance to each economy of maintaining a diversified energy mix was

emphasized. The projections by most economies indicated that the amount of coal and natural gas is expected to increase in the future. Asia-wide consumption of coal was projected by one speaker to double within 20 to 25 years; further necessitating continued efforts to ensure enforcement of sound environmental legislation, and the introduction of clean coal technologies, and greater use of natural gas and renewable energy.

A session on clean fuels in the APEC region, discussed the need for cleaner fuels for the transportation sector to reduce urban pollution. Alternative cleaner fuels were discussed and compared with respect to their implications to pollution.

Joint Eighth APEC Coal Flow Seminar & Ninth APEC Technical Seminar on Clean Fossil Energy	2001	Malaysia
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Project Summary

The conference theme was "Coal in Sustainable Development in the 21st Century". The seminar focussed on the technological and policy approaches that APEC economies are pursuing to allow the continued use of coal in the region and as a pillar for sustainable development around the world in the 21st century. The seminar was held in Kuala Lumpur, Malaysia in March 2002.

Project Outcome

Project report not available.

Joint Ninth APEC Coal Flow Seminar & Tenth APEC Technical Seminar on Clean Fossil Energy	2002	China
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Project Summary

Project summary not available.

Project Outcome

Project report not available.

CLEAN FOSSIL ENERGY TECHNICAL AND POLICY SEMINARS

First APEC Clean Fossil Technical and Policy Seminar incorporating Joint Tenth APEC Coal Flow Seminar & Eleventh APEC Technical Seminar on Clean Fossil Energy	2003	Korea
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Project Summary

This Seminar resulted from a decision to integrate the Coal Flow and Clean Fossil Energy Technical Seminars, which were held jointly in previous years. The event was held in Seoul, Korea in December 2003 under the theme "Technology: Coal's Way Forward".

Project Outcome

Project report not available.

Second APEC Clean Fossil Technical and Policy Seminar	2005	Philippines
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Project Summary

The theme of this second integrated clean fossil energy event was “Meeting Today’s Challenges to Supply Tomorrow’s Energy”. The Seminar for the first time added the natural gas area. Coal topics covered included coal policies and the outlook for coal utilization in a number of APEC economies, advanced clean coal technology development, coal mine methane technologies, and carbon capture and sequestration. In the natural gas area, natural gas expansion in the APEC area was the main focus, including bringing new gas reserves to markets and utilization in new gas-fired combined cycle power generating plants. The seminar was held in Cebu, Philippines in January 2005.

Project Outcome

Project report not available.

Third APEC Clean Fossil Technical and Policy Seminar	2006	Thailand
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Project Summary

The theme of this seminar was “Clean Coal - Diversifying and Securing Thailand’s Energy Future”. Areas covered included coal supply and demand developments and outlook in APEC economies, national coal strategies, existing and emerging clean coal technologies, zero-emission coal-fired power generation, and carbon capture and sequestration. The seminar was held in Lampang, Thailand in February 2006.

Project Outcome

Project report not available.

Fourth APEC Clean Fossil Technical and Policy Seminar	2007	Vietnam
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Project Summary

The theme of this seminar was “Clean Coal as a Sustainable Energy Development Strategy”. Areas covered were coal supply and demand outlook in APEC economies, advanced coal mining technologies, and commercial and emerging clean coal technologies including zero-emission power plants and carbon capture and storage. The seminar was held in Hanoi, Vietnam in February 2007.

Project Outcome

Project report not available.

APEC COAL TRADE AND INVESTMENT LIBERALISATION AND FACILITATION WORKSHOPS

Inaugural APEC Coal Trade and Investment Liberalisation and Facilitation Workshop – Indonesia	1997	EGCFF	EWG02/1997T
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Project Summary

This workshop focused on issues related to facilitating trade and investment in the coal and electricity sectors in APEC economies with particular attention on the Indonesian coal and electricity sectors. The workshop was held in Jakarta, Indonesia in August 1997.

Project Outcome

The papers presented in the workshop spanned the coal chain from coal resources and reserves, conversion technologies, economics and markets, legal and policy issues, to community and cultural concerns. Participants represented government, industry and academic interests, and provided perspectives of coal and technology suppliers, consumers, energy policy makers and legal experts.

Presentations reflected a pragmatic understanding of the functioning of open energy markets. Speakers encouraged policies and legislation that would increase transparency, predictability, risk reduction and competition. Both industry and government speakers agreed that it was important to move toward more transparent markets. A number of speakers emphasized the need to implement policies and legislation that will attract increased private sector investments in various elements of the coal chain. A review was presented of APEC activities in promoting trade and investment liberalization in energy. In addition to a number of papers on Indonesian coal, there were papers on coal and related issues in other APEC economies, including Australia, Canada., the Peoples Republic of China, Japan, the Philippines and the United States.

This APEC-sponsored workshop produced papers and results that may constructively influence APEC energy policy recommendations in member economies. It was also noted at the workshop that the goal was improving the openness and functioning of the energy system, while also respecting political differences among APEC member economies.

While the goal of open competitive markets was generally agreed by participants, the rate of introduction of reforms differs among economies. In some APEC economies, major reforms are being rapidly implemented, but in others, governments are more gradually introducing reforms. This phased approach to energy reforms allows governments more time to evaluate improvements and identify problems at each phase of the reform process.

It was suggested that an important difference in these APEC sponsored meetings from typical coal trade conferences is that APEC member cooperation is a continuous process, and not just periodic meetings to present papers. The APEC Energy Working Group, as well as APEC Experts Groups and subgroups, meet periodically to discuss energy policy issues, exchange energy and environmental research results and identify areas for cooperation. This ongoing cooperation increases the chances that important policy issues and recommendations will not be lost in workshop proceedings, but will influence APEC member economy thinking and policies.

Selected Observations from the Workshop Papers and Discussions

(1) There is an increasing emphasis on economic factors in guiding the coal system, government policies and contractual arrangements. A review of contractual terms and guidelines was presented for coal exploration and mining and for coal supply agreements to power plants.

(2) Coal faces major environmental challenges at both local and global levels that increasingly will require the introduction of advanced clean coal technologies. It was noted that most attention is presently given to reducing local and regional pollution associated with coal burning, with less attention given to CO₂ emissions and implications for global warming. The status of selected advanced clean coal technologies was reviewed along with their potential for reducing emissions of SO₂, NO_x and CO₂. Among clean coal technologies, integrated gasification combined-cycle (IGCC) was highlighted for its potential to produce multiple products and environmental benefits at the local, regional, and global levels.

(3) Coal quality varies widely among APEC economies, and in Indonesia, almost 60 percent of total resources are low quality lignite. It is recognized that in order for Indonesia to sustain growth in coal exports in the long term, it will need to introduce technologies for upgrading its lower grade coals at competitive costs. Papers were presented on technologies for producing both high quality briquettes and coal-water mixtures.

(4) Until recent years, coal workshops and conferences rarely included papers on cultural and community concerns related to large coal mine and power plant developments. However, the future of coal developments is increasingly dependent on local community acceptance. Papers reviewed activities underway in different economies to gain community acceptance of coal mining and coal-fired power plants. One paper outlined local community concerns that should be met at each stage of exploration and development of a mining project, and emphasized the need to ensure participation of all interest groups, including indigenous people.

Second APEC Coal Trade and Investment Liberalisation and Facilitation Workshop – Philippines	1998	EGCFE
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Project Summary

The theme of this workshop was “The Philippines Coal-Energy Sector: Facilitating Trade and Investment”. Important goals of the workshop were to ensure continued stability in the coal chain, promotion of greater transparency and competition in coal investments and trade, and clean coal technology options to ensure that coal can meet stringent environmental regulations. Particular attention was given to the Philippine coal and electricity sectors. The workshop was held in Manila, The Philippines in April, 1998.

Project Outcome

The Philippines keynote address to the workshop reviewed the history of energy and energy policy developments in the Philippines, including opportunities and possible concerns related to the further privatization, deregulation, and liberalization of the Philippine energy sector. Potential constraints to stable coal supplies were examined, and included: (i) an analysis of the Asian economic crisis, and implications for short and long term coal demand, (ii) mine health and safety problems in the Philippines, (iii) environmental regulations and environmental

challenges to coal at both the local and global levels, (iv) community concerns about the environmental impacts of coal mining and coal-fired power plants, and (v) an assessment of the adequacy of Philippine port infrastructure for coal.

Although the economic crisis in Asia was significantly impacting energy consumption in Asian APEC member economies, the conclusion was that there would be limited long term impacts on coal demand in Asia. It was suggested that economic reforms resulting from the Asian economic crisis might benefit coal and natural gas at the expense of more capital intensive options: nuclear power and hydroelectric projects. Meeting increasingly tight environmental regulations and gaining community acceptance were considered greater challenges to long term coal industry performance than the Asian economic crisis.

Energy case studies were presented for Australia, Japan, Malaysia, and the Philippines. Papers on policies and regulations emphasized the promotion of more efficient, transparent, and competitive energy markets. The goal of more open and competitive energy markets was generally agreed upon by participants; however, the rate of introduction of reforms varied among economies. The sometimes elusive goal of improving the image and community acceptance of coal was discussed, accompanied by a video presentation about a successful program to achieve community acceptance of a coal-fired power plant in Australia.

There were differing views on the seriousness of global warming, but the general consensus of opinion was that coal's best defence to protect its market share was a sustained offensive to meet tighter environmental standards at prices competitive with alternative energy options. A number of speakers referred to the critical role that clean coal technologies could play in coal's future. Papers covered both coal cleaning (beneficiation) and clean coal technologies to burn coal more cleanly. Two papers referred to the potential importance to coal of integrated gasification combined cycle (IGCC) technologies in meeting longer term environmental challenges. It was pointed out that IGCCs give coal three important advantages: (i) the highest efficiencies in electricity generation, (ii) potential for production of multiple energy and chemical products, and (iii) the lowest cost option for the eventual recovery of CO₂, if and when recovery is necessary.

Although IGCCs received considerable attention in the workshop, it was noted that there were a number of other promising clean coal technologies in commercial use in APEC economies. The complex economic and investment risk factors that influenced the selection of clean coal technologies suggested their selection should be the result of private investment decisions in competitive markets and not by government regulations.

The increasing role of the private sector in the coal chain and in electricity generation provided a common thread through the workshop sessions. The role of the private sector was also reflected in the mix of workshop participants, which included senior representatives from both the private and public sectors.

In conclusion, the Asian economic crisis was viewed as having limited long term implications for coal demand in Asia. The largest challenges were to ensure that coal could meet ever tightening environmental standards at prices competitive with alternative energy options, and could improve its image and achieve greater community acceptance. The consensus was that a strong coal industry could be sustained in a business environment of competitive, transparent energy markets, and sound energy and environmental policies. The role of coal in the Philippine

power sector was projected to greatly increase between 1998 and 2010.

Continued cooperation on both technical and policy exchanges among APEC members was viewed as beneficial to the enhancement of stable and environmentally sound energy sectors among APEC economies. This APEC sponsored workshop promoted active discussions among participants from industry and government, and contributed to the better understanding of coal-related problems and possible solutions in APEC economies.

Third APEC Coal Trade and Investment Liberalisation and Facilitation Workshop – Vietnam	1999	EGCFE	EWG05/1999T
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Project Summary

The theme of this workshop was “Vietnam: Facilitating Development in the Coal and Power Sectors”. An important objective for the workshop was to provide a forum for the exchange of technical and economic information among APEC member economies on facilitating the development of the coal and power sectors, with emphasis on issues important to Vietnam. The workshop was held in Hanoi, Vietnam in November, 2000.

Project Outcome

The workshop opened with presentations by senior Vietnamese officials on the energy situation in Vietnam, and the outlook and challenges facing its coal and power sectors. A review was presented on improvements underway in Vietnam's legal framework for foreign investment in the coal and power sectors. Another APEC economy, Indonesia shared its experiences in developing mining contracts and fiscal terms to promote active coal developments.

Regional and global energy and environmental trends were discussed, including possible implications for Vietnam of tighter environmental standards related to coal use. Speakers believed that continued growth in coal consumption in Asia, in conjunction with tighter environmental constraints, would promote more rapid introduction of cleaner coal and clean coal technologies.

A number of speakers discussed the technical aspects of environmental, health and safety issues associated with coal mining. A review was presented of the steps in the technical and economic evaluation of the commercial potential of coal mine methane for electricity generation. During the question and answer period a number of suggestions were made on potential sources of funding of investigations into the coal mine gas potential of Vietnam, including APEC Clean Fossil Energy Expert Group, the Asian Development Bank, World Bank and the UN Global Environmental Facility.

Speakers reviewed the status of research on clean coal products and clean coal technologies to achieve higher energy conversion efficiencies and enhanced environmental performance. Speakers agreed that Vietnam has a substantial and important energy resource in the form of anthracite, and examined specific problems in using anthracite for electricity generation. Four power plant options were suggested for Vietnam's anthracite, including: down shot fired boilers, atmospheric fluidized bed boilers, pressurized fluidized bed boilers and gasification of anthracite to produce multiple products, including chemicals in addition to electricity generation.

In the financing area, issues addressed included raising funds from equity sources,

commercial and multilateral banks, and a review of criteria used by investors and lenders to major projects. A list was presented of 17 leading companies providing advice on project financing.

Finally, an analytical review was presented on the positive and negative results of electricity reforms in Australia to produce more competitive markets. Although deregulation has produced lower prices to the consumer, the complexity of the resultant changes in market behaviour were not fully understood when reforms were implemented.

In conclusion, the workshop provided an excellent opportunity for participants from other APEC member economies to learn more about both the challenges and progress being made in Vietnam's coal and power sectors. The workshop provided a forum for constructive exchanges among participants from various APEC economies on their experiences in dealing with problems of common concern to APEC coal producing and consuming economies.

Fourth APEC Coal Trade and Investment Liberalisation and Facilitation Workshop – Malaysia	2000	EGCFE	EWG06/2000T
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Project Summary

Project summary not available.

Project Outcome

Project report not available.

CLEAN COAL

The Role of Coal and Clean Coal Technologies in the Asia Pacific Region	1993	EGCC	
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Project Summary

The aim of the project was to develop a better understanding of regional issues concerning environmental aspects of coal and coal technologies.

Project Outcome

Project report not available.

Technical Training Course on Clean Coal Technologies	1994	EGCC	EWG03/1994
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Project Summary

Training course held in Sydney, Australia in November/ December 1994 to strengthened understanding of both the technical aspects of clean coal technologies and the techniques for evaluating technology options.

Project Outcome

Project report not available.

Technical Training Course on Clean Coal Technologies	1995	EGCC	EWG06/1995
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Project Summary

Training course held in Kitakyushu, Japan in September 1995 to provide training on the technical, environmental and economic aspects of clean coal technologies.

Project Outcome

Project report not available.

How Can Environmental Regulations Promote Clean Coal Technology Adoption in APEC Economies?	2006	EGCFE	EWG05/2006
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Project Summary

The objective of this study was to assess experience to date in developed APEC economies regarding the interaction of environmental regulations with clean coal technology deployment and, based on this analysis, make recommendations on regulatory methods that promote investment in new commercial clean coal projects in developing APEC economies.

Project Outcome

Environmental regulations for coal-fired power are quite extensive and continue to evolve as new issues, such as water shortage, mercury emissions, and climate change have emerged. Particularly, the regulation of greenhouse gas emissions, such as carbon dioxide, promises to have a significant impact on the future use of coal for power generation. This study examined both existing and emerging regulatory frameworks in order to determine which type of regulations would be most effective in promoting clean coal technology adoption in developing APEC economies and would be practical to implement.

The pollutants and environmental regulations examined in the study covered the entire project cycle from permitting, construction, and operation of coal-fired plants and were generally categorized into three major groups:

- **Regulations targeting air emissions.** These include regulations concerning local air pollutants such as sulfur dioxide (SO₂), nitrogen oxides (NO_x), and coarse and fine particulate matter (PM₁₀, PM_{2.5}); mercury (Hg); and carbon dioxide (CO₂) which is the major greenhouse gas (GHG) attributed to coal-fired power generation.
- **Regulations targeting water use.** Relevant regulations or guidelines affecting coal-fired power plants including: 1) water temperature, 2) water intake, and 3) effluent standards for water released from the power plant.
- **Regulations concerning coal combustion by-products.** These typically involve: 1) classification as hazardous or non-hazardous wastes, which determines subsequent treatment and disposal; 2) allowable uses and disposal practices, such as recycling in other products; and 3) management practices of toxics in disposed and recycled combustion products.

When considering the potential effect of existing and new environmental regulations on the adoption of clean coal, the analysis of technologies was organized into three categories:

- **Environmental control technologies.** These typically include flue gas desulfurization (FGD), selective catalytic or non-catalytic reduction (SCR/SNCR) systems, electrostatic precipitators (ESPs) or fabric filters.
- **High efficiency coal combustion technologies.** These include supercritical, ultra- supercritical, pressurized fluidized bed combustion (PFBC), and integrated gasification combined cycle (IGCC) technology.
- **Carbon dioxide capture and storage.** Capture technologies may include pre- and post-combustion capture and oxyfuel combustion. Storage of CO₂ can be done in geological formations such as oil or gas fields, saline formations, or coal beds.

To target the recommendations towards APEC economies that would benefit the most from this analysis, the project focused on developing and transition APEC economies that are expected to rely on coal for a large part of their future generating capacity. These economies include China, Indonesia, the Philippines, the Russian Federation, Thailand, and Vietnam. Influenced by rising populations and increased standards of living, these APEC economies are turning to cheap energy sources to fulfill their energy demands and improve energy security. Coal will provide the fastest growing source of energy in all of these economies, except in Russia, where natural gas and nuclear will continue to represent the greatest share of power generation.

The project found that, in general, policies that provide flexibility in meeting environmental goals are more cost-effective than those obliging specific technologies or controls to be installed with all new fossil-fired plants. Therefore it was recommended to employ a mix of the possible regulatory options: emissions trading, technology standards, and thermal efficiency targets. Most likely, developing APEC economies would start with technology and/or efficiency standards, because these are more straightforward to implement. In the meantime, they could then begin preparing the infrastructure for emissions trading.

The project also identified other short-term options to strengthen environmental standards and encourage the adoption of clean coal technology in new coal-fired power plants, including:

- in the case of Malaysia, Philippines, Indonesia, Russia, Thailand, and Vietnam strengthening the existing NO_x, SO₂, and particulate standards, particularly for new capacity. Russia is a special case, because the first step in improving its regulatory framework, should involve moving from a system based on dispersion modeling to actual measurements of stack emissions;
- for all economies, increase emission fees and levies to incentivize abatement. The fees must be set at such a level that it becomes more cost-effective to invest in environmental controls or efficient coal combustion rather than paying the fee;
- for all economies, encourage a switch from emission limits based on mass concentration output (i.e., mg/m³) to performance standards based on energy production (i.e., kg/kWh). This approach would provide incentives to operate sources more efficiently, thus encouraging the use of more efficient combustion technologies;
- for all economies, encourage the addition of limits for mercury;
- building on ongoing efforts in China, implement government targets for the use of more efficient combustion systems in all economies, such as supercritical, ultra-

supercritical, and IGCC technology. Activities should start with improving regional information and data repositories on power plant efficiencies and combustion technologies;

- to build capacity for emissions trading, require the use of continuous emissions monitoring, starting with large new facilities.

Long-term options identified by the project included:

- introduce a CO₂ emissions trading system for China in the near term, and at a regional basis for the remaining developing APEC economies in the long term. The system must be designed in such a way (i.e., long-term timeframe and stringent caps for the electricity sector) that the market price will support investment in capital intensive clean coal projects. This could be done by gradually lowering the cap to give economies some time to adapt to the trading system, but at the same time providing a long-term signal that increased efficiency will be required.

Although it may be expensive and difficult to implement upfront, the quick introduction of more stringent environmental regulations could be beneficial to developing economies that plan to continue expanding their coal capacity. Because of economic and population growth in these economies, and the subsequent rapid expansion of coal-fired power, a slow introduction of legislative improvements could result in further degradation in air quality in the long-term and a significant increase in CO₂ emissions resulting from the long turn-over time for technology in the power sector.

Instead, the project found that 'technology leap' opportunities are possible by moving quickly towards efficient coal combustion and CO₂ control, which would allow developing nations to avoid projected increases in local air pollution and GHG emissions. Addressing both CO₂ and local air pollutants at the same time, would avoid costly technology retrofits and improvements at a later stage and would alleviate strains on water resources and landfills.

The expense of such systems would normally be prohibitive for developing nations. Therefore, significant funding from international organizations would likely be required. The project concluded that policies that attract such funding – either through the Kyoto Protocol or other technology transfer funds – would be beneficial.

ELECTRICITY GENERATION

Sustainable Electricity Supply Options for the APEC Region	2001	APERC
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Project Summary

The main objective of this study was to consider current and future electricity supply requirements in the Asia Pacific region within a framework of energy sustainability. The goal was to alert energy planners in the Asia Pacific region to the possibility that a continuation of past electricity supply practices may not make the most commercial sense in a world where a number of paradigm shifts over the next one or two decades could fundamentally change the way in which power is delivered and consumed.

Project Outcome

This project reviewed the major emerging energy technologies, including small and micro-scale power sources, cogeneration technologies, and advanced integrated

techniques. Many emerging energy technologies are renewable, including solar, wind, biomass, and small-scale hydropower. Some, such as micro-turbines and fuel cells, can operate on renewable and fossil fuels.

A key feature of almost all the technologies discussed is the fact that they are either small-scale by nature, or suited to small-scale applications. Rather than being a disadvantage in modern energy systems, such technologies are at the forefront of an emerging trend - distributed power - that may change the face of the energy supply industry over the next few decades.

The development of mini- and micro-scale energy technologies, as well as liberating energy consumers in economies where energy market reforms are allowing much greater choice with respect to power supply options, may also provide much needed solutions to the needs of isolated and poorer rural communities.

Remote area power systems have had a mixed history in terms of success, and both lending institutions and governments tend to promote investment in grid extension over investment in remote power systems. This is an area of policy that could benefit from further investigation. With the ongoing development of energy technologies suited to small-scale, micro-grid applications, it may prove more cost-effective, at least in the short-term, to focus on investment in micro-grid system development in many situations, and intensify efforts to ensure the success of such ventures.

Large-scale grids increase security of supply, and ensure higher quality of power for demanding applications, but may be much less cost-effective, and a poorer policy option for poor rural communities in immediate need of economic stimulation. It is clear that newly emerging small-scale energy technologies could play a very important role in meeting the energy needs of rural and poor communities in the Asia Pacific.

The project looked at some specific energy system issues in a number of Asia Pacific economies. Included were descriptions of the emerging energy systems and issues in some selected developed and developing APEC economies. Developed economies have very different energy growth patterns, and energy policy issues are different to those in the rapidly industrialising part of the APEC region. The developed case studies included consideration of specific emerging electricity supply situations in New Zealand and Japan. The developing economy case studies focused on China, the Philippines, Malaysia and Thailand.

How do fast developing APEC economies meet the challenge of exponential growth in electricity supply requirements, while at the same time minimising the impacts this growth will have on the environment? In this project, this challenge was addressed within the context of long-term sustainability. Decisions made now will have a great impact on the ability of individual economies to put in place electricity supply systems that can be maintained over the long-term. The continued construction of traditional coal-fired steam turbine plants can be considered an unsustainable practice, not because of resource scarcity (there are sufficient coal reserves world-wide to last for hundreds of years even with expanded consumption), but because the environmental and health impacts are too great.

Costs and Effectiveness of Upgrading and Refurbishment of Older Coal-Fired Power Plants in Developing APEC Economies	2003	EGCFE	EWG04/2003T
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Project Summary

This project assessed the costs and effectiveness of various power plants upgrades and operational and maintenance improvements to APEC developing economies' pulverised coal-fired power stations, indicating how to assess and prioritize them for detailed evaluation, and provided a methodology for evaluating the impacts of the higher priority improvements, both economic and environmental, as an aid to decision-makers.

Project Outcome

The report of this project provides information pertinent to the upgrading and refurbishment of older pulverized-coal plants in developing APEC economies. Included are:

- descriptions of equipment operational improvements, examples for assessing and prioritizing equipment improvement options for further evaluation, and a suggested methodology for evaluating the impacts of the high priority improvements. Power plant engineers and managers will find guidance for improving the operation of their plants in this report;
- reference information comprising descriptions of a generalised plant and certain equipment;
- rankings of the effectiveness and costs of a range of plant refurbishment and upgrade measures;
- assessments of the impact of the specific upgrade and refurbishment measures on plant generating efficiency, air and waste emissions (including CO₂), plant availability, power production, and the cost of electricity generated;
- an assessment of the amount of generating capacity in different APEC economies likely to benefit from the application of plant refurbishment and upgrade measures;
- an estimate of costs and potential CO₂ emission reductions achievable through application of a range of upgrading and refurbishment options to the existing inventory of coal-fired power plants in APEC member economies;
- identification of the major barriers to implementing successful upgrading and refurbishment projects at existing coal-fired power plants in APEC developing economies.

The project found that upgrading and refurbishment is usually best implemented by executing the following activities:

1. Conduct a plant assessment that identifies the potential highest priority plant equipment performance improvements. The project report includes descriptions of high priority equipment design and operation relevant to performance improvements.
 2. Based upon the prioritization, select the equipment improvements to be analyzed in detail. The selection should be based on feasibility, available
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capital funding, cost -benefits, and plant operations considerations

3. Complete a detailed analysis which provides estimated equipment performance improvements (including CO₂ reductions), estimated required capital costs, and operations and maintenance cost differences. This evaluation may also include operating reliability improvements that may be applicable.

The project report includes case studies for boiler air heaters, steam turbines, and condensers. An example economic spreadsheet is provided for each case study using the present worth evaluation methodology for comparing the estimated value of performance improvements to the required capital cost expenditures. Other economic evaluation methods could be used. The results of these case studies show that it is often economical to invest capital for performance improvements, which most often also brings the additional important benefit of reduced CO₂ emissions.

The information provided in the project report includes detailed technical equipment and systems improvement descriptions, prioritization tables and case studies that show how plant equipment upgrading and refurbishment projects can be justified. Also, the report provides a brief explanation of general overall pulverized-coal plant design and basic equipment operating concepts that can have a major impact on performance. This information is not at the design level of detail, which would require volumes, but should be sufficient to facilitate communications between government, plant operations, management, plant operators and others involved in upgrading and refurbishment projects. References are provided for additional design information. The focus is on pulverized-coal plants, but portions of the information and methodology provided are applicable to other types of plants.

Nuclear Power Generation in the APEC Region	2004	APERC
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Project Summary

Nuclear power has been an important component of the electricity systems in the APEC region since the 1950s. Yet there is debate concerning the viability of nuclear power due to concerns about its cost, safety, waste disposal and proliferation. The role nuclear power can play in APEC can be better assessed by analysing its current status and the forces driving the technology in the region, and by looking at the factors that will influence the development of nuclear power in the future. The objective of the project was to give policy makers a better understanding of nuclear power's present standing and recent developments, as well as to give an assessment of what role nuclear power can play in the future of APEC.

Project Outcome

The project found that the role nuclear power can play in APEC in this scenario can be better assessed by analysing its current status and the forces driving the technology in the region, and by looking at the factors that will influence the development of nuclear power in the future.

Drivers of Nuclear Power in APEC

The project concluded that the most important drivers of nuclear power in APEC are scarcity or uneven distribution of local energy resources, high expected electricity demand growth and the need to reduce greenhouse gas emissions.

- Economies in APEC with the highest share of nuclear power generation in their
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electricity systems were economies with high dependency on imported fuels.

The most notable cases were: Korea, with an energy import dependency of 84 percent and a nuclear generation share of 40 percent; Japan with an energy import dependency of 80 percent and a nuclear generation share of around 30 percent; Chinese Taipei with an import energy dependency of 89 percent and a nuclear share of 21 percent; and United States, with an energy import dependency of 27 percent and a nuclear share of 20 percent.

- APEC's characteristic fast growing electricity demand would have to be satisfied with a diversified pool of energy sources. Economies in the region with some of the most aggressive nuclear expansion programmes were economies that had expectations of fast electricity demand growth in the future: China with an expected average electricity demand growth rate in the next 20 year period of 5.6 percent, planned between 32 and 40 GW of nuclear capacity by 2020. Korea with an expected electricity demand growth rate of 4.7 percent average for the next 20 years, planned a total of 28 operational units by 2015. Russia, with an expected electricity demand growth rate of 3.8 percent, planned 50 GW of nuclear capacity by 2020 and 60 GW by 2030. Vietnam, the economy in APEC with the highest expected average electricity demand growth rate for the next 20 years, was evaluating plans for the construction of its first two nuclear plants to be operational by 2019, and a decision of whether or not to go ahead with the project was expected soon after the publication of the project report.
- All APEC economies with nuclear power programmes cited sustainable development as one of the major reasons behind implementing nuclear power. Many APEC economies were committed to reducing greenhouse gas (GHG) emissions and in a few cases were even bound by international obligations to do so. Canada, Japan, Russia and New Zealand were all required under the Kyoto Protocol to reduce GHG emissions and were hard pressed for cleaner electricity generation sources. The first three, with some of the lowest CO₂ emission targets under Kyoto in APEC, together with United States, with its own programme to fight global warming, had active nuclear power programmes and were counting on them to aid in meeting their CO₂ emission goals.

Economic Competitiveness

For nuclear power to become once again a viable option for electricity generation, it should strive to be economically competitive without relying on factors external to the nuclear industry, such as increases in the prices of alternative fuels, and carbon taxing or trading schemes. The economic competitiveness of nuclear power rests mainly on its ability to reduce investment costs.

Uranium Resources

The project concluded that enough uranium resources recoverable with today's technology existed to cover nuclear generation needs for the next 50 years or more. The higher the expansion of nuclear energy in that period, the more resources with less geological assurance and higher extraction cost would have to be used.

Radioactive Waste Management

The project found that enough experience existed in radioactive waste technology to safely manage every step of its handling and type of process required, except for the final disposal of high level radioactive waste (HLW).

Alternative Nuclear Futures in APEC

In the Moderate Nuclear Development Scenario, a nuclear generation share of 11 percent of the total power generation fuel mix could be had in the entire APEC region by the year 2050. This scenario reflects moderate nuclear expansion programmes in all APEC economies with nuclear power programmes and includes 3 new nuclear economies.

In the High Nuclear Development Scenario, that reflects the most optimistic nuclear expansion plans of APEC economies and incorporates 6 new nuclear economies, nuclear generation share in APEC could reach 19 percent by the year 2050.

Areas for Collaboration in APEC

There are areas for possible collaboration in APEC that could bring about benefits in cost, safety and security to all those involved. Some of the topics for collaboration could include: reactor technology development, centralisation of fuel cycle services, development of nuclear licensing procedures and regulation, and communication and social acceptance.

In waste management, especially beneficial areas for collaboration could be the construction and operation of regional deep geological high level waste repositories, although at present there are a number of legal and political difficulties to implement them. Other more achievable proposals could be high level waste technology research, low and intermediate level waste processing and preparation methods, waste standards and licensing, capacity building, and the joint construction and operation of underground research laboratories.

Conclusion

The project concluded that nuclear energy deserves to be reconsidered by APEC economies planning their future energy systems. In view of the world's rapidly increasing energy demand and the reduced number of environmentally sound and dependable options to meet such demand, nuclear power stands as a viable option.

There is an overstatement of nuclear energy's drawbacks; especially over issues such as safety, waste, and economics, and there is also an understatement of nuclear energy's benefits. Many important concerns presently existing in APEC can be addressed by nuclear power. A comprehensive balance of benefits versus drawbacks might result in nuclear power being beneficial to a number of APEC economies.

Comparison of nuclear power against competing power generating alternatives could also render it attractive in some cases in the APEC region. But for nuclear power to have a prominent position in the electricity generation scene, advances have to be made on the most controversial issues. This will entail from participating economies and their governments undertaking major responsibilities to ensure continued safe operation of nuclear facilities, political decisions to develop and implement national waste management strategies, and international action to adopt more effective nuclear proliferation controls.

Lessons Learned in Upgrading & Refurbishing Older Coal Fired Power Plants: A Best Practice Guide for APEC Developing Economies	2007	EGCFE	EWG05/2007
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Project Summary

A previous APEC project described upgrading and refurbishment options to improve plant efficiency, performance and reliability. The results of this project were considered sufficiently significant to warrant a follow-up of a more specific nature, drawing from project experience in APEC member economies. The objectives of this project were to (1) illustrate the methodology and its usefulness as a decision-making tool using actual case studies, (2) draw lessons from plant upgrading project experience that may serve to improve the prioritization and economic assessment methods proposed, and (3) make usable information, tools, and best practice guidelines more widely available to APEC developing economies faced with decisions on how to obtain the best value for the limited funds they have available for upgrading.

Project Outcome

This project examined various refurbishments and upgrades implemented by coal-based power plants located in developing economies in the APEC region. The study group collected and retrieved information from various sources, including the Internet, the APEC ECGFE and WorleyParsons databases. One other vital source of information was a visiting delegation electric power industry officials from the People's Republic of China (PRC), which provided the study group with an up-to-date perspective of the current trends in PRC's approach to aging power plant upgrades and refurbishments.

While the main focus of the project report was to draw lessons from actual cases of coal-fired power plant upgrades and refurbishments, it also explores the processes, which lead to decisions by power utilities to upgrade or refurbish their generating units. The report discusses ways of assessing major power plant component degradation and also analyses the effect of aging on plant efficiency, safety, availability and reliability and presents ways to countercheck plant equipment aging degradation. The latest approaches in the industry to assess the remaining service life of power generating units are discussed. These approaches include non-destructive testing methods, which are part of a thorough evaluation, inspection and review of all critical components of the power plant. The use of plant performance testing and trending is also discussed as part of the basis for decisions to implement upgrade and refurbishment activities.

Six study cases are presented in the project report. Case studies include upgrades and refurbishments of air heaters, boiler burners, soot blowers, steam turbines, condensers, instrumentation and control systems, induced draft fans, and coal pulverizers. The case studies include the costs incurred in the upgrades and the corresponding benefits derived. As a yardstick to measure economic viability of the upgrade projects, the Discounted Cash Flow Rates of Return (DCFROR), Net Present Values (NPV's) and payback periods are calculated in each study case.

The lessons learned from these coal-fired electric power generation plant upgrades, are compiled into a Best Practices Guide for Developing APEC Economies. This best practices guide can serve as a reference document for electric power utility companies; particularly those situated in developing APEC economies, which intend

to upgrade their older coal-fired electric power generation units.

Environmental Monitoring for Coal-Fired Power Plants in Developing Asian APEC Economies	2007	EGCFE	EWG06/2007
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Project Summary

The objectives of this project were: to gather, synthesize and assess experience in Asian APEC economies with regard to environmental monitoring and reporting by individual coal-fired power generating plants; and to make recommendations regarding how monitoring should be applied and how it should interact with regulations for effective adoption of clean coal technologies.

Project Outcome

The project report presented the following recommendations tailored to developing Asian APEC economies based on lessons learned and effective practices in Australia, Canada, the EU, and the US.

Strengthen the Overall Air Quality Monitoring Framework

The air quality monitoring systems in China and other developed Asian economies are at a relatively early development stage. Many of the local and regional monitoring systems cannot separate the impact of different sources of pollution and, as a result, authorities may not have sufficient information to determine whether measures targeting coal-fired power and other large industrial sources are effective at meeting their objectives.

To strengthen the ambient air quality framework, national authorities may want to require air quality monitoring in the vicinity of large plants. They could also require monitoring of coal-fired power plants prior to obtaining a permit for building a new unit or expanding an existing unit. In this case, the monitoring station must be set up before the new facility is built to assess air quality before the operation of the facility; this is usually done for at least one year. The monitoring has to be undertaken near and surrounding the source of interest and it has to be upwind and downwind of the prevailing wind direction. To meet this requirement, each source would need a minimum of three monitoring stations to produce a useful result. In addition, a dispersion model must be developed to predict the pollution around the source before the project is implemented. The model would be calibrated using the actual measurements and would then be used after project implementation to assess the impact of the new generating unit.

If interference from other pollution sources is low, the difference between the upwind and downwind measurements could be representative of the impact of the new emission source. However, in some cases, existing urban pollution in Asian cities may be too high to produce accurate results. In that case, local authorities must critically re-evaluate their entire air quality monitoring network.

Authorities should also begin to develop emission inventories of large sources that can be used for identifying and categorizing various sources. This should include any new sources that are expected within the near future.

Developing a more sophisticated air quality monitoring system will require a substantial amount of resources, both on the part of the utilities which will be required to install monitoring stations in the vicinity of the plants and on the part of the local authorities that must enhance the capabilities of the overall monitoring

framework and dispersion modelling system. Significant support from international organizations would likely be required. National and regional authorities must also weigh the near-term financial costs with the long-term benefits of improving air quality and reducing negative health impacts to local populations.

Streamline Regulations and Monitoring Practices

In some economies, such as China, a series of new regulations and monitoring guidance affecting coal-fired power have been introduced over the past ten years. In some cases, these national requirements have been augmented by local guidelines and standards. As a result, it is not always easy for plant operators to determine which practices to follow and local authorities have not always adapted to the federal mandates. For example, many local governments do not always incorporate data collected from CEMS into the calculation of emission fees thereby removing the incentive for using these systems once installed. Better coordination and streamlining among all regulatory and implementing bodies would help alleviate this problem.

Establish Pollutant Inventories for Public Data Disclosure and Regulatory Review

Public data disclosure, in addition to public involvement, is a key component of successful monitoring frameworks in developed economies and one that is often missing or underutilized in developing economies. Australia, Canada, and the EU each require coal-fired power plants to report on pollutants released to the air, water, and waste to national inventory programs in order to provide free, public information about environmental areas of concern. The information is also used to evaluate progress towards meeting environmental objectives and for identifying areas that need improvement. Over the years, these national inventories have become important indicators of environmental management in each individual economy.

A key component in developing an effective monitoring framework in developed Asian economies would be to establish such inventories. This would include investment in /development of the infrastructure required to support automated public data reporting, as well as guidance documents and training for operators.

Comprehensive Guidance for CEMS

If continuous emissions monitoring is not already required, national governments should begin working towards the use of such systems. If resources are short, governments may begin by requiring new facilities to adopt these. In the medium term, once the use of PEMS has become more established in the US and other developed economies, Asian economies may also want to begin including these in their monitoring regimes.

The use of CEMS should be accompanied by extensive technical guidance for its certification, operation and management. This includes standards for the plants using these and the local authorities overseeing their implementation and analyzing the reported data.

Develop Streamlined Monitoring Support Documents

Organized, easy-to-find references and guidance manuals on regulations and monitoring practices provide a meaningful, relatively simple way to help utilities fulfil their monitoring responsibilities. In many cases the regulations and monitoring regulations are highly detailed and potentially hard to follow. It often easiest to follow and understand regulations and corresponding monitoring requirements when

all the information – including emissions to air, water and land – is in one document. Presenting the material in such a manner may allow operators to use of synergies between different monitoring practices.

Ensure Effective Enforcement

A critical component of a successful monitoring framework is ensuring that monitoring practices are followed in order to meet all applicable standards/goals. Inconsistent, infrequent or minimal enforcement is problem in a number of developing Asian economies. Suggested improvements include:

- additional financial support to increase the number of auditors and their efforts;
- increased frequency and number of site-visits;
- development of metrics for tracking and improving performance;
- monitoring by techniques, such as CEMS or PEMS, that automate all data acquisition, so it can be reported and processed in a timely manner directly to authorities with minimal, if any, manual interference; and
- purchase/development of automated auditing software for tracking and analyzing reported data.

Technology Status and Project Development Risks of Advanced Coal Power Generation Technologies in APEC Developing Economies	2007	EGCFE	EWG06/2007A
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Project Summary

The objectives of this project were:

- to gather, synthesize, and assess information on experience to date in APEC economies with regard to the status, performance, relative costs, and project development/financing risks for integrated gasification combined cycle (IGCC) coal-based generating plants versus supercritical and ultrasupercritical pulverized-coal plants operating in different economies;
- to make recommendations on policy measures and financial incentives needed to favour projects using clean coal technologies in APEC economies where energy needs are expanding rapidly and coal is the fuel of choice, and on further international collaboration that would assist in achieving this objective;
- to make recommendations for power generation sector capacity-building in developing economies through improved knowledge and access to information on constructing, operating and maintaining cleaner and more efficient new coal-fired plants.

Project Outcome

The project examined the development status of advanced coal power generation technologies and the accompanying development risks of such technologies as they are adopted by developing economies in the APEC region.

The study collected and retrieved information from various sources, including the Internet, the APEC ECGFE and WorleyParsons databases. The study data collection also involved communicating directly with various power plants in APEC developing economies, where advanced coal power plant technologies are presently being developed.

Three types of advanced coal power generation technologies were included in the study:

- supercritical (SC) pulverized-coal power plants;
- ultra-supercritical (USC) pulverized-coal power plants;
- integrated gasification combined cycle (IGCC) plants and processes.

The project undertook a technology status review that described the historical backgrounds and the most recent developments in each of these technologies. The technology status review described in brief advanced coal-based power generation technology cycle features, current trends and future expectations.

Project development risks and barriers in relation to advanced coal-based power technology were identified in the study. For each perceived risk and barrier, risk management measures and countermeasures were proposed, tailored to the current situations prevailing in the APEC developing economies.

The study analysed the economic feasibility of each of the three advanced coal power generation technologies. The levelised life cycle cost of each of the technologies was evaluated. Multiple cost values were calculated, including sensitivity case analysis based on key project parameters, such as installed cost, fuel cost and plant capacity factor. The quantitative indicators and cost values of the three advanced coal technology options were calculated for each of a series of case studies.

The study concluded that coal will remain as a primary source of fuel for electricity generation in the APEC region, especially among the developing member economies. Coal as a source of energy was identified as a key factor for APEC developing economies, especially among the 'emerging' economies, in sustaining their economic growth and developments. The APEC developing economies that depend largely on coal must keep up with the growing trend in the electricity generation industry to achieve significant progress in mitigating greenhouse gas emissions.

To encourage power utilities to adopt advanced coal power generation technologies, the study recommended that developing APEC member economies implement the following policies and strategies.

1. Tariff discount grants or outright exemptions on customs duties for imported advanced technology coal power generation plant components, such as coal gasifier components for IGCC's, and high-alloy steel tubing for supercritical and ultrasupercritical steam generation plants. This measure would reduce the installation cost of the plant.
 2. Provision of tax credits to electricity utilities that build new plants using advanced coal-based power generating technologies, such as SCPC, USCPC, and IGCC. Legislation of new tax laws may be required to provide such credits and tax breaks.
 3. Establishment of licensing agreements with foreign suppliers or original equipment manufacturers (OEMs), in order to facilitate the local manufacture of major power plant components, thereby cutting installation cost of new coal power generating plants.
 4. Government support in the creation of an advanced technology coal power generation demonstration project, which can also provide a solid base for
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international exchanges and cooperation in the field of clean coal technology.

5. Improvement in coal handling and transport infrastructure to reduce the coal cost to power plants in the long run. A stable and competitive coal price is a very strong incentive for power utilities to build new coal-fired power generating units.
 6. Provision of funds for research, promotion, development and diffusion of knowledge and ideas pertinent to these advanced coal IGCC, SCPC and USCPC power generation technologies. Dissemination of such information could be channeled through government departments and agencies, which are dealing with energy and electric power generation. It could be more effective if done in coordination with the academic community and business sector.
 7. Development of IGCC test base and plan for the deployment of IGCC technology in APEC developing economies. The test base will make use of the IGCC demonstration plant and will rely on existing research, equipment, and installations to be located in a developing APEC-member economy, which could meet the requirements to host such a facility.
 8. Provision to key participants in advanced coal power generation technology projects the much needed support in the actual installation and operations of an advanced coal-based power plant that will be built using maximum possible local content, i.e., to reduce overall construction cost and to boost local industry.
 9. Establishment of a monitoring program related to advanced coal-based power generation technology. This technology monitoring program could be accomplished by a leading group at state or national level and could be incorporated into expert group(s) in the advanced coal power generation technology field. Such a combined, multi-disciplinary group could then conduct advanced technology project evaluations. The group can organize and coordinate the work of relevant research institutes, universities, manufacturers, and utilities
 10. Establishment of a state-level group of high-level experts from both the APEC member economies and technology provider economies. This would be another group distinct from the previous one. The responsibility of this group would be to make technical decisions regarding such matters as the import of technology, the evaluation and identification of relevant plans, the development of implementation schemes and feasibility reports, including development proposals related to advanced coal technologies for consideration by the government and concerned sectors of industry.
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NATURAL GAS AND COAL MINE GAS

APEC Joint Multilateral Demonstration Project for Recovery and Utilisation of Coal Mine Gas - Phase 1	1997	EGCFF	EWG06/1997
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Project Summary

The project published a site survey and selection report, an options analysis, a report evaluating possible options for use of coal mine gas in the region of the mine, and an environmental impact assessment report for a demonstration project for recovery and utilisation of coal mine gas.

Project Outcome

Project report not available.

Coal and Natural Gas Competition in APEC Economies	1998	EGCFE	EWG03/1998
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Project Summary

The project examined and summarised the status and potential role of coal and natural gas in each APEC economy. The survey paid particular attention to policy options that can enhance the participation of the private sector and open market forces in the selection and use of the competing energy reserves in meeting long-term electricity needs at the lowest long-term costs and with the lowest associated environmental impacts. The project also contributed to a technical resource database operated by APERC.

Project Outcome

The study focused on the technical, economic and policy issues affecting the competitive position between coal and natural gas in the power sector of the APEC economies. To provide insights to the changing roles of these two important energy resources, the study examined the following factors that affect fuel and technology choices:

- the competing sources of coal and natural gas;
- coal and gas prices;
- environmental constraints;
- technology options;
- and privatization and restructuring in the electric supply industry.

The study concluded that the competition between coal and natural gas was a complex process that involved the interplay of several parameters. It found that the competition between coal and natural gas was a result of an interaction among the above factors inextricably intertwined with the historical development of the energy sector.

The relative importance of coal and gas in the total energy mix was determined by the availability of coal and natural gas as indigenous resources. Economies with high reserves of coal tend to have higher shares of coal in power generation; economies with high reserves of gas use more gas; those with substantial reserves of both coal and gas tend to use both. Energy exporting economies however deviated from these trends due to the priorities of energy resources for exports. Economies without, or less endowed with, coal and natural gas, but with access to

the international market, tended to have balanced utilization of these fuels, though some economies preferred to use coal rather than gas.

The growth in the consumption of coal and natural gas was supported by those economies with a local resource base of these fuels and some net energy importing economies with access to these fuels in the international market. Unlike coal which has been a mainstay fuel in power generation, gas discoveries and development in most APEC economies (except in North America) have been recent. The momentum gained in gas consumption would likely be sustained in the medium and long term since national and regional gas infrastructures are currently being planned or developed.

The above trends were partly explained by fuel economics and the economics of electricity generation. Coal was cheaper than natural gas in the international markets. The domestic prices of these fuels however deviated from the international trend. Economies with huge reserves of coal tended to have coal cheaper than natural gas and those economies with big reserves of natural gas tended to have gas cheaper than coal. Similarly, for some APEC economies with certain price expectations, discount rate and technical assumptions, the levelized cost of electricity from coal was lower than from natural gas while, for some others, electricity generated from natural gas had a lower levelized cost than electricity generated from coal. There are other cost components that must be considered for which natural gas-fired technologies have a cost advantage over coal-fired technologies; these are capital costs, non fuel O&M and fuel efficiency.

Environmental factors are the main reason why some governments support the development of natural gas resources or continue to use imported but expensive natural gas. The rigidity of the command and control approach to environmental regulation (on which most of the APEC economies rely) favours an increase in natural gas utilization. In addition, the development of more efficient and cost-competitive gas-fired technologies makes natural gas an attractive fuel. However, the attractiveness of natural gas on environmental grounds did not diminish that of coal. The development of clean coal as well as advanced technologies that comply with stringent environmental standards retained coal as the fuel choice of those economies traditionally dependent on coal and those with huge coal reserves. Though the capital costs of these technologies are relatively higher, lower coal prices can offset this, resulting in still lower levelized cost of electricity.

Concerns about global warming, especially for those member economies with international commitments under the Kyoto Protocol, were not being resolved with these technological developments related to coal. The development of flexible and clean development mechanisms and global emissions trading could however maintain the level of coal use in APEC economies that are highly dependent on coal.

In addition to the above factors, liberalization in the electricity supply industry indirectly contributed to competition between coal and gas. IPPs tended to select fuel based on the availability of the resource in the economy. Thus, in economies with huge reserves of coal, IPPs invested in coal-fired technologies, while in gas-rich economies, they invested in natural gas-fired technologies. Other factors that influence the fuel choice of IPPs include relative fuel prices, attractiveness of the technology, environmental considerations and the costs of generation. However, IPPs tend to prefer natural gas when it is available since natural gas-fired technologies have relatively low capital construction cost, a well-established gas

technology, short construction time, higher conversion efficiency and lower environmental impact.

APEC Joint Multilateral Demonstration Project for Recovery and Utilisation of Coal Mine Gas - Phase 2	1999	EGCFE	EWG01/1999S
Site Survey Report of Phase 2 of the APEC Coal Mine Gas Project			
Study Report of Environmental Impact Assessment			

Project Summary

This project continued the development of a demonstration project for recovery and utilisation of coal mine gas. Specific activities and products of Phase 2 of the project included: 1) a site survey in Tiefert Coal Mining Administration and Tielin City of Liaoning Province, People's Republic of China in January 1998; 2) a Coal Mine Gas Experts Workshop in Tokyo in May 1998; 3) two reports.

Project Outcome

Project report not available.

APEC Joint Project for the Recovery and Utilisation of Methane Emitted from Municipal Landfills	1999		EWG SF99-3
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Project Summary

The major output of the project was an assessment of the quality and quantity of the land fill gas resource at selected sites in Thailand, Indonesia and the Philippines. Capturing and harnessing landfill gas represents one of the promising options for APEC economies to concurrently minimise energy costs, mitigate environmental impact at the local and global levels, improve the energy security and reduce safety and general health.

Project Outcome

Project report not available.

Industrial Sector Natural Gas Use in APEC Economies	2002	APERC	
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Project Summary

The objective of the study was to investigate the penetration of natural gas in the industrial sector for selected APEC economies, with the aim of providing some insights for other economies that have plans to promote the use of natural gas in the industrial sector after successfully utilising the fuel in the power sector. This study also provided a complementary analysis to the natural gas projection included in the *APEC Energy Demand and Supply Outlook 2002*.

Project Outcome

The project found that, in Northeast and Southeast Asia, most of the natural gas available in the market was utilised in the power generation sector. The prospects for increased consumption in other sectors, especially the industrial sector and residential/commercial sector, remained modest due to lack of infrastructure and

lack of high-volume consumption.

Gas producing economies, on the other hand, were placing greater emphasis on wider utilisation of natural gas to contribute to fuel diversification and reduce the environmental impact of energy consumption. The use of natural gas was more diversified in the more developed APEC economies. Natural gas was predominantly used in the industrial sector, with the power and residential sectors taking lesser shares. This diversified use was driven by a more balanced fuel share, as outlined by the economies' energy policy, and the availability of domestic reserves.

Also, the liberalised natural gas industry in developed economies had enabled the private sector to invest in a comprehensive and intricate network of gas pipelines and numerous storage facilities located at gas centres.

With the advent of natural gas as a major energy source and the emphasis placed on it in many international meetings, gas is likely to continue increasing its significance as it is propelled into the spotlight as the fuel for the new millennium. This is due to its many advantages, including its attractiveness as a clean fuel.

The project concluded that:

- in developed economies, there was widespread use of natural gas in the various sectors and adequate infrastructure is in place; and
- in developing economies, natural gas was used more as fuel for electricity generation and chemical and petrochemical industries, and there was a lack of infrastructure to enable its use. This was mainly because of lack of capital and individual national policies and interests.

Most developed APEC economies had their own indigenous natural gas resources and had been able to utilise natural gas widely across sectors, including the power sector, the industrial sector and the residential and commercial sector. Because of the wide availability of natural gas in Canada and the United States, North America had become a region in APEC where natural gas is more versatile in its use. Australia had a similar situation to North America.

However, in the developing and gas-producing economies (especially Malaysia, Indonesia and Thailand) the greatest use of natural gas was for the power sector. The amount used in the residential/commercial and transport sectors was small to the point of being almost insignificant. The gas used in the industrial sector was mainly concentrated in the chemical and petrochemical industries, including fertiliser manufacture, although some gas was being used in industries such as iron and steel (for Indonesia and Malaysia), and cement (for Indonesia).

Lack of an infrastructure network was one of the main reasons why, in developing economies where indigenous gas was available, natural gas was not being widely utilised in the industrial sector. Governments could encourage further utilisation of natural gas in the industrial sector through policies and strategies that would make it more accessible in the market.

Potential for Growth of Natural Gas as a Clean Energy Source in APEC Developing Economies	2004	EGCFE	EWG02/2004
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Project Summary

The report from this project was intended to be a reference tool for policymakers in APEC economies who are considering, or wishing to expand, natural gas as a clean energy fuel to meet their respective economy's growing energy needs.

Project Outcome

The project found that natural gas represented a major energy source in a number of APEC economies. Some economies, such as Japan, Korea, Malaysia, Russia and Thailand, were already heavily dependent on natural gas for energy production and industrial use. Most of the developing APEC economies had tended to rely more on coal for their energy needs, as coal was the more abundant domestic resource (China in particular). In some other economies, natural gas had only recently been discovered (Peru, the Philippines, and Viet Nam).

Natural gas was the fastest growing energy source globally, and the APEC economies were expected to be an important part of this growth. While some industrialized APEC economies, such as Japan, Korea, Chinese Taipei, and Thailand, might only experience limited growth because their natural gas markets were already mature, other APEC economies would be strong drivers in the growth of the global natural gas market. The United States was considering and building numerous LNG regasification terminals for power generation and industrial use as was China, which was also building LNG terminals in an effort to keep up with booming domestic electricity demand. Smaller economies, such as Peru and Viet Nam, were expected to develop their natural gas reserves and become both natural gas consumers and exporters.

For APEC developing economies with natural gas reserves, exporting gas could be an important part of their economic development strategy. Brunei Darussalam provided a successful example, and Papua New Guinea could follow in its footsteps.

The high number of new natural gas projects in the APEC economies also reflected the growing importance of natural gas as an environmentally friendly energy source. A key driver behind the increasing use of natural gas for power generation, in the light of the Kyoto Protocol and other initiatives, was to reduce carbon emissions.

Natural gas was also an important consideration in addressing the energy security issues of APEC economies. For those economies in which natural gas represents only a low percentage of the overall domestic energy mix, increasing the use of natural gas was a way to diversify away from other fossil fuels, such as coal and oil. This was particularly so in China and the Philippines. For economies where natural gas reserves had been discovered recently, such as Peru and Viet Nam, developing natural gas was another way to reduce the dependency on foreign energy imports.

The threshold consideration in introducing or increasing the use of natural gas in any economy was whether natural gas resources were located in proximity to centers of potential demand. If indigenous resources were located near a population center, the cost of field development and installation of pipelines and other required infrastructure might justify early development of the gas resources. By contrast, if the indigenous resources are located in a remote location, separated from population centers by natural barriers, such as rivers or mountains, or in

offshore coastal waters, the cost of field development and construction of transportation infrastructure would represent a far greater challenge.

If an economy had coal resources, coal bed methane (CBM) and/or coal mine methane (CMM) might also be an alternative resource that could be developed. Both CBM and CMM had considerable untapped potential in many APEC economies, but the accompanying enabling regulatory framework was often not developed.

Natural gas utilization posed a challenge of a far greater order of magnitude and complexity if there were insufficient indigenous resources and natural gas must be imported from abroad. Apart from the challenge of project scale, transportation costs would constitute an increasing proportion of the ultimate cost of natural gas, whether imports were procured by pipeline or by conversion to LNG and shipment to an LNG receiving terminal in the importing economy. In addition, the complexities associated with cross-border trade raised many policy, legal, and commercial issues that needed to be dealt with.

Institutional support for projects was required and this could be provided by the host governments by way of limited recourse underwriting or support, or by agencies such as the World Bank, Asian Development Bank and other multilateral organisations, providing various forms of project finance, aid, or guarantees.

The project concluded that most of the developing APEC economies could increase their usage of natural gas. The threshold consideration was really about affordability; there must be a certain critical mass of consumer demand or potential demand that would justify the high initial capital cost of installing the required infrastructure to bring the gas to market.

In encouraging investment in natural gas development, governments needed to introduce a favorable regulatory environment, at the same time providing a sense of security for investors and incentives to invest. For example, governments could provide fiscal incentives to power producers to encourage them to switch their fuel use from coal. Similar incentives could be devised on a smaller scale to encourage the use of natural gas for public transportation.

Governments should help with the collection of reliable data on natural gas demand and potential future demand. Governments also have an important role in spreading information on natural gas among their communities. One of the reasons some LNG terminal projects had been abandoned by their sponsors in the United States was the opposition of local residents, opposition spurred by a lack of knowledge on the actual risks and benefits of LNG.

As a broad initial strategy, the project recommended that governments of all APEC developing economies should adopt a clearly articulated "industry vision" for the natural gas sector as part of their individual domestic energy policies. This would give comfort to potential investors about the future direction of industry and power generation development. Ad hoc government decisions tended to hamper market efficiency and impair the development of a strong natural gas sector. Aided by a clear and realistic industry vision, private investors could usually be counted on to respond to opportunities in the market.

Workshop on Expanding the LNG Market in APEC: Policies, Commercial Practices and Technologies	2005	Chinese Taipei United States
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Project Summary

This workshop was held in and hosted by Chinese Taipei in February 2005. The aim of the workshop was to progress the recommendations and best practice principles presented to APEC Energy Ministers in June 2004, regarding the facilitation of natural gas trade in the Asia-Pacific region. The workshop prioritised and identified next steps for implementation, and recommended new areas to be addressed.

Project Outcome

The principal objectives of the Workshop were to focus efforts for the future by prioritizing what further needs to be done to facilitate LNG trade and recommending new areas of concern to be addressed; and to this end, to identify further steps required to achieve early implementation of best practice principles.

The workshop considered the following topics

- overview of global and regional natural gas and LNG supply and demand situation and forecasts, including the situation and prospects for LNG trade;
- LNG supply outlook, including expansion of existing production projects and new LNG projects coming on stream or planned;
- demand outlook in existing and new LNG importing economies;
- policies and regulations affecting LNG markets, including permitting issues;
- other LNG market trends and issues;
- progress in LNG technology;
- public education;
- a way forward on implementation of LNG best-practice principles.

Following are the main conclusions from the workshop:

- natural gas had a promising future in APEC;
- natural gas suppliers were gearing up;
- power generation would be a major driver;
- there would be upstream/downstream integration in gas supply and power generation;
- new gas markets were influencing the way LNG was purchased;
- U.S. imports would impact the global LNG market;
- short term LNG trade was growing, but long-term contracts would continue to predominate;
- the risks and benefits of new LNG facilities are often not well understood by the public.

The following Recommendations were adopted at the conclusion of the Workshop for transmission to the Energy Working Group.

1. The Workshop emphasized the urgency of implementing the EMM6 recommendations concerning adoption of best practices in LNG cross-border trade, which will accelerate expansion of natural gas markets in the region to meet its growing energy demand. To this end, it was recommended that high priority continued to be given to LNG activities within the Energy Working Group (EWG) and its Expert Group on Clean Fossil Energy (EGCFE), including adequate funding for gas-related projects.
2. The Workshop supported the Energy Business Network's (EBN's) initiative to launch the APEC Gas Forum (APGAS), as proposed in the November 2004 report "Great Expectations: Cross-Border Natural Gas Trade in APEC Economies".
3. The Workshop recommended that the EWG and the EGCFE, in coordination with the EBN and other appropriate industry representatives, organize specific expert workshops for APEC economies to increase their knowledge and capacities in different aspects of LNG Best Practices. Ideally, the sequence of workshops should be linked with, and support progress of work undertaken through the APGAS Forum.
4. The Workshop recommended that the EWG should promote activities to support the human capacity building needed to meet future LNG market requirements.
5. The Workshop recommended that exchange visits and study tours to LNG liquefaction plants and receiving terminals and companies involved with the design, construction, and operation of these facilities, be arranged, when appropriate, in conjunction with the specific expert workshops, as a means of sharing information and experiences.
6. The Workshop recommends utilization of the Implementation Facilitation Assistance Team (IFAT) mechanism to assist member economies in understanding LNG market issues.
7. The Workshop requests the Expert Group on Energy Data and Analysis (EGEDA) to consider further the timely collection and dissemination of LNG data.

Increasing LNG Trade and Investment in the APEC Region: Information Exchange on LNG Public Education Campaigns	2006	EGCFE	EWG06/2006T
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Project Summary

The objective of this project was to organize and hold a Workshop to exchange information on public education campaigns related to LNG in APEC economies. The project expanded the capacity of APEC members to absorb LNG technologies and promote a free flow of information on these technologies to the public, thereby enhancing public acceptance and encouraging natural gas trade and investment.

Project Outcome

Project report not available.

REDUCING CO2 EMISSIONS

Study on Atmospheric Emissions Regulations in APEC Economies and their Compliance at Coal Fired Plants	1996	EGCFF	EWG05/1996
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Project Summary

The output of this project was a major report, which for the first time correlated emission regulations within each of the 15 participating APEC economies and related actual emissions to control systems in each economy.

Project Outcome

Project report not available.

The Role of Petroleum Based and Alternative Transport Fuels in Reducing Emissions in the APEC Region	1999	EGCFE	EWG04/1999
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Project Summary

This project examined the options for petroleum-based and alternative transportation fuels and the contribution they could make towards reducing emissions and air quality impacts associated with transportation in the APEC region. The project analysed the more efficient and environmentally beneficial use of petroleum fuels, including fuel quality improvements through reformulated and oxygenated fuels. The use of alternative transport fuels such as compressed natural gas, liquid petroleum gas, alcohol fuels such as ethanol and methanol as well as coal and natural gas derived liquid fuels were also examined.

Project Outcome

The transportation sector is complex, involving different modes of transport, a variety of engines and vehicle types within each transport mode and the use of numerous fuels of different types and compositions. For this study, the transport sector was considered to include vehicles used to transport people and goods by road, air, rail and water

Transportation Energy Use and Vehicle Population

The project found that gasoline consumption for transportation exceeded diesel fuel consumption on an energy basis in the developed and some developing APEC economies, while in other economies diesel fuel consumption exceeded gasoline. The average distribution of energy used for transportation by all modes of travel was 47.3% gasoline, 38.8% diesel fuel and 13.9% other fuels.

On-road vehicles were the predominant consumer of transportation energy in APEC, with this energy demand comprising an average of 84% of the energy used by this sector in the surveyed economies. The modes of travel having the next largest shares of energy use were air travel at 11%, marine vessels at 4.3% and rail travel at 1.1%. Petroleum based fuels provide the vast majority of the energy used for road transportation, varying from 96% to essentially 100%.

The number of passenger cars and commercial vehicles per person in the APEC economies increased in proportion to the gross domestic product per capita. This indicated that under a current trends scenario, the number of vehicles and associated road transportation energy consumption, traffic levels, and problems with

congestion and air pollution were likely to increase at a faster rate than the growth in an economy's GDP per capita. The number of motor cycles used for transportation was very significant in some Asian economies where the number of motor cycles could equal the number of passenger cars.

The fleet average fuel economy of light duty vehicles had declined in the United States and a similar trend was occurring in Canada as a result of the increasing share of the light duty vehicle sales that are light and medium duty trucks. These vehicles had lower fuel economies than passenger cars. This shift in purchases to heavier and less fuel efficient vehicles in some of the developed economies could be a future issue for developing APEC economies. Developed economies projected the fuel economy of passenger cars and light duty trucks will increase gradually through to 2020, though this gain would largely be off-set by the increased weight and horsepower desired by purchasers of new vehicles.

Emissions and Air Quality Effects Associated with Transportation

In APEC economies, the contribution of on-road vehicles to emissions was significantly higher in urban areas than on a national basis. The study reviewed the main fuel options for light and heavy duty vehicles, including commercially proven fuel/vehicle technologies and potential fuel/vehicle technologies that might be of future interest in the APEC region. The project found that substantial reductions in emissions of criteria and toxic pollutants from motor vehicles were possible in developing and developed economies with the use of unleaded gasoline, moderate fuel reformulation and the latest commercial vehicle emission control technology. Low-sulphur and reformulated gasoline and diesel fuel were needed to support the use of advanced emission controls meeting proposed US EPA and EU emission standards. Several alternative vehicle fuels were also identified that have been used in the APEC region and can achieve lower criteria and greenhouse gas emissions than vehicles using gasoline or diesel fuel.

Fuel/Vehicle Options and Impacts on Emissions and Air Quality

The air pollutants from motor vehicles that appeared to be having the most impact on human health in the APEC economies were PM10 and PM2.5, ground-level ozone formed in the atmosphere from emissions of NO_x, VOC and CO, and air toxics. Also significant were emissions of SO₂ which contributed to respiratory problems and acid rain.

APEC economies could achieve large reductions in emissions from motor vehicles by implementing, as quickly as socially and economically acceptable, emission standards achievable with current catalytic emission control systems on light duty vehicles. Because of the time needed to displace older high emitting vehicles from the existing vehicle fleet, combined with the growth rates projected for developing economies, consideration should be given in these economies to accelerating the introduction of improved petroleum fuels and implementation of the most stringent emission standards presently proposed in developed economies.

Alternative fuels should be considered carefully for individual APEC economies as an effective means of reducing reliance on petroleum fuels and achieving reductions in emissions and the associated adverse health impacts. A range of alternative fuel options were identified in this study, enabling APEC economies to select the individual, or a combination of options that best suit their energy supplies and environmental priorities.

Harmonization of fuel and vehicle standards in the developing economies with those

in the developed economies in the APEC region could be beneficial in future as it would avoid redundant efforts to develop standards for individual economies and help streamline implementation of fuel/vehicle options to achieve emission reductions more effectively.

Opportunities existed for reducing emissions of greenhouse gases, as well as some criteria pollutants by increasing the average fuel economy of the on-road vehicle fleet. For significant improvement in the average fleet fuel economy in developing economies, the penetration of the vehicle fleet by vehicles having improved fuel economy would need to increase and off-set the trend to purchase heavier, less fuel efficient vehicles.

Obstacles and Data Gaps

Obstacles to improving petroleum based fuels or to switching to alternative fuels and vehicles existed, however, there was experience with many of these fuel/vehicle options in the APEC region that could be applied to help plan for, and minimize the impact of these obstacles. APEC economies would need to evaluate the viability of fuel/vehicle options with careful consideration of their own priorities and situation. The project developed ratings of the fuels to provide guidance regarding the merits of a range of fuel/vehicle technologies.

Improved and more complete emission inventory data was needed for the evaluation of emission control strategies for transportation and other emission sectors in some of the developing economies. Improved data on the characteristics of the vehicle fleet and fuel specifications in some APEC economies would also be beneficial to future assessments of fuel/vehicle options.

Options to Reduce CO2 Emissions from Electricity Generation in the APEC Region (Phase I)	2000	EGCFE	EWG04/2000
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Project Summary

This project was undertaken to help APEC economies address greenhouse gas emissions and environmental issues associated with use of fossil energy to generate electricity. The project furthers APEC's objectives by expanding the information available on methods for improving the efficiency of current technologies and on the performance of alternative and emerging technologies. The project surveyed the current approaches taken by APEC member economies in dealing with CO2 reduction from burning fossil fuels. The results of the survey formed the basis of further studies that examined individual economies and provided suggested solutions to reducing CO2 emissions that are tailored to specific APEC economies.

Project Outcome

Project report not available.

Options to Reduce CO2 Emissions from Electricity Generation in the APEC Region (Phase II)	2001	EGCFE	EWG02/2001
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Project Summary

This project provided broad insights into opportunities to improve electricity generation in APEC economies by reducing CO2 emissions. Examples were selected from within the APEC region and externally to provide quantified data that can be used as a guide for other APEC economies as they develop their energy planning.

Project Outcome

This project took into account local conditions to develop attainable targets for reducing CO2 emissions from electricity generation. A number of case studies were developed, including impediments, opportunities and financial information. The selection was broad enough to allow energy planners to take advantage of the projects already executed and incorporate them into their alternatives.

In most cases the improvements were economically viable in their own right. Repowering initiatives were most successful, giving large increases in generating capacity for the same fuel consumption and corresponding large reductions in greenhouse gas release. This was achieved with little change in existing infrastructure.

The next most effective process was refurbishment of older units. This gave increased capacity at a lower cost than new plant together with reduced greenhouse gas release.

The majority of case studies improved efficiency, increased plant output and reduced greenhouse gas release at economic cost. Most cases studied showed a CO2 abatement benefit rather than a cost. This, together with access to equity to proceed with the improvements were major enabling factors.

In all cases governments played a key role in facilitating the process to achieve project aims. This included introduction of competitive electricity markets to allow foreign investment, cross economy collaboration, implementation of national greenhouse abatement schemes, policies requiring high efficiency generation plant for new installations, development of new generation technologies and providing funding for appropriate demonstration projects.

In addition, the energy planning for two APEC economies, Malaysia and Viet Nam, was reviewed. These provided effective but quite different approaches to meeting generation needs using mainly indigenous resources economically and reducing greenhouse gas release. Suggestions, arising from the case studies, were made to enhance these plans and at the same time reduce CO2 emission.

The project recommended that the key stakeholders be brought together in a suitable forum to encourage and facilitate adoption of measures such as these case studies demonstrate to help meet expansion needs and at the same time improve greenhouse abatement. Further, even more specific work was recommended to investigate opportunities for the implementation of measures to reduce CO2 emissions within one APEC economy. Taking a longer term view, facilitation of international collaboration in the use and development of Zero Emissions Technologies (ZETs) in the APEC region was also recommended.

Options to Reduce CO2 Emissions from the Electric Power Generation Sector in APEC Economies (Phase III) - TILF Workshop for Developing Economies	2003	EGCFE	EWG03/2003T
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Project Summary

This project drew together the results of a multi-year, two-phase project, by organizing and holding a TILF Workshop on “Options to Reduce CO2 Emissions from the Electric Power Generation Sector in APEC Economies (Phase III).” An important objective of the Workshop, was its focus on issues that can affect the coal as a future energy source in developing APEC member economies, and in particular, how CO2 emission reduction issues may distort future trade and investment decisions.

Project Outcome

Project report not available.

Assessment of Geological Storage Potential of Carbon Dioxide in the APEC Region (Phase 1)	2003	EGCFE	EWG06/2003
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Project Summary

This project was a desk top study of the geological prospectivity for carbon dioxide subsurface storage in selected APEC member economies. The study did not attempt to quantify storage capacity.

Project Outcome

The regions assessed within APEC were PR China, Indonesia, Republic of Korea, Malaysia, the Philippines, Chinese Taipei and Thailand.

Within each member economy, prospective sedimentary basins for CO2 subsurface storage were selected on the basis of proximity to significant point CO2 sources. The significance of these internal emissions was assessed relative to the CO2 output of the specific economy and not in absolute terms across member economies. The term "emissions" in this report means point source emissions as estimated by the International Energy Agency; this includes power generation, cement manufacture and other industrial processes. Transport, agriculture and other distributed sources are not considered in the project report.

The study concluded that the three main options for subsurface storage of CO2 are deep saline reservoirs, depleted oil and gas fields and deep unmineable coal beds.

The prospectivity of each potentially viable sedimentary basin was assessed by examining basin evolution and geological characteristics in the published literature. Prospectivity is a term used in the exploration for any geological resource; in this case CO2 storage space.

Prospectivity was plotted against the scale of stationary emissions for the selected economies. In general, the selected member economies fell into four categories.

1. *Very High Emissions (103 Mt/yr) and Moderate to High Prospectivity for Storage PR China*

Sources in western China are negligible in relative terms. Sources are concentrated

in northern China. A number of well explored basins with good prospectivity underlie this area. Southern areas (eg Guangzhou) are challenged due to the absence of obvious high prospectivity onshore basins —offshore basins may offer a solution. Uncertainty exists regarding the offshore basins, however they are probably moderately prospective. Despite uncertainty, the Pearl River Basin may be the most prospective of the fully offshore basins.

The annual stationary source CO₂ emissions in China of 2970 Mt CO₂ are of the same order of magnitude as China's ultimate hydrocarbon field CO₂ storage capacity. Storage in depleted fields would be a favourable place to start using carbon capture and storage (CCS) technology, but their potential cannot match the scale of China's longer term emissions. Significant depleted field capacity may not be available in the near term due to the continuing productivity of the largest fields. Prospectivity of saline reservoirs for storage may be adequate to make a worthwhile impact on emissions reduction.

2. Moderate Emissions (102 Mt/yr) and Moderate Storage Prospectivity

Indonesia

The main source areas are near Jakarta on Java and gas processing in Kalimantan. There are basins with widespread high prospectivity reservoir-seal pairs adjacent to the main source areas, e.g. Jakarta — NW Java Basin, Kalimantan — Kutei Basin.

Malaysia and Thailand

Both economies have moderate emissions. Their moderate storage prospectivity may become an issue as emissions grow.

3. Low Emissions (101 Mt/yr) and Low Storage Prospectivity

Philippines

Philippines emissions are the lowest in this study but prospectivity for storage is very low; as emissions grow the challenge will become greater.

4. High Emissions (102 Mt/yr) and Low Storage Prospectivity

Republic of Korea and Chinese Taipei

Both the Republic of Korea and Chinese Taipei have limited sedimentary basins within their boundaries and consequently little option for saline reservoir, hydrocarbon field or coal bed storage.

Carbon Dioxide Capture and Geological Sequestration Potential of the APEC Region Phase II	2004	EGCFE	EWG03/2004T
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Project Summary

The objectives of Phase II of this project were to enhance the capacity of APEC economies to conduct their own carbon dioxide and geo-sequestration technical site assessments and to build awareness and capacity of the potential for the capture and geo-sequestration of carbon dioxide.

Project Outcome

The deliverables from this project comprised:

- a set of 13 training modules and two case studies aimed to build capacity around climate change and carbon capture and storage (CCS);

- a guidance document to trainers using the modular training package;
- a strategy for community outreach on carbon capture and storage; and
- a two-day pilot workshop held in Korea in 2005 to test the materials.

Carbon Dioxide Capture and Geological Sequestration Potential of the APEC Region (Phase III)	2005	EGCFE	EWG07/2005
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Project Summary

This project promoted carbon capture and storage (CCS) technology transfer into developing APEC economies by building on assessments of the geological potential in APEC economies (EWG06/2003) and the development of introductory training materials (EWG02/2004T). The project held two workshops to enable developing APEC economies to explore CCS technologies currently available or in development, and increase their adoption.

Project Outcome

The deliverables from this project comprised:

- updated training materials from Phase II to match economy-specific interests and characteristics;
- workshops in China and in Mexico; and,
- a final workshop report.

The workshops disseminated the results of the two previous projects, demonstrated projects and technologies currently being undertaken in APEC economies, and discussed the future potential of these technologies in the APEC region. The workshops also provided the opportunity to bring leading edge expertise on CO₂ capture geo-sequestration to APEC member economies.
