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Best Practices in Energy Efficiency and Renewable Energy Technologies in the Industrial Sector in APEC Region

Report to the

APEC Energy Working Group

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Submitted by

Resource Development Ltd
17 Bruce Street, Hunterville
New Zealand

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Prepared By:

Resource Development Ltd
PO Box 21
Hunterville, 4745
New Zealand
Tel: (64) 6 322,8773
Email: rdl@iconz.co.nz

Produced For:

Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 6891-9600
Fax: (65) 6891-9690
Email: info@apec.org Website: www.apec.org

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Foreword

This project, which was initiated by the Expert Group on New and Renewable Energy Technologies (EGNRET) under the APEC 21st Century Renewable Energy Development Initiative Collaborative IX, has been sponsored by Thailand in close collaboration with Australia, New Zealand, Chinese Taipei, and the USA as co-sponsors. It was supported by funding from APEC through the Energy Working Group (EWG). This project will build upon several other projects already completed by the EGNRET and supports both the short and long-term goals of the APEC Energy Security Initiative by promoting development of renewable energy and energy efficiency.

It is the intent of this work to provide a unique planning document for APEC member economies by sharing experiences of the successful introduction of renewable energy and energy efficiency in the industrial sector throughout APEC. It includes a generic roadmap that defines the actions required by Governments to support this implementation, their inter-dependence and the sequence in which they must be set in place.

The technological capability, infrastructure and government support necessary for the successful adoption of renewable energy and energy efficiency technologies in industry differs considerably amongst APEC economies. Consequently, there is a real opportunity for both technology transfer and the sharing of experiences and lessons learned. In particular, it is stressed that best practices, as defined in this study, relate not only to technologies but also to innovative policies, programs and projects that are advancing the combined use of renewable energy and energy efficiency practices throughout the APEC region.

The project team gratefully acknowledges the guidance and assistance provided by the Project Overseer, Dr. Nuwong Chollacoop and his colleagues Dr. Paritud Bhandhubanyong and Professor Peesamai Jenvanitpanjakul and recognizes the dedication of these persons to the pursuit of APEC energy goals. We also wish to thank Mr. Luis Enrique Vertiz, APEC Energy Program Director and Ms. Norila Mohd. Ali, Executive Assistant, APEC Secretariat, for their ongoing assistance and support.

Executive Summary

Renewable energy and energy efficiency are the "twin pillars" of a sustainable energy future and their combined application can result in the outcome exceeding the sum of the parts http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx.

The combined application of renewable energy and energy efficiency in industry is a natural marriage insofar as industry operators who have the foresight to convert their plants from using fossil fuels to renewable fuels are very likely to maximize the value of the renewable fuel by maximizing the efficiency of its use in their plants. Governments can create regulatory and business environments that promote development of renewable energy and energy efficiency in industry and industry will respond by developing business models configured to extract maximum value for the business from the opportunity available. There is, therefore, a need to broaden our thinking to include the goal of efficient use of renewable energy in industry to achieve maximum value. This value flows through to the whole economy and, ultimately, the planet and its inhabitants.

While there are many examples of the combined application of renewable energy and energy efficiency in industry, their penetration to date has not been extensive. The applications considered most likely to achieve significant penetration in the middle term are the use of:

- biomass energy for process heat,
- biomass as a petrochemical feedstock,
- solar thermal systems for process heat,
- heat pumps for process heat,

and it has been suggested that renewable energy, if used efficiently, has the potential to supply 23% of final energy use in the global manufacturing industry and up to 14% of fossil feedstock can be replaced by biomass. Together, this equates to 21% of total final energy use.

The obstacles encountered in the introduction and development of renewable energy coupled with energy efficiency in industry are very much the same as those for most other situations involving the introduction of new and unconventional technologies There do not appear to be any particular obstacles that are genuinely unique other than those applicable to specific technologies. Those that can be addressed by Governments include:

- lack of information about how the introduction of renewable energy and energy efficiency can benefit specific industries,
- insufficient manpower and management capacity to implement the technology in a timely and cost effective manner,
- high project establishment costs,
- reduced economic viability due to competition with subsided fossil fuels,
- difficulties in accessing capital,
- institutional obstacles such as:
    - lack, or inadequacy, of appropriate incentives,
    - ineffective regulatory regimes that are not supportive,
    - inadequate administrative structures and performance.

Many of these issues are being addressed successfully in a number of APEC economies and industries and their importance is diminishing with time as experience is gained, capacity built and costs reduced.

Many renewable energy and energy efficiency technologies are now commercially competitive in a number of different industrial applications throughout APEC. Combined production of heat and power (CHP) is probably the most important of these, but it should also be noted that several energy efficiency improvements can be implemented together to provide a high a high level of energy end use efficiency and reduce Greenhouse Gas (GHG) emissions. It is also apparent that opportunities for improving industrial energy efficiency extend beyond technology to include maximizing the market value of the energy products and by-products and streamlining process and plant management practices.

Many APEC economies already have policies and measures in place to promote the development of renewable energy and energy efficiency in industry although their effectiveness differs considerably and most are still evolving. There are considerable variations between the incentive policies and measures employed throughout APEC and differences are apparent between:

- developed and transition economies,
- Asian, Australasian and North American economies,
- industrial and agricultural economies.

Tax incentives and benefits are, however, the most common measure used by governments to promote the introduction of renewable energy and energy efficiency improvement in industry.

A roadmap has been developed for the introduction of renewable energy and energy efficiency in industry throughout APEC economies. It is designed to outline the steps that are required to plan and implement an industrial energy efficiency and renewable energy program. The steps and actions required are largely generic and are applicable in all APEC economies; however, there are some differences between both economies and their industries, so the actual implementation plan adopted, and mechanisms employed, will differ amongst economies.

The role of governments is to create and manage an implementation program that will foster and support the development of renewable energy and energy efficiency in industry and should include the following 10 elements:

1. Initial industry-wide review to identify opportunities for the development of renewable energy and energy efficiency in industry.
2. Commit to support these initiatives and develop an action plan.
3. Formulate policies to promote the introduction of renewable energy and energy efficiency by the industries.
4. Promulgate standards and regulations.
5. Facilitate access to technology and equipment.
6. Establish campaigns to inform industry and the public about Government objectives and policies and the actions that are being taken.
7. Build local technical capacity.
8. Develop appropriate financing packages and encourage the provision of private sector financing.
9. Lead by example by introducing renewable energy and energy efficiency improvements in government owned industrial plants.
10. Maintain ongoing program management and monitoring.

Most APEC economies have already embarked on implementation programs so are currently at different points along the road.

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1.0 INTRODUCTION

The technological capability, infrastructure and government support necessary for the successful adoption of renewable energy and energy efficiency technologies in the industrial sectors of APEC economies differ considerably amongst APEC economies. Consequently, there is a real opportunity for both technology transfer and the sharing of experiences of successful adoption of both renewable energy and energy efficiency development in the industrial sector and the lessons learned.

Both the short-term and long-term objectives of the APEC Energy Security Initiative call for development of the infrastructure needed to facilitate the entry of renewable energy into the energy mix of APEC economies and to promote energy efficiency as a primary focus of downside management in their energy industries. The present project has been formulated in response to this objective.

The key output from sharing successful experiences in the industrial sector is the formulation of a roadmap for the successful development and implementation of new and renewable energy and energy efficiency implementation in APEC member economies, together with their necessary infrastructure.

2.0 Project Objectives and Outcomes

It is the aim of this project to highlight best practices in the use of renewable energy and energy efficient technology based systems as they have been applied in the APEC industrial sector and to develop a roadmap for their introduction into the industrial sectors of APEC economies.

Specifically, the project is required to:

- provide information on, and examine in depth, the deployment of new and renewable energy and energy efficiency practices in the industrial sectors of APEC member economies,
- identify the obstacles that prevent adoption of new and renewable energy technologies and energy efficiency practices in the industrial sector,
- develop best practice guidelines that will assist both developed and developing APEC economies to increase the introduction of renewable energy and energy efficiency practices in their industrial sectors,
- prepare a roadmap for the successful implementation of industrial sector renewable energy and energy efficiency systems in the APEC member economies.
- build capacity in developing APEC economies to improve the efficiency of their current energy use and to introduce renewable energy technology in industry,
- recognize that the different cultural and socio-economic groups and interests in different APEC economies may require different technologies, energy efficiency practices and regulatory systems to achieve best practice in their economies.

3.0 Combination of Renewable Energy and Energy Efficiency.

Energy efficiency and renewable energy policies have been defined as the “twin pillars” of a sustainable energy future http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx, and their combined application can result in the outcome exceeding the sum of the parts.

The combined application of renewable energy and energy efficiency in industry is a natural marriage insofar as industry operators who have the foresight to convert their plants from using fossil fuels to renewable fuels are very likely to maximize the value of the renewable fuel by maximizing the efficiency of its use in their plants. There are also a number of synergies and similarities that include:

- improvements in end-use energy efficiency reduce the cost of delivering end-use services by renewable energy. The money saved through can help finance additional efficiency improvements and deployment of renewable energy technologies,
- reduction of pressure on electricity grid transmission and lower transmission losses and bottlenecks thereby lowering system-wide environmental and economic costs,
- lower end-use energy requirements increase the opportunity for renewable energy sources that have low energy density, such as solar, or of low energy content, such as low-temperature solar heat, to meet full energy-service requirements,
- achievement of targets for increasing the share of renewable energy in an economy’s energy portfolio by reducing total energy consumption (e.g., through improvements in energy efficiency) as well as by increasing the percentage of renewable energy,
- reduction of the energy intensity in an industrial plant, both through the introduction of new technology and energy end use efficiency gains, enhances the opportunity to introduce renewable energy,
- similarity of the obstacles to implementation that are often encountered and the regulatory frameworks and incentives required to ensure successful development of both renewable energy and energy efficiency technologies in industry.

While renewable energy and energy efficiency may be the twin pillars of a sustainable energy future, they are in fact fundamentally different concepts. Thus, renewable energy, sometimes referred to as Green Energy, is energy that either renews itself, or can be renewed, *ad infinitum.* Energy Efficiency, on the other hand involves using the least amount of energy to do a job or achieve an objective. There is, therefore, a need to broaden our thinking to include the efficient use of renewable energy in industry to achieve maximum value for the industrial end user, the community, the economy and, ultimately, the planet and its inhabitants.

To this end, we believe that the combined use of renewable energy and energy efficiency in industry needs to focus on how such combination can maximize the **benefits** that can be achieved. Such benefits include, but are not necessarily limited to:

- minimizing the specific energy consumption (SEC) required for production,
- maximising revenues and economic value for an industrial company,
- minimizing the use of fossil fuels,
- reducing GHG emissions,
- managing waste disposal,
- minimizing environmental impacts,

- job creation,
- improvement of industrial working conditions and safety.

The ways in which renewable energy and energy efficiency initiatives can be combined to achieve these objectives may be quite different depending on which are targeted by a particular industry or industrial plant.

We have attempted to incorporate these ideas in the following sections of this report and the examples presented in the next chapter focus on the outcomes sought and how they have been achieved through the combined applications of renewable energy and energy efficiency.

4.0 Renewable Energy and Energy Efficiency in Industry

The following examples of the combined use of renewable energy and energy efficiency in industry have been chosen to illustrate some of the applications that are currently in operation and have possible applications in other APEC economies.

A few examples from economies outside the APEC region have been included because they provide useful illustrations and because they have well documented case studies.

4.1 Bagasse Power in Sugar Mills - Australia

Many sugar mills across the globe that take advantage of bagasse – the waste product left after sugar cane has been crushed - for power generation, are making changes to their plants with the objective of improving their overall process efficiency. Mackay Sugar in Australia, the largest producer of sugar on the continent, has recently completed construction of a cogeneration power plant at its Racecourse Mill in Queensland that provides about one-third of the Mackay city region's electricity requirements.

Source: McKay Sugar Limited Website

Project Description

The state-of-the-art cogeneration plant generates renewable energy and steam from the combustion of bagasse. Additional bagasse is supplied from other mills in the group to extend the period of operation beyond the crushing season and any fuel shortfall will be made up with coal. Surplus steam is used to generate electricity for sale, via Australia's renewable energy trading scheme, through a national energy retailer. The project has replaced an outdated bagasse and coal fired boiler with a highly efficient new cogeneration steam power plant; comprising a grate fired boiler, wet scrubber, steam turbine generator and water cooled condenser.

Coupling with Energy Efficiency

The project, which Mackay has been working on for several years, has replaced traditional bagasse-fuelled boilers with a more efficient high-pressure boiler and a new steam turbine generator, capable of generating 36 megawatts (MW). This maximizes the efficiency of both extracting useable energy from the bagasse and utilizing it for combined industrial and utility purposes.

It should be noted that energy efficiency can be manifest in several ways which may involve production of subsidiary products (by-products), reduction of carbon emissions and minimization of waste product disposal requirements. In these regards the Racecourse plant maximizes the efficient use of energy by:

- Sequestration of carbon dioxide through composting and return to the cane fields,
- recycling mud and compost from the raw sugar making process to the cane fields as fertilizer,
- recycling vinasse (liquid waste from ethanol production) to the cane fields as fertilizer, or processing it further to extract valuable chemical products,
- use of molasses as animal feed or as feedstock for ethanol and/or biogas production.

In addition, McKay Sugar now manages the several sugar refineries that it owns so that bagasse surplus to the energy requirements at its larger Farleigh and Marion mills (located 10 and 25 km from the Racecourse mill, respectively) is transported to the Racecourse mill where it can be used to generate electricity for sale to the grid.

Project Highlights

In addition to providing power and steam efficiently to the Racecourse Mill and sugar refinery, 27 MW of electricity is exported to the grid. This "by-product" electricity is sufficient to power about 30 per cent of households and businesses in the city of Mackay, reduce the region's greenhouse gas emissions by 200,000 tonnes equivalent of carbon dioxide (CO_2) each year and add value for the company's grower shareholders. Energy end use efficiency is further enhanced by the use of otherwise waste materials from sugar cane processing for the production of a variety of valuable by-products, so the specific energy consumption (SEC) is very low and represents World Best Practice.

Economics

Details of the costs and economics have not been disclosed but the total construction cost has been recorded as A$120 million. Most of this was financed from shareholders capital and debt, but additional assistance was provided by the Commonwealth Government of Australia through a A$9.1 million grant from the Government's Clean Technology Food and Foundries Investment Program to support a A$27 million project aimed at boosting the company's overall efficiency. This was applied to a major upgrade of a boiler at the company's Marian mill together with construction of bagasse handling facilities at its Racecourse mill to improve the supply, transport and storage of surplus bagasse.

Obstacles Encountered

The main obstacles encountered related to lack of understanding of the new technology implications by regulatory authorities and financial institutions. There were, also, the usual problems associated with installation of major equipment in an existing plant (retrofitting) but the main obstacle related to the negative effects on industrial development of the contemporary international economic downturn. Despite these difficulties, the project was completed within time and, we understand, on budget.

Lessons Learned

The main lessons learned are that:

- the technology works and is a very good example of the combined application of renewable energy and energy efficiency in industry.
- financing and implementation of renewable energy and energy efficiency projects in industry is achieved much more easily when it is being done by a financially robust industrial company that does not need to operate on a shoestring.
- maximizing the monetarization of by-products – particularly those from co- and tri-generation – is key to the combined application of renewable energy and energy efficiency initiatives in industry,
- the project's several objectives, viz: reduced specific energy consumption (SEC), reduced GHG emissions, improved operational economics, utilization of waste materials and production of valuable by-products, have been achieved.

Contact Information

Location: Peak Downs Highway, Mackay (approx. 2 km west of Mackay).
Postal address:
PO Box 5720, Mackay Mail Centre, Queensland, 4741 Australia
Phone +61 7 4953 8300
Fax +61 7 4953 8350

http://www.mackaysugar.com.au

4.2 Bagasse Fired Cogeneration - Thailand

The United Farmer & Industry Company Limited (UFIC) is widely acknowledged to be one of the largest and most advanced sugar mills in Southeast Asia. Established in 1983, the mill utilises the computerised processing system developed by the British firm Tate & Lyle Industries Limited and 2,000 contracted farmers supply the 23,000 tonnes of sugarcane that are processed daily at this facility.

Bagasse is used as a fuel for generating electricity for use in the mill. The amount of bagasse available can, however, produce more electric power than can be consumed by the mill and the Biomass Cogeneration Plant Project now sells excess power to the grid. It is a new clean power source that helps reduce the use of conventional fossil fuel. It contributes to long-term sustainable development while offering a reasonable economic return. The high efficiency of cogeneration system reduces the cost of electricity.

Source: COGEN 3 Information Sheet, November 2004

Project Description

The project involves extension of an existing cogeneration plant installed at a sugar mill. The extension, supplied under a turnkey contract by ALSTOM, is designed to cover the needs of process steam for the mill during the sugar season and to export a guaranteed 29 MW of surplus electricity to the Electricity Generating Authority of Thailand (EGAT) during the daily peak electricity demand period throughout the year - a total of 65MWe. The upgrading also allows supply of the steam and electricity requirements of an adjacent particle board factory. The new plant consists of two vibrating grate boilers and 41MWe extraction-condensing steam turbo generator and is combined with the existing 24MWe scheme steam plant.

Coupling with Energy Efficiency

This example of coupling between the use of renewable energy and energy efficiency in industry illustrates how an existing facility, already efficient through the combined generation of heat and power (CHP), can be extended in capacity with associated improvement of its operating efficiency, net specific energy consumption, improved economic performance and utilization of otherwise waste bagasse.

Project Highlights

The Phu Khieo Cogeneration project consists in the extension of an existing cogeneration plant installed at UFIC Sugar Mill. The primary fuels used in the cogeneration plant are bagasse, rice husk, wood bark and cane leaves and the upgrading allows the generation of enough steam and electricity to:

- cover all the steam and electricity needs of the sugar mill during the crushing, refining, and off-milling periods,
- export a guaranteed 29 MW to the Electricity Generating Authority of Thailand (EGAT) during the peak period, throughout the year,
- cover the steam and electricity requirements of the adjacent particle board factory.

Obstacles Encountered

As an extension to an existing plant this project has not encountered any particular obstacles other than those normally encountered in such a plant extension. Connection to the grid for supply of electricity to EGAT has, of course, had its associated barriers that have been successfully overcome.

Lessons Learned

Although cogeneration and exporting some power onto a local grid is nothing new to the sugar industry, this plant is different in that it is designed as much for power generation as for meeting the needs of the mill. In many respects, it is closer to a small Independent Power Producer (IPP) than to a traditional sugar mill power plant and illustrates how an existing sugar mill, with CHP generation capability can be re-configured. The plant extension is one of the first of this type of project to actually proceed in this region.

Economics

The total investment cost is Euro 35.5 million, excluding civil works, building foundations and financing costs. The expected payback period is about 5 years after commissioning.

Contact Information

COGEN 3 Overall Co-ordination: EC-ASEAN COGEN Program
Asian Institute of Technology, Energy Building, Km. 42 Paholyothin Highway,
Klong Luang, Pathumthani 12120, THAILAND
Tel: +662 524 53 99, Fax: +662 524 53 96, cogen3@cogen3.net

Phu Khieo Bio-Energy Co. Ltd. (PKBE)
22 Ploenchit Center Building, 22nd Floor,
Sukhumvit Road, Soi 2, Klong Toey, Bangkok,10110 THAILAND
Tel: +662 656 8424 to 5, Fax: +662 656 9929

ALSTOM Power (Thailand) Ltd.
3354/6 Manorom Building, 2nd Floor,
Rama 4 Road, Klongton, Klongtoey, Bangkok 10110 THAILAND
Tel: +662 285 8600, Fax: +662 285 8777

http://www.cogen3.net/doc/fsdp_infosheet/PhuKhieo.pdf

4.3 Bagasse Power and Fuel Production – USA

When burned in a sugar mill, bagasse, the fibrous material left over after juice is extracted from sugarcane, can produce enough electricity to power all of the mill operations with a considerable surplus. For every 10 metric tons of sugarcane crushed, a sugar factory produces nearly 3 metric tons of wet bagasse.

Many sugar mills across the globe that utilize bagasse for power generation, are making changes to their plants to improve their overall process efficiency and to focus on production of electricity and fuels rather than sugar.

Source: Florida Crystal's website.

Project Description

California Ethanol & Power (CE&P) is growing sugarcane not for the production of sugar, but for the sole purpose of creating fuel and generating electricity. The project, located in California's Imperial Valley, is designed to harvest sugarcane for use both as a renewable chemical feedstock, by producing 66 million gallons per year of advanced biofuels (ethanol), and as a renewable fuel (bagasse) to generate 50 MW of electricity. Each facility houses an anaerobic digester that produces 880 million cubic feet of pipeline quality biogas. The company is growing a few hundred acres of sugarcane that will be used for seed purposes. This is harvested and replanted to increase the acreage required to produce enough feedstock for the plant - about 60,000 to 70,000 acres.

Of the 8.8 tons of sugarcane required at each plant per day, about one-third consists of bagasse that is converted into power. Storage is available to ensure that the plant can operate on a continuous basis.

Coupling with Energy Efficiency

This project provides a good example of how a renewable resource – in this case sugarcane – can be converted efficiently into electricity, biogas and ethanol for use either as a fuel or a chemical. The industrial efficiency component lies in the use of state-of-the art energy efficient technology to extract maximum value from the renewable feedstock through production of multiple products for which there is a ready market.

A recent technical analysis of CE&P's sugarcane-derived ethanol project using the California-modified version of Argonne National Laboratory's latest Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model indicates that the CE&P fuel pathway, including electricity as a co-product, would emit 95.2% fewer greenhouse gases (GHG) on a full fuel cycle basis than gasoline when consumed in California.

The project outcomes are, therefore, multifaceted in that the combined use of renewable energy and energy efficiency has been exploited to:

- maximize revenues and economic value for the company,
- minimize the use of fossil fuels,
- reduce GHG emissions,
- manage waste disposal.

Project Highlights

CE&P's sugarcane ethanol production has location advantages, will have lower feedstock costs, premium ethanol prices and higher co-product value and will use much less water than conventional corn-based ethanol plants, whether in the Midwest or California. CE&P will meet California sustainability criteria as well as those being formulated worldwide. CE&P will be producing two forms of renewable energy that will help California address environmental issues and bolster its economy, while not depleting natural resources. The project will provide:

- greater than 13:1 clean renewable energy produced per unit of fossil energy used,
- more than 95% potential reduction of greenhouse gases,
- a non-food feedstock,
- year-round growing and harvesting, and a higher crop yield,
- preferred treatment as an Advanced Biofuel under the Renewable Fuels Standard (RFS),
- valuable co-products such as green electricity

Economics

Details of the costs and economics have not been disclosed.

Obstacles Encountered

The main obstacles encountered related to the negative effects on industrial development of the contemporary international economic downturn. Although initial plans were delayed, CE&P's first plant is now underway and power off-take agreements have been negotiated.

Lessons Learned

The main lessons learned are that:

- a widely available primary renewable fuel, such as bagasse, can be converted efficiently into valuable energy and chemical products using existing state-of-the-art technology,
- financing and implementation of renewable energy and energy efficiency projects in industry is achieved much more easily when it is being done by a financially robust industrial company,
- maximizing the monetarization of by-products is essential to the combined application of renewable energy and energy efficiency initiatives in industry.

Contact Information

http://www.californiaethanolpower.com.
http://www.californiaethanolpower.com/why-sugarcane/how-it-works/

4.4 Bagasse Cogeneration in an Edible Oil Refinery – India

While this example is not from an APEC economy it does involve an activity, edible oil refining, that has widespread application throughout APEC and a comprehensive case study of the project is available.

Project Description

Parakh Foods Limited (PFL) operates an edible oil refinery in the MIDC Kurkumbh District, in Pune, India. Increased production called for refinery expansion with associated increases in electricity and steam for process requirements. Due to a shortage in grid supply, it was decided to install a 550 kW co-generation plant fuelled by locally available sugarcane bagasse. High pressure is produced by a bagasse-fuelled boiler and used to drive a steam turbine for power production while the low pressure steam is used for the oil manufacturing process.

Source: Government of India, Ministry of New and Renewable Energy Website.

The project uses GE Intelligent Platforms Proficiency Process Systems—a scalable, fully integrated system with the latest hardware and software technologies for process automation and control. This provides the ability to monitor, measure and analyze various operations within the plant in real time, including steam, power and water consumption, production efficiency, molasses output, steam generation, fuel quantity, and water quality and quantity so that all processes can be continuously optimized.

The open architecture system includes powerful high availability redundant controllers for continuous operations and an intelligent alarming system for production equipment efficiency and insight into critical plant conditions. With a single control environment and comprehensive engineering and operator functionality, it enables both ease of use and maximum flexibility.

Coupling with Energy Efficiency

Coupling with energy efficiency is achieved through the greatly increased conversion of primary fuel energy to both electricity and process heat. The project utilizes the latest energy efficient and cost-effective technology, which improves industry competitiveness and also helps in reducing GHG emissions. Renewable energy and energy efficiency therefore combine to achieve improvement in profitability and reduction in GHG emissions while also contributing to waste (bagasse) management.

Project Highlights

This is one of the first projects where an edible oil and solvent extraction company has established a cogeneration facility to use steam both for the refining process and to generate power. The industry is very cost sensitive so rationalization of production processes by introduction of operational efficiencies is important. Since the demonstration project was one of the first few of its kind in this industry, the replication potential among other manufacturers is fairly high.

Specific highlights include:

- the cost of power from cogeneration was found to be 40% cheaper than that available to the company from the grid at current rates,
- savings in terms of CO_2 emissions were 5,580 tonnes per year for the 550 KW bagasse fired cogeneration plant,
- savings in terms of energy efficiencies are estimated at US$3.1 million per year,
- the net surplus power from cogeneration is 550 KW

Economics

The cost of the project was US$817,000 of which the Industrial Credit and Investment Corporation of India (ICICI) Bank provided financial assistance of US$370,000 through USAID's ECO Program.

Obstacles Encountered

The obstacles encountered during the establishment and delivery of this project has not been recorded. However, since it is noted to be a demonstration project it is likely to have encountered all of the problems associated with the trialling of new technology, but without major difficulties in negotiating regulatory requirements and approvals.

Lessons Learned

The project has achieved an improvement in profitability and reduction in GHG emissions while also contributing to waste (bagasse) management through the combined use of renewable energy and energy efficiency.

It has also improved productivity and product quality while optimizing process efficiency and energy consumption through:

- increased visibility into plant processes,
- improved process control and system time on-line,
- faster deployment and increased productivity,
- lower total cost of ownership.

Contact Information

PARAKH FOODS LIMITED
Coment House
691A/10, Pune Satara Road

Pune - 411037 (Maharashtra) India
Tel: 020-24230231 / 24230233
Fax : +91-20-24230250
http://www.parakhagro.net/

http://www.ge-ip.com/biomass_customer_stories/krishna
http://www.mnre.gov.in/schemes/grid-connected/biomass-powercogen/

4.5 Biomass Gasification in Ethanol Production - USA

Although natural gas is the main fuel used for power generation in ethanol plants, there is increasing interest in renewable energy technologies that can enable these plants to produce a domestically grown fuel without using fossil fuels and a number of ethanol plants in the USA and Canada are working to reduce fossil fuel use through innovation. Whether producing power from a biomass boiler, gasifier or an anaerobic digester, or installing heat exchangers to utilize waste heat, the focus is on increasing energy end-use efficiency and reducing the amount of natural gas used per gallon of ethanol produced.

Source: BIOMASS GAS Website

Project Description

The Chippewa Valley Ethanol Company (CVEC) completed installation of a biomass gasifier which can provide 90 percent of its ethanol plant's power needs by burning primarily waste wood chips and corncobs. The gasifier thermally breaks down dry biomass at temperatures greater than 1,500 degrees, producing fuel gas (carbon monoxide and hydrogen) and can use a variety of feedstocks, such as sunflower hulls, corncobs and glycerine from biodiesel production. Since the gasifier is air blown, it produces gas with an energy content of only 150 Btu per cubic foot (cu ft) because the gas is diluted with nitrogen from the air. By comparison, the energy content of gas from an oxygen-blown system is about 600 Btu per cu ft and pipeline-quality natural gas has an energy content of 1,000 Btu per cu ft. In addition**,** CVEC has installed heat exchange equipment for waste heat recovery from the regenerative thermal oxidizer (RTO) for process heat and steam, thereby reducing the amount of gas consumed per gallon of ethanol produced.

Coupling with Energy Efficiency

Coupling between renewable energy and energy efficiency lies in the use of renewable biomass as the primary fuel and its efficient conversion to fuel gas with waste heat recovery for production of process heat and steam. The objective is to reduce the specific energy consumption (SEC) required for ethanol production and improve profitability for the company.

Project Highlights

The cost of energy in an ethanol plant is second only to feedstock cost and can have a major influence on plant profitability. By increasing energy end use efficiency economic viability becomes more robust in an industry where little can be done to improve the efficiency of the actual ethanol production process. Also, plants with advanced technologies that reduce environmental emissions may have an added advantage if their products qualify as an advanced biofuel (low carbon ethanol) and command a premium price as in California.

Economics

The cost of the project has not been disclosed by CVEC but it is known to be several million dollars with a payback period of two to three years. A US$500,000 low-interest loan was provided by the Minnesota Department of Commerce Energy Program in 2010 but has only recently completed the installation due to the global economic downturn.

Obstacles Encountered

The following obstacles to implementation of this project that have been identified include:

- the costs and time required to comply with the permitting process,
- difficulties in convincing regulatory officials of the realities associated with compliance requirements such as emissions measurements associated with the use of different feedstocks that are essentially similar,
- problems involved in convincing company management of the worth of pursuing new technology in a difficult financial environment,

Lessons Learned

The following lessons are forthcoming:

- a company will not utilize new technology, even when installed, when alternative fuels, such as natural gas, are available at low prices,
- biomass prices must remain sufficiently low to pay off investment.

Contact Information

Chippewa Valley Ethanol Company
270 20th St. NW, Benson, MN 56215
Operations Manager, John Kent, Phone: 320-843-4813
jkent@cvec.com

http://www.biomassmagazine.com/articles/5488/ethanol-producers-embrace-biomass-power-and-thermal

4.6 Biogas to Heat and Power – Canada

Source: Toromont Cat Power Systems Website.

Project Description

Pelee Hydroponics partnered with Alpenglow Energy and Gemini Power Corp., two established sustainable energy firms, to form Seacliff Energy. In 2009, Seacliff began construction on a C$6.5 million anaerobic digestion facility that transforms vegetable and animal waste from local farms and greenhouses into heat, electricity and natural fertilizer. Phase I of the Seacliff construction project was completed in late 2010, and the facility began supplying power to the grid from a single G3520C generator set in January 2011 which contributes to long-term sustainable development while offering a fair economic return. The high efficiency of the cogeneration system reduces the cost of electricity. Phase II construction, including the installation of a second G3520C generator set, will begin once a Feed-in Tariff (FiT) is granted by the Ontario Power Authority. Phase II is expected to be operational in late 2013.

Vegetable and animal waste is collected from nearby farms and greenhouses, generating enough biogas to fuel a power plant designed and supplied by the local Cat® Dealer, Toromont Cat Power Systems. This plant is designed to use two Cat G3520C 60 Hz 1.6 MW high-efficiency, low-emission gas generator sets as part of a combined heat and power (CHP) solution that meets Pelee Hydroponics' need for heat in their greenhouses. Excess heat can be pumped to neighboring greenhouses, while all electricity generated by the plant is sold to the Ontario Power grid.

Coupling with Energy Efficiency

Coupling with energy efficiency lies in the co-generation of heat and power, together with production of a natural fertilizer, based on the use of biomass.

Project Highlights

The first of its kind in Canada, the two-stage agriculture bio-digestion technology works in stages to break down 50 kinds of organic waste by exposing it to different bacteria and varying temperatures. By contrast, single-stage digesters, currently used in most municipal landfills, work more slowly and can generally break down only one type of waste at a time. The digestion facility provides multiple benefits to nearby greenhouses and farms, food processing plants and local residents. Seacliff charges lower tipping fees for local food processing plants to dispose of their organic waste, which reduces food costs and the need to expand nearby landfills.

At the conclusion of Phase II construction, the system will produce enough electricity for 2,400 homes and, by using renewable biogas; it will decrease dependence on fossil fuels while reducing emissions of carbon dioxide by about 10,400 metric tons per year.

Economics

The capital cost of the project is C$6.5 million. No additional information relating to the economics of the project have been disclosed pending its full implementation.

Obstacles Encountered

The only obstacles recorded relate to the costs and time associated with obtaining approvals – specifically with the time taken to obtain approval for the granting of a Feed-In Tariff (FIT) by the Ontario Power Authority.

Lessons Learned

The following lessons can be taken from this example:

- the technology exists for using agricultural farm waste biomass into heat, electricity and natural fertilizer with a high level of energy efficiency,
- this initiative offers an attractive opportunity for the coupling of renewable energy and energy efficiency to contribute to advantage for the agricultural industry,

- it illustrates how several different markets and stakeholders can benefit from the products of a multifaceted combination of renewable energy and energy efficient project,
- the cautious approach of the project proponents, and their pursuit of a Feed in Tariff (FIT), suggests that they still consider this to be a frontier project in commercial terms,
- partnership between an energy producer, a technology supplier and a power company combines all of the technical and commercial ingredients required to establish a coherent and effective commercial venture that can extract maximum benefit from the combined applications of renewable energy and energy efficiency.

Contact Information

Seacliff Energy
1200 Rd. 20, Leamington, ON N8H 3V7, Canada
Phone: +1-519-322-4435, Fax: +1-888-788-0187, secretary@seacliffenergy.com
http://www.seacliffenergy.com

Toromont Cat Power Systems
Ph: (905) 488 2500, powersystems@toromont.com

4.7 Large Scale Industrial Biogas – China

Biogas system for treating wastewater on the 200,000-pig Hangzhou Dengta Farm.
Photo courtesy of Hangzhou Energy & Environment.

China has biomass resources that are estimated at 5 billion tons annually. These include substantial animal wastes and organic industrial effluent which are appropriate raw materials for the production of biogas. There are about two million rural household digesters in

operation but industrial-scale production is much less – even though there are many opportunities for profitable biogas installations to provide both heat and power.
Water pollution from animal manure produced at livestock and poultry farms is a significant environmental problem. An estimated 900 million annual tons of manure is generated annually, with an electric power potential of over six gigawatts (GW). This has created both a requirement for effluent treatment and a sizeable biogas production opportunity.

Project Description

The United Nations Development Program (UNDP), Global Environment Facility (UNDP-GEF) program has co-financed three pilot industrial-scale biogas projects, representing advanced international best practice in design and construction of commercial facilities and covering the two key market sectors of industry and livestock. The largest of these is a plant that employs anaerobic digestion to produce biogas at the Dengta Pig Farm located in Hangzhou, Zhejiang Province which farms 200,000 pigs and produces 3,000 tons/day of wastewater. The plant produces 8,500 m3/day of biogas that is used to produce 230 kW of electricity, which is sold to the grid, together with process heat. It also produces 142 tons of fertilizer/day and supplies 1,000 m3/day of biogas to nearby households.

Coupling with Energy Efficiency

Energy efficiency is achieved through the CHP operation, which uses state-of-the-art technology, and through the economies of scale that are available to a project of this large size. The diversity of its products also contributes to the efficient use of biogas in industry.

The objectives of this project are to combine the applications of renewable energy and energy efficiency to maximize revenues and economic value for the company and to provide a cost effective way for disposing of agricultural industrial waste and reducing GHG emissions.

Project Highlights

The project is believed to be the largest of its kind in the world. Despite its large size it is still regarded as a pilot project, but one which is fully commercial and economically viable. One of the highlights is its easily replicable designs, as demonstrated when the local government shut down the Dengta Pig Farm, requiring that its biogas plant be reconstructed outside the city limits. The new plant was constructed with great efficiency, in only six months. The project has also achieved success as a catalyst for the spread of biogas development projects in China as at least 34 new biogas projects at livestock farms have been developed, based directly on the experience of the Dengta Pig Farm. In addition, the project has had an impact on local governments, such as Hangzhou, which have implemented new standards and regulations to promote similar biogas solutions.

Economics

The capital cost of the project was US$ 1,820,000 of which 20% was received from the United Nations Development Program, Global Environment Facility (UNDP-GEF), 40% self financed and 40% debt financed through a bank loan. The payback period was 7 years.

Obstacles Encountered

Probably the greatest obstacle encountered was when the local government shut down the Dengta Pig Farm, requiring that its biogas plant be reconstructed outside the city limits. Other obstacles included:

- a technical requirement to maintain the consistency of the effluent feedstock,
- compliance with environmental regulations. In 2002, China's State Environmental Protection Agency (SEPA) issued new standards for industrial wastewater discharge and increased enforcement.

Lessons Learned

The following lessons can be learned from this project:

- a large, industrial scale, biogas plant can be commercially viable in utilizing agricultural wastes from pig farming,
- energy efficiency is enhanced by the application of CHP and the production of several energy products and by-products,
- economic viability is enhanced by monetarizing the several products from the project,
- the project illustrates how an energy project can be coupled with a requirement to treat the substantial effluent from a large pig farming operation,
- production and utilization of biogas from agricultural industrial wastes can displace the use of fossil fuels,
- sharing the project outcomes and findings and outcomes of the project helps promote investment in new biogas projects at livestock farms,
- such a demonstration project can have a direct impact on policymaking. The project's China Biogas Project Development Guidebook is already being used by the National Development and Reform Commission (NDRC) in preparation of the biogas component of its Biomass Strategy through 2020. NDRC has also indicated that it will make use of the project's Biogas Action Plan as a key input to the biogas portion of its Biomass Strategy,
- enhancement of the capacity of biogas project developers. For example, the Hangzhou Bioengineering Company, which developed the Dengta pilot, has reported substantial expansion of its business, including cooperation with multinationals in China and contracts for projects abroad.

Contact Information

State Economic Trade Commission (SETC), UNDP/GEF Renewable Energy Project
A 2107 Wuhua Mansion, A4 Chegongzhuang Dajie, Beijing 100044, China.
Tel.+ 86 10 6800 2617/2618/2619, Fax.+ 86 10 6800 2674
renewpmo@163bj.com

Hangzhou Bioengineering Company
Hangzhou Economic and Technological Development Zone, Hangzhou, Zhejiang, China.
Tel: 86 571 56773688, Fax: 86 571 56773066

http://www.xebecinc.com/pdf/Wallace_et_al_biogas_GWREF2006.pdf
http://www.iadb.org/intal/intalcdi/PE/2010/05217.pdf

4.8 Tallow Fuelled Boilers – New Zealand

Use of tallow, which is a bi-product of the meat industry, as a clean and renewable fuel source for boilers, is a good example of the combined applications of renewable energy and energy efficiency in industry.

Tallow is derived from the fat trimmed off meat carcasses. New Zealand produces around 150,000 tonnes per year, most of which is exported to countries such as China for the production of soap and here is an internal market for the trading and transportation of tallow. The main difference between soap-grade tallow and fuel-grade tallow is that the latter requires an extra stage of filtering. This can increase its value to around two thirds that of diesel and it is an essential step in ensuring the performance, reliability, and clean burning of boilers.

Verkerks tallow tanker.

Collection of waste fat from cooking.
Source: EECA Website.

Project Description

Specialty meats processor Verkerks recently converted their 1.2MW diesel boiler to burn tallow, resulting in a forecast fuel saving of NZ$150,000 p.a., virtual elimination of fossil fuel consumption, and a 60% reduction in particulate matter emissions.

Optimal performance and reliability of the boiler is essential at the Verkerks processing facility and the 1.2MW boiler produces steam for heating the smoke houses and fermenting rooms, and for producing hot water. In particular, the production of salami requires precise and continuous heat control throughout a lengthy fermentation process. An unreliable heat supply could interrupt the fermentation process and spoil batches of product worth hundreds of thousands of dollars.

Coupling with Energy Efficiency

The new burner head and control system alone has improved boiler efficiency by 20% (i.e. reduced fuel consumption to 280,000 liters); however the concept is to increase the overall plant operating efficiency and reduce waste in as many ways as possible. A few of these being implemented by Verkerks include capturing and reusing the waste heat from their coolrooms, establishing a worm farm at their central Canterbury abattoir to convert thousands of tonnes of waste to vermicast, and separating and baling waste plastic for export.

Project Highlights

The tallow conversion at Verkerks is a success story. The boiler has now been operating for several years and has met all expectations for performance and reliability. The critical factors seem to be a reliable supply of good quality tallow and proper investment in the right boiler technology. Verkerks has established this supply of fuel grade tallow from their own abattoir.

Most boilers require significant capital investment in design and equipment retrofit to operate successfully with fuel-grade tallow. By accessing overseas experience, however, Verkerks engineers were able to minimize these design costs. Key elements in the conversion were:

- installing the 8,000 liter stainless tallow storage tank with an internal hot water coil circulating waste hot water to maintain the temperature at 55°C (tallow solidifies at 41.5°C), together with a 15kW emergency electrical heater,
- replacing the old forced-air burner head with a modern air atomizing head and Programmable Logic Controlled (PLC) fuel and air pressure drive,
- configuring the PLC controller to optimize combustion efficiency for both diesel and tallow over an infinitely variable range of heat output levels (Verkerks now has a dual-fuel system, using diesel only as a back-up),
- suitable pipe work, fittings, and lagging.

Economics

On paper the business case was overwhelmingly in favor of proceeding with the NZ$90,000 investment. Before the conversion, the Verkerks boiler was consuming around 350,000 liters of diesel per annum. At 90 cents per liter this equated to an annual cost of NZ$315,000. With the cost of the fuel grade tallow at around 60 cents per liter, however, the annual energy cost has fallen to NZ$168,000 – a saving of NZ$147,000 per annum and a 100% return on investment within eight months. Overall, the cost of the conversion project was around NZ$90,000, and this included an estimated 300 hours of in-house engineering time.

Obstacles Encountered

Part of the historical problem with tallow conversions in New Zealand has been to do with the quality and clarity of the tallow used. A further problem has been a failure to invest in the appropriate burner head and controller technology. This meant that there were significant concerns about the risk of the project. Even though the performance and reliability risk could be mitigated by converting the boiler to a dual-fuel system (i.e. it could always be switched back to diesel in about half an hour), there was still the issue of not getting the return on investment if the tallow system didn't work.

The New Zealand Energy Efficiency and Conservation Authority (EECA) was able to resolve this concern by providing financial support to the project. Interestingly, all of the obstacles that needed to be addressed were of a technical, rather than institutional, nature – largely due to the New Zealand Government's policy and strategies for promoting renewable energy and energy efficiency and the resulting strong support provided by EECA.

Lessons Learned

The interesting thing about tallow is that its energy value per liter is almost the same as that of diesel, yet when sold for use in soap its price is only about one third of diesel. In the past the major problem associated with use of tallow as a boiler fuel has been its quality and clarity. A further problem has been a failure to invest in the appropriate burner head and controller technology. These issues can easily and cheaply be addressed, however, making the efficient use of tallow as a small industrial boiler fuel a reality in all APEC economies were raw animal fat and/or waste cooking fat are readily available.

Contact Information

Project management
Verkerks engineers@verkerks.co.nz

Boiler head and controls
Scotts Engineering Co. Ltd
scotteng@ihug.co.nz

PLC design & configuration
Professional Electrics Ltd (Prolec)
energy.management@prolec.co.nz

Boiler set-up
Aquaheat Industries Ltd
bharwood@aquaheat.co.nz

Emission testing and resource consent applications
Specialist Environment Services Ltd
+64 3 3299 800

http://www.eeca.govt.nz/resource/verkerks-converting-boiler-burn-tallow-means-savings

4.9 Sawmill Powered by Wood Waste – Australia

Project Description

Reid Brothers timber has been operating a sawmill since 1940. The company processes around 17,500 m³ of timber per year of which 5000 m³ is kiln dried. 10 years ago the cost of using LPG in the boilers was growing. The company was also paying $1200 per month to send waste timber material to landfill. The decision was made to install a modern wood fired boiler which combines automated fuel supply feeding with efficient low cost low emissions operations and automated ash removal.

 

Source: NSW Dept of Primary Industries Website.

Project Highlights

The new system has an extensive number of sensors which allows operational monitoring at a very fine level of detail thereby optimising steam production. The company has been approached to install an Organic Rankine Cycle electricity generation system using surplus steam from the new boiler when the mill is not operating at full load. The existing LPG boiler was retained as a backup boiler but it has not been used since the new boiler was commissioned.

Coupling with Energy Efficiency

The aim of the project is to combine the applications of renewable energy and energy efficiency to save the owners around $10,000 per annum on the electricity costs.

Economics

The capital and installation cost of the wood boiler was $A360,000, annual operation and maintenance is $15,000. This compares with the annual cost of LPG at $.60 per litre for the previous installation of $270,000. In addition, the annual cost of waste wood disposal to landfill was $14,000. The payback period for the wood fired boiler was 1.3 years. Since the boiler was installed, the cost of LPG has risen from 40c/l to 55-60 c/l, thus giving rise to even greater savings.

Obstacles Encountered

The main problem encountered was the occurrence of bridging - where the waste wood forms an arch in the hopper above the feed mechanism. Excluding sticks from the feedstock has reduced the impact of this issue.

Contact Information

Department of Primary Industries
GPO Box 4440, Melbourne VIC 3001

http://www.dpi.vic.gov.au/energy/sustainable-energy/bioenergy/sawmill-powered-by-wood-waste\

4.10 Wood-waste in Different End Uses – Malaysia, New Zealand, Singapore

Wood residues are available in most APEC economies and their disposal often incurs significant cost. They include flat wood, pallets, packing material, boxes, formwork, wood off-cuts, wood shavings, sawdust, sander dust, reject Medium Density Fibreboard (MDF) fines, start-up fibre and sawmill residues. There are many examples of these residues, or their derivatives such as wood pellets, being used to produce process heat and, in some cases, combined heat and power (CHP) for industrial use, but there are a variety of ways in which energy efficiency is manifest in its end use. The following examples illustrate some of these and further information is provided in the case study website references included for each.

Source: PhotoSearch website.

4.10.1 Timber Drying

An example is the drying of rubber wood in Malaysia.
http://www.cogen3.net/fsdp-wood3malay.html

Steam from wood fuelled boilers provides a continuous supply of heat which is used to dry rubber wood lumber. This shortens the duration of the drying cycle and allows better control of the drying temperature, thereby providing an efficient use of renewable energy in the processing and production of sawn timber, and usually results in a better product which sells at a higher price. The installation of new equipment also reduces atmospheric emissions that frequently exceed air pollution limits.

The lesson is that timber drying is an ideal end use for process steam that can be generated from wood waste in the sawmilling industry. It can be replicated in those APEC economies where such industries operate.

Contact Information

Bekok Kiln Drying and Moulding Sdn Bhd (Malaysia)
Tel (60-7) 948 2697; Fax: (60-7) 9482708
Stephen Chew, Managing Director

4.10.2 Cogeneration of Heat and Power for Waste Processing

An example is conversion of wood wastes into energy for a waste management operation in Singapore http://www.cogen3.net/doc/fsdp_infosheet/ECOSWMinfosheetECO.pdf.

Resource recovery operations separate useful woody materials from the raw wastes delivered to the waste disposal facility and these are then processed into a suitable form for use as boiler fuel to produce steam which drives a high efficiency steam turbine to generate electricity. Half of the electricity is used in the cogeneration plant and half in a nearby hazardous waste disposal facility. Steam from the turbine is recovered and used for drum and ISO tank washing. The system provides a one stop waste management solution and companies pay for this service. Such an application maximizes both the efficiency and end use of energy produced from a renewable waste resource and provides a valuable community waste management service that can serve as a model for many APEC economies.

Contact Information

EC-ASEAN COGEN Programme
Asian Institute of Technology, Energy Building,
Km. 42 Paholyothin Highway, Klong Luang, Pathumthani 12120, THAILAND
Tel: +662 524 53 99, Fax: +662 524 53 96, cogen3@cogen3.net

4.10.3 Maximizing the End Use Efficiency of Wood Waste

An example is a Medium Density Fibreboard (MDF) manufacturing plant in New Zealand.
http://www.eecabusiness.govt.nz/sites/all/files/energy-audit-at-dongwha-unlocks-savings.pdf

A boiler used to produce steam for MDF production is fuelled by wood waste generated within the plant. Initially, the available fuel was more than that required for plant process heat and the boiler was effectively operated for the purpose of waste disposal rather than for maximum efficiency. This situation changed dramatically when a fuel market was found for the excess waste wood thus providing an additional revenue stream for the company. With appropriate emission controls, the project was eligible for carbon credits providing yet another revenue stream. In addition, use of an independent energy auditor identified seven energy management opportunities whose implementation provides a total of US$250,000 in annual savings with an overall payback period of 1.3 years.

The main lesson learned is that opportunities for improving industrial energy efficiency extend beyond technology to include maximizing the value of energy products and streamlining process and plant management practices. These can be identified by pursuing market research in situations where either the fuel or the resulting energy produced is excess to requirements and through energy audits that include a review of management protocols and practices.

Contact Information

Simon Callaghan (Dongwha Patinna Ops. Manager) simon.callaghan@dongwha-mh.com
Mike Savill (Dongwha Patinna Project Engineer) mike.savill@dongwha-mh.com
Kees Brinkman (Enercon Managing Director) keesb@enercon.co.nz
Jonathan Pooch (Enercon Energy Engineer) jonathanp@enercon.co.nz
http://www.eecabusiness.govt.nz/content/wood-processing

4.10.4 Production of Briquettes for Boiler Fuel

An example is production of briquettes for boiler fuel from MDF fines in New Zealand.
http://www.eecabusiness.govt.nz/sites/all/files/southern-pine-turns-by-product-into-fuel-jun-09.pdf

Disposal of MDF fines can be a problem because they contain low levels of formaldehyde that must be incinerated at the high temperatures available in industrial boilers rather than in domestic stoves. Initially, the MDF manufacturer sealed its dust in plastic sacks that were sent to a landfill at significant cost. After some research, the company installed a briquette press which turns MDF dust into combustible briquettes for boiler fuel. The briquettes are used to heat a nearby greenhouse complex.

The saving in waste disposal costs is US$160,000 a year, and annual revenue from the briquettes is US$22,000 at current production levels. The payback period is less than two years. The system can be further advanced by collecting MDF dust from other manufacturers who generate large amounts and utilizing the considerable additional capacity of the press to produce more briquettes, thereby helping suppliers to reduce costs, increase revenue and lessen their environmental impact in one fell swoop.

The main lesson is that energy efficiency can be manifest through upgrading the energy resource value of a waste product from the processing of a renewable feedstock. The benefits of the project include improving revenues and economic value for the company and cost effective waste management.

Contact Information

Energy Conservation and Energy Efficiency Authority (EECA)
44 The Terrace, Wellington, 6011
Phone +64 4 470 2200 or 0800 358676, Fax +64 4 499 5330, info@eeca.govt.nz
http://www.eecabusiness.govt.nz/content/wood-processing

4.10.5 Combined Application of Several Energy Efficiency Initiatives

An example is the application of a systems approach that implements a number of energy efficiency initiatives in a wood processing plant in New Zealand.
http://www.eecabusiness.govt.nz/sites/all/files/dust-extraction-system-saves-energy-for-pacific-wood-products-case-study-june-09.pdf

The company re-manufactures pine products such as weatherboards, timber mouldings and panels and all residual sawdust and shavings are used as boiler fuel. The boilers generate high pressure steam for a cogeneration plant and low-pressure bypass steam for kiln drying lumber. It runs a multi-shift wood processing operation using a variety of dust-producing equipment and these dust emissions must be extracted and contained to ensure an efficient and safe working environment.

An ECOgate system was installed at each workstation air extraction duct, controlled by a microprocessor unit that continuously monitors and senses machinery activity, and adjusts the workloads of the variable speed fans to meet actual dust extraction requirements. Prior to installing the system the fans were running at full load continuously regardless of the actual number of wood processing machines in use. Now, noise levels are lower, especially near work stations, and energy savings are 255,000 kWh per year, a reduction of US$20,000 (42%) of the annual energy bill. Payback is estimated to be 4 years. In addition greenhouse gas emissions have been reduced by 45 tonnes of CO_2 per year.

An important lesson to be learned from this example is that many energy efficiency initiatives can be implemented together to provide a high level of energy end use efficiency. In this case, the following can be identified:

- efficient collection of wood waste from all plant operations,
- use of high efficiency boilers,
- a high efficiency steam turbine,
- high pressure steam to generate electricity,
- cogenerated electricity powers the plant,
- low pressure steam used for lumber drying,
- efficient ECOgate dust extraction units fitted with variable speed fans,
- use of a smart (microprocessor) system controller to match extraction capability and load requirements,
- reduction in noise levels,
- Greenhouse gas emissions reduction,
- complete wood waste disposal.

A full energy audit would, no doubt, identify further ways in which energy efficient equipment, processes and practices are being deployed, but it is clear that this example, and others like it, could serve as a useful model for industrial wood processing in many APEC economies.

These combined applications of renewable energy and energy efficiency have achieved the following objectives:

- maximising revenues and economic value for the company,
- reducing GHG emissions,
- managing waste disposal,
- minimizing environmental impacts,
- improving industrial working conditions.

Contact Information

Energy Conservation and Energy Efficiency Authority (EECA)
44 The Terrace, Wellington, 6011
Phone +64 4 470 2200 or 0800 358676, Fax +64 4 499 5330, info@eeca.govt.nz

http://www.eecabusiness.govt.nz/content/wood-processing

4.10.6 Sewage Sludge Disposal

An example is sewage sludge drying in New Zealand.
http://www.eecabusiness.govt.nz/case-studies/govt-and-local-govt
http://www.eeca.govt.nz/sites/all/files/paraparaumu-sewage-plant-biomass-boiler-sept-2008.pdf

Sludge from human waste recovered from a sewage treatment plant must be dried before its disposal in a landfill site. This is the responsibility of the local council which also owns and operates the sludge drying plant. An existing diesel boiler that produces steam for sludge drying was replaced with an efficient wood chip boiler in response to the high cost of diesel which was about US$500,000 annually. Woody materials are sourced externally, including from residents of the town and forests owned by the council. In principle, it is a simple change to make but it translated into an efficient use of renewable energy. Annual savings in fuel costs are US$400,000 with a payback period of 2.3 years and savings of 1,300 tonnes of CO_2 per year.

Obstacles were encountered in the storage and drying of the wood chip fuel and local concerns about increased truck movements in the vicinity of the treatment plant, however these have been overcome.

The main lesson learned is that replacement of a fossil fuelled boiler with an efficient wood chip boiler can contribute significantly to the end use efficiency of a necessary industrial scale waste treatment operation which, together with the financial benefit achieved, was the main objective of the project.

Contact Information

Dave Bassett (project manager), Kapiti Coast District Council, +64 4 296 4799
Living Energy (main contractor for project), +64 9 377 9007
Better Technical Options (technical consultants), +64 4 920 7031
Solid Energy (wood pellet fuel supplier), +64 3 345 6000
http://www.eecabusiness.govt.nz

4.11 Watermill Upgrading – Nepal

Although this example is not in an APEC economy, it is a good illustration of the use, on a small scale, of run-of-the-river hydro energy to upgrade the efficiency of watermills that provide shaft power for small local businesses. Its objective was to improve the opportunities of local people to develop small revenue producing businesses and has application in several developing APEC economies.

The streams in the mountains and hills of the Himalayas in Nepal support many traditional water mills (ghattas), which use heavy grindstones to mill grains and make flour. Traditional mills are largely made from wood, and most parts have to be replaced every two years. With low operational efficiencies, these traditional mills are now unable to satisfy demand, with long delays for farmers wishing to get their crops milled and a rise in the number of diesel powered mills. Although diesel mills produce flour more quickly, the high grinding speed reduces flour quality.

Grinding maize with an improved water mill

Metal runner for an improved water mill
Source: Ashden Awards Website

Project Description

In order to power a traditional mill, water is led from a fast-flowing stream along a canal, and then down a steep chute or penstock into the mill house. The water, flowing at a rate of up to 100 litres per second, turns the wooden runner of the mill, which rotates a vertical shaft. The grindstones are attached directly to the shaft, on a raised floor above the runner. Grain is fed between the grindstones from a hopper, and flour pushes out from the sides. Key mill parts are made of wood, resulting in a lifetime of only two years. With an operational efficiency of less than 25% and a typical mechanical output of 0.2 to 0.5 kW, these mills grind between 10 and 20 kg of cereal per hour.

The Centre for Rural Technology (CRT) runs a program to upgrade traditional water mills, so that they work more cleanly and efficiently, can operate for a longer period of the year, and also be used to provide shaft power for other activities apart from grinding. The water mill modifications consist of replacing the wooden penstock with high density polyethylene pipe, and the shaft and runners with precision-made metal parts. The mill improvements increase the grinding capacity by more than 100% and also improve durability. The upgrades use a long shaft on the mill runner so other mechanical equipment (e.g. oil presses and rice de-huskers) can be used and also generate electricity using an induction generator. The mill improvements increase the grinding capacity to between 20 and 50 kg per hour, and improve durability.

Coupling with Energy Efficiency

Coupling between the use of renewable hydro energy and energy efficiency lies in upgrading the efficiency of watermills and their delivery of shaft power for grinding, other mechanical processes and electricity generation. It is estimated that the 2,400 mills upgraded by 2006 avoid about 2.16 million litres/year of diesel, equivalent to 5,760 tonnes/year of CO_2.

Project Highlights

CRT/N contracts manufacturing to twelve existing metal-workshops, which it has approved to produce parts for improved water mills. Service centres offer a one-year warranty on the parts that they install, after which users have to pay for servicing and repairs. The drive belt on the long shaft version needs replacing every six months, the grindstones every three to five years and the shafts every ten years. A total of 16 local service centres, which promote the improved water mills, train the millers, and provide repair and maintenance services have been established. Service centres consist of local NGOs, metal workers and Watermillers Association's authorised to provide service. Capacity building programs for both manufacturers and service centres, have been established and the service providers are continuously monitored to ensure that they are providing the required quality service. Eventually, CRT/N plans for the Watermillers Associations to take over the servicing. All the new mill parts have unique serial numbers, which are used to provide a traceable record in case of future faults.

Economics

Upgrades are partly paid by the mill-owners, assisted by the program subsidy. Short shaft upgrades cost about US$350, and long shaft upgrades cost about US$1,050. The millers pay part of the cost of the improvements, and the remainder is covered by a subsidy of US$300. The subsidy for the short shaft version was about 50% when the program began, but this was gradually reduced. In 2007, owners paid US$170 - $250 for a short-shaft upgrade, out of a total improvement cost of US$310 to $390. The millers' contribution is usually paid partly in cash (sometimes raised as a loan from a local micro-finance organisation) and partly in kind, through providing transport and labour for installation. The villagers who take their crops to the mills pay the full cost of the milling service. By tradition, this is charged as a fraction of the grain milled, usually 5-6%, and payment is often made in kind.

Obstacles Encountered

As in the case of micro-hydro electricity production, the main obstacles encountered relate to engaging the local stakeholders in the scheme. Specifically:

- informing the community about the nature of the project and how it will benefit them,
- setting up the community infrastructure to take ownership of the project and to manage it in a sustainable manner,
- establishing project monitoring protocols and a regime ensuring their ongoing successful operation.

In addition, there is the obstacle of transporting equipment to, and installing it in, a remote region usually located in challenging terrain.

Lessons Learned

The lessons learned are that:

- millers with improved water mills can earn more income and have extra time for other purposes,
- the flour produced from water mills is of better quality than from diesel mills and has a higher market value,
- the upgrades enable development of several new, or existing, small business opportunities,
- water mills are usually closer to the villages than diesel mills, so people will use them in preference. Business has declined for diesel mills in areas where there are

a large number of improved water mills, some have closed down and new diesel mills are not being built,
- an improved water mill can replace about half the capacity of a diesel mill and offset about 900 l/year of diesel, equivalent to 2.4 tonnes/year of CO_2,
- because improved water mills grind more slowly than diesel mills, the flour does not get so hot and does not pick up the taste of diesel. This means that the flour has a longer shelf life, is more nutritious and has a higher market value,
- the water mill upgrades have improved the self-respect and social standing of the mill owners,
- the formation of millers' associations has improved the advocacy power and livelihoods, of the mill owners by enabling them to negotiate for quality services, marketing of products and water rights issues. The associations also provide education and training to the millers,
- an improved mill has a higher throughput and will run with less water so can operate at a lower water flow rate than the traditional mills. This extends their period of operation into the dry season for up to two months each year. There are now mills operating for 6 to 12 months of the year depending upon the availability of water,
- on average, the annual income of traditional mill owner increases by at least 25% with a short shaft upgrade. Owners of long-shaft improved water mills can sell additional services such as rice-hulling, cutting timber and electricity, and this can increase income considerably more,
- additional employment in promotion, transporting and selling is estimated to be 25 days per unit,
- Improved water mill parts last ten years, compared with approximately two years for traditional mills,
- an unmodified water mill requires regular maintenance, which consumes timber at a rate of one tree every two years,
- the technology is directly applicable in other economies that operate traditional water mills.

Contact Information

Mr Lumin Kumar Shrestha (Director)
Mr Bhupendra Shakya (Improved Water Mill Programme Manager)
Centre for Rural Technology, Nepal (CRT/N)
PO Box 3628
Tripureshower, Kathmandu, Nepal
lumink@crtnepal.org, bhupendra@crtnepal.org
www.crtnepal.org

http://www.ashden.org/files/CRT%20full.pdf

4.12 Micro-Hydro Electricity Generation - Indonesia

Over one third of the population of Indonesia do not have access to grid electricity. There is considerable potential to provide off-grid hydroelectricity in these areas, but many schemes have been abandoned through lack of maintenance. The solution adopted by the Indonesian Institut Bisnis dan Ekonomi Kerakyatan (IBEKA) was to work in partnership with communities, successfully developing local skills to manage and maintain off-grid hydro schemes long-term, and community ownership to provide a continuing source of income from them.

The penstock and powerhouse of the 11 kW hydro plant at Palanggaran.
Source: Ashden Website

Project Description

The project, located in the village of Putri Betung, Aceh Province in Sumatra, is now up and running and seven rural villages are receiving clean electricity from the system. An agricultural processing facility has been constructed and women are now using stainless steel facilities to process their harvests of patchouli, candlenut, coffee, and other crops. The scheme is 'run-of-river' and only uses a small dam to redirect part of the river water along a canal or a pipe to a settling tank (fore-bay) which is sited above the power house. The outlet from the fore-bay has a screen to trap silt and floating debris. Water flows out into a pipe (penstock) which is made as steep as possible to transfer water to the turbine which rotates a shaft driving an electrical generator. Water leaving the turbine is led back to the river through the outlet pipe (tail-race) and can be used to recharge fish ponds and for irrigation on its way. Since the scheme is off-grid, a local electricity grid has been constructed to distribute power from the generator via an electronic controller to individual consumers.

Coupling with Energy Efficiency

Both off-grid and grid-connected hydro schemes cut greenhouse gas emissions. Energy efficiency is also manifest through the provision of electric power to replace kerosene for lighting, averaging about 15 litres/month of kerosene per consumer, and the efficient use of the energy delivered to a variety of small businesses that are now able to use new technology in the utilization of the new electricity supply to produce their products.

Project Highlights

The project has been developed with the community, in order to meet its specific needs so that the community has long term responsibility for its management and a community organisation manages, and legally owns, the scheme. It is also responsible for collecting fees, paying staff, and building up the maintenance and community funds, making payments for bank loans or private investors, as well as the operation, maintenance and community fund.

Economics

As a project sponsored by IBEKA, users do not pay the capital cost of the hydro. Costs of hydro schemes vary greatly, depending on the complexity of the site and how easy it is to reach. Typical costs for IBEKA off-grid schemes are between US$4,000 and US$8,000 per installed kW but grant funding covers all costs including design, installation, community preparation and setting up the cooperative to own the plant. IBEKA works with the community to agree a tariff structure that brings sufficient revenue to cover the day-to-day cost of operation, a maintenance fund, and a community fund. Fees for electricity are paid monthly to the co-operative by each consumer and have a tariff that depends on their power rating - typically between US$2 and US$10 per month.

Obstacles Encountered

The main obstacles encountered relate to engaging the local stakeholders in the scheme. Specifically:

- informing the community about the nature of the project and how it will benefit them,
- setting up the community infrastructure to take ownership of the project and to manage it in a sustainable manner,
- establishing project monitoring protocols and a regime ensuring their ongoing successful operation.

There have been, of course, the technical obstacles associated with building the hydro plant, and its associated infrastructure, in remote and topographically challenging terrain.

Lessons Learned

The following lessons have been learned:

- micro-hydro schemes such as that at Palanggaran provide temporary local jobs during construction, and long-term jobs for operation, maintenance and fee collection. At Palanggaran, the operator (who checks the scheme twice per day and also collects fees) earns US$20 per month, a significant addition to family income from cash crops which is typically US$30 per month,
- the availability of electricity also increases local employment opportunities and productivity. It also provides power levels that can run electric tools, so carpentry and metal workshops can expand their business. Jobs like tailoring and agricultural processing can also become more productive,
- the water management associated with a micro-hydro scheme can bring additional agricultural benefits, for instance irrigation that allows an extra crop to be grown, or clean water supply to fishponds,

- there is also significant potential for grid-connected micro and mini hydro
- IBEKA has demonstrated that community management of hydro systems, and the community benefit from them, can be achieved with a range of different financing mechanisms. This model is widely relevant in other countries.

Contact Information

Mrs Tri Mumpuni
Executive Director, IBEKA
Jalan Madrasah 11 no 10 RT 03 RW 02
Kelurahan Sukabumi Utara, Jakarta 11540, Indonesia.
Tri.mumpuni@gmail.com
www.ibeka.netsains.com

http://www.ashden.org/files/IBEKA%20full%20winner.pdf

4.13 Solar Crop Drying - Indonesia

A solar tea leaf dryer was installed at a plantation in Malabar, West Java, Indonesia. The perforated collector system was built with the assistance of the R&D Centre for Applied Physics (LIPI), and was funded by the Canadian government in cooperation with the Association of South East Asian Nations (ASEAN). The purpose of the project was to determine the feasibility of using solar energy to displace oil as the heating system for the wilting of tea leaves.

Project Description

The solar air heating system (SAH) is designed to wilt tea leaves through a batch process using the existing drying troughs and shelter. The troughs are manually loaded with tea leaves from a trolley that moves through the wilting area. An axial fan delivers solar-heated air at a rate of up to 24,000L/s to a chamber beneath the troughs. The original fan was replaced with a high efficiency unit such that the fan energy requirement did not increase. The 600 m2 solar collector is mounted on the north-facing roof of the shelter at an angle of 22o to the horizontal. The heated air then rises through the troughs and the tea leaves carrying moisture with it and gently drying the leaves as required.

Source: Photo credit-Conserval Engineering.

Coupling with Energy Efficiency

This is a simple application that can be readily replicated by a small business and in a developing economy. Its objective is to combine the applications of renewable energy and energy efficiency to improve the economic viability and product quality for a local industry. Solar energy is collected efficiently by optimum mounting and inclination of the solar collector and the heat is used efficiently through appropriate design of the tea drying troughs together with installation of a high efficiency axial fan.

Project Highlights

In 1993 and 1994, prior to installation of the solar system, industrial diesel oil was used at an average rate of 0.11 litres per kilogram of tea. After the conversion, no oil was burned and only the fan required energy. It is estimated that approximately the same amount of fan energy was required before and after the conversion. In September 1994, three of the solar-heated troughs produced 108,000 kg of high-quality wilted tea for a total saving of 11,880 L of oil. The cost of oil is $0.40 per litre. At this rate, the solar system is expected to deliver 850 MWh of heat on an annual basis.

Economics

The solar air heating system was able to meet the full heating load for tea drying at a payback of 1.5 years, not including design and development costs, which account for approximately 6% of this type of project, but they would be offset by credits for eliminating the fossil fuel heating system design, development and engineering

Obstacles Encountered

The only obstacles encountered were of a technical nature. Thus, the velocity of the wind hitting the solar collector has a significant influence on the estimated energy delivered by the solar air heating system. Obstacles such as other buildings, trees and fences will typically attenuate, but in some cases even intensify, the wind speed hitting the solar collector. In this case, a 0.70 wind sheltering coefficient was assumed in designing the collar collector.

Lessons Learned

The following lessons can be taken from this example:

- solar energy can be used to dry most crops and in processes requiring warm air. In fact, solar heat is often preferred since it does not burn or harm delicate foods, which often happens with steam or burning fuels, solar heat is non-polluting and best of all, it is free!
- drying of crops is an excellent application for SAH systems especially when used in sunny climates,
- the SAH system was able to completely displace oil heating,
- the system was easily integrated into the existing operation,
- year-round use and the low temperature required contribute to a short payback period of less than 2 years.

Contact Information

Natural Resources Canada
http://www.nrcan.gc.ca
RETScreen
www.retscreen.net
rets@nrcan.gc.ca
Fax: +1-450-652-5177

Enermodal Engineering Limited, 2000.
Vladimir Nikiforov, Ph: +1-450-652-4621

http://www.solarwall.com/media/download_gallery/cases/Malabar_Indo_Y94_SolarWallCaseCropDryingV3.pdf

4.14 Solar Thermal Process Heat - USA

Source: Williams Selyem Estate Website

Located in northern California's Russian River valley, Williams Selyem is an award-winning winery whose owners invested in solar thermal to reduce the cost of winemaking operations. The company chose a solar thermal hot water system because of its efficiency and short investment payback.

Project Description

SunWater Solar designed and installed a closed-loop glycol solar thermal system for process heating at Williams Selyem Estate Winery. Hot water produced by the system is used for wash-down of barrels, tanks, equipment and floors, as well as bottling line/bottle sterilization before filling. Its objective was to combine the utilization of renewable energy and energy efficiency to increase the revenue and economic value for the company.

Coupling with Energy Efficiency

The effectiveness of coupling renewable energy with energy efficiency lies both in the efficiency of harvesting solar energy and its end use in the winery, plus its replacement of a fossil fuel (propane) and thus reduction in carbon emissions.

Project Highlights

Previously, the winery heated its water with propane and solar thermal makes very strong financial sense because propane is even more expensive than natural gas or electricity which are also commonly used to heat water.

Economics

The installation costs and economics of the solar thermal system were significantly improved by a 30% federal Investment Tax Credit, accelerated depreciation tax breaks and a California

Solar Initiative (CSI)-Thermal commercial rebate which is available to utility customers who install solar thermal systems to replace water-heating systems powered by electricity or gas. The annual heat offset achieved by conversion to solar thermal process heating is 1,820 therms (estimated), the annual Carbon Offset is equivalent to taking 1.8 cars off the road and the annual savings in propane costs is US$6,000. The investment payback time is recorded as being very short.

Obstacles Encountered

Implementation of this project appears to have been remarkably obstacle free. The main barriers that had to be surmounted related to compliance and the rather time consuming applications to federal and state agencies for financial assistance.

Lessons Learned

The main lesson learned is that installation of solar thermal to provide hot water for use either directly or as feed water for industrial and commercial boilers is a relatively simple undertaking. Specifically:

- the technology is mature and is in widespread use throughout APEC economies – notably in China where there are millions of installations, mainly in residential use, but also in small and medium industrial enterprises (SMEs),
- the application is clearly cost effective as evidenced by the large number of installations,
- solar thermal can be applied in essentially all APEC economies in locations where sufficient solar energy is available throughout the year.

Contact Information

SunWater Solar
865 Marina Bay Pkwy., Suite 39, Richmond, CA 94804
Phone: (510) 233-0300, Fax: (866) 856-8867
http://www.sunwatersolar.com

Williams Selyem Winery
7227 Westside Road, Healdsburg CA 95448
Customer Service 707-433-6425; Administration 707-433-6446
http://www.williamsselyem.com
http://www.solarthermalworld.org/content/solar-thermal-case-study-williams-selyem-estate-winery-2011

4.15 Concentrated Solar Thermal Power Plant – Thailand

Source: DLR website.

In solar thermal power plants, infrared radiation from the Sun is concentrated using mirrors and converted into thermal energy; this process is referred to as Concentrating Solar Power (CSP). Temperatures of 400 to 1200 degrees Celsius can be achieved by focusing the radiation. This thermal energy can be used to generate steam that drives turbines, similar to a conventional power plant, or it can power a Stirling engine to generate electricity. Four different types of mirrors can be used to collect solar radiation: (1) a parabolic trough, (2) flat mirrors directed towards a single point near the top of a tower, (3) a parabolic dish or (4) linear Fresnel collectors.

Project Description

Energy supplier Thai Solar Energy Company Ltd (TSEC) commissioned Solarlite to design and build the the solar thermal facility which consists of 86 collector troughs, each 120 metres long, over an area of 100,000 square metres in the Thai province of Kanchanaburi. The plant has an output of five megawatts, but the company is planning more power plants in the region, with a total capacity of 135 megawatts with the objective of creating commercially viable operations.

The solar thermal power plant, which is the first parabolic trough collector array in which steam is generated directly in the collectors, fed its full output of five megawatts into the grid for the first time on 25 January 2012. Researchers from the German Aerospace Centre Deutsches Zentrum für Luft und Raumfahrt (DLR) have advised on both the development of individual components and on the overall design of the facility.

Coupling with Energy Efficiency

Solar thermal power plants are considered an indispensible component of future energy supplies based on reusable sources. They have the advantage of being able to store energy in the form of heat and are one of the most efficient ways of harvesting solar energy and converting it into process heat and/or power that can be used in industry. Such power plants can also be constructed as hybrid generators, using conventional fuels or biomass. They can provide power based on demand and further contribute to energy efficiency by compensating for fluctuations in energy production from wind power and photovoltaic facilities.

Project Highlights

The facility is the result of a lengthy, DLR-led research program in which direct steam generation in parabolic trough collectors is used for the first time in a commercial application. Direct evaporation involves water, instead of thermal oil, flowing in the absorber tubes onto which parabolic troughs focus solar radiation. The tubes are under a pressure of 30 bars and the temperature of the resulting steam is 330 degrees Celsius. By transferring the heat directly to the water, the process temperature of the power generator, and hence its level of efficiency, can be increased. This means that direct steam generation can be used to reduce the costs of solar thermal power plants.

Economics

Information about the costs and economics of this solar thermal power plant have not been made available, however, since it represents the first such installation of its kind it should, perhaps be regarded as a commercial demonstration so its costs and economics may not be particularly relevant

Obstacles Encountered

As a first commercial project the TSEC solar thermal power plant had to face a number of obstacles that would not be the case for a mature and established technology. Because the project formed part of the Government’s renewable energy strategy, however, the obstacles encountered were more in the form of barriers that had to be negotiated. Some of these include:

- lack of empirical evidence that the project would be successful,
- scepticism about the electricity costs that could be achieved,
- the need to set up the enabling environment (standards and regulations) for solar technology penetration at both centralized and decentralized (regional) levels,
- establishing grid connection and dispatch management protocols,
- setting up mandatory use of renewable energy purchase by utilities,
- identification and engagement of a suitable technology supplier and engineering contractor capable of implementing the project,
- negotiation of a Power Purchase Agreement (PPA) for a new technology,
- negotiation of regulatory incentives and exemptions.

Lessons Learned

The following lessons can be learned from this example:

- the system is already configured for generating steam for process heat, power generation, combined heat and power (CHP) generation or even tri-generation to provide solar cooling. It is, therefore, almost infinitely flexible,
- solar energy collection efficiency is optimized because the whole collector field automatically aligns itself with the sun,
- the power plant can easily and accurately be controlled when solar radiation levels vary,
- the principle of direct steam generation is being pursued by the German Federal Environment Ministry's DUKE research project, running until 2014. The aim is to improve the efficiency of the process and reduce electricity costs even further.
- the principle of direct steam generation is being further developed under the German Federal Environment Ministry's DUKE research project with the the aim of improving the efficiency of the process and reducing electricity generation costs even further.

Contact Information

Dorothee Bürkle
German Aerospace Center (DLR)
Tel.: +49 2203 601-3492, Fax: +49 2203 601-3249

Dirk Rinus Krüger
German Aerospace Center (DLR), DLR Institute of Solar Research
Tel.: +49 2203 601-2661, Fax: +49 2203 601-4141

http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10258/368_read-2343/

4.16 Hybrid Solar Thermal and PV for Process Heat and Power - USA

Kendall-Jackson has installed the nation’s largest rooftop solar cogeneration system at its Kittyhawk winery in Windsor, California. The project was implemented by Cogenra Solar which developed the technology and installed the 96-module hybrid array. Its objectives were to create revenue and economic value for the company and to reduce reliance on fossil fuel.

Project Description

This solar cogeneration system captures the suns energy and converts it into both solar electricity and solar hot water. The system reflects the sun’s rays upward using parabolic mirrors onto downward facing photovoltaic (PV) panels that generate electricity. To maximize efficiency the whole system pivots to keep aligned at right angles to the Sun as it arcs through the sky during the course of the day. The photovoltaic panels are attached to a metal plate with holes bored through it. Cold ground water at 60^{o}F is passed through the holes and the excess heat warms the water from 60^{o}F up to around 140^{o}F. The hot water is used to supply a boiler which then heats it to the preferred working temperature of 160^{o}F.

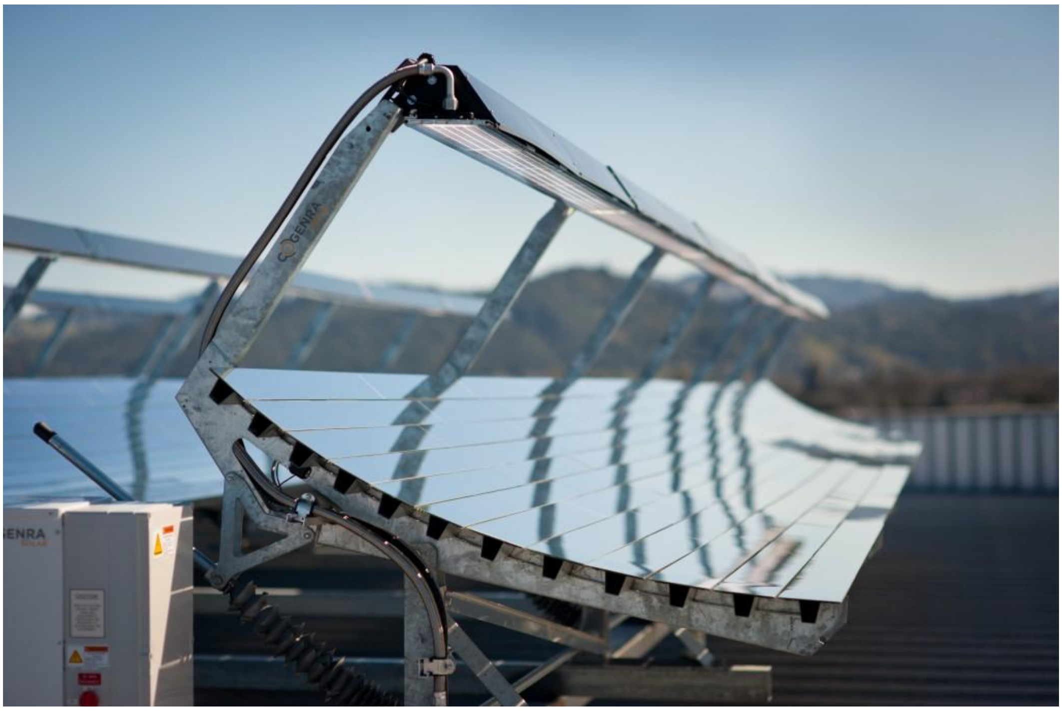

Photo courtesy of Kendall-Jackson.

Expanding on Kendall-Jackson's existing energy and water conservation projects, the 96-module, 241kW hybrid solar PV and thermal array is supplying both solar hot water and electricity to power the winery's extensive tank and bottle washing operations. Cogenra arrays are also being installed at Kendall-Jackson's Vinwood estate in Sonoma County and another winery in Monterey County.

Coupling with Energy Efficiency

Coupling with energy efficiency lies in the combination of heat and power (CHP) generation. The solar cogeneration system provides up to 60 percent of the building's hot water needs, with the electricity powering lighting and cooling. Solar cogeneration is now recognized as one of the industry's most effective tools to maximize the efficiency of solar energy production to meet both electricity and hot water needs.

Project Highlights

The energy conservation that comes from solar heating of the process water is regarded as a bonus in this application because less fuel is required to bring the water up to the proper temperature. Reducing the amount of fuel used to heat water is very important in this industry which is, essentially, bottling a food product so sanitization requires a lot of hot water.

Adding up the total solar energy employed and the energy savings achieved from improved energy efficiency, the amount of conventional energy being conserved is equal to the annual consumption of about 6,300 homes or green house gas emissions from over 3 million gallons of gasoline – equivalent to 27,000 tons of CO_2. By combining PV with cogeneration of heat the project enables production of clean renewable energy below utility rates while reducing natural gas and grid-fed electricity consumption, offering five times the energy, three times the greenhouse gas reduction and twice the savings of traditional PV.

Economics

The solar CHP installation saves approximately $30,000 in annual energy costs, and the winery system is eligible for a 30% federal Investment Tax Credit. Winery owners may also be able to take advantage of accelerated depreciation tax breaks and also be eligible for the CSI-Thermal commercial rebate. In addition, the company has been purchasing renewable energy certificates for some of its operations since 2008. Last year, it bought certificates equal to 130 percent of annual energy usage and took arguably a unique step by including the home energy use of its 1,000 employees.

Obstacles Encountered

This application of solar cogeneration was essentially purpose designed and built – even though the technologies involved are now well understood. The obstacles encountered, however, were more in the form of barriers that had to be surmounted. Some of these include:

- identification and engagement of a suitable technology supplier and engineering contractor capable of implementing the project,
- some uncertainty that the project would achieve its design goals,
- identification of, and compliance with, the various applicable standards and regulations,
- negotiation of regulatory incentives and exemptions,
- the rather time consuming applications to federal and state agencies for financial assistance.

Lessons Learned

The main lessons learned from this example are:

- energy efficiency can be maximized by combining solar thermal collection with PV,
- heat and power production are best balanced with the electricity requirements in an industrial plant so there is no need to dispose of surplus electricity by grid connection,
- the cost of capturing solar energy to produce both heat and power in this application appears to be very competitive with provision of these requirements
- in striving to achieve energy independence and reduce greenhouse gas emissions from electricity production, the following three step approach has been identified:
  - first, *conserve* energy by eliminating wasteful energy use,
  - secondly, *optimize* all equipment involved in energy production, handling and end use so that it works as efficiently as possible or is replaced,
  - thirdly, *access* renewable energy – either by generating it on-site or by buying it in.

Contact Information

Kelly Keagy
Jackson Family Wines
Kelly.Keagy@jacksonfamilywines.com

Katie Struble
Antenna Group for Cogenra Solar
Cogenra@antennagroup.com

http://www.cogenra.com/press/cogenra-solar-kendall-jackson-winery-unveil-nations-largest-rooftop-solar-cogeneration-array/

4.17 Solar Cooling and Process Heat – Singapore

While this example does not relate specific to an industrial application of renewable energy and energy efficiency, it does have real application to an industrial processing zone where energy use by a number of industrial plants can be integrated.

Project Description

This project is the world's largest solar cooling and heating installation. It supplies hot water and cooling to around 2,500 students, who live and study on a newly created 76,000 m2 campus, which incorporates facilities such as boarding houses, canteens, science labs, libraries, sport amenities and music studios. Its objective was to create a campus that maximizes the efficient use of renewable energy and minimizes GHG emissions.

The solar panels are supplied by the Austrian company Ökotech, a subsidiary of the SOLID Group, Austria. These highly efficient Gluatmugl collectors possess a convection blocker between absorber and glass cover to minimize heating losses and reach higher temperatures than usual, which will be necessary to operate the 1,759 kW absorption chiller supplied by Broad, China.

Source: S.O.L.I.D. website

Coupling with Energy Efficiency

While not strictly an example of Renewable Energy and Energy Efficiency in Industry, we have included this project application because it has the capacity to supply both cooling and process heating to a large industrial campus using district heating infrastructure to maximise the end use efficiency of the solar energy captured. The project is also particularly illustrative because the obstacles encountered and the lessons learned relate to both the use of renewable energy and energy end use efficiency.

Project Highlights

The project includes a 3,900 m² collector field with a cooling design capacity of 1.4 MW (about about 30% of total Campus demand) and supplies all of the campus heating requirements via a centralized heat distribution grid.

Economics

The Singapore Economic Development Board (EDB) provided 15 % of the investment costs for the solar installation, thereby ensuring that the new campus reached the Green Mark Platinum certification - the highest rating in Singapore´s green buildings grading system.

The system design and economics are, however, dictated by the fact that natural gas prices in Singapore are as high as electricity prices so the use of solar energy to produce hot water, rather than cooling, has prevailed.

On current estimates the project investment will be repaid within 15 years from the energy cost savings achieved with the help of the solar installation and the efficient use of the energy derived there from.

Obstacles Encountered

The project developer has identified a number of obstacles that were encountered during the delivery of this project. These are summarized as follows:

Lack of information across the value chain:

- Solar companies often lack an understanding of the complexity of industrial processes and system integration,
- industrial plant management is often not aware of the possibilities for using solar thermal process heating and cooling in their plants,
- specialists in industrial energy systems usually know very little about solar thermal technologies,
- communication between solar companies, industrial plant management and industrial energy system specialists is often poor and there is a lack of standardized solutions to assist,
- plant management and industrial energy specialists are usually wary of what they perceive as “new technology”,

- there is lack of know-how about the subsidies, technology and pilot projects that are available,
- doubts that projected solar yields will be achievable are common,
- doubts about quality and successful integration of the solar system are also common.

Economic obstacles

The following obstacles have been recorded:

- the static load of roof areas was too low for the installation of solar thermal collectors so additional costs for reinforcement were incurred,
- industry was reluctant to accept the comparatively long payback periods involved,
- other, more conventional, measures for improving energy efficiency such as heat recovery and process optimization of the process are usually given priority,
- the very low prices for subsidized fossil fuels often available to industrial companies is a significant barrier to investment in solar thermal technology,
- due to the frequently cloudy sky in Singapore, the maximum design capacity of the solar thermal system is not often available so the optimum economic advantage cannot be achieved,
- financial institutions are not well informed about how to assess risk for Solar Thermal project financing and negotiations for financing this project took more than a year because SOLID had to first prove the credit-worthiness of its financing partner, the Raiffeisen-Landesbank of Steiermark (RLB).

Lessons Learned

The project developer has identified the following lessons that were learned from previous industrial energy analysis reports. These are summarized as follows:

- many industries use steam for their processes, although they often do not need temperatures over 90 °C,
- many industries operate with very inefficient steam systems,
- a change from steam to hot water systems would often result in greatly increased energy end use efficiency,
- such a change would also increase a possible integration of solar thermal process heat.

Contact Information

S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH
Puchstrasse 85, 8020 Graz, Austria
CEO: Christian Holter & Franz Radovic
Tel: +43 316 292840-0, Fax: +43 316 292840-28, office@solid.at

Josef Buchinger, Project Development, j.buchinger@solid.at
Tel: +43 316 292840-28

http://www.solid.at

4.18 Changbin and Taichung Wind Farms - Chinese Taipei

Source: Climatefriendly Website

This example is designed to illustrate how integration of wind farms to supply electricity to an industrial park can provide revenue and economic value to both the developer and to the industrial occupants of the park through the combined applications of renewable energy and efficient energy end use.

Project Description

InfraVest Wind Power Group has developed two wind energy projects, the Changbin and Taichung wind farms on the west coast of Taiwan. The total quantity of about 483,864 MWh/year of power is "bundled" as a single power source for delivery to the state-owned power grid, Taipower, and used to supply the Changbin Industrial Park. The two farms offset significant amounts of carbon dioxide, and the developers are selling emission reductions (carbon credits) from the project.

Commissioned in 2007, the project involves a 103.5 MW wind farm located in Changbin Industrial Park; and a 46 MW wind farm in Taichung County. Each Enercon turbine has a capacity of 2.3 MW, and the wind farms are expected to generate over 507,000 MWh of electricity per year. The system will reduce coal use, leading to an estimated emissions reduction of 405,470 tonnes of CO_2 equivalent by year ten.

The two facilities were constructed and are operated by InfraVest Wind Power Group, a subsidiary of German-based VWind AG. The German company is providing training on the maintenance, safety and operations of the turbines.

Coupling with Energy Efficiency

This project is a highly efficient in that it reduces methane emissions from waste and produces renewable electricity and heat. Energy efficiency is also achieved by the Supply of electricity derived from renewable Electricity to an Industrial Park. Such parks are managed to achieve maximum efficiency in the use of the resources required for industrial production, of which energy use is a key ingredient.

The key point about Industrial Zones – especially Export Zones - is that they provide a central management facility that enables their resident industries to operate in an environment that promotes efficient use of resources. They also provide opportunity for selling surplus process heat and steam to other industries within the zone. This extends the opportunities for maximizing energy efficiency by utilising steam for cooling purposes, the application of heat pumps and the sale of excess electricity into the local grid.

Economics

The majority of wind farms in Chinese Taipei have been built by TaiPower. This utility has a mandate to install renewable energy, and the ability to cross-subsidize its wind farms using profits from its fossil-fuelled power plants. As a private developer, InfraVest did not have these same advantages. Instead, InfraVest was able to make its project economically competitive by making use of the carbon markets. The carbon credits are being certified according to the Gold Standard, which is a strict standard used widely on the voluntary market.

Obstacles Encountered

The main obstacle to InfraVest, was its inability to compete with state owned TaiPower by cross-subsidizing the wind farm from other generating assets. Furthermore, Chinese Taipei has not ratified the Kyoto Protocol so cannot host UN Clean Development Mechanism (CDM) projects. To overcome these obstacles, access to the voluntary carbon market was achieved by registering the project under the Gold Standard Voluntary Emissions Reduction (VER) label which provides the highest quality assurance in the voluntary market.

Construction challenges include high winds during the winter months and typhoons during the rainy season. Also, the foundations of the machines had to be designed and built to withstand the earthquakes that occur in this part of the world.

Lessons Learned

The following lessons have been learned from this project:

- The project would not have happened without the sale of Gold Standard VER carbon credits which provide access to carbon CDM finance where the host economy is not a Kyoto Protocol signatory,
- The Gold Standard label ensures that the project has clear environmental and socio-economic advantages and is therefore fully accepted by stakeholders,
- Location in an Industrial Park enables a wind farm, or any renewable energy supplier, to access a number of industrial consumers operating in an energy efficient environment,

- "Bundling" two or more wind farms together provides the opportunity to increase the efficient utilization of their electricity supply infrastructure.

Contact Information

InfraVest GmbH
10-2F, No. 9, Sec. 2, Roosevelt Rd., Taipei.

Mr. Renat Heuberger, South Pole Carbon Asset Management Ltd.
Technoparkstr. 1, Zurich 8005 Switzerland
Phone. 41 44 633 78 70, Fax. 41 44 633 14 23.

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5.0 Barriers and Obstacles to Implementation

A number of obstacles have been encountered in progressing the efficient use of renewable energy in Industry. For the most part, these tend to be generic to the introduction of new technology and are generally similar for both renewable energy and energy efficiency. A few are, however, specific to particular forms of renewable energy and some to individual configurations or locations of industrial plants.

The following sections provide an overview of these obstacles categorized in terms of whether they are:

- Generic to the introduction of any new technology,
- Technology specific,
- Industry specific.

5.1 Generic Obstacles

The introduction of any new technology or practice carries with it a number of obstacles that are intrinsic to its novelty. So it is with the introduction of renewable energy and energy efficiency practices in industry. Those obstacles that have been identified from the Case Studies and are considered to be generic to all of the industries, technologies, locations and economies involved can be classified under the following headings:

- Information Access and Implementation Capacity,
- Project Ownership issues,
- Technical issues,
- Financial and Economic issues,
- Policy and Institutional issues.

These are presented and discussed in the following sections.

5.1.1 Information Access and Implementation Capacity

Probably a first requirement for the introduction and development of any new technology is information. Those who can benefit from the new technology need to be fully informed about its pros and cons and it takes time to establish an understanding of what new technologies and processes have to offer and the likely risks involved.

New technologies need to develop their own support infrastructure which includes access to information and capacity to introduce and operate the technology. The efficient use of Renewable Energy in Industry is no exception and examples of inadequate access to information and lack of implementation capacity are widespread – not only throughout APEC economies, but worldwide. The following have been identified:

5.1.1.1 Access to information

Most industrial factory operators have some understanding of ways to improve the energy efficiency of their plants, but few are informed on how renewable energy can be introduced in conjunction with energy efficiency. In part, this is due to lack of available information and in part due to lack of interest by factory management.

Within the organization there needs to be a good understanding of the objectives of the organization, the materials being processed (e.g. sugarcane to produce sugar, sewerage being treated to produce clean water and biogas, timber being milled to produce house timber, paper for printing), the equipment being used to undertake the processing, the waste products, and the human and material resources required to achieve those objectives. This includes the flows of energy (energy audit). Absence of this information at an appropriate level of detail is a key barrier to decision-making and implementation of new technology or improved operation of the existing system.

Some of the specific obstacles involved include:

- limited access to general information on the opportunities for improving energy efficiency and using renewable fuels in industry, thereby inhibiting the investigation of particular project ideas by a company or industry,
- lack of information on a new project idea, whether generated within the organization or by external sources is a barrier to its implementation,
- a lack of know-how about the subsidies, technology and pilot project experiences that are available,
- the time and transaction costs incurred to obtain and process information on the new technologies so as to build an appropriate information base for staff and management,
- lack of reliable information on which to determine project feasibility, implementation requirements and business plans,
- the need to conduct significant research, development and demonstration (RD&D) activities to generate the information required for management to make a reasoned and robust investment decision,

5.1.1.2 Information transfer and personnel training

Once the requirements for information are identified it is, conceptually, quite easy to initiate information transfer and training initiatives and programs for those personnel who will be engaged in the implementation and operation of renewable energy, coupled with its efficient use, in industry. The company will also have to obtain information from equipment suppliers and this will have to be assimilated and verified to confirm that it is correct and appropriate for the particular project in terms of quality, reliability, price and value for money. This assessment imposes a cost on the company.

Some of the specific obstacles involved include:

- difficulties in accessing the right information,
- identifying the right people to train,
- transaction costs associated with information assembly and personnel training. The cost of staff time in particular is frequently seen as a barrier to the introduction of new technology,
- renewable energy companies often lack an understanding of the complexity of industrial processes and system integration,
- conversely, specialists in industrial energy systems often know very little about the efficient use of renewable energy,
- management and training procedures and their associated costs may represent significant barriers to the introduction of energy efficiency and renewable energy.

5.1.1.3 Implementation capacity

Implementation of efficient renewable energy systems in industry requires input from a number of equipment and service providers who need to work in close conjunction with industry operators and management. In many cases the resulting project implementation capacity is less than optimum.

Some of the specific obstacles involved include:

- limited availability of skilled service providers,
- long lead times for equipment supply,
- lack of mutual understanding and poor communication between service providers and industrial plant operators,
- lack of standardized solutions and coordination between these groups,
- the time required to buildup appropriate information and experience for staff and management,
- there may be a shortage of expertise in areas where it is needed for development of renewable energy or energy efficiency.

5.1.2 Project Ownership Issues

For a variety of reasons, management, a board of directors or members of the workforce may be reluctant to support a project that will make changes to an existing industrial operation and it may take some time to achieve acceptance and ownership. Some of the factors involved include:

5.1.2.1 Management and Worker perceptions

Industrial factory managers are, by nature, very conservative and risk-averse as their focus is on maintaining an uninterrupted revenue flow from their operations. It is understandable, therefore, that both management and workers often create obstacles and barriers to the introduction of renewable energy and energy efficiency into their plants. Some of the specific obstacles identified include:

- industry management is often not aware of the possibilities for using renewable energy and optimizing energy efficiency in their plants,
- plant managers and industrial energy specialists are usually wary of what they perceive as “new technology”,
- projected outcomes are frequently disbelieved,
- doubts about the successful integration and service quality of renewable energy and energy efficiency systems are also common,
- people in the organization may either knowingly or inadvertently become a barrier to energy projects if they feel threatened by the changes to a stable situation associated with introduction of new technology. This applies to both workers and senior staff.
- if the return on the investment accrues to one section of the company but the project has to be implemented by a different section, there can be an implicit barrier for the latter section to proceed with the actual implementation or to proceed with a project which is less than optimal.

5.1.2.2 Championship

Any modification of existing industrial plant or development of any new project must have its champion who is prepared to promote the project until such time as the organization takes ownership. Some of the specific difficulties associated with championship include:

- management may be predisposed to avoid making changes to systems which are functioning satisfactorily,
- proposed changes may require a substantial amount of new effort including training of both managers and other existing staff who are very comfortable with their existing situations even though the new systems or equipment may potentially have a large positive impact on the organization.
- divergent interests amongst different groups (e.g. administrative, technical).

Some of the actions that have proved successful in establishing champions for the efficient use of renewable energy in industry include:

- mobilizing people with strong environmental motivation to whom energy efficiency and renewable energy projects are likely to be attractive,
- capitalizing on divergent interests by having a group, or groups, as a collective champion,
- seeking championship at the most senior level possible.

5.1.2.3 Stakeholder engagement

The main stakeholders in any project designed to maximize the efficiency of renewable energy use in industry are usually:

- the owners, shareholders and directors of an industrial plant,
- the plant management,
- the plant workers,
- the responsible regulatory agencies,
- renewable energy technology suppliers,
- energy efficiency technology suppliers,
- the bank, or other financial institution, that is providing finance.

Experience in implementing industrial renewable energy and energy efficiency projects has repeatedly shown the need to engage all stakeholders and to ensure that they work harmoniously together with a good understanding of the perspectives and requirements of other stakeholders. Some of the barriers that relate to poor stakeholder engagement have already been noted as information transfer obstacles in section 5.1.1.2 above and are particularly important where emerging technologies are involved. Some examples noted for the examples of solar thermal heating include:

- solar companies often lack an understanding of the complexity of industrial processes and system integration,
- specialists in industrial energy systems usually know very little about solar thermal technologies,
- communication between solar companies, industrial plant management and industrial energy system specialists is often poor and there is a lack of standardized solutions to assist.

5.1.3 Technical Issues

Most of the technical barriers to the efficient use of renewable energy in industry tend to be technology specific rather than generic. There are, however several that are common to most industrial renewable energy and energy efficiency applications. These are:

- most renewable energy technology is at an early stage of development and the risks associated with adoption of such technology are a barrier to its widespread uptake,
- technical problems are frequently encountered in the accommodation and interfacing of energy efficiency outcomes. This means that the full efficiency improvement cannot be realized unless a valuable use can be found for the excess heat.
- renewable energy and energy efficiency equipment suppliers and installers are often unable to respond in short time – particularly where the equipment is not manufactured locally and needs to be imported at high cost,
- the technical infrastructure required for delivery of some forms of renewable energy, such as biomass or biofuels, may not be available or fully functional. Similarly, the infrastructure required to maximize energy efficiency gains may not be available. A notable example is the need for piping systems to enable sales of excess steam to a neighboring factory or throughout an industrial processing zone.
- considerable engineering modifications may be required to accommodate the new technology. For example, the static load of roof areas is often too low for installation of solar thermal collectors.
- A lack of resource assessments. Resource data are not normally available and must be assembled before decisions can be made about introducing renewable energy technologies and systems into industry. In many cases these data must be collected over a period time (e.g. wind resource assessments typically require the assembly of 1-2 years worth of data).

5.1.4 Financial and Economic Issues

Not unexpectedly, the greatest barriers to introduction of renewable energy and energy efficiency systems in industry relate to their economics and financing. Industrial factory managers are particularly risk-averse as their focus is on maintaining an uninterrupted revenue flow from their operations so heat recovery and optimization of their existing process usually have priority over the introduction of new technology.

Where such introduction is being considered, primarily interest will be focused on:

- its establishment cost,
- the payback period,
- the long term economic return for owners/shareholders,
- the availability of capital.

The following sections provide an overview of the obstacles associated with each of these issues.

5.1.4.1 Establishment costs

Renewable energy installations generally have higher upfront capital costs than conventional alternatives, however they usually have lower operation and maintenance (O&M) costs.

Nevertheless, the comparatively high cost of establishing efficient renewable energy systems in industrial plants is one of the major obstacles recognized by management.

A number of factors frequently combine to result in the high cost of project establishment. Some of those that have been identified, both from the case studies presented in Chapter 4 and from the literature, include:

- the higher capital cost of renewable energy installations per unit of energy delivered,
- failure, by most companies, to take full account of the total life cycle cost of the project so upfront capital costs loom disproportionately large,
- lack of integrated supply chains for renewable energy means that all supply chain costs (including the costs of sales and marketing, distribution, transport and on-site assembly and installation) are often assigned in full to the project rather than being part of an integrated supply chain. This means that reducing the costs of the full supply chain is as important as reducing, for example, the capital cost of renewable energy or energy efficiency equipment.
- very few economies have fast-track project approval mechanisms applicable to renewable energy and energy efficiency installations. Consequently, a project is often subject to long and unwarranted delays – and thus increased establishment costs – even though its renewable energy and energy efficiency components may be quite a small percentage of the total project cost. These delays adversely affect the financial viability of the entire project, and may well cause developers to avoid renewable energy and energy efficiency innovations,
- Import Duties on components, products and materials can be a serious financial impediment for local companies that need to import these for establishment of efficient renewable energy facilities,
- the absence, or inadequacy, of Investment Support programs applicable to the installation of high efficiency renewable energy systems in industry in most APEC economies constitutes a substantial obstacle to development.

5.1.4.2 Economic viability

The economic viability of a renewable energy and energy efficiency project is likely to be subject to different criteria and economic hurdle rates in different APEC economies. It may also differ between different sections of an organization and for the type of equipment involved. Furthermore, the risk of such projects often perceived to be high because of a lack of information or experience within the company and this may translate into a requirement for higher return on investment.

In general, however, the economic viability of most industrial renewable energy and energy efficiency installation project is not great and industrial management has little enthusiasm for the long payback periods involved.

Some of the factors that contribute to poor economic performance of renewable energy and energy efficiency projects in industry include:

- whether the economic analysis covers the full enterprise or an individual section,
- the difficulty of competing with very low prices for fossil fuels in many APEC economies. Thus, without a level playing field it is difficult, if not impossible, for renewable energy to compete on a cost basis with subsidized fossil fuels,

- the lack, or inadequacy, of Tax benefits for investment in industrial efficiency and the use of renewable energy. Some of the more common tax incentives that would, if available, improve economic viability include:
    - Income Tax Holidays,
    - removal of Value Added Taxes (VAT) from renewable energy and energy efficiency products,
    - tax credits for domestic capital equipment and services.
- the lack, or inadequacy, of corporate financial facilities in many APEC economies. These include:
    - net operating loss carry-over,
    - reduced corporate tax rate following income tax holidays,
    - accelerated depreciation on renewable energy assets.

5.1.4.3 Access to capital

Access to capital is definitely an obstacle to investment in efficient renewable energy technology by APEC industries and the problem is, in different degrees, common to all economies. Specific obstacles that have been identified include:

- many capital markets do not provide sufficient access to affordable finance for industry operators, project developers, equipment suppliers and service providers,
- Banks and other commercial financing institutions are often reluctant to fund renewable energy and energy efficiency projects due to poor understanding of the systems and technologies involved and adverse historic bank data on past loans,
- because of their lack of information, understanding and experience of these technologies, assessment of risk by most financial lenders is frequently much greater than is actually the case. This translates to higher interest rates. There is, therefore, a clear need to educate prospective lenders on how to assess and value risk for these emerging technologies.
- access to Carbon Finance through the UN Clean Development Mechanism (CDM), although potentially available to industries that are embracing renewable energy coupled with energy efficiency initiatives, is not easy and quite expensive – particularly for Small and Medium Enterprises (SMEs) which make up a high percentage of the industrial manufacturing sector. Most of the projects that have been registered are concentrated in a few large industrialized countries - primarily China, India, Brazil, Korea and Mexico. Other APEC economies that qualify for CDM financing include Chile, Indonesia, Malaysia, Papua New Guinea, Peru, the Philippines, Chinese Taipei, Thailand and Viet Nam.

5.1.5 Institutional Obstacles

Establishment of the institutional infrastructure necessary to regulate and provide support to the introduction of any new technology is one of the keys to its success. The infrastructure required must include:

- incentives designed to encourage introduction of renewable energy and energy efficiency in industry,
- a Regulatory Framework that provides guidance and governance of how the technology should be developed and maintained,
- an administrative structure that can provide the mechanisms for smooth and efficient operation of the regulatory and governance imperatives that have been established.

Some of the obstacles associated with imperfect operation of the institutional infrastructure are presented in the following sections.

5.1.5.1 Incentives

There are a wide variety of incentives offered by various governments aimed at promoting industrial energy efficiency investments. These include reduced income tax rates, accelerated depreciation, exemptions from sales tax or import duty, low interest loans, income tax credits and tax holidays. Incentives can be offered by national, state or local governments and vary considerably from economy to economy depending on economic and political circumstances. While they may be very acceptable to some organizations, however, they rarely suit all situations and most of the obstacles encountered relate to lack of balance or inequity in their provision and administration.

Some specific obstacles that have been noted include:

- the inequity created by fossil fuel subsidies, which operate in all APEC economies, constitutes a significant financial obstacle to the introduction of renewable energy and often make its introduction uneconomic,
- insufficient incentives offered to encourage industry managers to introduce renewable energy and energy efficiency technologies in their factories,
- failure of the government, or other organization providing the incentive, to make its rules sufficiently flexible to cover all deserving situations,
- inconsistencies of rules for qualification which can vary from place to place and in some situations exclude particular companies or industries. For example, investment incentives may be available for installing building insulation but not solar thermal collectors,
- similarly, some incentives are offered for one renewable energy or energy efficiency technology but not for others that provide equivalent advantages.

5.1.5.2 Standards and Regulations

Standards, codes of practice and regulations can range from workplace instructions to recognized international standards. Similarly, regulations can vary from internal company practices to those established to promulgate Government legislation. Government regulations applicable to the introduction and use of renewable energy and energy efficiency technology in industry are in place in most APEC economies which also have supporting energy efficiency standards. In some cases these are mandatory, in others they are voluntary. Energy efficiency labels for equipment such as electric motors and boilers are also required in some economies.

Standards, codes of practice and regulations define the targets the organization must achieve, both in terms of performance and safety, and problems occur when they are inadequate, inappropriate or nonexistent. In such cases these shortcomings can be obstacles to development. Several that have been identified include:

- absence of a required standard (e.g. energy efficiency or renewable fuel consumption standards). If the need is sufficiently great, the organization may have to instigate an activity to develop the necessary standard. This is likely to be both costly and time consuming,

- lack of suitable testing and certification facilities,
- inappropriate standards or regulations disallowing the installation of renewable energy and energy efficiency technology or adversely affecting the sale of its products. In many cases the rules and regulations causing the problem were not originally designed to recognize these new technologies and may apply to a completely separate activity (e.g. fossil fuel safety.
- standards or regulations that have unintended differential impacts on different technologies or situations can result in promoting one technology and deterring another and thus distorting the energy supply and end use portfolios available.

5.1.5.3 Administrative barriers

- regulations and standards simply ignored and not policed,
- bureaucratic sluggishness,
- lack of capacity to administer the legislation, e.g. where consents are devolved down to small local administrations that do not have suitably qualified personnel to do the job required,
- the laws in some economies may, either intentionally or otherwise, prevent or mitigate against some projects or situations, thus becoming a barrier to implementation,
- implementation of the project will usually require permits or consents to be obtained. The time and cost required to submit and negotiate such consents may be substantial to an extent that the capital cost, economic viability or timing of the project is significantly affected. The situation will vary in the different economies but there is the opportunity for Governments to remove or ameliorate some of the above barriers.

5.2 Technology-Specific Obstacles

This section discusses some typical technical challenges to the application of particular renewable energy technologies and systems in industrial applications that are representative of those encountered throughout APEC economies.

5.2.1 Solar Thermal Energy

Obstacles to the increased use of solar thermal energy in industry include:

- the conservative nature of the building industry, not wanting to stray beyond the familiar conventional systems,
- lack of adequate information about solar hot water heating,
- solar water heating systems must remain in un-shaded, south-facing areas (north-facing in the Southern Hemisphere) for maximum efficiency,
- hard or acidic water is not compatible with solar water heating systems because it gradually corrodes the water circulation system. These systems can be even more complex and expensive to operate in areas that experience freezing temperatures.
- The purchase and installation costs for solar water heating systems are normally higher than those of conventional electric or gas water heaters unless there are policies in place to reduce costs, such as in China.

5.2.2 Photovoltaic Power Systems

Obstacles to the proliferation of solar PV in industry include:

- high initial investments, despite low long-term operating costs (i.e. no ongoing fuel costs),
- lack of industry understanding about the technology and reliability issues,
- lack of stable pricing for solar-electric components and systems,
- the need for improved manufacturing infrastructure to increase the availability of PV products,
- lack of support, or even outright opposition, from some electric utility companies.
- availability of free and open access to the sun to ensure maximum efficiency of the solar PV systems.
- Grid integration issues which can damage sensitive electronic and electrical equipment and lighting, such as over/under voltage, voltage imbalances, harmonics, unintended islanding, short circuits, frequency fluctuations, electricity supply security and peak power supply cuts.

5.2.3 Concentrating Solar Power

Concentrating solar power (CSP) system development has been constrained by technical difficulties in producing power on a sufficiently large scale, for a given area of available surface and at sufficiently low cost. For industrial applications, a key obstacle is the lack of sufficient open space to set up reflecting parabolic troughs, dishes or towers. Regions with high humidity and high levels of atmospheric dust are poorly suited to CSP.

5.2.4 Wind Electric Power

Some obstacles to increasing the use of wind power to supply industrial plants include:

- the intermittent nature of wind energy which requires backup power or battery storage. Most wind applications in industry will be grid-tied, so the main obstacle is the cost of connection.
- time consuming and expensive administrative processes required to obtain permits and pre-construction activities such as feasibility studies, resource assessments and original engineering design,
- the need to have wind turbines in windy locations, especially on the top of hills, where they may create substantial visible pollution,
- land availability for dedicated supply of electricity to integrated industrial processing zones, coupled with safety concerns; generally restrict the use of wind turbines to small models with low power output. Small diameter wind turbines are less effective in producing energy because wind power generated is proportional to the area of the circle swept by the blades.
- creation of noise, which can be troublesome to nearby residents. Many turbine models can run at partial load to reduce the operating noise but this also reduces their efficiency.

5.2.5 Bioenergy

5.2.5.1 Power Generation

Key obstacles for bioenergy power generation in urban areas are, feedstock availability, and land availability for feedstock stockpiling, together with zoning, siting and permitting issues. Emission control requirements can also add significant costs for bio-power facilities.

5.2.5.2 Process Heating

Process heating is probably the best use of biomass energy industry. As in the case of power generation from biomass the main obstacles encountered are:

- availability of feedstock and maintaining its reliable supply,
- land availability for feedstock stockpiling,
- permitting issues.

5.2.5.3 Liquid Biofuels

Some typical obstacles to the use of biofuels in APEC industries include:

- the large land use requirements for the cultivation of biofuel crops,
- the transportation costs of bringing these resources to industrial sites,
- reliability of supply,
- the food versus fuel controversy,
- the need for infrastructure investment to collect, transport, blend and deliver biofuels to industrial consumers.

5.2.5.4 Landfill Gas Capture and Use

Some of the barriers include:

- remoteness of landfill gas production sites from industrial consumers,
- regulations forbidding injection of landfill gas into pipeline gas,
- establishment of the infrastructure for delivering gas to individual industrial plants or industrial processing zones,
- reliability of supply. Some landfill operations may not process enough garbage to produce sufficient gas to provide a reliable supply for industrial requirements.

5.2.6 Hydropower

Supply of large scale grid based hydropower to industrial plants is well established. It is, however, facing increasing opposition in many APEC economies due, mainly, to population displacement and environmental issues that are sometimes associated. Small scale hydropower, however, is a potentially attractive source of renewable electricity for industry but does have its own associated obstacles. These include:

- proximity of a water supply having the necessary potential energy,
- limitation of electricity distribution distances to a few kilometers from the point of generation Beyond this distribution becomes uneconomic or requires grid connection,
- difficulties in obtaining permits for diverting rivers near industrial locations as this may adversely impact other infrastructure, historical features or aesthetics.
- seasonal variations in water flow making output uncertain.

5.2.7 Geothermal Heat and Power

There are some very good examples of geothermal heat and power applications in industry in several APEC economies – notably New Zealand where geothermal heat is used very successfully for timber drying in several locations. Unfortunately, widespread use of Geothermal heat and power is limited to those places where there is geothermal activity so only a few strategically or fortuitously located industrial plants that can benefit other than from grid supplied electricity.

Geothermal heat pumps, on the other hand are becoming more widespread for residential and institutional heating and cooling in many APEC economies but industrial applications are rare and limited, primarily, to air conditioning. Some of the obstacles to development that have been reported include:

- the incremental cost of installing the ground loop,
- competition from cheap natural gas,
- shortage of equipment manufacturers, suppliers, dealers and loop installers,
- customer resistance to heat pump technology,
- lack of educational programs for installers and maintenance personnel,
- availability of suitable land for ground loop installation,
- permitting issues due to interference with groundwater systems

5.2.8 Heat Pumps

Introduction of heat pumps that operate on waste heat are rapidly increasing in industries throughout the APEC economies because they increase energy efficiency and make good economic sense. Most of the activity is taking place in North America but is mirrored by similar activities in Europe – particularly Sweden. Several obstacles to the introduction and growth of industrial heat pumps include:

- high initial capital cost,
- operating times less than forecast,
- inability to produce a sufficient amount of waste heat to run the heat pump cycle,
- maintenance problems with the heat pump units,
- the need for a relatively low cost electricity supply,
- effectiveness in offsetting heat generated elsewhere in the facility.

5.2.9 Smart Grids

Smart grids can both enable the use of discontinuous renewable electricity (e.g. /wind and solar) and considerably increase the efficiency of energy use in industry through Down-Side Management (DSM) of electricity consumption. There are, however, a number of obstacles to introduction of discontinuous electricity supply into a grid which necessitate the development and introduction of so-called Smart Grids that can accept and accommodate discontinuous asynchronous inputs. Some of the technical and technology barriers confronting grid-connected use of renewable energy systems in APEC economies include:

- inadequate technology and capacity to support high penetration of renewable electricity,
- adverse impacts on grid stability and electricity quality (voltage, frequency, non-sinusoidal harmonics and noise) can be barriers,

5.3 Industry-Specific Obstacles

Relatively few of the obstacles to renewable energy and energy efficiency are industry specific. Those that are include:

- availability of suitable land for installation of large-scale systems such as geothermal power plants, wind energy and bio-energy facilities,
- the cost of preparing brown-field locations to accommodate renewable energy and energy efficiency infrastructure,
- time and cost associated with obtaining resource consents for use of geothermal steam for timber drying,
- availability of a source of waste heat for heat pump operation,
- difficulties in finding a productive use for the considerable amount of additional heat obtained from combined heat and power (CHP) installations.

5.4 Summary

Realistically, the obstacles encountered in the introduction and development of renewable energy coupled with energy efficiency in industry are very much the same as those for most other situations involving the introduction of new and unconventional technologies. It is, of course, tempting to rank the various obstacles identified in terms of the extent to which they hinder the introduction of renewable energy and energy efficiency initiatives in industry. Such a ranking does not make much sense; however, because individual industries, technologies and locations each have their own characteristics and an obstacle that may be of major importance in one situation may well be quite minor in another.

We have not discovered any particular obstacles that are genuinely unique to the introduction of renewable energy and energy efficiency initiatives in industry. There are, of course, specific obstacles that apply to individual industrial applications as outlined in sections 5.2 and 5.3 above. Most of these are best addressed by individual industrial plant management.

Those obstacles that can be addressed by Governments include:

- lack of information about how the introduction of renewable energy and energy efficiency can benefit specific industries,
- insufficient capacity to implement the technology in a timely and cost effective manner,
- high project establishment costs,
- poor economic viability due to competition with subsided fossil fuels,
- difficulties in accessing capital,
- institutional obstacles such as:
  - lack, or inadequacy, of appropriate incentives,
  - ineffective regulatory regimes that are not supportive,
  - inadequate administrative structures and performance.

Governments can remove, or at least reduce, the obstacles hindering advancement of renewable energy and energy efficiency technologies by promoting the following initiatives:

- providing information about opportunities for the combined use of renewable energy and energy efficiency in industry,
- provision of incentives that encourage industry to introduce renewable energy and energy efficiency applications in their plants,

- capacity building for equipment suppliers, service providers and financial institutions to support the efficient use of renewable energy in industry,
- reducing the costs of implementation through strategic application of incentives,
- facilitating access to finance – particularly CDM finance,
- ensuring that appropriate standards and industry codes of progress are in place,
- ensuring that effective regulatory frameworks to assist the introduction of renewable energy and energy efficiency in industry are set in place,
- facilitating the administrative processes involved in obtaining permits, consents and approvals

These issues have been addressed successfully in a number of economies and industries around the world and there are a number of very effective models that can be replicated. The good news is that most of the obstacles identified are diminishing with time as experience is gained, capacity built and costs reduced.

6.0 Lessons Learned

The following sections describe the lessons that have been learned in progressing the efficient use of renewable energy in Industry. For coherence and continuity they are categorized under the same headings as used to describe the Barriers and Obstacles encountered when introducing renewable energy and energy efficiency applications in industry in Chapter 5.

In formulating these lessons we have relied both on the experiences recorded in the examples presented in Chapter 4 and on the considerable amount of material that is available in the public domain. Specifically, we wish to acknowledge the APEC EWG report entitled ***Renewable Energy for Urban Application in the APEC Region*** on which we have modelled parts of this report and several parts of which are repeated and reinforced herein. www.iadb.org/intal/intalcdi/PE/2010/05217.pdf

Most importantly, we have tried to highlight the lessons that have been learned about combining the applications of renewable energy and energy efficiency in industry to achieve desirable outcomes and added value for the industry stakeholders as discussed in Chapter 3.

6.1 Generic Lessons

As in the case of the barriers and obstacles discussed in the previous chapter, many of the lessons that have been learned about how renewable energy and energy efficiency are generic to the introduction of new technology and are generally similar for both renewable energy and energy efficiency. Some are, however, specific to particular forms of renewable energy and some to individual configurations or locations of industrial plants.

6.1.1 Benefits of Renewable Energy and Energy Efficiency

The application of renewable energy and energy efficiency technologies in industry offers significant benefits for APEC member economies because they:

- satisfy the needs for electricity, heat and fuel,

- utilize locally available resources such as solar energy, wind, sustainable biomass, geothermal energy and hydropower,
- conserve the natural resource base of each economy,
- reduce the need for fossil fuel imports with their attendant foreign trade impacts,
- provide a hedge against fluctuations in world oil, and local fossil fuel, prices http://www.cec.org/Storage/62/5461_QA06.11-RE%20Hedge_en.pdf,
- enhance energy security by diversifying the energy portfolio and improving price stability,
- contribute to a cleaner environment by reducing greenhouse gas and other harmful emissions, improving air quality and enhancing the general health and well-being of industrial workers,
- create jobs, revenue and income opportunities,
- enhance economic development through local manufacture of products and components, assembly and installation, operation of renewable and energy efficiency equipment and its servicing.

6.1.2 Early Industrial Adopters of Renewable Energy and Energy Efficiency

Several of the lessons learned apply particularly to early adopters of the new technology. These include:

- the need for political vision and leadership in promoting the economic and policy environments essential for the introduction of renewable energy technologies and energy efficiency in industry,
- the need for local scientific, technical and engineering competence and capacity to support early introduction and growth of new technologies,
- pilot and demonstration projects are valuable in creating awareness and an early experience base for new industrial renewable energy and energy efficiency systems and applications,
- early financial and risk underwriting of innovative approaches helps to stimulate technical innovation and enable costs to decline through the processes of scaling up and technology development,
- regulatory policies must adapt and evolve rapidly so they continue to address and support industry operators as the scale of implementation increases, technologies develop and new obstacles to implementation emerge,
- the industry type and industrial company size will usually determine the possibilities for renewable energy and energy efficiency development,
- competition and/or cooperation between companies in the same industry promotes the adoption of renewable energy and energy efficiency initiatives. Many pioneer companies see an “early adopter” advantage and look for competitive advantages from innovation. By contrast, some companies, start simply by targeting specific renewable energy opportunities, such as solar, wind or bio-energy,
- as early adopters, some companies act as innovation incubators, supporting new technology and policy approaches - thereby producing a “snowball effect,”
- performance based standards tend to facilitate technology advancement and cost reductions whereas prescriptive measures tend to freeze technology.

6.1.3 Information Availability and Capacity Building

Even though energy efficiency measures often exhibit short pay back times of only few years and sometimes even months, many are not implemented because:

- knowledge of the efficiency gains that can be achieved is not widespread,
- information about access to finance (e.g. via the clean development mechanism, other carbon finance or mainstream project finance) is not widely understood by most industry operators,
- capacity building is often regarded as having low productivity because it is a long-term process that needs to occur at several levels and involves more than just training,
- assistance is needed to build capacity in all aspects of technology research, development, demonstration, deployment, marketing, financing, operation and maintenance to bring down costs, improve performance and enhance competitiveness with conventional energy sources,
- a range of business planning and support services must be available to ensure development and delivery of renewable energy and energy efficiency services.

6.1.4 Technical Lessons

The technical lessons learned are that:

- the service markets needed to support and promote the introduction of renewable energy and energy efficiency initiatives in industry are mostly inadequate such that, in many developing economies, there are few qualified local service providers able to offer the assistance needed,
- there are gaps in technical expertise in many APEC economies so that suitable technical solutions are not always available on the local market,
- the supply of spare parts is often unreliable,
- there is often limited awareness of the technical or behavioral changes needed for the introduction of new technology,
- it is, however, encouraging to record that many industrial operations in developing economies are accessing international expertise to assist in their introduction of renewable energy and energy efficiency initiatives, while at the same time building local expertise and capacity,

Most of the technical lessons learned are, however, technology specific as discussed in section 5.2 below

6.2 Financial and Economic Lessons

The financial and economic lessons learned are that:

- financing and implementation of renewable energy and energy efficiency projects in industry is achieved much more easily when it is being done by a financially robust industrial company that does not need to operate on a shoestring,
- the monetarization of by-products is often essential to the combined application of renewable energy and energy efficiency initiatives in industry,
- a company will not utilize new technology, even when installed, when alternative fuels, such as natural gas, are available at low prices, if the cost benefits of using renewable energy are not sufficient to pay off investment,

- credit lines for investment in small scale demand side efficiency initiatives whether in the industrial sector, in small and medium sized enterprises or in the building sector are difficult to secure.

6.3 Institutional Lessons

Many of the barriers to introduction of renewable energy and energy efficiency applications in industry relate to difficulties in negotiating the institutional and regulatory requirements imposed in many economies. Most of these are not intended to impede new initiatives but are either too restrictive or not sufficiently advanced to accommodate new technology so do not provide the incentives required to assist advancement of the new technologies that are needed to overcome the hurdles encountered for their introduction.

6.3.1 Availability of Incentives

Industry operators are, by nature, cautious and risk-averse and will not generally pursue new initiatives unless there are adequate incentives to do so. Some of the lessons learned are that:

- policies need to be flexible and change as the numbers and types of industrial renewable energy and energy efficiency applications increase, as technologies develop and as scale-related obstacles to implementation appear,
- risk underwriting is often necessary during the initial stages of market entry and early diffusion but can be removed gradually as the market takes off, costs come down, production and experience learning curves go up and stakeholder risk perceptions abate,
- financial institutions operating in APEC member economies can be important sources of finance for renewable energy and energy efficiency projects and programs. However, they are often not well acquainted with the new technologies involved and are therefore reluctant to lend. Education and training are needed so they are aware of the risks and rewards of these projects and the risk mitigation instruments available - particularly to help local banks build new loan portfolios, either by reducing risk for the lending institution or by facilitating increased demand for their loans. Extending loan durations and collateral support can be useful support mechanisms.

6.3.2 Standards and Regulations

Performance standards tend to facilitate technology advancement and cost reductions whereas prescriptive measures tend to freeze technology. Standards that are incorporated into regulations give more confidence in products and for potential investors.

6.4 Technology Specific Lessons

The following lessons that are specific to the different renewable energy options have been learned.

6.4.1 Solar Thermal Energy

- Commercial solar water heating technologies are mature and there are no fundamental technical issues remaining. However, since each installation is unique, technical competence in system design, specification, construction and support is essential for the introduction of this technology in industry,

- solar thermal heating to provide hot water for use either directly or as feed water for industrial boilers is a relatively simple undertaking. It can be applied in essentially all APEC economies in locations where sufficient solar energy is available throughout the year,
- solar energy can be used to dry most crops and in other processes requiring warm air. It is often preferred since it does not burn or harm delicate foods, which often happens with steam or heat from burning fuels,
- crop drying is an excellent application for solar thermal utilization - especially in sunny climates,

6.4.2 Photovoltaic Power Systems

- energy efficiency can be maximized by combining solar thermal collection with PV,
- heat and power production need to be balanced in an industrial plant so there is no need to dispose of surplus heat or electricity by grid connection,
- the cost of capturing solar energy to produce both heat and power appears to be very competitive with conventional ways of providing these requirements,

6.4.3 Concentrating Solar Power

- concentrated solar power generation of steam for process heat, power generation, combined heat and power (CHP) generation or even tri-generation to provide solar cooling is almost infinitely flexible, but is still in the development stage,
- solar energy collection efficiency can be optimized by automatically alignment of collectors with the sun so they can easily and accurately be controlled when solar radiation levels vary.

6.4.4 Wind Electric Power

- location in an Industrial Park enables a wind farm, or any renewable energy supplier, to access a number of industrial consumers operating in an energy efficient environment,
- “Bundling” two or more wind farms together provides the opportunity to increase the efficient utilization of their electricity supply infrastructure,
- the Gold Standard label can ensure that a project has clear environmental and socio-economic advantages and is therefore fully accepted by stakeholders.

6.4.5 Bio-energy

Bio-energy can be derived from agricultural biomass (both plant and animal), forest biomass, and waste materials, but because of its comparatively low energy density transportation of biomass is expensive per unit of energy involved. Consequently, processing plants are usually quite small, by comparison with their fossil fuelled counterparts, and located at the centre of their feedstock capture area.

Most bio-energy today is derived from direct combustion of various forms of biomass to produce:

- heat, for industrial, commercial or domestic use,

- electricity, from its combustion, or co-firing with coal, in utility-scale thermal power plants,
- a combination of both to produce heat and power (CHP) for industrial use.

Biomass can also be gasified, and the gas used in gas turbines to generate electricity, or reformed to produce hydrogen that can be used in fuel cells. Biomass, in the form of organic residues, can be processed in anaerobic digesters to produce methane (biogas) which can in turn be used for heating, lighting or electricity generation and it can also be fermented at elevated temperatures and pressures to produce biofuels such as ethanol or biodiesel. With appropriate treatment, biogas can also be injected into an existing natural gas pipeline as a replacement for natural gas.

Because bio-energy is renewable, all projects in which it is used to substitute for fossil fuel-derived energy have access to finance from carbon trading under the United Nations Clean Development Mechanism (CDM).

6.4.5.1 Power Generation

- direct biomass combustion is a mature technology for power generation but plants are small and usually operate with low efficiency,
- biomass gasification in combined cycle plants can reach efficiencies exceeding 40% but this technology is in an earlier commercialization phase than those above. Gasification can also be used as a platform for bio-refineries, which co-produce energy and a range of higher value products,
- the most promising near-term option for large scale bio-power generation is co-firing biomass with coal in large power plants,

6.4.5.2 Process Heating

- the most common use of biomass in industry is for process heating,
- timber drying is an ideal end use for process steam that can be generated from wood waste in the sawmilling industry. It can be replicated in those APEC economies where such industries operate,
- sawdust and wood fines can readily be pelletized or pressed into briquettes for sale and use as boiler fuel,
- animal tallow can be used successfully as a boiler fuel,
- increasing the use and efficiency of industrial process control systems can result in shorter product drying times, lower steam requirements and less reject product and significantly complement the use of renewable biofuels.

6.4.5.3 Combined Heat and Power

- combined heat and power (CHP) applications using a waste fuel are generally the most cost effective of the biomass technologies and can yield very high energy end use efficiencies up to 90%,
- in applications where heat and power are derived from a reciprocating engine the amount of heat recovered is about twice that of the electricity generated. This is well suited to those industrial applications which have a high requirement for process heat. Conversely, where a boiler is used to produce high pressure steam to drive a steam turbine for electricity generation the reverse is often true so excess

electricity needs to be sold to a local or regional grid. This opportunity is particularly advantageous and energy efficient for an occupant of an industrial park as the excess power (or heat) usually has a ready market amongst the other part occupants,

- the sugar industry provides a very good example of the combined application of renewable energy and energy efficiency in industry (e.g. CHP from bagasse) and the technology is now well established,
- examples are emerging in the sugar industry where plants are being designed as much for power generation as for meeting the needs of the mill. In many respects, such mills are more like a small Independent Power Producer (IPP) than a traditional sugar mill power plant and illustrates how an existing sugar mill, with CHP generation capability, can be re-configured,
- cogeneration of heat and power for waste processing maximizes both the efficiency and end use of energy produced from a waste biomass resource and provides a valuable community waste management service that can serve as a model for many APEC economies

6.4.5.4 Biogas production

- the technology exists for converting agricultural waste biomass into heat, electricity and natural fertilizer with a high level of energy efficiency,
- a large, industrial scale, biogas plant can be commercially viable in utilizing a variety of agricultural wastes from farming,
- energy efficiency is enhanced by the application of CHP and the production of several energy products and by-products,
- economic viability is enhanced by monetarizing the several products from the project so that several revenue streams underpin the commercial business model,
- production and utilization of biogas from agricultural industrial wastes can displace the use of fossil fuels,
- it has been demonstrated that the top 20 percent of financially sound firms in the large-scale livestock and industrial sectors in China are able to finance new investments in renewable energy and energy efficiency themselves. Already, third-party investors have begun to get involved in biogas projects in China,
- a commercial scale demonstration project can have a direct impact on policymaking and the China Biogas Project Development Guidebook – produced by biogas project developers - is already being used by the National Development and Reform Commission (NDRC) to prepare the biogas component of its Biomass Strategy through 2020. NDRC has also indicated that it will make use of the project's Biogas Action Plan as a key input to the biogas portion of its Biomass Strategy,
- enhancement of the capacity of biogas project developers in China has resulted in substantial expansion of their businesses, including cooperation with multinationals in China and contracts for projects abroad.

6.4.5.5 Municipal Solid Waste Conversion

- energy production from municipal and industrial solid waste is a proven option in many APEC industrial areas and the technology is commercially proven,
- plants can be built in close proximity to the industrial areas – which are the source of large volumes of garbage with which they are fuelled.

- replacement of a fossil fuelled boiler with an efficient wood chip boiler can contribute significantly to the end use efficiency of a necessary industrial scale waste treatment operation,

6.4.5.6 Landfill Gas Capture and Use

- the capture and use of landfill gas (which is primarily methane) is potentially attractive as a source of renewable energy for industrial use in small and medium enterprises (SME's) in many APEC economies,
- the gas must be used within a short distance of the landfill site as it cannot be mixed with pipeline gas for widespread distribution or long distance transportation unless it is treated to be compatible with pipeline gas.
- CHP applications are required to make the economics attractive in many situations and this creates a problem in finding a productive use for the heat generated.

6.4.5.7 Liquid Biofuels

- a number of widely available primary biomass resources, can be converted efficiently into valuable fuel and chemical products using existing state-of-the-art technology,
- the biofuels produced include ethanol, biodiesel in its various forms and biogas – all of which can be used to fuel reciprocating engines and other prime movers,
- the efficient use of tallow as a small industrial boiler fuel is a reality in all APEC economies where raw animal fat and/or waste cooking fat are readily available.

6.4.6 Hydropower

Today, hydropower is most commonly used to generate electricity but it can also be harnessed to produce shaft power for small industrial use – usually in run-of-the river configurations similar to those that have been employed in water mills for thousands of years. The lessons learned about these two applications are presented in the following sections:

6.4.6.1 Hydro Electricity

Generation of hydro electricity for use in industry is nowadays classified according to the capacity of the generating plant. Thus, large scale (>10 MW) capacity hydro plants are usually designed to feed electricity into a local, economy-wide or even international grid from which most industrial plants get their electricity. In economies like New Zealand, which generates about 73% of its electricity from hydropower, this means that promotion of the combined use of renewable energy and energy efficiency in industry should focus on energy efficiency. However, this situation does not apply in most APEC economies.

Small hydro electricity generation is classified as <10 MW capacity, but in the USA this definition is extended to <30 MW and in Canada to <50 MW. Mini hydro is classified as <1,000 kW, micro hydro as <100 kW and pico hydro as <5 kW. It is micro-hydro that supplies electricity to small and medium enterprises which are the focus of this report.

- Micro-hydro schemes make electricity available for local industries to run electric tools, so carpentry and metal workshops can expand their business. Jobs like tailoring and agricultural processing can also become more productive,

- micro hydro schemes also provide temporary local jobs during construction, and long-term jobs for operation, maintenance and fee collection,
- the water management associated with a micro-hydro scheme can bring additional agricultural benefits, such as irrigation that allows an extra crop to be grown, or clean water supply to fishponds and there is also significant potential for grid-connected micro and mini hydro,
- community management of hydro systems, and the community benefit from them, can be achieved with a range of different financing mechanisms.

6.4.6.2 Hydro Shaft Power

Today, as in the historic past, hydro shaft power is utilized mainly for the the milling of grain in economies, like Vietnam, where the hilly terrain provides opportunities for harnessing hydropower from water running naturally downhill. Some of the lessons learned about how this energy is used, together with energy efficiency initiatives, to deliver benefits to SMEs are:

- grain millers with improved water mills can earn more income and have extra time for other purposes and the flour produced from water mills is of better quality than from diesel mills so has a higher market value,
- improvements in the efficient use of shaft power enable development of several new, or existing, small business opportunities,
- water mills are usually closer to the villages than diesel mills, so people will use them in preference. Business has declined for diesel mills in areas where there are a large number of improved water mills, some have closed down and new diesel mills are not being built,
- an efficiently operated water mill can replace about half the capacity of a diesel mill and offset about 900 l/year of diesel, equivalent to 2.4 tonnes/year of CO_2,
- because improved water mills grind more slowly than diesel mills, the flour does not get so hot and does not pick up the taste of diesel. This means that the flour has a longer shelf life, is more nutritious and has a higher market value,
- the water mill upgrades have improved the self-respect and social standing of the mill owners,
- the formation of millers' associations has improved the advocacy power and livelihoods, of the mill owners by enabling them to negotiate for quality services, marketing of products and water rights issues. The associations also provide education and training to the millers,
- an efficient mill has a higher throughput and will run with less water so can operate at a lower water flow rate than the traditional mills. This extends their period of operation into the dry season for up to two months each year. There are now mills operating for 6 to 12 months of the year depending upon the availability of water,
- on average, the annual income of traditional mill owner increases by at least 25% with a short shaft upgrade. Owners of long-shaft improved water mills can sell additional services such as rice-hulling, cutting timber and electricity, and this can further increase their considerably,
- improved water mill parts last ten years, compared with approximately two years for traditional mills,
- an unmodified water mill requires regular maintenance, which consumes timber at a rate of one tree every two years,
- the technology is directly applicable in other economies that operate traditional water mills.

6.5 Summary

Renewable energy and energy efficiency technologies have made significant advances in the last few years so they are now commercially competitive in a number of different industrial applications throughout APEC. The lessons learned from their implementation are valuable for stimulating their increased use to achieve industry goals. Given the growing energy demand of APEC economies and the need to provide solutions that are environmentally benign, enhance energy security and stimulate economic development, renewable energy and energy efficiency initiatives in industry are particularly well suited to the requirements of APEC member economies.

Many energy efficiency initiatives can be implemented together to provide a high a high level of energy end use efficiency and reduce GHG emissions. The following can be identified:

- efficient collection of waste from local sources of supply,
- use of high efficiency boilers, steam turbines and captive power gensets,
- use of a smart (microprocessor) system controller to match load requirements to available energy supply profiles,
- complete biomass waste disposal.

Efficiency gains can be achieved through improvement of such items as air leakage, controller inefficiency, compressor inefficiency, installation of variable speed drives, system pressure control and control of off load running of mechanical and electrical equipment.

Finally, it is important to note that opportunities for improving industrial energy efficiency extend beyond technology to include maximizing the value of the energy products and streamlining process and plant management practices. These can be identified by pursuing market research in situations where either the renewable fuel or the resulting energy produced is excess to requirements and through energy audits that include a review of management protocols and practices.

7.0 Incentives for Development

As illustrated by the examples in Chapter 4, a number of advantages can be achieved through the joint introduction of renewable energy and energy efficiency initiatives in many industrial plants in the APEC region. However, these advantages are often not recognized by the managers of industrial plants, many of whom tend to be focussed on operating their plants to maintain their production goals and are naturally risk averse.

The combined applications of renewable energy and energy efficiency in industries throughout APEC will proceed as their advantages are recognized, but the process can be greatly assisted and expedited by the provision of additional incentives by governments.

Renewable energy differs from conventional energy in terms of its cost structure. Thus, fossil fuels generally have moderate or low up-front capital costs but high operating costs, due to their ongoing fuel consumption, whereas primary renewable energy is usually effectively free (sunlight, wind, geothermal heat, ocean energy) but requires a fairly high initial investment with a high perceived risk. The financial community has initially been reluctant to invest in emerging renewable energy technologies but less so for investment in energy efficiency which is seen to have a lower level of risk.

Nevertheless, wind and solar power have emerged as the leaders in new electricity generation capacity in recent years in the leading European renewable energy economies, India, Japan, and the United States, with double-digit annual growth. This success is due to clear, directed government policies and support programs.

Governments must, therefore, establish an appropriate regulatory environment and the institutional infrastructure necessary to support the improvement of energy efficiency and introduction of renewable energy in industry. In reality, however, the first thing they need to do is to assist in overcoming the cost barriers associated with initial introduction of new technology. In this regard it is noted that while some energy efficiency projects may have long payback times, these can be reduced in later projects as experience is gained.

There are many options for policies and actions to promote the introduction of renewable energy use and energy efficiency improvements in industry. These have been compiled, and are described in detail, for all economies worldwide by the IEA and are available for renewable energy at the website http://www.iea.org/policiesandmeasures/renewableenergy and for energy efficiency at http://www.iea.org/policiesandmeasures/energyefficiency.

The information contained in the IEA database covers all of the APEC economies and can be categorised as fiscal/financial incentives, regulatory incentives and other incentives as summarized in Table 7.1. Those that apply in so-called developed and transition APEC economies are listed in Tables 7.2 and 7.3 for renewable energy and energy efficiency, respectively, and are briefly described in the following sections.

Table 7.1: Policies and Measures to promote Renewable Energy use and Energy Efficiency in Industry

FISCAL/FINANCIAL	REGULATORY	OTHER
Feed-In Tariffs and Net metering	Renewable Porfolio Standards, RPSs	Awareness building, training, technical support
Excise tax exemption or rebate	Minimum standards	Voluntary agreements with OEMs to develop and market equipment
Sales/Import tax exemption or income/profit tax credit (purchasers and OEMs)	Benchmarking and Labelling	Direct R,D & D funding
Investment tax credits for distribution infrastructure and R&D	Enforced compliance and end use restriction	Energy efficiency recognition
Grants/tax credits for equipment conversion or acquisition	Health and safety regulations	
Low interest loans and financing		
Accelerated depreciation for industrial plant		

7.1 Financial Incentives

Energy efficiency investment can be made more attractive by providing financial incentives to introduce the changes needed to improve the efficiency with which energy is used in industrial plants. Incentives can be designed to encourage or discourage certain actions or behaviours. Tax policy provides a good opportunity to ensure that, renewable energy forms can be priced competitively with conventional fuels and energy.

Tax relief helps to set and maintain a comparative price advantage and is an important element for the promotion of new technology initiatives.

Financial, or market-based, incentives can target energy/fuel production and supply, the sales or import of equipment and infrastructure or the end use. Taxation measures are the most cross-cutting and can be applied as a subsidy, a tax exemption or a penalty.

Table 7.2: Incentives for Industrial Renewable Energy use in APEC Economies

Country	Feed-in tariff	Net metering	Renewable port-folio standard	Capital subsidies, grants, or rebates	Investment or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Public investment, loans, or financing	Renewable energy recognition	R,D & D support
Developed and transition economies											
Australia	*		*	*			*		*	*	*
Canada	(*)	(*)	(*)	*	*	*			*	*	*
Germany	*			*	*	*			*	*	*
Japan	(*)	*	*	*			*		*	*	*
Korea	*			*	*	*			*	*	*
New Zealand				*					*	*	
Russia				*			*				*
Spain	*			*	*				*	*	*
United States	(*)	(*)	(*)	*	*	(*)	(*)	*	(*)	*	*
Chile			*	*						*	
China	*		*	*	*	*			*	*	*
Indonesia	*										*
Mexico		*			*	*				*	
Phillipines	*			*	*	*			*	*	*
Thailand	*	*		*					*	*	*

Table 7.3: Incentives for Industrial Energy Efficiency in APEC Economies

Country	Capital subsidies, grants, or rebates	Investment or other tax credits	Sales tax, Import tax, energy tax, or VAT reduction	Low interest loans, or financing	Minimum standards	Labelling and bench marking	Enforced compliance	Tradable renewable energy certificates	Training, awareness building, technical support	Energy efficiency recognition	R,D & D support
Developed and transition economies											
Australia	*	*	*	*	*	*	*	*	*	*	*
Canada	*	*	*	*	*	*		*	*	*	*
Chile	*			*		*			*	*	
China	*	*	*	*	*	*		*	*	*	*
Chinese Taipei					*	*			*	*	*
Indonesia	*				*	*	*		*	*	*
Japan	*	*	*	*	*	*	*		*		*
Korea	*	*	*	*	*	*	*	*	*	*	*
Malaysia	*	*	*	*	*	*	*		*		*
Mexico				*	*	*			*	*	
New Zealand	*			*	*	*			*	*	
Peru					*	*			*		
Philippines					*	*	*		*	*	*
Thailand	*	*	*	*	*	*	*		*	*	*
USA	*	*	*	*	*	*		*	*	*	*
Vietnam		*		*	*	*	*		*		*

The financial incentives listed in Table 7.1 are demand-side fiscal measures aimed directly at reducing the cost to the end user of switching to an alternative fuel or investing in energy efficiency. Supply-side fiscal measures that reduce the tax liability of energy providers and/or equipment manufacturers can also lower these costs in an indirect way. For example, profit-tax credits can be used to encourage Original Equipment Manufacturers (OEMs) to develop and market equipment dedicated to the utilization of renewable energy and energy efficiency requirements.

7.1.1 Feed in Tariffs

A Feed-in Tariff (FiT), also known as a Feed-in Law (FiL), renewable tariff or renewable energy payment, is an incentive structure that sets a fixed guaranteed price at which power producers can sell renewable power into the electric power network. Some policies provide a fixed tariff while others provide fixed premiums added to market prices - or cost-related tariffs which usually differ for different forms of power generation. A FiT is intended to be phased out once the renewable electricity achieves significant market penetration, such as 20%, when the provider is receiving an adequate return without the FiT incentive.

The feed-in tariff system has been enacted in some states in Australia, Austria, Brazil, Canada, China, Cyprus, the Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, the Republic of Korea, Lithuania, Luxembourg, the Netherlands, Portugal, Singapore, Spain, Sweden, Switzerland, and in some states of the United States. These economies all have different versions of the system. Some are introducing only part of the system, in an attempt to realize the success of FiT while keeping the market for fossil energy suppliers the same. In the UK the name FiTino was introduced to mean "Feed-in tariff in name only'.

The US National Renewable Energy Laboratory (NREL) has identified a number of key factors that are necessary to achieve a successful FiT policy. These are discussed at length at the website: www.**nrel**.gov/applying.../scepa_webcast_20090212_tariffs.ppt

7.1.2 Net Metering

Net metering is a way to encourage consumers to invest in renewable energy sources such as solar or wind power. In a net metering system, the electric company allows a customer's meter to run backwards when the electricity generated is more than that consumed. At the end of the billing period, the customer pays only for the net consumption i.e. the amount of electricity consumed, minus the amount generated.

Net metering lets industrial producers of electricity feed excess electricity into the public grid at the retail price. Thirty-nine US states have net metering which is also available in Mexico and is becoming popular in Canada - now being available in British Columbia, Ontario, and Manitoba.

7.1.3 Grants, Rebates and Loans

Grants or Capital subsidies are one-time payments made by the government or a utility to cover part of the capital cost of an investment, such as a new heat pump, a solar hot water system or an improvement in industrial energy efficiency. Grants to grid-connected renewable energy projects can come in the form of **buy-down grants** or **development grants**. There are multilateral, bilateral, and national sources for these grants. In most developing countries, renewable energy and energy efficiency development is carried out by small companies with low capital resources, and grant facilities that can share some of these costs can provide significant stimulus. However, these facilities need to be carefully structured to target the right projects and the committed developers.

Buy-down grants are used to lower the cost of a renewable energy project or system that is not yet commercially viable but has promising potential in the long term. Grants for grid connected renewable energy have been used mostly to promote technology demonstration projects, and are seldom used to promote commercial scale applications – generally because the size of the projects can lead to very high grant program costs and can cause market distortions.

Buy-down grants can come in the form of **co-investment funds,** which is typical for demonstration projects, or as **rebates**, which are more commonly used for market stimulation.

Development grants are a tool for helping to lower the high cost of development of an energy efficiency project in a factory or grid connected renewable energy projects, especially in new markets, where the cost and time to develop projects can be significant, amounting in some cases to millions of dollars and several years. Contingent development grants convert to loans if the project is successfully developed.

A **rebate** is an amount paid by way of reduction, return, or refund of money that has already been paid or contributed. It is use primarily as an incentive or supplement to product sales.
In the case of a **loan**, the borrower is obligated to repay the lender at a later time. Typically, loans are used to finance capital expenditure for new equipment or the development of infrastructure. They are often provided at a low rate of interest and/or guaranteed by government.

Subsidized loans may be used to promote the implementation of new technologies, i.e. technologies for which there is little or no implementation experience within the economy. The loan reduces the risk to the company implementing the technology and provides experience that will encourage other companies to successfully follow suit.

7.1.4 Tax Incentives and Benefits

Tax incentives and benefits are the most common measure used by governments to promote the introduction of renewable energy and energy efficiency improvement in industry. They can be applied to a wide variety of taxes but are usually only maintained for a period until the market for the energy product is deemed to be established.

Instead of tax exemptions for renewable energy and energy efficiency, some governments have implemented energy taxes on fossil fuels. These taxes are similar to, but usually much higher than, the system benefits charges (SBCs) that are levied for the purposes of system maintenance or improvement (e.g. for upgrading system efficiency). Similar taxes include emission-related taxes, levied on CO_2 or SO_2 emissions. These taxes are meant to correct a market failure by incorporating the external costs of fossil energy sources as costs attributed to the heat and electricity sectors. Such taxes (as implemented, for example, in Austria, Denmark, Finland, Italy, the Netherlands, Germany and Sweden) make it easier for renewable energy to compete in the marketplace. These tax revenues can also be used to support the introduction of renewable energy and energy efficiency technologies.

7.1.4.1 Excise Taxes

Fuel tax measures are employed by most economies to promote alternative transport fuels rather than industrial fuels. They can involve a lower rate of excise duty (and/or sales tax) or its complete exemption. In some cases, however, commercial/industrial vehicles may enjoy a rebate on fuel taxes. These measures reduce the payback period for converting to, or acquiring, an alternative fuelled vehicle and are also highly visible so they raise public awareness of the potential cost savings from using alternative fuels.

7.1.4.2 Tax Credits and Deductions

A tax credit reduces the recipient's tax obligations. Thus, an **investment** tax credit allows investments in renewable energy or energy efficiency to be fully or partially deducted from tax obligations or income. A **production** tax credit provides the investor or producer an annual tax credit based on the amount of electricity or fuel produced or the decrease in amount of energy purchased.

A tax credit is generally more valuable than an equivalent tax deduction because a credit reduces tax dollar-for-dollar, while a deduction only removes a percentage of the tax that is owed. Also, a tax credit can usually be carried forward and can have considerable value for sale to a third party that has a large tax liability. Indeed, this mechanism (known as the "Flip" model) has been employed in the United States to finance industrial scale renewable energy projects such as the Lanai'i solar farm in Hawaii.

7.1.4.3 Sales Taxes and Import Duties

The most common way of providing incentives for equipment purchase is to subsidise its cost by reducing the associated sales tax or import duty. Thus, the higher cost of installing the equipment required to introduce renewable energy energy efficiency improvements in industry or the effective cost of energy efficiency or renewable energy generating equipment can be reduced.

In most cases, these incentives apply for a specified time to limit the loss of tax revenue and the "free-rider problem" (where the financial benefit from the tax incentive is greater than is necessary to encourage the use of renewable energy or energy efficiency).

7.1.4.4 Energy End Use Taxes

Renewable energy end use can be made more attractive by reduction of, or exemption from, taxes on the energy end use. This applies most commonly to alternative transport fuels rather than industrial fuels but can be important for industries that use the UN Clean Development Mechanism (CDM) to finance the introduction of renewable energy and energy efficiency initiatives or benefit financially from participation in emissions trading schemes (ETS).

7.2 Regulatory Actions

Governments can strongly influence the speed with which renewable energy and energy efficiency technologies are adopted through appropriate design of the governing regulatory framework. Governments must also be responsible for development and enforcement of coherent regulations, standards and industry codes of practice covering the health and safety aspects of energy supply, distribution and end-use. Use of international standards can speed introduction of new technologies and assist in keeping capital costs down.

7.2.1 Mandates

The most direct form of regulatory measure is the use of legal mandates for public or private industries to purchase so-called green power or improve their energy end use efficiency. Mandates are best applied in conjunction with positive incentives and they must be both enforceable and enforced. In general, a transition approach, such as a gradual increase in the mandated quota over time, is most likely to be successful.

Mandates are not generally popular with industry operators because they involve enforced compliance with industry wide norms that may be difficult and costly for many to achieve. Nevertheless, a variety of mandates have been legislated and implemented to promote the introduction of both renewable energy and energy efficiency in industry. They include:

- mandates for utilities to include a percentage of electricity generated from renewable energy in their electricity supply portfolios – normally known as renewable portfolio standards (RPS),
- mandates for industries to meet **minimum standards** of energy efficiency within a specified period.

While such mandates can lead to fuel switching and result in short-term benefits, they should be used with caution as they can greatly inhibit technological innovation in the medium and long-term by misdirecting investment to non-viable and uneconomic technologies.

7.2.2 Renewable Portfolio Standards

A renewable energy portfolio standard (RPS) is a regulation that mandates the increased production of energy from renewable energy resources such as wind, solar, biomass and geothermal. Another common name for the same concept is a renewable electricity standard (RES).

The RPS mechanism generally places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. Certified industrial operators who produce surplus renewable electricity can earn certificates for every unit of electricity produced and they can sell these, in addition to their electricity, to electricity supply companies. Supply companies then pass the certificates to some form of regulatory body to demonstrate their compliance with their regulatory obligations. Because it is a market mandate, the RPS relies almost entirely on the private market for its implementation. Those supporting the adoption of RPS mechanisms claim that market implementation will result in competition, efficiency and innovation that will deliver renewable energy at the lowest possible cost, allowing renewable energy to compete with cheaper fossil energy.

With the notable exception of the United States, RPS programs have not been widely adopted by APEC economies and there is currently no federal RPS program in place. However, as of January 2012, 30 States and the District of Columbia had enforceable RPS or other mandated renewable capacity policies, In addition, seven States had voluntary goals for renewable generation as recently updated in Figure 7.1. These programs vary widely in terms of program structure, enforcement mechanisms, size and their means of application, http://www.pewclimate.org/sites/default/modules/usmap/pdf.php?file=5907.

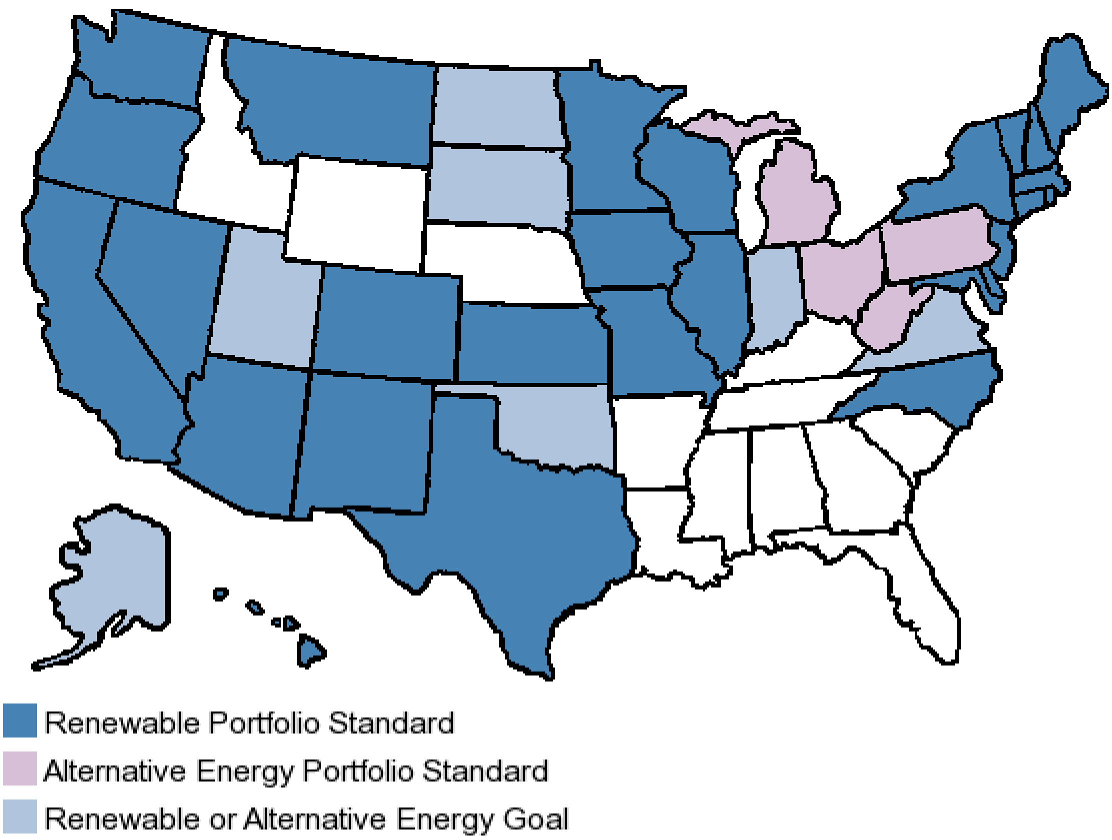

Figure 7.1: Renewable Energy Standards and Alternative Energy Goals in the USA.

It is worth noting that RPS mechanisms have been most successful in stimulating new renewable energy capacity in the United States where they have been used in combination with federal production tax credits (PTCs). During periods where PTCs have been withdrawn the RPS alone has not usually provided sufficient incentive to achieve large capacity increases.

7.2.3 Tradable Renewable Energy Certificates (RECs)

Green power purchases involve the voluntary purchase of renewable electricity, by residential, commercial, government, or industrial customers, directly from utility companies, from a third-party renewable energy generator, or through the trading of renewable energy certificates (RECs).

Each certificate represents the certified generation of one unit of renewable energy (typically one megawatt-hour). Certificates provide a tool for trading and meeting renewable energy obligations among consumers and/or producers, and also a means for voluntary green power purchases. They are mainly applicable in those industrial plants that generate electricity from a renewable fuel or energy source.

7.2.4 Regulations, Standards and Codes of Practice

Standards and codes of practice have already been developed nationally and internationally for the production and use of most renewable energy forms and for the actions required to improve energy end use efficiency in industry, but they require unification and universal adoption throughout APEC. Also, various international standards and regulations are available (e.g. ISO) for energy efficiency equipment and operating procedures.

Recognition of International standards lowers the capital cost of equipment because equipment manufacturers have to conform only to one standard. Regulations are required to ensure the application of these standards for the safe and efficient use of renewable energy and energy efficiency initiatives in industry. Policing and enforcement of regulations is essential for successful introduction and development.

7.3 Other Measures

There are several other measures that can be adopted by governments to promote the introduction of energy efficiency and renewable energy. These include:

- funding research, development and demonstration projects,
- recognition programs and awareness building,
- training and technical support,
- benchmarking and labelling,
- setting achievable targets,
- support for industrial energy audits,
- encouraging OEM participation.

These measures are generally quite affordable to governments but do have significant financial and public relations implications for stakeholders. The ways in which they operate are discussed in the following sections.

7.3.1 Funding Research, Development and Demonstrations

Many suppliers of the equipment required for introduction of energy efficiency and renewable energy in industry are small under-funded businesses that need assistance - either through direct funding, or from national research organizations - for product development and market introduction,

Governments can support the research, development, demonstration and deployment of renewable energy and energy efficiency technologies either through voluntary agreement with OEMs and fuel providers or through direct funding of such activities.

7.3.2 Recognition Programs and Awareness Building

Information dissemination and education can be a key element of government incentive programs for energy efficiency and renewable energy. They usually take the form of regular communications, such as TV and radio advertising, web site posts or newsletters to inform both industry and the public of market and technology developments and to explain how to apply for subsidies where available.

Governments can also provide leadership not only by encouraging industry to consider alternative renewable fuel and energy options and options for improving efficiency but also by introducing these in government owned industrial plants thereby leading by example, raising public awareness and kick starting the market. The aim is to advance understanding and awareness of the benefits of switching away from conventional energy and fuels and pursuing energy efficiency options and of the various incentives available to them.

7.3.3 Training and Technical Support

Training in how to proceed with the implementation of renewable energy and energy efficiency initiatives in industry and provision of technical support can greatly assist industry in their pursuit. A number of APEC economies, notably Canada and the USA, have programs to provide such training and technical support.

7.3.4 Benchmarking and Labelling

Setting and publishing benchmarks for energy efficiency in each industry is an important way of providing industry operators with targets that they are able to achieve in their industry. Such benchmarks can relate to:

- best practice in the economy,
- norms in other countries at a similar stage of development,
- international norms,
- international best practice,
- best available technology

Labelling of the products produced by each industry in terms of their efficient use of energy and the energy footprints of the products provides incentive to industry to improve energy efficiency in their production processes. Coupled with increasing public awareness of the need for energy conservation product labelling can be an important marketing tool for selling products that have low specific energy consumption.

7.3.5 Target Setting

Several APEC economies, mostly in Asia and, notably, Japan, have programs whereby the government or the industry set targets for energy use in the production of final goods. Such targets provide industries with an incentive to improve their specific energy consumption per unit of goods produced.

7.3.6 Energy Audits

Energy efficiency audits are an important first step in identifying how energy use in individual industrial plants can be made more efficient. In some APEC economies government programs are available for such energy audits and some extend to industry-wide identification and publication of opportunities and options for improving energy use in each industry.

7.3.7 Encouraging OEM Participation

Governments can also play an important role in encouraging original equipment manufacturers (OEMs) to develop and market the equipment needed for introduction of renewable energy and energy efficiency improvement in industry. OEMs must also have local representatives who can provide the services needed to install, commission and maintain the equipment and maintain an inventory of spares to ensure that down-time for maintenance is minimized.

7.4 Overview

Measures that are in place to promote renewable energy and energy efficiency generally are presented in an extensive report prepared by the Renewable Energy Policy Network for the 21st Century, http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx. Because different economies favour different approaches, however, there is considerable variation between the policies and measures employed. The data presented in Tables 7.2 and 7.3, however, show that many APEC economies already have policies and measures in place although their effectiveness in promoting the introduction of renewable energy in industry and improving the efficient use of that energy differ considerably and are still evolving.

8.0 A Roadmap for Development

Renewable energy and energy efficiency technologies have advanced dramatically over the last decade and are now commercially available for a number of applications in industry. Furthermore, as the technologies mature, investments continue to yield increased efficiencies, better manufacturing techniques and economies of scale that are both reducing costs and improving performance.

In this section, the steps that the Government should follow in embarking on, and pursuing, a national policy for the introduction of renewable energy in industry together with energy efficiency improvements are broadly outlined along with indication of the sequence with these steps need to be put in place.

Realistically, however, many APEC economies already have programs to introduce renewable energy and energy efficiency improvements in their industries and some have made considerable progress in implementing their own roadmaps. Interestingly, all of the roadmaps that have been formulated are essentially similar and differ only in the detail. Consequently, the following roadmap has effectively assimilated those already in place. It is offered as a guideline for the actions that need to be taken by governments and to indicate the inter-dependence of the actions required and the time sequence with which they need to be put in place. The steps that need to be accomplished are outlined in the following sections:

8.1 Roadmap Elements

In most economies decisions to introduce renewable energy and implement energy efficiency initiatives in industry will be taken by the industries themselves at an individual plant, factory or stakeholder level. The role of governments is to create a regulatory environment that will foster and support these initiatives. In order to achieve this objective governments should:

1. Conduct an industry-wide review to identify opportunities for the introduction of renewable energy and energy efficiency initiatives.
2. Commit to support these initiatives and develop an action plan.
3. Formulate policies to promote the introduction of renewable energy and energy efficiency by the industries in their economy.
4. Promulgate standards and regulations.
5. Facilitate access to technology and equipment.
6. Establish campaigns to inform industry and the public about Government objectives and policies and the actions that are being taken.

7. Build local technical capacity.
8. Develop appropriate financing packages and encourage the provision of private sector financing.
9. Lead by example by introducing renewable energy and energy efficiency improvements in government owned industrial plants.
10.
11. Maintain active ongoing program management and monitoring.

8.1.1 Industry-wide Review

The first step towards implementation is to undertake a scoping study which should provide a broad overview of how the various industries currently operate and identify the potential for improvement of energy efficiency and introduction of renewable energy in different facilities. It should include benchmarking against both in-country and international examples that are relevant in the APEC region and should aim to identify those industries that will benefit most from using the different forms of renewable energy available in conjunction with energy end use efficiency applications. It should include:

- a review of national, regional and international energy literature related to the existing and possible future industries in the particular country,
- identification of energy use in each industrial energy sub-sector and the potential for future growth,
- information on local sources of renewable energy which are either already available or could be developed for use in industry,
- appraisal of existing industrial renewable energy and energy efficiency applications, both locally and in other countries, to understand the lessons learned and to build on experience,
- assessment of local manpower resources required to support the introduction of renewable energy and energy efficiency initiatives in industry and the potential to import and train skills not currently available locally,
- information on relevant national and international standards and regulations applicable to the industrial use of renewable energy and improvement of energy efficiency with identification of the need for additional economy specific standards and regulations,
- information on the availability of suitable training courses and the potential to arrange for new or special courses.

A small number of energy audits could be undertaken in order to develop an initial understanding of the potential for economy-wide implementation of energy efficiency and renewable energy and to develop an understanding of specific needs of industry in terms of standards and regulations, skilled manpower and finance.

The scoping study should specifically investigate financial issues such as availability of capital, taxation, and ability of industrial companies to fund energy efficiency and renewable energy projects of various sizes. The financial impact of the proposed program should be estimated and consideration given to the need for establishing incentives.

Evaluation of the economy-wide impact of the program should be investigated, targets set and time lines established for a national implementation program. It may even be appropriate to identify some of the larger industries with the financial capacity to implement significant projects and to reward by providing them with one-time incentives during the initial phases of implementation in order to provide good examples to the rest of the industrial sector.

It should be recognized that the needs of small and medium sized enterprises (SMEs) for financial incentives may be different from those of large enterprises in the same industry or in a different industry. The design of the incentive programs must take into account these differences and monitor the success or otherwise of the incentives in each case.

This step should conclude with the preparation of an implementation plan which can be adopted by government, industry and the supporting sectors. The plan should cover all aspects with appropriate sections for different parts of the industrial sector and for other agencies and organizations including the Government itself. The plan should set reasonable and appropriate targets for each industrial sub-sector so that individual industries and companies can develop an understanding of what they can achieve.

8.1.2 Government Commitment

Governments need to commit to a national program to promote and implement the use of renewable energy and energy efficiency initiative in industry. If the government is seen by industry as being totally committed to the program, there is a good chance that considerable success will be achieved. Without that commitment, the chance of success is significantly reduced.

The implementation plan should be reviewed by government, its agencies, companies and industrial organisations. After appropriate modifications and consensus, it should be adopted as a national program for implementation of energy efficiency and renewable energy in industry. It should ensure coordination of all relevant activities across national, state, regional and local agencies with commitment to review the program periodically so that changes can be made to improve the outcomes.

8.1.3 Formulation of Policies

Governments need to formulate policies for promoting the use of renewable energy and energy efficiency in industry and to establish the institutional infrastructure to support and administer the program.

Development of incentive packages is an important factor that will have a considerable impact on the success of an implementation program because they reduce both cost and risk. As discussed in Chapter 7, the following incentives, which can apply to industry owners, equipment suppliers and equipment suppliers, have been introduced in several APEC economies:

- corporate deductions, depreciation, exemptions and tax credits,
- production incentives and tax credits,
- property and sales tax exemptions,
- personal deductions, exemptions and tax credits,
- grant, loan and rebate programs,
- industry recruitment, training and support,
- sales and import tax exemptions,

- accelerated depreciation on equipment for renewable energy supply and energy efficient manufacture,
- access to programs which reward greenhouse gas reduction such as the carbon trading and the UN Clean Development Mechanism (CDM)

Ideally, incentives should be framed in a way that enables them to be modified or removed when their impact has been tested in the implementation program. Time limits are often specified when an incentive is introduced.

Based on the government commitment, there will be a need for changes in existing government agencies and establishment of new agencies such as an overall coordination committee to maintain an ongoing review of the implementation program. This committee should recommend necessary changes to the program as it proceeds and experience builds up. The coordination committee should include membership or representation from all government and private sector stakeholders that have a significant contribution to make to the overall program.

8.1.4 Promulgation of Standards and Regulations

Industry standards, codes of practice and regulations are required for successful implementation. For this purpose representative groups from industry and both central and local government agencies should be charged with the task of developing standards and regulations compatible with good international and local practice

It may also be appropriate to establish research groups at universities or other institutions to ensure that expertise is available to investigate and solve problems and issues that will arise during the implementation of new technologies and to provide ongoing support both to the implementation program and to identify changes that need to be made to the standards and regulations.

8.1.5 Access to Technology and Equipment.

This includes determining the technology and equipment that is available locally, fostering local production capability, identifying suitable international sources and minimising import costs. It is important to ensure that the most cost-effective equipment is deployed and different requirements may apply to large industries and SMEs.

Development of local access to technology and equipment provides important benefits to the economy as it fosters new industries and skills. It may, however, be a lengthy process.

8.1.6 Industry Information and Education Campaigns

Information and education campaigns are frequently neglected or insufficient in most APEC economies and their importance cannot be overstated. They are effectively a marketing mechanism designed to acquaint the public with the reasons for, and importance of, the program, to incentivise industry and to keep industry informed of successful projects and emerging opportunities.

In particular, information and education campaigns should target employees working in industry who have the opportunity to encourage their employers to become involved in the program and to consider the use of renewable energy and energy efficiency improvements in their plants. Many people are particularly concerned about climate change and will be pleased to see what they think is an environmentally detrimental activity being turned into one which has environmentally beneficial effects.

Information and education campaigns need to ensure that they maintain a regular and frequent supply of information to ensure that the program has a high profile and to counteract any adverse publicity. Setting up appropriate websites and the use of social media are important elements and large industries should be encouraged to establish public information programs and resource centres to advertise what they are doing and to enhance their corporate profiles.

8.1.7 Technical Capacity Building

Considerable emphasis must be placed on ensuring that appropriately trained and experienced personnel are available and involved both in implementation of the program and the ongoing provision of their services so building technical capacity is an essential element of an implementation program. Personnel training and certification programs are, therefore, critical elements required for the implementation of renewable energy and energy efficiency initiatives in industry – both for service providers and for industry personnel.

Capacity building will be an ongoing activity as it might take several years to train a person and to build up a group of qualified personnel for some tasks,

8.1.8 Development of Financing Packages

The availability of capital to enable companies to purchase and install new equipment is essential and different financing packages are required for large industrial operations and SMEs.

As discussed in Chapter 5, most commercial banks and financial institutions are not well informed about new technology and how to assess the associated financial risk. It may, therefore, be necessary for governments to work with them to provide both industry-wide and industry specific information about renewable energy and energy efficiency so they are better able to evaluate loan applications.

Also, implementation programs may need to provide incentive packages that include interim measures such as low interest loans, loan guarantees or capital contributions to banks for on lending.

8.1.9 Leadership by Example

Leadership by example can be an important roadmap element by raising public awareness and kick starting the market. It is most commonly provided by Governments, large industry players or Industry Associations which have the financial and risk management capacities to pursue new technologies and can offer leadership, not only by encouraging industry to consider alternative renewable fuel and energy options and options for improving efficiency, but also by introducing these in their own, usually government owned, industrial plants. The aim is to advance understanding and awareness of the benefits of switching away from conventional fuels and pursuing the energy efficient use of renewable fuels in industry.

Probably the most common example of leadership by example is the conversion of government vehicle fleets to use an alternative fuel, thereby initiating the rapid development of refuelling infrastructure. The analogy for renewable energy and energy efficiency in industry is the rapid rise in technically competent service providers to support the new initiatives.

Consideration may also be given to the introduction of energy efficiency and renewable energy initiatives in all Government facilities (e.g. office buildings) in order to demonstrate consistent commitment.

8.1.10 Program Management and Monitoring

There is a need to track the progress of the implementation of the renewable energy and energy efficiency program because, as experience builds in the early stages of implementation, it may be necessary to make modifications both at macro and micro levels. For instance, more emphasis may need to be placed on the formulation of new or modified standards and regulations.

The program coordination committee will be an important entity in the overall program management. Regular reporting and surveys should be conducted to ensure that there is a good understanding of the ways in which the program is proceeding and should highlight those areas that require additional resources such as additional funding to accelerate the preparation of standards and regulations, changes to incentive packages for certain industries and interaction with existing energy suppliers. The program coordination committee will identify problems, will make recommendations to the appropriate government agency and will also keep track of the overall progress of the program.

There will be a wide range of organizations involved in the program, each with its own management issues. Overall program management involves dealing with all of these organizations and identifying barriers to implementation and activating remedial measures as appropriate.

8.2 The Roadmap Time Sequence

A suggested roadmap time sequence is presented in Figure 8.1. This roadmap has been developed on the assumption that APEC economies will be starting from the beginning of their activities to promote the introduction of renewable energy and energy efficiency initiatives in their industries. This is not, of course, the reality because most economies already have programs in place and have already progressed some way along the roadmap sequence. However, the proposed timetable is designed to illustrate the order in which each of the roadmap elements should be addressed and is intended both to indicate the times required for each of its steps and to inform on how they need to be sequenced. The time scale chosen for full implementation of the program is 5 years, but different APEC economies may well choose to modify this.

8.3 Summary

This roadmap is intended to outline the steps that are required to plan and implement an energy efficiency and renewable energy program in industry in APEC economies. There are considerable differences between both economies and their industries, so the actual implementation plan adopted in each economy will be different. However the roadmap steps and actions required, as summarised and illustrated in Figure 8.1, are largely generic and are applicable to all APEC economies.

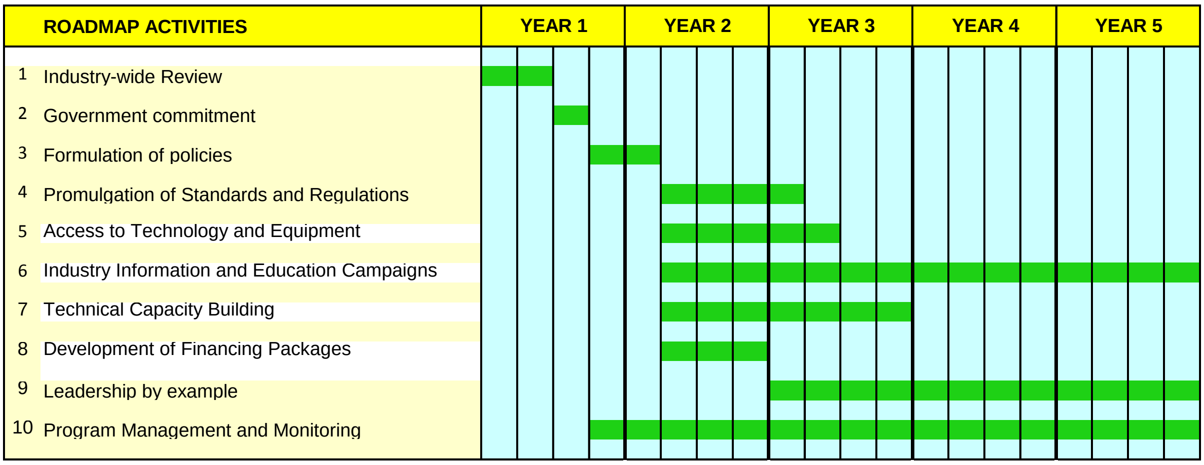

Figure 8.1: Roadmap time sequence

9.0 Conclusions

The following conclusions can be drawn from the findings presented herein. They are summarized by chapter for ease of reference.

9.1 Overall Conclusions

1. Renewable energy and energy efficiency are the "twin pillars" of a sustainable energy future and their combined application can result in the outcome exceeding the sum of the parts http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx.
2. There are already many successful applications of renewable energy combined with energy efficiency throughout APEC and their numbers are increasing.
3. Governments can create regulatory and business environments that promote development of renewable energy and energy efficiency in industry and industry will develop business models configured to respond by extracting maximum value for the business from the opportunity available. This value flows through to the whole economy.
4. There is no universal business model that can be used to introduce and sustain all different forms of renewable energy and energy technologies in industry.
5. Successful introduction of renewable energy coupled with energy efficiency improvement in industry often depends upon the people involved and the partnerships established.

9.2 Combination of Renewable Energy and Energy Efficiency

1. The combined application of renewable energy and energy efficiency in industry is a natural marriage insofar as industry operators who have the foresight to convert their plants from using fossil fuels to renewable fuels are very likely to maximize the value of the renewable fuel by maximizing the efficiency of its use in their plants.
2. There is, therefore, a need to broaden our thinking to include the efficient use of renewable energy in industry to achieve maximum value for the industrial end user, the community, the economy and, ultimately, the planet and its inhabitants.

3. The combined use of renewable energy and energy efficiency in industry needs to focus on how such combination can maximize the benefits that can be achieved. Such benefits include, but are not necessarily limited to:
   - minimizing the specific energy consumption (SEC) required for production,
   - maximising revenues and economic value for an industrial company,
   - minimizing the use of fossil fuels,
   - reducing GHG emissions,
   - managing waste disposal,
   - minimizing environmental impacts,
   - job creation,
   - improvement of industrial working conditions and safety.
4. The ways in which renewable energy and energy efficiency initiatives can be combined to achieve these objectives may be quite different depending on which is targeted by a particular industry or industrial plant.

9.3 Renewable Energy and Energy Efficiency in Industry

1. While there are many examples of the combined application of renewable energy and energy efficiency in industry, their penetration to date has not been extensive.
2. The applications considered most likely to achieve significant penetration in the middle term are:
   - biomass for process heat,
   - biomass as a petrochemical feedstock,
   - solar thermal systems for process heat,
   - heat pumps for process heat.
3. It has been suggested that renewable energy has the potential to supply 23% of final energy use in the global manufacturing industry and up to 14% of fossil feedstock can be replaced by biomass. Together, this equates to 21% of total final energy use.

9.4 Barriers and Obstacles to Implementation

1. The obstacles encountered in the introduction and development of renewable energy, coupled with energy efficiency, in industry are very much the same as those for most other situations involving the introduction of new and unconventional technologies.
2. There do not appear to be any particular obstacles that are genuinely unique to the introduction of renewable energy and energy efficiency initiatives in industry other than those applicable to specific technologies.
3. Individual industries, technologies and locations each have their own characteristics and an obstacle that may be of major importance in one situation can be quite minor in another.
4. Those obstacles that can be addressed by Governments include:
   - lack of information about how the introduction of renewable energy and energy efficiency can benefit specific industries,
   - insufficient capacity to implement the technology in a timely and cost effective manner,
   - high project establishment costs,
   - reduced economic viability due to competition with subsided fossil fuels,
   - difficulties in accessing capital,
   - institutional obstacles such as:
     - lack, or inadequacy, of appropriate incentives,

   - ineffective regulatory regimes that are not supportive,
   - inadequate administrative structures and performance.
5. These issues have been addressed successfully in a number of APEC economies and industries and are diminishing with time as experience is gained, capacity built and costs reduced.

9.5 Lessons Learned

1. Many renewable energy and energy efficiency technologies are now commercially competitive in a number of different industrial applications throughout APEC.
2. Several energy efficiency improvements can be implemented together to provide a high a high level of energy end use efficiency and reduce GHG emissions.
3. Combined production of heat and power (CHP) is probably the most important way in which the efficient use of renewable energy in industry can be maximised.
4. Efficiency gains can also be achieved through:
   - use of high efficiency boilers, steam turbines and captive power gensets,
   - use of a smart (microprocessor) system controller to match load requirements to available energy supply profiles,
   - improvement of such items as air leakage, controller efficiency, compressor efficiency, installation of variable speed drives, system pressure control and control of off load running of mechanical and electrical equipment.
5. Opportunities for improving industrial energy efficiency extend beyond technology to include maximizing the value of the energy products and streamlining process and plant management practices. These can be identified by pursuing market research and energy audits that include a review of management protocols and practices.

9.6 Incentives for Development

1. Many APEC economies already have policies and measures in place to promote the development of renewable energy and energy efficiency in industry although their effectiveness differs considerably and most are still evolving.
2. Tax incentives and benefits are the most common measure used by governments to promote the introduction of renewable energy and energy efficiency improvement in industry.
3. There are considerable variations between the incentive policies and measures employed throughout APEC. Differences are apparent between:
   - developed and transition economies,
   - Asian, Australasian and North American economies,
   - industrialized and agrarian economies.

9.7 A Roadmap for Development

1. The roadmap is intended to outline the steps that are required to plan and implement an energy efficiency and renewable energy program in industry.
2. The steps and actions required are largely generic and are applicable in all APEC economies; however, there are considerable differences between both economies and their industries, so the actual implementation plan adopted, and mechanisms employed, will be different in each economy.
3. Most APEC economies have already embarked on implementation programs so are currently at different points along the road.

4. The role of governments is to create and manage an implementation program that will foster and support the development of renewable energy and energy efficiency in industry and should include the following 10 elements:
    a. Initial industry-wide review to identify opportunities for the development of renewable energy and energy efficiency in industry.
    b. Commit to support these initiatives and develop an action plan.
    c. Formulate policies to promote the introduction of renewable energy and energy efficiency by the industries.
    d. Promulgate standards and regulations.
    e. Facilitate access to technology and equipment.
    f. Establish campaigns to inform industry and the public about Government objectives and policies and the actions that are being taken.
    g. Build local technical capacity.
    h. Develop appropriate financing packages and encourage the provision of private sector financing.
    i. Lead by example by introducing renewable energy and energy efficiency improvements in government owned industrial plants.
    j. Maintain ongoing program management and monitoring.

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GLOSSARY OF TERMS AND ABBREVIATIONS

ADB	:	Asian Development Bank
ASEAN	:	Association of South East Asian Nations
APEC	:	Asia Pacific Economic Cooperation
CDM	;	Clean Development Mechanism
CE&P	:	California Ethanol & Power
CHP	:	Combined heat and power
CO_2	:	Carbon dioxide
CRT/N	:	Centre for Rural Technology, Nepal
CSI	:	California Solar Initiative
CSP	:	Concentrated Solar Power
CVEC	:	Chippewa Valley Ethanol Company
DLR	:	Deutsches Zentrum für Luft und Raumfahrt (German Aerospace Center)
EDB	:	Singapore Economic Development Board
EE	:	Energy Efficiency
EECA	:	Energy Efficiency and Conservation Authority (New Zealand)
EGAT	:	Electricity Generating Authority of Thailand
ETS	:	Emissions trading scheme
FiL	:	Feed-in Law
FiT	:	Feed in Tariff
FiTino	:	Feed-in tariff in name only
GE	:	General Electric
GHG	:	Greenhouse Gas
GREET	:	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
IBEKA	:	Institut Bisnis dan Ekonomi Kerakyatan
ICICI	:	Industrial Credit and Investment Corporation of India
IPP	:	Independent Power Producer
IDA	:	International Development Association
IOCs	:	International Oil Companies
ISO	:	International Standards Organisation
km	:	Kilometres
kW	:	Kilowatts
kWh	:	Kilowatt hours
LIPI	:	R&D Centre for Applied Physics
MDF	:	Medium Density Fibreboard
MIDC	:	Maharashtra Industrial Development Corporation
MW	:	Megawatts
MWh	:	Megawatt hour
NDRC	:	National Development and Reform Commission
NREL	:	US National Renewable Energy Laboratory
O&M	:	Operations and maintenance
OEM	:	Original Equipment Manufacturer
PFL	:	Parakh Foods Limited
PKBE	:	Phu Khieo Bio-Energy Co. Ltd
PLC	:	Programmable Logic Control
PPA	:	Power Purchase Agreement
PTC	:	Production tax credit
PV	:	Photovoltaic

RE	:	Renewable Energy
REC	:	Renewable energy certificate
RES	:	Renewable electricity standard
RLB	:	Raiffeisen-Landesbank of Steiermark
RPS	;	Renewable Portfolio Standards
RTO	:	Regenerative thermal oxidizer
SAH	:	Solar air heating
SBC	:	System benefits charge
SEC	:	Specific Energy Consumption
SEPA	:	State Environmental Protection Agency
SETC	:	State Economic Trade Commission
SME	:	Small and medium enterprises
S.O.L.I.D	:	Solar Installation and Design
TSEC	:	Thai Solar Energy Company Ltd
UFIC	:	United Farmer & Industry Company Limited
UN	:	United Nations
USAID	:	United States Agency for International Development
VAT	:	Value Added Tax
VER	:	Voluntary Emissions Reduction

Prepared By:

Resource Development Ltd
PO Box 21
Hunterville, 4745
New Zealand
Tel: (64) 6 322,8773
Email: rdl@iconz.co.nz

Produced For:

Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 6891-9600
Fax: (65) 6891-9690
Email: info@apec.org Website: www.apec.org

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