Asia-Pacific
Economic Cooperation

Renewable Energy for Urban Application in the APEC Region

APEC Energy Working Group/
Expert Group on New and Renewable Energy Technologies

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Executive Summary

Purpose of Study

The Energy and Security Group was retained by the Asia-Pacific Economic Cooperation (APEC) Energy Working Group/Expert Group on New and Renewable Energy Technologies to assess best practices in renewable energy technologies, systems and resources in urban areas of APEC member economies. Best practices, as defined in this study, relate not only to technologies but also to innovative policies, programs and projects that are advancing the use of renewable energy throughout the APEC region.

Background

Cities worldwide consume over 70% of global energy demand, with many of the world's most dynamic and fastest growing cities located in APEC economies. With current plans to satisfy the bulk of these energy requirements from fossil fuel resources, there are strong and growing concerns about energy security, climate change and economic development.

Renewable energy technologies broaden the options for electricity, thermal energy and liquid fuels applications. Acknowledging the potential benefits these technologies offer, APEC Economic Leaders announced at a recent meeting in November 2009 **"…***We recognize the role of renewable energy in reducing emissions and encourage its development in the APEC region.*"

Rationale and Approach

Currently, there is no compilation of data on renewable energy technologies, policies and financial resources specifically for application and use in urban areas. This study provides a timely and unique platform for sharing information and best practices on advancing these technologies and systems in APEC urban areas. The study involved four tasks:

- Identification of **lessons learned** from renewable energy activities in APEC economies, particularly in urban areas.
- Review of **obstacles** preventing or inhibiting the widespread adoption of renewable energy in urban areas.
- Documentation of **case studies** of successful urban renewable energy projects and programs throughout the APEC region.
- Preparation of a **roadmap** to guide future urban renewable energy development.

A desk study was conducted, drawing upon primary and secondary resources.

Ten Priority Steps for Advancing Renewable Energy in APEC Cities

In terms of urban applications of renewable energy, it is *primarily cities*, not national governments, which have demonstrated early vision and have established leadership. The study identified a substantial number of renewable energy programs in APEC, spanning the residential, commercial, industrial, government, educational and utility sectors.

Ten priority "roadmap" activities emerged from the study as crucial for replication and expansion of renewable energy systems to cities throughout the APEC region. These are:

- *Understand What Renewable Energy Means for Your City:* Become familiar with the range of commercial renewable energy technologies in the marketplace today and their applications.

- *Make a Commitment to Renewable Energy:* Establish a time-bound renewable energy target for the city; assess the local energy supply and demand structure and likely growth patterns; inventory existing urban renewable energy incentives and disincentives at the regional, national and sub national levels; and understand the city's "authorities" with regard to energy in general and renewables in particular.

- *Initiate a Plan of Action*: Organize a planning task force and prepare a tailored plan of action based on local needs and conditions. As a "living" plan it can be expected to evolve, and the planning process should specifically allow updates and modifications.

- *Build an Effective Policy Framework:* Create a broad legislative framework on clean energy; put in place mega policies for renewable energy development (e.g., Renewable Portfolio Standards, Feed-in Tariffs and competitive tendering); and develop financial incentives to stimulate market stability and investment.

- *Establish Rules and Regulations:* To ensure that quality products and services are delivered into the marketplace.

- *Address Technical Issues:* Aimed at improving technology performance and costs, e.g., through in-country technical capacity, international collaboration and joint ventures.

- *Provide Access to Financing:* From a range of local, national and international sources and finance mechanisms, including insurance / risk underwriting.

- *Launch a Renewable Energy Awareness Campaign*: To increase the impact of renewable energy efforts through a coordinated education, awareness and training campaign.

- *Strengthen Local Capacity:* Through technical assistance and training that targets a range of public and private sector stakeholders.
- *Lead by Action:* Invest in renewable energy on public buildings and in day-to-day operations.

Expected Outcomes from Renewable Energy

Among the outcomes that cities can anticipate from increased use of renewable energy, and development of advanced technologies, products and renewable energy services, are:

- A cleaner, healthier environment through improved local air quality and reduced greenhouse gas (GHG) emissions.
- Greater energy security.
- A greener economy and expansion in availability of green jobs.
- Local industrial development.
- Trade and export opportunities.
- Urban renewal.
- Regional development.
- A safer, more secure, cleaner, reliable and more efficient energy system.

Acronyms and Abbreviations

AC	alternating current
ADB	Asian Development Bank
APEC	Asia-Pacific Economic Cooperation
AUD	Australian dollars
BOS	balance of system
BIPV	building-integrated photovoltaic
CDM	Clean Development Mechanism
CER	carbon emission reductions
CHP	combined heat and power
CIF	Climate Investment Fund
CNG	compressed natural gas
CO_2	carbon dioxide
CO	carbon monoxide
CSP	concentrating solar power
CTF	Clean Technology Fund
DC	direct current
DTIE	Division of Technology, Industry, and Economics (UNEP)
EGAT	Electricity Generating Authority of Thailand
EGNRET	APEC's Expert Group on New and Renewable Energy Technologies
EIA	environmental impact assessment
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
ESG	The Energy and Security Group
EWG	Energy Working Group (APEC)
FERC	Federal Energy Regulatory Commission, US
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas
GPS/GIS	global positioning system/geographic information system
GW	gigawatt
GWh	gigawatt hour
GWth	gigawatt-thermal
HVAC	heating, ventilating and air conditioning
IDA	International Development Agency
IEA	International Energy Agency
IP	intellectual property
IRENA	International Renewable Energy Agency
kWe	kilowatt of electrical energy
kWh	kilowatt hour

kWp	kilowatts-peak
LCC	life-cycle cost
LED	light-emitting diode
LFG	landfill gas
LIC	local improvement charges
LNG	liquefied natural gas
M&E	monitoring & evaluation
MECO	Maui Electric Company
MFH	multi-family housing
MPSG	Mitr Phol Sugar Group
MRET	mandatory renewable energy target
MSW	municipal solid waste
MW	megawatt
MWe	megawatt of electrical energy
MWh	megawatt hours
MWp	megawatts peak
NDRC	National Development and Reform Commission, China
NGO	non-governmental organization
NiMBY	"not in my backyard"
NOx	nitrogen oxide
NRE	new and renewable energy
NREL	National Renewable Energy Laboratory, US
OECD	Organization for Economic Co-operation and Development
O&M	operation and maintenance
PKB	Phu Khieo Bio-Energy
PPA	power purchase agreement
PTC	production tax credit
PV	photovoltaic
R&D	research and development
RE	renewable energy
REC	Renewable Energy Certificates
REEEP	Renewable Energy and Energy Efficiency Partnership
REN-21	Renewable Energy Network for the 21st Century
RET	renewable energy technology
RPS	renewable portfolio standard
S$	Singapore dollars
SCF	Strategic Climate Funds
SCS	Solar Capacity Scheme
SEPA	State Environmental Protection Agency, China
SFH	single family home (or housing)
SHW	solar hot water
SOx	sulphur oxide
SREP	Scaling Up Renewable Energy in Low-Income Countries

tCO_2e	ton carbon dioxide equivalent
TRC	Tradable Renewable Certificates
UFIC	United Farmer & Industry Company Limited
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Program
US$	US dollars
USEPA	United States Environmental Protection Agency
VAT	value added tax
WEO	World Energy Outlook (IEA)
WTE	waste-to-energy

1. Introduction

1.1 Purpose

The purpose of this report is to highlight best practices in the use of renewable energy technologies in urban areas of Asia-Pacific Economic Cooperation (APEC) member economies and to help guide APEC Leaders in developing clean energy roadmaps. Best practices as considered in this report are broad in nature, ranging from technology-specific applications, to innovative policy approaches stimulating renewable energy adoption in the APEC region.

This project is conducted under the auspices of the APEC Energy Working Group (EWG) which is one of 11 APEC working groups. Its objective is to maximize the energy sector's contribution to the region's economic and social well being through activities in five areas of strategic importance:

- Energy supply and demand
- Energy and the environment
- Energy efficiency and conservation
- New and renewable energy technologies
- Minerals and energy exploration and development.

In particular, this study falls under the purview of the APEC EWG Expert Group on New and Renewable Energy Technologies (EGNRET) which was established to promote and facilitate the expanded use of new and renewable energy—where it is cost effective. The target audience for this document is policymakers and private sector renewable energy developers.

1.2 Rationale

Currently, there is no compilation of data on renewable energy technologies, policies and financial resources specifically for application and use in urban areas. Thus, this report provides a unique urban energy planning document. Sharing experiences of successful urban renewable energy based systems will contribute to the development of new city/state renewable energy programs in the APEC region. These activities will benefit both the general population due to a reduction of air emissions and the economy as a whole due to increased energy security.

The key output from the sharing of experiences in urban energy systems is a suggested roadmap for the successful implementation of urban renewable energy systems in APEC member economies (Chapter 5). This roadmap will assist urban leaders and citizens to plan and implement their own renewable energy systems that are both cost effective and environmentally friendly.

This report aligns with both EWG and APEC-wide priorities and links with many completed projects of APEC EGNRET. It also supports both short- and long-term aspects of the APEC Energy Security Initiative that promotes development of renewable energy systems in urban energy applications.

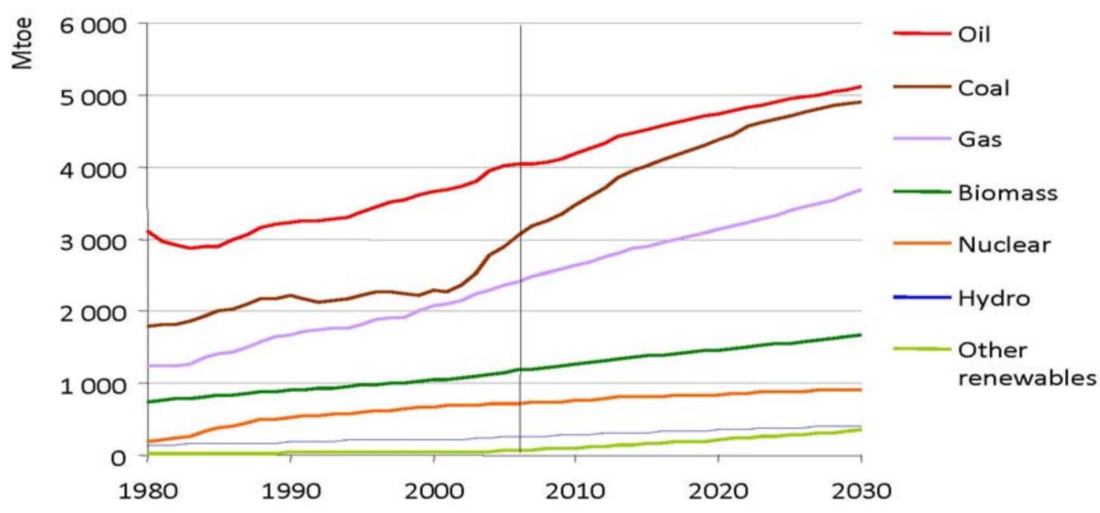
1.3 Background

According to the United Nations Development Program (UNDP), world population growth is expected to increase from approximately 6.5 billion in 2006 to about 8.2 billion in 2030. This represents an average rate of increase of 1% per year. By the year 2030, 52% of the global population will be in non-OECD (Organization for Economic Cooperation and Development) Asia. China will continue to be the world's most heavily populated country, with over 1.4 billion people. India is expected to match this population level by 2030. The share of OECD population in the global mix is projected to decline from 18% in 2008 to less than 16% in 2030.

Overall, the increase in world population is expected to take place in urban areas. In 2008—for the first time—the urban population equaled that of the rural population. From this point on the major part of the world's population will be urban areas, accounting for 60% by 2030. This growing rapid urbanization will yield a concurrent demand for energy in urban and peri-urban areas.

The International Energy Agency (IEA) projects that global energy demand will reach 17,000 million tons of oil equivalent (Mtoe) by 2030. Under business as usual conditions, this demand will be satisfied primarily by fossil fuels—oil, natural gas and coal— with negative consequences to the environment, particularly greenhouse gas emissions. Renewable energy technologies will have an increasing role to play as forecasted energy demand cannot be met adequately through exclusive reliance on conventional energy sources. However, though non-hydro renewable energy is the fastest growing of all the technologies today, expanding at a rate of 7.2% per year, this is starting from a small base. Projections call for renewable energy to continue to represent only a small portion of total energy consumption over the next few years in absence of more aggressive support (See Figure 1-1).

Figure 1-1: World Energy Consumption through 2030



Overall, roughly two-thirds of the world's energy, an estimated 7,900 Mtoe in 2006, is consumed in cities even though only about half of the world's population lives in these areas. These cities account for 70% of global carbon dioxide (CO_2) emissions. City residents consume more coal, gas and electricity than the global average but less oil. Buildings are responsible for 30 to 40% of national energy use in addition to roughly a third of GHG emissions and 25 to 40% of solid waste generation. By 2030, city energy use will significantly increase, accounting for 73% of total energy use and 73% of CO_2 emissions.

APEC's 21 member economies (see Table 1-1) represent 41% of the global population, 49% of international trade and 56% of the world's Gross Domestic Product (GDP). Half of the world's megacities (> 10 million people) are in APEC, with an aggregate population of 231.4 million people (see Table 1-2). This growth poses enormous infrastructure and service challenges for urban areas.

Table 1-1: APEC Member Economies

	Australia
	Brunei Darussalam
	Canada
	Chile
	People's Republic of China
	Hong Kong, China
	Indonesia
	Japan
	Republic of Korea
	Malaysia
	Mexico
	New Zealand
	Papua New Guinea
	Peru
	Philippines
	Russia
	Singapore
	Chinese Taipei
	Thailand
	United States
	Viet Nam

Table 1-2: The Largest APEC Megacities (January 2009)

World Rank	City	Country	Population
1	Tokyo	Japan	33,800,000
2	Seoul	Korea (South)	23,900,000
3	Mexico City	Mexico	22,900,000
6	New York	USA	21,900,000
8	Manila	Philippines	19,200,000
9	Los Angeles	USA	18,000,000
10	Shanghai	China	17,900,000
11	Osaka	Japan	16,700,000
14	Canton	China	15,300,000
15	Jakarta	Indonesia	15,100,000
18	Moscow	Russia	13,500,000
19	Beijing	China	13,200,000
		Total	**231,400,000**

Source: http://www.citypopulation.de/index.html

APEC member economies account for around 60% of world energy demand, with the region a net importer. Energy imports to APEC economies are projected to increase by approximately 92% between 2000 and 2020 as domestic supplies fail to keep pace with expanding energy demands. According to APEC's EWG projection, demand for energy in the APEC region will continue to increase into the foreseeable future.

Modern energy services will have to provide reliable high-quality and affordable electricity, fuels and thermal energy for all sectors of the economy while reducing the carbon intensity and the air and water pollution from traditional energy systems operations. These challenges apply to all APEC economies, with megacities presenting special requirements for infrastructure services. The imperative for making cities more livable and better able to meet the needs of all of their inhabitants is reflected in the sustainable development plans of hundreds of cities throughout much of APEC. These imperatives are reflected in the recent (November 2009) *17th APEC Economic Leader's Meeting Final Declaration***,** in which it is stated:

> *"Global action to reduce greenhouse gas emissions will need to be accompanied by measures, including financial assistance and technology transfer to developing economies for their adaptation to the adverse impact of climate change.*
>
> *We also commit to rationalize and phase out over the medium term fossil fuel subsidies that encourage wasteful consumption, while recognizing the importance of providing those in need with essential energy services. We will review progress on this at our meeting in 2010. We will also take steps to facilitate the diffusion of climate-friendly technologies, including through economic and technical cooperation and capacity building activities.*

We will advance work on sharing best practices in energy efficiency with a view to deploying cleaner and more efficient technologies and welcome the implementation of the voluntary APEC Peer Review on Energy Efficiency. We recognize the role of renewable energy in reducing emissions and encourage its development in the APEC region. We will encourage publication on a regular basis, of timely, accurate and complete data on oil production, consumption, refining and stock levels as appropriate."

Two key elements to respond to the above challenges and concerns are increasing urban energy efficiency and large-scale use of renewable energy technologies. Although the use of renewable energy technologies in cities has been ongoing in APEC over the last decade and longer, there are growing opportunities for rapid scale-up of these technologies given technical and cost advances, more widespread availability and use of renewable energy products and services and greater understanding of how to maximize use of these systems in complex urban landscapes.

1.4 Approach

This report focuses primarily on *commercial* application of renewable energy technologies in urban applications. These include biomass, geothermal, small hydropower, solar (photovoltaics, solar thermal, concentrating power) and wind technologies. However, where applicable, it also addresses *emerging* renewable energy technologies.

The report is the product of an extensive study that made use of a variety of primary and secondary data sources. These included private communications with professionals active in relevant fields and industries, as well as over 200 documents and web sites from a variety of international agency, government, private sector, non-government, financial and academic organizations. Secondary sources included published reports, journal articles, reports in renewable energy newsletters and magazines, workshop proceedings and on line news reports.

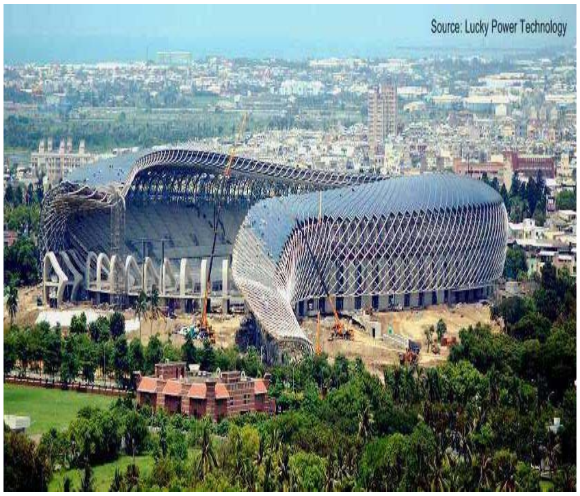
Notably, several recently published reports provide new data and insights on barriers and lessons learned to the widespread diffusion of renewable energy systems and technologies. These include the Renewable Energy Network for the 21st Century (REN-21) Annual Reports, and the International Energy Agency's World Energy Outlook (WEO) and other dedicated renewable energy reports. Information from these sources was particularly valuable in preparation of this document.

1.5 Organization of Report

The remainder of the report is organized as follows:

- Chapter 2 provides a review of the applicability of *lessons learned* from previous urban energy analysis reports.
- Chapter 3 discusses *obstacles* inhibiting the adoption of renewable energy technologies in urban areas.
- Chapter 4 describes *examples of successful adoption of renewable energy technologies* in the APEC urban areas.
- Chapter 5 provides guidance for creating a *roadmap* for successful implementation of urban renewable energy systems in APEC member economies.

Chapter 2: Lessons Learned



2. Lessons Learned

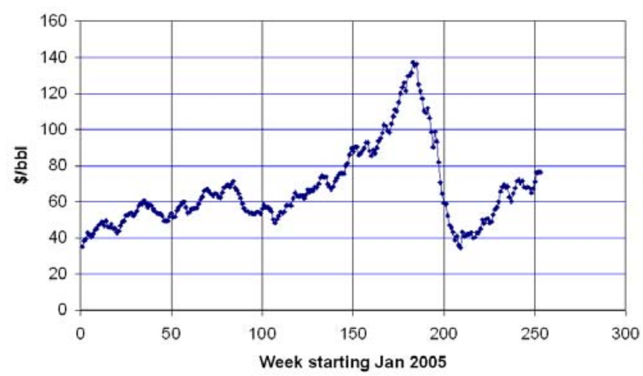
Over the past few years there has been increasing development and application of renewable energy technologies throughout APEC member economies. Although there is no single formula for success, experiences are emerging that can help to guide policy makers, the private sector and others in the development, deployment and scale up of renewable energy technologies for urban applications. This chapter provides lessons learned on APEC experiences of renewable energy, with a particular focus on issues related to technology, policy, financing and capacity building.

2.1 Benefits of Renewable Energy

Renewable energy technologies offer significant benefits for APEC member economies and particularly cities. These technologies:

- Utilize locally available resources—the solar energy, wind, sustainable biomass, geothermal energy and hydropower.
- Reduce the need for fossil fuel imports and their attendant foreign trade impacts.
- Enhance energy security by diversifying the energy portfolio, improving price stability due to fluctuating energy prices and hedging risks associated with future energy cost uncertainty.
- 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 local communities.
- Create job, revenue and income opportunities.
- Are modular and distributed in nature and thus can be sited close to the load requirement.
- Satisfy a variety of end use applications for power, heat and fuel.
- Conserve a country's natural resource base.
- Enhance economic development through local manufacture of products and components, assembly and installation, operation and/or servicing of equipment.

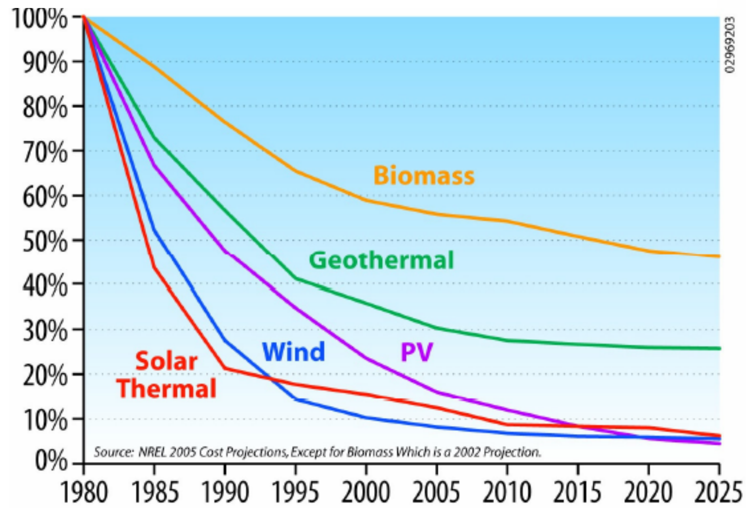
Figure 2-1: Renewable Energy: A Hedge Against Fluctuating World Oil Prices



http://www.pennenergy.com/index/articles/stats-display/3499352257/articles/pennenergy/weekly-statistics/world-crude-oil-price.html

Over the past few years, renewable energy technologies have experienced significant growth. In 2008, renewable energy power capacity grew to 280 gigawatts (GW)—up from 207 GW in 2006—representing a 35% increase. This growth is driven by a number of factors including improvements in technology performance, increasing scales of production and use, reduced costs, fluctuating prices for conventional energy sources and other market and policy drivers. These cost reductions have allowed mature renewable energy technologies, such as wind power, bioenergy, solar hot water and photovoltaic (PV) systems, geothermal energy and hydropower to achieve significant market penetration worldwide.

Figure 2-2: Renewable Energy Electricity Generation Costs as Percent of 1980 Levels: Historical and Projected



Source: Expert Group on Renewable Energy, *Background Report – Increasing Global Renewable Energy Market Share, Recent Trends and Perspectives*, Beijing International Renewable Energy Conference 2005, by UN Department of Economic and Social Affairs

2.2 Cities as Early Adopters—Lessons Learned

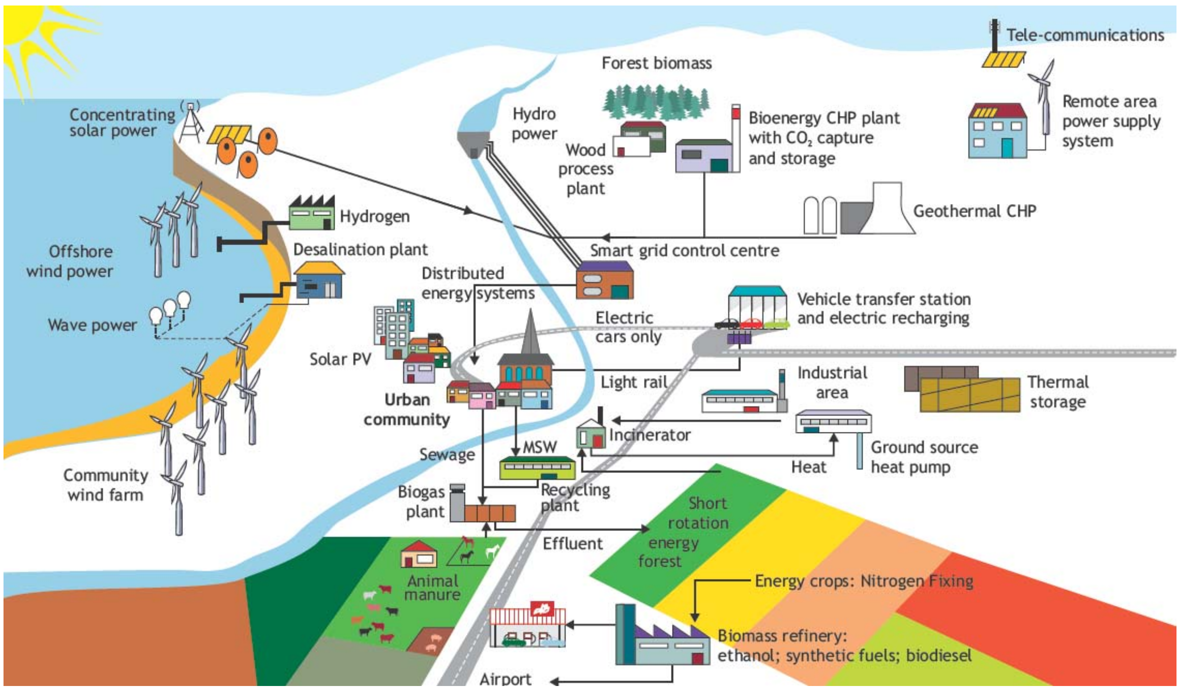
In terms of urban applications of renewable energy, it is *primarily cities*, not national governments, which have demonstrated early vision and established leadership in sustainable development including use of renewable energy systems for electrical and thermal power. Key lessons learned to date include:

- *Political vision and leadership* have proven essential in establishing the enabling technical, economic and policy environments essential for large-scale diffusion of renewable energy technologies.
- *Strong public support* is essential for establishment of the policies that foster sustainable urban development including increased energy efficiency and widespread use of renewable energy.
- *In-country scientific, technical and engineering competence and capacity* are required for innovative urban renewable energy systems to “take off.”

- *International collaboration* can decrease the time and risks in establishing sustainable urban renewable energy programs.
- *Innovative showcase projects* such as green buildings and zero energy buildings establish the "platforms" and early experience base for new commercial RE systems and applications, not unlike the role of concept cars at international automobile shows.
- *Early financial and risk underwriting* of innovative approaches helps to establish RE markets that stimulate technical innovation, "pull" technology enterprises into the marketplace and allow costs to decline through the processes of scaling up and technology development experience.
- *Policies* often have to be adaptive and change as the scale of implementation in urban renewable energy increases, as technologies develop and as *scale-related obstacles to implementation appear.*
- *Community size often determines approaches and possibilities for renewable energy development*. There are clear differences between the policies enacted and implemented by smaller versus larger communities. Smaller communities are establishing targets for 100% renewable energy, or have even reached this level already, whereas larger cities may find this almost impossible in the short and medium term. Smaller communities also tend to be motivated in a regional context and cooperate with other municipalities in their region. Among those pioneers, many see an "early adopter" advantage and look for competitive advantages from innovation. Larger cities, in contrast, tend to start by targeting specific renewable energy opportunities, such as solar, wind or bio-energy. Larger cities may then use these opportunities to portray the city as progressive (a "solar city") and to explore business ventures that will benefit the city.
- *Mid-sized cities can start more easily then large cities.* As observed in other local policy sectors, cities and towns of between 100,000 – 500,000 inhabitants tend to be pioneers. Innovation and implementation is often much easier for these mid-size cities than for larger cities, although international attention may focus more on the larger cities. Many APEC megacities cities have followed these early innovators with similar innovations, including Beijing and Shanghai, Seoul, Tokyo, Toronto and New York City.
- *Cities as Innovation Incubators.* As early adopters, cities often act as innovation incubators, supporting new technology and policy approaches that would be premature on a national or even provincial or state level. Smaller cities in APEC are also establishing important innovations in promotion and support of urban renewable energy applications.
- *Producing a "snowball effect."* In some countries, pioneering local governments have taken initiative, with other local governments then following. This is why "model cities" are so relevant and why city-to-city transfer of information and motivation are essential for ongoing diffusion of renewable energy innovations. One of the best examples is Barcelona's Solar Ordinance, which mandates solar hot water in new construction. This inspired similar initiatives by dozens of local governments in Spain and elsewhere.
- *Pilot/demonstration facilities act as laboratories.* For industry, consumers, government and others, these facilities can help the stakeholders identify potential problems and diffuse barriers at an early stage.
- *Performance standards tend to facilitate technology advancement and cost reductions; prescriptive measures tend to freeze technology.* Standards allow customers to have more confidence in products and investors in the market.
- *Risk underwriting is often essential.* During the initial stages of market entry and early diffusion, this support is often necessary 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.

Figure 2-3 provides a stylized view of how a range of renewable energy technologies and systems can contribute to urban energy needs.

Figure 2-3: A Stylized View of a Renewable Energized Community



Source: IEA/OECD (2009)

2.3 Technology — Lessons Learned

2.3.1 Bioenergy

Biomass includes organic matter such as vegetable oils, wood and agro-industrial residues and wastes. Most biomass today is directly combusted to produce: (1) heat; (2) electricity, such as combustion or co-firing with coal in utility-scale thermal power plants; or (3) a combination of both through combined heat and power (CHP) for industrial use. Biomass can also be gasified, with the gas used in gas turbines to generate electricity, or reformed to produce hydrogen that can by used in fuel cells. Biomass, in the form of organic residues, can be utilized in anaerobic digesters to produce methane which can in turn be used for heating, lighting or electricity generation. Finally, biomass can be fermented with heat and pressure to produce biofuels, including ethanol or biodiesel.

Relevance for APEC member economies:

- *Electricity Production.* Several APEC member economies generate large amounts of electricity from biomass combustion. Biomass power generation and cogeneration continued to grow at both large and small scales, reaching capacity levels of about 52 GW in 2008.

- *Direct biomass combustion* is a mature technology but plants are small with low efficiencies. The most promising near-term option for large scale biopower generation is co-firing. Co-firing biomass with coal in large power plants is efficient and less costly that existing biomass power plants.

- *Combined heat and power (CHP)* applications using a waste fuel are generally the most cost effective of the biomass technologies. Further, these systems can yield high efficiencies (90%).

- *Biomass gasification* 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.

- *Liquid Biofuels.* The global production and use of biofuels has increased dramatically in the past few years, primarily due to increasing oil prices, national security concerns, environmental considerations and efforts to revitalize rural communities. The liquid biofuels most widely used for transportation today are ethanol and biodiesel and there are other types of biomass-derived fuels under development. Today, ethanol production within APEC occurs mostly in Australia, Canada, China, Thailand and the United States. In 2008, ethanol production rose by 34% to 67 billion liters. Biodiesel production in APEC occurs largely in Australia, Canada, China, Indonesia, Malaysia and the United States. In 2008, biodiesel growth rates were even more impressive than ethanol. However, in absolute terms production remains significantly less at 12 billion liters in 2008, up from two billion liters in 2004.

  There are various levels of government involvement and support for biofuels development in the APEC region. While governments in some economies such as Indonesia, Mexico, Russia and Viet Nam have expressed interest and support for the biofuels industry, there are no policies in place. On the other hand, the governments of Australia, Canada, China, Thailand and the United States have adopted a range of policy instruments that affect the production and consumption of biofuels. The most common policy supporting biofuels in the APEC region is the mandate for compulsory blending with fossil fuels to a certain percentage. Other policy instruments applied in the region include fuel tax exemptions, loan guarantees, reduced enterprise taxes and subsidies (direct and indirect) for biofuels production and research and development (R&D) investments.

- *Landfill Gas Capture and Use.* The capture and use of landfill gas (which is primarily methane) in APEC urban areas holds great promise. Landfill gas production results from chemical reactions and microbes acting upon waste as biodegradable materials begin to break down in a landfill. Due to the constant production of landfill gas, the increase in pressure within the landfill provokes the gas's release into the atmosphere. Such emissions can lead to important environmental, safety and security problems in the landfill. To mitigate this problem, the gases produced within the landfill can be collected and flared off or used to produce heat or electricity. The City of Sioux Falls, South Dakota in the US installed a landfill gas collection system that collects, cools, dries and compresses the gas into an 11-mile pipeline. The gas is then used to power an ethanol plant operated by POET Bio-refining.

  Methane capture is another method of utilizing waste for energy. This is done by collecting decomposing materials, processing the gas and converting that gas into electricity which can be used on-site or sold to the grid. Landfill gas (LFG) can also be used as an alternate fuel, replacing natural gas. Landfill gas has been converted to vehicle fuel in the form of compressed natural gas (CNG) and liquefied natural gas (LNG). Projects to convert LFG to methanol are in the planning stages.

- *Municipal solid waste conversion.* Municipal solid waste (MSW), also called urban solid waste, includes predominantly household waste (domestic waste) with the addition of commercial wastes collected by a municipality within a given area. Municipal solid waste can be used to generate energy. Technologies that have been developed to make the processing of MSW for energy generation cleaner and more economical include landfill gas capture, combustion, pyrolysis, gasification and plasma arc gasification. While older waste incineration plants emitted high levels of pollutants, recent regulatory changes and new technologies have significantly reduced this concern. US Environmental Protection Agency (USEPA) regulations in 1995 and 2000 under the Clean Air Act have succeeded in reducing emissions of dioxins from waste-to-energy facilities by more than 99 percent below 1990 levels, while mercury emissions have been reduced by over 90 percent. The USEPA noted these improvements in 2003, citing waste-to-energy as a power source "with less environmental impact than almost any other source of electricity."

  Two benefits of waste-to-energy (WTE) plants are: 1) the technology is advanced and commercial; and 2) the plants can be built in close proximity to urban areas—the source of large volumes of garbage which provides the fuel for these plants. Energy from municipal solid waste is a proven option in many APEC cities and peri-urban areas. It can continue to be a viable option in other cities assuming the land is available for constructing the facility, zoning requirements are satisfied, permits obtained and other design considerations are addressed.

2.3.2 Geothermal Energy

Heat from the earth, or geothermal energy, can be accessed by drilling water or steam wells in a process similar to drilling for oil. Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no greenhouse gases), reliable (average system availability of 95%) and homegrown (reducing dependence on foreign oil). Currently, geothermal has three key applications:

Figure 2-4: Several geothermal power plants at The Geysers in the US

Source: www.nrel.gov

Power Generation. Geothermal energy has been used for space heating and bathing since ancient Roman times, but is now better known for generating electricity where adequate geothermal resources exist. To accomplish this, mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water to propel turbines that drive electricity generators. Today, geothermal energy is a major contributor to electricity production in least 40 countries worldwide, including many APEC-member economies. In 2008, geothermal power capacity reached over 10 GW.

Heating. Geothermal resources range from shallow ground to hot water and rock several miles below the Earth's surface and even farther down to the extremely hot molten rock called magma. Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications—space heating, spas, industrial processes, desalination and agricultural applications. Additionally, geothermal district heating uses networks of piped hot water to heat buildings in whole communities. In 2008, direct uses of geothermal heat amounted to 15GWth (gigawatt-thermal).

Geothermal Heat Pumps. Almost everywhere, the upper 10 feet of Earth's surface maintains a nearly constant temperature between 50 and 60°F (10 and 16°C). A geothermal heat pump system consists of pipes buried in the shallow ground near the building, a heat exchanger and ductwork into the building. In winter, heat from the relatively warmer ground goes through the heat exchanger into the house. In summer, hot air from the house is pulled through the heat exchanger into the relatively cooler ground. Heat removed during the summer can be used as a no-cost energy solution to heat water. In 2008, geothermal heat pumps reached 30GWth of installed capacity.

The three technologies discussed above use only a tiny fraction of the total geothermal resource; there are significant opportunities for expanded use in each of these areas. Further, several miles everywhere beneath earth's surface is hot, dry rock being heated by the molten magma directly below it. Technology is being developed to drill into this rock; inject cold water down one well; circulate it through the hot, fractured rock; and draw off the heated water from another well. Success in this area will further expand geothermal opportunities in APEC member economies.

2.3.3 Hydropower

Hydropower is a mature, proven, reliable, clean and affordable source of electricity in use worldwide. Today's hydropower turbines are also highly efficient, capable of converting more than 90% of available energy into electricity which is more efficient than any other form of generation (the best fossil fuel plant is only about 50% efficient). In 2008, small hydropower amounted to an estimated 85 GW installed worldwide, while large hydropower increased by an estimated 25-30 GW in 2008, outpacing that of prior years.

Hydropower can be developed across a wide range of size ranges, depending on various circumstances such as hydrological and topographical conditions, local and regional needs and electricity markets. Both continuous baseload operation and peaking requirements can be met. The volume of water stored relative to the schemes generating capacity will determine the operational flexibility. This storage capacity also provides an efficient and cost-effective way to support the use of intermittent renewable sources of power such as wind and solar energy.

Conventional hydropower technologies include:

- *Reservoirs* where river water is stored in a reservoir behind an impounding structure, typically a dam. The water may be released for generation either to meet changing electricity needs on a daily, weekly or seasonal basis or to maintain a reservoir level for other purposes such as flood control, irrigation, water supply or recreation.
- *Run-of River* where flowing river water is run through a hydropower turbine and generator, then returned to the river.
- *Pumped Storage* where water is pumped from a lower reservoir to an upper reservoir when demand for electricity is low. During periods of high demand, the water from the upper reservoir is released back to the lower reservoir through the reversible units to generate power.

Additionally a number of new hydropower technologies are in development:

- *Wave energy* conversion devices which capture mechanical power from the waves and use it directly or indirectly to power a turbine and a generator.
- *Tidal energy* where the flow from the tides of an ocean or stream is captured to make power.

- *Hydrokinetic energy* which captures the moving energy from the flow of water across or through the blades to power a generator (similar to how a wind turbine captures the wind).
- *Constructed waterways* whereby conduits that use vast amounts of flowing water, like irrigation canals, aqueducts and water supply or effluent streams, capture water for power generation.

In the future, hydropower offers significant potential for meeting the energy needs of many APEC economies, including both greenfield projects and rehabilitation of existing facilities.

2.3.4 Concentrating Solar Power

Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect the solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine driving a generator.

CSP is a well-established technology, with efforts underway to reduce costs and increase competitiveness in the next 5-10 years. Three types of technology are in development:

- Linear Concentrator Systems—includes R&D on parabolic troughs, but also on other line-focus systems such as linear Fresnel reflectors.
- Dish/Engine Systems—includes R&D on dish structures, mirrors and Stirling engines.
- Power Tower Systems—includes links to R&D being done within other CSP areas, but that are relevant to heliostats, receivers and overall systems issues for central-receiver solar plants.

Concentrating solar power parabolic trough and power tower technologies offer a utility-scale, firm, dispatchable renewable energy option that can help meet a nation's demand for electricity. Larger, utility-scale CSP applications provide hundreds of megawatts of electricity for the power grid. Both linear concentrator and power tower systems can easily be integrated with thermal storage, helping to generate electricity during cloudy periods or at night. Alternatively, these systems can be combined with natural gas, and the resulting hybrid power plants can provide high-value, dispatchable power throughout the day.

Smaller CSP systems can be located directly where the power is needed. For example, single dish/engine systems can produce 3 to 25 kilowatts of power and are well suited for such distributed applications.

Given the large land requirements associated with parabolic trough and power tower systems, it is unlikely these will be developed in urban areas. However, power may be generated in surrounding areas and fed into the urban grid. Dish stirling engines may be more amenable to direct urban application.

While to date, all the fully operational CSP plants were located in the United States, recently the CSP market has been experiencing a growing interest by a number of countries (e.g., Spain, Israel, Morocco, Algeria, Portugal, Egypt and Italy). In 2008, the pipeline of projects under development or construction increased dramatically to more than 8 GW. A growing number of future CSP plants will include thermal storage to allow operation in the evening. Success in these markets could generate future interest in the technology and help to improve efficiencies and costs related to the systems.

2.3.5 Solar Photovoltaics

Solar photovoltaic (PV) power generation systems are highly versatile and well-suited to urban areas. As with solar thermal, solar PV is commercially viable and competitive and is of major importance for APEC urban areas. Solar PV technologies continue to evolve in terms of improved performance, lower cost per watt-peak, greater flexibility, lower deployment costs and improved balance of system (BOS) components.

Currently, grid connected PV is the fastest growing power generation technology, with a 70% increase in existing capacity in 2008 to 13 GW. This represents a six-fold increase in global capacity since 2004. Including off-grid applications, total PV in place worldwide increased to more than 16 GW worldwide. Overall, three clear trends emerged for PV in 2008: (1) growth in building-integrated PV (BIPV); (2) thin film technologies became a larger share of total installations; and (3) utility-scale solar PV (greater than 200 kilowatts, kW) grew in large numbers.

The modularity of PV has opened a wide variety of market opportunities in urban areas. These include free-standing ground-and roof-mounted PV systems, residential and commercial grid-tied systems, BIPV, central power generation and special uses including PV/LED (light-emitting diode) street lights, traffic lights and warning signs. Table 2-1 shows the installed PV in distributed applications in select countries, along with new residential BIPV potential. As indicated, Japan had the largest amount of grid-connected distributed PV installed as of 2003, as well as significant BIPV potential.

Table 2-1: Installed PV in Distributed Applications and New Residential BIPV Potential at 1% Market Penetration, 2003

	Annual Grid Connected Distributed PV Installed 2003 (kWp)	Annual New Residential BIPV Potential (kWp)	Market Potential Percentage compared to existing market
Austria	1 833	720	39%
Canada	37	3 538	9 563%
Denmark	300	323	108%
France	5 900	7 220	122%
Germany	78 000	4 523	6%
Japan	216 535	19 007	9%
Netherlands	1 547	1 786	115%
Norway	7	333	4 751%
Portugal	33	631	1 912%
Sweden	15	300	2 000%
Switzerland	1 300	540	42%
USA	32 000	33 778	106%

Source: IEA 2008

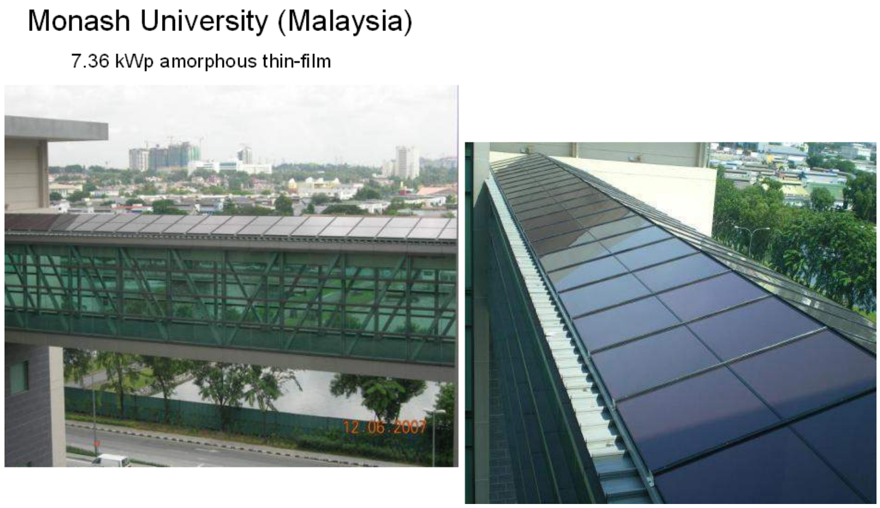
Because PV systems are still expensive sources of electricity compared with fossil fuel generation, financial incentives, either direct or indirect, are often necessary for urban applications. Support for use of PV systems in APEC urban areas—particularly building integrated PV— include subsidies, green electricity promotion, net metering, enhanced feed-in tariffs and loans with reduced rates or tax credits. Key lessons learned for broad acceptance of PV include the need for: new or modified urban regulations; new or reinforced guidelines; financial instruments to promote bundling of individual investments into larger projects; planned PV concentration in defined areas; new practice or standards for aesthetics evaluation and enhanced financial incentives for smooth integration of these systems.

A few examples from APEC economies include the following:

- **Japan** has increased national solar PV subsidies for schools, hospitals and railway stations from 33 percent to 50 percent, in addition to reinstating subsidies for households that had expired in 2005 (although at a lower level of about 10 percent). Japan also plans to have more than two-thirds of newly built houses equipped with solar PV by 2020.

- **Australia** has enacted a new solar PV subsidy program.

Figure 2-5: Building-Integrated Photovoltaic Power Generation in Malaysia



Source: Ir. Ahmad Hadri Haris (April 2009). *Status of Renewable Energy in Malaysia*. PowerPoint presentation at EGNRET meeting, Honolulu April 2009.

- In the **United States,** the states of Massachusetts and New Jersey have adopted capital subsidies (US$1.75 per watt for residential PV up to 10 kW and US$1 per watt for non-residential up to 50 kW in New Jersey). A number of US states and cities have been considering residential solar lease/loan programs, following the lead of emerging programs in Connecticut and the city of Berkeley, California.
- **Mexico** has established a standard contract for net metering that includes commercial solar PV installations up to 30 kW.
- **Malaysia** has become a leader in development of building-integrated PV systems. Showcase BIPV projects in Malaysia are leading the way to widespread use of this technology in energy-efficient buildings.

Architectural integration, such as the use of roof-integrated flat arrays, is of special interest due to the potential for reduced costs per thermal kilowatt of capacity and for achieving visually attractive installations. The latter can help reduce public opposition to installations that may be considered unsightly, especially in residential applications, or stimulate building designers and architects to design more aesthetically pleasing buildings. Of course this means that the *local* aesthetic sensibilities need to be understood, since these are extremely variable, reflecting prevailing social and cultural norms and preferences. The most effective way to accomplish such harmonization with local community concerns and opinions is to *involve community stakeholders in the planning and design process from the beginning*.

2.3.6 Solar Thermal

Solar thermal technologies are well-suited for use in urban areas and widely used in many cities. Solar hot water and heating capacity grew by 15 percent to 145 gigawatts-thermal (GWth) in 2008, doubling capacity in 2004.

Solar hot water systems use thermal energy from the sun to heat water for use in homes, commercial buildings, industrial processes and other applications. Solar thermal technology is mature and commercially available. It is often financially attractive where fuel prices (for thermal applications) and energy and power rates are high. Solar thermal technologies continue to evolve in terms of improved performance, lower costs, greater flexibility and lower deployment costs. While many of the solar thermal installations are either roof-mounted or ground-mounted adjacent to the end-use facility, architects and engineers are increasingly working to *integrate solar thermal systems in energy-efficient buildings*, especially in new construction. Building-integrated solar thermal technology has emerged over the past few decades as an important new option in urban areas for water heating, space heating and potentially cooling and air conditioning.

Commercial solar thermal systems are being used in some APEC economies for commercial and industrial processes including food processing, cleaning and drying of textiles, and even pharmaceutical and biochemical processes. 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. Cities and local governments, including some in APEC, have expanded their support for solar hot water:

- **Tokyo** has newly required that property developers assess the possibilities for solar hot water and other renewables and report their assessments to landowners. It has also introduced "green heat certificates," similar to green electricity certificates, which were to be used in a municipal carbon cap-and-trade system beginning in 2010.
- The state of **Hawaii** (United States) requires solar water heating in all new single-family homes constructed—starting in 2010.
- **Australia's** capital cities have committed to building retrofits and clean energy applications. For renewable energy this means replacing 100% of low-density residential systems, 80% of multi-unit systems and 30% of commercial building hot water systems with solar hot water, and using renewable energy to generate 25% of the remaining electricity used by homes and businesses in urban areas.
- **China**, with the world's largest solar water heating production capacity and the largest domestic solar thermal market, mandates solar water heating in most new residential construction. China also strongly supports retrofit applications where possible.
- **Viet Nam's** energy master plan is establishing yearly targets for solar water heating penetration of the residential market.

For *solar industrial processes*, most of the thermal energy required worldwide is at temperatures below 250C. Advanced solar thermal systems can deliver heat in the range 80C to 250C. Commercially available solar thermal collector technology can provide heat at temperatures below 80C. Solar industrial process heat (SIPH) applications are not yet widespread, but are beginning to be implemented in some APEC economies such as China, the Republic of Korea and the United States.

Figure 2-6: Solar Industrial Process Heat Installation using Evacuated Tube Collectors

Source: Paradigma (China)

For *residential applications*, solar water heating systems are employed in over 50 countries, including most of the APEC economies. Increasingly, solar water heating is required in all or most new residential construction by some APEC municipalities, provinces/states and in the case of China, at the national level. In most APEC economies, these initiatives are of fairly recent origin (in the last 10 years), reflecting decreasing costs and improved performance of solar thermal hot water systems. Other factors contributing to solar water heating growth include concerns over high and uncertain oil prices, national energy security, municipal air quality and initiatives to reduce the growth of greenhouse gas (GHG) emissions.

In the United States, the state of Hawaii was the first to require solar water heating in all new residential buildings. China has the first national requirement for incorporation of solar hot water (SHW) systems in new residential buildings and also has an active policy promoting SHW retrofits in the residential sector.

To most effectively integrate solar thermal projects into urban buildings, it is most desirable to incorporate these systems into original building design and therefore into new construction. This is preferred to adding them in remodeling and retrofitting efforts, which can create challenges such as voiding warrantees in the event of penetrating existing roofs.

China, which is the world's leading producer of solar thermal collectors and systems, is also the largest solar thermal market, with about 80 GWth installed at the end of 2007. This is more than all other countries combined. The United States and Australia are in the top ten rankings due to their dominant use of unglazed collectors, primarily for swimming pools. Of the APEC economies, only China and Japan rank in the top ten of all countries in terms of solar thermal applications for combined domestic, commercial and industrial operations. Almost all of the installed solar thermal capacity at the end of 2007 was for single family housing (SFH) and multi-family housing (MFH).

Table 2-2: Basic Typology of Solar Thermal Energy Systems for Urban Applications

Technology types
- Glazed flat plate collectors (fluid)
- Unglazed flat plate collectors (swimming pool heating)
- Flat plate collectors (air)
- Evacuated tube collectors
- Parabolic trough collectors

Applications
- Water heating
- Space heating
- *Solar-assisted air conditioning (pre-commercial)*
- Low- and medium-temperature industrial process heat (IPH)
- District heating (supplementary energy)

End use sectors
- Residential
- Commercial / industrial buildings
- Institutional buildings (universities, research centers, etc.)
- Government buildings
- Commercial / industrial processes

Application classes
1. New buildings and facilities
2. Retrofit of existing buildings and facilities

2.3.7 Wind Electric Power

Wind power capacity grew by 29% in 2008 amounting to 121 gigawatts (GW), more than double that of 2004 (48 GW). In APEC member economies, wind electric power is emerging as an urban power generation option, although its potential is highly dependent on the availability of suitable sites and wind resources. Several approaches are underway.

- Small (kilowatt-scale) vertical axis wind turbines designed to sit on masts atop buildings. This approach is being tried using commercially available small wind turbines and may be useful on a limited building-specific basis providing: (1) the wind resources are sufficient to justify the investment; (2) the local building and zoning codes permit such installations; and (3) there is provision for net metering at the site.

  Currently, in APEC urban areas, small wind turbines are being used in some applications. Defined for this report as 100 kW or smaller, these turbines can be versatile enough to provide distributed generation for urban residences and businesses in locations with suitable wind resources. Although small turbines produce less power than larger machines, they also require less wind and less land space for operation. Small turbines can also supply power directly to the end-user, avoiding the need for transmission.

Figure 2-7: V3.5 Installation at McMaster University, Innovation Centre, Hamilton, Ontario, Canada

Source http://www.cleanfieldenergy.com/site/sub/p_we_installations.php

- Use of lakefront and oceanfront (or near off-shore) wind turbines in the 500 kWe (kilowatt of electrical energy) to multi-megawatt scale, which can provide significant amounts of power for some APEC cities. This approach is being planned in several locations in the United States and has been implemented in Denmark, which has been an early leader in such applications. While technically these large off-shore wind turbines are not inside urban built-up areas, they are within the urban/city/municipal boundaries, are owned or to be owned by the municipal utilities and will directly serve the cities that own and operate them.

- Individual large wind turbines and small groups of such turbines are starting to be used in urban and near-urban applications in some APEC economies. Hong Kong has a demonstration wind turbine that feeds power into the Hong Kong electrical system. Small wind farms are being constructed on urban brownfields in the United States. (See Figure 2-8). These projects may be useful pilots for other APEC economies.

Wind energy is a mature technology with proven reliability. The cost of wind power has decreased significantly in the last two decades and continues to fall steadily driven by technology development, increased production levels and larger machines. Further new turbine technologies for low wind speeds and increased development of offshore wind will provide additional opportunities. The creation of policies that allow wind to compete on a level playing fired with conventional power will further increase the prospects of this technology.

Figure 2-8: Productive Use of Brownfield

Turbines rise above the former Bethlehem Steel Mill in Lackawanna, New York (USA). The US federal government hopes to convert more abandoned industrial sites such as this one to industrial-scale solar and wind facilities. (Photo courtesy First Wind, October 2009)

2.3.8 Smart Grids

Maintaining and improving the quality and stability of electricity services from urban grids is a central goal of electric utility companies throughout the APEC economies. While a small number of grid-connected PV and other renewable energy units will have little or no noticeable impact on urban grids, the evolution of urban grids to accommodate very large numbers of distributed renewable energy systems requires the transformation of existing power grids to "smart" grids. These grids communicate actively with both electricity customers (demand), and potentially, thousands of distributed renewable energy sources. The need for smart grids applies to both the interconnection of very large PV power plants and wind farms in the range of 1–100 MWe (megawatt of electrical energy) and to the primarily urban and peri-urban interconnections of thousands of smaller PV, wind and other systems (from several kilowatts to several megawatts).

Smart grids combine transmission of electrical energy with electronic communication and power management technologies. These systems are essential for:

- Integration and integrated operation of decentralized renewable energy power generation systems within a large growing complex power grid,
- Economic optimization of renewables, energy storage and energy demand (through the use of continuous pricing signals and responsive control systems),
- Net metering, permitting local energy producers to provide electricity to the grid as well as purchase it from the grid, and
- Use of distributed storage including *electrical and thermal storage systems of consumers.*

Smart grids are evolving with and in response to the establishment of more and larger renewable power generation facilities. APEC economies with major solar electric and wind electric power development programs are also investing heavily in development and implementation of smart grid technologies. These economies include China, Japan, the Republic of Korea and the United States. There is considerable cooperation among APEC economies in this pivotal technology, including the recently announced collaborations between the United States and China and between the United States and Chile.

Japan is working to develop and implement the technology for securing power system stability in preparation for the massive introduction of new energy sources such as PV power generation, including BIPV systems. Verification tests of the pilot technology will be carried out on an electrically isolated island in cooperation with electric utilities in order to determine if smart grid technology can be introduced into Japan's national power system.

With further expansion of renewable energy sources, the integration into system operation will likely be the most economic solution for balancing load and power generation. This is the core element of smart grids and makes them the electrical power supply systems of the future.

2.3.9 Energy-Efficient Buildings Incorporating RE Technologies

Given the high energy consumption levels of commercial, industrial, government and institutional buildings in APEC economies (40 – 60%), it is essential that planned energy activities include a major effort to increase energy efficiency of buildings and incorporate renewables into the urban energy infrastructure where practical. Energy efficient buildings need to be designed as integrated systems incorporating renewable energy technologies such as solar thermal water and space heating, BIPV, passive solar heating, daylighting and geothermal heat pumps for heating and cooling.

In most countries, including many of the APEC economies, there is typically no ongoing evaluation of building performance after energy-efficient buildings receive an energy performance certification. As a result, the performance of many potentially efficient buildings often deteriorates. In order to achieve and maintain energy-efficient operations in commercial buildings, an ongoing process of monitoring, evaluation and feedback (e.g., to building owners, managers and operators) is essential. It is not sufficient to have an energy-saving building envelope or architecture and an optimum HVAC (heating, ventilating and air conditioning) system design. Expert operation and maintenance of the building's energy systems is needed to capture the energy efficiency potential embodied in the architectural and engineering design.

2.4 Renewable Energy Policies are Pivotal—Lessons Learned

Government support for renewable energy technologies and effective policy and regulatory environments are essential for improving the investment climate for renewable energy. This section reviews the three "mega" policies that APEC member economies are employing to accelerate adoption of renewable energy, as well as financial incentives to encourage use of these technologies.

2.4.1 Mega Renewable Energy Policies

To date, three main policies have been used in APEC member economies to promote deployment of renewable energy into national, state and city markets. These are feed-in laws, renewable portfolio standards (RPS) and tendering policies.

- *Feed-in Laws:* The government sets a mandated *price* to be paid for renewable electricity, usually technology-dependent, and the utility must take power from eligible facilities. Feed-in laws are focused on new and emerging technologies and there are three methods for price setting: (1) estimated long-term cost plus reasonable profit, (2) wholesale avoided cost of power; and (3) percent of the retail electricity rate. Key success factors in feed-in laws are long-term contracts of 15-20 years, guaranteed buyers under a standard contract, tariffs that provide reasonable rates of return and flexibility to capture cost efficiencies.

- *Renewable Portfolio Standard (RPS):* The government sets a mandated *quantity* of renewable energy (e.g., electricity, fuels) to be purchased in a specific timeframe and there is a requirement on wholesale or retail market participants (utility or grid company) to purchase the power generated. RPS policies sometimes specify which renewable energy technologies must be used to comply with regulations.[1] RPS success factors require good policy design, establishment of an energy/output-based target that increases over time, strong and effective enforcement methods (it is better not to have an RPS than to have a non-enforceable one) and creation of a certificate trading platform based on compliance tracking. The use of certificates makes for a more liquid market.

- *Tendering:* Tendering policies involve government-sponsored competitive bidding processes for the acquisition of renewable electricity, whereby long-term contracts are awarded to lowest priced projects. The government contract guarantees the purchase of all power generated at a specified price over a fixed period and the government pays the incremental cost of the renewable energy. Tendering is usually done in conjunction with other policies, such as public benefit funds or resource concessions (e.g., wind). Success factors for tendering include long-term standard contracts which reduce the risk for investors, contracts/tenders that are large enough to achieve economies of scale and are awarded annually to create stability, appropriate penalties for not meeting milestones and a stable source of funding.

Table 2-3 provides an assessment of the advantages and disadvantages of the three “mega” policy options, using the following criteria: quantity of renewable energy development over a specific timeframe; impact on both cost and price reductions; results in resource diversity; long-term market sustainability; local industry development; certainty for investors and simplicity of implementation.

To date, *feed-in laws* have resulted in the largest renewable energy installed capacity. They are the simplest to administer and enforce; produce the greatest resource diversity and local industry development; can be cost-effective if the tariff is periodically and wisely adjusted over time to eliminate excess rent payments and work best in regulated markets. They are flexible and can be designed to accommodate differences in technologies and in the marketplace. They invite steady growth of small- and medium- scale players, result in low transaction costs, offer easy entry by new players and facilitate financing. The key challenge is establishing the tariff, particularly for new technologies where the true costs of the systems are unknown and/or variable.

Though feed in tariffs have been in place for a number of APEC economies at the national level, there is an emerging trend towards cities and local governments to consider feed-in policies and explore how to implement these. Such policies depend on whether a local government has jurisdiction to regulate the appropriate electric utilities. For example, in 2008, the Gainesville Regional Utility in Florida, United States announced plans to develop a feed-in tariff for PV with a 32 cents (US$0.32) per kilowatt hour (kWh) payment for 20 years (although the four megawatt program cap for 2009 was reached before the program even became effective). The mayor of Los Angeles announced a solar feed-in tariff to develop 150 megawatts (MW) of solar by 2016. Canberra, Australia has introduced a feed-in tariff for small-scale producers.

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[1] For example, the state of Colorado (US) requires that four percent of a utility’s RPS obligation must come from solar power

Table 2-3: Renewable Energy Policy Review[2]

	Quantity Of RE Development	Cost/ Price Reduction	Resource Diversity	Market Sustainability	Local Industry Development	Investor Certainty	Simplicity
Feed-In Laws	Large amounts RE in short time	Cost efficient if the tariff is periodically and wisely adjusted	Excellent	Technically & economically sustainable	Excellent	Can reduce investor risk with price guarantee & PPA	Most simple to design, administer, enforce, contract
RPS	If enforced, can meet realistic targets	RPS and Tendering best at reducing cost & price with competitive bidding	Favor least-cost technologies	Technically & economically sustainable	Favor least-cost technologies & established industry players	Lack of price certainty difficult for investors/PPA can reduce risk	More complex to design & administer & complex for generators
Tendering	Related only to quantity RE established by process	Good at reducing cost	Favor least-cost technologies	Tied to resource planning process; sustainable if planning supported, stable funding	Favor least-cost technologies & established industry players	Can provide certainty if well designed (more risk than feed-in)	More complex than Feed-in, simpler than RPS

The *RPS* is good at minimizing costs and prices but only if accompanied by long- term, well designed power purchase agreements (PPAs); offers good resource development, especially if combined with tradable certificates and is more compatible with reformed electricity markets. They provide certainty regarding market share (if targets are met), are perceived as being more compatible with open or traditional power markets and are more likely to fully integrate renewable energy into electricity supply infrastructure. They also facilitate the establishment of a renewable energy credit trading system. Challenges are that an RPS may take longer to build local industry and meet resource targets; can be complex to design, administer and enforce; have high transaction costs and lack flexibility (e.g., difficult to adjust in short-term if needed). In the United States, RPS regulations at the state and local levels are credited with driving most of the renewable energy expansion over the last few years. (See Table 2-4)

Competitive tendering is best at minimizing costs, as long as industry is well established; can be combined with an RPS; will not build a market by itself, but needs companion policies; can discourage local industry formation if not carefully used and can be politically challenging as it requires a stable source of funding. Competitive tendering tends to favor large, centralized merchant plants at the expense of small investors and ensuring that signed contracts are realized is a key challenge. If tendering is tied to resource planning and a transparent procurement process, investor certainty can be enhanced.

In each of these cases, the policies can enable electricity suppliers to recover the incremental cost from consumers and connection to the grid is vital.

[2] Source: Dr. Jan Hamrin, President, Center for Resource Solutions

Table 2-4: Examples of Renewable Energy Targets for Select Cities

- *Ballarat, Australia:* 10% of total energy from renewables by 2016.
- *Melbourne, Australia:* 25% of residential electricity and 50% of public lighting by 2010.
- *Guelph Ontario, Canada:* 25% of total energy by 2023.
- *Halifax Nova Scotia, Canada:* 30% of energy for commercial buildings.
- *Beijing, China:* 4% of electric power capacity by 2010 and 6% of heating capacity.
- *Shanghai, China:* 5% of energy (Capacity) by 2010.
- *Kobe, Japan:* 3-4% of energy by 2010.
- *Tokyo, Japan:* 20% of total energy by 2020.
- *Daegu, Korea:* 5% of total energy by 2012.
- *Gwangju, Korea:* 2% of total energy by 2020.
- *Los Angeles, USA:* 1.3 GW of solar power by 2020, enough to meet 10% of the expected electricity supply.
- *Salt Lake City, USA:* 10% of energy used for new building.

Source: REN21, 2009

Overall, the three policies offer various pros and cons; there is no perfect policy solution. Thus, it is vital for policy makers to articulate and prioritize their goals in order determine which policy interventions makes the most sense; recognize that this is a dynamic decision that must be continually reviewed and assessed; understand that enforcement of mandates is critical and ensure good policy design which is fundamental to success.

2.4.2 Financial Incentives

Many renewable energy policy measures have been developed to lower upfront costs, create new revenue streams and encourage investment in the use of renewable energy technologies. These policies contribute to an enabling environment that attracts investments in urban renewable energy applications. Table 2-5 summarizes important renewable energy initiatives for APEC economies at the national and sub national levels. Table 2-6 provides a summary description of various financial incentives used at the national, state and local levels worldwide.

Table 2-5 Renewable Energy Promotion Policies in APEC Economies

	Mega-Policies			Financial Incentives						
APEC Economy	Feed-in tariff	Renewable portfolio standard	Public competitive bidding	Capital subsidies, grants or rebates	Investment or other tax credits	Sales tax, energy tax, excise tax or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans or financing
Australia	(*)	√		√			√		(*)	√
Canada	(*)	(*)	(*)	√	√	√			(*)	√
Chile		√	√	√	√					√
China	√	√	√	√	√	√				√
Indonesia	√									
Japan		√		√			√		√	√
Korea	√			√	√	√				√
Malaysia	√									√
Mexico			√		√				√	√
New Zealand				√		√				√
Peru	√		√		√	√				
Philippines	√	√		√	√	√				√
Russia				√			√	√	√	√
Thailand	√			√					√	√
United States	(*)	(*)	(*)	√	√	(*)	(*)	√	(*)	(*)

√ indicates that the policy was adopted on a national level
(*) indicates that the policy was adopted by local, state or provincial government(s)

Source: www.ren21.net/map

Table 2-6: Description of Renewable Energy Financial Incentives in APEC Member Economies

- *Accelerated Depreciation* on renewable energy assets.
- *Bond Programs* enabling governments (and corporations) to raise money by borrowing.
- *Carbon Finance* including the Clean Development Mechanism (CDM) established by the Kyoto Protocol, and voluntary emission reduction programs.
- *Corporate Tax Incentives* such as tax credits, deductions and exemptions for the purchase and installation of eligible renewable energy equipment or green building constructions.
- *Grant Programs* to pay down the cost of eligible systems or equipment, conduct research and development or support project commercialization.
- *Green Building Financial Incentives* to promote design, construction and materials that minimize building impacts on the environment and on human health, including the use of renewable energy.
- *Green Power Purchases* whereby utility customers have the option of paying a premium (usually small) to purchase electricity generated from NRE sources—amounts to voluntary subsidy to electric utilities.
- *Industry Recruitment/Support* to promote economic development and job creation through financial incentives to recruit, cultivate manufacturing and develop renewable energy systems/equipment.
- *Loan Programs* that provide financing for the purchase of renewable energy or energy efficiency systems or equipment.
- *Manufacturer Incentives* in the form of government tax credits and grants to encourage manufacturers to site their facilities in specific areas.
- *Net Metering* which enables electric customers who generate their own renewable electricity to sell excess power to the grid, offsetting electricity the customer otherwise would have to purchase at the utility's full retail rate.
- *Property-Assessed Clean Energy (PACE)* or financing that allows property owners to borrow money to pay for renewable energy and/or energy-efficiency improvements.
- *Personal Tax Incentives* including personal income tax credits and deductions to reduce the expense of purchasing and installing renewable energy or energy efficiency systems and equipment.
- *Production Incentives* involving cash payments based on the number of kilowatt-hours (kWh) a renewable energy system generates.
- *Production Tax Credit (PTC)* which allows companies that invest in renewables to write off this investment against other investments they make.
- *Property Tax Incentives* which include exemptions, exclusions and credits.
- *Rebate and Subsidy Programs* which provide financial incentives to purchasers of SHW systems.
- *Renewable Energy Certificates (RECs)* which permit consumers to buy green power that is generated outside their utility's service territory.
- *Sales Tax Incentives* which provide an exemption from sales tax to purchase a renewable energy system.
- *Private Power contract,* for private companies to supply electricity to the grid at commercially attractive power and energy rates.
- *Long-term standard offer contracts* which focus on renewable energy power generation, with very attractive payments for capacity and energy.

2.4.3 Rules and Regulations

A number of APEC member economies have established rules and regulations regarding renewable energy deployment at the national, state and local levels. Examples include:

- **Building Energy Codes** requiring that commercial and/or residential construction to adhere to certain energy standards.
- **Contractor Licensing** which involves adopting a licensing process for renewable energy contractors and licensing requirements for solar water heating, active and passive solar space heating, solar industrial process heat, solar-thermal electricity and photovoltaics (PV). These requirements work to ensure that contractors have the necessary experience and knowledge to install systems properly.
- **Energy Standards for Public Buildings** whereby some governments require that government buildings meet strict energy standards.
- **Equipment Certification** requiring renewable energy equipment to meet certain standards which serve to protect consumers from buying inferior equipment. These requirements not only benefit consumers; they also protect the renewable energy industry by making it more difficult for substandard systems to reach the market.
- **Interconnection Standards** that govern the technical and procedural process by which an electric customer connects an electric-generating system to the grid.
- **Solar and Wind Access Laws** to protect a consumer's right to install and operate a solar or wind energy system at a home or business.
- **Solar and Wind Permitting Standards** to facilitate the installation of wind and solar energy systems by specifying the conditions and fees involved in project development.

2.4.4 National Renewable Energy Laws and Goals

Urban-based RE policies and incentives exist within the larger national legal and regulatory framework of each APEC economy. A few APEC economies have enacted nationwide renewable energy laws (see below), while others are in development.

- **Australia** has expanded the Mandatory Renewable Energy Target (MRET) to increase from 9,500 gigawatt-hours (GWh) in 2010 to 45,000 GWh in 2020. It has established a Solar Cities program (2006) to demonstrate high penetration diffusion of solar technologies, energy efficiency and smart metering, backed by AUD$75 million.
- **China** has developed a renewable energy law that went into effect on January 1, 2006. The Renewable Energy Law is the product of an extensive process of international research and consultation, as planners within the powerful National Development and Reform Commission sought to learn from the success and failures of other nations. It is notable that the passage of the Renewable Energy Law in China was among the fastest in the entire world. China has changed value-added tax (VAT) and import-duty-related promotion mechanisms to further favor domestic wind turbine production.
- **Mexico** has adopted a new renewable energy law that mandates utility purchases of renewable energy generation, sets up a project fund and mandates a national target (to be determined).
- The **Philippines** has recently adopted a milestone renewable energy law that mandates both renewable portfolio standards (to be developed within one year) and feed-in tariffs for wind, solar, biomass, small hydro and ocean power. The Philippines law also provides connection priority and transmission priority for renewable generators, allows consumers to voluntarily

choose to purchase renewable power from suppliers and provides tax and import-duty incentives for investment.

- **Chile's** new 2008 national renewable energy development program has created a market-facilitation, best-practices and promotion center for renewable energy.

2.4.5 GHG Emissions Reduction Goals

Several APEC cities and local governments have adopted GHG reduction goals—and the number is growing. Although not exclusive to renewable energy, these technologies play an important role in helping the localities to meet their goals, objectives and targets.

For example:

- In 2008, Sydney pledged to become **Australia**'s first carbon neutral government, obtaining 100% of city government energy supply from renewable energy (i.e., for municipal services and buildings) and pledging that all city activities, from collecting garbage to running libraries to lighting streets, will have no net carbon emissions.
- In **Japan**, a new policy and associated program is promoting buildings that emit zero CO_2 on an annual net basis by: (1) reducing energy consumption through enhancement of the energy efficiency of the building envelope and energy equipment; (2) local energy networks; and (3) and the use of renewable energy on site. The goal, announced in mid-2009, is to make all new public buildings zero emission buildings by 2030. Also, more than 300 Japanese municipalities provide ongoing solar PV subsidies and support the purchase of "green" electricity services and other renewable energy policies through a new policy/communications platform established in 2008.
- The **United States** *Mayors Climate Protection Agreement* grew to include over 930 mayors from all 50 states in 2008. The US Department of Energy's Solar America Partnership grew likewise, doubling from 13 cities in 2007 to 25 cities in 2008.

Table 2-7: Major APEC Cities with Climate Action Plans (2009)

Megacities in 2009 (> 10 million people)	Fewer than 10 million people in 2009	APEC Economies with Cities with Climate Action Plans
• Beijing • Jakarta • Los Angeles • Mexico City • Moscow • New York • Philadelphia • Seoul • Shanghai • Sydney • Tokyo	• Bangkok • Chicago • Hanoi • Houston • Hong Kong • Lima • Melbourne • Toronto	• Australia • Canada • China • Indonesia • Republic of Korea • Mexico • Peru • Russia • Thailand • United States • Viet Nam

2.4.6 "Green Energy" Policies

There are several effective policy instruments for incorporating renewable energy into municipal infrastructures and operations. One example is providing green energy options for consumers—this option provides electricity customers with the opportunity to purchase some or all of their electricity from "green" or environmentally sustainable energy sources. Often there is a small (1–5%) surcharge on the electricity bill.

Some cities have also begun to purchase green power for government energy consumption in municipal buildings and operations—called "own-use." Within APEC, local governments in Australia, Canada, Japan and the United States have established official targets for combined municipal government electricity production and use. A few examples are shown below in Table 2-8.

Table 2-8: Examples of APEC Cities with Green Energy Policies

Australia (Sydney):	100% of own-use energy, 100% of own-use electricity for buildings, 20% for street lighting
Canada (Toronto):	25% of own-use electricity by 2012
Canada (Calgary):	100% of own-use electricity by 2012
Japan (Kawasaki):	5% of own-use electricity (currently)
Japan (Tokyo):	5% of electricity by 2020 for public facilities
USA (New York City):	20 MWe of wind power for own-use by 2008

Source: REN21, 2009

2.4.7 Green Building Initiatives

Buildings and communities are responsible for over 40 percent of the GHG emissions into the atmosphere. Within APEC, there have been notable green building initiatives over the past decade to reduce GHG emissions and other degradation from buildings—many of these from just the past few years. These initiatives foster a systems integration approach to building energy use, including the incorporation of renewable energy systems, primarily solar thermal and PV systems.

Among these crosscutting initiatives are:

- The Greenstar program in Australia and New Zealand
- Canada's ecoEnergy program
- The Green Building Labeling System and energy efficiency building standards in Chinese Taipei
- Hong Kong's use of life cycle assessments and life-cycle cost (LCC) requirements for buildings
- Japan's Comprehensive Assessment System for Building Environmental Efficiency
- Green building programs and net zero energy building goals for 2025 in the United States

- Singapore's promotion of low-energy and zero-energy buildings through the integration of optimal insulation, efficient windows, shading, green (literally) facades, efficient ventilation and cooling and BIPB systems. Singapore's Green Mark system for buildings encourages and partially subsidizes increased energy efficiency and use of renewables in existing and new buildings. Singapore's goal is to have 80% of all buildings achieve the Green Mark Certification by 2030.
- Malaysia's introduction of a Green Building Index system for both residential and non-residential buildings and creation of "showcase buildings" that demonstrate the potential for integrated energy-efficient design and PV systems. Malaysia's Green Technology Policy includes the goal of increased energy independence and improved efficiency in energy use.
- China's requirement for use of solar water heating in virtually all new residential buildings and its active promotion of retrofit applications.

2.5 Financing— Lessons Learned

Over the last few years, financing for renewable energy projects and programs has increased from a number of sources. Although the financial crisis of the last year combined with a drop in oil prices has reduced the availability of funds from some sources, particularly the private sector, other funders have stepped up and the future for renewable energy financing looks promising. Potential sources of renewable energy financing are summarized below.

2.5.1 Private Sector Investment

In 2008, approximately US$120 billion was invested in renewable energy worldwide. This is double comparable investments in 2006 of about US$63 billion. The bulk of this investment was for wind, solar PV and biofuels, with the primary recipients the US, Spain, China and Germany. In addition to these investments, PV and wind industries increased their investments in new manufacturing plants and equipment and research and development was on the rise.

In the last few years the private sector, including private equity and venture capital firms, has significantly increased its investment in renewable energy. However, like other sectors, renewable energy investments did show a decline in the fourth quarter of 2008 due to the financial crisis. However, projects have continued to advance particularly in countries with supportive policies (feed-in tariffs, RPSs, etc.)

2.5.2 APEC Governments

Governments have a major role to play in both facilitating the enabling environment for investment in renewable energy and providing direct and indirect financial support. Several APEC member economies have provided a range of policy and financial incentives to spur investment in renewable energy as discussed in the policy section above. This has included stimulating investment in renewable energy, improving price incentives for products and services, increasing public investment in these technologies, leveraging access to financial services and reducing risks (real and perceived) to investors. Financing for renewable energy has spanned the project cycle to include research, development and demonstration projects; market development services; project development support; prefeasibility and feasibility support; loans; loan/credit guarantees; structured finance; equity support; insurance and dedicated renewable energy funds. Government agencies also engage in consumer awareness and energy education programs. To finance these activities, countries, states and cities are utilizing a variety of sources including tax revenues, a surcharge on electricity consumption (e.g., US$0.002/kWh), carbon taxes, fuel surcharges, etc.

Over the last year, in large part due to the financial crisis, several APEC economies have increased support for renewable energy, often with goals of economic stimulus and employment enhancement.

For example, Japan announced 1 trillion yen (US$12.2 billion) for five years. The United States set a goal of US$150 billion for renewable energy over the next 10 years. Korea created a US$36 billion package over four years. Australia plans to accelerate its existing AUD$500 million (Australian dollars 500 million = US$370 million) renewable energy fund from an initial eight year period to 18 months. China has provided substantial energy over the last few years, with a pledge of about US$15 billion for renewable energy, the bulk of which is for wind power. Mexico's recently established renewable energy law commits to an US$800 million fund, which includes funding for renewable energy.

2.5.3 Local Financial Institutions

Financial institutions operating in APEC member economies can be important sources of finance for renewable energy projects and programs. These organizations understand the markets and players and operate in local currencies—thereby reducing currency risks. However, they may be reluctant to lend for renewable energy projects and require education and training on the risks and rewards of these projects, as well as risk mitigation instruments. These programs can 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 also be useful support mechanisms.

2.5.4 International Organizations

A variety of international organizations are active in renewable energy development in APEC member economies.

2.5.4.1 The World Bank Group

In the last five years, the World Bank Group has increased its financing for renewable energy and energy efficiency, reaching approximately US$7 billion over the period 2005-2009. In 2009 alone, new renewable energy and energy efficiency investments reached US$3.1 billion, a historic high which exceeded 40 percent of total energy lending commitments. Activities included both new financial instruments as well as technical and policy support. These projects have increased the ability of public institutions to enable markets and enhanced the ability of domestic financial institutions and industries to deliver renewable energy products and services.

World Bank Group provides funds for governments through the International Bank for Reconstruction and Development (IBRD) and the International Development Agency (IDA). Additionally, the International Finance Corporation of the World Bank Group provides funding to the private sector. All these organizations are actively promoting the use of environmentally sustainable technologies, such as renewable energy. Further, the Bank is complementing these activities with new concessional funding that can support renewable energy. The US$6.2 billion Climate Investment Funds (CIF) offer a fresh source of financing for pilot projects to initiate transformational change toward low-carbon and climate resilient development in the largest GHG-emitting developing nations. As part of the CIF, the US$5.1 billion Clean Technology Fund (CTF) promotes investments in clean technologies to allow developing countries to grow on a low-carbon path. Another part of the CIF—the Strategic Climate Funds (SCF)—provides financing to pilot new approaches that have potential for scaled-up transformational application targeting specific climate change challenges or sectoral responses. For example, a program for Scaling Up Renewable Energy in Low-Income Countries (SREP) will be capitalized at US$250 million and piloted in up to 10 low income countries.

The establishment of two new carbon facilities in the World Bank—the Carbon Partnership Facility and the Forest Carbon Partnership Facility—focus on scaling up climate mitigation work and deepening and broadening the carbon market beyond the Bank's existing carbon funds and facilities which have a total capital value of US$2 billion.

In the past two years alone, the World Bank Group launched a number of initiatives to provide expanded support for renewable energy and energy efficiency. The 2008 Strategic Framework for the World Bank Group targets an increase in funding for low-carbon projects to 50 percent of total energy lending by 2011. This includes increasing financing for renewable energy and energy efficiency systems and technologies by 30 percent per year, from a baseline of US$600 million, and expanding lending to hydropower that meets environmental and social safeguards and is economically and financially viable.

2.5.4.2 Asian Development Bank (ADB)

Clean energy has become one of the highest priorities of the ADB, with over one fourth of the total approved loans in 2008 supporting projects with clean energy components. ADB's Clean Energy Program is multi-pronged. It seeks to increase regional energy efficiency in energy, transport and urban sectors; adopt renewable energy sources and improve access to energy for the poor and remote regions—avoiding the use of traditional biomass. The clean energy program aims to meet energy security needs, facilitate a transition to a low-carbon economy, promote universal access to energy and achieve ADB's vision of a region free of poverty. With high levels of confidence for clean energy investments, ADB's newly approved Energy Policy targets the annual lending for related programs at US$2 billion by 2013.

2.5.4.3 Inter-American Development Bank

IDB is the main source of multilateral financing in the Latin America and Caribbean (LAC) region. The IDB Group provides solutions to development challenges by partnering with governments, companies and civil society organizations, thus reaching its clients ranging from central governments to city authorities and businesses. The IDB lends money, provides grants and offers research, advice and technical assistance to support key areas like energy. Since 2000, the IDB has financed more than US$2.1 billion in renewable energy projects in LAC, including hydropower, wind power and geothermal.

2.5.4.4 The Global Environment Facility (GEF)

The Global Environment Facility (GEF) was established in 1991 and helps developing countries fund projects and programs that protect the global environment. GEF grants support projects related to climate change land degradation, biodiversity, international waters, the ozone layer and persistent organic pollutants. Climate change mitigation projects reduce or avoid GHG emissions in the area of renewable energy—including for grid electricity and rural energy services. The GEF seeks to expand markets for renewable energy by removing barriers to the large-scale application, implementation and dissemination of the technologies. The GEF represents a major source of financing for renewable energy projects in developing countries, having invested over US$1 billion in these technologies to date and leveraging an additional US$5 billion in co-financing.

2.5.4.5 United Nations (UN) Agencies

Over 20 UN agencies provide support for renewable energy, including policy assistance, technical support, capacity development and training. Among the more active organizations are the United Nations Development Program (UNDP), the United Nations Environmental Program (UNEP), the United Nations Industrial Development Program (UNIDO) and the Economic and Social Commission for Asia and the Pacific (ESCAP).

2.5.4.6 Bilateral Agencies

A variety of governments provide research, technical, policy, finance and capacity building support to other countries in the area of renewable energy. These include APEC member economies (e.g., Australia, Canada, China, Japan, and the US), as well as those from Europe (particularly German GTZ /KfW and the Netherlands) and elsewhere.

2.5.4.7 Global Partnerships

A number of international partnerships concentrate specifically on fostering renewable energy development. Notably, the Renewable Energy and Energy Efficiency Partnership (REEEP) offers financial support to projects involved in policy and financing issues in the promotion of renewable energy and energy efficiency. Since 2004, REEEP has supported 58 such projects and invested over US$6 million. The Global Village Energy Partnership (GVEP) provides a range of products and services to partners on the ground, including access to finance, training and technical assistance; development of knowledge and skills through information sharing; and support for adaptation within the context of climate change.

2.5.4.8 Foundations

Foundations can also provide support in the advancement of renewable energy. Examples include the UN Foundation, the Shell Foundation, the Rockefeller Foundation, the Energy Foundation, and others. Many of these organizations are driven by an interest in mitigating global climate change.

2.5.5 Carbon Finance

The Kyoto Protocol, which was adopted in 1997 by more than 170 countries, committed many industrialized countries and economies in transition, the so-called “Annex 1 countries,” to individual, legally binding targets to limit or reduce their overall GHG emissions by at least 5% below 1990 levels during the period 2008 to 2012. In addition to setting the first ever international target for reducing GHG emissions, the Kyoto Protocol established a means for developing countries to get involved in climate change mitigation. The Kyoto Protocol approved the use of three “flexible mechanisms” for facilitating the achievement of its GHG emission reduction targets: (1) emissions trading, allowing the international transfer of national allocations of emission rights between different Annex 1 countries; (2) the Clean Development Mechanism (CDM), which allows for the creation of Certified Emission Reduction (CER) credits through emission reduction projects in developing countries, regulated by the CDM Executive Board; and (3) Joint Implementation (JI), which involves creation of emissions reduction credits undertaken through transnational investment between Annex 1 countries and/or companies. These three flexible mechanisms, along with the European Union Trading Scheme (put in place by the EU to meet its Kyoto target), has created the largest environmental market in the world for the trading of carbon credits.

In addition, *voluntary carbon markets* support activities that reduce GHGs by producing verified emission reductions (VERs) that can be sold to companies/individuals wishing to voluntarily reduce their carbon footprints. Although voluntary reductions are similar to regulated credits, they are different in some important ways. VERs can be generated from projects that are based in a country that has not ratified the Kyoto Protocol or does not have the infrastructure to support CDM project development; have not yet been registered under the CDM; fall outside of the scope of the CDM; and are too small to warrant the costs of CDM approval and/or are specifically developed for the voluntary market. Several voluntary markets are in development around the world.

2.6 *Capacity Building —Lessons Learned*

For renewable energy to takeoff in urban areas, capacity development is required in all stages of technology development. *Capacity building is a long-term, continuing process, in which all stakeholders need to participate—governments, local authorities, the private sector, non-governmental organizations, academics and others*. Capacity building is more than training. In the renewable energy area, it will need to occur at several levels and these must be coordinated to maximize effectiveness.

- **Technology.** Capacity is needed to develop academic, professional and vocational skills. Assistance is needed on all aspects of technology research, development, demonstration, deployment, marketing, financing, operation and maintenance. On-going efforts are required to bring down costs, improve performance and enhance competitiveness with conventional energy sources.

- **Institutional.** Cities need assistance in formulating, implementing and enforcing effective policies and programs and these will need to be coordinated at the national and sub-national level. Financial institutions, whether public or private, require training on the costs and rewards of renewable energy, how to review and assess projects and the risks and risk mitigation instruments associated with renewable energy.

- **Businesses.** A range of business planning and support services are required to ensure development and delivery of renewable energy services. These need to be aimed at utilities, private firms and entrepreneurs across the value chain, non government organizations (NGOs), communities and community organizations.

- **Consumers.** Consumer awareness will be instrumental in advancing renewable energy. This will include providing information on renewable energy generation options, their costs and benefits, the uses of renewable energy and how to access, finance and deploy the technologies. This often requires a consumer outreach campaign that involves the development and dissemination of information, products and processes that promote the renewable energy market in general, as well as validating retail product claims.

A variety of programs have been put in place to address these various issues, many within the APEC member economies. For example, several APEC economies have national and sub-national renewable energy facilities which have substantial information on all aspects of renewable energy for various end users. Further, APEC's Renewable Energy Working Group has convened a range of international workshops and meetings that have successfully engaged senior decision makers from APEC economies on the status and potential of renewable energy options for national economies and for their cities.

Moreover, many international institutions, including IEA, multilateral and bilateral organizations, REN21, the newly formed International Renewable Energy Agency (IRENA) and others can help to engage urban decision makers via seminars, meetings, presentations and on-line information. Perhaps most useful are city-to-city information exchanges, for example through sister city partnerships, or through organizations such as ICLEI—an international association of local governments and their associations that have made a commitment to sustainable development.

Some examples of what APEC member economies are doing to enhance capacity on renewable energy for urban applications include:

- In 2009 the Australian *Solar Institute* was established to advance and accelerate innovation in solar thermal and solar PV technologies in Australia, drive the research capable of improving the efficiently and cost-effectiveness of these technologies and establish Australia as a key player in the development of solar technologies in the Asia-Pacific Region. Similarly the

National Renewable Energy Laboratory (NREL) in the US provides information and outreach on all aspects of renewable energy.

- *Renewable Energy Demonstration Centers* allow participants to see, touch and learn about renewable energy—the best way for people to acquaint themselves with new technologies. Many "model cities" have established information and demonstration centers for renewable energy and energy efficiency to provide training and expertise, and to bring together a critical mass of experts, small businesses and stakeholders to move local innovation. For example Chile's new 2008 national renewable energy development program has created a market-facilitation, best-practice and promotion center for renewables.

- Malaysia has established an *Approved Service Provider Scheme* for its building-integrated PV program. This scheme licenses companies for one year at a time, with annual review and recertification if appropriate. The companies have to use certified licensed electricians, be financially sound, carry appropriate insurance (workers' insurance, public liability insurance) and meet specific requirements for demonstration of good business practices and ethics.

- The city of Milwaukee, Wisconsin in the United States created a "*Green Team*" that involved bringing together energy technology companies with local workforce development agencies to ensure the city has a well trained job force that can support green jobs.

- In some countries, competitions are established and awards provided for "solar cities," "solar towns" and "solar villages," often on a regular or annual basis. This creates communities of motivated and like-minded individuals and local officials who can serve as mentors and resources for those who wish to start similar activities in their own community.

- Shared information facilitates effective initiatives and helps to "weed out" less effective approaches, based on experience by municipalities. International urban collaboratives such as the Clinton Foundation's E40 (green cities) are helping to accelerate and expand smart policies and programs for urban renewable energy deployment. The International Solar Cities Initiative helps to benchmark cities that commit to ambitious emission reduction goals. This Initiative helps cities to integrate renewable and energy efficient technologies and industries into environmental, economic and city planning, and provides scientific support for the validation and design of effective measures and policies for its solar cities.

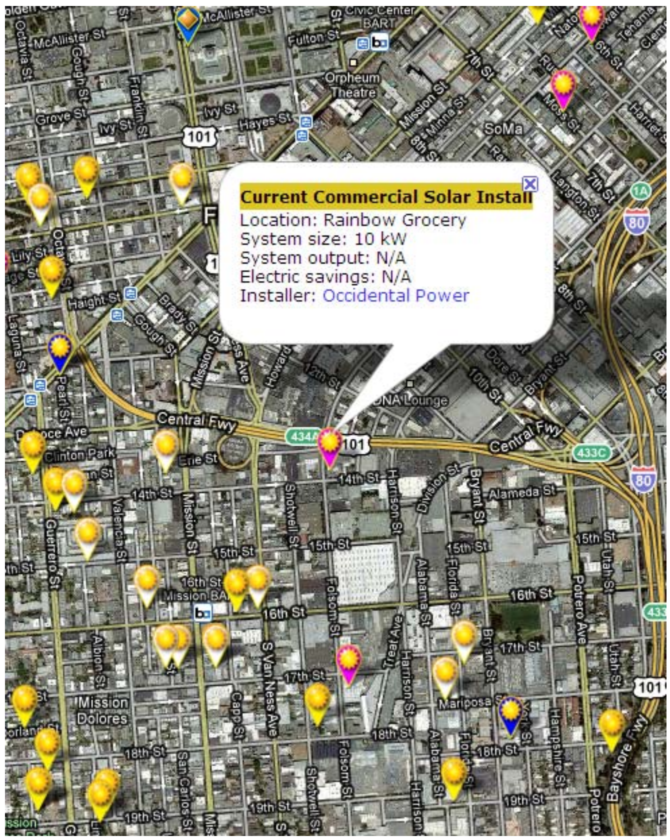
2.7 Land Use — Lessons Learned

2.7.1 Innovations in Urban Renewable Energy and Land Use Planning

For renewable energy to make a major contribution to urban energy needs in APEC economies over the coming several decades, innovations are needed to integrate energy and land use policies and planning. This will require coordination with a variety of government entities that issues such as address transportation, air quality, economic development, land use and water, waste management.

Several tools are emerging to assist in this area. The UN Environment Program's Division of Technology, Industry, and Economics (DTIE) program *Energy for Cities* can help provide an assessment of renewable energy and energy efficiency measures in reducing GHG emissions and providing other environmental benefits. In parallel with UNEP's program, several cities have established interactive Internet accessible web-based urban maps that show the locations of all renewable energy installations, including solar water heating, photovoltaic arrays and small wind. Global positioning systems (GPS) and geographic information systems (GIS) technology can be used to map and characterize urban renewable energy installations and to assess the available rooftop areas and urban land suitable for solar thermal and PV installations. Several cities in Canada and the United States are using this technology. This mapping shows the location of renewable energy systems, characteristics of the buildings (roofscapes), open land and its potential suitability for solar installations (e.g., PV and solar thermal). As of June 2, 2009, San Francisco had 1,311 PV systems with a total peak generating capacity of 7.5 megawatts-peak (MWp).

Figure 2-9: Map showing renewable energy installations in San Francisco, California (USA)



Source: UNEP 2009

2.7.2 Urban Brownfield Development Using Renewable Energy

Brownfield sites—abandoned or underused industrial and commercial facilities available for re-use—may offer an interesting model for developing renewable energy facilities in some cities. For example, this could involve development of local PV and small wind power plants and large-scale thermal energy systems on urban and peri-urban land unsuitable for housing, commercial buildings or even parks. Since many brownfield sites are in cities and other industrial locations that have been affected by job loss, brownfield applications of renewable energy could provide a benefit to local communities. This application could address current constraints to brownfield redevelopment (markets and remediation costs), while providing an immediate opportunity to produce clean new renewable energy.

Brownfield sites potentially offer multiple advantages to renewable energy development. These include:

- A ready market for renewable energy-based power production, as brownfields are usually close to areas of high energy consumption, including local industries that could invest in and benefit from such development.
- Proximity to grid transmission.
- Available land with few current competing uses.
- Access to existing transportation systems.
- Proximity to consumers and homeowners, which may allow more localized energy supply in the future.
- Site improvements over existing use (or non-use).
- Flexibility to adapt sites to higher uses in the future.
- Access to existing incentive programs for brownfield development.

Figure 2-10 demonstrates how brownfields are in use for renewable energy development in the United States.

2.8 Conclusion - Lessons Learned

Renewable energy technologies have made tremendous advances in the last few years, making these technologies competitive today for a variety of applications in APEC cities. Lessons learned on policy, finance, technology, capacity development and awareness will foster increased use of these technologies and stimulate market penetration. 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, renewables can be particularly well suited to requirements of APEC member economies.

Figure 2-10: Brownfields to Brightfields

In 2007, two US local companies from the state of Tennessee were instrumental in the development of one of the first wind farms in the US constructed on a brownfield. TVIG (Tennessee Valley Infrastructure Group) installed the first eight wind turbines at the Steel Winds Wind Farm, located on 30 acres of the old Bethlehem Steel Mill plant, along the shores of Lake Erie in upper state New York. The wind farm provides enough electricity to serve the needs of approximately 7,000 homes.

A 425 kilowatts-peak (kWp) PV plant has been built on a brownfield in Massachusetts, US. It is the largest "brightfield" project—renewable energy transformation of a brownfield—in the country.

Source: http://www.chattanoogachamber.com/newsandvideo/businesstrend/2008spring/page25.asp

Chapter 3: Obstacles

3. Obstacles to the Use of Renewable Energy in Urban Areas

Although renewable energy technologies have made major advances in the last few years, they continue to experience barriers that hinder their widespread adoption. As APEC cities seek ways to meet their growing energy needs in a cost-effective, secure and sustainable manner it will be important to understand potential obstacles to renewable energy development as well as specific ways in which they can be minimized or eliminated. This chapter organizes and discusses these barriers as follows: policy and institutional, financial, technology-specific, and capacity and awareness.

3.1 Policy and Institutional Obstacles

The key policy barrier is lack of political will and commitment at the city-level to put in place renewable energy and associated policies that will accelerate adoption of these technologies. Mega policies such as a renewable energy portfolio standards, feed in tariffs and competitive tendering will help to create markets and spur investment. These policies must be clear and transparent and long term in nature. In many cases these policies may have a "carve out" for technologies that are particularly beneficial to an urban area such as solar thermal or PV. Related policies and targets on GHG emission reductions, green energy and green buildings will also further adoption of renewable energy projects. These policies should be coordinated with national and sub-national policies related to renewable energy development in the country.

In addition, there are a variety of municipal-level planning and permitting obstacles to distributed renewable energy systems in APEC urban areas—as summarized below—which can be addressed through policy interventions.

- Complex and/or unclear local permitting requirements.
- Land use, zoning and siting restrictions.
- Restrictions on utility interconnection of renewable energy power generation units.
- Lack of sufficient inspectors and permitting authorities experienced with RE systems in urban applications.
- Permitting requirements/fees that vary significantly across jurisdictions.
- Lack of "certified" renewable energy systems for purchasers, lenders, investors, insurance companies and others that meet technical, environmental, safety and performance standards.
- Difficulty for private power developers to sell power generated from renewable energy systems, to the national utility.
- Protection of contracts and intellectual property.
- Existing electricity laws that can be counter-productive.

3.2 Financial Obstacles

Financial and other incentives are generally necessary to facilitate and support widespread use of renewable energy systems and technologies in urban applications. In part, such incentives act to internalize and thus monetize some of the environmental, sustainability and energy security benefits of renewable energy relative to traditional fossil fuel options. Following are some of the most important financial considerations for renewable energy options:

- **Higher upfront costs of Renewable Energy:** Even with continuing cost reductions in a number of applications, renewable energy systems have higher upfront capital costs than conventional alternatives, yet lower operation and maintenance (O&M) costs. Although decision making based on life-cycle costing would benefit renewable energy systems, it is not often used in many economies.
- **Fossil Fuel Subsidies:** Without a level playing field it is difficult if not impossible for renewable energy to compete on a cost basis with subsidized fossil fuels prevalent in many APEC economies.
- **Capital Market Constraints:** Imperfect capital markets; insufficient access to affordable financing for project developers, entrepreneurs, and consumers; and financing risks and uncertainties.
- **Lack of Income Tax Holidays:** Income taxes reduce the attractiveness of renewable energy investments for urban areas. "Tax holidays" for such systems would increase the financial opportunity for renewable energy system proliferation. This would allow for cost reductions through economies of scale and experience (learning curves and experience curves). Such a provision would give partial or total exemption of national and other income taxes for specified periods (e.g., 5 – 10 years), depending on the technology and application.
- **Import Duties on Renewable Energy Components, Products and Materials**: This is a serious financial impediment for local companies that need to import equipment and materials for new renewable energy facilities.
- **Access to Carbon Finance**: Despite the dynamism of the carbon marketplace, with US$26 billion worth of transactions in carbon emission reductions (CERs) conducted in 2008 under the CDM market, the projects registered are concentrated in a few large industrializing countries. These are primarily China, India, Brazil, Korea and Mexico. Other APEC economies that qualify include Chile, Chinese Taipei, Indonesia, Malaysia, Papua New Guinea, Peru, the Philippines, Thailand and Viet Nam.
- **Corporate Financial Considerations:** The following provisions for renewable energy, which are not available in many APEC economies, would contribute to the financial attractiveness of urban renewable energy projects: (1) Net operating loss carry-over, (2) Reduced Corporate Tax Rate following Income Tax Holidays, and (3) Accelerated Depreciation on Renewable Energy assets.
- **Reluctance of Traditional Sources of Project Financing:** Banks and other commercial financing institutions are often reluctant to fund renewable energy technologies due to a lack of: understanding of the systems and technologies; historic bank data on past loans; and appropriate financing arrangements for these technologies.
- **Value Added Taxes (VAT):** Application of VAT to electricity and/or thermal energy produced from renewable energy projects decreases the financial attractiveness of such projects and investments.
- **Lack of Tax Credits for Domestic Capital Equipment and Services:** Lack of tax credits also increases the costs and risks of renewable energy systems and project development.

- **Lack of Fast-Track Project Approval Mechanisms:** The renewable energy component of a commercial or industrial building project may be a fairly small percentage of the total project cost, but its presence can and usually will cause delays in the overall project development and implementation process. These delays affect the financial viability of the entire project, and may cause developers to avoid renewable energy innovations.

- **Limited City Government Investments in Renewable Energy Facilities:** If city governments do not invest in renewable energy facilities, many opportunities for urban projects are lost. City investments in showcase projects can demonstrate the benefits of renewable energy technologies, document that they work and exhibit leadership in the clean energy field. Opportunities include renewable energy installations for municipal buildings, schools, hospitals, recreation facilities and other public facilities. Cities with community or district-scale heating systems may also invest in renewable heating infrastructure. Some APEC cities have renewable energy policies for municipal infrastructure and operations; their experience provides examples and models for adoption by others.

- **Lack of Integrated Supply Chains:** The installed price of urban solar thermal and PV systems reflects the full supply chain, including the costs of sales and marketing, distribution, transport and on-site assembly and installation. Reducing the costs of the full supply chain will be as important, for example, as reducing the price of the PV modules.

- **Lack of or Inadequate High Technology Investment Programs:** APEC economies that want to develop and expand their capacities for high-technology urban renewable energy systems development will benefit from targeted investment programs For example, Chile's new high-tech investment program offers the following.
    - Pre-investment studies (60% of cost up to US$30,000).
    - Project launch assistance (up to US$30,000 for start-up activities).
    - On the job human resource training (up to 50% of annual salaries, max of US$25,000 per employee).
    - Equipment and infrastructure (up to 40%, maximum US$2 million).
    - Long-term property leasing (maximum 40% of leasing costs over 5 years, maximum US$500,000).
    - Specialized training (up to 50% of the costs with US$100,000 maximum).

3.3 Technology-Specific Obstacles

This section discusses some typical technical challenges for applying specific renewable energy technologies and systems in APEC urban applications. The technology-specific obstacles presented herein are representative of those faced by APEC urban areas, and not meant to be all-inclusive.

Two cross cutting obstacles for renewable energy technologies include:

- **Available land can be hard to come by:** Finding adequate land in urban areas for installing large-scale systems such as geothermal power plants, wind energy and bioenergy facilities is a challenge. Land is generally expensive in urban areas, and large plots are not always available. Where brownfields exist, the costs required for clean-up to make them renewables-ready may be prohibitive unless municipalities, provincial and/or national government authorities support the necessary clean-up.

- **Lack of Resource Assessments:** Before decisions can be made about integrating renewable energy technologies and systems in APEC urban areas, a clear understanding of the prevailing energy resources is necessary. Further, depending on the technology, resource data will need to be collected over a period time (e.g., wind resource assessments typically require 1-2 years worth of data).

3.3.1 Solar Thermal Energy

Obstacles to the increased use of solar thermal in APEC urban settings 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.
- Areas with hard or acidic water are problematic for solar water heating systems due to gradual corrosion of the water circulation system. These systems can be 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 except in cases where the national government has policies in place to reduce costs—such as in China.

3.3.2 Photovoltaic Power Systems

Obstacles to the proliferation of solar PV in urban areas include:

- High initial investments, despite low long-term operating costs (i.e., no ongoing fuel costs).
- Lack of consumer knowledge about the technology and reliability issues.
- Lack of stable pricing for solar-electric components and systems.
- Need for improved manufacturing infrastructure to increase throughput and yield.
- Lack of support or even outright opposition from some electric utility companies.
- Shading from large buildings which reduces free and open access to the sun—this is important for achieving 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. *These issues also apply to other renewable energy electricity supply units such as small wind turbines.*

3.3.3 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 land and at sufficiently low cost. For urban applications, a key obstacle is the lack of sufficient open space to set up reflecting parabolic troughs, dishes or towers. Strong direct beam or focusable solar radiation is required; regions with high humidity and high levels of atmospheric dust are poorly suited for CSP.

3.3.4 Wind Electric Power

Some obstacles to increasing the use of wind power in APEC urban areas include:

- Wind power for electric generation in urban areas is most often supplied by large-scale wind turbines that feed power into the power grid from rural locations. Given that energy generated from wind power plants must often be transported over long distances via the grid, a lack of adequate transmission line capacity is considered a barrier for this technology in China, the United States and other APEC economies.
- Urban areas present challenges for the utilization of wind energy technologies. Buildings and other tall obstructions can adversely impact wind direction and speed. The power generation potential of a wind turbine is determined by wind speed and consistency of the wind resource. Wind turbines are generally most effective in remote areas with proven and consistent high wind speeds and smooth airflows, where large turbines can generate significant amounts of electricity. For coastal areas adjacent to urban areas, wind farms are gaining popularity.
- Reduced land availability in APEC cities, coupled with safety concerns**,** generally restrict the use of wind turbines to small models with low power output. Small diameter wind turbines which are more appropriate for urban areas, are less effective in producing energy because wind power is proportional to the area of the circle swept by the blades.
- The moving parts of a wind turbine (rotor blades and gearboxes) tend to create noise which can be troublesome to residents. Many turbine models have the option of running at partial load which reduces the operating sound but lowers overall efficiency.
- Turbine models designed for urban environments are still maturing, and designs are constantly improving and evolving aimed at increased efficiency, less noise and improved safety standards. There is still very little information available on urban wind turbines, and with the lack of regulation and technical quality standards, manufacturers often provide unverified information.
- The administrative process to obtain permits is lengthy and expensive, and pre-construction activities such as feasibility studies, resource assessments and design can be time-consuming and costly.
- The NiMBY problem (“Not in My Backyard”) affects the installation of wind systems. People are reluctant to support wind technology if it is sited in scenic areas, obstructs their views or could potentially ruin property values.
- The intermittent nature of wind energy is a commonly raised issue (e.g,, without backup the power is available only when the wind blows). However, most wind applications in urban areas will be grid-tied, so this should not be a significant barrier.

3.3.5 Bioenergy

3.3.5.1 Power Generation

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

3.3.5.2 Combined Heat and Power

Although technologies used in CHP systems have improved in recent years, significant hurdles limit widespread use. Importantly, these hurdles have the effect of tending to "lock in" continued use of polluting and less-efficient electricity generation equipment. The main hurdles to CHP are:

- A site-by-site environmental permitting system that is complex, costly, time consuming and uncertain.
- Current regulations do not recognize the overall energy efficiency of CHP or credit the emissions avoided from displaced grid electricity generation.
- At present, many utilities charge discriminatory backup rates and require prohibitive interconnection arrangements. Increasingly, utilities are charging (or are proposing to charge) expensive "exit fees" as part of utility restructuring to customers who build CHP facilities.
- Depreciation schedules for CHP investments vary depending on system ownership and may not reflect the true economic lives of the equipment.
- The market is unaware of technology developments that have expanded the potential for CHP.

3.3.5.3 Liquid Biofuels

Biofuels produced outside of urban areas are consumed in urban areas (mainly for transport). Some typical obstacles to the use of biofuels in APEC urban areas include the following:

- The immense land use requirements for the cultivation of biofuel crops typically precludes production in urban areas. Additionally, and the transportation costs of bringing these resources to urban centers can be restrictive.
- The reliability of supply can be an obstacle, as well as the unavailability of sufficient areas of land in urban areas to build a processing facility. APEC economies have tremendous biofuel feedstock potential in rural areas, but little in urban areas.
- The food versus fuel controversy.
- The need for infrastructure investment to collect, transport, blend and deliver biofuels to local retail stations for sale to consumers.

3.3.5.4 Landfill Gas Capture and Use

Some of the barriers include:

- Municipalities often lack the funds necessary for purchasing the required equipment.
- Municipal managers may be unaware of the benefits of landfill methane capture.
- Landfills may be far away from potential energy users.
- Small and medium scale cities might not generate enough garbage to produce a reasonable amount of methane.

3.3.5.5 Municipal Solid Waste Conversion

Trash can be burned in waste-to-energy plants to generate heat and electricity. While this has the benefit of decreasing the amount of waste in landfills, harmful pollutants may be released into the air, land and water in the absence of effective controls. The ash can contain harmful metals, such as lead and cadmium. Further, coal contains (on average) four times as much heat energy as garbage, making WTE more expensive than coal-fired energy generation.

3.3.6 Hydropower

Large scale hydropower can have significant environmental and population displacement problems. For small scale hydropower, electricity can be delivered economically up to few kilometers from the point of generation, but this distance may not be adequate for reaching urban areas. It may also be difficult to obtain permits for diverting rivers in urban or peri-urban areas, since this may impact other infrastructure, historical features and/or aesthetics. Seasonal variations in water flow can impact system output.

3.3.7 Electricity from Ocean Waves and Currents

Waves are intermittent and power generation requires significant space. Even in high wave, energy dense areas such as the Pacific Northwest of the US, energy production rates of about 1.5 MW require that 100 feet of shoreline be occupied by generators. Given that coastline is often allocated to residential areas or wilderness preserves, obtaining the land needed for power generation can be difficult. Safety is also a concern; storms will cause ocean wave generators to occasionally dislodge from their anchors and become serious navigational hazards. Potential environmental impacts associated with wave energy conversion are still being investigated.

The technology for ocean wave and tidal energy lags behind other renewable energy technologies. In the United States, the first commercial project is not expected until the 2014-2019 timeframe. The first pilot tidal project in New York's East River took five years to obtain a permit from the Federal Energy Regulatory Commission (FERC). Since they are not commercially available options, ocean thermal energy conversion, ocean current energy conversion and tidal power are not discussed here in greater detail.

3.3.8 Geothermal Heat and Power

Due to the necessity to build at tectonic plate boundaries, and particularly through the "Pacific Ring of Fire," there is an inherent risk of earthquakes compromising the power plant. Additionally, geothermal power plants typically require large areas of land which are not normally available in urban areas and the local populace is often opposed to any power-generating options in the vicinity of their residences. Thus, most geothermal projects will not be established in urban areas, but may provide power to these areas. Geothermal heat pumps, on the other hand are viable options in many APEC cities and present minimal obstacles to development.

3.3.9 Smart Grids

Some of the technical and technology barriers confronting grid-connected use of renewable energy systems in APEC urban areas are summarized below.

- **Inadequate Technology and Capacity to Support High Penetration of Electricity from Renewables.** For example, there is a need for:
    - Improved understanding of and capacity to deal with issues associated with high-penetration PV systems, such as voltage regulation, reverse power flow, unintentional islanding, false inverter trips, reactive power control, fault contribution, protection, communications and intentional islanding operation. This is important at all scales of PV deployment, but especially important as the fraction of PV-generated electricity grows.
    - Modeling, testing and evaluating the impact of large amounts of PV-generated electricity on the reliability and stability of the electric power system. These projects will help pave the way for broader adoption and growth of grid-tied solar energy systems by improving understanding of the impact of PV electricity on the grid.
    - Developing advanced modeling tools and electric power control strategies to optimize electric power value and remove or reduce the impact of PV-sourced electricity on existing micro-grids and the smart grid. Factors to be modeled and evaluated include monitoring of micro-climate effects and sky imaging systems to enable 1-hour-ahead PV-sourced electric power output forecasting in conjunction with a utility's dynamic price signals.
- **Grid interconnections** of wind and solar-generated electricity. Impacts on grid stability and electricity quality (voltage, frequency, non-sinusoidal harmonics and noise) can be barriers.
- **Impact of increasing penetration of grid-connected solar and/or wind electricity.** A significant issue is how much power the grid can absorb without stability or reliability consequences. China, for example, could not accommodate power from 20% of its wind turbines in 2008 due to grid limitations. In 2009, China introduced legislation (amendment to the renewable energy law) that includes plans for a "massive" upgrade of the electric power grid.
- **Integration of renewable energy-based urban energy supply and end-use energy demand management.** This includes energy end use efficiency and peak power management. This is also the case for solar thermal water heating, space heating and cooling. Hence RE supply for urban areas must be considered in the context of the efficiency with which the energy is used.

3.4 Capacity and Awareness Obstacles

In every APEC economy and indeed in every country there are gaps between the level of existing capacity and the ability to deliver on the rapid and efficient scale-up of urban renewable energy systems. Additionally, lack of awareness of renewable energy benefits, applications and costs can hinder support for these technologies and delay/stop their advancement.

At the same time, many APEC economies are actively supporting urban decentralized renewable energy applications, and are gaining understanding and capacity along the way. APEC economies that are especially active in this area include: Australia; Canada; China; Republic of Korea; Malaysia; Mexico; Chinese Taipei and the US. Following are some representative examples of capacity constraints to the increased use of renewable energy technologies and systems in APEC urban areas:

- Lack of research and development capacities to continue to improve technology cost, efficiencies, performance and maintenance requirements.
- Inadequate institutional capacity for renewable energy policy development, project/program design and implementation.
- Lack of knowledge by service providers as well as programs to train and qualify these individuals/organizations in the proper installation, operation and maintenance of renewable energy systems.
- Limited scale-up experience, including successful models for replication.
- Insufficient mechanisms for technology transfer.
- Lack of support to renewable energy project developers, lenders, investors and others in understanding the technologies and helping to lower transaction times, decrease costs and increase success rates for new urban renewable energy initiatives.
- Lack of public and political awareness of renewable energy options, costs and benefits as well as support for these technologies. (See Table 3-1)
- Lack of public and political support for large-scale use of RE in urban areas.
- Stakeholder engagement—early and often—to help mitigate barriers. Table 3-2 summarizes key barriers to renewable energy development in APEC cities as well as potential stakeholders to be involved in barrier mitigation.

Table 3-1: Promoting Photovoltaics in Malaysia—The Role of Public Perception and Support

Photovoltaic (PV) technology is not new in Malaysia; it was first introduced in the year 2000. Nonetheless, PV still encounters many barriers for penetration into the public realm, especially in the urban residential sector. Identification and assessment of non-technical barriers that hinder the rapid diffusion of this technology into the Malaysian urban residential sector is important. Understanding the public awareness of this emerging renewable technology is vital as perceptions of what people believe to be real is real in its consequences, and perceptions/ preferences are themselves facts that describe the social world in which people operate. People's perceptions and preferences about energy and the environment are influenced by objective factual information. Therefore, by assessing the public perceptions on acceptance of PV technology, more effective strategies can be drawn for implementing programs for adoption of this technology.

Source: Assessment of Public Perception on Photovoltaic Application in Malaysia Urban Residential Areas. European Journal of Social Sciences-Volume 8, Number 4. 2009

Table 3-2: Urban Renewable Energy Barriers and Principal Responders	
Category of Barrier	**Principal Stakeholders to Address the Barriers**
Technical and Technological	• National and regional research and development organizations • International R&D Centers • Public and private manufacturers • Professional engineering societies in relevant fields • Universities • National standards, testing and certification organizations
Economic and Financial	• National, state/provincial and city governments • Public and private financial institutions • International financial institutions (e.g., multilateral development banks, specialized United Nations agencies such as UNEP) • Public and private investors
Institutional and policy	• Governments at national, provincial/state and metropolitan level • Policy analysis centers (national and international) • Standards setting institutions • Manufacturer associations
Capacity	• Universities and trade schools • Specialized training organizations (e.g., offering short courses) • Professional societies, both international and national • Private R&D centers • Financial institutions
Awareness	• Public, private and NGO websites • Professional societies (e.g., conferences, publications) • Private sector through advertising, product showcasing and exhibitions at conferences • Government agencies • International agencies and organizations (e.g., REN-21) • News media (newspapers, magazines, on-line media) • Renewable energy expositions and fairs

3.5 Conclusion — Obstacles

A rapid increase in renewable energy applications in urban areas will require addressing barriers hindering advancement of these technologies. This will include development of supportive policy and regulatory frameworks, securing public sector commitment, strengthening local capacities and entrepreneurship, transferring technologies and increasing access to affordable financing and consumer credit. It will require transitioning to cleaner fuels; maximizing use of distributed renewable energy technologies in an environmentally sustainable manner; more efficient use of energy for urban end uses; and ongoing reductions in the cost of relevant renewable energy technologies for production of electricity and thermal energy. These issues have been tackled successfully in several countries/cities around the world, and good models exist for replication.

Chapter 4: Case Studies

4. Case Studies

4.1 Purpose

The purpose of this chapter is to provide case studies on the successful adoption of renewable energy technologies, systems and resources in APEC urban and peri-urban areas. It includes examples in the residential, commercial, industrial and utility sectors.

Case studies selected for this study address the following:

- Utilize a renewable energy technology for an urban application that has been successfully operating for at least six months.
- Represent an innovative project design or policy measure.
- Offer the potential for replication in other APEC member economies.
- Replace the need for "conventional" energy-based systems such as oil, gas, coal.
- Demonstrate carbon emission reduction potential and/or other environmental benefits.
- Promote economic development and/or revenue savings.
- Expand public knowledge and acceptance of renewable technologies.

Projects included encompass a breadth of renewable energy technologies and represent a diversity of APEC member economies. For each of the case studies included in this report, the following information is presented: brief project description, project highlights, stakeholder contact information and links to source documents. Table 4-1 provides a snapshot of the projects included in the report. Further, the report includes a section on renewable energy technologies and applications for urban areas in APEC, which are currently in the development stage and/or are poised to grow. These include offshore wind, concentrating solar power, smart-grid technology and sustainable cities.

4.2 Organization of Case Studies Section

The remainder of this section is organized as follows:

- **Residential Sector Case Studies,** including projects where energy is consumed in homes, apartments, family housing and equivalent. Typical residential energy use is for heating, air conditioning, lighting and for appliances.
- **Commercial Sector Case Studies,** defined as businesses, institutions and organizations that provide services or sell products. Most commercial energy use occurs in buildings or structures, for space heating, water heating, lighting, cooking and cooling.
- **Industrial Sector Case Studies,** defined as manufacturing, agriculture, mining and construction. Energy consuming activities include process and assembly, space conditioning and lighting.
- **Utility Sector Case Studies,** including projects that connect to a local or regional electric grid.
- **Emerging New and Renewable Energy Applications** in APEC.

Table 4-1: Projects Covered in this Report

Title	Sector	Location	Technology	Noteworthy Features
China Solar Water Heating and Lighting	Residential, Governmental	Rizhao, Shandong Province, China	Solar water heating and lighting	• Government supported solar technology applications throughout the city of Rizhao.
GeoExchange in Residential Buildings	Residential sector	British Columbia, Canada	Geothermal heat pumps	• Led to significant energy savings. • Can be replicated anywhere.
Malaysia Building Integrated Photovoltaic (MBIPV)	Residential sector	Throughout Malaysia, inclusive of major cities	Solar PV	• Capacity-building policy; countrywide residential, commercial solar PV installations.
Queen Victoria Market	Commercial sector	Melbourne, Australia	Solar Roof	• Large array of solar panels on roof of historic building.
Wal-Mart stores	Commercial sector	California, USA	Solar PV	• System wide commitment to renewable energy.
Chinese Taipei Green Stadium	Commercial sector	Kaohsiung, Chinese Taipei	Solar PV	• High profile urban solar PV installation put in place for the 2009 World Games. • Innovative design.
Solar Capacity Scheme	Commercial sector	Singapore	Building design and construction, solar	• With support of the government, the program is designed to grow Singapore's clean energy industry, to create jobs, and contribute to the GDP.
Suntech BIPV HQ Building	Commercial sector	Wuxi, China	Building-integrated PV	• Integration of PV panels on the roof and façade of Suntech's HQ building supplies 1 MW of power capacity, and handles 80% of the building's electric requirements
Bagasse-fired Cogeneration Plant	Industrial sector	Phu Khieo, Thailand	Cogeneration plant powered by agricultural waste	• Feedstock supplied by 2,000 area farmers. • High efficiency system, steam and electricity sold to national utility and adjacent factory.
Large-Scale and Industrial Biogas Program	Industrial sector, large-scale	Three Cities in China: Hangzhou, Zhejiang Province. Shunyi, Beijing Municipality. Qingdao, Shandong Province.	Biogas production. Used for electricity generation and/or heat	• Biogas technology implementation in peri-urban areas near major cities in China. • Already replicated.
La Ola Solar Farm	Utility sector	Lana'i, Hawaii, USA	7,400 PV panels on 10 acres, single-axis tracking systems	• State of the art system, large array of solar panels, producing a large amount of power – over 1 MW.
Changbin and Taichung Wind Farms	Utility sector	Changbin and Taichung, Chinese Taipei	103.5MW bundled wind farm	• Privately developed wind project that uses carbon financing.

4.3 Residential Sector Case Studies

This subsection highlights successful examples in the residential sector. These include a case study on solar water and electricity throughout the city of Rizhao, China; the effective use of geothermal heat pumps in Vancouver, Canada; and the Malaysia building integrated photovoltaic project that promotes grid-connected installations.

4.3.1 People's Republic of China – Solar Water Heating and Lighting

The follow case study describes the deployment of renewable energy technologies on a city-wide scale. Rizhao has taken a holistic approach to planning, innovation and public education in support of cleaner energy.

Project Description

In Rizhao City, which means City of Sunshine in Chinese, most of the rooftops and walls are covered with solar heat collectors. A city of three million people in Shandong Province in northern China, Rizhao is using solar to provide energy, heating and lighting. As many as 99 percent of Rizhao's households use solar water heaters, while almost all traffic signals, street lights and park lighting are powered by photovoltaic (PV) solar cells. In total, the city has over a half-million square meters of solar water heating panels, the equivalent of about 0.5 megawatts of electric water heaters.

Source: www.inhabitat.com

Increased use of solar water heating and lighting was the result of an unusual convergence of three key factors: a government policy encouraging solar energy use and financially supporting research and development; local solar panel industries seizing the opportunity to improve products; and the strong political will of the city's leadership for implementation.

The Shandong provincial government provided subsidies for research and development activities of the solar water heater industry, leading to lower equipment costs for consumers. The cost of a solar water heater was brought down to the same level as an electric one: about US$190[3], which is about four to five percent of the annual income of an average household in Rizhao city and about eight to ten percent of a rural household's income. Using a solar water heater for 15 years saves 15,000 Yuan (US$1,934) or US$120 per year per household. This savings is significant in an area where per capita incomes are lower than the national average. Rizhao also mandated that all new buildings incorporate solar panels and oversaw the construction process to ensure proper installations.

The city was critical to the success of the program by passing important regulations, assisting in the solar panel installation process, and raising public awareness. Rizhao ran television advertising campaigns in support of the program.

[3] Source: "China's Solar-Powered City," *Renewable Energy World*, May 22, 2007, article by Xuemei Bai.
http://www.renewableenergyworld.com/rea/news/article/2007/05/chinas-solar-powered-city-48605

Project Highlights

After 15 years of effort, solar heaters have become common in Rizhao. "You don't need to persuade people anymore to make the choice," according to Wang Shuguang, a government official. Annual CO_2 reductions have reached 52,860 tons.

The project demonstrates how different levels of government can work together towards a common objective. The Shandong provincial government provided subsidies to bring down technology costs to levels competitive with traditional hot water heaters. The Rizhao city government passed supporting legislation and achieved an impressive adoption rate as a result of its public education campaign and support to installers. The city prides itself on being green and has expanded beyond solar power. The marsh gas generated from sewage is converted and used for cooking and electrical power generation.

Contact Information

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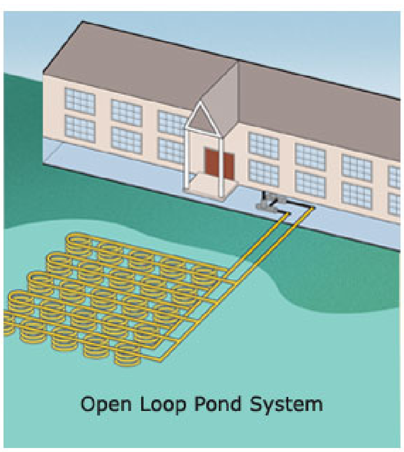
4.3.2 Canada - GeoExchange in Residential Buildings

Project Description



Source:www.envirotechgeothermal.com

In an effort to reduce the environmental impacts and operation costs of buildings in the Lower Mainland, Vancouver became the premier Canadian city to incorporate energy efficiency measures into a by-law. Based on Vancouver's By-law 6871, new standards apply to all buildings and additions (but do not include one-family and two-family dwellings). Geothermal energy has proven to be a dependable means to reduce the conventional energy needs for space heating and domestic hot water, in existing and future Canadian communities.

GeoExchange uses a system of buried pipe (the loop), which carries a heat transfer fluid. The loop consists of pipes removing heat from the earth in the heating mode and releasing heat to it in the cooling mode. This is accomplished by a refrigeration process that transfers heating or cooling via forced air or water. The process uses a geothermal heat pump that works much like a refrigerator, removing heat from food and passing it into the kitchen through its back coils. After circulating through the loop in the ground, the mixture is piped into the home, where it is connected to the heat exchanger in the heat pump. This process replaces the need to burn fossil fuels or circulate current through electric elements. The illustration below shows this type of system.

A condominium development in Kitsilano uses many different energy efficient technologies and methods, including GeoExchange. Developer Harold Kalke, the project manager, was chosen to spearhead the project, due to his desire to change peoples' lives by providing them a different way to do things. He has utilized recycled carpeting, a central filtration system through which all residential water is processed, and thermally-broken window frames for heat insulation and leak prevention. Chief among the efficient and effective methods of energy technologies is the design's use of geothermal energy. Cost-efficiency is one reason why Kalke chose to make the Kitsilano project the first Western Canada complex to use the geothermal comfort system. The earth's energy was selected to heat and cool 25,000 square feet of office space, and 40,000 square feet of retail space, as well as to provide all of the hot water in the condominiums.

Two 10-ton units, one for the commercial division and the other for residential, were installed by Dandelion Geothermal to provide hot water to the project. The retail and office space is heated and cooled by 68 geoexchange units. The geothermal technology integrates with the tenant's cooling system, reducing the need for additional equipment and lowering costs. "By utilizing the geothermal system, we were able to devote less space for mechanical equipment, therefore reducing construction costs in these areas," proclaims Marvin Breyfogle, Project Manager. A small room in the project's lower parking level houses the technology.

Facility specifications include:

- 75,000 gross square feet commercial;
- 78 condominium residences;
- 46 bore holes, the 42 deepest holes reach a depth of 300 feet;
- Two 10-ton units;
- 68 premier units; and
- A central water filtration system.

GeoExchange B.C., a multi-agency group established to promote geothermal technology, stated that a geo exchange program reduces greenhouse gas emissions by almost two thirds and uses up to 70 percent less electricity than conventional electric heat/cooling systems. In British Columbia alone, it is estimated that more than 14,000 metric tons of greenhouse gas emissions could be saved annually if only one percent of the new or retrofit market could be captured. Average total maintenance costs are one-third less than that of conventional systems.

Project Highlights

"Incorporation of geothermal technology enabled us to reduce energy consumption, allowing us to completely eliminate the use of gas in the commercial component of the project," adds Breyfogle. "We don't even have a commercial gas meter."

In an attempt to make the development a quiet, full-service neighborhood, the commercial division houses an exclusive population that includes a bookstore, a deluxe natural food store and a garden supply store. Of note, the final prices are competitive with other new units in the area.

Tenants took up residence in the fall of 1993; the entire complex has proven to be cost effective. "The project has been a complete success with a payback estimated to be a period of less than three years," exclaims Bruce Tidball, general contractor. The low maintenance will also benefit the project with reduced costs in the future.

Contact Information

- Facility: Condo commercial development, Kitsilano, British Columbia
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- Architect: Hotson Bakker Architects Norm Hotson, J.P. Mahe (604) 255-1169
- Designer/Project Manager: Dandelion Geothermal Ltd, Marvin Breyfogle (604)739-250

- General Contractor: Intertech Construction Ltd. Bruce Tidball (604) 733-4700
- Drilling Contractor: Bertram Drilling Corporation, Pete Herzog (604) 245-2402
- Authorized Dealer: Dandelion Geothermal Ltd.
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4.3.3 Malaysia Building Integrated Photovoltaic Technology Application Project

The following case study highlights work done in Malaysia to promote the use of solar resources in the country, especially in major cities. The program used a multi-faceted approach: information services, awareness and capacity building; market enhancement and infrastructure development; policies and financing mechanisms program; and building-integrated photovoltaic (BIPV) industry development and research and development (R&D) enhancement.

Photos courtesy of Ministry of Energy, Water, and Communication.

Project Description

The Malaysia BIPV project promotes the successful implementation of Grid Connected-Building Integrated Photovoltaic installations. The project implementation period coincides with the 9th Malaysia Plan period (2006 – 2010).

The project includes the development of appropriate, proactive and integrated plans and policies that will create a conducive environment for widespread adoption of BIPV beyond the 9th Malaysia Plan period to exploit solar PV energy in Malaysia. The Project also aims to develop the framework for a national BIPV program for the 10th Malaysian Plan (2011 – 2015) to accelerate market development for the PV industry.

The Malaysia BIPV is intended to hasten cost reductions for non-GHG-emitting technologies via integration of solar PV technology with building designs and envelopes. It is aimed at creating a sustainable market in Malaysia that will generate widespread BIPV installation. The project will catalyze BIPV technology acceptance among the public, policy makers, financiers and building industry, which will lead to a sustainable BIPV market.

SURIA 1000 Program

SURIA 1000 is a national MBIPV program targeting the residential and commercial sectors to help establish a new BIPV market and to provide direct opportunities to the public and industry for involvement in renewable energy initiatives and environmental protection. This program is co-financed by the public (owners of the system), Suruhanjaya Tenaga (for the Government of Malaysia) and the PV industry (via discounts for the hardware). Since 2007, a limited number of grid-connected solar PV systems have been auctioned to the public annually. The minimum price is increased in each subsequent call for bidding in order to facilitate the creation of sustainable BIPV market upon the completion of the program.

Successful bidders install the PV system supplied by the participating PV Service Providers as Building Integrated PV at their premises. The costs of the PV systems are borne by successful bidders and supplemented by the project. Selection of successful bidders is based on lowest contribution from the MBIPV Project. Subsidies decrease over time from a 75 percent to 45 percent maximum program contribution. It is expected that PV installers will offer BIPV system prices equivalent to those seen in Europe and Japan. Today, the cost of a 5kWp BIPV turnkey rooftop system in Malaysia is about RM 135,000 (approximately US$39,000). The system will produce approximately 6,000 kWh of energy per annum.

Project Highlights

The policy was successfully implemented and several rounds of bidding have already been completed through the SURIA 1000 program. These auctions helped fund numerous residential (and more recently, commercial) solar photovoltaic installations in major cities and throughout the country. Installed BIPV capacity increased by about 330 percent over the project implementation period.

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4.4 Commercial Sector Case Studies

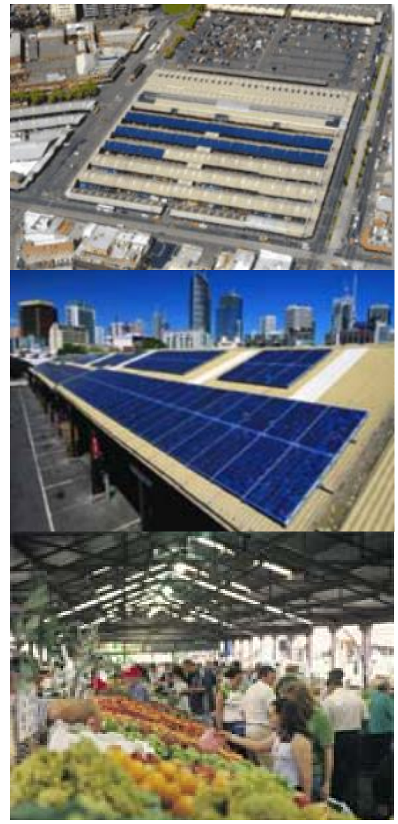
This section highlights examples of successful renewable energy applications in the commercial sector. These include: solar energy on the Queen Victoria Market in Australia; Wal-Mart's installation of solar panels on its stores in the United States; a solar-powered green stadium in Chinese Taipei built for the 2009 World Games; and Singapore's Solar Capacity Scheme which has helped the city-state to be a world leader in clean energy systems and technologies.

4.4.1 Australia – Queen Victoria Solar Energy Market

Australia has showcased urban applications of solar PV by installing solar panels on the roof of a historic market and displaying real-time power production data.

Project Description

The historic Queen Victoria Market in the center of Melbourne is the largest tourist attraction in Victoria. The popularity of the market makes it an ideal location to showcase renewable energy in an urban environment. To help visitors understand more about the project and solar power, the City, along with BP Solar and Origin Energy, installed a permanent, real-time display inside to show the latest power readings and CO_2 emissions savings. Real time readings can be found at: http://www.melbourne.vic.gov.au/qvm/QVM.cfm.



Photos illustrating the solar installation at the Queen Victoria Market. Courtesy of New York City Climate Summit

The City of Melbourne is generating 252,000 kilowatt-hours of electricity each year from what is the largest urban solar installation of its kind in the Southern Hemisphere. Housed on the roof of a "heritage building" which has been in operation since 1878, the system has cut CO_2 emissions by almost 1,700 tons since it was installed in 2003 and is providing enough energy to power 46 homes a year.

More than 1,300 solar photovoltaic panels were installed on one third of the Queen Victoria Market's roof. Each panel measures 1.59 meters by 0.79 meters. The panels convert sunlight into DC (direct current) electricity and then the electrical current is distributed to one of 83 solar inverters located under the eaves of the Queen Victoria Market. Inverters are used to convert the DC to AC (alternating current) so the power is the same as normal grid power. During the day, the electricity is distributed within the market. At night, when the solar panels are not generating electricity, the market consumes electricity from the national grid. The PV solar panels are expected to generate power for at least the next 30 years. The project cost 1.7 million AUD[4] in joint funding (AUD$1.0m from the City and AUD$700,000 from the Australian Greenhouse Office through a Renewable Energy Grant scheme). The system will save the Melbourne City Council AUD$40,000 per year in energy costs.

[4] In January 2010, one Australian dollar was equivalent to .90 US dollars.

The installation began in October 2002, and the task to assemble and secure the solar photovoltaic panels to the existing timber on the market roof was completed in March 2003. The installers used a combination of scaffolding, roof barriers and a scissor lift to move the panels onto the roof, using equipment such as battery-powered hand tools and special clamps for handling the solar panels.

Project Highlights

This project was chosen as a success largely because of its demonstration value. It shows that a large solar panel array can be installed even on a building with historic significance. In addition, the web-based real time "counter" showing cumulative energy generation and CO_2 reductions showcases the benefits of renewable energy to the public in an interesting way. As of April 3, 2009, the system generated 1,225,907 kWh (kilowatt hours) and avoided 1,691 tons of CO_2.

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4.4.2 United States – Solar PV in Wal-Mart Retail Stores

Wal-Mart is a major retail chain with over 7,900 stores in 15 countries around the globe. As part of its Sustainability 360 initiative, Wal-Mart established the following goals: obtain 100 percent of its energy from renewable sources; create zero waste; and sell products that sustain resources and the environment. As part of these efforts, Wal-Mart is purchasing as much as 20 million kWh of solar power from BP Solar, SunEdison and PowerLight (a subsidiary of SunPower Corporation), for 22 combined Wal-Mart stores, Sam's Clubs,[5] and distribution centers in Hawaii and California. Wal-Mart is seeking alternative energy at competitive prices, in a form that is replicable at multiple sites and for a variety of building formats.

Solar PV on a Wal-Mart in Palm Desert, CA. Photo courtesy of BP Solar.

Wal-Mart is positioning itself as a leader in corporate purchasing of renewable energy. The company has experimented with different financing structures and technologies to find the most cost effective solutions for providing green power in its operations.

Project Description

In January 2008, Wal-Mart Stores and SunPower

[5] Sam's Club is a corporate entity owned by Wal-Mart. Sam's Club is a warehouse-type store which sells general merchandise and large volume items.

Corporation, a Silicon Valley-based manufacturer of high-efficiency solar cells, solar panels and solar systems, announced completion of a 390-kilowatt solar power system at the Sam's Club store in Chino, California. The store is the first of seven Wal-Mart facilities in California to receive high-efficiency SunPower solar power systems, totaling 4.6 megawatts (MW).

Wal-Mart's SunPower solar power systems are financed through the SunPower Access Program— a power purchase agreement that allows customers to take advantage of the environmental and financial benefits of solar power with no upfront capital costs. The solar electricity will be competitively priced, providing Wal-Mart with a long-term hedge against rising peak power prices.

Each solar power system installed can provide up to 30 percent of a store's power. Wal-Mart will use the power generated by the solar panels onsite at each store and will also keep the Renewable Energy Credits (RECs) the units produce. RECs — also known as Green tags, Renewable Energy Certificates or Tradable Renewable Certificates (TRCs) — are tradable

> ***Renewable portfolio standards*** *(RPS) require utilities to use renewable energy or renewable energy credits (RECs) to account for a certain percentage of their retail electricity sales – or a certain amount of generating capacity – within a specified timeframe. The term "set-aside" or "carve-out" refers to a provision within an RPS that requires utilities to use a specific renewable resource, usually solar energy, to account for a certain percentage of their retail electricity sales or a certain amount of generating capacity within a specified timeframe. More than half of all U.S. states have established an RPS. http://www.dsireusa.org/glossary/*

environmental commodities in the United States which represent proof that one megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource. These certificates can be sold and traded, and the owner of the REC can claim to have purchased renewable energy. They can be valuable in meeting state requirements under Renewable Portfolio Standards (RPS) or in achieving voluntary renewable energy goals.

Wal-Mart has laid out three possible financing/ownership options for prospective solar energy and solar equipment providers:

1 A direct purchase of a turnkey system with a maintenance agreement included within the proposal.

2 A supplier-installed, owned and operated system governed by an end-user power purchase agreement (PPA) for 100 percent of the electric output (with Wal-Mart retaining a purchase option exercisable at Wal-Mart's discretion).

3 A lease agreement between supplier and Wal-Mart, with Wal-Mart taking ownership of 100 percent of the electrical output. In this instance, Wal-Mart retains a purchase option exercisable at its discretion.

SunEdison will provide four solar power systems in California, while PowerLight and BP Solar will each supply seven systems in California. On the roof of Wal-Mart's Chino store, SunPower installed the proprietary SunPower T-10 solar roof tile, which tilts at a 10-degree angle to increase energy capture.

In December 2008, BP Solar completed the final three photovoltaic systems specified under the terms of its solar power construction program agreement with Wal-Mart. The company recently finished building a 494-kilowatt system at the Sam's Club in La Habra, a 606-kilowatt array at the Wal-Mart Super Center in Palm Springs, and a 675-kilowatt system at the Beaumont Super Center. With these three systems totaling over 1.7 megawatts, BP Solar's 4.1-megawatt commitment to Wal-Mart is fulfilled as part of the retailer's solar pilot project. The project consists of nearly 24,000 crystalline-silicon solar panels, which are expected to produce 6.7 million kWh of electricity per year.

By Wal-Mart's estimates, installing the solar power systems will help reduce greenhouse gas emissions by 6,500 – 10,000 metric tons per year. "Pilot project stores are expected to achieve savings over their current utility rates immediately — as soon as the first day of operation," said David Ozment, energy director for Wal-Mart.

Wal-Mart has also established prototype stores that utilize renewable energy technology, energy efficiency equipment and water saving devices. These stores are located in McKinney, Texas and Aurora, Colorado. Once successful energy savings measures have been identified, such as the installation of light emitting diode (LED) lights in refrigeration units, they will be rolled out across more Wal-Mart stores worldwide.

Project Highlights

This project provides an excellent case study of corporate "buy-in" of renewable power. Wal-Mart is exploring different financing arrangements with vendors, and is seeking the rights to sell electricity back to the grid in North Carolina.

Wal-Mart is a highly visible user of PV power, with large numbers of the public going to Wal-Mart stores. The project also shows how commercial entities are helping meet California's regulations for use of clean energy resources.

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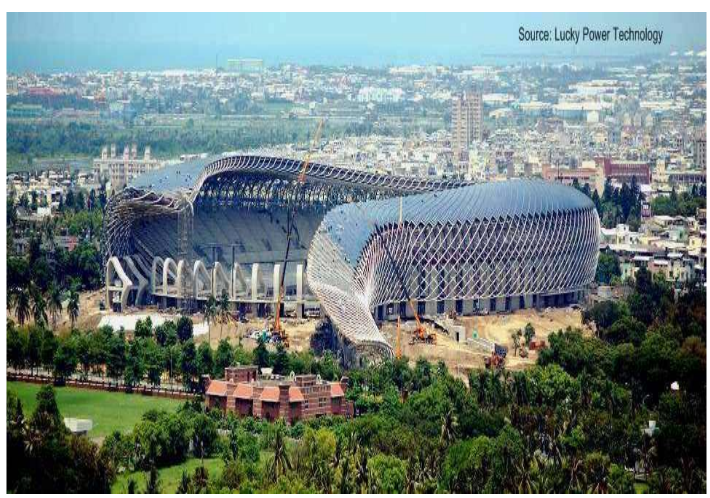
4.4.3 Chinese Taipei's Green Stadium

A gigantic solar roof on Chinese Taipei's Green Stadium provides power to the facility and supplies the local grid with green electricity.



The Green Stadium under construction. Photo courtesy of Lucky Power Technology Co., Ltd.

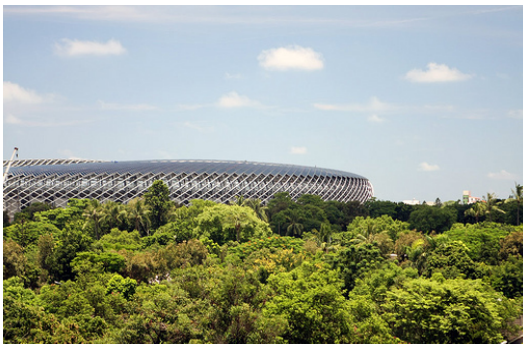
Project Description

When the city of Kaohsiung was granted the right to host The World Games 2009,[6] the organizing committee immediately launched venue renovations and

[6] The World Games feature sports that are not contested in the Olympic Games.

construction projects in order to meet International Federation standards. The most important project was the Main Stadium in Kaohsiung City, which has 40,000 seats. This stadium is estimated to be the world's largest single-edifice solar installation, with peak generating capacity of 1 megawatt of clean electric power, and the ability to reduce CO_2 emissions by more than 500 tons a year. On days when no competitions are taking place, the electricity generated is fed back into the grid.

The Japanese architect Toyo Ito planned the ultra-modern stadium as a green building. Construction on the Main Stadium was completed in early 2009. The new sports arena is also Chinese Taipei's largest photovoltaic installation to date. It is fitted with solar modules manufactured by the company Lucky Power Technology Co. Ltd., using equipment provided by 3S Swiss Solar Systems AG. The project was installed by Delta Electronics, Chinese Taipei.




Photos courtesy of World Games 2009

The system illuminates the track and field with 3,300 lux (a lux is a unit of illumination equal to one lumen per square meter). The stadium has 8,844 solar panels on a surface area of 14,155m² integrated into the roof construction. The solar roof, which emulates the form of a flowing river, can cover up to 75 percent of the energy needs of the stadium (depending on the strength of the sunshine).

Project Highlights

The green stadium is impressive in terms of scale. It is currently the world's largest solar-powered stadium. The project is a good case study of knowledge transfer between countries, which resulted in the mass production of solar equipment in Chinese Taipei.

The design of the stadium maximizes its eco-friendliness. The positioning of the building and it shape provides spectators with shelter from the southwestern summer wind and the northwestern winter wind. At the same time, the orientation provides shelter from sunlight, thus providing a more comfortable viewing environment.

Contact Information

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  Lin Ching-po, chairman of Fu Tsu Construction Co., Ltd. (Constructed the stadium)
  3S Swiss Solar Systems AG (Project manager)
  Delta Electronics (Chinese Taipei-based installer)

- Toyo Ito (Japanese architect)
- Lucky Power Technology Co., Ltd. (PV module supplier)
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4.4.4 Singapore – Solar Capacity Scheme

Singapore aims to be a global hub where clean energy products are developed, made and exported overseas. In early 2008, the Singapore government identified the clean energy industry as a strategic growth area for their economy. Since then, the city-state has been implementing a comprehensive blueprint to grow the industry, starting with a funding commitment of S$350 million (US$233 million) from the government[7].

Photo courtesy of Singapore Economic Development Board

The Solar Capacity Scheme (SCS) blueprint is comprised of five key pillars: R&D, developing manpower, grooming Singapore-based enterprises, branding the industry internationally and growing a vibrant industry ecosystem. The objectives of the SCS are twofold: 1) build capabilities of companies such as those engaged in engineering, architecture and system integration; and 2) encourage innovative design and integration of solar technologies into energy efficient buildings.

Singapore's clean energy push centers on solar energy, given its strategic location in the tropical Sunbelt. Besides solar, resources are also channeled towards biofuels, wind energy, tidal energy, energy efficiency and carbon services. By 2015, the clean energy industry is expected to contribute S$1.7 billion (US$1.1 billion) to Singapore's gross domestic product (GDP) and create 7,000 jobs.

Projects must be for new buildings in the private sector that have attained a minimum Green Mark Gold standard (administered by the Singapore Building & Construction Authority). A minimum system size of 10 kW peak is required. Applications for existing buildings undergoing extensive retrofit are considered on a case-by-case basis. The SCS will offset from 30 to 40 percent of the total capital cost of solar technology, capped at S$1.0 million (US$670,000) per project. The actual amount of grant is dependent on evaluation criteria, including: innovation, design, effectiveness and skill development.

To date, the city-state has attracted leading industry players such as the *Renewable Energy Corporation* of Norway and *Vestas Wind Systems* of Denmark. The Renewable Energy Corporation (REC) will build the world's largest solar manufacturing complex in Singapore for S$6.5 billion (US$4.3 billion) producing 1.5 gigawatt production capacity. This was first announced in October

[7] Only part of these funds have been released to date. There is an initial government allocation of $20M Singapore dollars (US$13.4 million) for the SCS.

2007, with construction to begin in early 2010. When completed, the manufacturing complex will incorporate wafer, cell and module production facilities. Vestas Wind has set up Asia-Pacific HQ in Singapore and will invest up to S$500 million (US$333 million) over the next 10 years, from 2009 to 2019, in its R&D center in Singapore.

Successful implementation of the SCS is expected to result in skills development and capacity building for architects, engineers, system integrators, master planners and financiers.

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4.4.5 BIPV - Suntech Headquarters in Wuxi, China

Suntech Power Holdings Company is the world's largest PV module manufacturer and its headquarters building in Wuxi, China incorporates a 1 MW grid-connected building integrated solar roof and facade, the largest in the world.

Photo Source – Suntech

Project Description

Suntech Power Holdings Company recently announced the opening of its new, state of the art solar headquarters in Wuxi, China – completed in December of 2008. The 18,000 square meter building incorporates the world's largest on-grid photovoltaic facade system, with over 2,500 semi- transparent "Light Thru"[9] solar glazing panels and an annual power output of 710 kilowatt hours of electricity. The solar roof consists of 1,800 solar panels with an installed power output of 300 kW. The façade and roof combined account for approximately 1.0 MW of installed power capacity.

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[8] EDB is the lead government agency responsible for planning and executing strategies to enhance Singapore's position as a global business center and to grow the Singapore economy. EDB "designs and delivers solutions that create value for investors and companies in Singapore." Objective being to attract economic opportunities and jobs for the people of Singapore, and help shape the country's economic future.

[9] Suntech *Light Thru* modules use crystalline cells sandwiched between two sheets of glass. The gaps between the cells allow light to pass through creating shaded areas. With the flexibility to specify the desired light levels passing through the glass, Suntech Light Thru is both a power generator and an aesthetic sunshade in one package.

The façade consists of approximately 6,900 square meters of surface area, quite large! The PV panels used for the façade measure about 2.2 meters x 1.1 meters, and for the roof they measure 1.5 meters x 1 meters. The solar energy produced at the headquarters building will save an estimated 1,000 tons of carbon emissions every year.

> *"We believe that building integrated solar systems are the way forward for environmentally friendly architecture and our new headquarters is an excellent demonstration of how solar can be seamlessly incorporated into modern and attractive buildings."* Suntech's Chairman and CEO, Dr. Zhengrong Shi.

Suntech chose their proprietary *Light Thru* modules for their ability to generate clean power, and also to contribute to the elegant design aesthetic that was desired for their office building. The panels form the cornerstone of Suntech's overall design strategy for an environmentally responsible headquarters.

Project Highlights

The use of this building-integrated PV system reduces the demand on the regional electrical grid to the tune of 1,020,000 kilowatt hours of electricity annually. The electricity produced by the BIPV system supplies about 80% of the total power requirements for the entire building.

In addition to the BIPV system, Suntech headquarters in Wuxi features energy efficient building materials, geothermal temperature control, movement sensor lighting and a comprehensive water recycling system. This highly visible project demonstrates to the community and to outside visitors how a building can be energy self-sufficient and at the same time be an aesthetically pleasing architectural design.

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4.5 Industrial Sector Case Studies

Case studies from the Industrial Sector include bagasse-fired cogeneration plants in Thailand, and three large-scale biogas projects in China.

4.5.1 Thailand – Bagasse-Fired Cogeneration Plant

The sugar mill's operations utilize waste to generate power, creating multiple environmental benefits.

Project Description

Phu Khieo Bio-Energy (PKB) is one of the subsidiaries of the Mitr Phol Sugar Group (MPSG) in Thailand. For many years, MPSG has been the leader in the sugar industry, not only in Thailand but in the whole of Southeast Asia. The Group is continuously improving its ability to produce and process sugar by enhancing production capacity and increasing productivity. The United Farmer & Industry Company Limited (UFIC) is widely acknowledged as one of the largest and most advanced sugar mills in Southeast Asia. Established in 1983, the mill utilizes a computerized processing system developed by the British firm Tate & Lyle Industries Limited. The Phu Khieo Cogeneration Project located in Chaiyaham is an extension of an existing cogeneration plant installed at the UFIC

Photos courtesy of COGEN 3/Phu Khieo Bio-Energy

Sugar Mill. The upgrading allowed 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 29 MW to the Electricity Generating Authority of Thailand (EGAT) during the peak period, on a firm basis throughout the year.

- Cover the steam and electricity requirements of the adjacent particle board factory.

The fuels used in the cogeneration plant are bagasse, rice husk, wood bark and cane leaves. Two thousand farmers are contracted to supply the 23,000 tons of sugarcane that is processed daily at this facility. Years of experience in advanced European technologies, together with strong support from the government, have enabled the biomass power plants to generate electricity throughout the year.

Phu Khieo Bio-Energy (PKB) was established as a subsidiary of the Mitr Phol Sugar Group (MPSG). PKB is located in Khoksa-at, Phu Khieo District, Chaiyaphum Province, in Northeast Thailand. The plant was engineered by Alstom Power.

PKB generates its main revenues from the sale of: 1) steam and electricity to United Farmer & Industry Co., Ltd. (UFIC) and to Mitr Particle Board; and 2) 29 MW of electricity to EGAT, on a firm basis throughout the year.

The total cost of the project was 40 million Euro (approx. USD$56.3 million), including land and civil works. The new plant consists of the following components:

- Two vibrating grate boilers with an hourly capacity of 120 tons of steam at 68 bar and 5100C each.

- A 41 MW extraction-condensing steam turbo-generator.

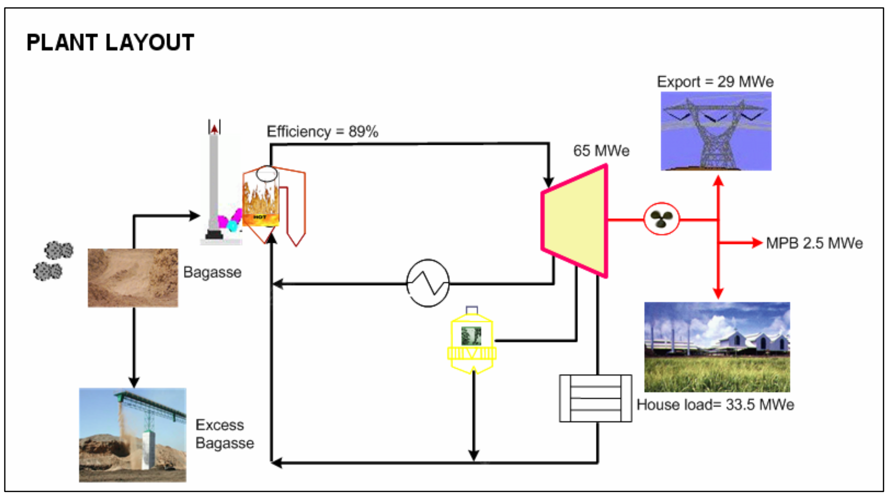

Illustration courtesy of COGEN 3/Phu Khieo Bio-Energy

Results to Date

The performance monitoring of the project was conducted in May 2005. The plant was running very efficiently, with boiler efficiencies exceeding 90 percent. The cogeneration plant produces steam and electricity to cover the needs of the sugar mill and a particle board factory, and also exports power to the grid. All the steam generated by the boilers is sent to the 41 MW extraction-condensing turbo-generator for the production of process steam and electricity.

After submitting the Environmental Impact Assessment (EIA), the PKB cogeneration plant received approval by the government environment authorities. All measurements and observations made during monitoring revealed that the plant is well-operated and that the carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx) and particulate emissions are far below the accepted Thai limits. Wet scrubbers allow an effective control of the particulate emissions. The total CO_2 emission reduction potential from this plant is around 98,500 tons per year. Ash and wastewater are properly disposed.

Project Highlights

The cogeneration plant provides many economic and environmental benefits. The implementation and operation of the plant generated several new jobs, and the capacity of PKB workforce has been developed through a strong cooperation with the equipment supplier. The stable and reliable supply of power throughout the area has stimulated new business activities. Moreover, by using indigenous renewable fuels, PKB contributes to the nation's effort to reduce the import of fossil fuel for power generation. The plant productively uses various agricultural wastes which would otherwise be burned or left to decay. This project could easily be replicated if feedstocks, such as agricultural waste, are available from nearby areas. The project significantly reduces greenhouse gases and is formally registered under the Clean Development Mechanism, or CDM.

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4.5.2 People's Republic of China: Large Scale and Industrial Biogas Program

The experiences of industrial biogas facilities in China will help shape a Biogas Action Plan for expanding the use of biogas technology throughout the country.

Project Description

China's extensive biomass resources (estimated at 5 billion tons annually) include substantial animal wastes and organic industrial effluent — appropriate raw materials for the production of biogas. While China has extensive experience with biogas at the household level, with roughly two million rural household digesters in operation, industrial-scale production is lagging. China's industrial sector holds particularly high promise for profitable biogas installations, given its suitability for cogeneration of heat and power and the availability of advanced combined heat and power (CHP) technologies.

As meat consumption continues to rise in China, water pollution from animal manure produced at livestock and poultry farms has emerged as a key environmental problem. This has created both a treatment necessity and a sizeable biogas production opportunity. Estimates place manure generated at such farms at over 900 million tons annually, with an electric power potential of over six gigawatts (GW).

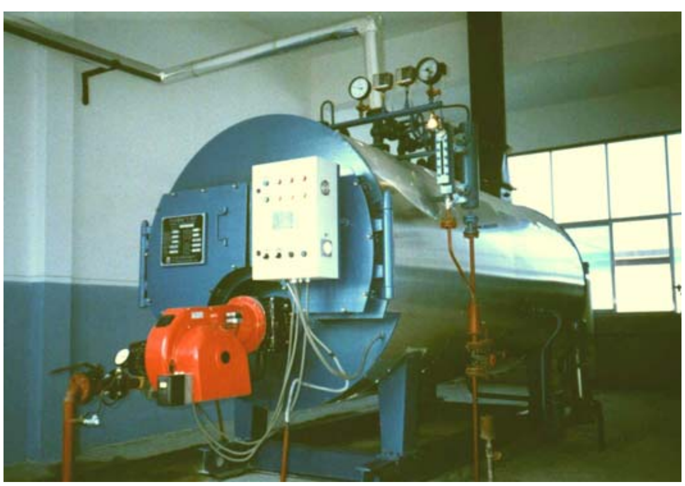
The major driver of China's industrial-scale biogas projects has been compliance with environmental regulations. In 2002, China's State Environmental Protection Agency (SEPA) issued new standards for industrial wastewater discharge and increased enforcement, stimulating greater interest in biogas. The use of anaerobic fermentation technology for wastewater treatment is well developed in China. China has more than 700 small to mid-size industrial-scale biogas plants, but there is a need for more plant deployment and the incorporation of international best practices to promote commercial viability.

This United Nations Development Program — 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 table below provides details on the characteristics of these projects, which include two pig farms (one formerly the largest in the world) and a distillery.

Characteristics of Pilot Biogas Facilities

Characteristics	**Dengta Pig Farm (Hangzhou, Zhejiang Province)**	**Shunyi Pig Farm (Shunyi, Beijing Municipality)**	**Jiuchang Distillery (Qingdao, Shandong Province)**
Scale	200,000 pigs	60,000 pigs	10,000 t/year alcohol
Wastewater	3,000 tons/day	600 tons/day	10,000 m3/day
Biogas produced	8,500 m3/day	2,200 m3/day	10,000 m3/day
Biogas application	Electricity, some heat	Electricity, some heat	Boiler fuel for processing heat
Generating capacity	230 kW	100 kW	N/A
Use of electricity	Sold to grid	Used on site	N/A
Other output	142 tons fertilizer/day	8 tons fertilizer/day	Solids recycling

The project has aggressively pursued the goals of catalyzing deals among developers, end-users and the financial sector while also introducing them to international best practices. Through a series of four workshops, each held near one of the pilot sites or a similar facility for demonstration of economic and technical performance, these stakeholders had an opportunity to hold discussions with bioengineering companies about potential projects. To further introduce international best practices, the project has financed the preparation of a detailed guidebook, *International Biogas Best Practices Report*—soon to be published in Chinese.



Biogas used in boiler on Hangzhou Dengta Farm. Photo courtesy: Hangzhou Energy & Environment Co.

Current project work focuses on facilitating a transition from motivations for environmental compliance, to profit-motivated biogas projects and assisting policymakers in promoting biogas. As part of its commercialization strategy, the project is supporting feasibility studies for large-scale centralized biogas digesters, which will each serve several industrial end-users and thus have greater potential for selling electricity to the grid. In the policy arena, the project is compiling experiences and preparing a draft Biogas Action Plan. The Plan will utilize stakeholder input in identifying roles and action items for various groups associated with the technical, business development, financing, environmental and policy aspects of biogas commercialization. The national action plan will offer a blueprint for improving the domestic policy environment for creating favorable investment-grade biogas power projects that will further stimulate the deployment of biogas technologies for industrial applications.

Project Highlights

The project has already achieved a number of notable successes to date, suggesting a substantial impact on the development of industrial-scale biogas in China. These include:

- Concrete results in catalyzing the spread of biogas development projects in China. A limited survey of bioengineering companies indicates that 34 new biogas projects at livestock farms have been developed, with deals resulting directly from discussions held at the project's first three workshops. Ongoing multiplier effects are likely much greater. Already, third-party investors have begun to get involved in biogas projects.
- 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.
- 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. In addition, the project has had an impact on local governments, such as Hangzhou, which took action to implement new standards once the project demonstrated the potential of biogas solutions.
- Enhanced 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.

The biogas workshop series and the subsequent biogas investments by industry, which were facilitated by the workshops, demonstrated that the top 20 percent of financially sound firms in the large-scale livestock and industrial sectors are able to finance such investments themselves.

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4.6 Utility Sector Case Studies

The first case study below highlights the La Ola Solar farm, located in Lana'i Hawaii in the United States and focuses on island grids. The second case study describes a wind farm project on the west coast of Chinese Taipei near Taichung.

4.6.1 United States – La Ola Solar Farm

La Ola Solar Farm is helping to reduce high energy costs in Hawaii.

Project Description

Hawaii has joined other states in US Environmental Protection Agency's (EPA) Clean Energy-Environment State Partnership. The Partnership, which began in February 2005, works to promote cost-effective energy efficiency, clean distributed generation, renewable energy and other clean energy sources that can provide air quality and other benefits. Hawaii currently imports most of its fuel, but through its work with the partnership, hopes to increase its use of energy efficiency and renewable energy sources. There is a legislative push to increase the use of alternative energy sources on the island, where energy costs are very high.

Hawaii Governor Linda Lingle joined local dignitaries and business representatives at a blessing ceremony for the La Ola Solar Farm on the Island of Lana'i in early 2009. La Ola, is translated from Hawaiian as "sun that gives life." The US$19 million facility comprises 7,400 photovoltaic panels on 10 acres of land that previously grew pineapples. The solar farm now produces 500 kilowatts of electricity, but the developer plans to increase generation after installing battery storage in June 2009. The increased generation is expected to provide up to 30 percent of Lana'i's daily peak power needs.

Lana'i has traditionally depended on diesel-fueled engines to generate electricity. Power provided by La Ola will help the most oil-dependent state in the US reduce its demand for imported fossil fuel. La Ola will also build on the progress of the Hawaii Clean Energy Initiative, a state partnership launched in January 2008 with the US Department of Energy, which aims to generate 70 percent of Hawaii's energy from clean sources by 2030.

The solar farm was built by Castle & Cooke Hawaii, a real estate developer that owns 98 percent of Lana'i and employs 85 percent (about 2,700) of the island's residents. Twenty four workers from **Keo Construction** and **Hawaii Island Diggers** built the farm, starting in November 2007. Completion was delayed by eight months to work out permitting problems with the land's agricultural designation, which at that time prohibited the construction of a solar farm.

The solar farm was built with panels from California-based **SunPower Corporation.** At the La Ola site, SunPower installed a single-axis SunPower Tracker system. The Tracker tilts toward the sun as it moves across the sky, increasing energy capture by up to 25 percent over fixed systems while reducing land-use requirements. The system is expected to generate about 3 million kilowatt hours of electricity per year.

Under a 25-year power purchase agreement approved by the state Public Utilities commission in October, Maui Electric will purchase power from the company for 27 cents a kilowatt hour for the first 10 years, 30 cents a kilowatt hour for the second 10 years, and 33 cents a kilowatt hour for the following five years. The solar panels are guaranteed for 25 years.

This installation will help reduce more than 2,300 tons of CO_2 emissions in Lana'i each year, which is approximately the same amount of CO_2 emitted from the consumption of almost 5,000 barrels of oil or more than 237,000 gallons of gasoline. Maui Electric Company (MECO) utilizes more renewable energy sources than the average US utility company, with non-hydro renewables accounting for six percent of all electricity supplied by MECO. This compares to the national US average of two percent of total electricity coming from non-hydro renewables.

On January 6, 2009, Castle & Cooke Hawaii and SunPower Corporation dedicated the 1.2-megawatt La Ola Solar Farm on Lana'i in Hawaii. "Castle & Cooke is committed to helping the state of Hawaii achieve energy independence. With the dedication of Hawaii's largest solar farm, we are delivering on our commitment by bringing clean solar energy to the people of Lana'i," stated David H. Murdock, chairman and owner of Castle & Cooke, Inc. "This state-of-the-art solar farm helps pave the way for Hawaii to become a leader in the production of renewable energy. La Ola is just the initial step of Castle & Cooke's plans for renewable, sustainable energy." He continued, "having installed the first commercially-financed solar power system in the US on the Big Island of Hawaii in 1998, followed by more than six megawatts of solar power systems across the Hawaiian islands since that time, we are pleased to dedicate this very significant project on the island of Lana'i."

Photo courtesy of US Department of Energy

The system came on line in early 2009 and is producing 500 kilowatts of energy. Capacity is expected to rise to 1.2 megawatts upon completion by June of 2009. To provide citizens of Lana'i reliable and affordable power into the future, Castle & Cooke Hawaii also plans to build a wind farm on Lana'i, pending tests of the wind resource, environmental studies of endangered birds, financing arrangements and permitting. If all goes well, the company says it could build a US$750-million wind farm that would generate 300 to 400 MW of electric power to be used on the island and also sent to Oahu via undersea cable.

Project Highlights

- Help to alleviate high cost of electricity and fuel on this island, due to high transport costs.
- With Hawaii being a series of islands, clean and renewable programs in the state can serve as models to other countries, such as Indonesia and the Philippines, which face the same challenges of providing energy and power to islands.
- State of the art system.
- Large array of solar panels, producing a large amount of power – over 1 MW.

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- Tom Werner, chief executive officer of SunPower
- Maui Electric Company (MECO)

4.6.2 Chinese Taipei – Changbin and Taichung Wind Farms

This project includes two onshore wind farms which are "bundled" as a single power source. The wind farms offset significant amounts of carbon dioxide, and the developers are selling emission reductions (carbon credits) from the project.

Project Description

Wind Farm, Chinese Taipei

Photo courtesy of South Pole Carbon Asset Management, Ltd

Commissioned in 2007, this project involves two wind farms in Chinese Taipei: a 103.5MW 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 507 MWh of electricity per year. The system will reduce coal use, leading to an estimated emissions reduction of 405,470 tCO_2e/year[10]. 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. Construction challenges include high winds during the winter months and typhoons during the rainy season. The foundations of the machines were made to withstand earthquakes that may occur in this part of the world.

Project Highlights

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-fueled power plants. As a private developer, InfraVest did not have these same advantages. Instead, InfraVest was able to make

[10] Tons of carbon dioxide equivalent, tCO_2e

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.

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4.7 Emerging New & Renewable Energy Applications & Technologies in APEC

In addition to the success stories highlighted in the prior chapters, there are a number of innovative and important initiatives that could have significant potential for APEC urban sector deployment in the future. Many promising renewable energy technologies and applications are in the research and development, testing, pilot or application phases in APEC member economies. A number of these are highlighted in this section, including offshore wind, concentrating solar power, smart-grid linked technologies and sustainable cities.

4.7.1 Offshore Wind

Offshore wind is not a new technology, but it is just starting to gain momentum. Offshore wind is currently more expensive than onshore wind, however, due to the expected benefits of added wind capacity and the lower visual impact of the larger turbines, several countries now have very ambitious goals concerning offshore wind. Japan is planning a series of offshore wind farms, closer to population centers than their land-based counterparts. In the past, electric utilities purchased power from project developers. The new approach is for utilities, such as Tokyo electric, to build and own the wind farms themselves. Some key barriers in Japan, such as restrictive building codes and siting constraints, have recently been overcome. Several other APEC economies – Canada; China; Korea; Malaysia and the United States, also have plans for offshore wind farms. In fact, the National Offshore Oil Corporation in China has been supplying power to its operations with wind since 2007. Further, RusHydro plans to install 30 MW of wind on islands near Vladivostok, Russia by 2012 – in time for the APEC summit to be held in that city.

4.7.2 Concentrating Solar Power

Concentrating solar-thermal technology uses mirrors to concentrate sunlight to produce heat. That heat creates steam to spin turbines and generate electricity. Research and development continues to make concentrating solar power (CSP) cost-competitive, and analysts at *The Economist* state that “a massive scale-up of the industry is imminent.” The technology has several advantages. It is less expensive that solar PV, can provide power when most needed (on hot days) and can be supplemented with natural gas boilers to enhance reliability. Approximately 12 GW (i.e., 12,000 MW) of CSP is planned worldwide, building upon the experience base of the 500 MW of capacity that is currently installed. The US has approximately 6,000 MW of CSP under contract. Mexico is planning for 30 MW and China has 100 MW already under contract.

4.7.3 Smart-Grid Technology: Google's PowerMeter

The Google PowerMeter tool will be a platform for collecting, managing and analyzing home energy information. This tool tracks historical data and forecasts future trends. It is expected that Google's PowerMeter tool will ultimately interface with smart meters, thermostats and other devices. Google PowerMeter will show consumers their electricity consumption in near real-time in a secure iGoogle Gadget. It is expected that the device will offer more useful and actionable feedback than complicated monthly paper bills that provide little detail on consumption or how to save energy.

Google cites figures showing that regularly viewing real-time energy use will urge people to cut electricity by five to 15 percent on average through behavioral changes. With its smart-grid push, Google is seeking to appeal directly to consumers, rather than working through utility-sponsored programs. Typically, smart-grid companies sell to utilities, giving them smart meters and software to help them operate the power grid more efficiently. As part of those programs, consumers can often get real-time information on energy use.

Google's PowerMeter is not yet available to the public since it is in the testing stage. Google is expanding its partnership with utilities and independent device manufacturers to roll out the program in pilots. It is expected to be more widely available after testing is complete.

4.7.4 Sustainable Cities (Eco-cities)

A sustainable city, or eco-city, is designed with consideration of environmental impact. It is inhabited by people dedicated to minimization of required inputs of energy, water and food as well as waste output of heat, air pollution (such as CO_2 and methane gasses) and water pollution. A sustainable city can be maintained with minimal impact on the surrounding environment, and power itself with renewable sources of energy. Objectives of eco-city planners are to: create the smallest possible ecological footprint; produce the lowest quantity of pollution; use land efficiently; compost used materials; and recycle or convert waste into energy. These measures make the city's overall contribution to climate change as minimal as possible. Several examples of planned cities can be seen in APEC economies and around the world, such as:

- Dongtan (near Shanghai, China)
- Tianjin Eco-City (Tianjin, China)
- Treasure Island (San Francisco, California, USA)

Dongtan is planned as an eco-city which would be sustainable not just environmentally, but also socially, economically and culturally. If and when completed, Dongtan is expected to be as close to carbon neutral as possible. Energy will be produced from wind, solar, biofuels and recycled city waste. Agricultural waste from rice paddies around Dongtan will be burned to power people's homes, and the sewage from the city will fertilize the fields. Solar and wind power will help fill any energy shortfalls and all transport within the city is expected to be powered by hydrogen or electricity. Green corridors of public space will enhance quality of life.

Arup, the British engineering consultancy firm, was contracted in 2005 by the developer, Shanghai Industrial Investment Corporation (SIIC), to design and masterplan Dongtan. Dongtan was originally planned to open in time for Expo 2010 in Shanghai. By 2040 the city was slated to be one-third the size of Manhattan (New York City), with a population of 500,000. However no significant construction of the eco-city has of yet taken place. The plan for the eco-city showed that energy demand will be substantially lower than comparable conventional cities due to the high performance of buildings and a zero emission transport zone within the city.

Dongton East Village and East Lake artists rendering. Source: Arup (planned developer)

Dongtan proposes to have only green transport movements along its coastline. People will arrive at the coast and leave their cars behind, traveling along the shore as pedestrians, cyclists or on sustainable public transport vehicles. The only vehicles allowed in the city were supposed to be powered by electricity or hydrogen – although the controlling authorities are now backtracking on these commitments and allowing private, gas-powered vehicles onto the site.

The planned housing, water taxis, sewage-recycling plant and energy park have so far all failed to materialize. The project was stopped and all references to Dongtan were removed from the Shanghai World Expo website. Currently the project seems stalled as the UK's Daily Telegraph reported that the planning permits, which must be renewed annually, had expired. The future of the project is unclear.

The "Sino-Singapore Tianjin Eco-City" near Tianjin, China is billed as a "…socially harmonious, environmentally friendly and resource efficient city – a model for sustainable development." The project is a joint partnership between the People's Republic of China (PRC) and the Republic of Singapore. The PRC faces significant challenges due to its rapid economic growth and the needs of its huge population. The Tianjin Eco-city is one way of demonstrating the determination of both the PRC and Singapore in reconciling global climate change, strengthening environmental protection, conserving resources and energy and building a harmonious society. The aim of the project is to create a model that will benefit not only other cities in the PRC, but also other countries that are facing similar challenges. The project will broaden and deepen the PRC-Singapore partnership, and provide a new platform for engagement between the leaders, officials and businesspersons of both countries.

The Eco-city site is located 40 km from the Tianjin city center and 150 km from Beijing. Groundbreaking for the project occurred in September 2008. The start-up phase of the project (3 sq km) is expected to be complete within the following three to five years. The entire 30 sq km should be completed in 10 to 15 years' time. Upon completion, the population is projected to reach 350,000 residents.

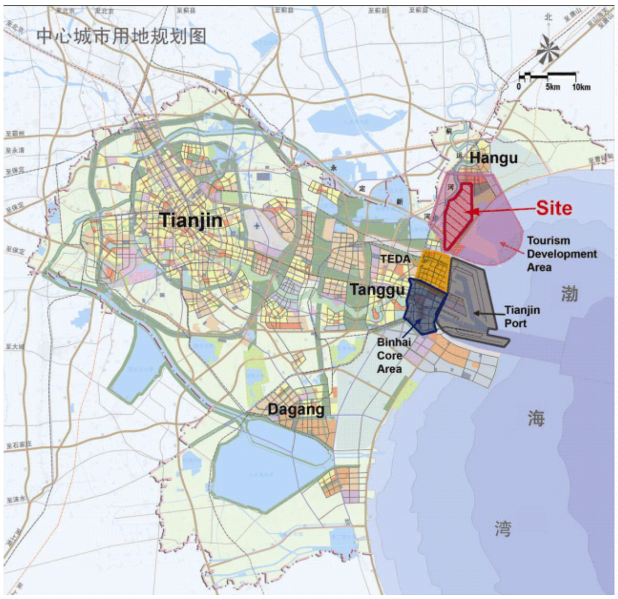
The Tianjin Eco-city adopts a holistic approach, taking into account lessons learned from Singapore's own developmental experience. The approach to sustainability starts at the macro-level - comprehensive master planning, integrating land use and transport planning to ensure that those living and working in the Eco-city have a satisfying living and working environment. Residents will also have convenient access to facilities like schools, socio-communal facilities, medical care, parks and the like.

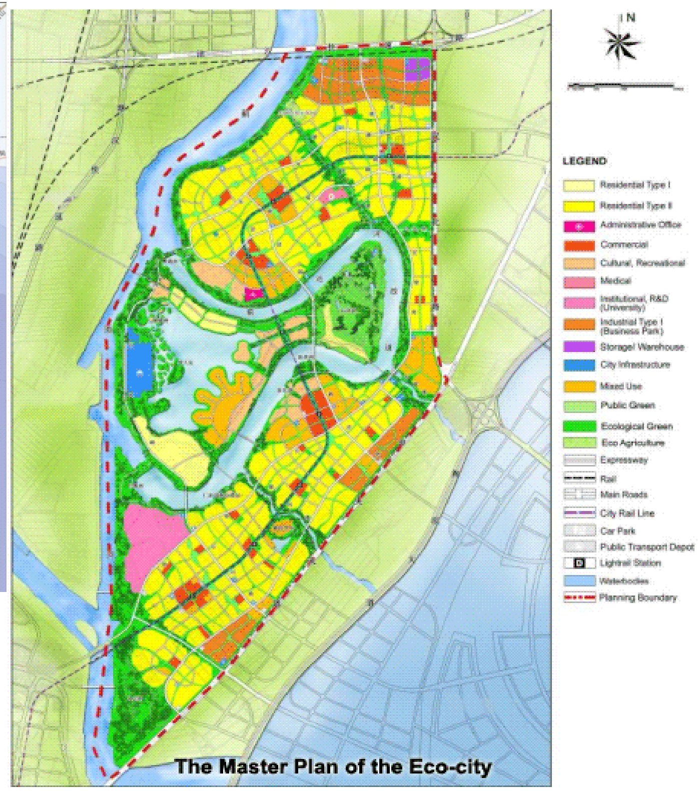
The basic building block of the Eco-city Master Plan[11] is a single cell, or "Eco-Cell", that serves to integrate the different land uses within a modular 400m by 400m grid. Educational institutions, commercial areas, workplaces and recreational areas are distributed within these Eco-Cells and located close to the residential areas to minimize commuting. Together, these Eco-Cells add up to form neighborhoods, districts and eventually the urban centers.

Another highlight of the Master Plan is an "Eco-Valley" running through the Eco-city as a north-south connector. It serves as the main ecological green spine and incorporates water-sensitive urban design elements, such as eco-swales and dry streams. The Eco-Valley will connect the major transit nodes, residential areas, community facilities and commercial centers. It will be a key public open space and focal point of the Eco-city.

[11] The Master Plan of Sino-Singapore Tianjin Eco-city lays down the guidelines for the Eco-city's development as a scalable, practicable, and replicable model for sustainable development for other cities in China and around the world. It was jointly developed by the China Academy of Urban Planning and Design, the Tianjin Institute of Urban Planning and Design, and the Singapore planning team led by the Urban Redevelopment Authority.

Land use considerations are well integrated with the public transportation network to encourage more green transport and less use of private vehicles. Land use also facilitates the economic positioning of the Eco-city to ensure a vibrant economy and the creation of adequate well-paying jobs for its residents. The project also seeks good urban solutions in water and waste management, and the use of renewable energy. Technologies will be utilized to create "green" buildings.





Site location of Tianjin Eco-City (above) and Master Plan (right).

Source: http://www.tianjinecocity.gov.sg/

Apart from hardware, the "software" aspects of this effort are also being considered. The project aims to foster strong and cohesive communities within the Eco-city. Residents will play a critical role in realizing the vision of the Eco-city. For example, if public and green transport are to be the main modes of transportation within the Eco-city, residents will need to be prepared to walk, cycle or use public transportation and forego use of the car while in the Eco-city. Residents also play an important role in proper waste management, including waste reduction and recycling.

As of June 2009, construction of key infrastructure such as roads and the utilities network were proceeding on schedule. The construction of the wastewater treatment plant has started. Various technical studies relating to the environmental rehabilitation of the polluted water-bodies within the Eco-city site are ongoing. A set of green building standards has been jointly formulated by both countries, China and Singapore. Construction works of the first batch of residential and commercial developments in the start-up area are scheduled to commence in late 2009.

"Treasure Island" is a human-created island in the San Francisco Bay between San Francisco and Oakland. It is connected by a small isthmus to Yerba Buena Island. It was created in 1936 and 1937, from fill dredged from the bay, for the Golden Gate International Exposition. According to the United States Census Bureau, Yerba Buena Island and Treasure Island together have a land area of 2.334 km2 (0.901 sq mi) with a total population of 1,453 as of the 2000 census. The island is named after the novel *Treasure Island*, by Robert Louis Stevenson, who lived in San Francisco from 1879 to 1880. Treasure Island is entirely within the City and County of San Francisco. The island used to have a gas station, but it is currently unused. It is served by a single Muni bus route, the 108 Treasure

Island. It has a job training center, and is also home to San Franciscans and many college students who attend school downtown.

Treasure Island was built with imported fill on shoals on the north side of Yerba Buena Island for the Expo in 1939. The island sits in the "middle" of the San Francisco – Oakland Bay Bridge. Built by the federal government, Treasure Island was planned for and used as an airport for Pan American Airline's Pacific Rim service of flying boats. After the 1939–40 World's Fair of the Golden Gate International Exposition, the island was used by the US Navy as an airport. During World War II, Treasure Island became part of the Treasure Island Naval Base, and served largely as an electronics and radio communications training school, and as the major Navy departure point for sailors in the Pacific. In 1996, Treasure Island and the Presidio Army Base were decommissioned and opened to public control, under stipulations. Treasure Island is now part of District 6 of the City and County of San Francisco, though it is still owned by the Navy.

Building One is a Streamline Modern-styled remnant of the World's Fair and is one of the few buildings remaining from the exposition. Originally intended as the terminal for the airport, it housed the Treasure Island Museum from 1976 to 1997. Today it serves largely as offices for The Villages, a private apartment rental agency. The former housing for officers and their families is rented out to the general public, pending redevelopment and reconstruction of buildings on the island, slated for 2012-2014.

View of San Francisco from Treasure Island. Source: Leonard G, Wikipedia.

After the Naval Station closed in 1997, Treasure Island was opened to residential and other uses, but according to the United States Environmental Protection Agency and the state Department of Toxic Substances Control, the groundwater and air are contaminated with asbestos, plutonium, radium and other substances which are known to cause cancer and other illnesses. Another risk of living on Treasure Island is the high risk of liquefaction during an earthquake. All of Treasure Island is built on landfill, and few if any of the buildings on the island were built to withstand a major earthquake, much less an earthquake magnified by liquefaction.

In 2005, Lennar Corporation, one of the largest developers in the United States, proposed to build a self-sustaining city on Treasure Island. The development plan contains several midrise towers, four 40-story towers and one 60-story tower called the Sun Tower (formerly Treasure Island Tower). It also has an organic farm, a wind farm, parkland and tidal marshes. The proposal is designed to be as car-independent as possible, with the ferry terminal and basic goods within a 10-minute walk of the residences. A toll of five US dollars has been proposed to deter non-residents from driving onto the island. This is a change from the original plan which was more car-dependent and had only one high-rise tower. The Navy has signed two "Findings of Suitable Transfer" or FOST documents which allow development plans to continue.

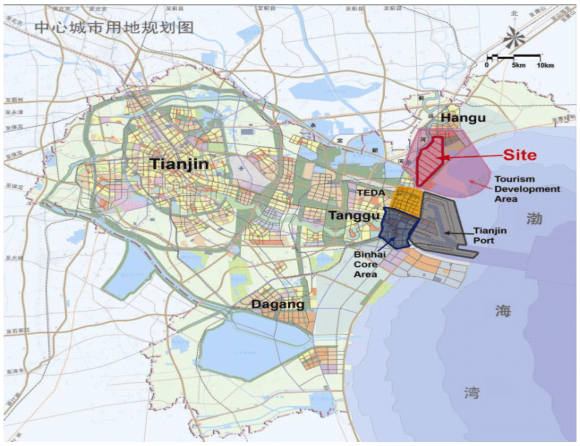
Currently there exists a public-private partnership on the redevelopment of Treasure Island. In December of 2006, the Development Plan and Term Sheet for Redevelopment of Naval Station Treasure Island was approved by the San Francisco Board of Supervisors. The development plans for Treasure Island include 6,000 new residential units (30% of which will be offered at below-market rates), three hotels, a 400-slip marina, restaurants, retail and entertainment venues—plus nearly 300 acres of parks and open space. The development is clustered around a new ferry terminal and is designed to prioritize walking, biking and public transit. Already projected to be the most environmentally-sustainable large development project in US history, the project was recently announced as one of sixteen founding projects of the Clinton Climate Initiative's Climate Positive Development Program.

The City of San Francisco, acting by and through the Treasure Island Development Authority (TIDA) as the local redevelopment authority, is responsible for the long-term redevelopment planning of Treasure Island. On behalf of TIDA, the City's Office of Economic and Workforce Development's Joint Development Division manages the day-to-day redevelopment planning process.

4.8 Conclusion - Case Studies

There has been substantial progress in recent years with APEC economies embracing renewable energy technologies, systems and resources for their urban areas. Today, there are numerous examples of successful application of such systems, as evidenced by the small sampling of clean energy projects and systems highlighted in this chapter. APEC cities looking to expand their activities in this area will benefit from the insights and experience of their colleagues across the globe, and hopefully, save time and money by accelerating the learning curve.

Chapter 5: Road Map



5. Road Map

5.1 Introduction

This chapter provides a roadmap for successful implementation of renewable energy technologies, projects and programs in APEC member economies – focusing on cities and local governments.

5.1.1 Rationale

Cities cover just two percent of the world's land mass but account for 70% of global Gross Domestic Product (GDP), more than 70% of energy consumed and over 70% of the greenhouse gas emissions from human activities. In 2009, half of the world's megacities were in APEC, with 231 million people and 60% of global primary energy demand.

Figure 5-1: Skyline, Kuala Lumpur, Malaysia

Source: Pusat tenaga Malaysia (Ptm), Malaysia Energy Centre, Ir. Ahmad Hadri Haris PPT presentation

Meeting the growing energy needs of these 21 economies, particularly the rising demand for urban energy services, is a priority for APEC's Economic Leaders. Collectively, they have committed to increasing use of renewable energy to help in meeting the region's needs, led by three key market drivers:

- *Energy Security*, to diversify a city's energy mix, reduce dependence on fossil fuels and provide a hedge against fuel price uncertainty.
- *Climate Change*, to ensure a cleaner environment by reducing CO_2, greenhouse gases and other harmful emissions. Renewable energy can be an essential element in city strategies to become low GHG or carbon neutral cities.
- *Economic Development*, to generate new and improved jobs, incomes, revenues and profits; diversify and strengthen local economies; and enhance the export base.

Cities can lead in fostering renewable energy development in their economies and providing a healthier environment for their residents. This can occur through their own activities and by creating an enabling environment that encourages citizens, businesses, schools, institutions, financiers and communities to move along a more sustainable energy path. Table 5-1 highlights the crucial role that cities can play in promoting renewable energy applications at the local level.

Table 5-1: Cities as Change Agents in Promoting Renewable Energy

Cities and local governments are in an ideal position to stimulate a transition to cleaner renewable energy technologies in their communities due to a number of factors:

- Serve multiple roles—decision makers, planning authorities, municipal infrastructure managers, role models for citizens and businesses— that position them as change agents.
- Empowered to govern and guide their communities, provide services and manage multiple assets.
- Maintain legislative and purchasing power that can be used to alter behavior in their own operations and the broader community.
- Poised to pilot innovative policies, financing approaches, and business models and bring successes to replication and scale-up.
- Broad access to a range of stakeholders to spread the word on renewable energy attributes for local applications.
- Positioned to lead cities into the "energy world of tomorrow," one based on distributed energy systems, improved efficiencies and smart grids.
- First stop for local citizens interested in energy security, job creation, climate protection and urban development—all of which can be enhanced through renewable energy systems and technologies.

Source: Presentation by Jose Etcheverry, York University, at Workshop on Developing Ontario's Green Energy and Green Economy Act, June 19, 2009

5.1.2 Value of a Roadmap

To achieve these benefits, it will be useful for APEC cities to develop action plans that specify a set of activities to accelerate adoption of environmentally beneficial renewable energy technologies in their own locales. In a few cities this planning has been completed; in most it has not yet begun or is in an early stage of development.

This roadmap provides information for urban leaders in the design of these action plans. Although each APEC city will have special and sometimes unique requirements in their planning— recognizing specific local needs and conditions—there are many common elements to be considered as set forth in this roadmap.

5.1.3 Expected Outcomes

Among the outcomes that cities can anticipate from increased use of renewable energy—including development of advanced technologies, products and services nationally—are:

- A cleaner, healthier environment through improved local air quality and reduced GHG emissions.
- Greater energy security.
- A greener economy and expansion in availability of green jobs.
- Local industrial development.
- Trade and export opportunities.
- Urban renewal.
- Regional development.
- A safer, more secure, cleaner, more reliable and more efficient energy system.

5.1.4 Ten Key Steps for Renewable Energy Action Plans

The remainder of this chapter focuses on ten priority steps for developing an effective renewable energy action plan for cities and local governments.

Table 5-2: Ten Steps for Developing a Renewable Energy Action Plan for Urban Areas

Step	Action	Report Section
1	Understand What Renewable Energy Means for Your City	5.2
2	Make a Commitment to Renewable Energy and Initiate a Plan of Action	5.3
3	Build an Effective Policy Framework	5.4
4	Establish Rules and Regulations	5.5
5	Address Technical Issues	5.6
6	Provide Access to Financing	5.7
7	Launch a Renewable Energy Awareness Campaign	5.8
8	Strengthen Local Capacity	5.9
9	Lead by Action: Cities Investing in Renewable Energy	5.10
10	Plan Management	5.11

5.2 Understand What Renewable Energy Means for your City

Over the last decade renewable energy technologies have made tremendous advances. Today, these technologies are commercially available for a range of electricity generation, thermal power and clean fuels applications. Further, investments by both the public and private sector continue to yield increased efficiencies, improved manufacturing techniques and economies of scale that are reducing costs while improving performance.

5.2.1 Renewable Energy Options for Urban Application

Technologies available for urban applications are summarized below, and in Table 5-3.

- *Biomass energy*—derived from agricultural, forestry, animal and some industrial wastes and by-products—is a widely available form of renewable energy. Biomass can be converted to electricity, liquid and gaseous fuels and a variety of useful products. Through effective use of urban and peri-urban resources cities can obtain a locally available source of fuel, heat and power while reducing wastes and harmful emissions.

- *Geothermal energy* in the form of steam and hot water can provide utility-scale electricity and urban-scale hot water for district heating. Such geothermal resources are limited geographically; only a few APEC economies make use of them on any important scale. (These include Indonesia; Japan; New Zealand and the United States.) Where the resources do exist, geothermal power plants are invariably located outside of cities, with geothermal electricity imported via the power grid.

- Geothermal heat pumps, which are commonly used employed in the heating and cooling of buildings, use the constant temperature of the earth below about 10 meters to provide an efficient and cost effective means for reducing energy consumption by 30-60%. Easy application and short payback times have resulted in many cities providing incentives for integrating these into new construction projects.

- *Solar energy* conversion is environmentally clean and opportunities are abundant worldwide. Solar thermal and PV equipment are modular and deployable on urban buildings and land parcels of varying size. PV system output closely matches peak power requirements in many cities and can provide electricity to meet building power requirements. Solar thermal systems can satisfy energy requirements for hot water and space heating. Incorporating solar energy into new construction/retrofits of existing buildings is often cost effective. In addition to installing systems on public buildings, many cities are encouraging their use on private buildings through tax credits, grants, and loans.

- *Small hydropower* is a mature, proven, efficient and reliable source of electricity. In near-urban locations it contributes to the electricity supply of many cities worldwide.

- *Wind energy* offers the largest near-term potential. It is cost competitive with coal-fired plants in some APEC economies, emission free and offers price stability. Municipal utilities in areas with strong wind resources can increase their supply of wind power to customers. Where cities have private utilities, governments can commit to purchasing a set amount of wind electricity each year and encourage consumers to do so as well. Cities can also promote small-scale urban wind turbines via wind-friendly zoning and planning regulations.

Figure 5-2: 7.5 MW Urban Windfarm, Atlantic City, NJ (USA).

The electricity is used by both the AC Utilities Authority Wastewater Treatment Plant and delivered to the regional electric grid. Source: Newark, NJ (USA) Star-Ledger newspaper, July 21, 2009 http://www.nj.com/news/index.ssf/2009/07/surveys_on_wind_turbines_sent.html

Table 5-3: Illustrative Urban Applications of Renewable Energy

	Technologies	Applications	2009 World Totals[12]
Thermal energy (from solar energy and earth energy)	Solar water heating (roof and facade mounted, tops of available structures such as parking lots, factories, etc.)	Hot water and space heating of residential, commercial, institutional and industrial facilities	145 GWth (solar heating capacity)
	Solar heat production (50C to 200C) using concentrating collectors and thermal storage	Industrial process heat with parabolic solar collectors & natural gas backup; operating temperatures 80 to 200C	
	Solar air heating	Space heating in buildings, heated air for process heat (e.g., production of high-value dried fruits)	
	Passive solar design of buildings, combining architecture with extensive daylighting, low-emissivity coatings of windows, responsive HVAC systems	Climatically responsive building designs to capture heat in winter and reject it in the summer, and to maximize use of natural light (daylighting). This approach combines daylighting within integrated architectural and energy design processes.	
	Geothermal heat pumps	Using the constant temperature thermal reservoirs > 10m below ground for air conditioning and space heating using heat pumps	30 GWth
	Geothermal energy	Some urban areas have regions of hot springs that could provide energy for space heating and industrial-commercial use	10 GW
Electri-city	Photovoltaic systems	Building-integrated grid-interactive PV systems for rooftops and facades	16 GW
		Free-standing grid-interactive PV arrays mounted on rooftops, tops of parking structures, other large available structures and available land, including brownfields	
		Free-standing PV-powered streetlights, traffic signals, emergency equipment not requiring grid power	
	Wind electric power	Grid-connected wind turbines and small wind farms on available and windy land in urban and peri-urban areas (e.g. brownfield development sites) and off-shore lakes and oceans	121 GW
	Small hydropower	Electricity generation	85 GW
	Biomass	Electric power, cogeneration	52 GW
Renewa ble fuels	Ethanol	Motor fuel and fuel additive	67 billion liters/year
	Biodiesel	Biodiesel is meant to be used in standard diesel engines, mostly for transportation	12 billion liters/year

[12] All gigawatt (GW) numbers are estimates. Source: REN21, 2009.

5.2.2 Outstanding Barriers to Renewable Energy Development

Despite their significant progress, renewable energy technologies continue to confront a number of barriers. As cities develop plans, policies and programs to increase their use of these technologies, it will be important to conduct activities that mitigate these barriers. Some of the key obstacles inhibiting the widespread use of renewable energy technologies are discussed below.

5.2.2.1 Policy

- *Policy Limitations*: Unfavorable or non-existent policy, regulatory and legal frameworks.
- *Fossil Fuel Subsidies:* Subsidies for fossil fuels that erode the competitiveness of renewable energy options, even with life-cycle costing.
- *Insufficient Rules and Regulations:* Land use, zoning, permitting and siting restrictions; building code limitations.

5.2.2.2 Finance

- *Higher Costs:* Higher upfront capital costs for some of the renewable energy technologies—despite lower operation and maintenance costs (O&M)—can yield higher installed costs than fossil fuel systems. Life cycle costing could address this situation but is not widely used in many countries.
- *Capital Market Constraints:* Imperfect capital markets; insufficient access to financing for project developers, entrepreneurs and consumers; and financing risks/uncertainties.

5.2.2.3 Capacity and Awareness

- *Limited Capacity:* Inadequate institutional capacity for renewable energy project/program design, development and implementation, including lack of skills/ knowledge; lack of government planning and approval capacity for urban renewable energy systems, especially in building-integrated applications.
- *Limited Awareness:* Lack of awareness and understanding of the benefits, costs and applications of renewable energy among policymakers, the local private sector, financial institutions and prospective customers.
- *Opposition:* Reluctance to explore/adopt renewable energy by utilities, building owners, private developers and others.

5.2.2.4 Technical

- *Renewable Energy Resource Data Availability:* Inadequate information on the prevailing renewable energy resource potential (solar and wind energy resources) for most APEC cities.
- *Dated Grid Forecasting Capacity:* Does not account for renewable energy benefits.
- *Lack of Smart Grid Infrastructure*: To efficiently and effectively tie renewable energy into the grid.
- *Technology Transfer:* Insufficient mechanisms for technology transfer.

5.3 Make a Commitment to Renewable Energy and Initiate a Plan of Action

In preparation for plan development a number of preliminary activities need to be undertaken.

5.3.1 Make a Commitment to Renewable Energy

Commit to increasing the city's use of renewable energy in the context of increased end-use energy efficiency. This should include quantifiable, time-bound goals for solar thermal, solar PV and other renewable energy applications.

5.3.2 Take Stock of Energy Status and Needs

This requires understanding the current and projected energy profile of the city. Activities would include:

- *Assess the current state of the city's energy resources*—fossil energy, renewable energy potential for increased energy efficiency ("negawatts"), etc.
- *Project future energy needs* of the city—residential, commercial, industrial and institutional—for a set timeframe. Typically this would be for the plan duration, with mechanisms for updating the plan and extending the operational time horizon.
- *Inventory national, sub-national and city incentives and disincentives* for renewable energy development and deployment.
- *Understand your constraints*, including what policy, regulatory and decision-making authorities the city government has when it comes to energy supply in general and renewable energy in particular. It is important that the renewable energy plan developed for the city reflects what can realistically be done to influence energy decisions within its boundaries.

5.3.3 Organize a Planning Task Force

Mobilize key stakeholders and assemble a task force to initiate plan development. This should include individuals spanning a range of interested parties including utilities and other energy service providers, energy consumer groups, government representatives, architects/engineers, citizen groups and non-governmental organizations. The Task Force would help in completing the stock taking exercise above, as well as in developing recommendations for the policies, practices and actions set forth in the plan. (See Table 5-4)

Table 5-4: New York Sustainable Energy Roadmap

To launch its plan, New York City established an Energy Planning Board comprised of ConEdison (utility company), the City's Economic Development Corporation, the NY Energy Research and Development Agency, the Association for Energy Affordability, the New York Building Congress, the New York Independent System Operator, Consumer Power Advocates and others to centralize and coordinate planning activities.

5.3.4 Prepare Action Plan for Renewable Energy Development

Plan components are presented below. The first step is to establish the planning horizon for the document. A realistic timeframe would be 2-5 years.

- *Planning Framework:* Provides the context for the plan including background, issues and barriers; establishes the plan vision, goals and quantifiable objectives; and sets forth an approach for conducting the program.
- *Situational Assessment:* Summarizes the existing energy resource base; current and planned energy consumption and use; and key organizations involved in energy delivery.
- *Renewable Energy Status:* Reviews viable renewable energy technology options and applications for the city in the planning timeframe.
- *Plan Actions*: Identifies specific activities to be undertaken by the city in the plan timeframe. This is the core component of the plan. The remainder of the roadmap addresses the key strategic activities to be addressed in the plan, including to:
    - Build an Effective Policy Framework
    - Establish Rules and Regulations
    - Address Technical Issues
    - Provide Access to Financing
    - Launch a Renewable Energy Awareness Campaign
    - Strengthen Local Capacity
    - Lead by Action: Cities Investing in Renewable Energy
    - Implement and Manage the Plan

5.4 Build an Effective Policy Framework

The most important activity a government can play in fostering renewable energy is to establish the policy and regulatory framework that will lead to ongoing investment in this sector. This section identifies activities that could be established to incentivize renewable energy development and deployment in urban areas.

5.4.1 Set Targets

As mentioned above, cities should first commit to aggressive targets for renewable energy as part of their primary energy supply. For example, some of the targets established by APEC economies include 12% of energy supply from renewables by 2012, 15% by 2015 and 20% by 2020.

5.4.2 Establish Legislative Framework

Establishment of an enabling legislative framework is essential in prioritizing the development of renewable energy as an area of strategic importance for cities and local governments. This framework contributes to a favorable investment climate that is crucial for attracting finance and ensuring sustained renewable energy development locally.

Table 5-5: Ontario's Green Energy Act

Efforts are underway in Ontario Province, Canada to develop and enact strong renewable energy legislation that could result in adoption of a *Green Energy Act.* This is aimed at developing a stable investment environment for renewable energy. The Act is based on the experiences of Germany and Spain whose renewable energy laws have led to their current leadership positions in the industry.

5.4.3 Mandate Markets

Mandates create markets and this has certainly been shown to be the case for renewable energy. Today, three main policies have been used in APEC economies to promote renewable energy at the national, state and city level and to support market stability. These include:

- *Renewable Portfolio Standards*, which require a mandated *quantity* of renewable energy (electricity, fuels) to be purchased in a specific timeframe. The wholesale or retail market participants (e.g., utility) are required to purchase the associated power/fuel.
- *Feed-in-Tariffs*, which permit producers of renewable-based electricity to connect to the grid and provide electricity at a mandated *price*. In 2008, a number of cities and local governments began to consider feed-in-tariffs in earnest and to explore how to implement these policies. Feed-in-tariffs can be an option in instances where a local government has jurisdiction to regulate the appropriate electric utilities.
- *Tendering*, which involves government sponsored competitive bidding processes for the acquisition of renewable energy electricity, with long term contracts awarded to lowest priced projects.

Renewable Portfolio Standards have been the foundation of the renewable energy markets at the state-level in the US, while the use of feed-in-tariffs was pioneered by Germany. In 2008, 49 countries, states and provinces worldwide had established RPS policies. At least 45 countries and 18 states, provinces or territories had implemented feed-in tariffs.

5.4.4 Offer Incentives

Because renewable energy technologies provide a number of benefits, many cities (as well as national and state governments) are offering a variety of incentive programs that: 1) enable businesses and homeowners to significantly reduce the cost of purchasing and installing a renewable energy generating system; and 2) provide rewards for using solar and wind-turbine produced electricity. These include:

- 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/support.
- Sales and import tax exemptions.
- Accelerated depreciation on renewable energy assets.
- Access to carbon finance through either the Clean Development Mechanism (CDM) or voluntary markets.

5.4.5 Coordinate Activities across National, State and Provincial Agencies

In many cases regional, national and/or state/provincial governments have created policies for renewable energy and climate change. As local governments put in place their own plans, policies and programs it will be important to coordinate with these activities, understand their benefits and limitations and ensure that activities are complementary. Appendix B includes a sampling of APEC cities with climate action plans.

5.5 Establish Rules and Regulations

Many APEC member economies have established rules and regulations regarding renewable energy deployment to ensure quality products and services are delivered into the marketplace, and to protect consumers from procuring inferior products and services. Examples are discussed below.

5.5.1 Embedding of Distributed Energy Systems in the Local Electricity Grid

- **Interconnection Standards**: Interconnection standards are needed to manage the technical and procedural process by which power producers connect power generation systems to the grid. Interconnection standards specify the technical, contractual, metering and rate rules for system owners and utilities.

- **Net Metering**: For electric customers who generate their own electricity, net metering allows the sale of surplus power (for example from their own PV system) to the grid to offset their electricity consumption at retail rates. This can be particularly attractive if there is "time of day" pricing where the electricity that is being offset is very expensive peak power.

5.5.2 Renewable Energy and Buildings

- **Building Energy Codes and Standards:** Require commercial and/or residential construction using renewable energy to meet certain energy standards. Many APEC economies already have such standards and codes in place, but they may be too conservative in light of the substantial technical advances and cost reductions of the past decade in energy-efficient building design, technology and operation. APEC economy governments at the municipal as well as regional and national levels can lead by example, requiring very high energy efficiency and low GHG-emissions in new public buildings and through retrofit of existing buildings.

- **Specific Mandates:** Some countries, states and provinces mandate the use of solar water heating in all new residential construction (subject to building height and other limitations) and as part of any energy-efficiency upgrade or retrofit. The leading APEC economy in this regard is China, which requires solar hot water systems on virtually all new residential buildings.

- **Solar and Wind Access Laws**: Solar and wind access laws protect a consumer's right to install and operate a solar or wind energy system at a home or business. Some solar access laws also ensure a system owner's access to sunlight.

5.5.3 Licensing/Certification/Permitting

- **Contractor Licensing**: Licensing standards and supportive training ensure that renewable energy contractors have the required experience and knowledge to properly install systems—solar water heating, active and passive solar space heating, solar industrial process heat, solar-thermal electricity and photovoltaics.

- **Equipment Certification Requirements**: Policies are needed that require renewable energy equipment to meet certain standards. This protects consumers from purchasing inferior equipment while safeguarding the industry as it is difficult for substandard systems to reach the market.

- **Solar and Wind Permitting Standards**: Permitting standards can facilitate the installation of wind and solar energy systems by specifying the conditions and fees involved in project development. Some local governments have adopted simplified or expedited permitting standards for renewable energy systems.

- **Zoning Laws:** APEC Leaders wishing to start their own roadmap need to examine the prevailing zoning, siting and permitting laws as they pertain to renewable energy. This information should be incorporated into the planning process.

5.6 Address Technical Issues

A number of activities can be undertaken by cities to increase technology performance and move technologies into the marketplace. These include:

- Support the development of renewable energy resource data collection and analysis, including geographic information systems (GIS) systems.
- Work with utilities to update outmoded grid forecasting capacity which does not account for renewable energy benefits.
- Work with utilities and others to reduce technical and procedural barriers to grid interconnection and increase the percentage of renewable energy on the grid. At present, renewable energy is not always compatible with existing grids; reliability requirements and permitting processes can take a long time.
- Work with local authorities, utilities, distribution companies and other key stakeholders to begin the transition to a smart grid infrastructure.
- Explore storage options to expand and firm up renewable energy supplies.
- Explore options for more effective technology transfer from other parts of the country, and internationally.
- Create renewable education and demonstration centers to increase visibility for renewable energy.
- Support pre-commercial R&D and applied research at academic institutions to assist in solving the scientific challenges and technical barriers for cost reduction and efficiency improvements. Also, ensure a smooth transition of this information to industry.
- Cost-share support of technology development centers with the private sector to stimulate technology advancement and encourage industry to find technical solutions needed for commercialization.

- Demonstrate innovative technologies in integrated systems to rapidly increase supply of renewable energy power. An accelerated prototype and scale up program can help to bridge the gap from development to manufacturing of components.
- Work with industry on promotion of a renewable energy supply chain.

5.7 Provide Access to Financing

Policy measures discussed above offer significant support in the area of finance facilitation. In addition, cities have a range of options for renewable energy fund-raising. Some of these are discussed below.

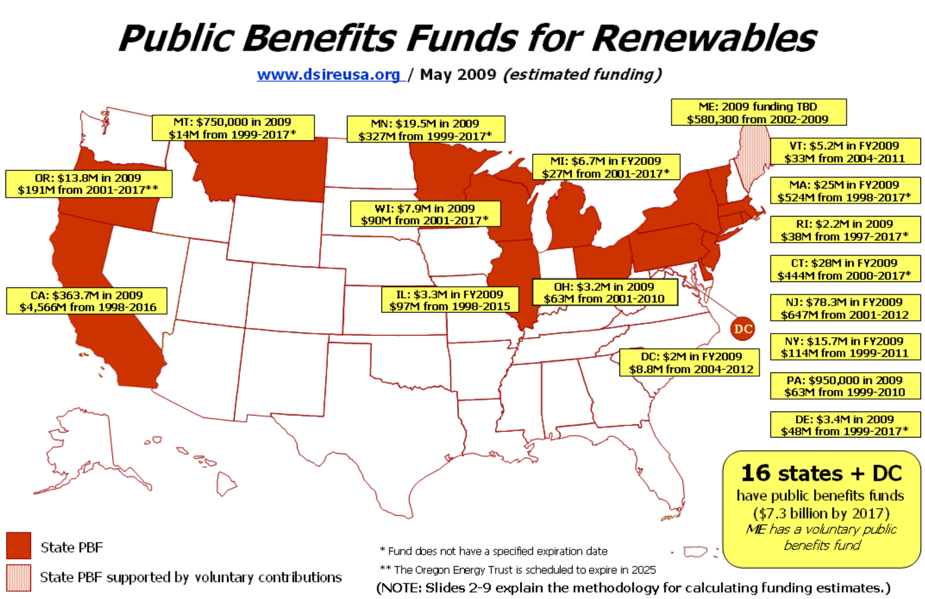
5.7.1 Municipal Financing

Renewable energy projects will save nearly all cities money in the long run. However, many of these projects may require significant upfront capital that cities and residents may not have readily available. Examples of funding sources cities can consider include:

- Establishing a dedicated renewable energy fund to support the development of renewable energy projects. Funding can be raised from a variety of public sources, e.g., bonds, carbon tax, surcharge on electricity bills, etc. This could operate as a revolving fund to provide low- or no-interest loans that will not have to compete for funding in the annual budget process. States in the US have been particularly active in setting up public benefit funds for renewable energy (see Figure 5-3).
- Leveraging bond ratings to obtain affordable financing for clean energy projects and to lower the risk for outside investors.

- Investing a small percent of city employee pension funds in renewable energy projects with good returns—often better returns than could be obtained from the stock market.

Figure 5-3: Public Benefits Funds for Renewables



Source: http://www.dsireusa.org/documents/summarymaps/PBF_Map.ppt

- Pledging a city's unused assets as collateral for a dedicated loan fund. A city's unused assets can include the value of property in parks, foreclosed homes and vacant lots held by the city. By pledging these assets as collateral, cities can significantly increase the number and dollar size of community and economic investments without additional funding.

- Accessing available funds from other government programs that may not be dedicated to renewable energy per se, but from which these technologies could benefit. These include clean energy funds; the use of local improvement charges (LICs) to finance renewable energy projects (often used for infrastructure programs); urban development funding; green mortgages to incorporate renewable energy systems through new home sales of refinancing; green bonds; and export assistance support, etc. Urban leaders interested in renewable energy planning will need to inventory available funding programs for their applicability to renewable energy and may need to make the case for eligibility of these technologies.

5.7.2 Local Financial Institutions

Local commercial banks can be important sources of financing as they understand local markets, conditions and players. However, bank managers and loan officers are often not be familiar with the technologies and their merits, and thus are reluctant to lend. In these instances targeted training for bank staff may be necessary on the technologies, their performance, costs, financing requirements and types of companies that could be requesting loans. Also they may require risk mitigation support (e.g., loans, loan guarantees, partial guarantees) to enhance their initial unwillingness to lend in this area. Over time, based on successful performance, this support could be reduced or eliminated.

5.7.3 Other Funding Sources

Beyond local funding sources, there are other entities that provide financial support for various aspects of renewable energy development, ranging from policy support to capacity building to technical assistance and awareness and to project and program development. Examples include the following:

- The World Bank
- Regional development banks such as the Asian Development Bank (ADB) and the Inter-American Development Bank (IDB)
- The Global Environment Facility (GEF)
- UN agencies
- Bilateral government agencies
- Global partnerships such as the Renewable Energy and Energy Efficiency Partnership (REEEP)
- Foundations
- Carbon Finance organizations

5.8 Launch a Renewable Energy Awareness Campaign

A barrier to mainstream adoption of renewable energy is the lack of awareness among consumers. Although many residents may have heard references to renewable energy, they do not necessarily know what it means for their daily lives and they lack the tools to purchase renewable energy equipment or support technology development.

Increasing awareness of renewable energy is important to educate consumers, generate public interest about renewable energy resources and build and maintain a consumer-driven market for renewable power. Enhanced knowledge will empower consumers to feel more in control of their purchasing decisions and be better able to identify products and services that most closely match their wants and needs in terms of quality, variety, service and value.

An awareness campaign will provide the framework to help in advancing renewable energy development. Awareness campaign objectives include:

- Raise awareness of renewable energy options, applications and benefits.
- Provide information on government-supported consumer programs and services, and their terms and conditions.
- Drive demand by promoting renewable energy as a viable means for developing sustainable energy solutions for the city and a sustainable industry base.
- Create demand by influencing community attitudes and producing fact-based information on the technologies.
- Stimulate the purchase of small-scale renewable energy systems installation.
- Leverage strategic alliances and partnerships with organizations connected to renewable energy in the city.
- Develop information, products and processes that promote the renewable energy market in general as well as add consumer value by verifying product quality.

Specific actions include:

- *Conduct market research* aimed at understanding key target markets, identifying early adopters and determining issues/obstacles.
- *Develop a communication and marketing strategy*— engaging key stakeholders from government, industry and consumer groups.
- *Create a "branding" campaign*.
- *Foster strategic partnerships* with key public, private and NGOs to promote the program.
- *Implement the marketing strategy*— collaborating with key partners and participating in high profile events.
- *Generate consumer education materials*, which can take several forms:
    - *Consumer outreach*: brochures and other consumer guides, factsheets and materials distributed through local forums
    - *Public relations activities:* news releases and public service messages
    - *Mass media:* television, radio and/or billboard messages
    - *Education of children or adults:* through school programs
    - *Consumer information resources*: hotlines, websites, YouTube, blogs, etc.
- *Engage key champions* (e.g., government officials, public figures, etc.) to provide assurance of renewable energy benefits and value, and stimulate public debate
- *Track outcomes*.

5.9 Strengthen Local Capacity

The transition from a conventional, centrally planned energy supply model as has been the case in most countries, to a more diverse, decentralized system with a multitude of players requires associated capacity strengthening support. The unique nature of renewable energy markets and their relatively short-lived experience worldwide—particularly in urban areas—also explains why capacity building needs are particularly great in this sector.

For renewable energy markets to grow and deepen in urban areas, capacity building is needed in all phases of renewable energy development. Further, capacity-building initiatives must target the range of stakeholders required for technology delivery including governments, local authorities, the private sector, nongovernmental organizations, academics and others.

Capacity building is more than just training. In many cases, targeted capacity building activities and technical assistance can be particularly effective in overcoming persistent challenges facing the deployment of renewable energy in urban areas. To be most effective, it should focus on "market-ready" technologies and applications that apply to cities or local governments.

Examples include:

- *Technology*: Capacity may be needed to develop academic, professional and vocational skills. Support is required on all aspects of technology research, development, demonstration, deployment, marketing, financing and operation and maintenance.

- *Policy:* Capacity activities support policy design, development and implementation, including information on the array of policy measures available and their experiences in other countries. Target audiences include government agencies, such as city and local governments in urban areas and their counterparts at the national, state and provincial levels. It also involves utilities and energy service providers, the private sector, consumer groups, nongovernment organizations and other stakeholders who will engage in the policy process.

- *Financial:* Financial institutions require training on the costs and rewards of renewable energy, how to review and assess projects, and the risks and risk mitigation instruments available for use to analyze potential renewable energy projects.

- *Businesses*: A range of business planning and support services may be required to assist companies across the value chain in the development and delivery of renewable energy products and services. This can include manufacturers, distributors, service providers, utilities, entrepreneurs, small and medium enterprises and NGOs.

The needs for capacity support may vary in cities across APEC economies—as each are in different stages of renewable energy development. Nonetheless, the fact remains that more effective strengthening of individuals and institutions is a prerequisite for the sustained scale-up of renewable energy.

To determine specific capacity requirements in your city:

- *Catalogue Capacity Needs*. This will need to address the range of eligible clean energy technologies, as well as to characterize the various end user groups. A needs assessment will help to pinpoint activities that should be undertaken and prioritize responses.
- *Develop a Capacity Plan.* This should include identification of target audiences, specific technical assistance and training needs, training medium (e.g., conferences, workshops, meetings, on-line training, study tours and guidebooks) and trainers and organizational partners (e.g., local universities, industry associations and international organizations).
- *Develop Strategic Partnerships.* To conduct capacity building, it will be useful to identify and engage individuals and organizations at the local, national and international level that can serve as key strategic partners in the development and delivery of training programs. This can include universities, industry associations, research centers, government agencies and others. Also, cities planning a renewable energy capacity building program can benefit from work that has been on-going internationally by governments, the private sector and international organizations (e.g,, IEA, REN21, UN agencies, national laboratories and others). Moreover, the newly formed International Renewable Energy Agency (IRENA) has been created as a clearinghouse for renewable energy knowledge, including the collection, generation and sharing of information on all aspects of the technologies.

Table 5-6: Illustrative Capacity Requirements for Renewable Energy in Urban Areas

• Creating or enacting renewable energy legislation and/or a legal framework that includes targets for development of renewable energy markets, and induced private sector investments. • Establishing mechanisms to encourage large- and small-scale grid-connected renewable energy generation such as feed-in directives, portfolio standards, etc. • Fiscal and financial incentives for renewable energy investments. • Conducting resource assessments and creating GIS databases. • Technology/application overviews. • Effective business models for renewable energy delivery. • Business planning and financing. • Job training/certification/employment programs. • Project development, feasibility studies and evaluation. • Standards development, testing and certification. • Finding and accessing carbon finance. • Increasing the use of renewable energy for heating applications. • Lessons learned from successful experiences in renewable energy promotion in leading countries/cities. • Public procurement/tendering for bulk renewable energy purchases.

- *Secure Funding and Support from Local and International Sources.* This could be in the form of financial, technical or human resources (e.g., provision of trainers and secondments of experts).
- *Begin implementation.*

5.10 Lead by Action: Cities Investing in Renewable Energy

Cities have a tremendous opportunity—some would say responsibility—to lead by example in conducting renewable energy projects in public buildings and city operations. This creates a market for the local renewable energy industry, encourages firms to locate in the city and creates good jobs in manufacturing, construction and maintenance. It also provides an environmentally sound, efficient and less expensive way of providing energy to government facilities. Further, installing solar and other renewable energy equipment and systems on public buildings increases familiarity with the technologies and demonstrates the city's commitment to technology development and innovation.

Examples of activities being conducted in cities worldwide include:

- Develop a Green Building Program requiring sustainable building design and construction practices, including renewable energy, into new municipal building projects.
- Retrofit city-owned buildings and facilities with renewable energy systems, such as solar and cogeneration.
- Replace aged, electric-based heating/cooling systems in city buildings with geothermal heat pump systems.
- For city-managed dumps, harness landfill gas and use power for a biodiesel production facility.
- Convert wood wastes collected by the city into a feedstock for power generation at cogeneration facilities.

- Construct a community anaerobic digester to process organic waste from food processors into biogas that generates electricity for city buildings.
- Convert city fleets to vehicles that run on ethanol or biodiesel.
- Explore opportunities for renewable energy projects in "brownfield developments."

5.11 Plan Management

The final step in the renewable energy action planning process is to describe how the plan will be managed. This includes: preparation of plan milestones and timetables; identification of management responsibilities, budgets and timelines; and creation of a process for monitoring and evaluation. The timeframe for these activities must correspond with the duration of the action plan (e.g., 3 years, 5 years, etc.).

5.11.1 Milestones and Timetables

The plan should include a clear, concise summary of key tasks and subtasks outlined in the plan, with associated milestones for completion of work. This can be presented in tabular form.

5.11.2 Management Responsibilities

This includes identifying the lead organization responsible for plan oversight and implementation. It also entails identifying other key actors that will be involved in plan implementation and clearly defining their roles and responsibilities. This would involve other government agencies at various levels (e.g., national, state, provincial, local), utilities and/or other power system actors, the private sector, consumer groups, academia, financiers, international organizations and others. An organizational chart should be included that graphically depicts the management structure.

5.11.3 Budget

Provide a budget for the planning horizon. This should entail both funding requirements and funding sources (committed and expected), organized by the key activities in the plan.

5.11.4 Monitoring and Evaluation (M&E)

This should address the purpose of the evaluation, how the findings will be used, performance indicators, data sources and collection methods, who will be undertaking the evaluation and the timing of the evaluation. Details of the M&E process can be provided in an appendix to the plan, as appropriate.

5.12 Conclusion—Roadmap

This roadmap provides information for urban leaders in the design of their own clean energy action plans. It offers 10 key steps for planning and implementing a comprehensive, sustainable renewable energy program and shares experiences gained from other cities and local governments. The roadmap identifies obstacles that need to be addressed in action plan development, offers pragmatic solutions for addressing these, and outlines requirements for managing, budgeting and tracking progress on this effort. Development and implementation of a renewable energy action plan can yield a range of economic and social benefits for the city and its residents. APEC member economies have initiated this process in select locales—the time is now to scale up and replicate these successes, demonstrating APEC commitment and leadership around the world.

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Appendix B: Sample of APEC Cities with Climate Action Plans

APEC Economy and City	Population	Web links
Melbourne, Australia [CPDP]	3,800,000	www.melbourne.vic.gov.au
Sydney, Australia	4,280,000	Sydney Climate Change Action Plan (http://www.cityofsydney.nsw.gov.au/2030/)
Toronto, Canada [CPDP]	5,500,000	Toronto Climate Change Action Plan (http://www.toronto.ca/changeisintheair/)
Beijing, China	15,380,000	www.ebeijing.gov.cn
Shanghai, China	18,450,000	www.shanghai.gov.cn/shanghai/node8059/index.html
Hong Kong, China	6,985,000	Hong Kong Climate Change Action Plan (http://www.epd.gov.hk/epd/english/climate_change/)
Jakarta, Indonesia	8,389,000	www.jakarta.go.id/v21/home/default.asp?lg=2
Tokyo, Japan	12,800,000	Tokyo Climate Change Action Plan (http://www.kankyo.metro.tokyo.jp/kouhou/english/)
Seoul, Republic of Korea [CPDP]	10,300,000	http://www.c40cities.org/cities/english.seoul.go.kr
Mexico City, Mexico	8,700,000	Mexico City Climate Change Action Plan (http://www.sma.df.gob.mx/sma/index.php?opcion=26&id=531)
Lima, Peru	7,800,000	www.munlima.gob.pe
Moscow, Russia	10,300,000	www.mos.ru
Bangkok, Thailand	8,160,552	www.bangkoktourist.com
Chicago, USA	2,833,000	Chicago Climate Change Action Plan (http://www.chicagoclimateaction.org/)
Houston, USA	2,200,000	Houston Climate Change Action Plan (http://www.greenhoustontx.gov/reports/emissionreduction20080909.pdf)
Los Angeles, USA	3,800,000	Los Angeles Climate Change Action Plan (http://www.lacity.org/index.htm)
New York, USA	8,200,000	New York Climate Change Action Plan (http://www.nyc.gov/html/planyc2030/html/plan/plan.shtml)
Philadelphia, USA	5,800,000	www.phila.gov
Hanoi, Viet Nam	3,399,000	www.hanoi.gov.vn/hanoien
Source: Clinton Global Climate Initiative www.c40cities.org/cities		