Energy Security and Sustainable Development in Asia and the Pacific

Biofuels
Biomass
Coal
Fuel cell
Gas
Geothermal
Hydro
Nuclear
Oil
Solar
Wind

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ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

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United Nations
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ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

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Foreword

From driving massive 3000cc-engine cars, to cooling rooms below 24 degrees Celsius, and from cooking on firewood stoves, to reading under kerosene lamps, Asia and the Pacific covers the entire spectrum of energy consumption. But the region is facing a serious energy security challenge in supporting its rapid economic growth. The question is: how can we secure, produce and consume these energy resources in a sustainable way—ensuring that socio-economic development does not compromise the carrying capacity of natural resources?

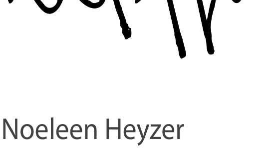
A few decades ago, energy consumption on this scale would have been celebrated as an indicator of economic success. And, of course, it still signals many remarkable achievements—especially for the millions of poor people who now have electricity in their homes, who can travel more easily to schools or health centres, or who have power supplies in their farms and workshops.

But nowadays the picture is growing darker. Many of the region's cities are being choked by pollution, our poorest families are being hit by escalating fuel costs—and, even more serious, we are all faced with the reality of global warming, which is jeopardizing many hard-won human development gains. As a result, an issue that had previously been taken for granted as part of the development backdrop has now thrust itself into the foreground and demands an urgent response.

So, what should this response be? Apply the brakes, raise prices, and trust that the shocks will not be too severe? The region has no time to waste in shifting towards a new energy paradigm which reduces high dependency on fossil fuel. Whether we like it or not, international energy markets are already forcing some painful adjustments. But this can only be part of the answer, indeed only a small part. Countries of the ESCAP region determined to achieve greater energy security have many other options for matching supply and demand in more sustainable and equitable ways. We can still meet today's urgent social needs, as encapsulated in the Millennium Development Goals, while protecting the natural environment—and the climate—for future generations.

That is why it is so important that energy policy is being considered at the sixty-fourth session of the Commission—presenting us with an opportunity to make a wide-ranging assessment of the region's potential for energy security.

In this spirit, we have prepared this theme study. It presents the latest data on our current and prospective use of energy while also exploring the innovations in technology, finance and governance that can set the region on a more sustainable path. I hope it will be helpful to policymakers and many other concerned stakeholders—illuminating the complexities, gaps and barriers, but also demonstrating how a new energy paradigm shift can contribute to more inclusive economic and social development.



Noeleen Heyzer
Under-Secretary-General of the United Nations and Executive Secretary of ESCAP

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Abbreviations

ACE	ASEAN Centre for Energy
ACMECS	Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy
ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
ALRI	acute lower respiratory infections
APCTT	Asia Pacific Centre for the Transfer of Technology
APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
APP-CDC	Asia-Pacific Partnership on Clean Development and Climate
ASEAN	Association of Southeast Asian Nations
BCM	billion cubic metres
BEE	Bureau of Energy Efficiency
BGF	gaseous biofuels
BIMP-EAGA	Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BLF	liquid biofuels
BOT	build operate and transfer
BSEC	Organization of the Black Sea Economic Cooperation
BTA	bilateral trade agreement
CAREC	Central Asia Regional Economic Cooperation
CCS	carbon capture and storage
CD4CDM	Capacity Development for Clean Development Mechanism
CDM	Clean Development Mechanism
CEIF	Clean Energy for Development Investment Framework
CER	certified emission reduction
CIS	Commonwealth of Independent States
CLASP	Collaborative Labelling and Appliance Standards Program
COPD	chronic obstructive pulmonary disease
CROP	Council of Regional Organizations of the Pacific
CTI	Climate Technology Initiative
ECNEA	Intergovernmental Collaborative Mechanism on Energy Cooperation in North-East Asia
ECO	Economic Cooperation Organization
ECT	Energy Charter Treaty
EESD	Efficient Energy for Sustainable Development Partnership
EGAT	Electricity Generating Authority of Thailand
EJ	exajoule
ENERGIA	International Network on Gender and Sustainable Energy
EPA	Economic Partnership Agreement
EPCA	Electricity Pool of Central Asia
ESCAP	Economic and Social Commission for Asia and the Pacific
ESI	Energy Security Initiative
EUEI	European Union Energy Initiative for Poverty Eradication for Sustainable Development
EurAsEC	Eurasian Economic Community

FAO	Food and Agriculture Organization of the United Nations
FDI	foreign direct investment
G8	Group of Eight
GATS	General Agreement on Trade in Services
gcm	gram of coal equivalent
GDP	gross domestic product
GEF	Global Environment Facility
GERIAP	greenhouse gas emission reduction from industry in Asia and the Pacific
GHG	greenhouse gas
GMS	Greater Mekong Subregion
GNESD	Global Network on Energy for Sustainable Development
GS	Grameen Shakti
GTI	Greater Tumen Initiative
GUSP	Gasohol Utilization Strategic Plan
GVEP	Global Village Energy Partnership
GW	gigawatt
GWh	gigawatt-hour
HVAC	high voltage alternating current
HVDC	high voltage direct current
IAEA	International Atomic Energy Agency
IBEKA	People Centered Economic and Business Institute
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IFC	Infrastructure Financial Corporation
IGCC	Integrated gasification combined cycle
IIEC	International Institute for Energy Conservation
IIFCL	India Infrastructure Finance Company Limited
INFORSE	International Network for Sustainable Energy
INPRO	Innovative nuclear reactors and fuel cycles
IPCC	Intergovernmental Panel on Climate Change
IPHE	International Partnership for the Hydrogen Economy
IREDA	Indian Renewable Energy Development Agency
ITDG	International Technology Development Group
JBIC	Japanese Bank for International Cooperation
JPoI	Johannesburg Plan of Implementation
KfW	Kreditanstalt Für Wiederaufbau (German Bank)
kgoe	kilograms oil equivalent
ktoe	kilotons oil equivalent
LNG	liquefied natural gas
LPG	liquefied petroleum gas
mb/d	million barrels per day
MDG	Millennium Development Goal
MEA	multilateral environmental agreement
MEPS	minimum energy performance standards
MFN	most-favoured nation
MIEEIP	Malaysian Industrial Energy Efficiency Improvement Project
MIGA	Multilateral Investment Guarantee Agency

MOU	memorandum of understanding
Mt	million tons
Mtoe	million tons of oil equivalent
MW	megawatt
NAFTA	North American Free Trade Agreement
NCMP	National Common Minimum Programme
NGO	non-governmental organization
NTB	national trade barriers
OECD	Organisation for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
PCFV	Partnership for Clean Fuel and Vehicles
PEG	Pacific Energy and Gender Network
PEG	Partnership for Equitable Growth
PIEPSAP	Pacific Islands Energy Policy and Strategic Action Planning
PIESD	Pacific Islands Energy for Sustainable Development
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Islands Renewable Energy Project
PPA	power purchase agreement
PPP	public-private partnership
PRETI	Pacific Renewable Energy Training Initiative
PRGF	Poverty Reduction Growth Facility program
PV	photovoltaic
R&D	research and development
RDI	Renewable Development Initiative
RE	renewable energy
REAP	renewable energy action plan
REEEP	Renewable Energy and Energy Efficiency Partnership
REM	renewable energy market
RPS	renewable portfolio standards
RTA	regional trade agreement
SAARC	South Asian Association for Regional Cooperation
SAIF	South Asia Investment Promotion Fund
SARI/E	South Asia Regional Initiative for Energy Cooperation and Development
SASEC	South Asia Subregional Economic Cooperation
SCO	Shanghai Cooperation Organization
SDPC	State Development Planning Commission
SEC	South Asian Association for Regional Cooperation Energy Center
SECSCA	Subregional Economic Cooperation in South and Central Asia
SEFI	Sustainable Energy Finance Initiative
SNV	Netherlands Development Agency
SOPAC	Pacific Islands Applied Geoscience Commission
SPECA	Special Programme for the Economies of Central Asia
SPM	strategic planning and management
SPV	special purpose vehicle
SSC	South-South cooperation
T&D	transmission and distribution
TERI	The Energy Resource Institute

TFC	total final consumption
TNB	Tenaga Nasional Berhad (electric power utility in Malaysia)
TOE	ton of oil equivalent
TPES	total primary energy supply
TW	terawatt
TWh	terawatt-hour
UNAPCAEM	Asian and Pacific Centre for Agricultural Engineering and Machinery
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNSD	United Nations Statistics Division
USAID	United States Agency for International Development
VAT	value-added tax
WEC	World Energy Council
WESM	wholesale electricity spot market
WHO	World Health Organization
WTO	World Trade Organization

EXECUTIVE SUMMARY

Over the past few years, energy security and sustainable development have moved up the global agenda. There are two main reasons for this: first, the impact of high and often volatile energy prices; second, concerns over environmental sustainability and particularly about the global climate. Both issues are critically important for Asia and the Pacific—a region in which impressive economic growth has boosted the demand for energy and put corresponding strains on the environment.

To pursue energy security, the countries of the region will want to ensure that energy supplies are available, sufficient, affordable and sustainable. This will mean taking a broad range of measures: conserving and raising energy efficiency; rationalizing pricing and taxation systems; improving energy sector governance; and diversifying energy supplies, in particular making greater use of alternative and renewable resources.

Energy-producing and -importing countries also need the appropriate legal frameworks, regulatory environments and systems for pricing and taxation, along with fair and transparent processes that will encourage public-private partnerships for developing energy infrastructure.

At the same time, they will want to consider the ecological and social implications. Across the region, some 1.7 billion people still rely heavily on traditional biomass for cooking and heating, and almost 1 billion lack electricity. This has enormous socio-economic costs—degrading the environment, spreading disease, increasing child mortality and weakening social services. It also restricts the opportunities for women, who have to gather and use traditional fuels. All of these have major implications for the Millennium Development Goals (MDGs): without better access to energy services, many of the MDGs may be missed.

RAPID GROWTH IN ENERGY CONSUMPTION

Since 1980, the world has doubled its use of primary energy and much of the increase has come from Asia and the Pacific. This is due to rapid economic growth, massive investments in infrastructure and a booming construction industry, rising populations and a decline in the use of non-commercial energy, such as biomass and waste. Moreover, this growth is likely to continue: as of 2005, annual per capita energy consumption in the ESCAP region was only 749 kilograms of oil equivalent (kgoe) compared with 1,580 kgoe in the rest of the world.

Compared with other parts of the world, this region also produces and consumes energy inefficiently. A viable strategy for energy security and sustainable development must therefore stress measures to reduce energy intensity—by boosting efficiency in production, conversion, transmission and utilization.

The region also has to find ways of reducing the impact on the environment and on the climate. This will mean diversifying to low-carbon energy resources, including natural gas, and renewable resources, and in some cases nuclear energy, while improving efficiency by making better use of new and more advanced technologies.

RENEWABLE ENERGY AND CLIMATE CHANGE

As yet, the countries of Asia and the Pacific have taken relatively little advantage of renewable energy. The entire region has abundant renewable resources, excluding hydropower, but these contribute less than 2 per cent of the commercial energy mix. This is partly because potential investors perceive renewable energy technologies to be risky—involving many small projects with high initial and transaction costs. Governments need therefore to make such investment more attractive, for example through public-private partnerships that enable the private sector to invest in project development, provide management skills and introduce modern technologies.

Renewable and other more efficient technologies would also help mitigate climate change. About 70 per cent of total greenhouse gas (GHG) emissions are related to energy, mainly from the combustion of fossil fuels for heat, electricity generation and transport. Countries have many options for reducing GHG emissions—at minimal, zero or even net negative costs. These include energy conservation along with increases in efficiency, better energy management, cleaner production and consumption, and changes in lifestyles. Other measures would include the removal of subsidies, applying peak-hour surcharges, and introducing energy efficiency regulations for industrial processes. Overall, countries can foster science-based decision-making that creates incentives for cleaner and more energy-efficient economic activities while increasing people's access to modern energy services.

Most countries in Asia and the Pacific have considered energy policies in isolation from policies for environmental protection and poverty. In reality, however, these and many other issues are closely connected, so the relevant policies have to be integrated to ensure that meeting the needs of one sector does not make it more difficult to meet the goals of the others.

THE POTENTIAL FOR TRADE

The region as a whole is rich in energy resources, both fossil and non-fossil. Asia and the Pacific has more than 50 per cent of the world's proven natural gas and coal reserves, 25 per cent of oil reserves, and close to 60 per cent of uranium reserves. But these are not evenly distributed. The best endowed subregion is North and Central Asia—which is the rich in natural gas, coal and uranium, and competes closely with South and South-West Asia in oil.

Making these resources available in the regional market at affordable prices will mean boosting energy trade. By global standards, however, the region's energy trade is underdeveloped: in 2005, the ESCAP region accounted for only 12 per cent of the annual electricity trade worldwide, about two thirds of which was in North and Central Asia. Imports and exports currently represent about 30 per cent of the region's total primary energy supply and production: the region is a net importer of energy but a net exporter of solid and gaseous fuels and primary electricity.

Energy security would be enhanced not just by more trade but also greater transboundary collaboration. Oil stockpiling is a good example. In an era of high prices and volatile markets with the potential to disrupt supplies, some oil-dependent countries in the Asia-Pacific region have either initiated strategic oil reserves or are considering doing so. This is an area that could benefit from a broader regional approach.

INVESTMENT AND FINANCE

At present, the production and distribution of energy is hampered by inadequate infrastructure. Between 2006 and 2030, demand in the region is projected to grow by about 2.75 per cent per year from 5,380 to 8,936 million tons of oil equivalent (Mtoe). This would require total investment in infrastructure of about $9 trillion—though, if countries take sustainable energy measures, the demand could fall to 7,710 Mtoe—reducing the required investment to $8.3 trillion.

Investment on this scale cannot come from traditional sources of funding. Official development assistance has generally contributed only $5.4 billion per year to energy projects in developing countries worldwide—far short of the $344 billion required annually for energy infrastructure development in Asia and the Pacific for the next 22 years. Bridging the gap will require innovative financing solutions, including special funds for infrastructure development and greater private-sector participation. Attracting sufficient capital will also require appropriate policies on pricing and taxation along with larger and more efficient financial markets that can draw on domestic savings and tap into international financial resources.

INNOVATION AND COMPETITIVENESS

Using fossil fuel resources more efficiently and developing alternative sources of energy will require technological innovations. But it will also need reforms in energy sector governance—in strategic planning, implementation and management of energy systems. These would be facilitated by effective knowledge management structures—sharing at both the national and regional levels vital information regarding renewable energy technologies, technology transfer, and ways to encourage private-sector participation. Additionally, rationalizing energy prices is crucial to ensure that economic competitiveness will provide additional funds to be injected into sustainable energy development

REGIONAL AND SUBREGIONAL COOPERATION

Since energy is a global commodity, it cannot be addressed only at the national level. The Asia-Pacific region is very diverse, and many countries have rich experiences and successful policies that can feed into regional and subregional cooperation systems. Initially, this might simply consist of joint projects for interconnections—transporting fuels or electricity from one region or country to another—but it could develop subsequently into frameworks for subregional and regional energy security.

Some of the cheapest and most practical solutions can come through South-South cooperation. Many countries in the region have expertise and experience that can serve as best practices and case studies for customized replication by others—particularly in renewable energy.

Many of these issues are already being considered by regional and subregional organizations. A number of those are working to identify the best intercountry policies, but they would be more effective if they could work together to integrate regional energy systems. It may also be useful to amalgamate these and future initiatives in an inclusive and strategic package—for example, through an Asia-Pacific sustainable energy security framework.

Thus far, much of the focus in the region has been concentrated on the highly populated and strongly growing economies—with less consideration for the interests and priorities of least developed countries, landlocked developing countries and small island developing States. These vulnerable countries now need special attention—through measures to widen their access to energy services, reduce import dependency and improve subregional and South-South cooperation.

Energy has become one of the most critical areas for government policy. The choices made now will have profound implications across Asia and the Pacific—for economic and social progress and the protection of the environment. The options are not simple and will inevitably involve trade-offs. But if they are made on a well-informed and rational basis, today's policy choices can not only ensure energy security and sustainable development for many decades ahead, but also help achieve the Millennium Development Goals.

ENERGY AND SUSTAINABLE DEVELOPMENT

Photo: Marie Ange Sylvain-Holmgren

"Energy security concerns have moved up the global agenda due to unpredictable supply and rising demand of energy"

1

ENERGY AND SUSTAINABLE DEVELOPMENT

Countries in the Asia-Pacific region concerned about energy security are seeking to protect themselves against shortages of affordable fuel and energy resources. But the policies they choose will have ramifications far beyond the supply of fuels and energy resources. They will also have a profound impact on economic and social development, and on the natural environment and the global climate. Indeed, it is clear that better policies on energy will be essential if the countries of the region are to meet the Millennium Development Goals.

Over the past few years, energy security concerns have moved up the global agenda. There are two main reasons. The first is unpredictable supply: the region's economies have been faced with high and often volatile prices for energy, particularly for oil and gas, combined with supply disruptions caused by political instability in some main supplier countries. The second reason is rising demand: rapid industrialization and impressive economic growth are increasing the use of oil, as China and India in particular have emerged as economic powers.

Although there is no internationally agreed definition of the term, a country is generally understood to have "energy security" if it is protected against shortages of affordable fuel and energy resources (box 1-1). The form this security takes will necessarily depend on national circumstances. For countries with their own resources, energy security involves the capacity to cope with changes in energy supplies using their own resources, while countries with fewer resources will be looking for reliable external supplies. Energy-exporting countries, on the other hand, will be looking for security in demand, from a stable energy market.

Box 1-1—Definitions of energy security

Different organizations have coined various definitions of energy security. For example:

Asia Pacific Energy Research Centre—In its report, *A Quest for Energy Security in the 21st Century*[a], the Asia Pacific Energy Research Centre defines energy security as the ability of an economy to guarantee the availability of energy resource supply in a sustainable and timely manner, with the energy price being at a level that will not adversely affect the economic performance of the economy.

European Union—The aim of the European Union is to ensure the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers, private and industrial, while respecting environmental concerns and looking towards sustainable development.

United Nations Development Programme—The UNDP *World Energy Assessment* report[b] defined energy security as the availability of energy at all times in various forms, in sufficient quantities and at affordable prices, without unacceptable or irreversible impact on the environment. These conditions must prevail over the long term. Energy security has both a producer and a consumer side.

[a] Asia Pacific Energy Research Centre, A Quest for Energy Security in the 21st Century, APEC # 207-Re-01.2, 2007 (available online at www.ieej.or.jp/aperc).
[b] UNDP, World Energy Assessment: Overview 2004 Update (United Nations publication, Sales No. E.04.III.B.6).

To sustain economic growth and raise living standards, energy shortages could be met by increasing supplies. But there are two other important considerations: environmental sustainability and social development. The current pattern of economic growth has caused serious environmental damage—polluting the air, creating large quantities of waste, degrading biological systems and accelerating climate change—with many of these effects coming from the energy sector. At the same time, it is also vital to consider the impact on social development. The lack of access to energy services aggravates many social concerns, including poverty, ill-health, unemployment and inequity—and threatens the achievement of the Millennium Development Goals.

STRUCTURE OF THIS THEME STUDY

This study covers energy security from the perspectives of supply and demand, and of environmental sustainability. It uses publicly available data, country studies and other information, including reports from

Box 1-2—Units of energy

The international unit for energy, is the joule, which is the energy of one kilogram moving at one metre per second. One watt is equivalent to one joule supplied each second. The following conventional abbreviations are used for watts:

kW = kilowatt = thousand = 10^3
MW = megawatt = million = 10^6
GW = gigawatt = billion = 10^9
TW = terawatt = trillion = 10^{12}

Correspondingly, GJ = gigajoule.

The two most commonly employed measures for large quantities of energy are millions of tons of oil equivalent (Mtoe) for fossil fuels, and terawatt hours (TWh) for electricity. One Mtoe is the amount of energy released when one million tons of crude oil is burnt. One million tons of gas would release rather more than one Mtoe of energy; one million tons of coal rather less. One Mtoe is equivalent to an average rate of energy supply of 1.33 GW over a period of one year and an average rate of energy supply of one GW over one year is equivalent to 0.754 Mtoe.

One TWh is the quantity of energy supplied when one trillion watts of electrical power is generated continuously for one hour—or one billion watts for 1,000 hours. One TWh supplied per annum (1 TWh/a) is equivalent to an average rate of energy supply of 0.114 GW and an average rate of energy supply of one GW is equivalent to 8.78 TWh/a.

In describing national or global energy budgets, it is also common practice to use large-scale units based upon the joule: EJ = Exajoule = 10^{18}

Source: www.rcep.org.uk/pdf/def-units.pdf and others

ESCAP, the United Nations Statistics Division, UNDP, APERC, BP and IEA. For demand forecasts, it uses IEA methodology, albeit modified for Asia-Pacific conditions. The study uses the international standard energy units (box 1-2).

Chapter 1—Energy and sustainable development— analyses the synergies between energy policies and economic, social and environmental policies. It also considers the implications for the Millennium Development Goals.

Chapter 2—Available energy resources—reviews the current status of energy supply, demand and available resources. It points out, for example, that energy supplies are dominated by fossil fuels and that energy use in industrial, transport and household sectors is often very inefficient. It also emphasizes the importance of energy trade.

Chapter 3—Financing energy infrastructure—looks at future energy demand, analysing market trends, and policies on pricing and taxation and likely needs for energy infrastructure. It also assesses where the finance could come from, including special funds for infrastructure development and other innovative financing options.

Chapter 4—Policies and institutional mechanisms— finds that current energy policies are inadequate, especially for the region's developing countries, and considers innovative approaches in technology, financing and governance.

Chapter 5—Energy trade and closer transboundary collaboration—deals with international energy cooperation, including the proposed trans-Asian energy system and the potential for South-South cooperation in technology transfer and in sharing knowledge and experience.

Chapter 6—New technology and better energy governance—looks at the changes that will be needed if countries are to make best use of conventional energy resources or introduce alternative and renewable energy sources. It also explores the opportunities for knowledge management and sharing of experience.

Chapter 7—Priorities for the most vulnerable countries—highlights the concerns of the least developed countries, landlocked developing countries and small island developing States. It considers how they could widen access to energy services, reduce import dependency and benefit from subregional South-South cooperation.

Chapter 8—Policies for energy security and sustainable development—summarizes the options presented in the study.

ENERGY SECURITY AND THE MILLENNIUM DEVELOPMENT GOALS

In September 2000, the General Assembly adopted the Millennium Declaration, a document that identified to some degree the need for energy, as did the goals that subsequently emanated from it. Goal 7 on environmental sustainability, for example, has indicators on energy use and solid fuels—along with targets to integrate the principles of sustainable development into country policies and programmes, and to reverse the loss of environmental resources.

While it may be thought that the MDGs underplay energy issues, numerous subsequent forums have recognized that efforts to achieve the MDGs should include strategies on energy. For example, in the Plan of Implementation of the World Summit on Sustainable Development, also known as the Johannesburg Plan of Implementation, the Summit agreed on actions to improve access to reliable and affordable energy services—and linked these to the MDGs.[1] Similarly, in the 2005 World Summit Outcome,

> "MDGs underplay energy issues, but efforts to achieve the MDGs should include strategies on energy"

the General Assembly recognized the importance of meeting energy demand and achieving sustainable development.[2] UN-Energy, a consortium of United Nations agencies, programmes and organizations, is also collaborating to achieve the MDGs by providing affordable and modern energy services.[3]

There is clearly some way to go. Many people lack access to such services—for lighting, cooking, heating, mechanical power, transport and communication.[4]

In the Asia-Pacific region, about 1.7 billion people still rely heavily on traditional biomass for cooking and heating, and one billion people lack access to electricity. South Asia had an average electrification rate of 52 per cent, with "developing Asia" having 73 per cent.[5] Across the region, this leaves 762 million rural dwellers and 167 million urban dwellers without electricity.

> "In the Asia-Pacific region, about 1.7 billion people still rely heavily on traditional biomass for cooking and heating, and one billion people lack access to electricity"

This has severe socio-economic costs. A lack of energy services keeps people in poverty, undermining social services, limiting opportunities for women and exacerbating environmental degradation—while increasing child mortality and contributing to the spread of disease. Services are particularly weak in the least developed countries, most of which are "off-track" in meeting the MDGs, and their people tend to spend a high proportion of their incomes on energy. The implications of energy services for the MDGs can be summarized briefly as follows:

> "Services are particularly weak in the least developed countries, most of which are "off-track" in meeting the MDGs"

Goal 1: Poverty—Energy services help provide communities with social services and opportunities for income and employment.[6] Households with access to modern fuels will be able to earn more from small businesses—and save time on domestic labour.

Goal 2: Education—Children in households with energy for lighting are better able to study.

Goal 4: Child survival—Providing energy for boiling water will help reduce waterborne infections, and replacing traditional fuels—fuelwood, charcoal, local coal, kerosene, crop residues and dung—with modern fuels, such as liquid petroleum gas, can reduce the incidence of respiratory diseases.

Goals 3 and 5: Gender equality—Women with better access to modern fuels spend less time gathering fuelwood and can cook more efficiently, and will thus have more time for educational, economic and other income-generating activities—as well as being less exposed to air pollution and waterborne illnesses.

Goals 5 and 6: Health—Electricity improves facilities in health clinics, providing illumination for night-time deliveries and treatment as well as for refrigerating vaccines and sterilizing medical equipment.

Goal 7: Sustainable development—Overexploitation of forests contributes to natural disasters, such as flash floods and mudslides, destroying entire settlements, properties, cattle, crops, and transport and communications facilities—and often provoking outbreaks of disease. Burning fuels also adds to greenhouse gas emissions.

Goal 8: Partnerships for development—Innovative collaboration mechanisms between governments, civil society and the private sector can ensure that the benefits of new energy technologies are widely shared and practiced in an affordable manner.

FUELLING ECONOMIC GROWTH

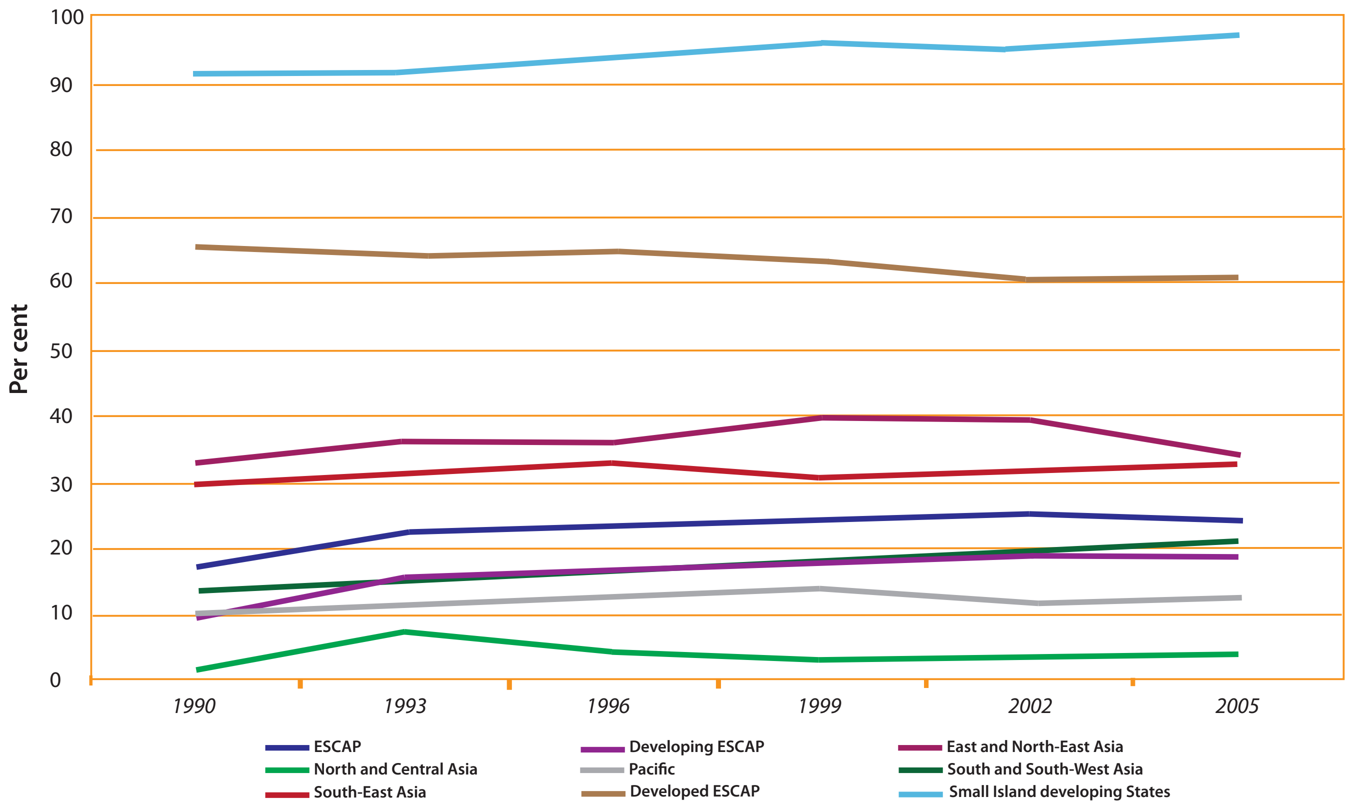
The Asia-Pacific region has experienced rapid economic growth which has boosted the demand for energy. Between 1980 and 2005, world energy consumption more than doubled, from 3,326 to 6,977 Mtoe, with much of the increase in Asia and the Pacific. Between 2004 and 2005, for example, while global consumption rose by almost 2 per cent, consumption in Asia and the Pacific rose by more than 4 per cent. The contrast was greatest for natural gas: globally, the increase was 1 per cent while in Asia and the Pacific it was 6 per cent—more than 6 times greater.[7]

> "While global energy consumption rose by almost 2 per cent, in Asia and the Pacific consumption rose by more than 4 per cent"

Although the region as a whole is richly endowed with energy resources, many individual countries are increasingly facing shortages and have to rely mostly on imports. Although over the past 15 years import dependency has varied across subregions, countries of the ESCAP region, in general, have increased their imports, as can be seen in figure 1-1. Small island developing States in particular are highly dependent on imported fuel and are therefore vulnerable to energy market fluctuations.

Many countries are very dependent on fossil fuels. A study in 2002 of six Asian countries—China, India, Indonesia, the Philippines, Thailand and Viet Nam—found that these fuels provided more than 75 per cent of total final energy consumption. This dependence has exposed people in many countries to rising international prices. A UNDP report published in 2007 pointed out that, even if the macroeconomic impacts thus far have been limited, or have yet to appear, many economies are at risk, and the report placed the countries of the region in one of three categories according to newly devised "oil price vulnerability index". It also confirmed that millions of poor people

Figure 1-1—Import dependency, 1990-2005



Source: United Nations Statistics, 2007.

Notes: Import dependency is calculated as the proportion of imports to the available energy supply (production and imports) excluding exports, transfers and stock changes.
Developed ESCAP includes Australia, Japan and New Zealand. Developing ESCAP refers to all other ESCAP countries.

across the Asia-Pacific region were being affected by soaring oil prices and considered the implications for the MDGs.[8]

> "Fossil fuels in China, India, Indonesia, the Philippines, Thailand and Viet Nam provide more than 75 per cent of total final energy consumption"

Economic competitiveness

An increasingly important factor affecting economic competitiveness is energy trade. A number of countries in the region—including Australia, Brunei Darussalam, the Islamic Republic of Iran and the Russian Federation, have substantial fossil fuel and uranium resources. On the other hand, many other countries lacking their own resources rely on imports—and those in remote locations or without significant capacity for stockpiling are vulnerable to price rises and market volatility.

All this has a major bearing on economic competitiveness. Naturally, exporters try to sell their energy products for the highest price, while importers want to purchase at the lowest price—and negotiate in a competitive market which encourages countries to improve efficiency. But the market can also create problems since prices exclude a number of external costs. Dirty coal, for example, may be cheap, but using it to generate electricity has long-term environmental and health costs. Governments are increasingly recognizing, however, that it is possible to grow economically and sustainably. While taking measures to boost competitiveness, they will also want to take account of non-economic concerns.

> "Dirty coal, for example, may be cheap, but using it to generate electricity has long-term environmental and health costs"

Impact of liberalization and regulatory reforms

Many countries have instituted reforms in their energy markets with the aim of boosting efficiency and extending energy services to the majority of their populations, while also reducing the financial burden of loss-making public utilities. Electricity supplies, for example, had long been regarded as requiring a public monopoly. This started to change in late the 1980s and early 1990s partly as a result of advances in electricity generation technologies. Governments were also putting more emphasis on markets in the belief that retail customers should be able to choose their supplier.

The reforms have differed greatly from one country to another, however, reflecting differences in the initial structure of the industry and in motivation. Some countries reformed only parts of the supply chain or chose to maintain a degree of vertical integration. Some countries retain public ownership, while others now have a mixture of public and private sector participation.

Differences may also have arisen depending on whether or not a country imports energy, on its size and on whether it had a centralized or federal system of government. Many have followed the model of having their independent power provision driven by foreign investment—as in Bangladesh, China, India, Indonesia, Malaysia, Nepal, Pakistan, the Philippines, the Republic of Korea, Thailand and Viet Nam. Overall, however, provision is still dominated by State ownership, regulation remains largely untested and competition is restricted.

Liberalization raises many difficult issues. For example, private enterprises may not invest sufficiently in maintenance or build enough reserve capacity to meet the rising demand. To reduce costs, they default to the cheapest fuels—though this increases damage to the environment or public health. They may also be less keen to invest in cleaner, and particularly renewable, technologies.[9] Above all, they may be less concerned than State enterprises about serving the poor, for while governments have used energy pricing and subsidies as a tool for social development, this is more difficult in a more liberalized market.

“Rising energy costs could be beneficial if they encourage greater efficiency and the use of new technologies, but could also harm the poor”

“The keys to successful reform are effective regulation and constant vigilance to ensure that efficiency gains translate into lower consumer prices”

The keys to successful reform are effective regulation and constant vigilance to ensure that efficiency gains translate into lower consumer prices. Unfortunately, in the early stages of reform, in the spirit of decreasing the role of the State, many countries did not pay much attention to regulation. The kinds of reforms needed for governance in the energy sector are: better cost recovery; increased competition; greater transparency and accountability; and human and institutional capacity-building.[10]

Impact of energy prices

Whether they are producers or importers of fossil fuels, developing countries generally subsidize energy prices and tariffs. This strategy, usually complemented by low labour costs, has boosted their GDP growth, but it has also enabled manufacturers to use energy inefficiently. Now, as countries have become richer and labour costs are rising, manufacturers are relying even more on subsidized energy. However, as energy costs, too, are rising, so are overall production costs.

Rising energy costs could in some ways be beneficial, particularly for the environment, if they encourage greater efficiency and the use of new technologies, but they could also harm the poor, who pay a greater percentage of their household income on energy services.

The UNDP study cited previously reported that, despite subsidies, oil price rises had a substantial impact on the poor. In four developing Asian countries between 2002 and 2005, poor households had to pay dramatically more for energy services.[11] For example:

- 171 per cent more for cooking fuels;
- 120 per cent more for transportation;
- 67 per cent more for electricity;
- 55 per cent more for lighting fuels;
- 33 per cent more for petroleum-based fertilizers and other agricultural inputs.

In coping with these price increases, many households had reverted to more traditional forms of energy or had seriously limited their energy use; for example, walking instead of using motorized transport or not using lights at night. Moreover, as the price of oil has recently exceeded $100 a barrel, there is some uncertainty as to how much longer Governments can offer subsidies, so the impact is likely to increase.

Rationalizing energy pricing and taxation

Energy prices are strongly affected by world demand and by both external geopolitical factors, including the policies of the Organisation of Petroleum Exporting Countries (OPEC) and the political situation in the Middle East. However, the prices within countries have generally been modified by government policy. Many Governments provide subsidies: worldwide subsidies are about $100 to $150 billion annually, three quarters of which is in developing countries. Under the earlier, socialist regimes, energy prices were indeed often lower than the cost of production. Generally, these involved cross-subsidies, with lower tariffs for rural households and agriculture and higher ones for other customers. Governments have also applied differential tax rates particularly for transport—higher for gasoline, for example, and lower for diesel.

Some Governments also set prices directly. In China, for example, prices are set by the central Government through the National Development and Reform Commission. In India, the prices of coal, electricity, oil products and gas are administered by the state-owned utilities: various state electricity boards, the oil corporations and Coal India Ltd.

Nevertheless, many Governments are now trying to reform their systems—gradually liberalizing energy prices and removing cross-subsidies. As a result, final prices for most fuels, except those of renewables, have increased and now better reflect the costs of production. Since the 1990s, the most significant price increases have been for household oil and electricity. In 1991, industry was often paying more than three times the prices of households, but subsequently prices have converged and in most countries household electricity prices are now only about 30 per cent less than those of industry.

Even after modification through subsidies and taxation, currently energy prices in many countries do not reflect the real costs of energy as they exclude ″externalities″ such as damage to health or the environment.[12] This is partly because it is very difficult to measure such impacts, which are highly dependent on local and national conditions. Most efforts in this region, such as ″green GDP″ in China, are still at the research stage.

Impact of energy efficiency on the economy

All countries want to use energy efficiently—to reduce production costs, conserve limited energy resources, increase productivity and offer lower prices to consumers. Efficiency also benefits the environment by reducing emissions of pollutants and greenhouse gases.

Energy efficiency can be defined as the effectiveness with which energy resources are converted into usable work.[13] This varies widely across industries and processes and between individual plants. Overall, however, there is still much more to be done. One estimate suggests potential worldwide energy savings of about 25 per cent by 2020 and over 40 per cent by 2050.[14]

“One estimate suggests potential worldwide energy savings of about 25 per cent by 2020 and over 40 per cent by 2050”

Much of this savings will be in Asia and the Pacific, particularly in the five most energy-intensive industrial sectors, which account for 45 per cent of all industrial energy consumption—iron and steel, petroleum refining, cement production, pulp and paper and chemicals.[15] There will also be considerable scope in the transport sector: Asia has some of the world’s most polluted cities and there are many opportunities for improving emission standards and vehicle efficiency.

As a way of increasing efficiency among energy-intensive industries, Governments in the Asia-Pacific region have been taking a number of measures, including changing pricing policies, and introducing economic and fiscal incentives.

ENERGY AND SOCIAL DEVELOPMENT

Modern societies have become highly dependent on energy—in businesses, industries and residences. Consumption has therefore risen along with the growth in population, particularly in the cities. This places considerable pressure on infrastructure, housing, facilities, social services and utilities, and, as a result, many urban centres are experiencing shortages of electricity, natural gas, gasoline, kerosene and biomass. Almost half the world's population still depends on inefficient and highly polluting solid fuels for their everyday household energy needs, in particular coal and biomass—wood, animal dung, and crop wastes.[16]

Across the region, however, the situation does vary considerably. As table 1-1 demonstrates for electricity, access in 2005 ranged from close to 100 per cent in many countries to 11 per cent in Myanmar and only 7 per cent in Afghanistan.[17] Countries such as Australia or New Zealand consume almost 100 times more electricity per person than Bangladesh, Cambodia or Myanmar. In 2002, about two thirds of electricity was generated in China, Japan and the Russian Federation.[18]

The situation is particularly difficult for the 641 million people in the Asia-Pacific region living on less than $1 per day[19] who spend a higher proportion of their income on energy.[20] They are also under greater pressure as a result of rising oil prices. Poor households depend on a variety of energy sources for urban and rural income generation, cooking food, communication, and obtaining education and health-care services. If they are to escape from poverty, they will need access to sources of modern energy—a "necessary, although not sufficient, requirement for economic and social development".[21] Easy access to energy can free the poor, and in particular women, from collecting fuel and allow them to carry out more productive activities, thereby increasing their income.

One priority is to integrate energy issues within rural development; another is to ensure that access for the poor plays a central part in national energy and economic planning. It seems clear, however, that many Governments lack the resources to fund energy investments for the poor.[22]

> "Half the world's population still depends on inefficient and highly polluting solid fuels for their everyday household energy needs"

Table 1-1—Population without access to electricity, 2005

	Electrification Rate %	Population without electricity million	Population with electricity million	Sources
Brunei Darussalam	99.2	0.0	0.4	APERC
Cambodia	20.1	10.9	22.9	World Bank (2004), Ministry of Planning
China	99.4	8.5	1,302.1	Ministry of Science and Technology, DOE, national Renewable Energy Laboratory
DPR Korea	22.0	17.7	5.0	IEA estimate
Indonesia	54.0	101.2	118.8	PLN Annual Report (2005), MEMR (2002)
Malaysia	97.8	0.6	24.7	GNESD (2000)
Mongolia	64.6	1.0	1.8	Helio International (2000)
Myanmar	11.3	45.1	5.7	Myanmar Electric Power Enterprise (2003)
Philippines	80.5	16.2	66.8	National Electrification Administration (2005), GPOBA (2003), JICA (2006)
Singapore	100.0	0.0	4.3	GNESD (2000)
Taiwan Province of China	99.2	0.2	2.7	IEA estimate
Thailand	99.0	0.6	64.1	AFREPREN/GNESD (2004), Electricity Generating Authority Annual Report (2004)
Viet Nam	84.2	13.2	70.3	World Bank (2005), Electricity of Viet Nam (2005)
Other Asia	82.0	8.3	37.9	IEA estimate
China and East Asia	**88.5**	**223.5**	**1,727.5**	
Afghanistan	7.0	27	2.0	World Bank, USAID (2005)
Bangladesh	32.0	96.2	45.3	GNESD (2000), Bangladesh Power Development Board, USAID (2005)
India	55.5	487.2	607.6	USAID (2005), TERI (2006), Ministry of Power (2004/2005), Census (2001)
Nepal	33.0	18.1	8.9	ADB (2004) USAID (2005)
Pakistan	54.0	71.1	83.5	Water and Power Development Authority (2005), USAID (2006)
Sri Lanka	66.0	6.7	13.0	GNESD (2001), USAID (2005)
South Asia	**51.8**	**706.2**	**760.3**	
Developing Asia	**72.8**	**929.8**	**2,487.8**	

Source: International Energy Agency, *World Energy Outlook 2006* (Paris, 2006).

Energy access for the rural poor

The need to provide energy access for the rural poor has been emphasized at a number of global gatherings, including the World Summit on Sustainable Development, which produced the Johannesburg Plan of Implementation, and the High-level Regional Meeting on Energy for Sustainable Development, held in Bali, Indonesia, in 2000, which endorsed the Sustainable Energy Development Action Programme.[23]

One problem is that policies to promote rural and community development and poverty often do not include energy considerations. Recognizing this shortcoming, ESCAP between 2002 and 2006 implemented a project entitled Capacity-Building on Integration of Energy and Rural Development Policies and Programmes—in Bangladesh, Cambodia, the Lao People's Democratic Republic, Myanmar, Nepal, Sri Lanka and Viet Nam. This project aimed to enhance the capacity of its developing member States to improve access for the rural population to clean and affordable energy services based on locally available resources. One of the outputs was a set of guidelines, covering such issues as the planning process, gender concerns, involving stakeholders, and building institutional capacity.[24] Some countries, including Bangladesh and Nepal, have been applying the ESCAP concept more broadly and developing national projects funded by multilateral funding agencies or donor countries.

> "Policies to promote rural and community development and poverty often do not include energy considerations"

Energy access for the urban poor

Urban poor households need energy for lighting, cooking, and cooling or heating, and also income generation in the informal sector where activities are often home based. Many live in informal overcrowded settlements with insecure land tenure and inadequate access to many services, particularly water and sanitation. Nevertheless, they will probably have electricity connections: only one person in five without electricity access lives in urban areas. However the quality of the service is often poor and erratic, and urban settlements suffer from frequent brown-outs and black-outs—to the detriment of small businesses operating on very narrow profit margins.

In some cases, where there is no direct supply from the electricity company, the urban poor make informal arrangements with a nearby house that has a legal electricity connection. Alternatively, those who can afford it, may turn to the private sector for generators. However, in both cases the poor pay more for the service than those with an official grid connection.

> "The poor pay more for the service than those with an official grid connection"

Health risks from energy use

Energy policies need to take into consideration the damage to health from the production and consumption of energy resources, especially the high consumption of fossil fuels and biomass. Much of the Asia-Pacific region, in both rural and urban areas, has serious problems from air pollution which across the region accounts for about 540,000 deaths per year.[25]
In urban areas the main sources of pollution are transport and industry. Countries could achieve a great deal without compromising economic growth by switching to cleaner fuels and increasing fuel efficiency.

In rural areas much of the pollution is generated indoors by burning solid fuels and biomass in open fires or traditional stoves.[26] Smoke carries a range of pollutants, including carbon monoxide and small particles which contribute to acute lower respiratory infections, chronic obstructive pulmonary disease, lung cancer, and other risks such as low birth weight, asthma, and nasopharyngeal cancer.[27] Across the world, indoor air pollution is responsible for 2.7 per cent of the global burden of disease and affects 800,000 children.[28] Asia has the largest toll with 407,100 deaths in India and 394,200 in China.[29] In 2002, as a result of indoor air pollution, 483,000 people, including 288,000 under-five children, died from pneumonia and other acute infections of the lower respiratory tract in South-East Asia alone.[30] Some of the smoke inhalation could be reduced by introducing improved stoves and ventilation. But the real solution is to help households switch from stoves that burn wood and dung to modern appliances that burn kerosene, liquefied petroleum gas or modern biomass fuels.

> "Asia has the largest number of victims from indoor air pollution with 407,100 deaths in India and 394,200 in China"

Gender issues

In poor households securing energy sources is generally the responsibility of women and children, and particularly young girls who often have to travel long distances to collect firewood, charcoal, cow-dung or waste materials—leaving them little time for other activities, including going to school or earning additional income for the household. Since women and girls are also generally responsible for household cooking and water boiling they also face serious smoke-related health hazards (box 1-3). Meeting the energy needs of poor households will thus improve education and help to empower women and girls.

> "Meeting the energy needs of poor households will improve education and empower women and girls"

Box 1-3—Impact of indoor air pollution on women and children

Women are particularly vulnerable to ill health caused by cooking with fuelwood or other biomass. Working indoors over open fires in smoky conditions they are exposed to harmful levels of gases, particulates, and dangerous compounds such as carbon monoxide, benzene and formaldehyde.

A report to the Commission on Sustainable Development in 2006 estimated that globally 1.6 million deaths per year were due to pneumonia, chronic respiratory disease and lung cancer. Other diseases associated with indoor pollution include asthma, bronchitis, tuberculosis, cataracts, low birth weight and heart disease.[a]

Acute respiratory infections related to indoor air pollution are a primary cause of disease and mortality in children under five and cause more deaths than malnutrition, diarrhoea or other childhood diseases such as measles or mumps.[b]

[a] Discussion paper entitled "Contributions by women" (E/C1/N.17/2006/5/Add.1) submitted to the Commission on Sustainable Development at its fourteenth session, New York, 1-12 May 2006 (the paper was developed through joint contributions by the ENERGIA International Network on Gender and Sustainable Energy, LIFE/Women in Europe for a Common Future, the World Conservation Union and the Women's Environment and Development Organization, in consultation with women's organizations throughout the world.)
[b] UNDP, *Gender and Energy for Sustainable Development: A Toolkit and Resource Guide (2004).*

ENVIRONMENTAL SUSTAINABILITY

The growth in energy use has serious environmental implications. Apart from depleting energy resources it can cause environmental damage, such as GHG emissions, air pollution, acid rain, loss of biodiversity and discharges of waste.

For the modern economic sectors one of the main sources of energy is oil. Although the world's largest oil consumer is still the United States, four Asian countries are not far behind; China comes second, Japan third, India fourth and the Republic of Korea sixth. For many countries, however, the main source of energy, domestic or imported, is still coal; the region has three of the five largest coal-producing countries—Australia, China and India.[31] Natural gas is also increasingly important: its fuel efficiency makes it an attractive choice for new power generating plants and for the industrial sector.

According to the IEA, if governments stick with current policies, global energy needs are likely to grow for at least 25 years, and by 2030 will be about 50 per cent higher than today. More than two-thirds of the growth will come from developing countries. On this "baseline" scenario, between 2006 and 2030 energy demand in the Asia-Pacific region, is projected to grow by about 2.75 per cent per year, with 45 per cent of this increase in demand coming from China and India.[32] Fossil fuels, especially oil and coal, will continue to dominate, meeting more than 90 per cent of the projected increase in primary energy demand.

This is raising serious concerns about greenhouse gases (GHG). Of global GHG emissions, about 70 per cent result from energy use. The most rapid growth is from the energy supply sector which between 1970 and 2004 increased GHG emissions by 145 per cent.[33]

Rising energy consumption and the continuing heavy reliance on coal also is contributing to worsening air pollution. Burning fossil fuels produces a number of toxic and noxious emissions, notably SO_x, NO_x, carbon monoxide and particulate matter and contributing to increased concentrations of ozone. Many of these problems are localized: despite some improvements in recent years, all large cities especially in China and India suffer from locally produced air pollution.

However, the pollutants generated by burning coal and oil products also drift across national borders. Pollution from China, India and other Asia-Pacific countries is not only causing soot deposition and acid across Asia; it is also contributing to acid rain in North America—undoing some progress that has been made there in reducing emissions in the last two decades.[34]

Other environmental concerns include water pollution and the disposal of waste, particularly nuclear waste. Though management of nuclear waste is covered by international treaties, proper disposal is still problematic. Given the long half-lives of some radioactive waste products, it is essential that disposal be done in a manner that ensures long-term safety.

There are also environmental concerns about the transport of energy products. Accidental release of crude oil, for example, has led to considerable damage to marine and coastal ecosystems. Despite measures to minimize the risks, accidents continue to happen.

In the rural areas one worry is the overexploitation of environmentally sensitive areas. Many people in rural areas rely on biomass fuels for cooking, heating and lighting. Overuse of these can lead to degradation of watersheds, and loss of biodiversity and habitats. On the other hand, when local populations are empowered to manage wood and other biomass resources properly they can make a major contribution to environmental protection.[35]

Improving patterns of energy production and consumption

An effective way to maximize long-term environmental sustainability is to promote more eco-efficient growth. This will mean, for example, fostering eco-efficient energy consumption—in production processes, buildings, transportation and electric appliances. At present, however, in most countries of the region energy efficiency is far below the global average. Energy efficiency, or "energy intensity", is usually measured as energy use per unit of GDP. Compared with developed

> An effective way to maximize long-term environmental sustainability is to promote more eco-efficient growth

countries, the developing and transition countries in Asia and the Pacific region have quite high energy intensities. Table 1-2 indicates the position of China, which in most sectors has a long way to go to achieve either the efficiency levels of OECD countries or those corresponding to global best practice.

Increasing energy efficiency would not only protect the environment and reduce emissions of greenhouse gases, it would also produce significant financial savings. The IEA estimates that, if countries focused on boosting energy efficiency, they could not only reduce global energy demand by 2030 by 10 per cent but also have saved $560 billion. There would also be lower investment requirements since it has been estimated that every $1 invested on demand-side management of electricity can save more than $2 of investment in the power sector—or almost $3 in developing countries where efficiency is currently much lower. Table 1-3 shows the potential energy savings that India could make over the period 2010-2030 for various types of electrical equipment.

Table 1-2—Primary energy intensities, China and OECD, 2003

Sector	Indicator	China	OECD countries	Best practice
Iron and steel	GJ/ton (crude steel)	36	18-26	*16*
Aluminium	MWh/ton (primary aluminium)	16.3	14.1-19.3	
Cement	GJ/ton (cement)	5.6	3.7-4.4	*3.4*
Petroleum refining	GJ/ton (refined product)	3.5-5.0	2.9-5.0	*1.3-3.8*
Ammonia	GJ/ton (ammonia)	39-65	33-44	*19.1*
Ethylene	GJ/ton (ethylene incl. feedstock)	73-90	58-68	*52*
Electricity	gce/kWh	380	312 (Japan)	

Source: ESCAP, 2004; *China Energy Statistical Yearbook 2005,* compiled by the Department of Industry and Transport Statistics of the National Bureau of Statistics, Energy Bureau of the National Development and Reform Commission, China, China Statistics Press.

Table 1-3—Potential energy efficiency improvements of equipment in India, 2010-2030

Product	Energy savings		GHG reductions MT CO_2	Saved energy (cents/ KWh)	Efficiency improvement potential (% unit energy consumption)
	Mtoe	TWh			
Refrigerator	77	16	259	1.0-3.0	45
Room air conditioner	23	5	78	1.1-2.5	6
Electric motor	14	4	47	1.3-5.2	12-39
Distribution transformer	45	7	153	3.4-3.9	56-62

Source: United States Agency for International Development, 2007, *From idea to action: Clean energy solutions for Asia to address climate change.*

Boosting energy efficiency will require considerable industrial restructuring, but at a time of high oil prices this is becoming increasingly cost-effective. Efforts to improve energy efficiency are under way in many member countries, including China, India, Japan, Kazakhstan and Thailand. At the same time, countries can take steps to boost eco-efficiency, which is "doing more with less impact".[36] This involves using natural resources more sustainably while reducing the environmental impact.[37]

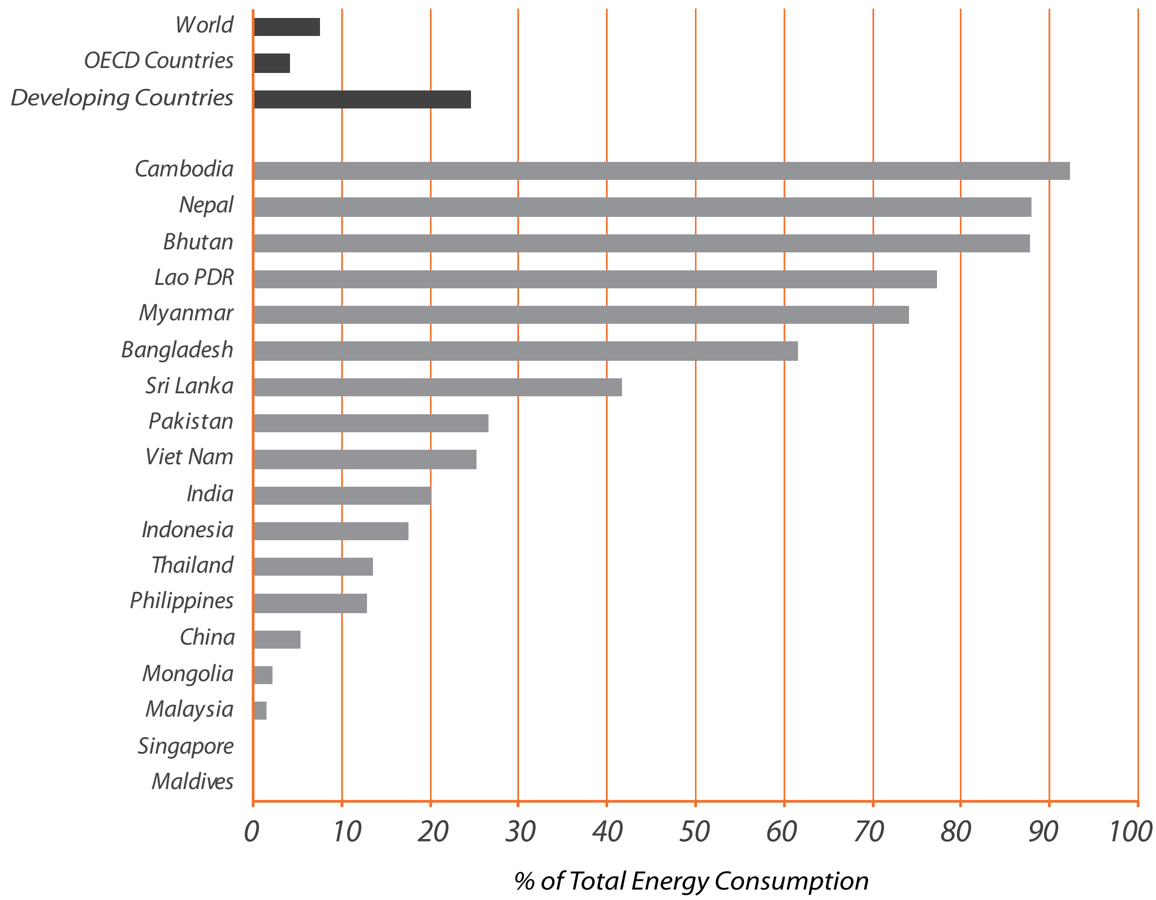
> "Every $1 invested on demand-side management of electricity can save more than $2 of investment in the power sector—or almost $3 in developing countries"

Increased use of renewable energy

Many countries are now aiming to make much greater use of renewable energy sources—including biomass, hydropower, wind, solar, geothermal and biofuels. All are key elements of sustainable and low-carbon development, but more importantly offer affordable and clean energy services to the rural poor.

Renewable energy has a relatively large proportion of the energy mix—by 2004, it accounted for 17 per cent of global primary energy consumption.[38] The proportion is even higher in Asia and the Pacific, where so many households use biomass for cooking and for cottage industries. In countries with low electrification rates, wood and other biomass are the source of over 70 per cent of residential energy consumption (figure 1-2).

Figure 1-2—Proportion of primary energy supplied by traditional biomass, 2002



Source: ADB report: Energy for all: Addressing the Energy, Environment, and Poverty Nexus in Asia, April 2007.

Note: Data for Nepal and Pakistan are for 2001.

Given the reliance on biomass, it will be important to take advantage of ways of using it in cleaner and more efficient ways. Options include: using improved cooking stoves and cogeneration; concentrating biomass into small pellets or briquettes; converting it to biogas in digesters, or gasification, which involves heating biomass to generate "producer gas".

Biogas technology has been widely utilized in rural areas to provide fuel for cooking and lighting—for example, in Bangladesh, China, India, Nepal and Sri Lanka. In Sri Lanka, many households have switched from kerosene bottle lamps to biogas, which not only gives them safer lighting but provides slurry for fertilizer. A number of local governments also find biogas technology useful for disposal of garbage. Biomass gasification is growing rapidly in some developing countries, such as China and India, where the resulting "producer gas" is being used for cooking or power generation. India in 2002 had about 35 MW of installed gasifier capacity. Gasifiers have also been demonstrated in Indonesia, Sri Lanka, Thailand and Viet Nam.[39]

In rural areas, different forms of renewable technology have been use to generate "off-grid" electricity. By 2005, more than 2 million households in developing countries in the region were generating electricity from stand-alone solar home systems—mostly in Bangladesh, western China, Fiji, India, Indonesia, Mongolia, Nepal, Sri Lanka and Viet Nam. As the costs of solar photovoltaic systems fall, markets are expected to expand steadily. Thailand, for example, had by 2006 electrified the remaining 300,000 non-electrified households in remote areas with solar home systems. Rural households are also generating electricity through small-scale hydro (< 50 MW) and wind power (<10 kW per turbine) technologies. By the end of 2005, China had installed 40 GW of small hydropower in rural areas, providing electricity to 300 million people. India, too, has been installing small hydrosystems: over the past 10 years, capacity has increased threefold. In the past three decades, Nepal, too, has made significant progress in the private sector in developing micro-hydro.

In addition to rural electrification, renewable energy has contributed to energy security by helping to diversify the energy mix. Grid-connected solar photovoltaic and wind power generation technologies have grown at an annual rate of over 20 per cent. The use of biofuels has also risen: in 2004, total production of bioethanol and biodiesel exceeded 33 billion litres, equivalent to about 3 per cent of global gasoline consumption.[40]

> **"Renewable sources of energy are likely to increase in importance as technology improves and costs continue to fall"**

Renewable sources of energy are likely to increase in importance as technology improves and costs continue to fall. At present, however, they provide only a small proportion of total energy needs. This is partly because many Governments continue to subsidize the distribution of conventional fuels, such as kerosene and diesel, in rural areas. This also discourages the private sector, which often views renewable energy projects as relatively risky undertakings, with high initial costs and high transaction costs.

Since renewable technologies offer ways of delivering sustainable energy services to the rural poor, Governments could instead take measures to offset these disadvantages. They could, for example, provide infrastructural support and make payments per poor household served. These subsidies could correspond to the benefits already allocated to urban households who gain from tax credits and subsidies on conventional grid-connected energy supplies. Governments could also work with the private sector to provide capital, entrepreneurship and linkages to modern technology providers through public-private partnerships.

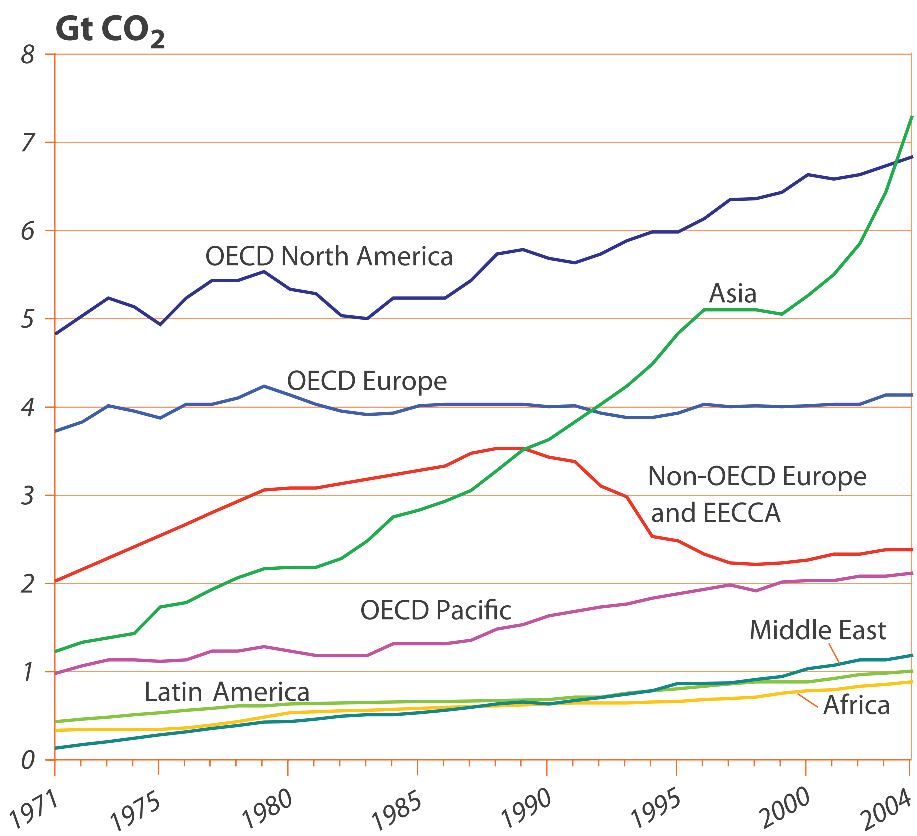
CLIMATE CHANGE

Corresponding to the rapid rise in primary energy use, there has been a surge in emissions of greenhouse gases. As is clear from figure 1-3, carbon dioxide emissions have been growing most rapidly in Asia, where between 1990 and 2004 they grew annually by 3.2 per cent.[41] This is not surprising in a region which has two thirds of the world's poor people and which has been aiming to alleviate poverty through economic growth, with a corresponding increase in the demand for energy, largely from fossil fuels.[42]

Per capita emissions in the region are lower than the average for the world, or of developed countries, but, as table 1-4 shows, these are almost all from the use of energy.[43]

> "Between 1990 and 2004, carbon dioxide emissions in Asia grew annually by 3.2 per cent"

Figure 1-3—Global trends in carbon dioxide emissions from fuel combustion, 1971 to 2004



Source: IPCC, Working group III report.

Note: EECCA-Eastern Europe, Caucasus and Central Asia.

Table 1-4—CO_2 emissions by sector, 2003

Sector	Mt CO_2		%	
	World	ESCAP region	World	ESCAP region
Electricity and heat	11,276	8,230	44.5	45.9
Manufacturing and construction	4,509	3,141	17.8	17.5
Transportation	5,122	3,495	20.2	19.5
Other fuel combustion	3,258	2,247	12.9	12.5
Fugitive emissions	151	54	0.6	0.3
Industrial processes	1,008	752	4.0	4.2
Energy total	24,317	17,167	96.0	95.8
Total	25,324	17,919	100	100

Source: World Resources Institute, Climate Analysis Indicators Tool (CAIT), http://cait.wri.org/.

Notes: Excludes land use change.

Increasing the atmospheric concentrations of greenhouse gases will have a serious impact in Asia and the Pacific.[44] There will, for example, be changes in water resources: over the next two or three decades, higher temperatures are likely to melt glaciers in the Himalayas, which will increase flooding and destabilize slopes, leading to rock avalanches. And by the 2050s climate change, in conjunction with rising demand, will reduce the availability of freshwater in Central, South, East and South-East Asia, affecting more than 1 billion people. The impact will be particularly significant in the coastal areas, especially the heavily populated mega-delta regions in South, East and South-East Asia which will be subject to flooding both from rivers and from the sea.

Also extremely vulnerable are small island developing States, particularly those in the Pacific. Deterioration in coastal conditions will damage local resources, such as fisheries, and inhibit tourism. Sea level rise is also expected to exacerbate inundation, storm surges, erosion and other coastal hazards—threatening vital infrastructure, and the livelihoods of island communities.

Climate change may also bring some positive effects, such as increased agricultural productivity at middle and high latitudes, but most natural systems will be adversely affected, particularly by an increase in extreme weather events. In Japan, for example, a mean temperature increase of 1°C for June to August has been projected to boost the consumption of summer products, such as air conditioners, beer, soft drinks, clothing and electricity, by about 5 per cent (table 1-5).[45]

Climate change will, however, hit hardest at the poorest developing countries that lack the necessary financial, technical and institutional resources. It will also have a more severe impact on poor people: while the rich may have the resources to adapt, the poor have fewer choices and may have to migrate as "environmental refugees".[46]

Developing countries are faced with objectives that are difficult to balance: on the one hand, they want to increase the use of modern energy services; on the other, they will want to reduce GHG emissions from the burning of fossil fuels. Nevertheless, for the region as a whole, improving energy security and boosting industrial competitiveness will become increasingly compatible with action to mitigate climate change. Dramatic increases in the prices of oil and other energy sources create strong incentives to increase energy efficiency and develop renewable energy—which also help to minimize GHG emissions and promote sustainable development.

Table 1-5—Impact of climate change in Japan

Changes in climate parameters	Impacts
1°C temperature increase in June to August	About 5 per cent increase in the consumption of summer products.
Extension of high temperature period	Increase of consumption of air-conditioners, beer, soft drinks, ice creams.
Increase in thunder storms	Damage to information devices and facilities.
1°C temperature increase in summer	Increase in electricity demand by about 5 million kW; Increase in electricity demand in factories to enhance production.
Increase in annual average temperature	Increase of household electricity consumption in southern Japan. Decrease in total energy consumption for cooling, warming in northern Japan.
Change in amount and pattern of rainfall	Hydroelectric power generation, management and implementation of dams, cooling water management.
1°C increase in cooling water temperature	0.2 to 0.4 per cent reduction of generation of electricity in thermal power plants, 1 to 2 per cent reduction in nuclear power plants.

Source: Harasawa H., N. Mimura, and Y. Hayashi. 2003.

Options to reduce GHG emissions

Countries have many ways to reduce greenhouse gas emissions and energy costs. These include measures for energy conservation and improving end-use energy efficiency in residential, industry and transport sectors—along with encouraging cleaner production, and changing consumption patterns and lifestyles (table 1-6).[47]

China, for example, recently publicized its first national climate change programme, which aims at improving energy efficiency (box 1-4). In 2007, the Government of Japan launched "Cool Earth 50" initiatives. The Government of India is currently working to develop a national climate change strategy.

Another important option is to switch to clean or low-carbon-emitting technologies, which include, as discussed above, renewables and nuclear power. Nuclear power appears to be experiencing a renaissance. Globally, four gigawatts (GW) of new nuclear plants have come online since 1 January 2005,

"Countries have many ways to reduce greenhouse gas emissions and energy costs, including measures for energy conservation and improving end-use energy efficiency in residential, industry and transport sectors along with cleaner production and changing consumption patterns and lifestyles"

Table 1-6—Measures to reduce greenhouse gas emissions and enhance energy security

Issue	Measures
Renewable energy resources	• Setting targets for an increase in the share of renewable energy (e.g. Renewable Portfolio Standards); • Subsidies for renewable energy- based electricity generation (e.g. feed-in tariffs, grid connected photovoltaic roof-top programmes); • Promotion of research and development on renewable energy; • Shifts to smaller-scale and distributed technologies through funding renewable-based distributed generation systems in rural areas (e.g. solar home system, hybrid system).
Fuel switching and diversification	• Setting targets for biofuel use (e.g. 5 per cent blending with gasoline); • Diversify energy mix away from oil (e.g. switching from oil to natural gas); • Development of alternative fuels (e.g. gasohol, biodiesel).
Energy efficiency and conservation	• Setting legislative measures for energy efficiency; • Setting mandatory targets for energy efficiency (e.g. vehicle fuel efficiency standards, building energy standards, energy labelling standards for appliances energy monitoring); • Subsidies for energy-efficient technologies; • Higher taxes for larger vehicles; • Funding R&D for energy/carbon efficient demonstration/ pilot projects; • Establishing an Energy Service Company (ESCO).

Source: based on Institute for Global Environmental Strategies (IGES), *Asian Aspirations for Climate Regime beyond 2012,* 2006.

and an additional 19 GW, representing 24 new plants, are currently under construction.[48] However, adopting these options widely will mean overcoming a number of barriers—informational, institutional, financial, technical, technological, and political.

National initiatives have been supported by regional ones. These include: the Asia-Pacific Partnership on Clean Development and Climate, involving Australia, China, India, Japan, the Republic of Korea and the United States with a focus on technology, and the United States-led High-Level Meeting of Major Economies on Energy Security and Climate Change, held in 2007. In addition, 40 of the world's major cities have established the "C40 Cities-Climate Leadership Group" to make joint efforts to reduce energy consumption and use cleaner energy.[49] In Asia, the C40 cities in addition to those in developed countries include Bangkok, Beijing, Jakarta, and Seoul.

Box 1-4—China's National Climate Change Programme

China's actions to control its GHG emissions by 2010 include a reduction in energy consumption per unit of GDP of 20 per cent compared with 2005; the stabilization of nitrous oxide emissions from industrial processes at 2005 levels; the control of methane emissions; and significant improvements in scientific research and technological innovation.

To help realize these objectives, the country will: develop a medium- and long-term energy programme to achieve a more diversified energy mix; raise the proportion of renewable energy (including large-scale hydropower) in primary energy supply to 10 per cent by 2010; and extract up to 10 billion cubic metres of coal bed methane.

China's actions will rest upon the following principles:

- addressing climate change within a framework of sustainable development;
- common but differentiated responsibilities;
- equal emphasis on mitigation and adaptation;
- integrating climate change policies with other interrelated policies;
- relying on advances and innovation in science and technology;
- international cooperation.

Source: National Development and Reform Commission, www.ndrc.gov.cn

Mitigation of greenhouse gases from the energy sector

According to the Intergovernmental Panel on Climate Change (IPCC), between 1970 and 2004, global GHG emissions due to human activities increased by 70 per cent. Reversing this trend will require a large shift in investment patterns. If levels in 2030 are to return to 2005 levels, according to the IPCC some 60 to 80 per cent of the reductions would need to come from energy supply and use.[50]

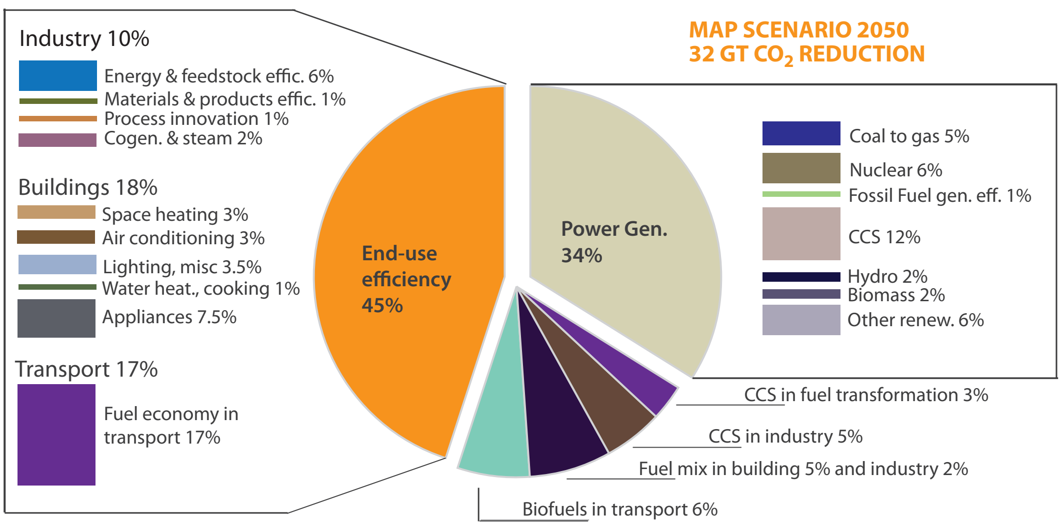
A similar perspective comes from the International Energy Agency (IEA). In its Energy Technology Perspective, which considered potential reductions in CO_2 emissions by 2050, it concluded that 45 per cent of the reductions could come from increased efficiency in the use of energy—far more than from any measure on the supply side (figure 1-4).

Those who act early on energy efficiency will be in a strong position. Renewable energy will turn into a huge business. The carbon market is projected to be the world's largest commodity market,[51] in Europe, carbon emissions reductions now trade at about $30 per ton, and there are also business opportunities in improving energy efficiency.

Trading in carbon emissions is one of the flexibility mechanisms within the framework of the Kyoto Protocol.[52] Another is the Clean Development Mechanism (CDM), which allows developed countries to offset emissions by investing in emissions reduction in developing countries. There are many concerns about technology transfer commitments and the effectiveness of the current CDM, but it has nevertheless resulted in significant investment in Asia and the Pacific. Currently, 18 countries in the region host CDM projects and Asia as a whole has 80 per cent of volumes transacted.[53] Another similar Kyoto mechanism is joint implementation, which allows one industrialized country to gain credits from investment in emissions reduction in another, usually an economy in transition.

In addition to the carbon market governed by the United Nations Framework Convention on Climate Change,[54] there are a number of voluntary carbon

Figure 1-4—Energy Technology Perspective scenario for reduction of GHG emissions



Source: International Energy Agency, *Energy Security and Climate Policy* (Paris, 2007).

CCS: Carbon Capture and Storage

markets. Since 2003, these "carbon offsets" have been expanding rapidly. Individuals contribute voluntarily to carbon reduction projects as a way to offset the GHG emissions linked to their way of life. Corporations investing in voluntary markets tend, however, to make such actions not to obtain carbon credits per se but to prove their commitment to corporate social responsibility.

The way forward

Mitigating climate change in the energy sector will require a broad range of measures. These include improving energy efficiency, investing in renewable energy, and shifting from unsustainable patterns of consumption and production.

Governments can provide incentives for greater energy efficiency—for example, by removing electricity subsidies, applying peak hour surcharges, and introducing appropriate regulations for industrial processes. They can also help small and medium- sized enterprises to improve energy efficiency.

At the same time, Governments can work together to expand the carbon market and steer energy systems investors into more climate-friendly alternatives—optimizing the use of available funds by spreading the risk across private and public investors.

AVAILABLE ENERGY RESOURCES, SUPPLY AND DEMAND

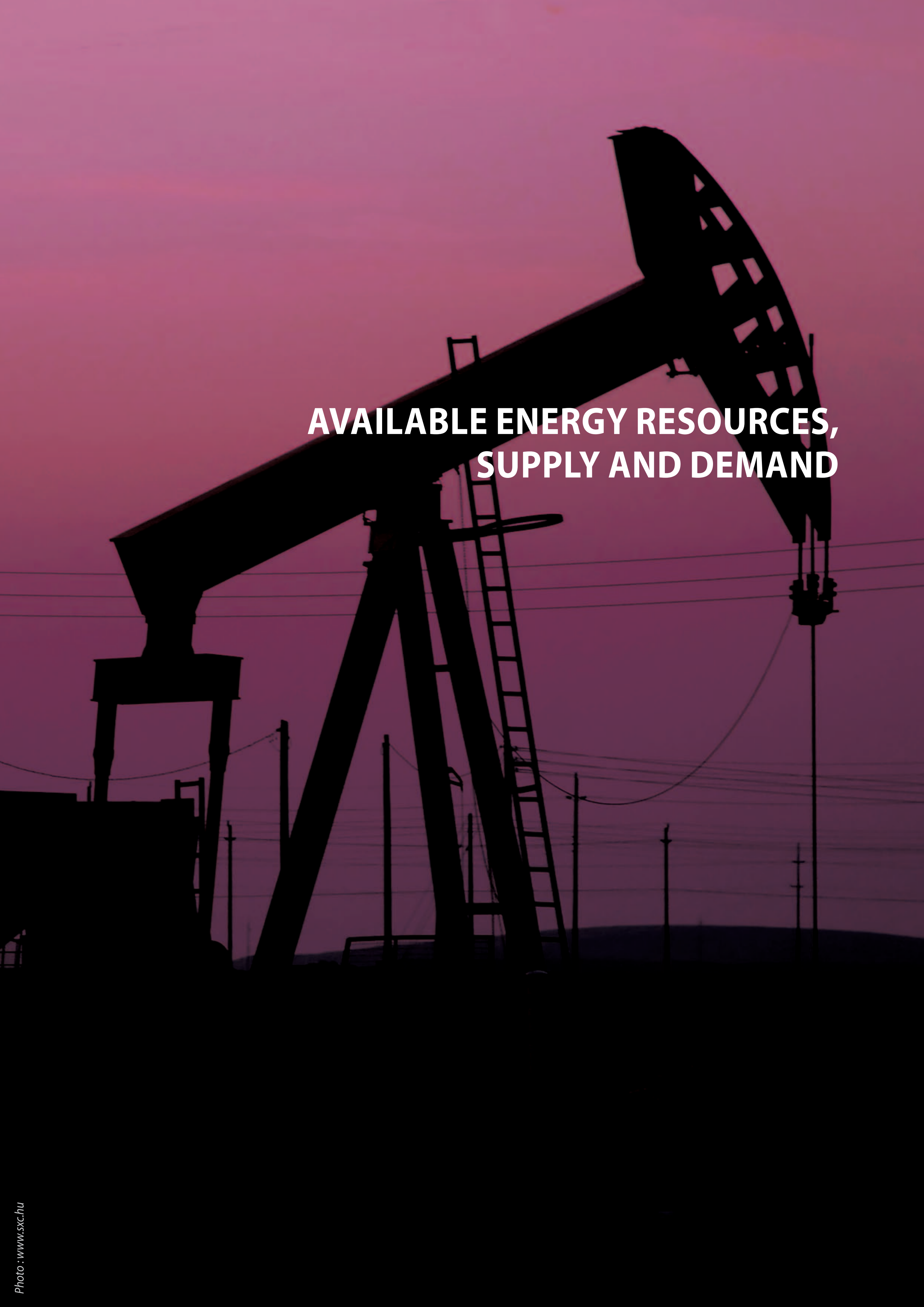


Photo : www.sxc.hu

"The ESCAP region as a whole is rich in energy resources both fossil and non-fossil, but these are not evenly distributed"

2

AVAILABLE ENERGY RESOURCES, SUPPLY AND DEMAND

Energy security hinges on the availability of diverse energy resources produced in sufficient quantities and at reasonable prices. This chapter looks at the key aspects of energy security—availability, production, and demand. It also looks at energy efficiency, which contributes to global energy security in an environmentally responsible manner.

ENERGY AVAILABILITY

Asia and the Pacific is rich in energy resources—with more than 50 per cent of the world's proven resources of natural gas and coal, 25 per cent of oil reserves, and close to 60 per cent of uranium reserves. For natural gas, coal and uranium, the richest subregion is North and Central Asia, while for oil it is South and South-West Asia (table 2-1).

The region is also well-endowed with renewable energy resources. It has 40 per cent of the world's total hydroelectric technical potential (table 2-2), and about 35 per cent of its annual solar and high temperature geothermal energy potential (table 2-3). It also has substantial potentials of biomass and wind energy.

Table 2-1—Fossil fuel reserves, 2006

	Oil reserves			Natural gas reserves			Coal reserves		
	Billion barrels	*% World*	*Years[a]*	*Trillion cubic metres*	*% world*	*Years[a]*	*Billion tons*	*% world*	*Years[a]*
East and North-East Asia	16	1.4	12	2.5	1.4	42	116	13	49
North and Central Asia	128	10.6	29	56.7	31.3	75	188	21	464
Pacific	4	0.4	21	1.4	0.8	33	79	9	208
South and South-West Asia	143	11.9	76	30.4	16.8	167	100	11	194
South-East Asia	13	1.1	14	6.7	3.7	35	6	1	26
ESCAP region[b]	***306***	***25.3***	***34***	***98.0***	***54.0***	***79***	***489***	***54***	***123***
ESCAP region	226	18.7	42	52.0	28.7	83	332	36	91
Developed ESCAP	4	0.4	21	1.0	0.5	22	79	9	209
Developing ESCAP	301	24.9	35	97.1	53.5	81	410	45	114
World Total	***1,208***	***100.0***	***41***	***181.5***	***100.0***	***63***	***909***	***100***	***147***

Source: BP, *BP Statistical Review of World Energy* June 2007, http://www.bp.com/statisticalreview, accessed in November 2007.

Notes: [a] Years = ratio of reserves to production.
[b] Including the Russian Federation.

Table 2-2—Hydroelectric potential and uranium reserves

	Hydroelectric technical potential, 1997		Uranium reserves, 2003	
	TWh	*% world*	*Metric tons '000s*	*% world*
East and North-East Asia	6,821	14.8	118	2.8
North and Central Asia	3,517	7.6	1,230	28.7
Pacific	593	1.3	1,058	24.7
South and South-West Asia	4,244	9.2	68	1.6
South-East Asia	3,461	7.5	8	0.2
ESCAP region	***18,636***	***40.5***	***2,482***	***57.9***
Developed ESCAP	1,134	2.5	1,065	24.8
Developing ESCAP	17,502	38	1,417	33.1
World	**46,000**	**100**	**4,288**	**100**

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Table 2-3—Other renewable energy resources potential

	Biomass energy potential, 2050[a] (Mtoe)		Solar energy potential (Mtoe/year)		Wind energy theoretical potential[b] ('000 TWh/ year)		Geothermal energy potential (TWh/year)		
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low temp (EJ/a)*	*High temp, conven-tional*	*High temp, conven-tional and binary*
ESCAP region	310	502	11,159	415,257	62	88	>430	4,020	8,000
World	5,398	9,458	37,618	1,190,336	500	483	>1,400	11,200	22,400
ESCAP % of world total	5.7	5.3	29.7	34.9	12.4	18.2	50.0	35.9	35.7

Sources: Biomass, solar, and wind energy potentials are adapted and estimated from United Nations Development Programme, United Nations Department of Economic and Social Affairs and World Energy Council, *World Energy Assessment*: *Energy and the Challenge of Sustainability,* (2000); geothermal potential is from International Geothermal Association "Contribution of geothermal energy to the sustainable development," submission to the Commission on Sustainable Development at its ninth session, 28 March 2001.

Notes: [a] Excluding the Commonwealth of Independent States.
[b] Excluding the former Soviet Union.

Oil reserves and resources

At 306 billion barrels as of end-2006, the ESCAP region's proven oil reserves are one quarter of the world's total (table 2-4). Close to 85 per cent of this is in three countries: the Islamic Republic of Iran, which after Saudi Arabia holds the world's second largest reserves, the Russian Federation and Kazakhstan. In total, North and Central Asia has 127 billion barrels of proven oil reserves, though owing to the Russian Federation's high annual production this could last for less than 30 years. South-East Asia also holds substantial oil reserves at 13 billion barrels, which at current production rates will last less than 15 years. These subregions are currently net exporters, but this is likely to change as a result of rising demand and dwindling reserves.

India and China contribute about 6 and 16 billion barrels, respectively, to oil reserves but are using this mainly to satisfy their own energy demands. Overall, the ESCAP region's proven reserves are expected to last for 34 more years—but the periods range from 20 years or less for most countries to more than 70 years for Kazakhstan and the Islamic Republic of Iran.

Table 2-4—Oil reserves in the ESCAP region, end 2006

	Billions of barrels	% of ESCAP total	% of world total	Years
Islamic Republic of Iran	137.5	45	11.38	87
Russian Federation	79.5	26.04	6.58	22
Kazakhstan	39.8	13.04	3.3	77
China	16.3	5.33	1.35	12
Azerbaijan	7.0	2.29	0.58	29
India	5.7	1.86	0.47	19
Indonesia	4.3	1.41	0.36	11
Australia	4.2	1.38	0.35	21
Malaysia	4.2	1.37	0.35	15
Viet Nam	3.3	1.06	0.27	24
Brunei Darussalam	1.1	0.36	0.09	14
Uzbekistan	0.6	0.19	0.05	13
Turkmenistan	0.6	0.18	0.05	9
Thailand	0.5	0.15	0.04	4
ESCAP region	**305.5**	**100**	**25.29**	**34**
World	**1,208.2**		**100**	**41**

Source: BP, *BP Statistical Review of World Energy June 2007*, http://www.bp.com/statisticalreview, accessed in November 2007.

Natural gas

At the end of 2006, the ESCAP region held about 100 trillion cubic metres of proven gas reserves—55 per cent of the world's total. As with oil, this is concentrated in only a few countries. Three quarters is in the Russian Federation and the Islamic Republic of Iran, the world's two leading countries, with 40 per cent of the world's total. Other countries in North and Central Asia also possess significant gas resources: Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan together account for 5 per cent of the world's total proven reserves. The other countries in the region with significant reserves are Australia, China, India, Indonesia, Malaysia and Pakistan, but they exploit this largely for domestic consumption. On average, the region's total natural gas reserves can support current production rates for the next 80 years, compared with a world average of 60 years (table 2-5).

"At the end of 2006, the ESCAP region held 55 per cent of the world's total gas reserves"

Table 2-5—Natural gas reserves in the ESCAP region, end 2006

	Trillion cubic metres	% of ESCAP region	% of world total	Years
Russian Federation	47.65	48.6	26.3	78
Islamic Republic of Iran	28.13	28.7	15.5	268
Kazakhstan	3	3.1	1.7	125
Turkmenistan	2.86	2.9	1.6	46
Indonesia	2.63	2.7	1.5	36
Australia	2.61	2.6	1.4	67
Malaysia	2.48	2.5	1.4	41
China	2.45	2.5	1.4	42
Uzbekistan	1.87	1.9	1.0	34
Azerbaijan	1.35	1.4	0.7	214
India	1.08	1.1	0.6	34
Pakistan	0.8	0.8	0.4	26
Myanmar	0.54	0.6	0.3	40
Papua New Guinea	0.44	0.4	0.2	111
Bangladesh	0.44	0.4	0.2	29
Viet Nam	0.4	0.4	0.2	57
Brunei Darussalam	0.34	0.3	0.2	27
Thailand	0.3	0.3	0.2	12
Other Asia Pacific	0.34	0.3	0.2	49
ESCAP region	**99.68**	**100.0**	**54.9**	**80**
World	**181.46**		**100.0**	**63**

Source: BP, *BP Statistical Review of World Energy* June 2007, http://www.bp.com/statisticalreview, accessed in November 2007.

Coal

As at end 2006, the region had almost 490,000 million tons of proven coal reserves—54 per cent of the world's total. Much of this is concentrated in a few countries. The ESCAP region has four of the world's top five countries in proven coal reserves—Australia, China, India and the Russian Federation—which together account for 90 per cent of the ESCAP region's total and 49 per cent of the world's total (table 2-6).

> "As at the end of 2006, the ESCAP region held 54 per cent of the world's total coal reserves"

Table 2-6—Coal reserves in the ESCAP region, end 2006

	Anthracite and bituminous (million tons)	Sub-bituminous and lignite (million tons)	Total proven coal reserves (million tons)	% of ESCAP total	% of world total	Years
Russian Federation	49,088	107,922	157,010	32.1	17.3	>500
China	62,200	52,300	114,500	23.4	12.6	48
India	90,085	2,360	92,445	18.9	10.2	207
Australia	38,600	39,900	78,500	16.0	8.6	210
Kazakhstan	28,151	3,128	31,279	6.4	3.4	325
Indonesia	740	4,228	4,968	1.0	0.5	25
Turkey	278	3,908	4,186	0.9	0.5	66
Pakistan	-	3,050	3,050	0.6	0.3	>500
Thailand	-	1,354	1,354	0.3	0.1	70
DPR Korea	300	300	600	0.1	0.1	20
New Zealand	33	538	571	0.1	0.1	99
Japan	359	-	359	0.1	<0.05	268
Viet Nam	150	-	150	0.0	<0.05	4
Republic of Korea	-	80	80	<0.05	<0.05	28
ESCAP region	**270,081**	**219,283**	**489,364**	**100.0**	**53.8**	**123**
World	**478,771**	**430,293**	**909,064**		**100.0**	**147**

Source: BP, *BP Statistical Review of World Energy June 2007*, http://www.bp.com/statisticalreview, accessed in November 2007.

Uranium reserves and resources

As of end 2003, the latest year for which data are available for most ESCAP economies, the region had close to 2.5 million metric tons of uranium reserves, or 60 per cent of the world's total. Of this, 43 per cent were in Australia and Kazakhstan. China, India, Mongolia, the Russian Federation and Uzbekistan also held significant reserves (table 2-7).

"At end 2003, the ESCAP region held 60 per cent of the world's total uranium reserves"

Table 2-7—Reserves of uranium, ESCAP region, 2003

	Metric tons	% of ESCAP total	% of world total
Australia	1,058,000	42.6	24.7
Kazakhstan	847,620	34.1	19.8
Russian Federation	264,240	10.6	6.2
Uzbekistan	118,460	4.8	2.8
Mongolia	61,950	2.5	1.4
India	59,915	2.4	1.4
China	49,750	2.0	1.2
Turkey	6,845	0.3	0.2
Japan	6,600	0.3	0.2
Viet Nam	6,440	0.3	0.2
Indonesia	1,155	<0.05	<0.05
Islamic Republic of Iran	1,070	<0.05	<0.05
Thailand	10	0	0
ESCAP region	**2,482,055**	**100.0**	**57.9**
Total World	**4,288,081**		**100.0**

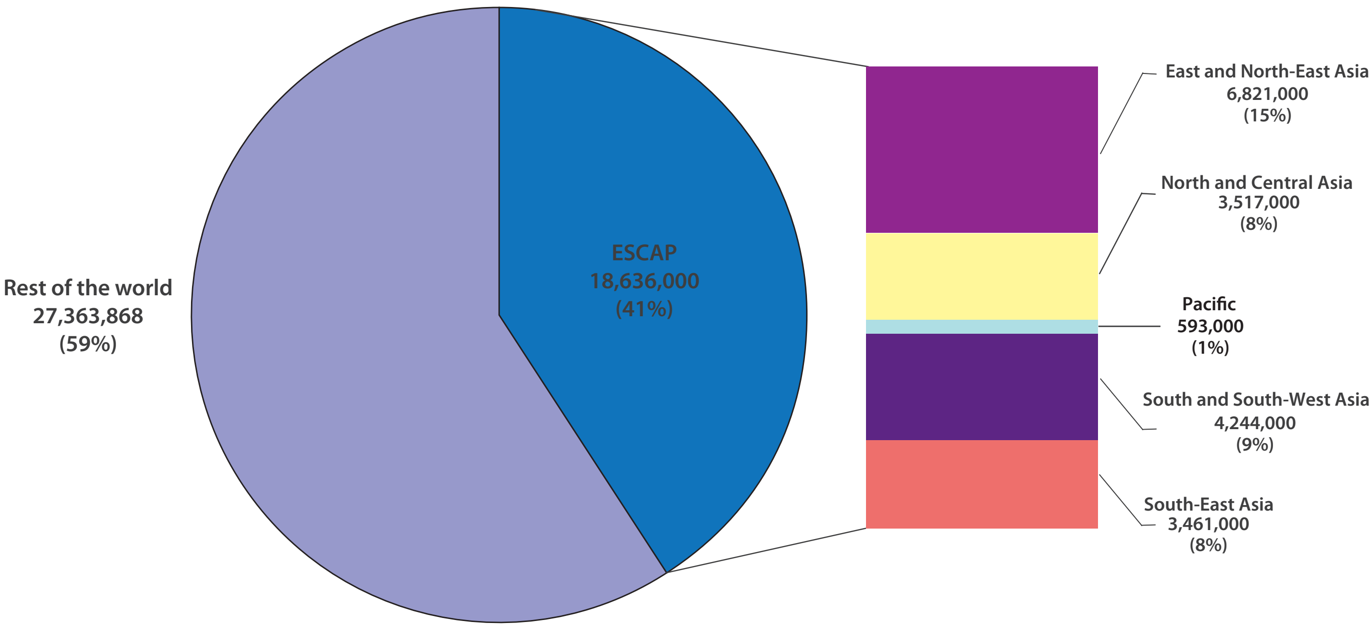
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Hydroelectric resources

As of 1997, the latest year for which data are available for most countries, the ESCAP region accounted for 41 per cent, or 18,636 TWh, of the world's hydroelectric technical potential. The bulk of this is in just a few countries—though it is more widely distributed than fossil fuels or uranium—with 37 per cent (or 15 per cent of world's total) contributed by East and North-East Asia, largely because of China, which alone had 32 per cent of the region's total or 13 per cent of the world's total. South and South-West Asia accounted for 23 per cent of the region's total, or 9 per cent of the world's total, largely in India, which alone had 14 per cent of the region's total, or 6 per cent of the world's total. Other countries with rich hydroelectric resources are the Russian Federation and Indonesia. North and Central Asia and South-East Asia each held close to 19 per cent of the region's total, or about 8 per cent of the world's total. Several countries in the region had 100 TWh or more of hydroelectric technical potential (figure 2-1).

> "As of 1997, the ESCAP region held 41 per cent of the world's total hydroelectric resources"

Figure 2-1—Hydroelectric technical potential in ESCAP subregions, 1997 (kWh)



Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Biomass resources

Some countries of Asia and the Pacific possess huge amounts of biomass resources that can be used as fuel. The *World Energy Assessment* in 2000 estimated the biomass technical potential in "developing Asia" at 311 to 502 Mtoe—which was 5 to 6 per cent of the world's total. These estimates excluded the biomass potential from North and Central Asia, which was included with that of the OECD and Central and Eastern Europe. These estimates also assumed that 80-100 per cent of future biomass supply would come from energy plantations.

South-East Asia also produces huge amounts of agricultural crops, led by paddy and oil palm fruit. In 2005, Indonesia was the largest producer of paddy, maize and cassava, providing 33, 46 and 44 per cent, respectively, of the region's totals. Thailand was the largest producer of sugarcane, producing 37 per cent of the total, while Malaysia topped oil-palm fruit production with a share of 52 per cent. The Asian and Pacific region thus has huge potential for utilizing biomass resources.

Solar energy resources

Based on the World Energy Assesment estimates, the solar energy potential in the ESCAP region could be between 11,159 and 415,257 Mtoe per annum, or 30-35 per cent of the world's total. The highest potential exists in the Russian Federation and Central Asia, which comprise the economies of North and Central Asia. Together, they could account for 20-26 per cent of the world's total solar energy potential (table 2-8).

Table 2-8—Annual solar energy potential worldwide (Mtoe/year)

Subregion	Minimum	Maximum
Middle East and North Africa	9,850	264,164
Sub-Saharan Africa	8,883	227,572
Former Soviet Union	*4,760*	*206,721*
North America	4,325	176,985
Centrally Planned Asia	*2,759*	*98,763*
Latin America and Caribbean	2,689	80,849
Pacific OECD	*1,734*	*54,051*
South Asia	*927*	*31,981*
Pacific Asia	*979*	*23,741*
Western Europe	600	21,831
Central and Eastern Europe	107	3,678
ESCAP region	**11,159**	**415,257**
World total	**37,618**	**1,190,336**

Source: United Nations Development Programme, United Nations Department of Economic and Social Affairs and World Energy Council, *World Energy Assessment: Energy and the Challenge of Sustainability, (2000).*

Wind energy resources

According to the *World Energy Assessment* in 2000, the theoretical wind energy potential of the ESCAP region was in the range of 62,000-88,000 TWh per year—12-18 per cent of the world's total theoretical potential. Of this, the technical potential is in the range of 4,000-8,000 TWh per year. These estimates do not, however, show the wind energy potential in North and Central Asia, which should be included in the estimates for Eastern Europe and the former Soviet Union.

Geothermal energy resources

In terms of high-temperature geothermal resources suitable for electricity and steam production, the ESCAP region could produce 8,000 TWh per year—36 per cent of the world's total potential. Low-temperature resources suitable for direct use are estimated to be at least 430 EJ per year for the ESCAP region, compared with the world's total potential of at least 1,400 EJ per year (table 2-9).

Table 2-9—Geothermal and wind energy potential worldwide

Region	High-temperature resources suitable for electricity generation		Low-temperature resources suitable for direct use (EJ/year, lower limit)
	Conventional technology (TWh/year)	Conventional and binary technology (TWh/year)	
Europe	1,830	3,700	>370
Asia	***2,970***	***5,900***	***>320***
Africa	1,220	2,400	>240
North America	1,330	2,700	>120
Latin America	2,800	5,600	>240
Oceania	***1,050***	***2,100***	***>110***
World total	11,200	22,400	>1,400
	Land surface with wind class 3-7 ('000 sq km)	**Wind energy resources without land restriction ('000 TWh)**	**Wind energy resources if less than 4 per cent of land is used ('000 TWh)**
Pacific Asia	4,188	67	2.7
China	1,056	17	0.7
Central and South Asia	243	4	0.2
World Total	30,200	483	19.3

Source: International Geothermal Association, "Contribution of geothermal energy to the sustainable development," submission to the Commission on Sustainable Development at its ninth session, 28 March 2001 and UNDP, UNDESA, WEC, *World energy assesment; energy and the challenge of sustainability,* (New York, 2000).

Ocean energy resources

There are four types of ocean energy:

Tidal—Transferred to the ocean from the earth's rotation through gravitational pull from the sun and moon.

Wave—Mechanical energy from wind retained by waves.

Ocean thermal—Energy stored in warm surface waters than can be made available using the temperature difference with deeper water.

Salt gradient—The energy coming from salinity differences between freshwater discharges and ocean water.

Most of these resources have not yet been developed for commercial applications. Only tidal energy has commercial plants already in operation. The *World Energy Assessment* does not therefore break down the potential by subregion (table 2-10). But since the ESCAP region includes the Pacific and Indian oceans, which cover 46 and 20 per cent, respectively, of the earth's water surface, its potential could easily be half of the global estimate.

ENERGY PRODUCTION

In 2005, the ESCAP region accounted for 46 per cent of the world's total primary energy production. The largest contributions were in primary solid fuels, including non-commercial solid fuels, for which the region contributed more than 60 per cent of global energy production, and gaseous fuels, in particular natural gas, for which the region contributed 40 per cent of global production. In the case of primary electricity and primary liquid fuels, on the other hand, the region accounted for just 30 per cent of global production, though over the period 1992-2005 production of these grew faster than global production. Overall, primary energy production in the ESCAP region grew almost 3 per cent per annum in 1992-2005, faster than the world average of just over 2 per cent per annum (table 2-11).

“The ESCAP region accounted for 46 per cent of the world's total primary energy production”

Table 2-10—Annual ocean energy potential worldwide

Resource category	Terawatt-hours
Tidal energy	22,000
Wave energy	18,000
Ocean thermal energy	2,000,000
Salt gradient energy	23,000
Total	2,063,000

Source: United Nations Development Programme, United Nations Department of Economic and Social Affairs and World Energy Council, *World Energy Assessment: Energy and the Challenge of Sustainability, (2000).*

In 2005, East and North-East Asia and North and Central Asia were the largest energy-producing subregions, contributing 17 and 13 per cent, respectively, to world total primary production. East and North-East Asia produced the bulk of the region's solid fuels—mainly hard coal, but also lignite, fuelwood, animal wastes, bagasse, industrial wastes, municipal wastes, oil shale, peat, pulp and paper, and vegetable wastes. In 2005, East and North-East Asia produced 45 per cent of the world's total primary production of solid fuels. North and Central Asia, on the other hand, produced the bulk of the region's gaseous and liquid fuels—mainly natural gas and crude oil. In 2005, North and Central Asia accounted for 23 and 15 per cent, respectively, of the world's total production of natural gas and crude petroleum. Nevertheless, all the other subregions, including the developed ESCAP economies, have substantial primary production of solid fuels, and South and South-West Asia and South-East Asia produce large quantities of both liquid and gaseous fuels (figure 2-2).

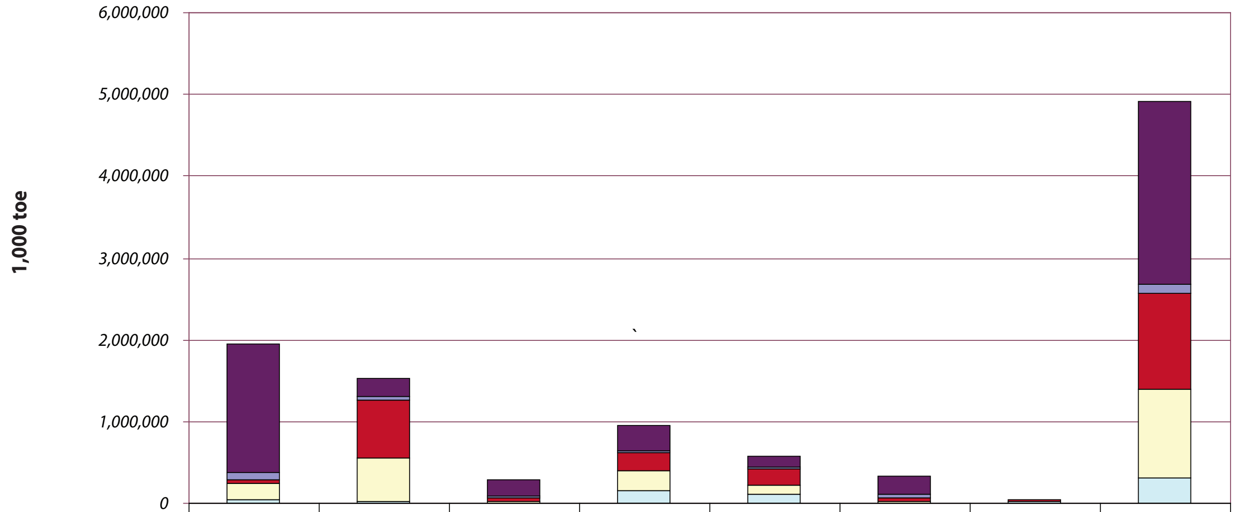
“East and North-East Asia produced 45 per cent of the world's total primary production of solid fuels”

Table 2-11—Primary energy production, 1992-2005

	ESCAP region, 2005 (ktoe)	% of world total, 2005	ESCAP average annual growth, 1992-2005	World average annual growth, 1992-2005
Primary electricity	153,470	30.1	3.5	2.2
Hydro	89,028	34.6	3.2	2.1
Nuclear	61,612	25.9	3.8	2.1
Other new renewable energy	2,522	18.6	7.9	10.2
Commercial gaseous fuels	1,240,259	39.5	2.9	3.7
Biogas	616	6.8	17.3	26.2
Liquid fuels	1,105,144	30.3	0.9	0.8
Crude petroleum	1,105,121	30.5	1.2	1.4
Solid fuels	2,802,074	64.6	3.9	2.3
Commercial solid fuels	2,461,277	69.6	4.2	2.4
Non-commercial solid fuels	340,797	42.6	3.1	2.8
Total	**5,301,563**	**45.5**	**2.9**	**2.1**

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-2—Primary energy production by subregion and fuel type, 2005 (ktoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Least developed countries	Other developing ESCAP
Commercial solid fuels	1,566,775	225,100	218,001	314,076	137,325	218,001	1,138	2,242,138
Electricity	91,068	33,252	3,937	18,586	6,628	37,799	1,085	114,586
Gaseous fuels	49,493	725,551	43,304	221,611	200,299	46,364	22,941	1,170,954
Liquid fuels	181,763	535,063	23,404	241,460	123,454	21,820	1,233	1,082,090
Non commercial solid fuels	52,409	11,753	7,373	161,329	107,934	6,352	28,147	306,298

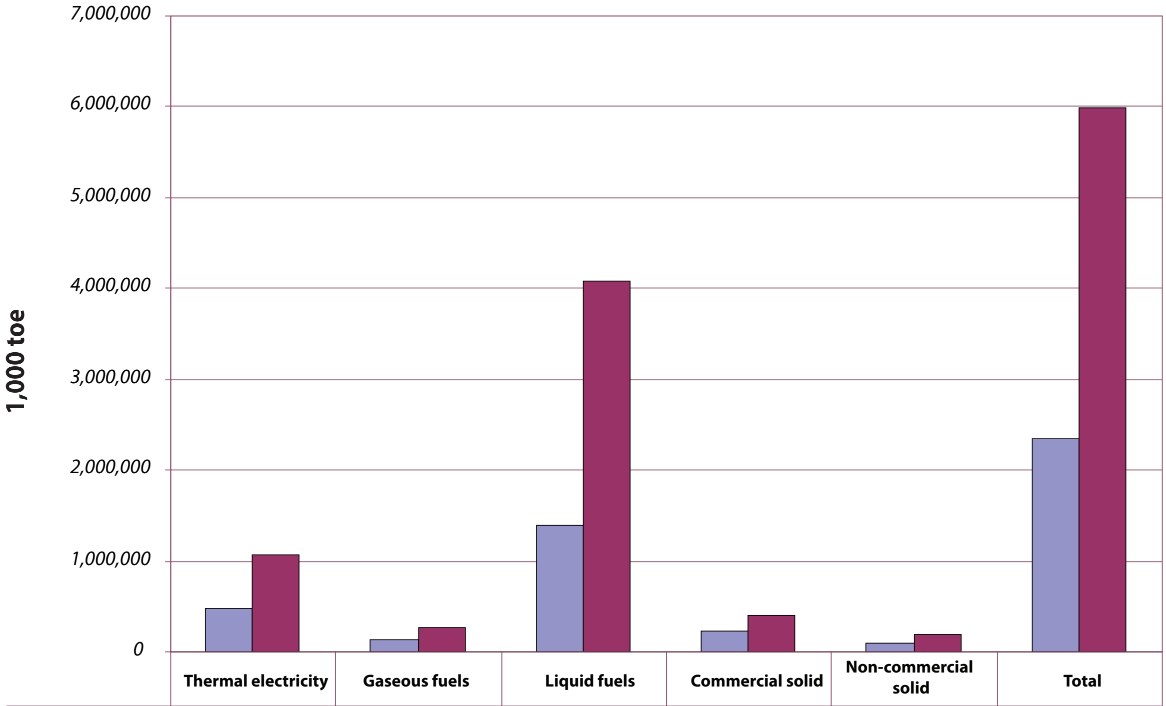
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Other developing ESCAP" includes the Russian Federation and Central Asia.

In 2005, the ESCAP region accounted for close to 40 per cent of the world's total secondary energy production. Broken down by type of fuel, the region produced 60 per cent of the world's secondary solid fuels—primarily coke; 50 per cent of the secondary gaseous fuels—including blast-furnace gas, coke-oven gas, gasworks gas, and refinery gas; 45 per cent of thermal electricity; and 34 per cent of the secondary liquid fuels—including mainly petroleum products (figure 2-3). The ESCAP region also recorded 3.7 per cent average annual growth in secondary fuels production over the period 1992-2005, higher than the world's annual average growth of 2.5 per cent.

By subregion, secondary energy production was dominated by East and North-East Asia, which accounted for 52 per cent of the region's total and 20 per cent of the world's total. East and North-East Asia was also ahead in the production of all major categories of secondary fuels except non-commercial solid fuels, in which South and South-West Asia dominated, and registered a high average growth over the period 1992-2005 of 4.7 per cent per annum, second only to South and South-West Asia at 6.8 per cent (figure 2-4).

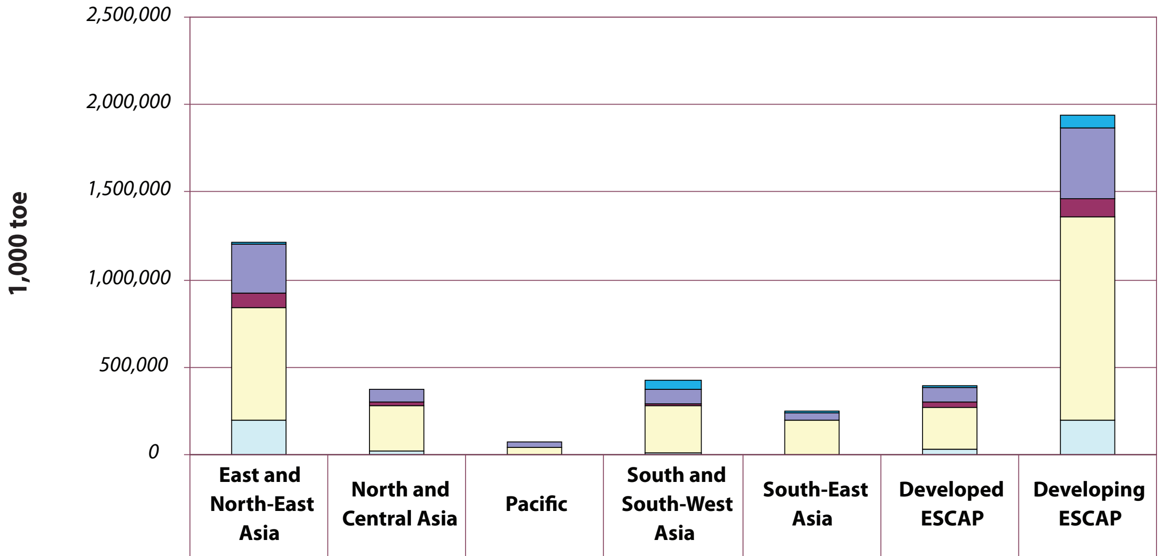
Figure 2-3—Secondary energy production, 2005 (ktoe)



	Thermal electricity	Gaseous fuels	Liquid fuels	Commercial solid	Non-commercial solid	Total
ESCAP region	484,621	130,813	1,401,435	232,307	90,073	2,339,249
World total	1,067,349	261,872	4,077,630	393,177	196,556	5,996,585

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-4—Secondary energy production by fuel type, 2005 (ktoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Developing ESCAP
Non-commercial solid fuels	8,791	3,488	3,565	55,933	18,297	9,104	80,969
Thermal electricity	277,232	66,069	22,137	82,049	37,133	82,270	402,351
Gaseous fuels	90,375	23,883	3,207	9,010	4,337	31,797	99,016
Liquid fuels	639,754	260,450	40,822	267,368	193,041	242,141	1,159,294
Commercial solid fuels	197,572	20,492	2,595	11,627	20	30,261	202,045

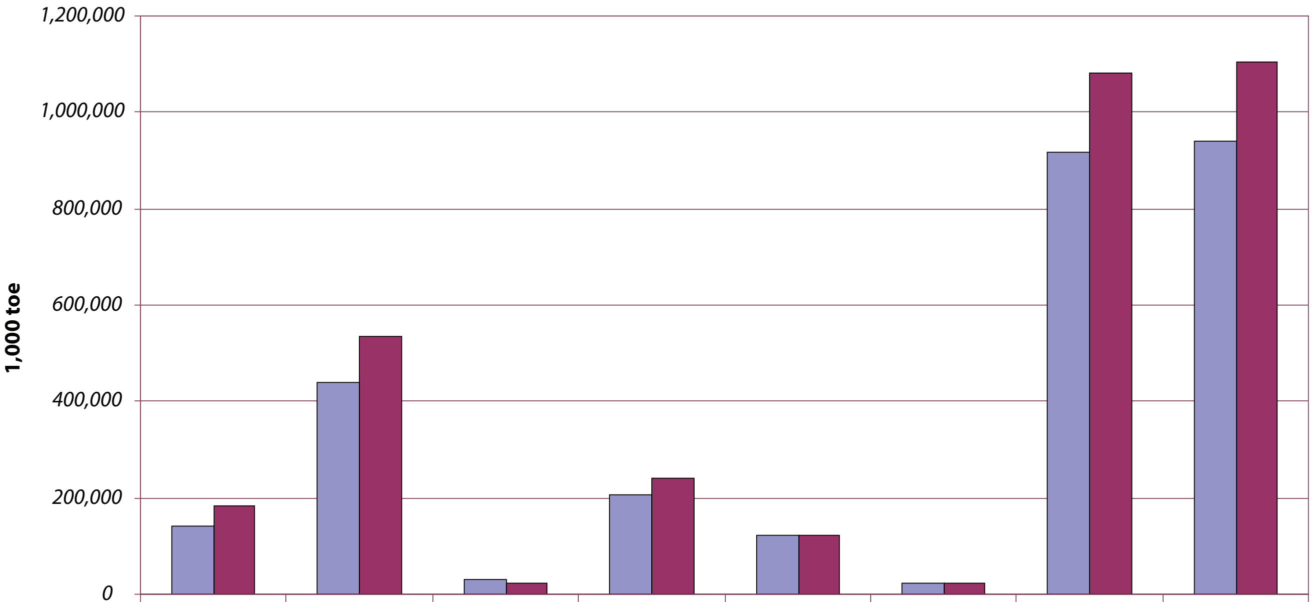
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Crude oil production

In 2005, crude oil production in the ESCAP region accounted for about 30 per cent of the world's total and over the period 1992-2005 grew 1.2 per cent per annum, slightly less than the world's annual average growth rate of 1.5 per cent. Over 40 per cent of this came from North and Central Asia, primarily from the Russian Federation, the world's second largest producer, with significant production also from Azerbaijan and Kazakhstan. Over the period 1992-2005, North and Central Asia also recorded average annual growth of 1.5 per cent in crude oil production, which was higher than the ESCAP region's total and second only to that of East and North-East Asia at 1.9 per cent. East and North-East Asia contributed 16 per cent to the region's total crude oil production, practically all from China. With large production from the Islamic Republic of Iran, which was ranked fourth worldwide, and India adding substantial production, South and South-West Asia contributed 22 per cent to the ESCAP region's production and registered 1.2 per cent annual average growth over the period 1992-2005. In addition to the countries mentioned above, the other main producers in the ESCAP region were Australia, Indonesia, Malaysia and Viet Nam (figure 2-5).

> "In 2005, crude oil production in the ESCAP region accounted for about 30 per cent of the world's total"

Figure 2-5—Growth in crude oil production, 1992-2005 (ktoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Developing ESCAP	Total ESCAP
1992	142,772	440,183	29,350	207,063	122,602	24,663	917,307	941,970
2005	181,752	535,063	23,392	241,460	123,454	21,808	1,083,313	1,105,121

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

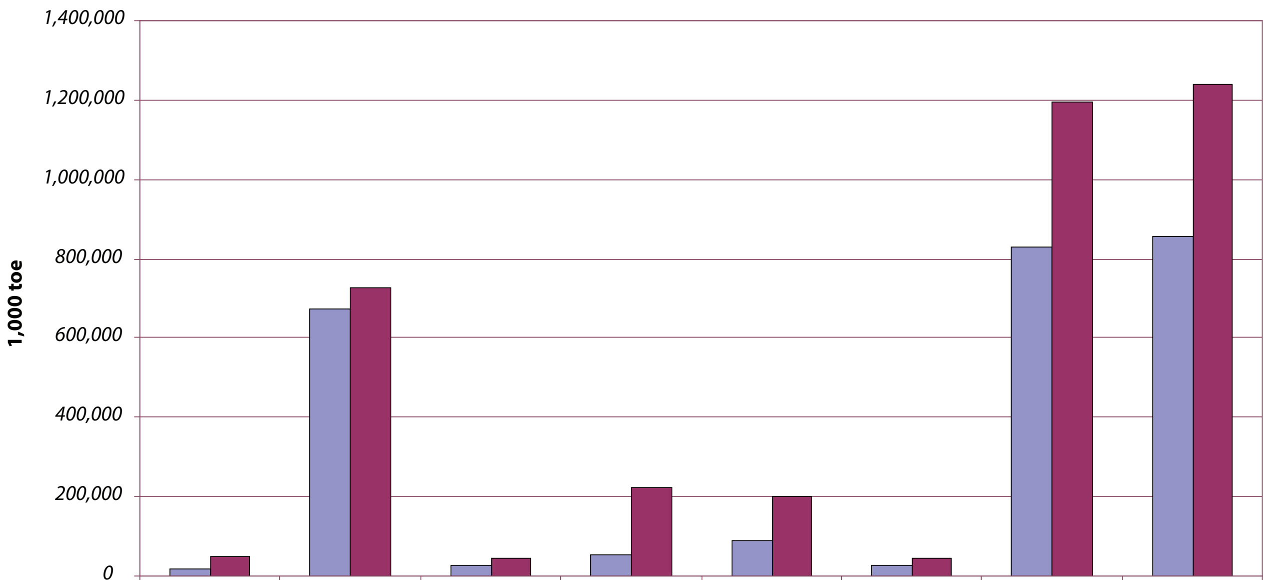
Note: "Developing ESCAP" includes the Russian Federation.

Natural gas production

In 2005, the ESCAP region's natural gas production represented 40 per cent of the world's total and grew by 2.9 per cent per annum over the period 1992-2005, slower than the world average of 3.7 per cent. North and Central Asia produced 58 per cent of the ESCAP region's total and 23 per cent of the world's total. This came mainly from the Russian Federation, the world's largest natural gas producer, along with substantial contributions from Turkmenistan, Uzbekistan and Kazakhstan. South and South-West Asia accounted for only 18 per cent of the region's production but recorded average annual growth of 11.5 per cent. South and South-West Asia's production came largely from the Islamic Republic of Iran, ranked number six worldwide, Pakistan, India and Bangladesh. South-East Asia's production contributed 16 per cent to the region's total and grew by 6.5 per cent per year over the period 1992-2005. Six of the ten South-East Asian countries are large natural gas producers: Brunei Darussalam, Indonesia, Malaysia, Myanmar, Thailand and Viet Nam. Natural gas production in East and North-East Asia, mainly from China, also saw strong growth at 8.3 per cent per annum over the period 1992-2005, but remained less than 4 per cent of the region's total production (figure 2-6).

> "In 2005, natural gas production in the ESCAP region, coming mostly from the Russian Federation, represented 40 per cent of the world's total"

Figure 2-6—Growth in natural gas production, 1992-2005 (ktoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Developing ESCAP	Total ESCAP
1992	17,570	671,736	26,605	53,944	88,361	28,649	829,568	858,217
2005	49,493	725,551	43,304	221,611	200,299	46,364	1,193,895	1,240,259

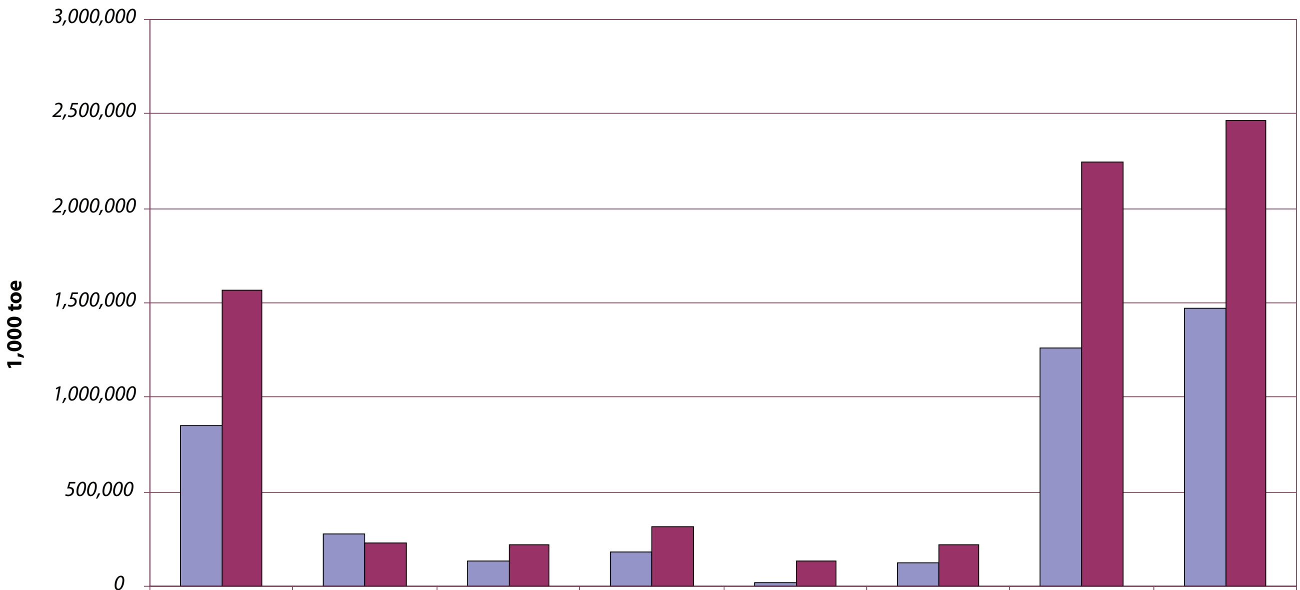
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Coal production

Home to six of the world's top ten coal producers, the ESCAP region was responsible for 70 per cent of the world's total and over the period 1992-2005 the growth in production averaged 4 per cent per year, faster than the global average of 2.4 per cent. East and North-East Asia contributed 64 per cent to the region's total, and growth was 4.8 per cent per year. East and North-East Asia's production came almost entirely from China, which with 44 per cent of the world's total is the world's leading producer. India contributed 13 per cent of the region's total and the Russian Federation and Kazakhstan together contributed 9 per cent. The Pacific added 9 per cent, almost all from Australia, the world's fourth largest producer. South-East Asia contributed 6 per cent, mostly from Indonesia, the world's seventh largest producer, and Viet Nam, while its production grew on average by 14 per cent per year due to strong demand for coal for power production (figure 2-7).

Figure 2-7—Growth in coal production, 1992-2005 (ktoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Developing ESCAP	Total ESCAP
1992	854,089	273,685	137,472	186,060	23,865	128,572	1,263,441	1,475,171
2005	1,566,775	225,100	218,001	314,076	137,325	218,001	2,243,276	2,461,277

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Electric power generating capacity and electricity production

Over the period, 1992-2005 the installed power generating capacity in the ESCAP region increased from 936 to 1,642 GW—an annual growth rate of 4.4 per cent. In 2005, thermal plants accounted for 73 per cent of total installed capacity in 2005 and for 77 per cent of absolute capacity additions over the period (table 2-12). Other sources, though much smaller, grew more rapidly over this period: solar by 76 per cent and wind by 34 per cent. East and North-East Asia led in terms of installed capacity and annual capacity additions, equivalent to 56 and 68 per cent, respectively, of the region's totals.

In 2005, most of this capacity—93 per cent—was owned by public utilities which usually run the thermal, nuclear, geothermal, and hydroelectric power plants. Self-producers, on the other hand, owned 95 per cent of solar and 54 per cent of wind power capacity.

In 2005, from this total installed power capacity, the ESCAP region generated 7,417 TWh of electricity in 2005, from 4,142 TWh in 1992. This is equivalent to an annual average growth of 4.6 per cent. East and North-East Asia dominated production in the region with 58 per cent in 2005, and over the period 1992-2005 recorded an annual average growth of 6.1 per cent. South and South-West Asia and South-East Asia

Table 2-12—Ownership of electric power plants, ESCAP region, 1992-2005

	Public	Self-producer	Total installed capacity, MW 2005	Capacity addition, 1992-2005 (MW/year)	Capacity expansion, 1992-2005 (%/year)
Thermal[a]	1,083,107	112,715	1,195,822	41,662	4.75
Nuclear	105,444	0	105,444	2,725	3.20
Hydroelectric	328,749	4,220	332,969	9,470	7.25
Geothermal	4,014	46	4,060	187	3.61
Solar	74	1,610	1,684	129	77.10
Wind	1,063	1,229	2,292	173	34.42
Total	**1,522,451**	**119,820**	**1,642,271**	**54,346**	**4.42**

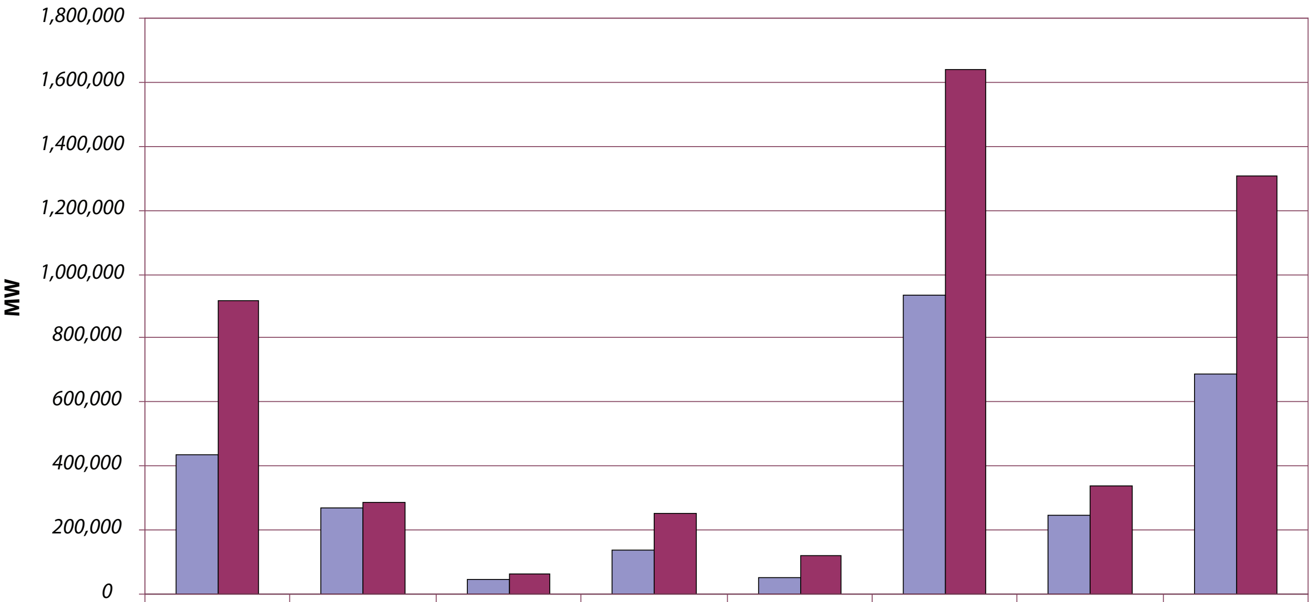
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: [a] Including biomass plants.

also had rates higher than the regional average, at 6.3 and 7.3 per cent respectively. Overall, electricity production from developing ESCAP economies grew by 5.4 per cent per annum, while from the developed ESCAP economies it grew by 1.9 per cent per annum (figure 2-9).

As might be expected, the bulk of electricity production comes from fossil fuels, including solid, liquid and gaseous fuels. The main fuel inputs for power generation are solid fuels—mainly coal—except in North and Central Asia and South-East Asia, where natural gas contributes a higher proportion. Nuclear energy's shares were also significant but only in East and North-East Asia and North and Central Asia. In contrast, in all subregions hydroelectricity has had a steady contribution, between 10 and 20 per cent (figure 2-10).

Figure 2-8—Growth in installed electric power capacity by subregion, 1992-2005 (MW)

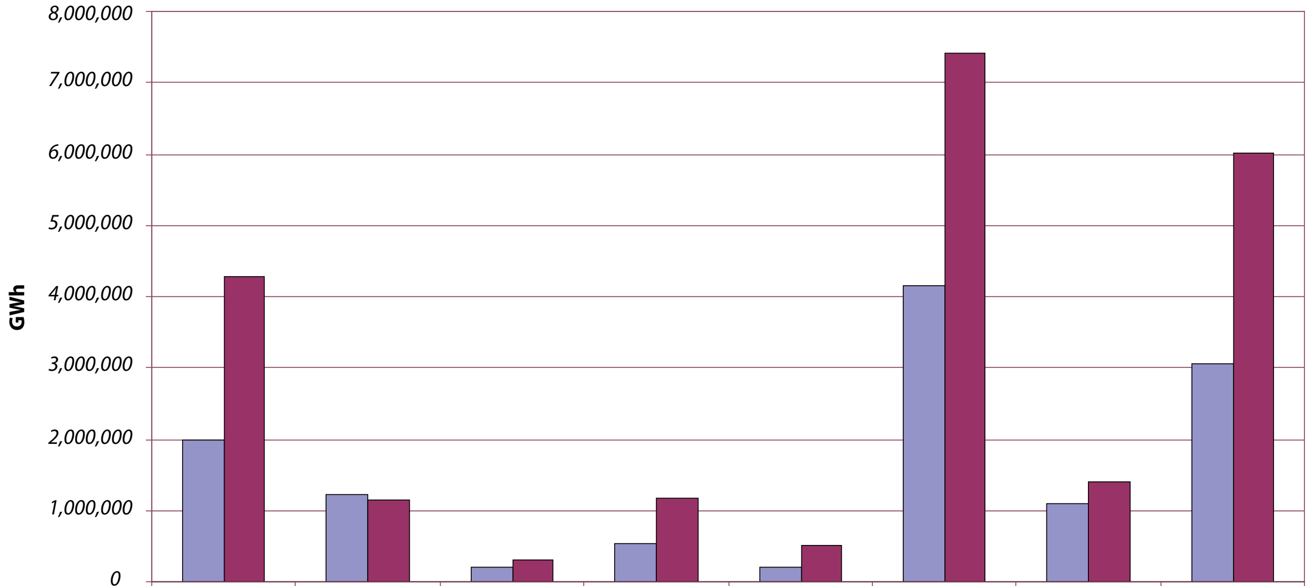


	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	ESCAP region	Developed ESCAP	Developing ESCAP
1992	438,003	267,184	45,287	135,702	49,596	935,772	248,968	686,804
2005	916,159	288,407	61,617	254,638	121,450	1,642,271	336,825	1,305,446

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Figure 2-9—Growth in total electricity production by subregion, 1992-2005 (GWh)

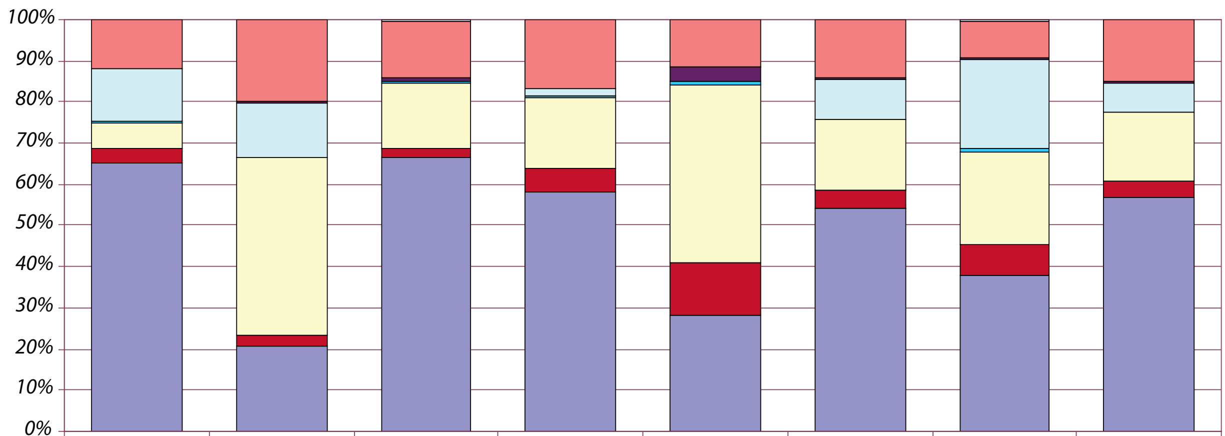


	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	ESCAP region	Developed ESCAP	Developing ESCAP
1992	1,986,791	1,223,967	197,904	530,494	202,650	4,141,806	1,087,496	3,054,310
2005	4,283,328	1,151,515	303,241	1,170,392	508,940	7,417,416	1,396,406	6,021,010

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Figure 2-10—Electricity production mix, 2005 (GWh and per cent)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	ESCAP region	Developed ESCAP	Developing ESCAP
Wind	1,884	7	1,508	61	1	3,461	3,251	210
Solar	17	0	11	0	193	221	13	208
Hydro	509,598	230,552	41,413	196,207	57,623	1,035,393	125,706	909,687
Geothermal	3,027	410	2,852	94	19,263	25,646	5,879	19,767
Nuclear	544,594	152,162	0	19,797	0	716,553	304,755	411,798
Biomass	8,000	4,532	1,384	3,360	3,507	20,622	8,209	14,142
Gaseous fuels	275,785	493,545	47,991	204,475	219,013	1,282,958	315,801	1,003,102
Liquid fuels	153,067	32,075	6,476	66,258	66,229	316,664	105,119	230,413
Solid fuels	2,787,319	238,206	201,550	680,352	142,827	4,015,633	527,318	3,431,697

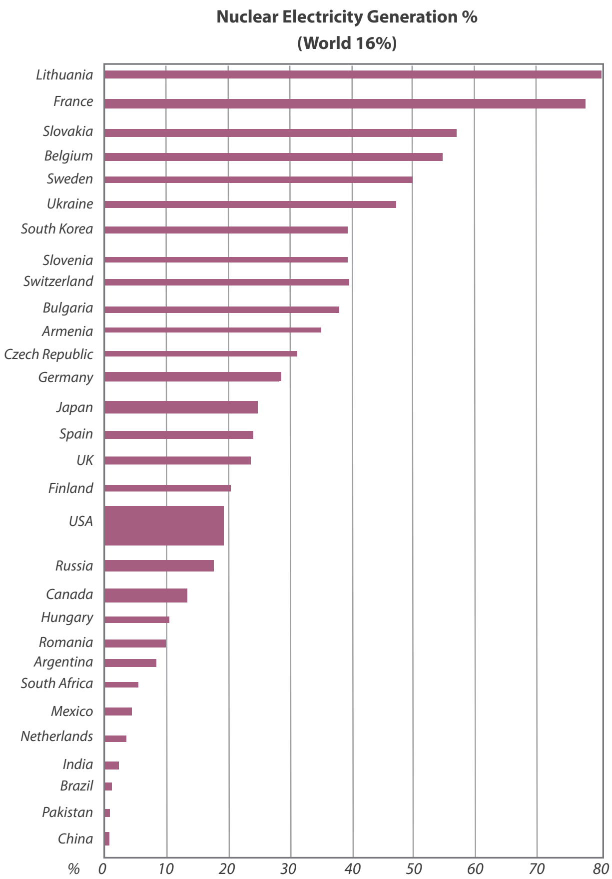
Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Nuclear energy production

In 2005 the ESCAP region's nuclear capacity stood at 105,444 MW, representing 28 per cent of the world's total installed nuclear capacity and producing electricity equivalent to 26 per cent of the corresponding world total (table 2-13). Within the ESCAP region, nuclear energy contributed close to 10 per cent of electricity production and grew by 3.8 per cent per year over the period 1992-2005, faster than the 2.1 per cent average annual growth in global nuclear electricity production. It is relatively more important in East and North-East Asia and North and Central Asia, where it contributes 13 per cent of electricity production, while in South and South-West Asia it contributes less than 2 per cent. Table 2-13 also shows that the region hosts 143 nuclear reactors out of 439 worldwide. It is also building 25 out of the 31 reactors under construction worldwide.

Figure 2-11—Nuclear power generation in selected countries, 2007



Source: World Nuclear Association, "Nuclear Power in the World Today" 2007 (www.world-nuclear.org/info/inf01.html).

> "The ESCAP region's nuclear capacity represents 28 per cent of the world's total"

Table 2-13—Nuclear energy production in ESCAP region

Country	Installed capacity, 2005 (MW)	% of world total	% of ESCAP total	Expansion, 1992-2005 (MW/year)	Energy generation, 2005 (GWh)	% of world total	% of ESCAP total	Growth, 1992-2005 (%/year)	Reactors in operation as of August 2007	Reactors under construction as of October 2007
China	6,572	1.7	1.3	483	53,088	1.9	2.1	43.17	11	5
Japan	49,580	13.0	17.9	1,154	304,755	11.0	27.7	2.42	55	1
Republic of Korea	17,176	4.5	25.8	735	146,779	5.3	37.7	7.62	20	2
Taiwan Province of China	5,144	1.4	12.3	0	39,972	1.4	17.6	1.29	6	2
Armenia	408	0.1	12.6	n.a.	2,716	0.1	43.0	7.24[a]	1	none
Russian Federation	22,742	6.0	9.8	192	149,446	5.4	15.7	1.73	31	7
India	3,360	0.9	2.3	104	17,313	0.6	2.5	7.54	17	6
Pakistan	462	0.1	2.4	25	2,484	0.1	2.7	14.69	2	1
ESCAP region	**105,444**	**27.6**	**100**	**2,725**	**716,553**	**25.9**	**100**	**3.81**	**143**	**25[b]**
World total	**381,847**	**100**		**3,835**	**2,767,941**	**100**		**2.09**	**439**	**31**

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007 and IAEA.

Notes: [a] 1995-2005

[b] Including one under construction in the Islamic Republic of Iran.

Renewable energy production

In 2005, renewable energy accounted for 9 per cent of the ESCAP region's primary energy production. A high proportion of this, equivalent to 6 per cent of the region's total primary production, is heat energy produced from biogas, biomass, and wastes, together called "combustible renewables and wastes" (CRW).[55] The rest is primary electricity production from hydropower, geothermal, solar and wind, which together contributed 14.3 per cent to total electricity production, including that from secondary fuels (figure 2-12).

> "In 2005, renewable energy accounted for 9 per cent of the ESCAP region's primary energy production"

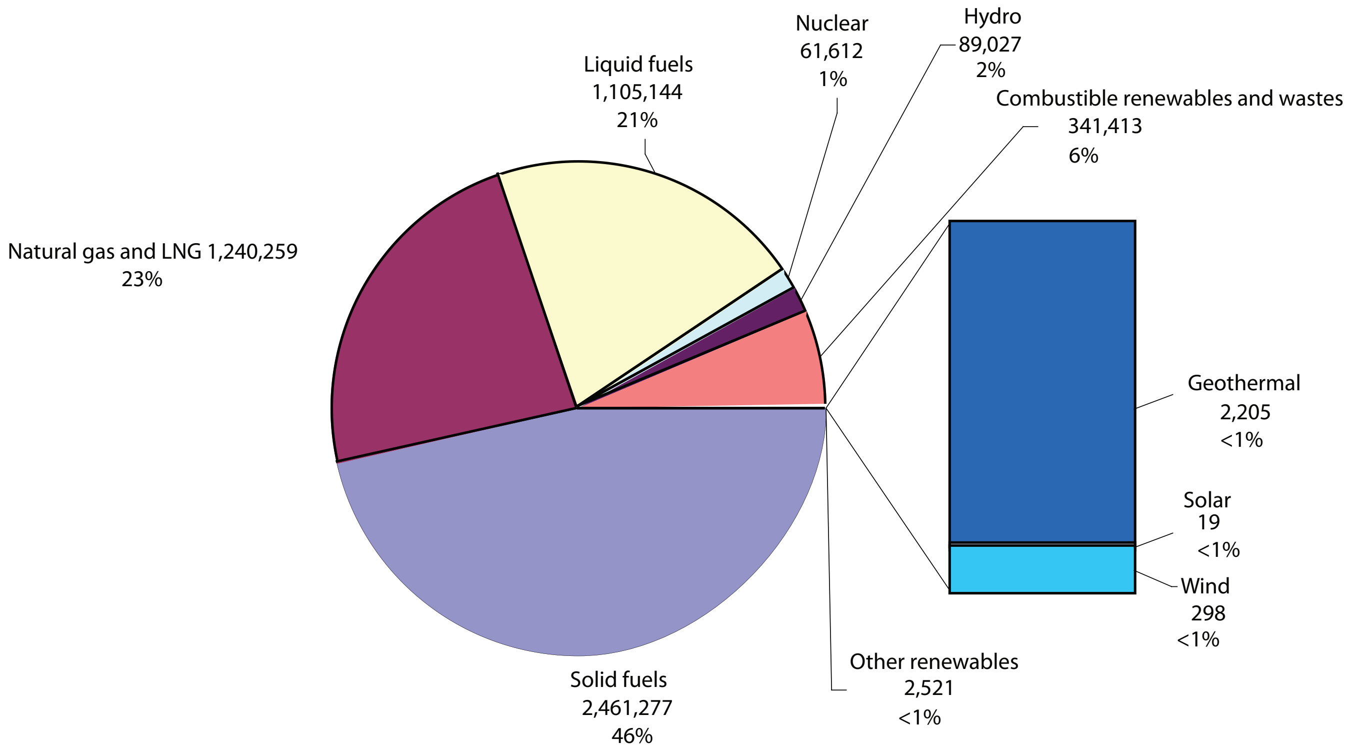
i. Combustible renewables and wastes

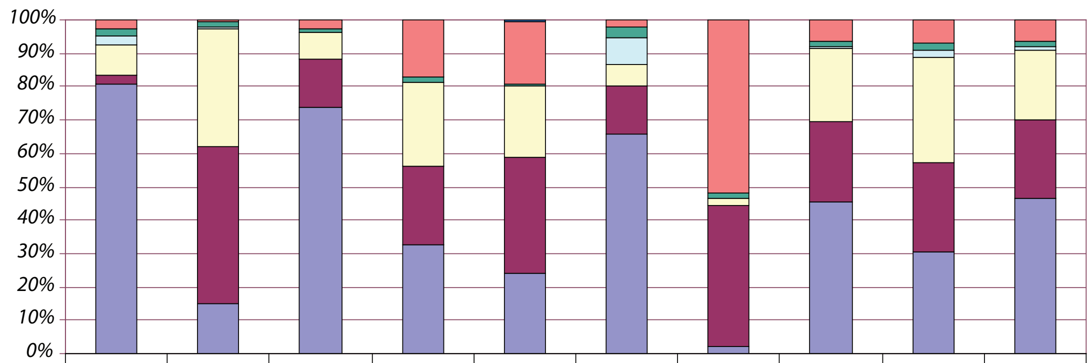
In 2005, combustible renewables and wastes accounted for 2 and 7 per cent, respectively, of primary energy production in developed and developing ESCAP economies. Their shares in South and South-West Asia and South-East Asia, however, were 17 and 19 per cent, respectively. These two regions also have the lowest per capita energy consumptions and include many least developed countries, which are usually associated with the use of CRWs.

ii. Hydropower

Hydroelectricity is a long-standing but still important energy source. In 2005, it was responsible, on average, for 14 per cent of the region's total electricity production, and for 15 per cent of that of developing ESCAP economies. Indeed, hydropower contributed significantly to all subregional electricity requirements, from a low of 11 per cent in South-East Asia to a high of 20 per cent in North and Central Asia.

Figure 2-12—Renewables in primary energy production, 2005 (ktoe and %)





	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	Developed ESCAP	Least developed countries	Other developing ESCAP	World total	Total ESCAP
Wind	162	1	130	5	0	280	0	18	8,176	298
Solar	1	0	1	0	17	1	17	1	207	19
Geothermal	260	35	245	8	1,656	506	0	1,700	5,153	2,205
Non-commercial solid fuels	52,409	11,753	7,373	161,329	107,934	6,352	28,147	306,298	800,001	340,797
Hydro	43,818	19,824	3,561	16,871	4,955	10,809	1,069	77,150	257,596	89,028
Nuclear	46,827	13,084	0	1,702	0	26,204	0	35,408	238,000	61,612
Liquid fuels	181,763	535,063	23,404	241,460	123,454	21,820	1,233	1,082,090	3,647,653	1,105,144
Commercial gas	49,493	725,551	43,304	221,611	200,299	46,364	22,941	1,170,954	3,139,404	1,240,259
Commercial solid fuels	1,566,775	225,100	218,001	314,076	137,325	218,001	1,138	2,242,138	3,536,393	2,461,277

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Notes: Combustible renewables and wastes includes non-commercial solid fuels and biogas.
Commercial solid fuels include hard coal, lignite, and peat.
"Other developing ESCAP" includes the Russian Federation and Central Asia.

The ESCAP region accounts for about one third of global hydroelectricity production but about 40 per cent of the world's total hydroelectric potential; clearly, a substantial part of the region's hydroelectric potential has yet to be tapped. Nevertheless, over the period 1992-2005, the region's hydroelectric production grew on average by 3.2 per cent per year, which was higher than the global annual average growth of 2.1 per cent. Contributing to this growth was the addition of hydropower capacity at an average rate of almost 9,500 MW per year during the same period.

> "The ESCAP region accounts for about one third of global hydroelectricity production but about 40 per cent of the world's total hydroelectric potential; clearly, a substantial part of the region's hydroelectric potential has yet to be tapped"

East and North-East Asia accounted for close to half of the region's total hydroelectricity production. This was due primarily to China, which is also the world's number one hydropower producer. East and North-East Asia's hydroelectricity production growth of 5.3 per cent per annum over the period 1992-2005 was also largely responsible for the region's growth. Its capacity expansion rate of around 6,700 MW per year over the period 1992-2005 represented 70 per cent of the total growth for the region. South and South-West Asia, mainly because of India, also posted a high growth of 3.1 per cent, accounting for 19 per cent of the region's total. North and Central Asia, mainly due to the Russian Federation, contributed 22 per cent to the region's total production in 2005, but grew only 0.3 per cent per year over the period 1992-2005 (table 2-14).

Table 2-14—Contribution and growth of hydropower generation by subregion, 1992-2005

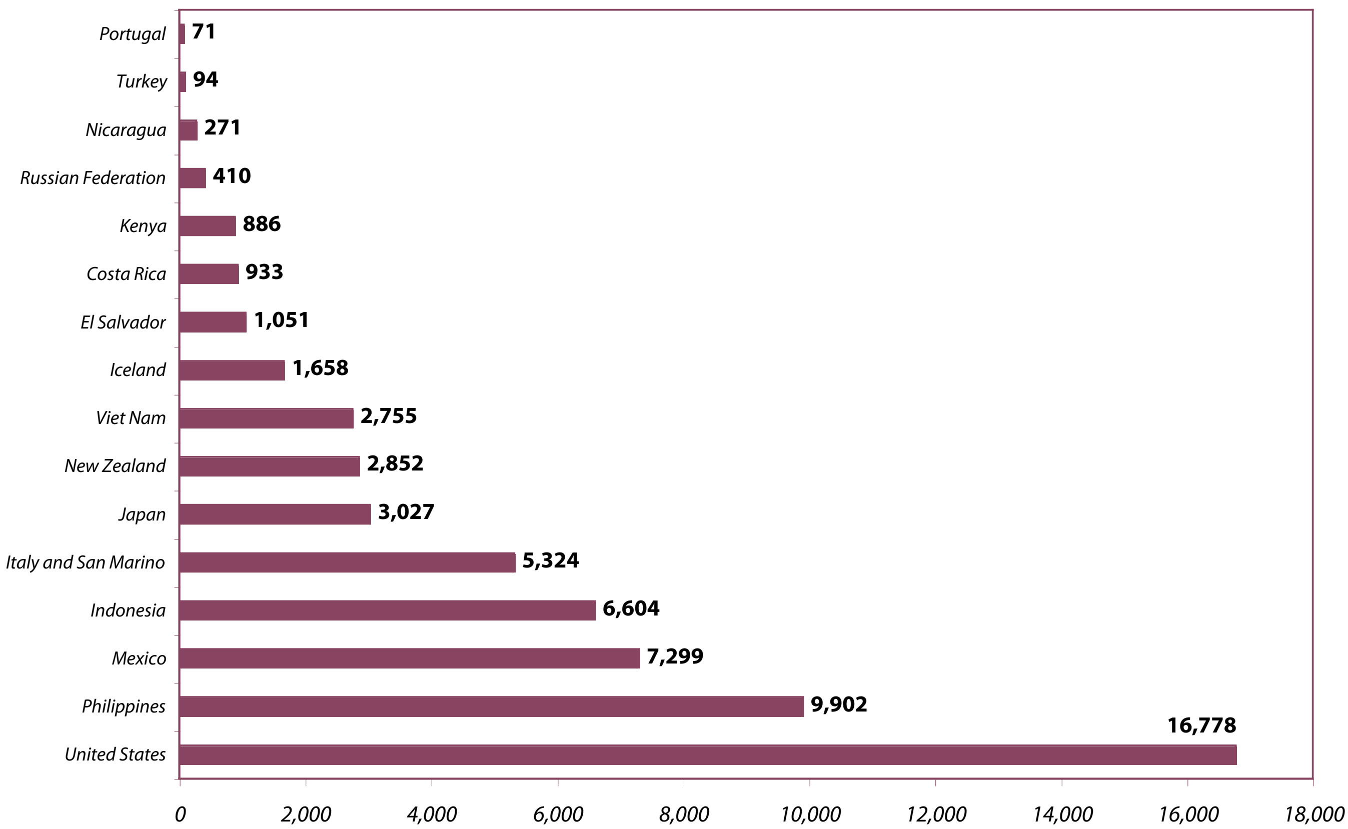
	% of hydropower in total electricity generation, 2005	Hydropower capacity additions, 1992-2005 (MW/year)	Annual % of hydropower generation, 1992-2005
East and North-East Asia	12	6,690	5.3
North and Central Asia	20	227	0.3
Pacific	14	179	0.7
South and South-West Asia	17	1,855	3.1
South-East Asia	11	519	3.6
ESCAP region	**14**	**9,470**	**3.2**
Developed ESCAP	9	764	0.0
Developing ESCAP	15	8,706	3.8
World total	**16**	**15,122**	**2.1**

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

iii. Geothermal energy

In 2005, despite strong growth of 6.8 per cent per year over the period 1992-2005, geothermal production accounted for less than 0.5 per cent of the region's total electricity production. South-East Asia accounted for 75 per cent of this, relying on it for 4 per cent of its electricity production. Indeed, the Philippines and Indonesia are respectively the third and fifth largest geothermal producers worldwide. East and North-East Asia and the Pacific accounted for 12 and 11 per cent, respectively; Japan and New Zealand are also among the top ten producers. In 2005, the ESCAP member countries accounted for 43 per cent of the world's total geothermal production (figure 2-13).

Figure 2-13—World's major geothermal energy producers, 2005 (GWh)



Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

iv. Wind energy

In 2005, the ESCAP region's wind energy production was only about 3,500 GWh and contributed 0.05 per cent to the region's electricity production, but it only represented 3.6 per cent of the world's total wind energy output. Nevertheless, wind energy production in the region grew on average by 35 per cent per year compared with the world average of 25 per cent.

In terms of installed capacity, the total for the ESCAP region rose between 1992 and 2005 from 49 to 2,292 MW, though even this represented only 5 per cent of the world's annual wind capacity additions. In 2005, East and North-East Asia had 58 per cent of the region's total installed capacity and accounted for 54 per cent of the region's production. The subregion also added 101 MW of wind capacity per year over the period 1992-2005, which is more than half of the total for the whole ESCAP region. The leadership of East and North-East Asia in wind energy production can be attributed largely to Japan, which in 2005 had an installed wind capacity of 1,227 MW, equivalent to 53 per cent of the region's total. The Pacific subregion, with combined capacity from Australia, New Zealand and New Caledonia, installed 70 MW per year over the period 1992-2005 to accumulate a total wind capacity in 2005 of 916 MW. The other countries that reported wind capacities in 2005 were the Philippines, Sri Lanka, Thailand and Turkey.

> **"In 2005, India topped the region both in installed and added wind capacity, and now ranks fourth worldwide in total installed capacity"**

In 2005, India topped the region both in installed and added wind capacity, and now ranks fourth worldwide in total installed capacity.[56] In 2005 alone, India added 1,430 MW, raising its installed wind capacity to 4,430 MW.[57] China is also reported to have added 500 MW in 2005, raising its installed wind capacity to 1,260 MW. This raised the installed capacity of the ESCAP region to almost 8,000 MW.[58]

v. Solar energy

Solar electricity production is also growing at double-digit rates.[59] Over the period 1992-2005, the ESCAP region recorded an average of 36 per cent annual growth compared with 11 per cent global average. As a result, solar electric capacity for the whole ESCAP region increased by 129 MW per year out of 297 MW globally, reaching 1,508 MW in 2005, equivalent to 43 per cent of the world's total.

Of the region's total installed capacity in 2005, 95 per cent was in East and North-East Asia. Japan alone had 1,421 MW. In addition, Australia, the Republic of Korea, and Thailand reported installed solar electric capacity.

SUPPLY AND CONSUMPTION

The ESCAP region is producing just enough to meet its primary energy demand—or supply (table 2-15). However, the extent of energy independence or self-sufficiency varies among the subregions and between the developing and developed economies and in each case has changed over time. These variations may be explained by the differences between the growth in total primary energy production and total primary energy demand. For example, the Pacific and North and Central Asia produce twice their primary energy requirements, and between 1992 and 2005 both subregions increased their energy self-sufficiency ratios, but the reasons for these increases were different. The Pacific increased production faster than demand while North and Central Asian experienced a decrease in demand. On the other hand, the decreases in energy self-sufficiency in South and South-West Asia and South-East Asia were both due to demand rising faster than production.

> **"The ESCAP region is producing just enough to meet its primary energy demand"**

Energy self-sufficiency tends to be higher in developing than developed ESCAP economies. While the developing economies are becoming less self-sufficient, however, as demand rises faster than production, the developed economies are growing more self-sufficient as production rises while demand tapers off (table 2-16).

Table 2-15—The ESCAP region's primary energy supply, 2005 (Mtoe)

	Commercial solid fuels	Traditional solid fuels	Liquid fuels	Gaseous fuels	Electricity	Total
Production	2,461	341	1,105	1,241	153	5,301
Imports	323	0.3	1,116	188	5	1,632
Export	-391	-0.2	-856	-332	-7	-1,587
Bunkers	0	0	98	0	0	98
Stock changes	9	0.02	-9	5	0	6
TPES	2,383	341	1,275	1,091	151	5,242
Share of fuels to TPES (%)	45.5	6.5	24.3	20.8	2.9	100.0
Average annual growth, 1992-2005 (%)	3.9	3.1	1.5	3.0	3.5	3.0

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Table 2-16—Energy self-sufficiency of ESCAP and subregions, 1992-2005

ESCAP and subregions	Primary energy production, Mtoe			Total primary energy supply, Mtoe			Energy self-sufficiency ratio[a]	
	1992	*2005*	*1992-2005 average annual growth (%)*	*1992*	*2005*	*1992-2005 average annual growth (%)*	*1992*	*2005*
East and North-East Asia	1,116	1,942	4.35	1,623	2,763	4.18	0.69	0.70
North and Central Asia	1,437	1,530	0.48	1,046	816	-1.89	1.37	1.88
Pacific	202	296	2.98	110	138	1.76	1.84	2.14
South and South-West Asia	595	957	3.72	557	1,010	4.68	1.07	0.95
South-East Asia	316	576	4.73	223	514	6.63	1.42	1.12
ESCAP region	3,666	5,301	2.88	3,557	5,242	3.03	1.03	1.01
Developing ESCAP	3,435	4,970	2.88	3,038	4,634	3.30	1.13	1.07
Developed ESCAP	231	331	2.81	519	608	1.22	0.45	0.54

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: [a] Energy self-sufficiency ratio is the ratio of total primary energy production over primary energy supply (or demand).

Primary energy mix

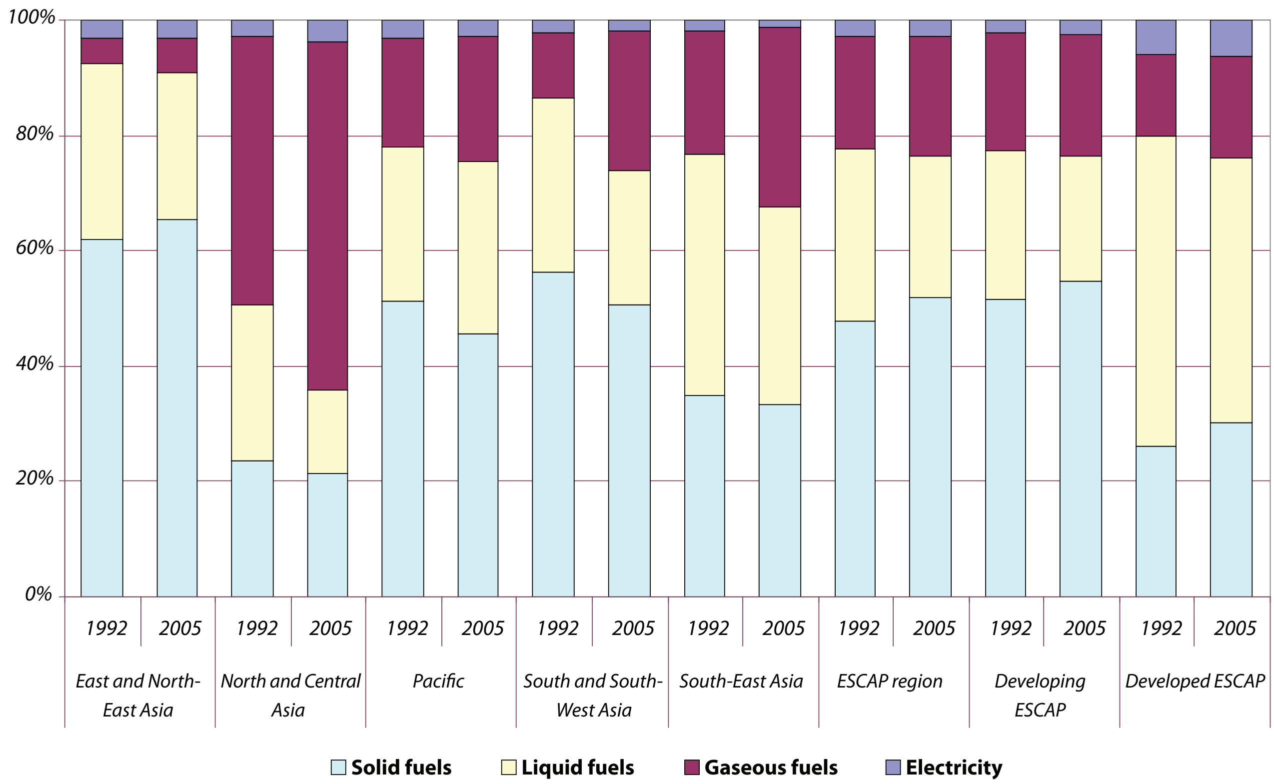
The biggest contribution to the region's total primary energy supply (TPES) comes from solid fuels, mainly coal; in 2005, solid fuels provided 52 per cent of the region's primary energy compared with 47 per cent in 1992 (figure 2-14). The demand for solid fuels has also grown faster than that for other fuels. Meanwhile, the share of gaseous fuels decreased from 31 to 21 per cent. Electricity and liquid fuels maintained their respective shares at below 3 per cent and about 24 per cent, respectively.

> "Solid fuels are also the dominant fuels in the primary energy mix across the subregions"

Solid fuels are also the dominant fuels in the primary energy mix across the subregions. In East and North-East Asia, the Pacific, and South and South-West Asia they accounted for 65, 46, and 51 per cent, respectively. In North and Central Asia, the main contributor to the subregion's primary energy mix is gaseous fuels, primarily natural gas, its share increasing between 1992 and 2005 from 46 to 60 per cent. In South-East Asia, the largest share was for liquid fuels, though over the same period its share fell from 55 to 34 per cent, while gaseous and solid fuels increased their shares, from 17 to 26 per cent and from 27 to 34 per cent respectively.

Deregulation of the power sectors in South-East Asian economies increased competition between coal and natural gas and boosted their shares in the fuel mix. In fact, the deregulation of the power sectors and

Figure 2-14—The ESCAP region's primary energy supply mix by subregion, 1992 and 2005 (%)



Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

increased private investments in power generation are the main reasons for the increased shares of natural gas in all subregions. In the Pacific, the share of gaseous fuels increased from 18 to 22 per cent, and in South and South-West Asia from 11 to 24 per cent.

Nevertheless, the dominant fuel is still coal, thanks to its wider availability and stable prices and the development of clean-coal technologies. This is particularly true in the developing economies, in which between 1992 and 2005 the contribution of solid fuels increased from 50 to 55 per cent. Among the three developed ESCAP economies, liquid fuels continued to dominate, but between 1992 and 2005 their share dropped from 55 to 46 per cent.

TRADE IN ENERGY

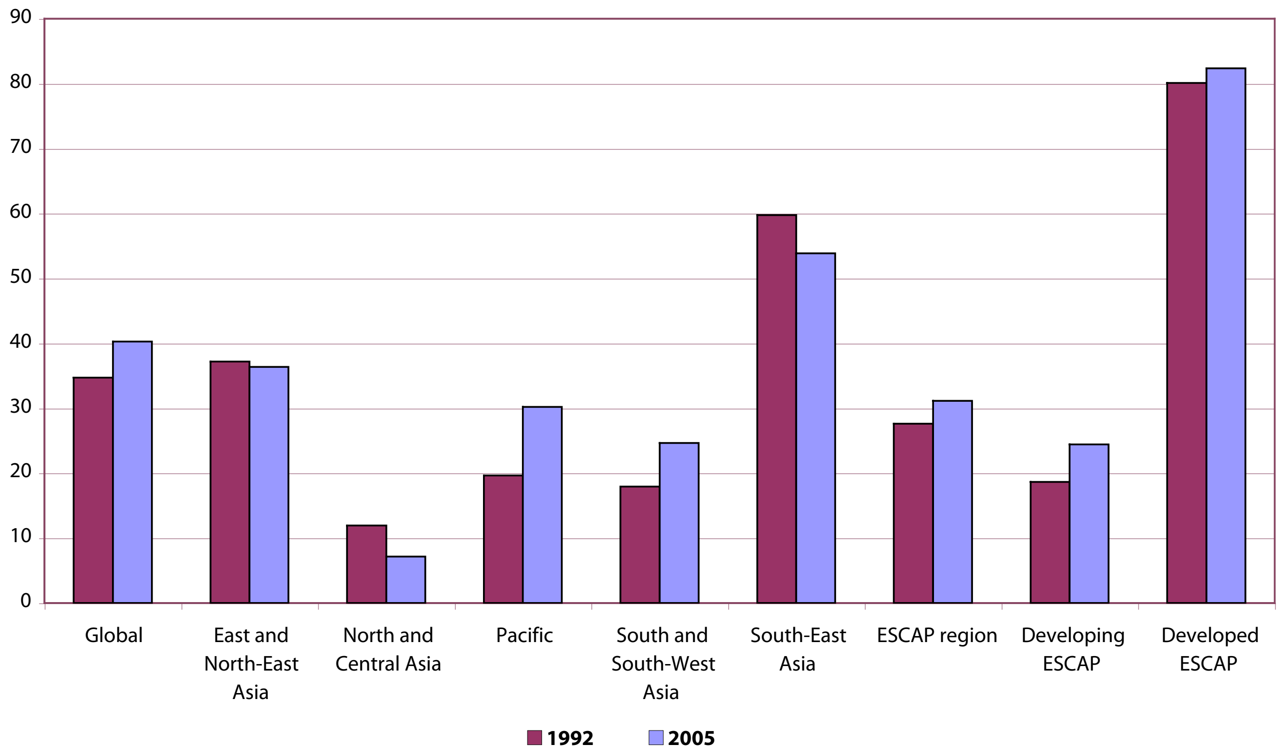
As a proportion of total primary energy supply and primary energy production, imports and exports both amount to about 30 per cent. The region is a net energy importer of liquid fuels but a net exporter of solid and gaseous fuels and primary electricity.

Energy imports

Between 1992 and 2005, the ESCAP region's energy import dependency rose from 28 to 31 per cent, while over the same period the world average rose from 35 to 40 per cent (figure 2-15). Among the subregions,

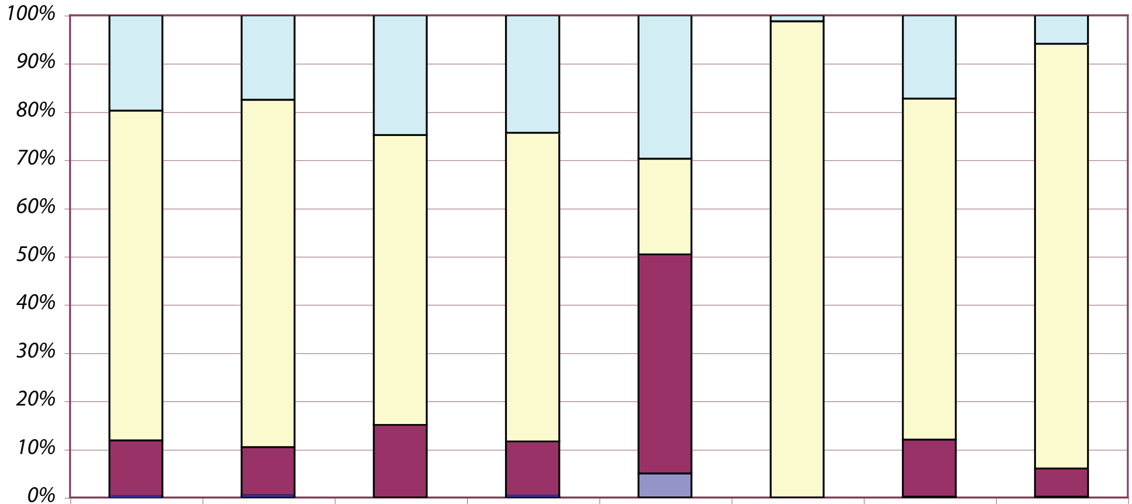
> "Between 1992 and 2005, the ESCAP region's energy import dependency rose from 28 to 31 per cent"

Figure 2-15—Energy import dependency of ESCAP subregions (%)



Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-16—Total ESCAP energy imports, 2005 (ktoe and %)



	ESCAP	Developing ESCAP	Developed ESCAP	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia
Noncommercial solid fuels	281	279	1	153	2	2	88	35
Commercial solid fuels	322,539	198,214	124,325	245,152	17,434	530	43,025	16,397
Liquid	1,115,801	814,996	300,806	643,091	11,596	41,043	175,936	244,134
Gas	187,834	112,499	75,335	115,619	26,587	0	29,458	16,170
Electricity	5,163	5,163	0	1,421	2,928	0	408	406

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

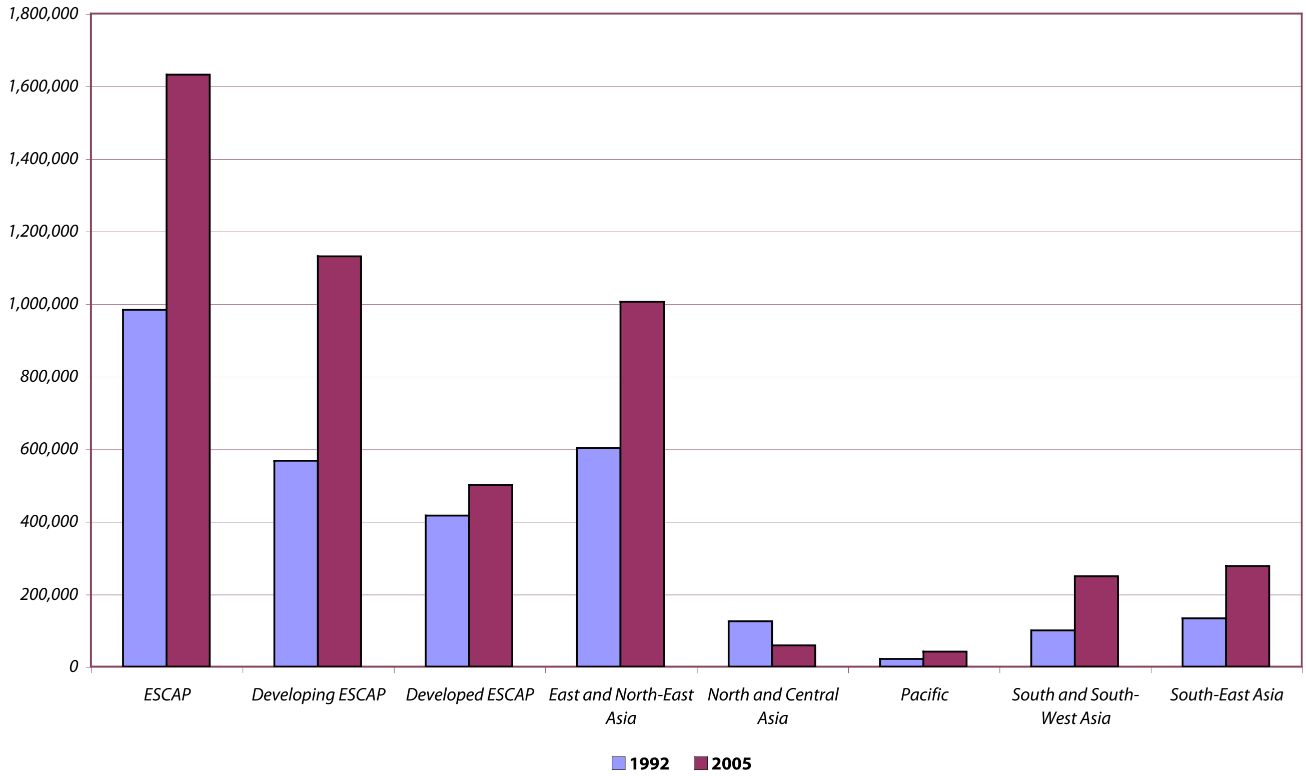
import dependency was highest in South-East Asia at about 60 and 54 per cent respectively in 1992 and 2005. In the developing ESCAP economies dependency was lower, but grew between 1992 and 2005 from 19 to 24 per cent, indicating an increased reliance on imports to meet energy needs resulting from economic expansion and recovery.[60] Dependency was, however, much higher in the developed economies, primarily because Japan had a rate of 82 per cent, which increased slightly over the 13-year period.

Figures 2-16 and 2-17 indicates that in 2005 the ESCAP region's total energy imports reached 1,632 Mtoe, more than 60 per cent of which went to East and North-East Asia. The ESCAP region's imports accounted for 36 per cent of the world's total.

Of the region's total imports, 70 per cent were liquid fuels—similar to the global average. Liquid fuels also accounted for the largest share of energy imports across all the ESCAP subregions—close to 90 per cent in South-East Asia and 100 per cent in the Pacific. Only North and Central Asia, which is a net exporter of liquid fuels, had a diversified import energy mix.

The highest annual growth rates over the period 1992-2005 were in South-East Asia and South and South-West Asia at 5.8 and 7.3 per cent per year respectively. Indeed, in the entire group of developing ESCAP economies imports grew 5.5 per cent per year, while in the developed ESCAP economies they grew by only 1.4 per cent—slower than the 4.0 per cent average for the whole region.

Figure 2-17—Growth of ESCAP energy imports, 1992-2005 (ktoe)



Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

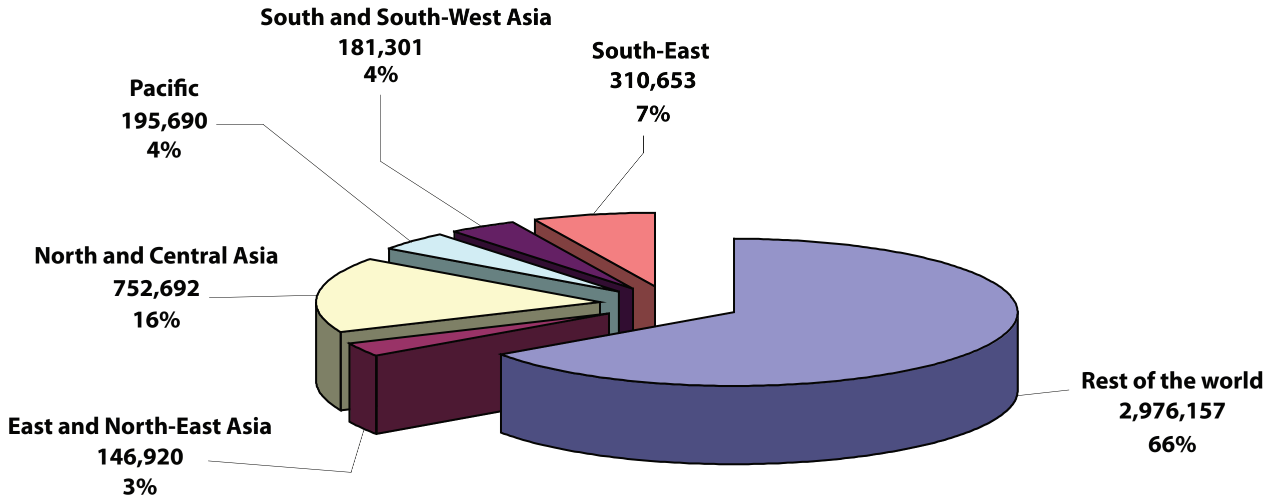
Energy exports

The ESCAP region's energy exports reached 1,587 Mtoe in 2005 and accounted for 35 per cent of the world's total (figure 2-18). The largest contribution came from North and Central Asia, 47 per cent of ESCAP region's total; the other subregions, except East and North-East Asia, which is a net energy importer, also had double-digit contributions. The developing ESCAP economies contributed 87 per cent.

Largely because of North and Central Asia, more than half the region's exports were liquid fuels. These represented 97 per cent of the energy exports in South and South-West Asia, mainly because of the Islamic Republic of Iran, one of the world's top oil exporters. The only exception was the Pacific subregion. North and Central Asia was also the largest contributor to the region's exports of gaseous fuels—77 per cent. A substantial contribution also came from South-East Asia, at 17 per cent.

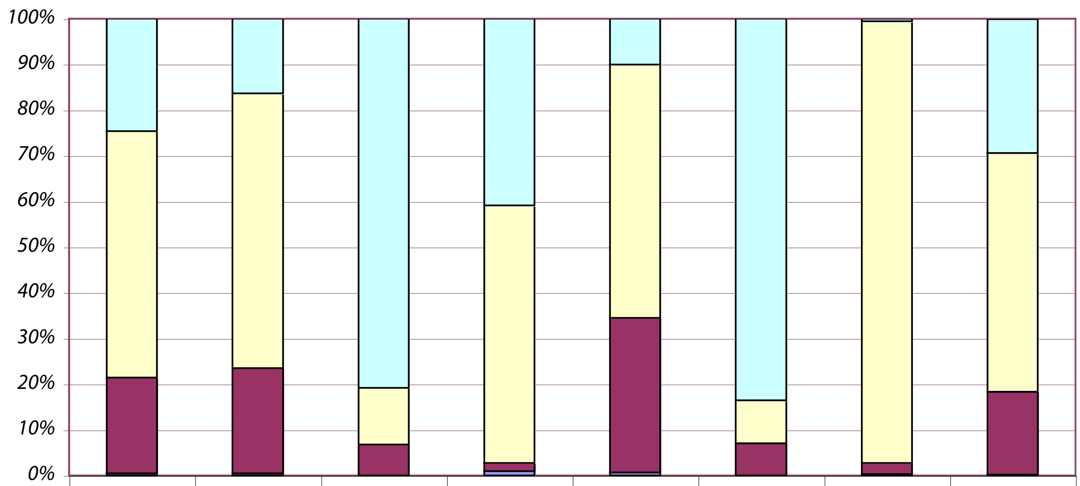
In 2005, the region's exports of solid fuels were also substantial—close to 70 per cent of the world's total. The Pacific subregion contributed 42 per cent to the region's total and 29 per cent to the world's total, mainly because of Australia, the world's largest coal exporter.

Figure 2-18—Energy exports of ESCAP subregions 2005 (ktoe and %)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-19—Energy exports by subregion and fuel categories, 2005 (ktoe and %)



	ESCAP	Developing ESCAP	Developed ESCAP	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia
Noncommercial solid fuels	234	229	4	29	1	4	10	188
Commercial solid fuels	391,255	226,648	164,607	60,083	75,465	163,550	1,082	91,075
Liquid	856,386	830,993	25,393	82,816	417,502	18,376	175,206	162,486
Gas	332,270	318,510	13,760	2,642	255,018	13,760	4,451	56,399
Electricity	7,113	7,113	0	1,350	4,707	0	551	505

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Oil trade

In 2005, crude oil represented 72 per cent of the ESCAP region's liquid fuels imports and 63 per cent of the region's liquid fuels exports. In turn, the ESCAP region's crude oil imports accounted for about 37 per cent of the world's total, and crude oil exports were 25 per cent of the world's total. East and North-East Asia was the single largest crude-oil importing subregion, accounting for 63 per cent. Japan was the world's second largest crude-oil importer, accounting for more than 9 per cent of the total, though it was a long way behind United States.

> "In 2005, crude oil represented 72 per cent of the ESCAP region's liquid fuels imports"

China, the Republic of Korea and Taiwan Province of China together accounted for about 14 per cent of the world's total crude oil imports. South and South-West Asia was responsible for about 6 per cent—due mainly to India, which alone accounted for about 5 per cent. Over the period 1992-2005, South and South-West Asia's crude oil imports grew 7.0 per cent per year, contributing to the 3.8 per cent growth in crude oil imports in the entire ESCAP region. East and North-East Asia's crude oil imports grew at 3.6 per cent per year. Data from BP Statistics indicate that in 2005 the ESCAP region imported about 930 million tons (Mt) of crude oil, representing 38 per cent of the world's total imports. Of this, 84 per cent came from outside the region, mainly from the Middle East and West Africa.

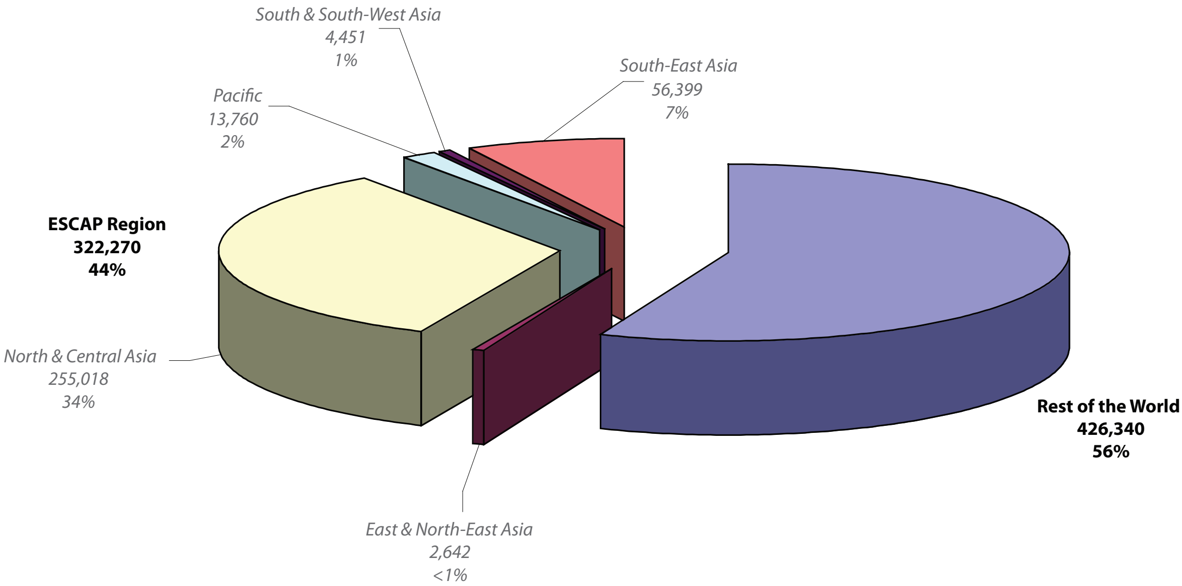
Meanwhile, the ESCAP region exported 498 Mt of crude oil in 2005, or 20 per cent of the world's total crude oil exports. Of this 69 per cent went outside the ESCAP region, mainly to Europe. Moreover, 70 per cent came from the Russian Federation or the former Soviet Union, which is the world's second largest crude oil exporter. In 2005, the North and Central Asian subregion contributed 59 per cent of the region's crude oil exports, nearly 15 per cent of the world's total. Between 2000 and 2005, crude oil exports from that subregion grew at 12 per cent per year and were responsible for most of the ESCAP region's growth of 6.8 per cent per year. The Islamic Republic of Iran was also an important exporter: with more than 6 per cent of the world's total, it was the fourth largest crude oil exporter.

Gas trade

With 55 per cent of the world's proven reserves of natural gas, the ESCAP region is a net exporter. In 2005, these exports represented more than one fifth of its total energy exports and 44 per cent of the world's total natural gas exports (figure 2-20). Of this, 77 per cent was from North and Central Asia and 17 per cent from South-East Asia. North and Central Asia alone contributed more than one third. The Russian Federation and Turkmenistan were, respectively, the largest and fifth largest natural gas exporters in the world. Indonesia in South-East Asia was the seventh largest, contributing 5 per cent. Nevertheless, the growth in exports was relatively slow—1.6 per cent annually during 1992-2005—compared with 7.7 per cent in the rest of the world.

> "With 55 per cent of the world's proven reserves of natural gas, the ESCAP region is a net exporter"

Figure 2-20—Natural gas exports, 2005 (ktoe and %)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Imports, on the other hand, grew more rapidly. The ESCAP region's natural gas imports, which represented more than 11 per cent of its total energy imports and 24 per cent of the world's total natural gas imports, grew by 5.1 per cent per year during 1992-2005—higher than the world average of 4.4 per cent. East and North-East Asia was the largest gas-importing subregion, accounting for 62 per cent of the region's total natural gas imports and 15 per cent of the world's total. Japan and the Republic of Korea are among the world's largest natural gas importers, and in 2005 together accounted for 13.5 per cent of global imports.

In 2005, LNG trade (exports/imports) worldwide amounted to 189 billion cubic metres (bcm). The ESCAP region, particularly Australia, Brunei Darussalam, Indonesia and Malaysia, exported 84 bcm, or 45 per cent of the global total. Almost all of this went to the rest of the ESCAP region. In fact, only 0.49 bcm went outside the region. On the other hand, the region's total LNG imports, particularly to India, Japan, the Republic of Korea and Taiwan Province of China, reached 127 bcm, or 67 per cent of the world total. Of this, 44 bcm—or 34 per cent of the total LNG imports to the ESCAP region—came from outside the region, mainly from Algeria, Egypt, Oman, Qatar, and the United Arab Emirates.

Some natural gas is transported by ship as liquid natural gas, but about three quarters of the global natural gas trade is by pipeline. Of this, the ESCAP region exported 33 per cent, and imported 8.2 per cent. The Russian Federation, the single largest exporter, was responsible for 28 per cent of the total natural gas trade by pipeline—of which almost 90 per cent went to Europe; the balance went to Turkey. Including Turkmenistan's 1.1 bcm of natural gas exports to Poland, more than 75 per cent of the ESCAP region's exports by pipeline went outside the region. In contrast, the region's natural gas imports by pipeline were sourced entirely from within the region, with Turkey being supplied by the Russian Federation and the Islamic Republic of Iran. The excess gas demand of the Islamic Republic of Iran was met by Turkmenistan, that of Singapore by Indonesia, and those of Malaysia and Thailand by Myanmar.

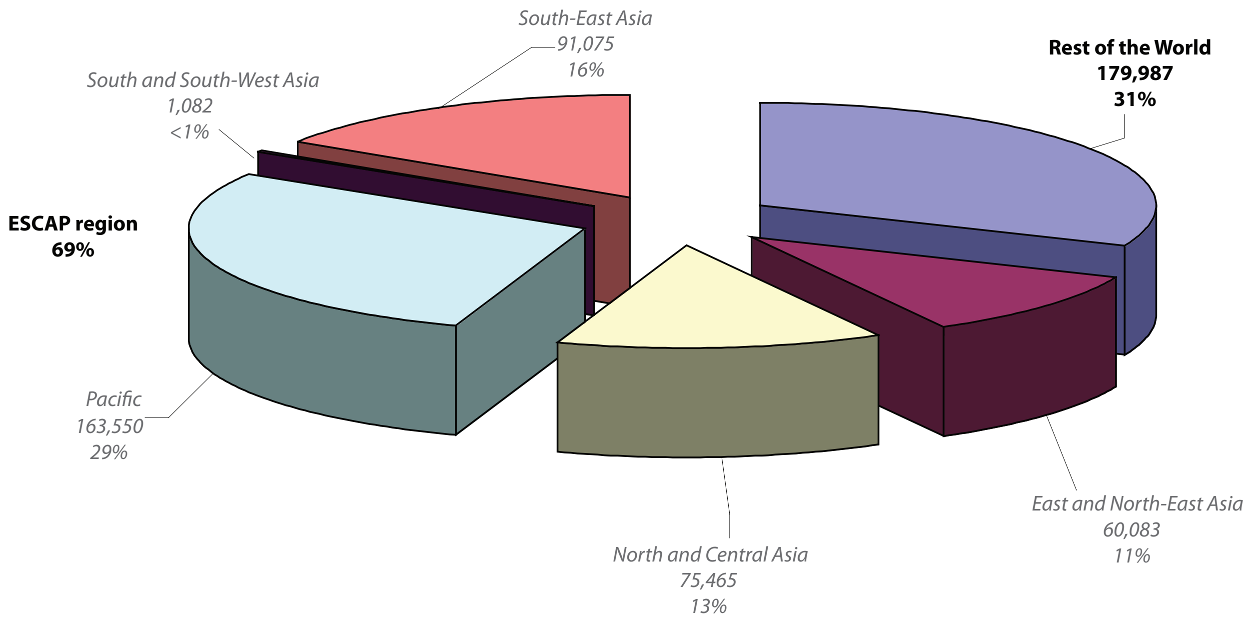
Coal trade

In 2005, about 97 per cent of the ESCAP region's solid fuel imports and exports were of coal. In that year, the ESCAP region accounted for 69 per cent of total hard coal exports (figure 2-21) and 57 per cent of imports. Except for South and South-West Asia, all ESCAP subregions contributed substantial shares to exports. Indeed the ESCAP region has 6 of the world's top 10 coal exporters. Australia, the world's number one, was practically the only source of coal exports from the Pacific region, while almost all of South-East Asia's coal exports were from Indonesia, the world's number two exporter, and Viet Nam, the world's number 10. China was the world's number four exporter and practically the sole source of exports from East and North-East Asia. The Russian Federation, the world's number three coal exporter, was responsible for 76 per cent of North and Central Asia's exports; most of the rest came from Kazakhstan, ranked number eight in the world.

Over the period 1992-2005, the ESCAP region's coal exports grew 6 per cent per year, while the rest of the world grew by only 0.4 per cent and in fact over the period 2000-2005 suffered a slight annual decline of 0.25 per cent. The fastest annual growth was in South-East Asia at 17 per cent, while North-East Asia's exports grew by 8.7 and the Pacific's by 5 per cent.

"The ESCAP region has 6 of the world's top 10 coal exporters"

Figure 2-21—Coal exports by subregion, 2005 (ktoe and %)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

While coal supply in 2005 was fairly evenly distributed across the subregions, demand for imported coal was dominated by East and North-East Asia, which in 2005 accounted for 77 per cent of the region's coal imports and 45 per cent of the world's total. Japan alone, the world's largest coal importer, cornered 23 per cent of the world's total. The Republic of Korea and Taiwan Province of China ranked a distant second and third, respectively, and accounted for 9.6 per cent and 7.8 per cent of the world's total. With India and Turkey also importing substantial amounts, South and South-West Asia was the destination for 7.6 per cent of world's total coal imports. The Russian Federation also imports coal and was practically the sole reason for North and Central Asia's 3 per cent share in total coal imports. South-East Asia's share was also almost 3 per cent of the world's total but coal imports in that subregion were evenly distributed between Malaysia, the Philippines and Thailand.

Over the period 1992-2005, South-East Asia recorded annual growth of 14 per cent in coal imports, while South and South-West Asia, which accounted for 13 per cent of the region's total coal imports, recorded 12 per cent annual growth. In the whole ESCAP region, the demand for imported coal grew by 5 per cent per year.

The market for internationally traded coal is divided into two regional markets: the Atlantic and the Pacific, the latter dominated by ESCAP economies and significantly influencing the international coal trade. In 2005, the overall international coal trade reached 775 million tons, of which Australia exported 30 per cent. Japan, the Republic of Korea and Taiwan Province of China, the top three coal importers, together imported 41 per cent of the global total. China and India imported 62 Mt and in 2005 were also among the top 10 coal importers.

Electricity trade

In 2005, annual electricity trade in the ESCAP region amounted to around 142,000 GWh—11.6 per cent of total electricity trade worldwide. However, potential electricity trade, both current and planned, is enormous across all the ESCAP subregions, except the Pacific. This includes trade both within and between subregions. The bulk of the trade in the ESCAP region, 63 per cent, is in North and Central Asia, but extensive plans to boost electricity trade are also under way in the other subregions.

“In 2005, annual electricity trade in the ESCAP region amounted to 11.6 per cent of total electricity trade worldwide”

TOTAL FINAL CONSUMPTION

Throughout the 1992-2005 period, total final consumption (TFC) in the ESCAP region accounted for about 40 per cent of the world's total and grew at 5.4 per cent per year, compared with the global average of 4.4 per cent (table 2-17). As might be expected, East and North-East Asia had the largest share—close to 50 per cent in 2005. East and North-East Asia also registered the highest growth in TFC at 6.1 per cent per annum, similar to that in South and South-West Asia at 6.0 per cent.

Table 2-17—Growth in total final consumption, 1992-2005 (Mtoe)

	1992	2005	% of ESCAP region total	Annual average growth, 1992-2005 (%)
East and North-East Asia	685	1,473	49	6.1
North and Central Asia	303	497	17	3.8
Pacific	66	85	3	1.9
South and South-West Asia	294	621	21	6.0
South-East Asia	157	316	10	5.6
ESCAP region	**1,506**	**2,992**	**100**	**5.4**
Developed ESCAP	337	382	13	1.0
Other developing ESCAP	1,169	2,610	86	6.4
Least developed countries	25	47	1	5.0
World total	**4,005**	**6,977**	-	**4.4**

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Table 2-18—Per capita energy consumption, 1992-2005 (kgoe per person)

ESCAP region and subregions, rest of the world	1992	1995	2000	2005	Change, 1992-2005 (%)
East and North-East Asia	498	813	794	968	94
North and Central Asia	1,396	2,347	2,360	2,276	63
Pacific	2,402	2,513	2,538	2,560	7
South and South-West Asia	225	261	298	374	66
South-East Asia	343	425	500	566	65
ESCAP region	**445**	**652**	**658**	**749**	**68**
Global	733	934	1,018	1,071	46
Rest of the world	1,201	1,393	1,597	1,580	32
ESCAP economies by level of development	**1992**	**1995**	**2000**	**2005**	**1992-2005**
Developed ESCAP	2,320	2,600	2,490	2,507	8
Developing ESCAP	299	466	494	617	107
Least developed countries	118	167	146	170	44
Commonwealth of Independent States	1,396	2,347	2,360	2,276	63

Source: United Nations Energy Database (http://unstats.un.org/unsd/energy/edbase.htm), accessed in December 2007.

Despite the strong growth in TFC, per capita consumption in the ESCAP region as a whole remained lower than the global average (table 2-18). Nevertheless, it has been growing faster than the rest of the world's: between 1992 and 2005 it increased by 70 per cent. The Pacific had the highest per capita consumption among the ESCAP subregions and the lowest increase between 1992 and 2005. North and Central Asia had consumption similar to that in the Pacific subregion but has a larger increase during the 13-year period.

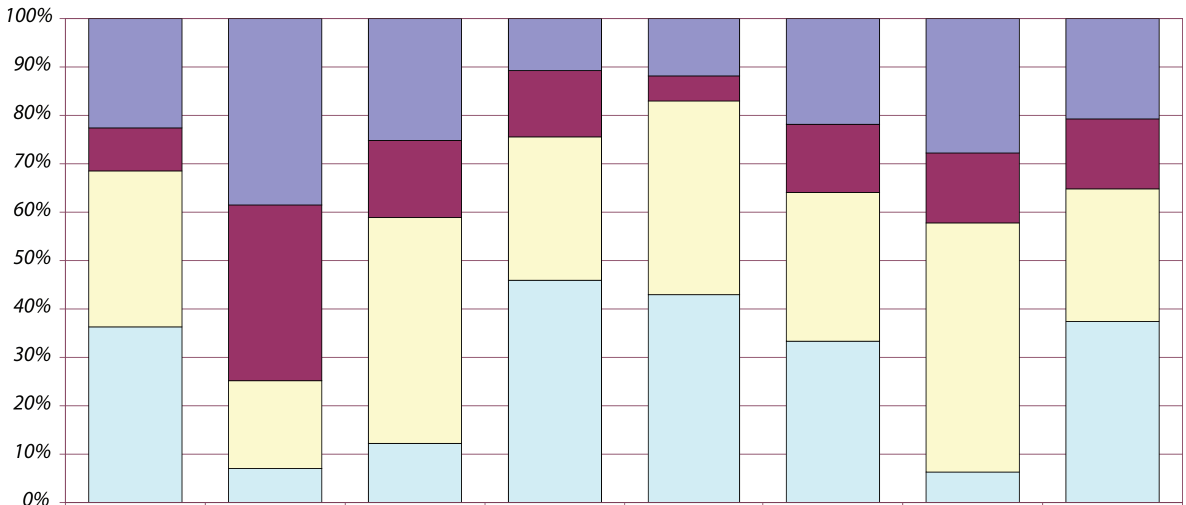
> "Despite the strong growth in TFC, per capita consumption in the ESCAP region as a whole remained lower than the global average"

Per capita consumption was greater in the developed ESCAP economies—three times larger than the average of the ESCAP region, and 14 times that in the least developed countries. Nevertheless, these gaps have been narrowing as consumption has grown in the developing ESCAP economies. In the least developed countries, however, consumption is lower and growing more slowly than the average.

FINAL ENERGY MIX

Solid and liquid fuels play the major role in fuelling the ESCAP region's final energy demand, each accounting for about one third (figure 2-22). North and Central Asia, however, relied more on electricity and gaseous fuels. Another exception is the Pacific subregion, in which liquid fuels alone accounted for 46 per cent. In the developed economies, liquid fuels contributed more than 50 per cent.

Figure 2-22—Total final consumption by subregion and fuel, 2005 (Mtoe)



	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia	ESCAP region	Developed ESCAP	Developing ESCAP
Electricity	331	191	22	68	38	650	106	544
Gaseous fuels	133	181	14	85	15	428	55	373
Liquid fuels	473	89	40	183	127	912	196	715
Solid fuels	536	36	10	285	135	1,002	24	978

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

SECTORAL CONSUMPTION

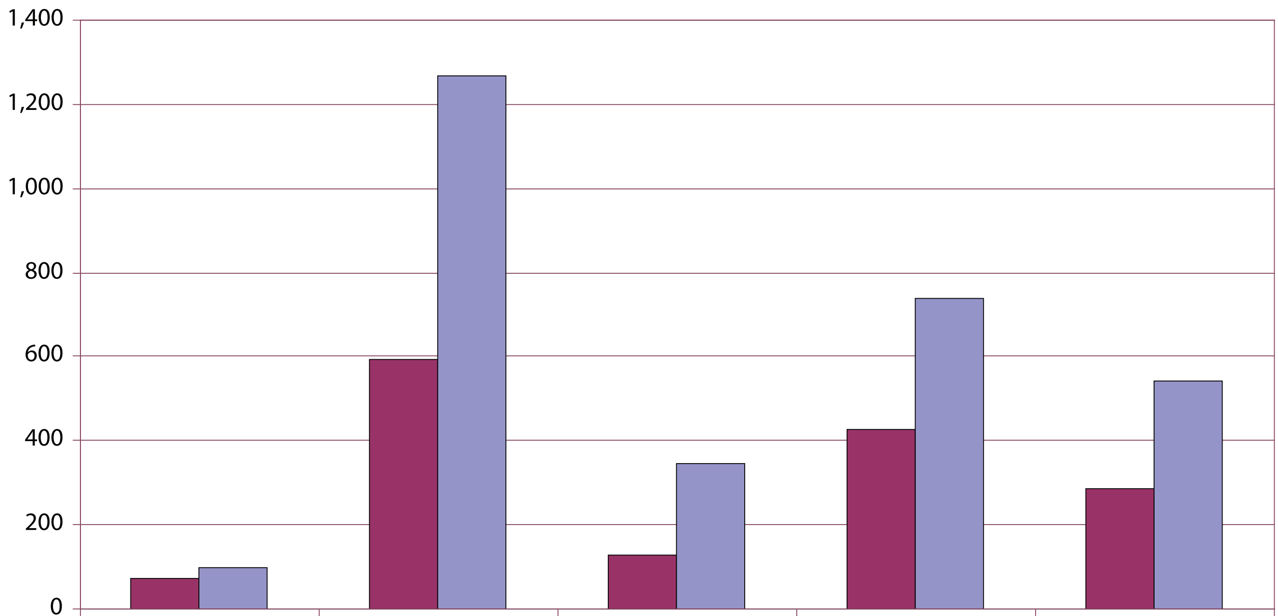
The strong demand for solid and liquid fuels was driven by demand in the industry, household, and transport sectors, which were the region's largest energy-consuming sectors—and the fastest growing, at 6.0 per cent per year over the period 1992-2005, above the regional average of 5.4 per cent. Growth in the household and transport sectors' final energy consumption was also significant at 4.4 and 5.0 per cent per year respectively (figure 2-23).

The highest growth, however, was in the services sector, including public lighting, which grew 7.9 per cent per annum and between1992 and 2005 increased its share in the region's TFC from 8.4 to 11.5 per cent. The same trends were also evident at the subregional level and across the developed and developing ESCAP economies: the services sector either had the highest growth rates or, as in South-East Asia and North and North-East Asia, was second only to industry. These trends are to be expected: after a certain level of industrialization the services sector tends to grow fastest.

> "The strong demand for solid and liquid fuels was driven by demand in the industry, household, and transport sectors"

> "The highest growth was in the services sector"

Figure 2-23—Sectoral final consumption, 1992-2005 (Mtoe)

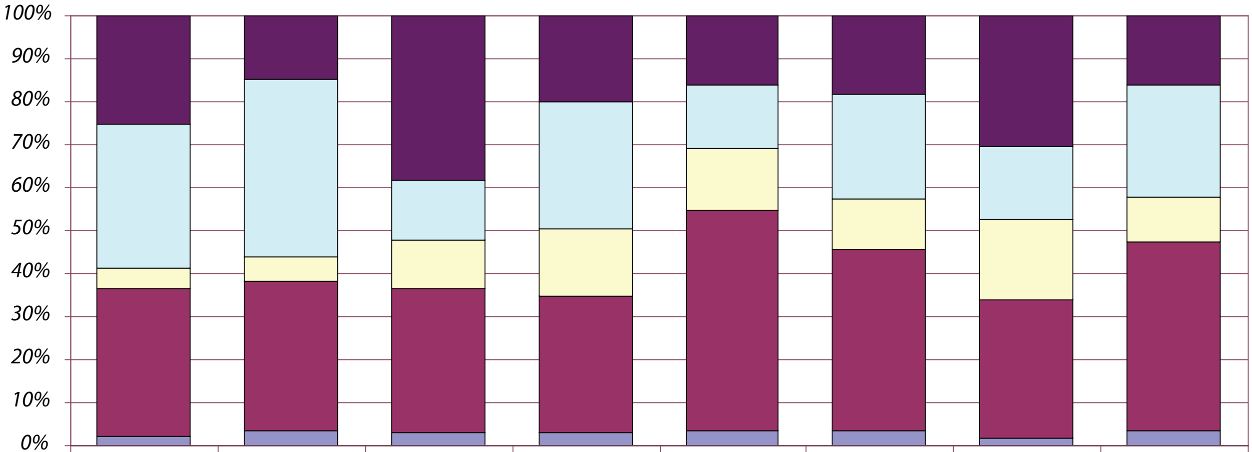


	Agriculture	Industry	Services*	Households	Transport
1992	73	594	126	426	286
2005	99	1,268	344	740	540

*Other consumers and public lighting

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-24—Sectoral final energy mix by subregion, 2005 (Mtoe)



	South-East Asia	South and South-West Asia	Pacific	North and Central Asia	East and North-East Asia	ESCAP region	Developed ESCAP	Developing ESCAP
Transport	80	91	33	99	238	540	116	424
Households	105	257	12	146	219	740	65	675
Services*	16	35	10	77	207	344	72	272
Industry	108	217	28	159	755	1,268	122	1,147
Agriculture	6	21	3	14	54	99	7	91

*Other consumers and public lighting

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Note: "Developing ESCAP" includes the Russian Federation.

Industry also increased its share in region's final energy mix—from 40 per cent in 1992 to 43 per cent in 2005 (figure 2-24). The subregion primarily responsible for this was East and North-East Asia, with its energy consumption by industry growing at 8.5 per cent per year and reaching a 51 per cent share in 2005. Industry also dominated final sectoral energy consumption in South-East Asia (35 per cent) and North and Central Asia (32 per cent), as well as in the developed (32 per cent) and developing ESCAP economies (44 per cent).

The household sector's share over this period dropped from 28 to 25 per cent, with low proportions in the Pacific and in East and North-East Asia, and in the developed countries. Transport, however, maintained its share at 16 per cent as a result of higher growth in the developing economies and a steady share of about 30 per cent in the developed economies' final energy mix.

END-USE ENERGY EFFICIENCY

"Energy saved is energy produced".[61] Energy efficiency is the most cost-effective means of meeting energy demand—and is complementary to renewable energy for achieving a secure and clean energy future and addressing global climate change.

> "Energy efficiency is the most cost-effective means of meeting energy demand"

Most Asian countries have broad energy laws which include energy efficiency objectives. A number of countries have also adopted legislation focusing specifically on energy efficiency and conservation. These include: China (Energy Conservation Law); India (Energy Conservation Act); Japan (Law concerning the Rational Use of Energy), Kazakhstan (Energy Saving Law); and Thailand (Energy Conservation Promotion Act). These laws are generally comprehensive and involve many sectors from industry to households.

One barrier to energy efficiency is the lack of information and public awareness. Generally neither producers nor consumers have access to updated and reliable information on technologies and their associated costs and benefits. Lacking information on the life-time cost of equipment, they often purchase the cheapest item, irrespective of its energy efficiency. To address this, governments have carried out a range of information activities, including media campaigns, technical publications, training, education, and energy-efficiency labelling and awards. One effective option is to site energy information centres close to specific target groups, such as housing associations, citizens' groups, local institutions, small businesses, farmers, politicians, and schools. Australia, China, the Philippines and Viet Nam[62] have set up such centres.

Some countries also have energy conservation days, weekly or annually, or give energy efficiency awards to recognize best practices and achievements. For example, since 1997, the NGO Consumers Korea, with support from the Government of the Republic of Korea and ESCAP, has presented the Energy Winner Award. This goes to products, systems and activities in five areas: green appliances, green lighting and equipment, energy-efficient cars, sustainable (green) buildings, and energy efficiency activities. Similarly, the ASEAN Center for Energy coordinates the ASEAN Energy Awards, which recognize excellence in public and private entities in the fields of energy efficiency and renewable energy.

Aggregate energy intensity

The traditional but still fairly reliable indicator of energy efficiency is "energy intensity"—the amount of energy per unit of economic output. Energy intensity is usually determined for total consumption and sectoral levels, as for final electricity consumption. At the total level the appropriate economic output variable is real GDP at 1990 prices and current GDP at international purchasing power price parity, though at the sectoral level, it is the sectoral gross value added.

Energy intensity is higher in developing Asia than in the OECD countries. There are also large variations within Asia.[63] These correspond to such factors as: the economic structure, income levels, technological factors, the level of development, dependence on traditional fuels, energy self-sufficiency, and the fuel mix.[64] Energy intensity tends to be lower in the poorest countries but then rises with per capita income, before tapering off at higher income levels. Since much of developing Asia's economic activity is centred on the industrial and manufacturing sectors, which often use inefficient technologies, their energy intensities have remained high.[65]

"Energy intensity is higher in developing Asia than in the OECD countries"

"Energy intensity tends to be lower in the poorest countries but then rises with per capita income"

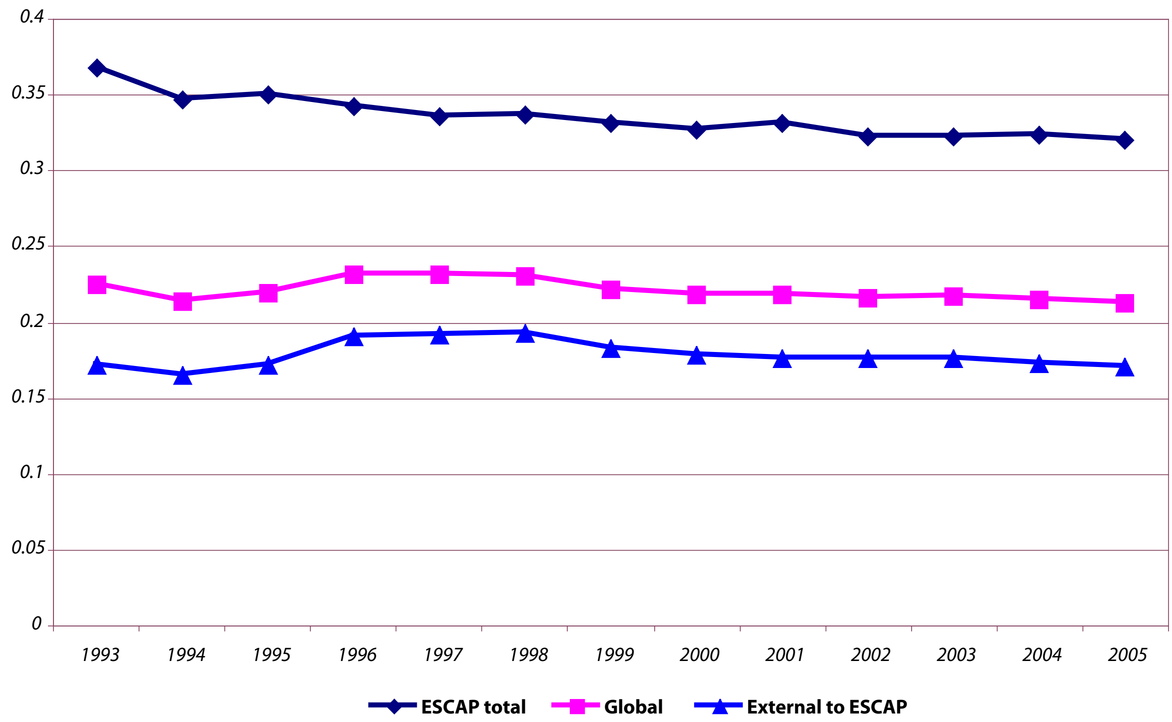
Reducing energy intensity requires good energy sector governance and an integrated energy vision. Prices can also play an important role—leading to advances in technology and also to structural changes that promote a pattern of growth that optimizes the use of energy resources.[66]

According to The Energy and Resources Institute, however, structural and technological factors have resulted in a general decrease in energy intensity.[67] Prior to 2005, aggregate final energy intensity in the ESCAP region had been about 50 per cent above the global average. But it has certainly been coming down. Between 1993 and 2005, the ESCAP region's energy intensity fell by close to 20 per cent, compared with a global average drop of about 7 per cent.

At the subregional level, the highest energy intensity has been in North and Central Asia, though it has fallen steeply (figures 2-26 and 2-27). It is lowest in the Pacific. East and North-East Asia managed a significant 5 per cent decline while South and South-West Asia and South-East Asia experienced an increase.

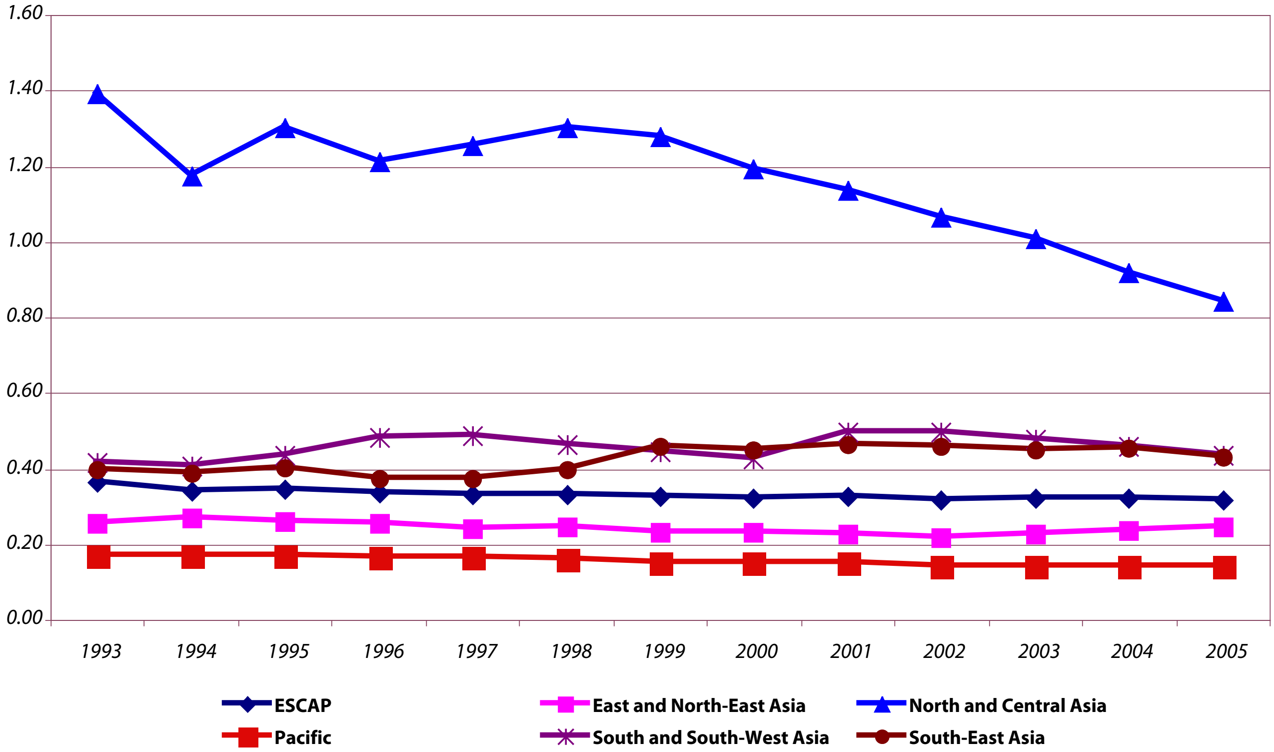
The level and path of energy intensity have always been linked to the level of development. Expressed in this case as a ratio of total final consumption and 1990 value GDP rates, all ESCAP economies grouped by level of development have shown substantial improvements. Using this measure, between 1993 and 2005 the ESCAP regions experienced a drop in energy intensity of 4.5 per cent per year. Intensity is lowest in the developed ESCAP economies but also decreased at a lower rate—2.9 per cent. The developing ESCAP economies saw a faster decline, of 5.2 per cent per year, much of which came from the CIS economies which decreased their aggregate final energy intensities by 6.1 per cent annually. The least developed countries, on the other hand, only managed a 2.1 per cent annual decrease; indeed, between 1993 and 1999 they had a 3.6 per cent annual increase.

Figure 2-25—Aggregate final energy intensity, 1993-2005 (toe per $1,000, 1990)



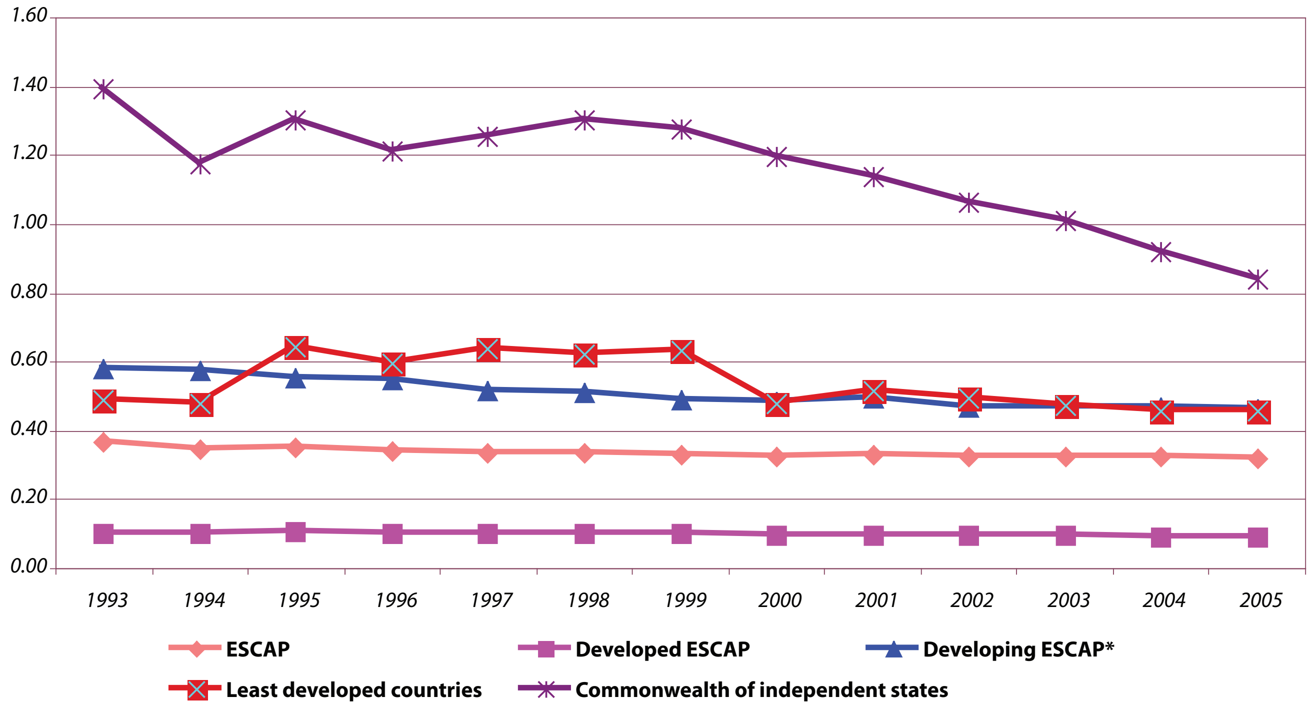
Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-26—Aggregate final energy intensity by subregion, 1993-2005 (toe/'000 1990 USD)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-27—Aggregate final energy intensity, 1993-2005 (toe/$PPP 1,000 current)



*Excluding least developed countries and Commonwealth of independent states.

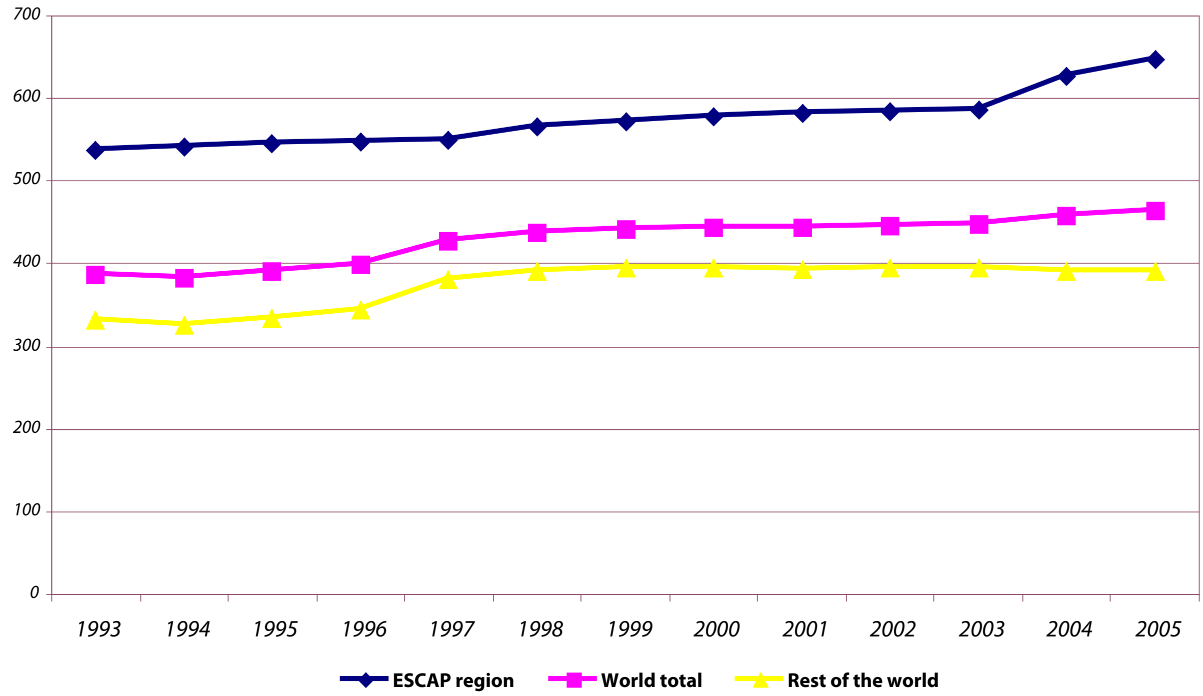
Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Sectoral energy intensities are derived from sectoral gross value added. Data for these are not readily available for all countries, but it is clear that the transport sector has lower energy intensity in the Pacific and East and North-East Asian subregions—as a result of improvements in the developed economies. On the other hand, it is higher in South-East Asia, North and Central Asia, South and South-West Asia and the developing ESCAP economies, which have been less effective at raising the efficiency of gasoline- and diesel-powered vehicles.[68]

For equipment that uses electricity, the usual indicator is electricity intensity, which is expressed in kWh per $1,000 (1990). Between 1993 and 2005, this increased by 20 per cent to 647 for the ESCAP region, which was similar to the 20 per cent global increase to 463. The Pacific subregion, which already had the lowest figure, registered a further slight decline of 4 per cent, while the North and Central Asia region decreased by 29 per cent. The other subregions, on the other hand, recorded double-digit increases—East and North-East Asia by 52 per cent, South and South-West Asia by 12 per cent, and South-East Asia by 44 per cent.

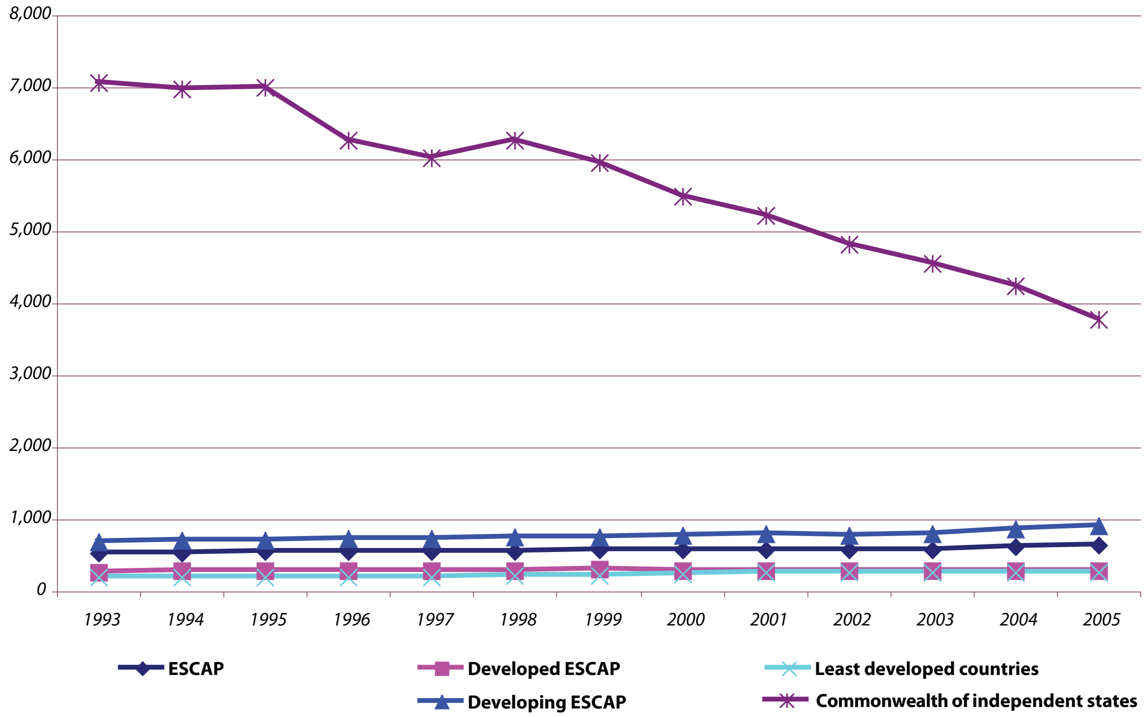
Figures 2-28 and 2-29 show electricity intensity by level of development and reveals similar trends. Between 1993 and 2005, the developed ESCAP economies recorded a 7 per cent increase, while developing ESCAP economies, excluding the Commonwealth of independent states and least developed countries, managed a 30 per cent increase. The least developed countries, on the other hand, with low electricity usage, saw a 42 per cent increase, from 192 kWh in 1993 to 273 kWh in 2005. The high electricity intensities of the CIS economies could be due to their still-inefficient industrial processes and high household energy use—though they have seen dramatic improvements reflected by the 29 per cent decrease.

Figure 2-28—Electricity intensity, 1993-2005 (kWh/'000 1990 US Dollars)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Figure 2-29—Electricity intensity by development status, 1993-2005 (kWh/$1,000 1990)



Source of basic data: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

Economic energy efficiency potential

The *World Energy Assessment* estimates the energy efficiency potential for selected countries and regions, with some ESCAP countries shown in table 2-19. This suggests that developing countries could make substantial energy savings, mostly 10-20 per cent, from improvements in energy-intensive industries. Similar savings can also be realized in both developed and developing economies in the household and commercial sectors, both in building design and in the use of electric lighting and appliances. In the developing economies' transport sector, the greatest potentials are in trains and cars –especially in countries that use two- and three-wheelers, as in India, Indonesia, Thailand, the Philippines and Viet Nam.

Table 2-19—Economic energy efficiency potential by sector, selected economies

	China[a] 2010	Japan[b] 2010	Russian Federation[c] 2010	India[d] 2010	South-East Asia[e] 2020
Industry	8-40%	2-18%	3,370-4,980 PJ	8-40%	2,017 PJ
Household/ residential	10-40%	20-75%	1,905-2,198 PJ; 20-40%	10-70%	20-60%
Commercial and public sectors		240-280 PJ			293 PJ
Agriculture	10-50%		791-879 PJ		
Transportation	5-15%		967-1,172 PJ	5-25%	2,275 PJ

Source: Compiled from UNDP (2000); quoted and compiled by UNDP (2000) from various sources.

Notes: [a] Assumes today's prices and 1995 base year.
[b] Assumes different prices for each sector, and 1990-1995 base year for most sectors.
[c] Assumes 1990-1995 price levels of Western Europe and 1995-1997 base year.
[d] Assumes today's prices and 1992-1997 base year.
[e] Assumes 1998 prices and 1992-1998 base year.

Electric power system efficiency

Energy efficiency is achievable not only on the demand side but also on the supply side. For the efficiency of electric power supply systems there are three measures:

Generation efficiency—efficiency of energy conversion in power plants;

System losses—electricity lost during transmission and distribution;

Station use—electricity used by power generation facilities and substations.

Figure 2-30 summarizes the performance of electric power systems in the ESCAP region for thermal power plants that use hydrocarbons and biomass. This shows that the ESCAP region as a whole has improved thermal generation efficiency, albeit only slightly. A closer look shows, however, that this improvement came largely from the Pacific subregion. All other subregions had no improvement—probably due to the continued reliance on old and ageing thermal power plants, particularly those using solid and liquid fuels. But the entry of modern gas-fired power plants has offset this, resulting in increased efficiency overall. Nevertheless, except for the developed and some South-East Asian economies, the ESCAP region's performance was still below the world average.

> "ESCAP region as a whole has improved thermal generation efficiency, albeit only slighty"

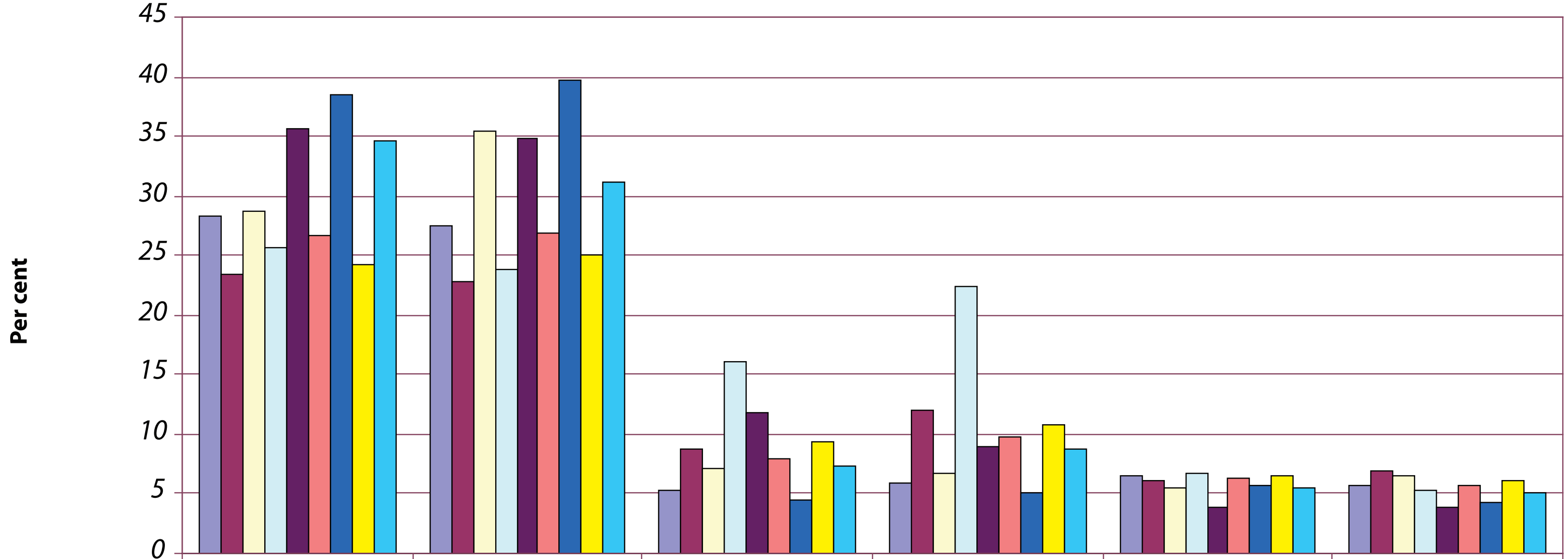
Figure 2-30 shows significant improvement in system losses: between 1992 and 2005, the average electricity used at generating facilities and substations dropped from 6.2 to 5.8 per cent. This was achieved by overall efficiency improvements in both developed and developing ESCAP economies despite some deterioration in the North and Central Asian and Pacific subregions. The areas needing greatest efficiency improvement are transmission and distribution (T&D): Figure 2-30 also shows that electricity lost during T&D increased from 8.0 to 9.7 per cent, with much of the increase coming from the developing economies. T&D system losses are usually disaggregated into technical and non-technical. Technical losses are inherent in the systems and are higher in old and dilapidated ones. Non-technical losses, on the other hand, are usually caused by electricity theft or pilferage, particularly in distribution—generally beyond the control of electricity utilities, though they could exert some influence into bringing them down.

System losses have been higher in the ESCAP region than in the rest of the world. Indeed, since 1997 the gap has widened, especially for distribution losses, which between 1997 and 2001 rose from 9.9 to 11.2 per cent.

> "The areas needing greatest efficiency improvement are transmission and distribution"

> "System losses have been higher in the ESCAP region than in the rest of the world"

Figure 2-30—Efficiency of electric power systems, 1992-2005



	Efficiency of thermal conversion (%) 1992	Efficiency of thermal conversion (%) 2005	Electricity lost during T & D (%) 1992	Electricity lost during T & D (%) 2005	Electricity used by faciliities (%) 1992	Electricity used by faciliities (%) 2005
East and North-East Asia	28	28	5	6	6	6
North and Central Asia	23	23	9	12	6	7
Pacific	29	35	7	7	5	7
South and South-West Asia	26	24	16	22	7	5
South-East Asia	36	35	12	9	4	4
Total ESCAP	27	27	8	10	6	6
Developed ESCAP	39	40	5	5	6	4
Developing ESCAP	24	25	9	11	6	6
Total World	35	31	7	9	6	5

Source: United Nations Energy Database http://unstats.un.org/unsd/energy/edbase.htm, accessed in December 2007.

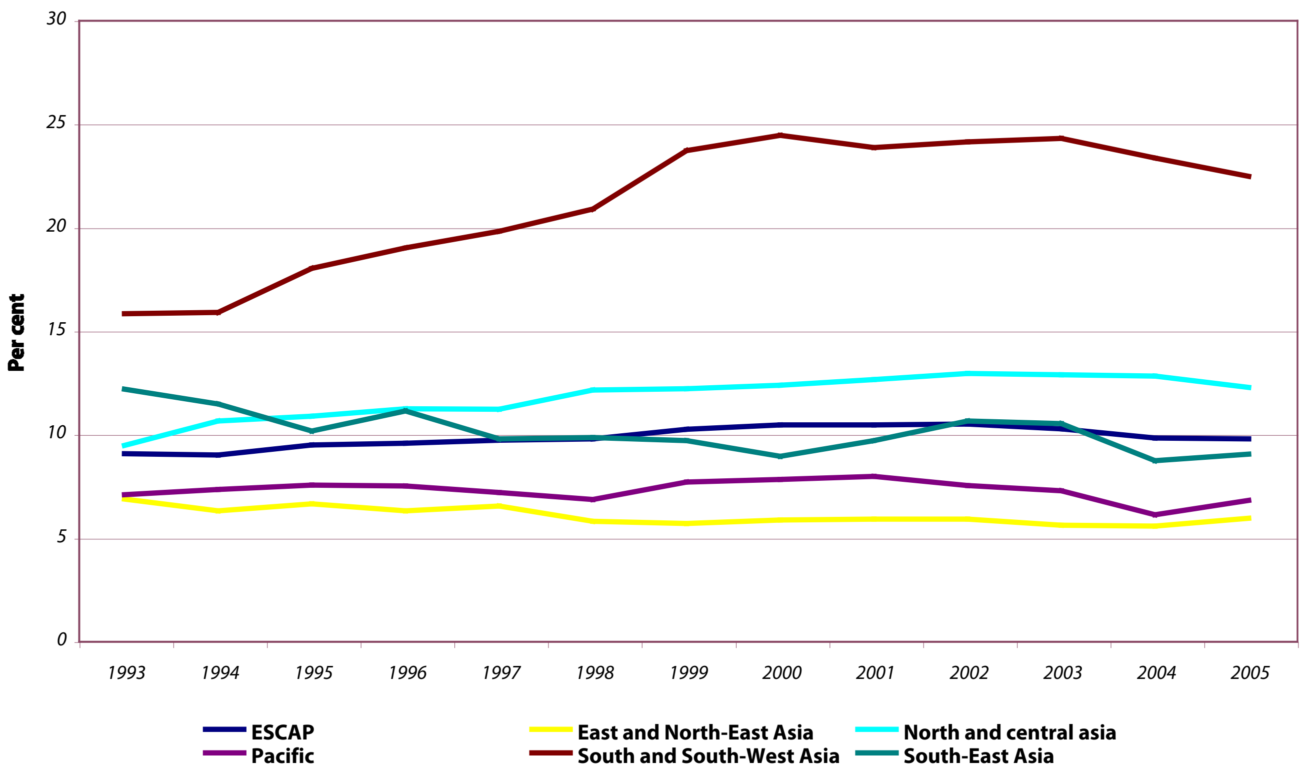
Note: "Developing ESCAP" includes the Russian Federation.

The deterioration in distribution efficiency can be traced largely to the South and South-West Asian subregion. One reason for this could be economic growth itself, which has led to rising demand. South-East Asia, on the other hand, curbed this tendency with policy and regulatory measures. For example, in the Philippines, distribution utilities are mandated by law to reduce their distribution system losses within a specified time period to acceptable single-digit levels. If they miss the targets, they cannot pass on the cost of the additional losses to consumers.

CONCLUSIONS

The ESCAP region has abundant conventional energy resources, including oil, natural gas, coal, uranium and hydropower. At current production rates, the region's oil and coal resources are expected to last longer than the world average, while its natural gas resources should be available for a few years less than the world average. These fossil-energy resources are, however, concentrated in only a few countries, resulting in energy trade between economies and subregions as well as economies outside the region. Only a few ESCAP economies use nuclear energy.

Figure 2-31—Distribution system losses, 1992-2005 (% of net generation)



Source: Energy Information Administration, Department of Energy, United States, www.eia.doe.gov/emeu/international/electricityother.html, accessed in November 2005.

Hydroelectric and other renewable energy potentials are substantial—though they remain largely untapped. Of these, hydropower has been making a steadily larger contribution, along with biomass, solar and wind, which have been growing rapidly. A few countries have substantial geothermal energy resources.

The ESCAP region is producing energy at twice the world average rate and except in North and Central Asia, which produces more natural gas and oil, and where production is dominated by solid fuels, mainly coal. In addition, all the subregions produce oil.

This production is, however, only just enough to meet demand, which is growing faster than in the rest of the world. Growth has occurred in all sectors, including industries, transport and households, but the greatest growth in demand has come from the service sector. Nevertheless, in per capita terms the ESCAP region's final energy consumption is still below world average—and is very low in the least developed countries. It has however, been growing in the developing economies. There are enormous opportunities for increasing energy efficiency in the region.

FINANCING FOR ENERGY INFRASTRUCTURE DEVELOPMENT AND INVESTMENT NEEDS

Photo : ESCAP

"By 2030, it is estimated that Asia and the Pacific will account for half the world energy demand of 17.7 billion toe"

3

FINANCING FOR ENERGY INFRASTRUCTURE DEVELOPMENT AND INVESTMENT NEEDS

Over the coming decades, largely as a result of economic growth, most countries in the Asia-Pacific region will see a surge in the demand for energy. Whether they meet that demand from fossil fuels, or nuclear energy, or from renewable resources, they will need to upgrade and expand their energy infrastructure. How will they finance such a huge undertaking? This chapter assesses how much investment will be needed and where the funds might come from.

The trend between 2006 and 2030, on current trends under a "baseline" scenario, world energy demand will increase by 47 per cent to 17.7 billion toe, with the Asia-Pacific region accounting for almost 50 per cent of the total global energy demand in 2030. If countries in the region were to change their policies and embark on more sustainable energy paths, this demand could be contained to 7.7 billion toe. Nevertheless, there could still be a wide supply-demand gap and the region's economic powers are concerned about their energy security since tight supplies and high prices may constrain economic growth.[69]

One of the major concerns is financing. The cost of expanding and modernizing the region's energy systems on the baseline scenario would be $375 billion annually—over $9 trillion in total. For example, China will need to spend $1 trillion on transmission and distribution networks alone and India will need to spend close to $700 billion in the electricity and oil sectors. On the sustainable energy scenario, however, the demand would be less—$8.3 trillion—resulting in a saving of nearly $766 billion.

> "The cost of expanding and modernizing the region's energy systems on the baseline scenario would be $375 billion annually—over $9 trillion in total"

Finance from traditional sources, mostly public investment, will fall far short of what is required, leaving a widening gap that will need to be filled by innovative forms of financing—including public-private partnerships and environmental funding. But attracting private-sector funds will require market reforms and impartial regulation, and energy projects that look beyond political boundaries and make economic sense for the region as a whole.

> "Finance from traditional sources, mostly public investment, will fall far short of what is required"

METHODOLOGY

There are two basic approaches to demand forecasting: top-down and bottom-up. The top-down approach considers large-scale economic factors, such as world GDP, levels of global trade, world inflation, and average energy intensity. Then, it makes some assumptions about the oil/GDP ratio in each region of the world energy market. The bottom-up approach, on the other hand, works on a country-by-country and fuel-by-fuel basis—paying attention to such features as population and economic growth, end-use of energy carriers, appliance stock, government policies and other socio-political factors. The demand projections made here follow the popular IEA methodology as presented in the *World Energy Outlook 2004*.[70] Though this chapter uses the IEA methodology, it makes certain modifications:

(i) United Nations Statistics are used throughout this publication. However, as more recent data have become available through the BP Statistical Review of World Energy, and these are very close to United Nations Statistics, they are used for the base year of 2006 in these projections;[71]

(ii) For the fuel-specific growth rates for the prominent countries of the Asia-Pacific region this chapter uses the publications of the Institute of Energy Economics, Japan, though these also use the IEA methodology as the basis for energy projections;[72,73,74]

(iii) For energy projections for the world this chapter uses the growth rates provided by IEA, while for those of Asia-Pacific countries it uses those of the Institute of Energy Economics. However, in the case of projections made for 2010 with the new base year of 2006, some corrections in growth rates have been made to reflect the change in incremental demand during the period 2004-2006.

This chapter presents a 24-year forecast of energy demand for two cases: "baseline" and "sustainable energy". For both scenarios, the assumptions are the same as those of IEA. The baseline scenario assumes the present patterns of population growth, economic development and energy use—with no policy interventions to limit energy demand or to ensure environmental compliance.

The sustainable energy scenario, on the other hand, assumes supply-side as well as demand-side management. Supply-side management involves practices and technologies that improve the efficiency with which energy is produced and delivered, focusing on increasing the share of renewable energy technologies—along with such technologies as coal beneficiation (washing), advanced technologies of energy conversion, sugar co-generation and efficient natural gas-burning turbines. Demand-side management involves end-use efficiency, and fuel substitution using solar power technologies, biomass energy for heat or power generation or for conversion to liquids or gas for later combustion.

Estimations for investment needs are broadly based on energy demand projections with some modifications for some countries producing energy for export. However, these investment estimates and the production capacity on which the estimates are based may not fully take into account expansion in production capacity for trade purposes.

"Fossil fuels are expected to continue dominating the world energy system"

DEMAND OUTLOOK—BASELINE SCENARIO

Typical demand predictions for the coming decades in Asia and the Pacific point to the need to double or triple installed capacity. Based on assumptions about economic and population growth, as well as on developments in energy intensities, between 2006 and 2030, energy demand in the Asia-Pacific region is projected to grow by about 2.75 per cent per year.

Table 3-1 shows which fuels will meet this need in 2030. Fossil fuels are expected to continue dominating the world energy system—meeting almost 90 per cent of total energy demand of 8.9 billion toe in 2030. The main source of energy will be coal, 35 per cent, followed by oil, 28 per cent, and natural gas, 25 per cent, while nuclear and renewable energies together will account for slightly more than 10 per cent.

Table 3-1—Primary energy demand outlook by fuel type (Mtoe)

Fuel	Region	2006	Baseline scenario			Increments	
			2010	*2020*	*2030*	*2010-2020*	*2020-2030*
Oil	Asia Pacific	1,283	1,445	1,897	2,398	452	501
	Asia Pacific [a]	1,412	1,584	2,063	2,596	479	533
	World	3,890	3,953	4,772	5,593	819	821
Natural gas	Asia Pacific	599	692	999	1,351	307	352
	Asia Pacific [a]	988	1,082	1,443	1,847	361	404
	World	2,575	2,710	3,504	4,229	793	726
Coal	Asia Pacific	1,853	1,981	2,420	2,801	439	381
	Asia Pacific [a]	1,965	2,096	2,545	2,929	449	384
	World	3,090	3,216	3,732	4,289	516	557
Nuclear	Asia Pacific	128	169	236	286	67	50
	Asia Pacific [a]	164	207	279	334	73	54
	World	636	641	722	782	81	60
Hydro	Asia Pacific	196	208	276	312	68	36
	Asia Pacific [a]	236	254	326	366	73	39
	World	688	729	854	953	125	99
Biomass and other renewables	Asia Pacific	645	717	787	865	70	78
	World	1,176	1,365	1,590	1,861	225	271
Total	Asia Pacific	4,704	5,212	6,615	8,013	1,403	1,398
	Asia Pacific [a]	5,410	5,940	7,443	8,937	1,505	1,492
	World	12,055	12,614	15,174	17,707	2,559	2,534

Note: [a] Including the Russian Federation.

From now until 2030, demand for oil is expected increase by 2.6 per cent per year and thus should almost double from 1,283 to 2,397 Mtoe or, including the Russian Federation, to about 2,596 Mtoe. Driven by electricity demand, the fastest-growing energy source will be natural gas, by 3.5 per cent per year, reflecting its advantages of low GHG emissions and efficiency when used in combined cycle gas plants. The demand for coal will continue to grow, but at a slower rate, reflecting concerns about its contribution to global climate change.

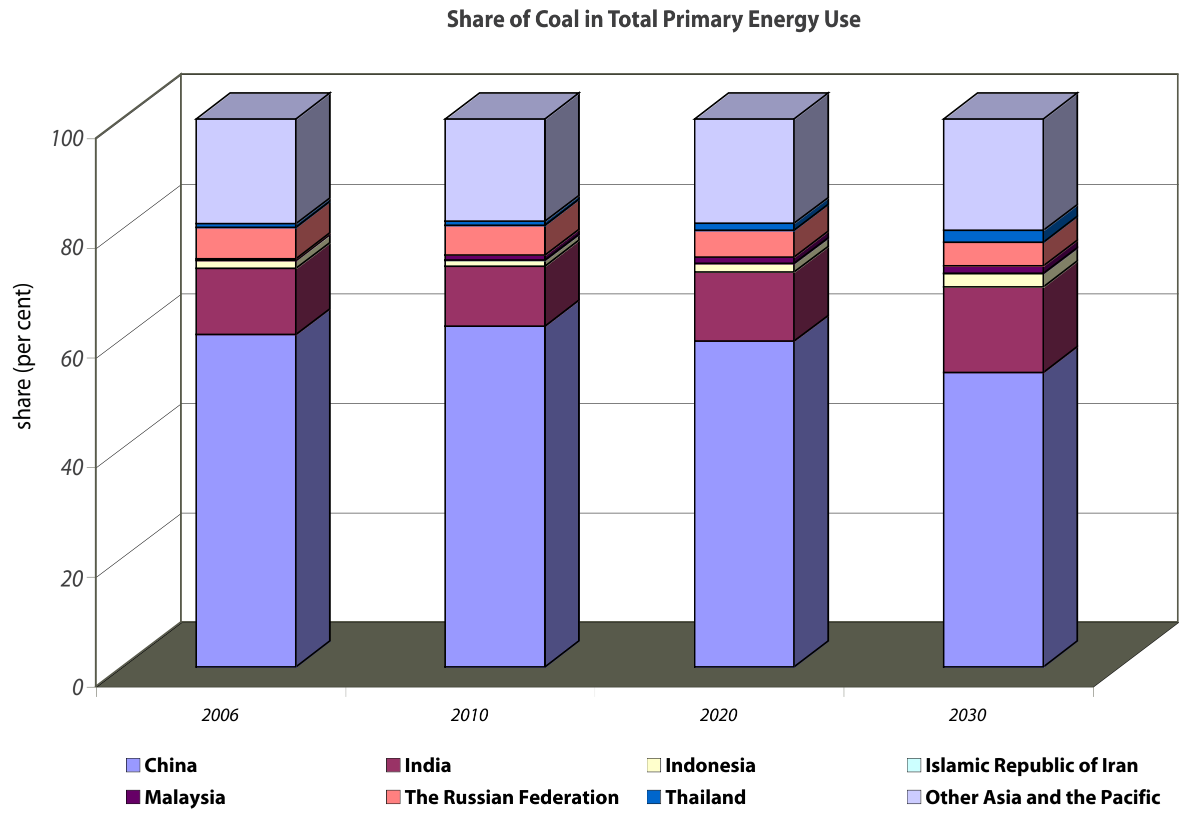
The demand for other renewables, such as biomass and hydro, is likely to be relatively flat. Nuclear power is clearly an option though growth will be restricted by plant location and waste-management issues. Table 3-1 shows, nevertheless, that in the Asia-Pacific region all energy carriers will grow faster than the world average. The average annual growth rate of oil, natural gas, coal, nuclear and hydro for the next 24 years (2006 to 2030) will be 2.6, 3.4, 2.4, 3.7 and 2.5 per cent respectively, compared with the respective global values of 1.5, 2.1, 1.8, 0.9 and 1.7 per cent. Growth in Asia and the Pacific thus is going to be more energy-intensive than in the rest of the world.

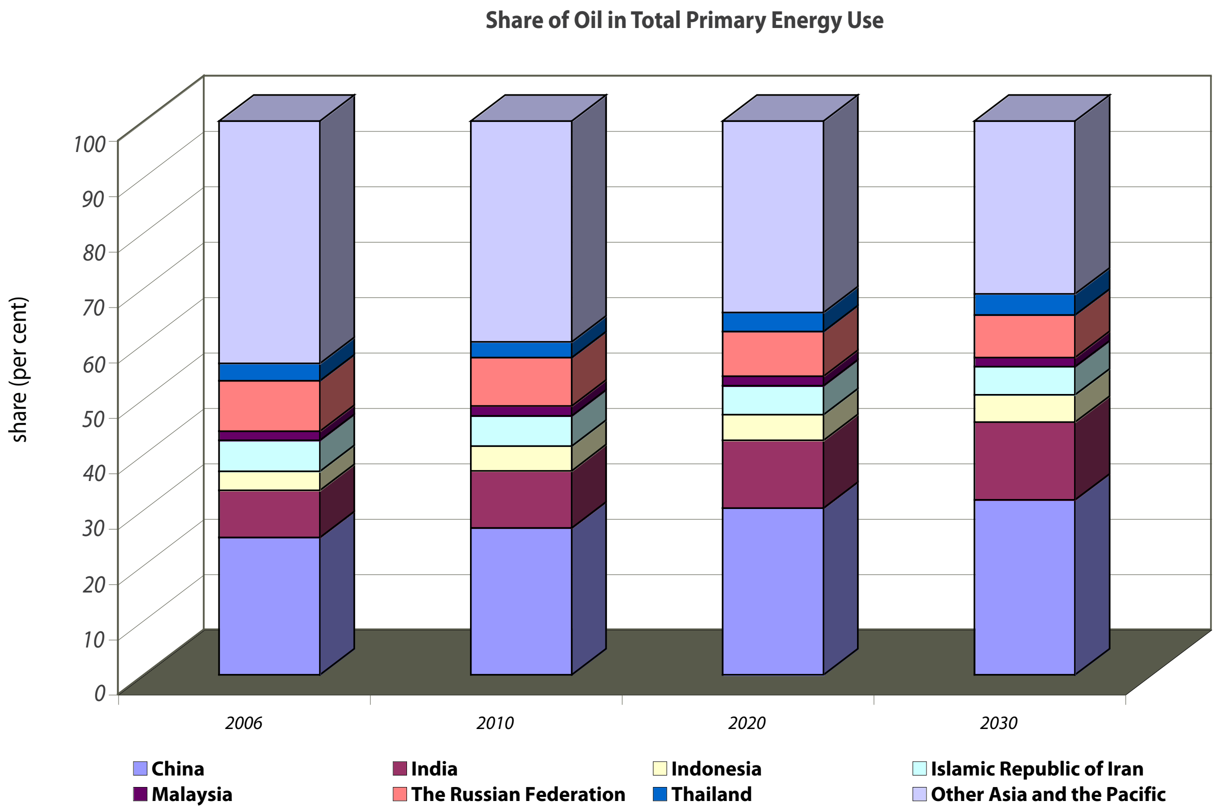
Figure 3-1 shows how the region's use of energy resources is distributed between countries. China and India dominate coal consumption with three quarters of the region's usage, and this is likely to continue. China and India will also have a growing share of oil and natural gas—for oil reaching close to 50 per cent by 2030. India's demand growth will be 4.7 per cent per year, compared with 3.6 per cent for China, mainly because of India's higher population growth. Both countries will also use more natural gas: their share of the region's demand will climb from 16 to 22 per cent. In the case of nuclear energy, output in these two countries will take off after 2010, and give them a share of 36 per cent by 2030. In hydropower, China and India are ahead of other economies and their advantage will continue.

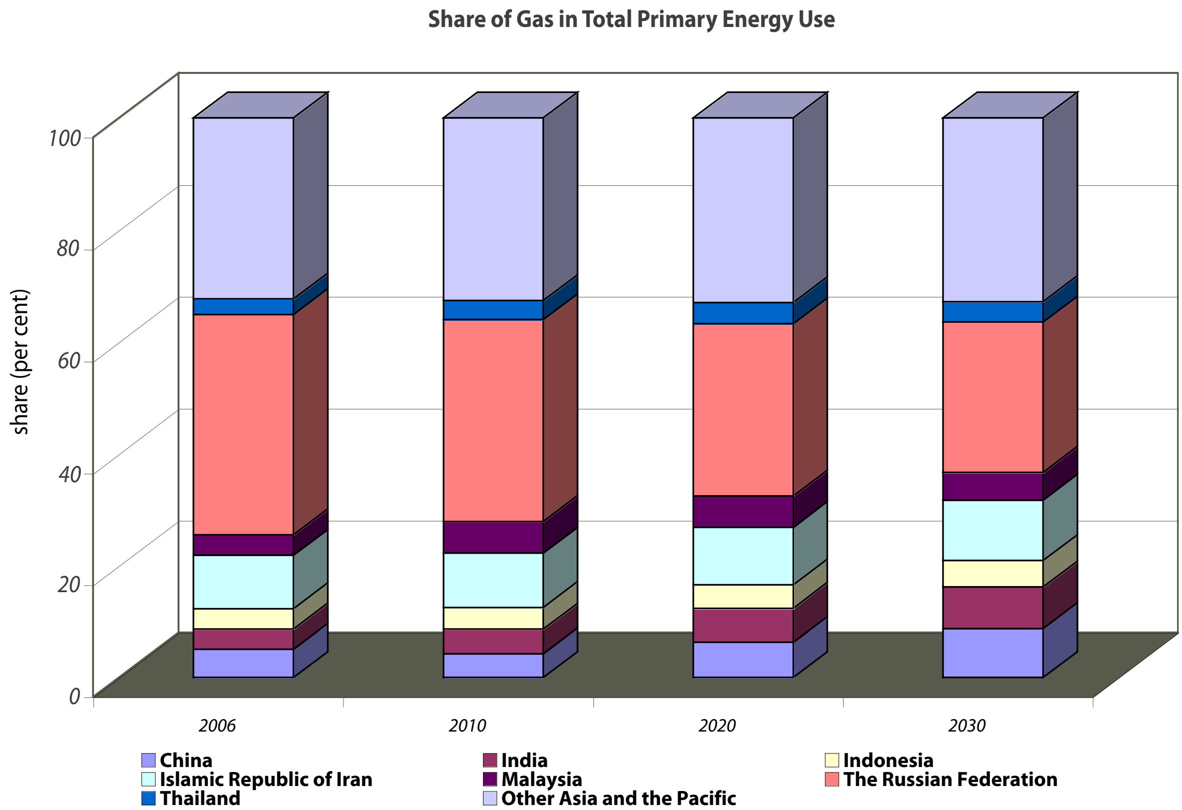
Table 3-2 shows the electricity demand in various countries by 2030. Electricity sales are expected to grow at an average annual rate of 2 per cent. Installed generation capacity is projected to grow 5.4 per cent per annum until 2010 from 6,957 to 7,917 TWh, then at 3.4 per cent until 2020 reaching 11,099 TWh. Then it will increase at a more moderate rate of 2.7 per cent, reaching 14,512 TWh by 2030—or 15,937 TWh including the Russian Federation. Over this period, Indonesia will have a fivefold increase in electricity generation.

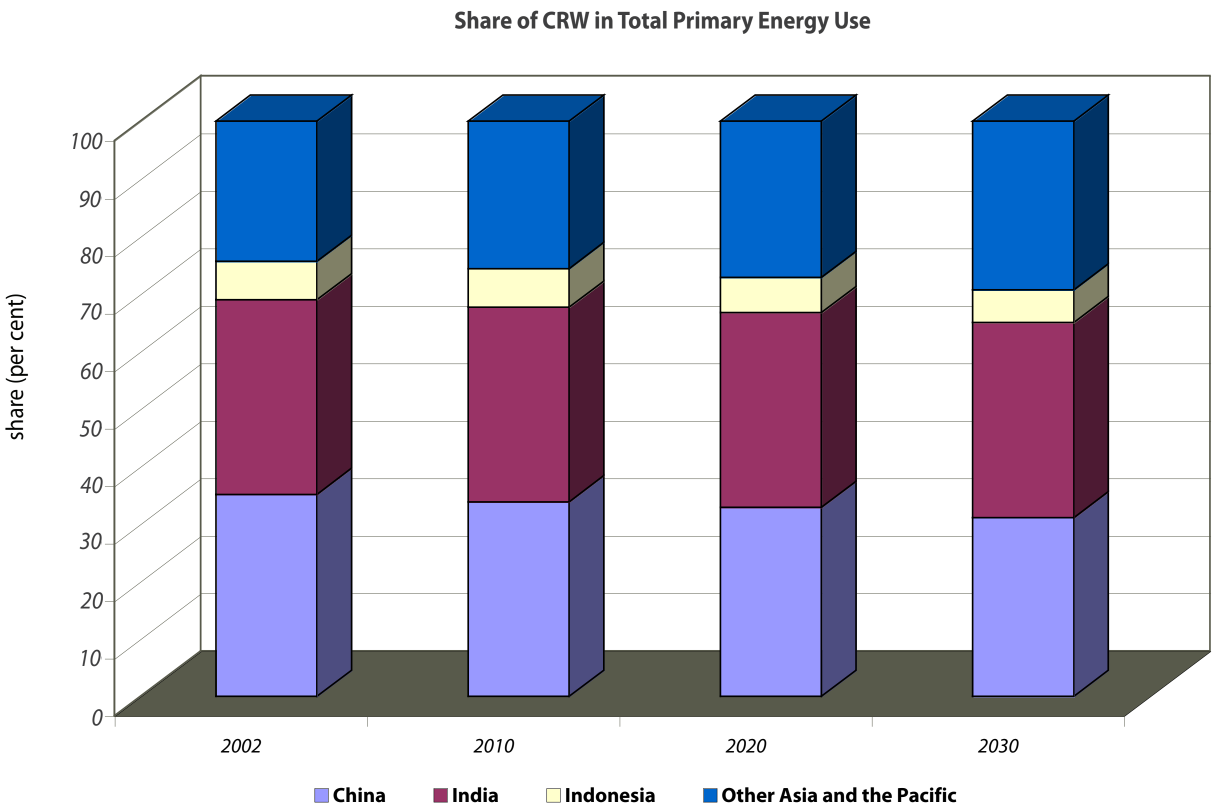
“China and India dominate coal consumption with three quarters of the region's usage, and this is likely to continue”

Figure 3-1—Use of coal, oil, natural gas and renewables in the ESCAP region






Share of Gas in Total Primary Energy Use
share (per cent)
100
80
60
40
20
0
2006
2010
2020
2030
China
India
Indonesia
Islamic Republic of Iran
Malaysia
The Russian Federation
Thailand
Other Asia and the Pacific


Share of CRW in Total Primary Energy Use
share (per cent)
100
90
80
70
60
50
40
30
20
10
0
2002
2010
2020
2030
China
India
Indonesia
Other Asia and the Pacific

Electricity demand in India, the Islamic Republic of Iran, Malaysia and the Philippines is expected to grow more than threefold. However, China is expected to have a twofold increase, whereas developed countries, such as Australia and Japan, will experience a slowdown, indicating saturating economies. India's demand will overtake that of Japan somewhere between 2010 and 2020. Similarly, Indonesia, which is ranked eighth at present, will overtake Australia, the Islamic Republic of Iran, and Thailand to occupy fourth position. China and India, because of their size, account for more than half the region's electricity generation and their share will remain the same.

India's per capita consumption is only 30 per cent that of China—because 487 million people in India live without electricity (refer to table 1-1)[75]. India is a large consumer of electricity but still has a long way to go to extend access to most of its people. As shown in table 3-2, in terms of increments in electricity generation, India comes a distant second to China, followed by the Russian Federation. The relative positions of countries in the region will change in the coming decades as the developed countries reach saturation.

Table 3-2—Electricity generation outlook (TWh)

Country/area	Generation (TWh)				Increments		
	2006	*2010*	*2020*	*2030*	*2006-2010*	*2010-2020*	*2020-2030*
Australia	258	277	362	454	19	85	92
Azerbaijan	24	27	43	62	3	16	19
Bangladesh	25	29	46	72	4	17	26
China	2,834	3,307	4,620	5,632	473	1,313	1,012
Hong Kong, China	39	42	49	56	3	7	7
India	727	838	1,418	2,244	111	580	827
Indonesia	126	186	350	645	61	164	295
Iran (Islamic Republic of)	198	214	285	358	16	71	73
Japan	1,150	1,183	1,281	1,333	33	98	52
Kazakhstan	72	82	132	191	11	49	59
Malaysia	101	179	273	349	78	94	76
New Zealand	43	49	64	81	6	15	17
Pakistan	114	119	191	297	6	72	106
Philippines	57	81	134	208	24	53	74
Republic of Korea	416	450	570	702	34	120	132
Russian Federation	993	1,037	1,228	1,425	45	191	197
Singapore	40	42	61	80	3	19	19
Taiwan Province of China	235	250	360	474	15	110	115
Thailand	136	182	309	517	46	126	209
Turkey	176	173	226	284	-3	53	58
Turkmenistan	13	14	22	33	1	8	10
Uzbekistan	49	61	97	142	12	37	44
Other Asia Pacific	125	129	206	298	4	77	93
Total Asia Pacific	6,957	7,917	11,099	14,512	960	3,182	3,413
Total Asia Pacific [a]	**7,950**	**8,954**	**12,327**	**15,937**	**1,004**	**3,373**	**3,610**
Total World	**19,028**	**20,348**	**26,560**	**33,342**	**1,320**	**6,212**	**6,782**

Note: [a] Includes the Russian Federation.

DEMAND OUTLOOK—SUSTAINABLE ENERGY SCENARIO

All countries should be aiming for affordable, clean and secure energy. Fortunately, it is indeed feasible to decrease the use of fossil fuel while maintaining energy services at the levels described in the baseline scenario. This would, however, require strong policy action to shift towards renewable energy and energy-efficient technologies.

> "It is indeed feasible to decrease the use of fossil fuel while maintaining energy services"

The sustainable energy scenario, equivalent to the IEA alternative policy scenario, can significantly reduce energy demand. In Asia and the Pacific, given the high growth imperatives, the reductions are unlikely to be dramatic before 2030 but subsequently could result in substantial reductions in demand and shift supply away from fossil fuels. The key features of this sustainable energy scenario are energy savings and renewable energy.[76] This requires both supply-side and end-use energy efficiency management, which can be combined with "integrated resource planning"—practices that help energy planners and regulators evaluate the options and employ the mix which will provide energy at the least financial and environmental cost.

Supply-side management

This involves practices and technologies that improve the efficiency with which energy is produced and delivered. Most prominent in terms of cost-effectiveness and potential are coal beneficiation (washing), efficient coal boilers, sugar co-generation and efficient natural gas-burning turbines. One of the easiest options is coal beneficiation: in India, for example, the quality of coal is very low and beneficiation reduces the levels of ash and sulphur.

> "Supply side management involves practices and technologies that improve the efficiency with which energy is produced and delivered"

Another option is to switch for power generation from coal to natural gas. This can involve combined cycle gas turbine technology, which allows for the construction of smaller plants. These plants not only have shorter gestation periods, they are also 20 per cent more efficient than conventional coal thermal plants and have much lower capital costs.

Significant savings are also possible with efficient transmission and distribution systems, which can use new technologies, such as amorphous-core transformers and high-voltage direct-current transmission. China, for example, envisages expanded support for more efficient and cleaner coal-fired power plants. Another important strategy is to increase the share of hydro and nuclear energy and renewable sources, such as biomass, wind, solar and micro-hydro.

End-use energy efficiency management

This involves efficiency improvements, fuel switching and transportation mode shifts, along with appropriate pricing policies, good housekeeping practices, and load management strategies. Fuel substitution embraces sources such as small-scale solar, biomass for heat or power generation or for conversion to gas, and other technologies such as wind power. Demand-side management technologies with significant conservation potential include: energy-efficient motors, variable-speed drives, compact fluorescent lamps, and solar water-heaters.

• Industry—Nearly half of electricity in the industrial sector is used for driving motors. Better design and materials can increase efficiency by 3 to 5 per cent. Variable-speed drives have significant scope in paper, chemical, fertilizer, pharmaceutical and cement

> "End-use energy efficiency involves efficiency improvements, fuel switching and transportation mode shifts, along with appropriate pricing policies, good housekeeping practices, and load management strategies"

industries and can reduce electricity consumption by 25 to 30 per cent. For lighting, incandescent bulbs can be replaced by compact fluorescents, with energy savings of up to 75 per cent. Similarly, the temperature required to heat water is about 45°C, which can easily be achieved by solar water heaters.[77]

• Residential and commercial sectors—Options here include switching fuels—from firewood to kerosene or LPG for cooking. But many households should also be able to replace inefficient appliances: in rural regions

Table 3-3—Energy demand outlook (Mtoe), baseline and sustainable energy scenarios

Country/area	2006	Baseline scenario			Sustainable energy scenario		Savings	
		2010	*2020*	*2030*	*2020*	*2030*	*2020*	*2030*
Australia	120.8	133.2	160.1	185.9	137.5	157.6	22.6	28.2
Azerbaijan	13.9	15.6	20.1	24.9	19.7	23.0	0.4	1.9
Bangladesh	18.5	32.8	50.8	72.5	46.1	71.1	4.7	1.4
China	1,913.8	2,131.8	2,636.3	3,038.1	2,385.1	2,589.1	251.1	449.0
Hong Kong, China	22.9	24.9	27.7	31.5	23.5	26.6	4.2	4.8
India	631.2	727.6	948.5	1,297.6	872.9	1,113.9	75.6	183.8
Indonesia	155.3	189.5	245.6	352.2	221.9	296.5	23.7	55.7
Iran (Islamic Republic of)	178.8	197.5	263.7	340.3	247.8	309.8	15.9	30.5
Japan	520.3	517.1	519.4	507.4	528.8	455.1	-9.5	52.3
Kazakhstan	60.3	64.4	92.0	124.2	69.3	103.0	22.7	21.2
Malaysia	67.0	113.5	154.4	180.6	120.2	159.8	34.2	20.7
New Zealand	18.0	20.4	25.4	30.0	24.4	27.9	1.0	2.2
Pakistan	58.0	100.0	148.8	204.2	142.9	201.8	5.9	2.4
Philippines	25.2	42.7	62.0	88.8	57.8	78.2	4.3	10.6
Republic of Korea	225.8	244.0	297.2	340.0	285.1	312.0	12.1	27.9
Russian Federation	704.9	728.0	828.9	922.9	746.8	790.4	82.1	132.5
Singapore	50.0	50.5	65.0	85.3	60.5	77.2	4.4	8.1
Taiwan Province of China	113.6	117.2	147.5	178.5	129.9	151.4	17.6	27.2
Thailand	86.1	109.0	169.2	243.6	142.0	211.6	27.2	32.0
Turkey	94.7	95.0	115.0	133.3	113.2	117.0	1.8	16.3
Turkmenistan	22.3	22.6	28.7	35.6	27.9	33.3	0.8	2.2
Uzbekistan	48.5	61.0	77.4	95.3	73.7	87.8	3.6	7.4
Other Asia Pacific	230.0	338.5	362.2	423.4	237.4	316.0	124.8	107.4
Total Asia Pacific	**4,675.0**	**5,348.9**	**6,617.0**	**8,013.1**	**5,967.7**	**6,919.8**	**649.3**	**1,093.3**
Total Asia Pacific [a]	**5,379.9**	**6,076.8**	**7,445.9**	**8,936.1**	**6,714.4**	**7,710.1**	**731.2**	**1,225.7**

Note: [a] Includes the Russian Federation.

they often use traditional stoves with efficiencies as low as 10 per cent; they can replace these at negligible cost with improved stoves with efficiencies of up to 30 per cent.[78]

• Transport—Options to reduce air pollution include: switching from diesel to compressed natural gas or biofuels; more efficient vehicles and technologies; and switching from road to rail. Another is to move from personal to public transport, since a car consumes 15 times more energy per passenger-kilometre than a bus, and 150 times more than a train.

• Agriculture—Replacing motors so as to increase efficiency from 70 to 90 per cent will save significant amounts of electricity.

If governments and consumers adopt these measures, they can achieve the results projected in the sustainable energy scenario. As 3.4 indicates, by 2030, the countries of the region would make substantial energy savings. China and India would save about 45 per cent,[79] similar to the savings for the region as a whole.[80] On the other hand, energy-poor countries, such as Bangladesh, will virtually have zero or negative savings, as even in the baseline scenario their energy demand is already low. The savings in energy described in this scenario would serve all three of the principal goals of energy policy: improved economic efficiency, greater environmental protection and greater security.

Table 3-4—Primary energy demand outlook—sustainable energy scenario (Mtoe)

Fuel	Region	Baseline scenario			Sustainable energy scenario		Savings	
		2010	2020	2030	2020	2030	2020	2030
Oil	Asia Pacific	1,445	1,897	2,398	1,757	2,120	140	277
	Asia Pacific [a]	1,584	2,063	2,596	1,917	2,298	146	298
	World	3,953	4,772	5,593	4,326	4,845	446	748
Natural gas	Asia Pacific	692	999	1,351	978	1,323	21	28
	Asia Pacific [a]	1,082	1,443	1,847	1,357	1,719	86	128
	World	2,710	3,504	4,229	3,304	3,790	200	439
Coal	Asia Pacific	1,981	2,420	2,801	2,074	2,150	346	652
	Asia Pacific [a]	2,096	2,545	2,929	2,179	2,246	366	683
	World	3,216	3,732	4,289	3,186	3,268	546	1,021
Nuclear	Asia Pacific	169	236	286	270	327	-35	-41
	Asia Pacific [a]	207	279	334	323	394	-44	-60
	World	641	722	782	759	888	-37	-107
Hydro	Asia Pacific	208	276	312	276	312	0	0
	Asia Pacific [a]	254	326	366	326	366	0	0
	World	729	854	953	857	958	-3	-5
Renewables	Asia Pacific	717	787	865	823	953	-36	-88
	World	1,365	1,590	1,861	1,662	2,050	-72	-189
Electricity	Asia Pacific	1,792	2,512	3,284	2,263	2,838	249	446
	Asia Pacific [a]	2,026	2,790	3,607	2,514	3,117	276	490
	World	4,605	6,011	7,546	5,535	6,611	476	934

Note: [a] Includes the Russian Federation.

Barriers to implementation

While these responses may be economically rational, the sustainable energy scenario may nevertheless be hindered by various barriers: technological, financial, institutional, and markets.

> "Sustainable energy scenario may nevertheless be hindered by various barriers: technological, financial, institutional, and markets"

- Technological—Many countries in the Asia-Pacific region spend very little on research and development (R&D) with the exception of the developed countries. Other countries can consider investing more while also identifying technologies available elsewhere, and importing and diffusing them.

- Financial—Introducing sustainable energy technologies requires finance, which at present is very limited. In this regard, international funding agencies, such as the Global Environment Facility (GEF), the Asian Development Bank (ADB) and the World Bank, have a major role. GEF, for example, can fund a few pilot and demonstration projects; once their viability has been established, it may then be easier to raise resources elsewhere.

- Institutional—Implementation of sustainable energy options will demand proper programme design and monitoring through appropriate institutional mechanisms. One option would be to form a consortium. Consisting of representatives from the government, financial institutions and equipment manufacturers, this could define, evaluate and monitor optimal mechanisms.

- Market—Certain powerful firms, fearing loss of market domination, may be able to slow the introduction by competitors of sustainable technologies. But even when there are appropriate public policies, such as minimum-efficiency standards, there will never be a single best policy solution. Countries that want to overcome market failures or reduce high transaction costs can choose from the many available options and tailor them to particular circumstances.

If countries can overcome these barriers through appropriate strategies and policies, they will be able to reduce energy consumption significantly and move towards renewable energy technologies.

ENERGY INFRASTRUCTURE EXPANSION—BASELINE SCENARIO

Energy infrastructure has many components, including: the physical network of pipes for oil and natural gas; electricity transmission lines; ocean tankers; the rail and highway networks; specialized trucks; and a substantial inventory of river- and ocean-side port facilities. One of the most powerful tools for implementing development strategies is therefore investment in these and other capital facilities and infrastructure. To estimate requirements, this chapter again uses the methods of IEA.

Coal production capacity

Between 2006 and 2030, coal production is likely to increase by about 70 per cent, driven mainly by consumption in China, India and Indonesia (table 3-5). China and India are the world's largest coal producers and consumers, accounting for just under 50 per cent of the total. They have proven recoverable coal reserves estimated at 207 billion tons, much of which will be used for power generation. The Russian Federation is the third largest coal producer and consumer in the region.

> "Over the next 24 years, coal production is likely to increase by about 70 per cent"

Table 3-5—Coal production, million tons, baseline scenario

Country	2006	2010	2020	2030
China	2,327	2,545	2,954	3,074
India	464	449	627	893
Indonesia	195	200	221	239
Iran (Islamic Republic of)	2	3	3	4
Malaysia	12	37	58	77
Russian Federation	309	315	340	366
Thailand	24	30	61	124
Other Asia Pacific	594	606	803	1,060
Total Asia Pacific	3,618	3,868	4,726	5,471
Total Asia Pacific[a]	**3,928**	**4,184**	**5,066**	**5,837**
Total World	**6,035**	**6,280**	**7,288**	**8,375**

Note: [a] Includes the Russian Federation.

Oil production and refinery capacities

The supply of petroleum products depends on the availability of crude oil and refining capacity. Although the Asia-Pacific region accounts for approximately 60 per cent of the world population, it produces only 30 per cent of the world's oil—a proportion that will remain almost the same in the coming decades. In 2006, the total baseline oil production capacity in the Asia-Pacific region, excluding the Russian Federation, was 11 million barrels per day (mb/d), of which approximately 70 per cent was from China and the Islamic Republic of Iran. By 2030, the output expected to increase to almost 16 million mb/d.

The capacity of the Russian Federation will increase from 9.8 to 11.1 million barrels per day, but most of the additions are expected from other Asia-Pacific countries, such as Viet Nam and the countries of the Central Asian region, such as Azerbaijan and Kazakhstan where between 2006 and 2030 production is expected to increase from 0.3 to about 3.4 mb/d.

With increasing production and demand, new refinery additions will struggle to keep pace. Historically refining has been the low-margin sector of the petroleum industry. As indicated in table 3-10, the countries of the Asia-Pacific region are building refineries for their own oil as well as imported oil. Even with the expected reductions in their oil production, countries, such as China and India are adding refinery capacity. China's capacity is projected to increase by 40 per cent to reach 10 mb/d in 2030. However, in 2030 it will still be a net importer of refined products. In the region's other important oil producer, the Islamic Republic of Iran, the installed refinery capacity will reach only 2.7 mb/d in 2030. The oil-producing countries of the Middle East will play an increasingly important role in meeting the demand for refined products.

“The Asia-Pacific region accounts for approximately 60 per cent of the world population, it produces only 30 per cent of the world's oil”

“With increasing production and demand, new refinery additions will struggle to keep pace”

Table 3-6—Oil production and refinery capacities (mb/d), baseline scenario

Oil Capacity	Country	2006	2010	2020	2030
Production capacity	China	3.7	3.8	2.7	2.8
	India	0.8	0.6	0.4	0.4
	Indonesia	1.1	1.2	1.2	1.1
	Iran (Islamic Republic of)	4.3	4.5	5.5	6.8
	Malaysia	0.6	0.8	0.9	1
	Russian Federation	9.8	10.2	10.9	11.1
	Thailand	0.3	0.3	0.4	0.4
	Other Asia Pacific	0.3	0.4	2.0	3.4
	Total Asia Pacific	11.1	11.6	13.1	15.9
	Total Asia Pacific[a]	**20.7**	**21.7**	**24.1**	**27.1**
	Total World	**80.9**	**82.3**	**99.3**	**116.4**
Refinery capacity	China	7.0	7.0	8.0	10.0
	India	3.0	3.0	4.0	5.0
	Indonesia	1.1	1.2	1.2	1.1
	Iran (Islamic Republic of)	1.7	1.7	2.2	2.7
	Malaysia	0.6	0.8	0.9	1.0
	Russian Federation	5.5	6.2	6.3	6.4
	Thailand	1.1	1.2	1.3	1.4
	Other Asia Pacific	9.4	11.0	12.0	14.3
	Total Asia Pacific	23.9	25.9	29.6	35.5
	Total Asia Pacific[a]	**29.4**	**32.1**	**36.0**	**42.0**
	Total World	**83.8**	**85.2**	**102.8**	**120.5**

Note: [a] Includes the Russian Federation.

Natural gas production, transmission and distribution

Natural gas is expected to increase its share of energy production significantly, particularly for power generation, due to its high quality, convenience of use and environmental benefits. By 2030, production will have increased by more than 125 per cent, 60 per cent of which will come from the Russian Federation, the region's largest producer. Other countries of the region, such as Azerbaijan, Kazakhstan and Turkmenistan, are also expected to increase their share in natural gas production from nearly 47 per cent in 2006 to about 57 per cent by 2030. On the other hand, Indonesia, the region's third largest producer, will not have significant growth as its potential has already been tapped. The other big players include China, India and Malaysia.

> "Natural gas is expected to increase its share of energy production significantly to more than 125 per cent by 2030"

> "This increase in natural gas output will require expanding transmission and distribution networks"

Table 3-7—Natural gas production, and T&D pipelines, baseline scenario

	Countries	2006	2010	2020	2030
Production (BCM)	China	59	66	92	115
	India	32	39	57	69
	Indonesia	74	79	89	99
	Iran (Islamic Republic of)	105	117	177	240
	Malaysia	60	68	85	93
	Russian Federation	612	645	765	898
	Thailand	24	33	44	47
	Other Asia Pacific	309	364	574	849
	Total Asia Pacific	663	765	1,117	1,514
	Total Asia Pacific[a]	**1,275**	**1,410**	**1,882**	**2,412**
	Total World	**2,848**	**2,998**	**3,876**	**4,678**
T & D ('000 km)	China	184	169	301	482
	India	60	72	128	191
	Indonesia	59	63	87	121
	Iran (Islamic Republic of)	158	159	215	277
	Malaysia	60	93	117	127
	Russian Federation	598	601	684	763
	Thailand	46	56	79	94
	Other Asia Pacific	432	436	521	584
	Total Asia Pacific	999	1,048	1,447	1,876
	Total Asia Pacific[a]	**1,597**	**1,649**	**2,132**	**2,640**
	Total World	**7,253**	**7,678**	**9,220**	**10,573**

Note: [a] Includes the Russian Federation.

This increase in output will require expanding transmission and distribution networks (T&D). A few decades ago gas was transported for relatively short distances, but with the expansion in supplies it is now being delivered over much longer distances. Table 3-7 shows the region's T&D networks. In 2006, excluding the Russian Federation, these extended over almost 1 million kilometres and by 2030 are expected to reach almost 1.9 million kilometres, of which about one quarter will be in China. The Islamic Republic of Iran will account for 15 per cent of T&D lines and India for 10 per cent.

Electricity installed capacity

In 2006, the gross electricity capacity in the Asia-Pacific region (excluding the Russian Federation) stood at 1,331 GW and by the year 2030 will reach 3,224 GW. The highest absolute increase is in China—from 588 to 1,169 GW, followed by India—from 128 to 391 GW.[81] The maximum growth in the region will, however, be in Indonesia, where capacity will grow more than fivefold. Compared with these countries, the Islamic Republic of Iran still has a low level of electric power development (table 3-8).

> "By 2030, the electricity installed capacity in Asia and the Pacific will have more than doubled from its 2006 level"

Table 3-8—Electricity generation installed capacity outlook (GW)

Countries	2006	Baseline scenario		
		2010	*2020*	*2030*
China	588	686	957	1,169
India	128	148	248	391
Indonesia	26	39	74	143
Iran (Islamic Republic of)	41	44	64	80
Malaysia	21	37	58	78
Russian Federation	197	206	220	273
Thailand	28	38	66	115
Other Asia Pacific	498	648	894	1,249
Asia Pacific	1,331	1,640	2,362	3,224
Asia Pacific[a]	**1,528**	**1,846**	**2,582**	**3,497**
World	**3,941**	**4,215**	**5,643**	**7,407**

Note: [a] Includes the Russian Federation.

Table 3-9—Additional electricity generation installed capacity by fuel type for Asia and the Pacific (excluding the Russian Federation) (GW)

	2006-2010	2010-2020	2020-2030	Total
Coal	112	420	496	1,028
Oil	7	27	29	63
Natural gas	41	135	182	359
Nuclear	21	84	92	197
Hydro	18	76	81	176
Renewables	9	21	41	71
Total	**208**	**764**	**922**	**1,894**

In 2006, electricity installed capacity was 1,528 GW. By 2030 this will have more than doubled to 3,197. As table 3-9 shows, the largest increase will come from coal, followed by natural gas. Hydropower generation capacity is expected to rise by about 176 GW. If renewable energy resources, such as wind, continue to rise at their present growth rate, they will add 71 GW.

BASELINE SCENARIO INVESTMENT NEEDS

Reaching the baseline scenario will require investment in a number of areas: coal mining, transmission and distribution, oil and gas exploration and transportation, and in power plants, and transmission and distribution networks. The estimates in the following sections are based on the norms used by the IEA *World Energy Investment Outlook 2003*.

Oil industry

The oil industry requires significant investment in production, refinery and transportation. Based on the most recent information, the cost breakdown for petroleum products is: the price of crude, 54 per cent; refining, 21 per cent; transportation, 2 per cent; and marketing, 2 per cent; the rest is taxes and profits to refiners, transporters and retailers.

In many countries, it is becoming expensive to build new "grass-roots" refineries, which means that to meet the shift in demand towards lighter products, mainly for road and air transport, major investments will be needed to upgrade existing units. The conversion units for this are costly and take several years to plan and build. Presently, the share of light products and middle distillates in oil consumption is 80 per cent.

The investment in infrastructure required by the oil industry over the period until 2030 has been estimated at $34 billion per year—over $800 billion—of which nearly two thirds is for exploration and development. China and the Islamic Republic of Iran will dominate these investment needs, accounting for 41 and 32 per cent, respectively. Of the total refining investment of the region, China will have the most, nearly 40 per cent, and India 16 per cent.

"The investment in infrastructure required by the oil industry over the period until 2030 has been estimated at $34 billion per year"

Table 3-10—Crude oil and refinery investment ($billion, 2006)

Countries	Exploration and development			Refining			Others		
	2006-2010	2011-2020	2021-2030	2006-2010	2011-2020	2021-2030	2006-2010	2011-2020	2021-2030
China	16.1	27.4	23.8	7.1	22.6	22.6	0.0	0.0	0.0
India	3.6	4.8	3.6	2.4	8.3	10.7	0.0	0.0	0.0
Indonesia	5.7	7.6	5.7	1.0	0.2	0.5	0.0	0.0	0.0
Iran (Islamic Republic of)	13.6	58.7	76.7	2.4	11.4	14.2	2.2	14.0	20.8
Malaysia	12.7	6.6	5.0	2.3	1.3	0.9	2.1	1.6	1.4
Russian Federation	25.2	41.1	11.8	4.5	7.9	2.2	4.1	9.8	3.2
Thailand	0.3	8.7	1.4	0.1	1.7	0.3	0.1	2.1	0.4
Other Asia Pacific	22.3	97.2	82.8	3.9	18.8	15.3	3.6	23.1	22.4
Asia Pacific	74.3	211	199	19.1	64.3	64.5	7.9	40.7	44.9
Asia Pacific[a]	**99.5**	**252.1**	**210.8**	**23.6**	**72.2**	**66.7**	**12.0**	**50.5**	**48.1**
World	**328.1**	**1,000.6**	**1,007.9**	**58.1**	**193.4**	**186.8**	**53.3**	**238.0**	**273.3**

Note: [a] Includes the Russian Federation.

Gas industry

By 2030, the region is likely to require more than 1,350 bcm of gas, most of which will have to be imported over long distances. Investment for the natural gas chain has been estimated at $1,372 billion, of which more than half is for exploration and development—17 per cent in the Islamic Republic of Iran and 12 per cent in China (table 3-11). However, the Russian Federation has the highest investment requirements.

> "Investment for the natural gas chain has been estimated at $1,372 billion"

Table 3-11—Natural gas investment ($billion, 2006)

Countries	Exploration & Development			Transmission & Distribution			Others		
	2006-2010	*2011-2020*	*2021-2030*	*2006-2010*	*2011-2020*	*2021-2030*	*2006-2010*	*2011-2020*	*2021-2030*
China	5.0	12.8	17.4	11.4	22.7	34.5	1.4	1.2	3.7
India	4.3	9.5	10.8	3.1	8.6	8.4	1.2	2.5	3.6
Indonesia	3.0	6.8	9.5	2.1	4.2	5.3	0.8	1.3	1.4
Iran (Islamic Republic of)	7.5	43.2	55.4	5.3	26.7	30.7	2.1	8.3	8.3
Malaysia	4.6	12.1	7.7	3.2	7.5	4.3	1.3	2.3	1.2
Russian Federation	20.9	86.0	116.9	14.7	53.3	64.9	5.8	16.5	17.6
Thailand	5.2	8.4	2.7	3.7	5.2	1.5	1.4	1.6	0.4
Other Asia Pacific	35.1	110.9	176.8	16.8	51.2	70.8	9.8	21.7	23.6
Asia Pacific	64.8	203.8	280.4	45.6	126.1	155.4	18.1	38.9	42.2
Asia Pacific[a]	**85.7**	**289.8**	**397.3**	**60.3**	**179.4**	**220.3**	**23.9**	**55.4**	**59.8**
World	**95.4**	**628.9**	**705.8**	**67.1**	**389.4**	**391.4**	**26.5**	**120.3**	**106.2**

Note: [a] Includes the Russian Federation.

Coal industry

Coal is the most commonly used energy resource in the Asia-Pacific region, supplying more than half of primary energy consumption, and providing feedstock to about 70 per cent of power generation. The average total cost of coal production is $8 to $12 price per metric ton.[82] One of the major challenges for coal is transportation. The costs per ton per kilometre are: truck—$0.05 to $0.8, and rail—$0.02 to $0.03. The loading costs (barge, rail, trans-shipment, coal terminal) are about $5 to $6 per ton. The required total investment for the baseline scenario until 2030 is $546 billion, of which almost two thirds will be for mining—37 per cent in China and 26 per cent in India (table 3-12).

"The required total investment for coal until 2030 under the baseline scenario is $546 billion"

Table 3-12—Coal investment ($billion, 2006)

Countries	Mining			Others		
	2006-2010	*2011-2020*	*2021-2030*	*2006-2010*	*2011-2020*	*2021-2030*
China	38.8	73.8	20.9	18.4	40.8	12.2
India	8.1	32.2	46.3	3.8	17.8	27.0
Indonesia	0.0	6.1	10.6	0.0	3.4	6.2
Iran (Islamic Republic of)	0.1	0.1	0.1	0.0	0.1	0.1
Malaysia	4.3	3.9	3.2	2.0	2.2	1.9
Russian Federation	1.1	4.5	4.5	0.5	2.5	2.6
Thailand	0.9	5.6	11.0	0.4	3.1	6.4
Other Asia Pacific	5.2	33.1	37.4	2.5	18.3	21.8
Asia Pacific	57.3	154.9	129.6	27.2	85.7	75.7
Asia Pacific[a]	**58.4**	**159.4**	**134.1**	**27.7**	**88.2**	**78.3**
World	**63.4**	**182.1**	**189.2**	**20.6**	**100.7**	**110.5**

Note: [a] Includes the Russian Federation.

Electricity generation

The cost of generating electricity includes: capital expenditure to engineer, procure and construct the plant and the distribution grids; the fixed costs of operation and maintenance, such as staff salaries; insurance rates and other costs; and variable costs, such as those for fuel. Powered plants also need a dependable transportation infrastructure to deliver fuel, and plants that create by-products will need transportation networks for waste disposal. In India, for example, the installation cost of a coal-based power plant is $1.25 million per MW, and generation costs are about $0.04/kWh. In China, the fixed cost per kWh is about $0.02 and the variable cost is about $3.5.

By 2030, electricity generation among Asia-Pacific countries will increase by 1969 GW. The scale of this challenge is phenomenal—requiring investment of $6 trillion, of which 45 per cent should be invested between 2020 and 2030. China's share of investment during 2010-2020 would be 46 per cent, and during 2020-2030, 36 per cent. In the case of India, more investment has to happen in the latter decade (54 per cent) than in the former (38 per cent). Investment in T&D will be slightly greater than that in installation (table 3-13).

“By 2030, electricity generation among Asia-Pacific countries will require an investment of $6 trillion”

Table 3-13—Electricity investment ($billion, 2006)

Countries	Generating capacity			Transmission & distribution		
	2006-2010	*2011-2020*	*2021-2030*	*2006-2010*	*2011-2020*	*2021-2030*
China	138	398	321	191	461	344
India	28	148	215	38	171	231
Indonesia	18	53	104	25	61	112
Iran (Islamic Republic of)	5	29	24	7	33	25
Malaysia	23	31	30	32	36	32
Russian Federation	11	22	79	16	25	85
Thailand	13	41	75	19	47	80
Other Asia Pacific	210	362	537	292	419	576
Asia Pacific	433	1,061	1,305	603	1,228	1,401
Asia Pacific[a]	**444**	**1,083**	**1,384**	**619**	**1,253**	**1,486**
World	**583**	**2,099**	**2,669**	**534**	**2,430**	**2,865**

Note: [a] Includes the Russian Federation.

Total investment

The assumption is that infrastructure investments will begin in 2010 and continue through 2030—to expand energy supply capacity and to replace existing and future supply facilities. The electricity sector dominates the picture—power generation, transmission and distribution absorbing almost three quarters of the total. If investment in the fuel chain for power-stations is included, this proportion rises to over 80 per cent. Renewables will capture nearly one third of investment in new power plants. The oil and gas sectors will take about one fifth of total energy investment, with the rest taken by the coal industry (table 3-14).

By 2030, total investment in infrastructure for the Asia-Pacific region will be about $9 trillion, of which nearly 45 per cent will be in China, India and the Russian Federation. China will need $2.3 trillion and India slightly over $1 trillion (table 3-15).

“By 2030, total investment in infrastructure for the Asia-Pacific region will be about $9 trillion”

Table 3-14—Total investment by fuel type in Asia and the Pacific ($billion, 2006)

Fuel	2006-2010	2011-2020	2021-2030	Total
Coal	86	248	212	546
Oil	135	375	326	836
Gas	170	525	677	1,372
Electricity	1,063	2,336	2,870	6,269
Total[a]	**1,454**	**3,484**	**4,085**	**9,023**

Note: [a] Includes the Russian Federation.

Table 3-15—Total investment by country ($billion, 2006)

Countries	2006-2010	2011-2020	2021-2030	Total	% of Asia-Pacific	% of world
China	427	1,060	800	2,287	25.4	12.9
India	92	403	557	1,052	11.7	5.9
Indonesia	55	143	255	453	5.0	2.6
Iran (Islamic Republic of)	44	225	255	524	5.8	3.0
Malaysia	87	104	87	277	3.1	1.6
Russian Federation	104	268	388	761	8.4	4.3
Thailand	44	125	179	348	3.9	2.0
Other Asia Pacific	601	1,156	1,564	3,321	36.8	18.7
Total Asia Pacific	1,350	3,214	3,697	8,262	91.6	46.6
Total Asia Pacific[a]	**1,454**	**3,484**	**4,085**	**9,023**	**100.0**	**50.9**
Total World	**1,829**	**7,383**	**8,505**	**17,717**		**100.0**

Note: [a] Includes the Russian Federation.

SUSTAINABLE ENERGY SCENARIO INVESTMENT NEEDS

For the sustainable energy scenario the investment is different. Compared with $9 trillion in the baseline scenario, the total required would be $8.3 trillion—15 per cent less (table 3-16). There are also important differences at the regional and sectoral levels. On the supply side, the overall reduction in demand pushes down the need for investment in infrastructure by a cumulative $766 billion, more than two thirds of which is in electricity supply. The fall in investment in power generation is, however, proportionately much smaller because initial investments for renewables and nuclear power are greater than those for fossil fuels.

> "Following a sustainable energy path, the total investment would be $8.3 trillion, or 15 per cent less than the baseline scenario"

It is important to note that the supply-side savings also require significant investments on the demand side—for the advanced technologies for energy efficiency and fuel shifts as well as for training in the skills to use this technology. The many forms of renewable energy will not enter the mainstream without greater support for R&D, better incentives, and markets in which energy prices incorporate environmental and social costs. The benefits of moving to a sustainable energy path are likely, therefore, to come less from investment savings than from minimizing dependence on fossil fuels and mitigating climate change.

The changes in investment vary considerably among regions. For the industrialized countries, in the sustainable energy scenario, greater investment will generally be needed. In Japan and Australia, for example, savings on the supply side will not compensate for costly new investments in end-use efficiency. In developing regions, on the other hand, introducing more efficient end-use technologies is less expensive and the new power-generation technologies are less capital-intensive and as a result their total investment falls.

> "For the industrialized countries, in the sustainable energy scenario, greater investment will generally be needed"

Table 3-16—Total investment by fuel, sustainable energy scenario ($billion, 2006)

Fuel	2006-2010	2011-2020	2021-2030	Total	Savings
Coal	85	206	158	448	82
Oil	96	250	212	558	48
Gas	128	346	458	932	17
Electricity	1,036	2,038	2,340	5,414	616
Total	1,344	2,840	3,168	7,352	763
Total[a]	**1,454**	**3,184**	**3,618**	**8,256**	**766**

Note: [a] Includes the Russian Federation.

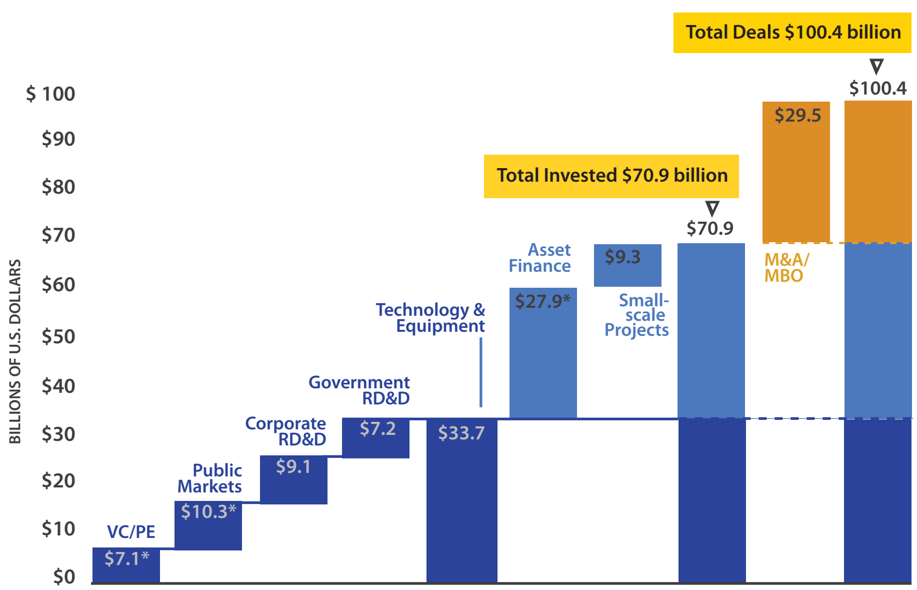
In certain areas, there does appear to be progress, with a rapid increase in funding for renewable energy. According to New Energy Finance, globally such investments increased in 2006 by more than 50 per cent to $100 billion (figures 3-2 and 3-3).[83] The upward trend continued in 2007, as private and institutional investors were attracted to sectors and regions previously considered too risky and illiquid.

Table 3-17—Investment by fuel type and scenario ($billion, 2006)

Fuel	Baseline scenario	SE scenario	Savings		
			2011-2020	*2021-2030*	*Total*
Coal	546	448	34	48	82
Oil	836	558	20	28	48
Gas	1,372	932	7	10	17
Electricity	6,269	5,414	240	376	616
Total[a]	**9,023**	**8,256**	**299**	**467**	**766**

Note: [a] Includes the Russian Federation.

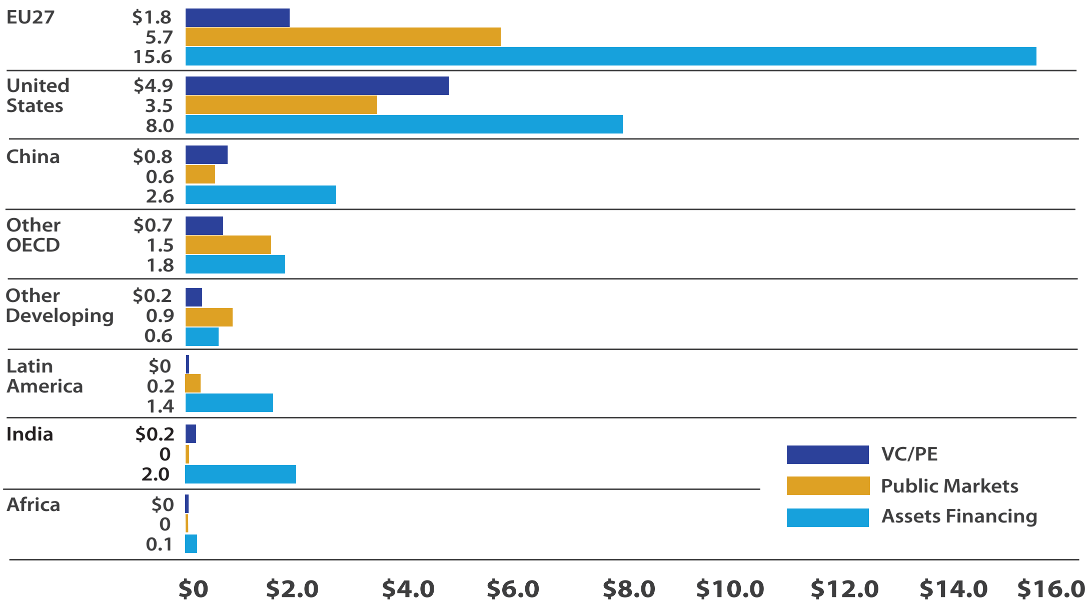
Figure 3-2—Global investment in sustainable energy, 2006



Source: Cited as "New energy finance", http://www.newenergyfinance.com, in United Nations Environment Programme and New Energy Finance, *Global Trends in Sustainable Energy Investment 2007,* (Paris, UNEP, 2007).

Note: VC = Venture capital; PE = Private equity; M&A = Mergers & acquisitions; MBO =Mergers and buy-outs

Figure 3-3—Global investment in sustainable energy, by type and region, 2006 ($billion)



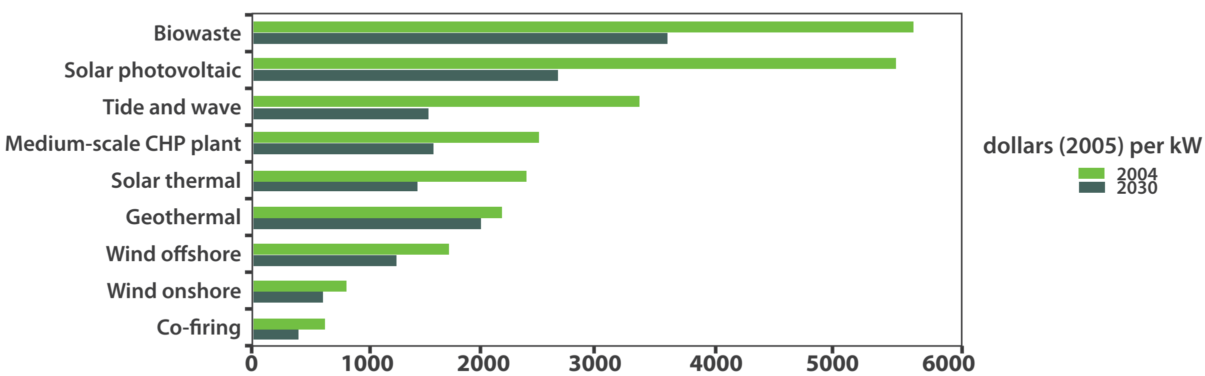
Source: Cited as "New energy finance", http://www.newenergyfinance.com, in United Nations Environment Programme and New Energy Finance, *Global Trends in Sustainable Energy Investment 2007,* (Paris, UNEP, 2007).

Note: VC = Venture capital; PE = Private equity

If the Governments of developing countries fulfil the commitments they made in 2004 in the Bonn International Action Plan,[84] this would mean an additional 80 GW of renewable (other than large-scale hydropower) capacity by 2015, requiring $90-120 billion, or about $10 billion per year. And since not all developing countries made commitments at Bonn, the actual investment could be much higher.

Investment as well as generation costs vary greatly among renewable energy technologies. However, at the midpoint of their respective cost ranges, several technologies are already approaching competitiveness with conventional power generation technologies. A few countries will have exhausted the prime locations, especially for generating electricity, but most have large unexploited potential. IEA has projected that, by 2030, learning effects will have pushed investment and generation costs further down.

Figure 3-4—Capital costs for renewable-based technologies, 2004 and projected for 2030



Source: IEA, *World Energy Outlook 2006,* (Paris, 2006).

Some investors are recognizing the opportunities afforded by the growth in demand for renewable energy and energy efficiency enabling the sector to reach a critical mass. They are also being encouraged by Governments, which are introducing appropriate legislation and support mechanisms. Some are encouraging private investors using innovative financial products. These include hybrid products, such public-private partnerships and quasi-equity, to allow private equity investors easier exits, risk management tools such as currency swaps, and bridging mechanisms for financing. They can also look to multilateral or bilateral sources, such as the World Bank, the Asian Development Bank, JBIC and KfW, which can leverage private investment.

“Some investors are recognizing the opportunities afforded by the growth in demand for renewable energy and energy efficiency enabling the sector to reach a critical mass”

In the least developed countries in particular, the aim must be to increase energy access for the poorest. This will require significant investment, some of which can come from the private sector. India, for example, has promoted the provision of decentralized technologies for rural energy by private energy enterprises, Nepal has companies selling biogas equipment, and China has rural energy service companies. Indonesia, in cooperation with the secretariat, embarked on a pilot pro-poor public-private partnership to improve access to electricity in a remote community (box 3-1).

Box 3-1—Pro-poor public-private partnerships for electricity in Indonesia

In 2005, 48 per cent of the population of Indonesia, mostly in rural areas, still lacked access to electricity. After researching and reviewing various possible rural electrification models, ESCAP, in consultation with the relevant government agencies, community-based NGOs and other stakeholders, implemented a pro-poor public private partnership for a micro-hydropower project in Cinta Mekar Village in Segalaherang Subdistrict, Subang District, in West Java Province.

The aim was to mobilize private sector involvement and investment to provide sustainable electricity and financial resources for social infrastructure. This was a cooperative venture between the public and private sectors, built on the expertise of each partner and with the appropriate allocation of resources, risks and rewards. It also includes a strong element of capacity-building for relevant government agencies, establishing an institutional mechanism for mobilizing and allocating financial resources for rural electrification projects accessible to, among others, public-private partnerships. This has proved successful: the village now has a mini-hydropower plant, better infrastructure, a social development plan and a sustainable source of income.

Within the project, the assistance was carried out in support of the institutional capacity-building through exchange visits, round-table discussion and advisory services. The exchange visits between the relevant officials from India and Indonesia have resulted in a better understanding of and a clear idea for an institutional mechanism in Indonesia.

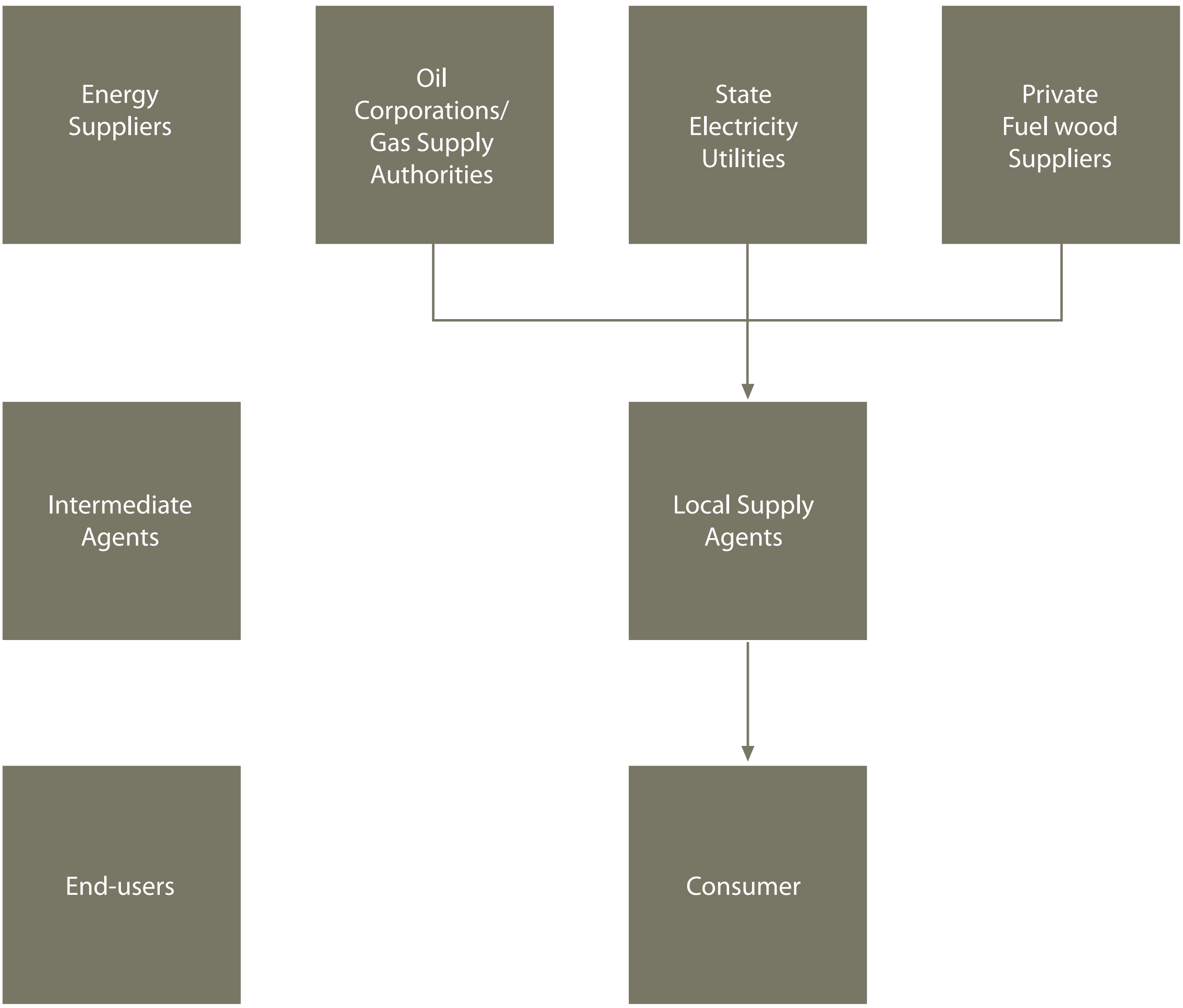
ESCAP also organized a round table in Jakarta to share the experience of Bangladesh and the Philippines in addition to that of India. Advisory services were provided by ESCAP to the Directorate General of Electricity and Energy Utilization (DGEEU), Indonesia. A policy report was prepared and submitted to the Government for its consideration in making a decision on the establishment of an institutional financing mechanism for rural electrification projects in Indonesia.

ENERGY MARKETS

The Asia-Pacific region has large energy markets. Historically, the production, supply and transportation/transmission of electricity, oil and gas have been dominated by public utilities based on franchise operations within a regulated price regime. These vertically integrated utilities have encouraged centralized decision-making processes. Nuclear energy, too, is completely controlled by the Government. On the other hand, the bulk of non-conventional energy production and distribution is by regional private players.

> "Utilities that are publicly owned are typically short of investment funds, but all face a number of problems, including concentration of supply in wholesale markets, bottlenecks in transportation capacity from abroad; and the cost of new import infrastructure"

Figure 3-5—Existing energy market structure



In recent years, it has been recognized that energy may be supplied more efficiently by privately owned systems. Many countries, including India and Australia, have therefore been opening up their energy markets to competition, allowing a number of private companies to compete with the government-owned utilities in the import and supply of oil and gas to large customers and distribution companies.

Utilities, private or public, have three main sets of functions: production and import; transmission and storage; and distribution and sales. Those that are publicly owned are typically short of investment funds, but all face a number of problems, including concentration of supply in wholesale markets, bottlenecks in transportation capacity from abroad; and the cost of new import infrastructure.

Countries such as China and India have reserves of coal. However, across the region proven oil and gas reserves are small in relation to current levels of consumption. Most countries have insufficient capacity in production, transportation and downstream infrastructure. This is evident for electricity and oil, but even more so for gas; there are no cross-border gas imports and no interregional gas grid connections. Although most large cities have networks for manufactured gas, these will need to be converted to natural gas. The continuity of the electricity supply varies greatly between countries: while in Australia customers enjoy average availability of 99 per cent, those in China and India experience power interruptions, on average, 20 to 60 days per year.

Production costs

The cost of coal is likely to remain below $1-2/GJ in almost all regions due to the combination of low demand and expansion and innovation in surface coal mining. The cost of producing crude oil will remain below $2/GJ for the big producers, but Japan, Eastern Europe, and later India, Africa and East Asia, are likely to see oil production costs rise to more than $5/GJ.

The cost of production of liquid biofuels is estimated to drop in several regions to $3-8/GJ, with Latin America and Africa being the major producers and exporters. Gas production costs should rise in gas-poor regions, such as Africa, China and India, but in the major producing regions they should remain below $1/GJ and well below oil production costs. North America and Asia may become leading producers of commercial gaseous biofuels at costs below $4/GJ.

In the case of electricity, the marginal cost of producing one kWh of electricity would vary from $0.08 to $0.15 depending upon the type of fuel used. For combined cycle gas plants, the cost of $1,000-$1,250 per kW in 2006 represents a considerable increase from the 2005 prediction of under $900 per kW—following temporary cost increases in steel and other materials as a result of a surge in demand in China and India. For coal-based generation, a cost of about $1,250 per kW is indicated for Kogan Creek, Australia, if there are no mine development costs.

SOURCES OF FINANCE FOR ENERGY INFRASTRUCTURE

Energy infrastructure offers large economies of scale, which has resulted in huge investment requirements, particularly in the fossil fuel and electric-power sectors. Even the sustainable energy scenario will demand an average investment requirement of $344 billion per year from 2006 to 2030.

“Energy infrastructure offers large economies of scale, which has resulted in huge investment requirements, particularly in the fossil fuel and electric-power sectors”

“Even the sustainable energy scenario will demand an average investment requirement of $344 billion per year from 2006 to 2030”

Where will this come from? Official development assistance has generally contributed only $5.4 billion per year to energy projects in developing countries worldwide—far short of what is required.[85] In many Asia-Pacific developing countries, public institutions find it difficult to raise the necessary funds, while in all but a few countries the private sector is unwilling to invest in larger projects.

> "Official development assistance has generally contributed only $5.4 billion per year to energy projects in developing countries worldwide"

Multilateral institutions such as the World Bank believe, therefore, that if the energy sector is to attract large-scale private capital, it will need to be reformed. The characteristics of an energy policy that will attract capital will be strength, clarity and stability. The energy sector will also have to compete with other sectors for capital. There are significant differences between investment projects in manufacturing and those infrastructure. These include:[86]

> "The characteristics of an energy policy that will attract capital will be strength, clarity and stability"

- *Longer maturity*—Infrastructure finance tends to have maturities between 5 and 40 years, reflecting the project gestation and its life expectancy. For example, a hydroelectric power project may take 5 years to construct and could have a life of about 100 years.

- *Larger amounts*—A meaningful infrastructure project could cost a great deal of money. For example, a kilometre of road or a megawatt of power could cost as much as $1 million, so each project could cost $200 to $250 million.

- *Higher risk*—Since large amounts are typically invested for long periods of time, underlying risks are correspondingly high. These arise from a variety of factors, including demand uncertainty, environmental surprises, technological obsolescence and, most important, political, governance and policy-related uncertainties.

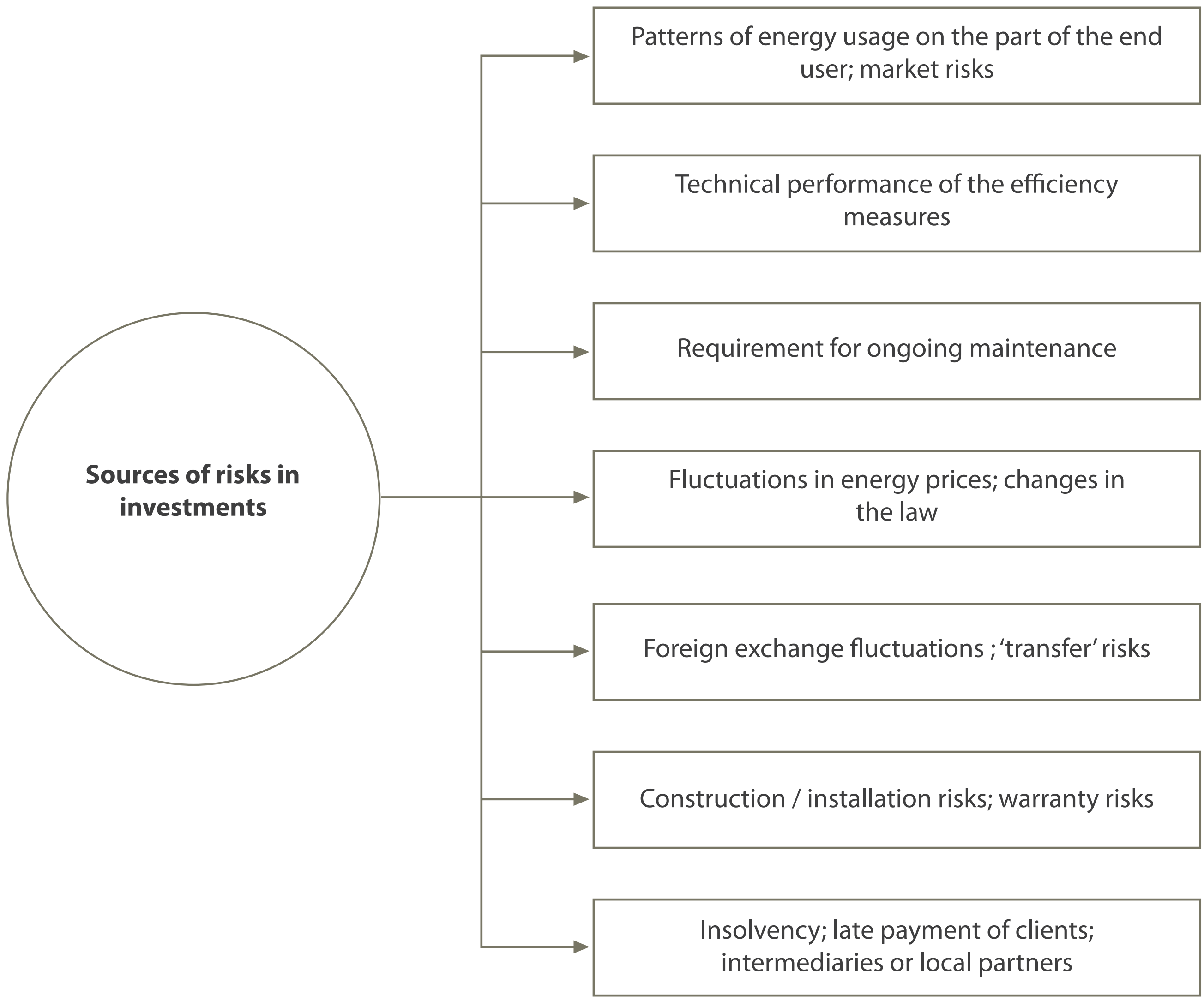
- *Low real returns*—The scale of these investments and the cascading effect of higher pricing could have serious negative impacts on the rest of the economy, resulting in annual returns that in real terms are often near zero. However, while real returns could be near zero, they are unlikely to be negative for extended periods of time—which may not be the case for manufactured goods.

Risks in financing

The risks associated with energy infrastructure investments are different from those in other types of investment. They can be divided into two types: commercial and policy.[87] Commercial risks are connected with developing and constructing the project and include interest-rate changes, inflation, currency risks and movements in international prices of raw materials and energy inputs. The policy risks include changes in the regulatory framework, war, civil disturbance and strikes. Some of the common risks are shown in figure 3-6.

To mitigate these risks, the financial institutions commonly check the macroeconomic record of the Government as well as the technical and managerial competence of the sponsors. Equity investors, long-term lenders, contractors and suppliers each face different kinds of risk. The methods in preventing exchange rate risks include: fixing forward rates; adjusting energy prices in accordance with the exchange rate; and guaranteeing the availability of currency.[88]

Figure 3-6—Sources of risks in energy infrastructure investments



Loan and risk guarantee schemes

The significance of particular risks will differ from project to project. Road projects, for example, may have high construction risks, low operating risks and high market risks. Power projects with suitable off-take guarantees may have high construction risks and high payment risks but relatively low operational and market risks. The situation is further complicated because each project may involve many actors, including project developers, lenders, government agencies and regulatory authorities. Risk mitigation schemes are therefore likely to be difficult, time consuming and involve complex legal and contractual agreements.

> "It is important to have effective loan guarantee mechanisms to limit the risk of financing energy infrastructure."

Under these circumstances, it is important to have effective loan guarantee mechanisms. Although Governments in developing countries offer guarantees and protection to foreign investors, their financial capacity to deliver on such commitments is in doubt. Host Governments need, therefore, to cooperate with multilateral development banks and export credit agencies to cover various risks, such as those associated with currency transfers or breach of contract by government entities, and, when necessary, introduce appropriate reforms.

> “Host Governments need to cooperate with multilateral development banks and export credit agencies to cover various risks”

Export credit agencies often work in partnership with multilateral development banks to finance capital and infrastructure projects, employing such instruments as investment insurance and political and commercial risk guarantees. One of the main features of guarantees is that they extend maturities of debt instruments. Loan guarantees may also affect the interest rate pertaining to the non-guaranteed private credits. The credit enhancement that results from the use of guarantees can provide developing countries with access to capital markets under reasonable terms. However, guarantees should be tailor made to take into account market imperfections; otherwise, they might undermine initiatives to enhance private capital flows.

Projects may also involve various forms of risk-sharing and ownership arrangements, including “build-own-operate” and “build-operate-transfer” structures. Public-private infrastructure partnerships can also help Governments promote private-sector involvement.

> “Financing in emerging energy markets usually involves domestic savings, local institutions and financial markets, private organizations and the international financial community”

FINANCIAL INSTITUTIONS

Conventional financing typically involves only two main participants: the government and the private sector. Financing in emerging energy markets, however, usually involves many important actors which can be classified broadly into, micro, meso, macro and meta categories.

Micro level—domestic savings

The usual measure of the availability of domestic savings is their share of GDP. Globally, in 2000, savings accounted for nearly 23 per cent of global GDP while energy-investment needs were only 1 per cent. But the ratio of domestic savings to energy investment varies between regions, and, of course, there is considerable competition for these funds for other forms of investment. In China, for example, savings at nearly 40 per cent of GDP, are among the highest in the world—15 times the average annual energy investment requirement, which is 2.4 per cent of GDP. India has a savings rate of 20 per cent, while energy investment needs are 2.2 per cent of GDP.

Meso level—financial markets and local institutions

Local financial institutions, such as banks and private players, can offer finance through leasing and term loans—following well-defined due diligence processes for evaluating loan and investment proposals. This is not happening much at present due partly to a lack of information about the potential of infrastructure investment but also to a lack of resources.

In the Asia-Pacific region, infrastructure development will depend to a large extent on banks. This is because of the high degree of concentration in the banking sector.[89] The China Development Bank, for example, is primarily responsible for raising funds for large infrastructure projects and is one of three policy banks in China. Countries such as India and China can also use the stock and bond markets, though these are usually fairly small: the value of listed shares divided by GDP is between 30 and 40 per cent of that in OECD countries. [90]

Countries with more developed financial sectors can provide better access to equity, bonds and borrowing. Only deep and sophisticated financial markets can support the long-term debt needed for energy and other capital-intensive infrastructure projects. Long-term maturities are generally only available to large companies in countries with active stock markets and small companies in countries with large banking systems. In general, the absolute size of financial institutions is correlated with national income, but China is an exception: the banking sector is active and large in relation to GDP. If companies have high standards of corporate governance, they can also raise long-term funds in international markets.

For financing overseas electric power investment, there are also several new options, particularly in the area of equity finance. Some of these new sources of capital include the world's major petroleum companies, natural gas pipeline companies, electric utilities, and also some of the world's major construction and power equipment manufacturing companies. There is a long way to go, but the process has undoubtedly begun.

Macro-level financing

Governments that want to boost the international competitiveness of a particular sector may do so by providing key infrastructure to influence the decisions of entrepreneurs. By concentrating on a critical mass of firms in a chosen industrial sector, on their upstream suppliers and on their service providers in a specific geographic location, they can rationalize the necessary infrastructure—including transport, logistics, communications, education and training.

In recent years, due to a lack of resources, public-sector organizations in many countries have been soliciting the involvement of private players.[91] However, in India, the construction, maintenance and management of infrastructure is expected to remain under government control for some time to come.[92] In China, the Government has established the State Grid Corporation of China, which controls approximately 80 per cent of all power assets, through a large number of exclusively owned subsidiaries; this is arguably the world's largest utility.

If Governments want to attract private-sector investment, they will aim to pursue the right policies and create conditions that encourage competition. However, the private sector should be seen neither as a panacea nor a substitute for public-sector investment, but rather as a partner. Filling the infrastructure gap will still require substantial public-sector investment.

Financing at the meta level

In developing countries, there is a vicious circle of high risk perception, leading to a high premium on financing cost, leading to an even higher risk perception, and so on. The challenge is to convert the vicious circle into a virtuous one.

Before becoming involved in large projects, banks and private investors often wait for signals from the international financial community—the World Bank, the Asian Development Bank and others. As the largest sources of development finance, these multilateral institutions have enormous influence. Sometimes, when they provide joint finance, they also require "structural adjustment policies", typically deregulation, privatization and liberalization of the national economy. For example, when the World Bank partnered with the Japan Bank for International Cooperation to provide $530 million for a rehabilitation package for 24 open-cast coalmines in India, its criteria included liberalizing coal imports, deregulating coal prices and reducing the workforce—costing 20,000 jobs.

Multilateral agencies have also provided over $20 billion for fossil fuel plants in Bangladesh, Cambodia, China, India, Indonesia, the Lao People's Democratic Republic, Malaysia, New Zealand, Pakistan, the Philippines, Thailand and Hong Kong, China. Of the $28 billion which the United States Export Credit Agency Export-Import Bank provided in loans and guarantees for energy-related projects from 1990 to 2001, 93 per cent was used to finance fossil fuel projects and 3 per cent was for renewable energy projects.

If domestic saving are insufficient countries can seek capital from international markets. This brings both benefits and risks. Financing from abroad reduces the cost of capital and provides longer debt maturity, since international financial markets are usually better organized and more competitive and have a large base of investors and lenders. Nevertheless, overdependence on foreign investment flows can destabilize an economy since overseas capital inflows can be volatile. Moreover, currency depreciation can increase the debt burden if the revenues generated by the investment are mainly in the local currency—which is generally the case in the electricity and downstream-gas sectors.

In addition, countries that already have a large external debt will face difficulties in securing additional foreign capital. Although there are no firm criteria on the acceptable level of external indebtedness, only those countries with rapidly growing economies and/or exports are normally able to sustain rising levels of debt. Competition for foreign capital has increased since the early 1990s as market reforms, including privatization, have increased opportunities for private investors to participate in energy projects. This has exacerbated the difficulty of securing funding for new investments in developing countries.[93]

FINANCING MECHANISMS

For many years, energy infrastructure was funded almost exclusively by the public sector, and many projects were designed and implemented by multilateral institutions without significant private participation. Now, the sector is at a second stage, which increasingly involves cooperative arrangements between Governments, multilateral institutions and private investors. A third, future, stage may involve full commercialization, in which the roles of Governments and multilateral institutions are reduced to a minimum.

> "The energy sector is at a stage which increasingly involves cooperative arrangements between governments, multilateral institutions and private investors"

This approach involves decentralized modes of governance, shifting responsibility for the design and implementation of development plans to partnerships between the Government and the private sector. In some countries, local authorities are responsible for planning as well as financing, while in others, such as in India, planning is done by the Government but financing comes at least in part from private agencies.

Given these public-sector features, it may be justified to call these investment vehicles "private-sector oriented", for three reasons: first, they make investment decisions primarily on a commercial basis; second, they involve investments in projects with majority private ownership and management; and third, they contain capital mobilized from profit-driven private investors.

These factors have not thus far been common in energy infrastructure activities in developing countries. For such an approach to succeed, what is needed is "systemic competitiveness"—referring to the set of intertwined elements of the socio-economy. Systemic competitiveness terminology helps clarify the roles played by government, the private sector and other institutions—and identifies the success factors for particular activities and the changes needed to attract more funding.

An example of a contemporary approach to infrastructure development is the India Infrastructure Financial Corporation. This was established in 2006 by the Government of India to raise funds from domestic and external markets on the strength of government guarantees. In the first year of operation, the Government set a guarantee limit of 100 billion Rupees ($2.2 billion). Such public-private partnerships are flexible instruments, which offer tailor-made solutions—though they can be difficult to evaluate.

Finally, there is the option of privatization. In some cases, foreign companies, either alone or in consortia with domestic companies, have purchased one or more utilities. In other cases, foreign companies or investors have purchased shares in newly privatized electric utilities.

FINANCING CHANNELS

The channels of finance will vary considerably with the size of the project. While microprojects may be replicated from elsewhere, mega-projects are more distinct and project managers have fewer lessons to draw from. They need, therefore, to approach mega-projects with an open mind and place the emphasis on learning while doing.

Mega-projects are also complex and require the cooperation of many different types of experts, professionals and organizations. The Gwadar port project in Pakistan, for example, involved building a port, two oil terminals and a grain terminal as well as procuring millions of dollars' worth of port handling equipment. Also crucial for its success, though not officially part of the project, were the construction of a coastal highway from Karachi, a railway line from Dalbandin, a transmission line from Turbat, and residential facilities.

Mega-projects are typically spread over a large area, affect millions of people and take many years to complete. A pertinent example is the "Sardar Sarovar" dam project in India.[94] Its 214 kilometre-long reservoir and 0.58 million hectare-metre capacity will produce 0.4 billion kWh of electricity per year. During the three decades of its construction, about $5 billion were spent and millions of people were displaced. Mega-projects such as this come with enormous risks and uncertainty. Even after careful planning, things rarely go exactly as planned, so investors tend to be wary.

> "It is important to have effective loan guarantee mechanisms to limit the risk of financing energy infrastructure"

Financing is less risky for microprojects. Small-scale water power, or micro-hydro schemes with capacity less than 100 kW, can be a particularly attractive option for electrification in many rural areas. For example, the International Technology Development Group has developed micro-hydro schemes with the involvement of communities in Kenya, Nepal and Sri Lanka, with the support of the Inter-American Development Bank which provided a "revolving fund"—the pay-back of an original loan is used to provide funding for further micro-hydro plants.[95] So far, 15 plants have been installed, benefiting approximately 10,000 people. Three major factors contribute to the success of such projects: participation of the beneficiaries in planning and implementation; development of a local manufacturing base for low-cost equipment; and capacity-building at the community level to enable the replication of the technology.

Sources of financing for energy infrastructure projects in the emerging markets of the Asia-Pacific region range from commercial banks to specialized energy infrastructure funds provided by socially responsible investors. Access to funds may be relatively easy for large projects but that is not always the case for small projects. The processes involved for large infrastructure projects are entirely different. External financial resources are needed for several purposes among others:

> "Sources of financing for energy infrastructure projects in the emerging markets of the Asia-Pacific region range from commercial banks to specialized energy infrastructure funds provided by socially responsible investors"

1. To bridge the gap between domestic demand and supply;

2. To resolve cash flow problems. The outputs of a project accrue only after months or years whereas the inputs must be paid for immediately;

3. To cushion the short-term impacts of policy reforms, or to pay compensation;

4. To cover the foreign-exchange components of investments;

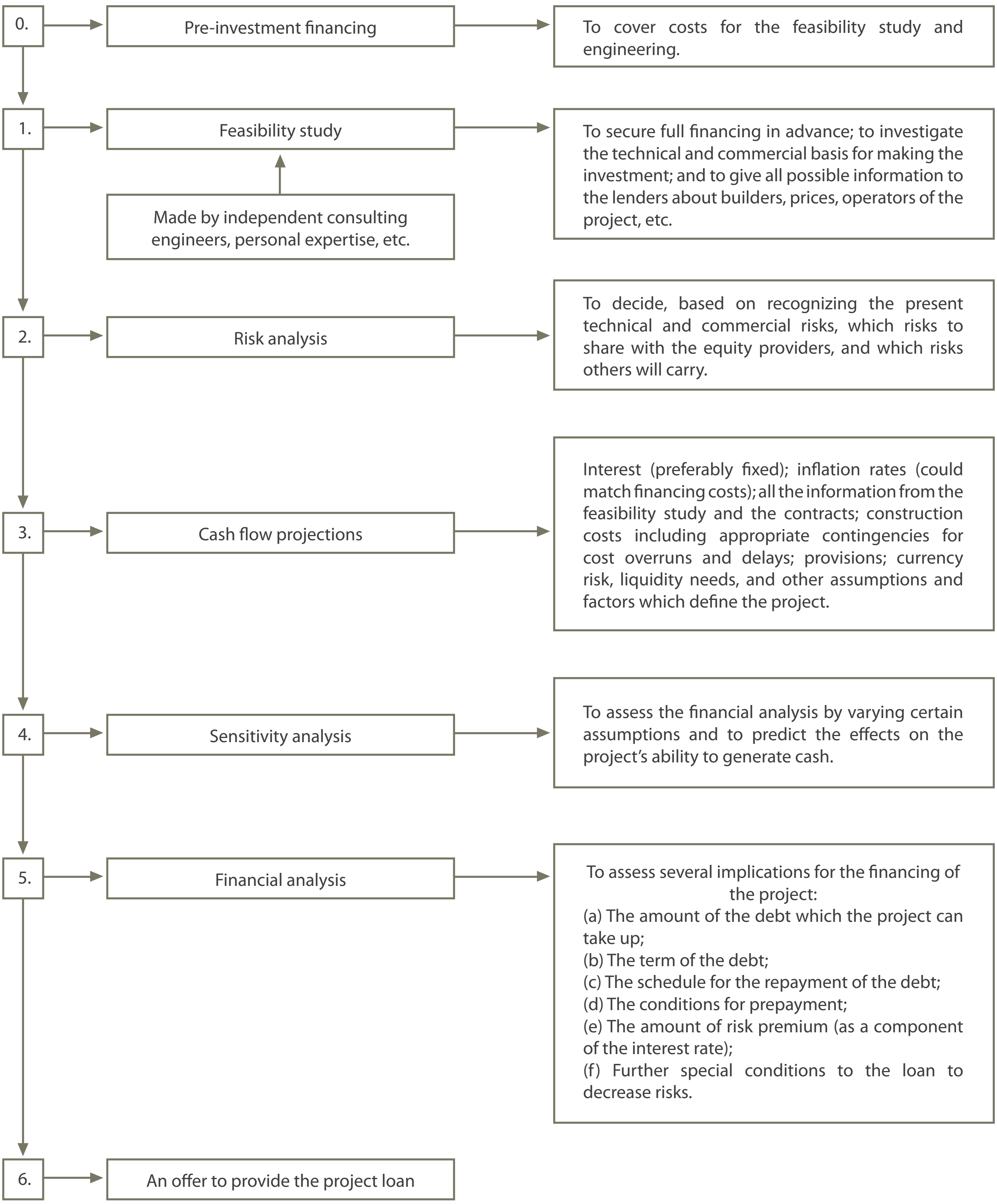
5. To fix and clean up contaminated sites.

Banks are interested in energy infrastructure projects only if they can accommodate the risks, returns and transaction costs. The risks must be adequately balanced by the returns: the greater the risk, the greater must be the return. Figure 3-7 provides details about pre-offer financial analysis.

In fact, for infrastructure investments in many countries of the Asia-Pacific region, financing is not a major constraint—indeed, not even the most important investment constraint. The issue is not one of resource constraints but of learning and practicing new financial methods and engaging in complex process of planning, budgeting, evaluating other investment opportunities and the relevant rate of return, and, lastly, making the financing decision.

> "Banks are interested in energy infrastructure projects only if they can accommodate the risks, returns and transaction costs"

Figure 3-7—Pre-offer financial analysis



Source: Adapted from Laurson, Peter et al., 1995. 'Final Report by the Consultants: A Strategy to Enhance Partnerships in Project Financing for Environmental Investments in Central and Eastern Europe'. London, Great Britain: EBRD.

Financing for energy efficiency

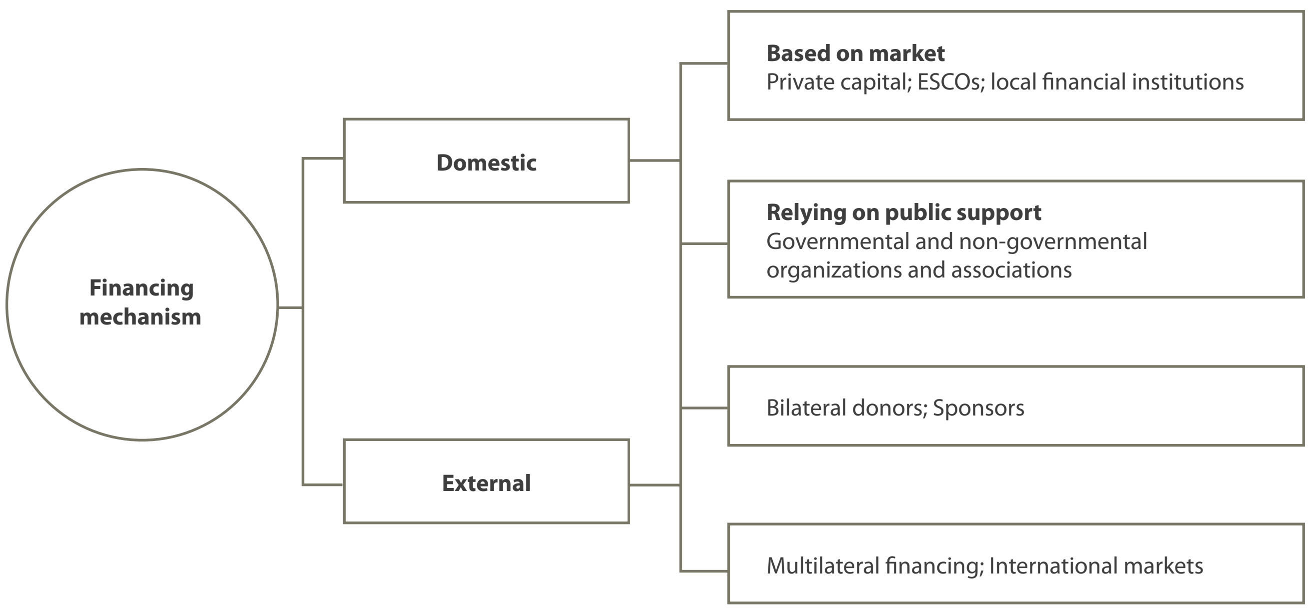
Although investment in energy efficiency is important, it is hard to track. This is especially true of investments made by consumers for their own benefit. However, it is more feasible to track larger-scale efficiency projects, such as those for grid distribution and power storage and for establishing energy service companies.

In many cases, it is difficult for these projects to obtain finance from commercial banks since they often do not meet the standard investment criteria, such as requirements for collateral. Nevertheless, a growing number of specialized sources are financing energy efficiency. Each source has its own priorities and selection criteria but all have one thing in common: they want to invest in projects that will generate enough cash flow to repay their investment.

For financing energy-efficient projects, countries should rely largely on domestic resources. Foreign aid may stimulate domestic resource mobilization, but it is not a sustainable source of funding. To encourage domestic funding, the State should set realistic conditions and, through performance standards, provide incentives to use the best available environmental technology. The State should not be too ambitious, however, for it will take time for environmental authorities to earn the creditworthiness to access such funds as municipal bonds. Figure 3-8 shows the financing mechanisms for energy efficiency projects.

> "A growing number of specialized sources are financing energy efficiency with the view of investing in projects that will generate enough cash flow to repay their investment"

Figure 3-8—Financing mechanisms for energy efficiency



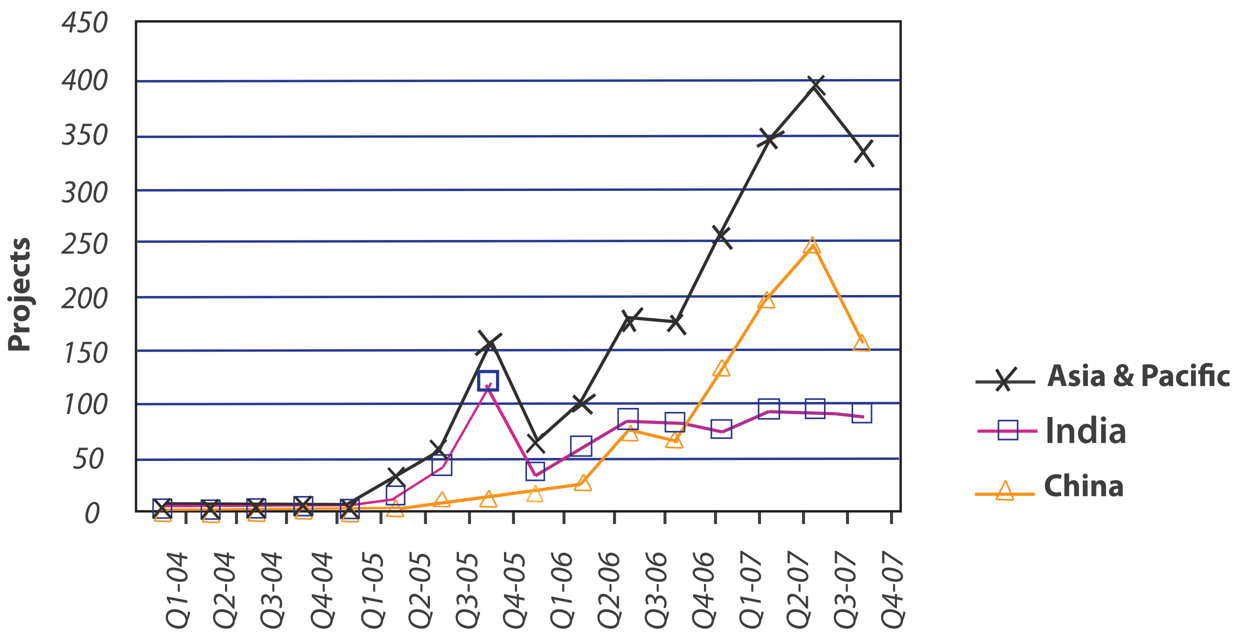
Clean Development Mechanism

A number of countries in the region are taking advantage of the Clean Development Mechanism (CDM). This is a provision of the Kyoto Protocol which was devised originally as a bilateral mechanism through which entities in industrialized countries could gain certified emission reductions (CERs) by investing in clean technologies in developing countries. For the recipient developing countries, this can boost returns on projects by up to 12 per cent for wind, hydro and geothermal projects and by 15-17 per cent for biomass and municipal waste projects.[96]

By the end 2007, Asia and the Pacific had more than 2,100 CDM projects either registered or in the pipeline at that validation stage (figure 3-9).[97] More than 90 per cent were energy related—for improving energy efficiency (for example, fuel switching) or renewable energy (figure 3-10).

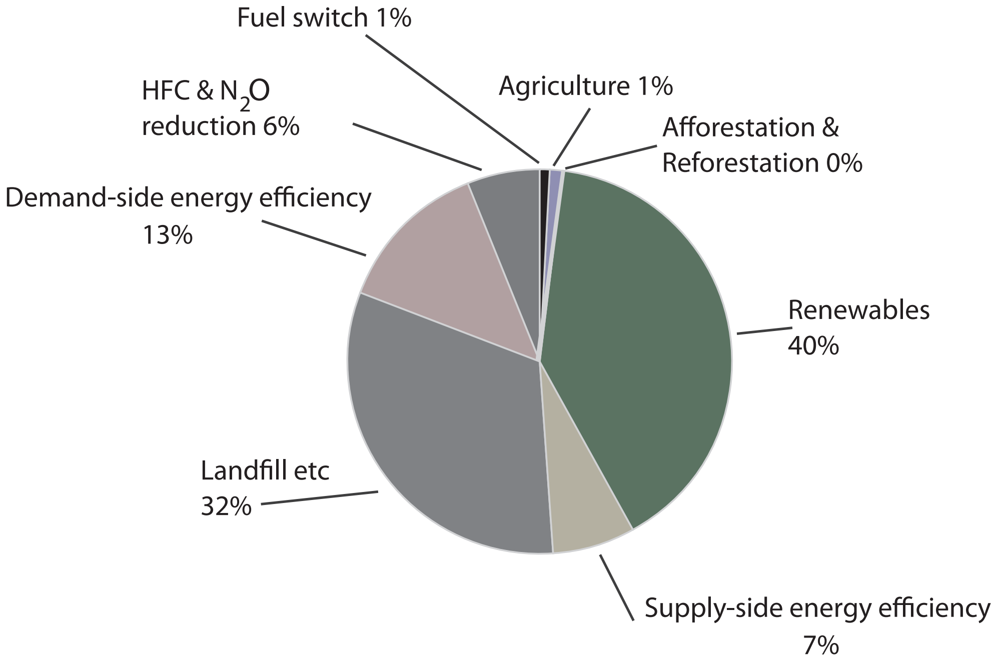
> "By the end 2007, Asia and the Pacific had more than 2,100 CDM projects"

Figure 3-9—New CDM projects in Asia and the Pacific in the pipeline, by quarter (2004-2007)



Source: UNEP Risoe CDM/JI Pipeline Analysis and Database, http://www.cdmpipeline.org/

Figure 3-10—Number of CDM projects, by sector (December 2007)

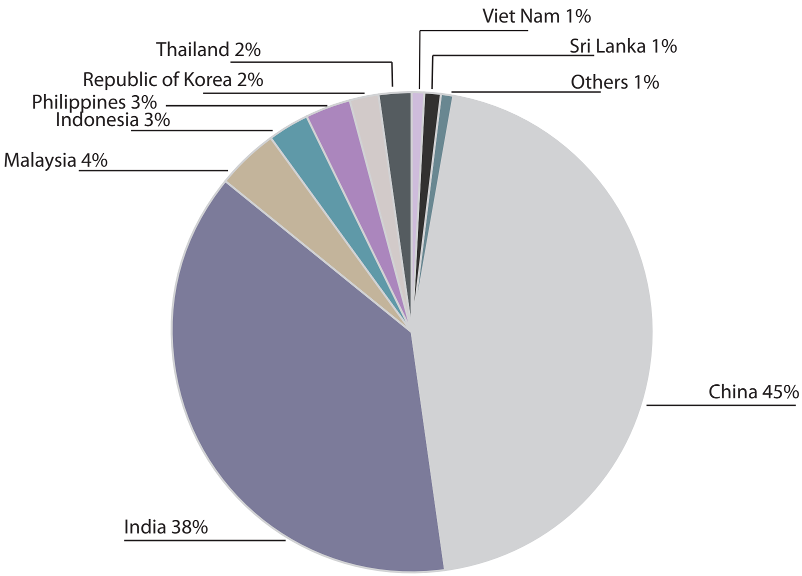


Source: UNEP Risoe CDM/JI Pipeline Analysis and Database (http://www.cdmpipeline.org/).

However, much of this is concentrated in a few countries. Globally, 10 developing countries provide over 90 per cent of annual certified emission reductions. Other countries face a number of technical and financial barriers and the overall take-up has been slower than expected. In Asia, the largest number of projects are in China and India (figure 3-11), with China responsible for an even higher proportion of certified emission reduction units (figure 3-12).

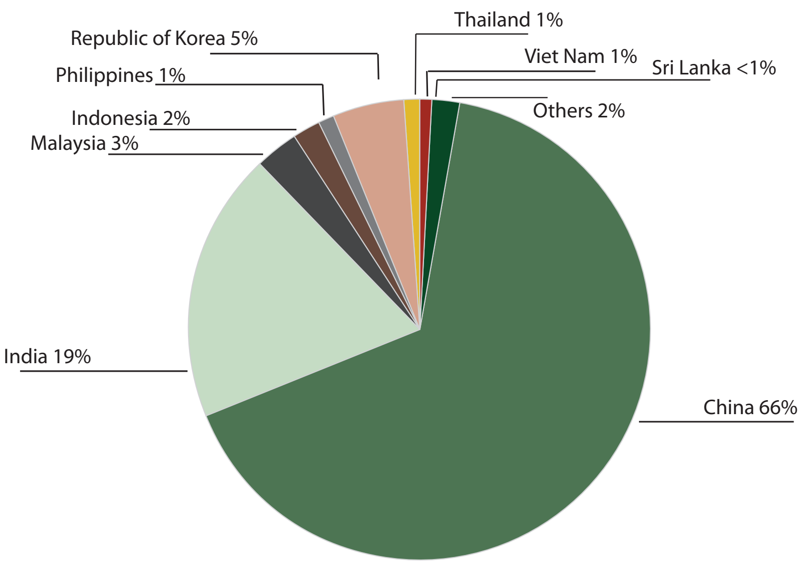
> "However, globally only 10 developing countries provide over 90 per cent of annual certified emission reductions"

Figure 3-11—Number of CDM projects in Asia and the Pacific (December 2007)



Source: UNEP Risoe CDM/JI Pipeline Analysis and Database, http://www.cdmpipeline.org/

Figure 3-12—Volume of certified emission units until 2012 in Asia and the Pacific



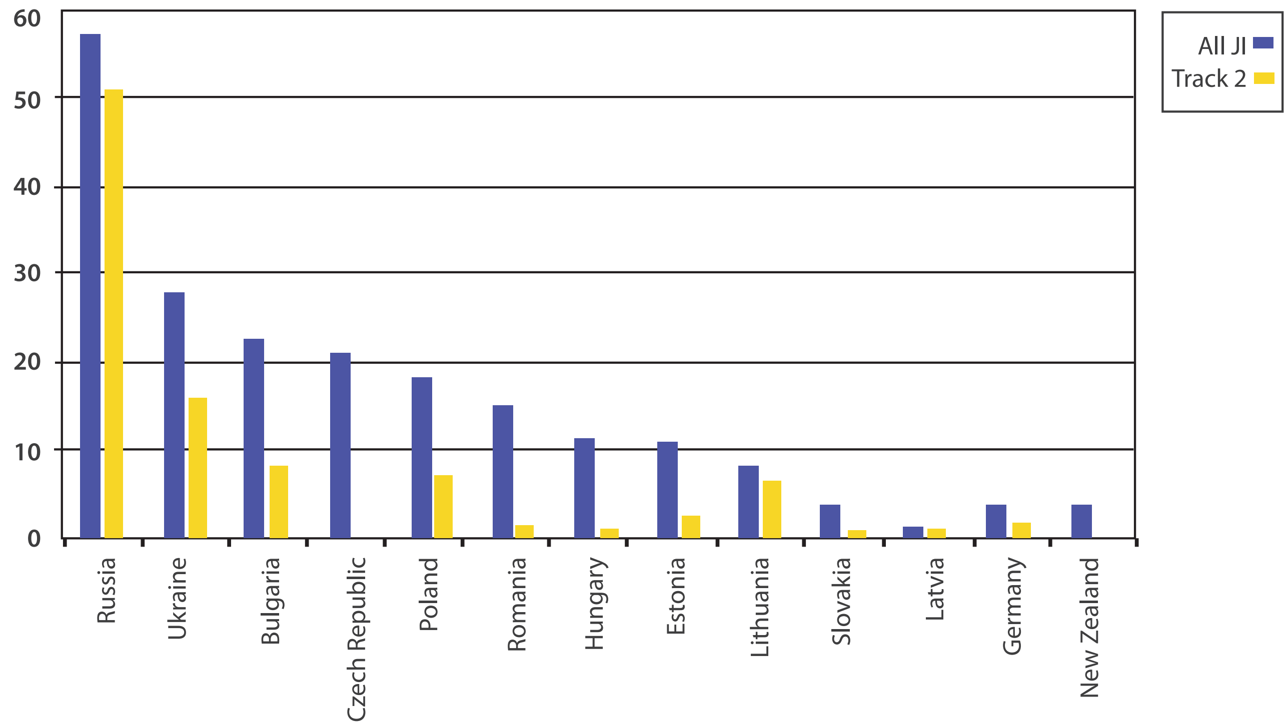
Source: UNEP Risoe CDM/JI Pipeline Analysis and Database, http://www.cdmpipeline.org/

To address these problems, another option, which ESCAP has been promoting since 2004, is unilateral CDM. In this case, the developing country unilaterally plans and finances the project and, after certification, sells the CERs directly to an industrialized country. The CDM Executive Board approved the unilateral approach in April 2005. Globally in 2006, there were projects worth $25 billion in the pipeline, half of which was unilateral. More than 60 per cent of unilateral.[98] CDM projects have been developed by Asia-Pacific countries.

> "One possible option is the unilateral CDM where a developing country unilaterally plans and finances the project and, after certification, sells the CERs directly to an industrialized country"

Another model is joint implementation (JI), which generally involves one industrialized country investing in projects in another industrialized country, then counting the resulting emission reductions towards its own Kyoto target. Joint implementation can potentially achieve greater emission reductions than might be possible for each country on its own. Joint implementation may also spur cooperation in technology. The number of joint implementation projects has been growing in the eligible member countries in the region since the official launch of the "JI Track 2" process in October 2006. Track 2 allows for verification by an independent entity accredited by the Joint Implementation Supervisory Committee of UNFCCC. Among eligible countries in the region, the Russian Federation has the largest number of projects (figure 3-13).[99] According to ICF International, the risk-weighted potential of emission reduction units likely to be generated in the Russian Federation over the period 2008-2012 is about 100 $MtCO_2e$ per year.

Figure 3-13—Number of Joint implementation projects by host country (2007)



Source: UNEP/Risoe CDM/JI projects analysis and database (http://www.cdmpipeline.org/ji-projects.htm).

Other funding opportunities

Another funding mechanism for developing countries is the Global Environment Facility (GEF). This is an operating entity of the financial mechanism of UNFCCC which funds climate change projects mostly on renewable energy and energy efficiency. Since its inception in 1991, GEF has allocated over $3.3 billion, with further co-financing of $14 billion[100] and between 1997 and 2005 had 1.6 per cent of total multilateral and bilateral funding.

> "Since its inception in 1991, GEF has allocated over $3.3 billion"

The GEF has also established the Least Developed Countries Fund for Climate Change (LDCF) and the Special Climate Change Fund (SCCF).[101] The LDCF is designed mainly to provide least developed countries with assistance in the preparation of national adaptation programmes of action. The SCCF is designed to finance activities related to climate change that are complementary to those funded by GEF in four areas: adaptation to climate change; technology transfer; energy, transport, industry, agriculture, forestry and waste management; and economic diversification.

Much of the innovative financing for scaling up the transition to a low-carbon economy has come from the international and regional financial institutions. This includes the World Bank's Clean Energy Development Investment Framework and the Asian Development Bank's Clean Energy and Environment Program (box 3-2).

> "Much of the innovative financing for scaling up the transition to a low-carbon economy has come from the international and regional financial institutions"

ESTABLISHING A REGIONAL CAPITAL INVESTMENT FUND

In recent years, a number of specialized private equity funds that concentrate on infrastructure development have emerged. These "infrastructure funds" offer private-equity investors a range of options with different risk profiles and investment objectives. As a result, investing in infrastructure development is no longer limited to large, institutional players with abundant cash and long-term investment horizons. Governments that wish to attract such funds but lack the necessary capacity can consider resource pooling. This entails exchange of surplus resources—energy, finance or knowledge—between two or more neighbouring countries. At the regional level, two options, described below, could be considered.

> "Investing in infrastructure development is no longer limited to large, institutional players with abundant cash and long-term investment horizons"

Box 3-2—International financial institution support for clean energy

In 2006, the World Bank initiated the Clean Energy for Development Investment Framework and since then its total energy support is expected to be in excess of $10 billion. Within this, carbon finance has 10 funds with $1.86 billion under management, including such experimental funds as the BioCarbon Fund, which pilots forestry projects, and the Community Development Carbon Fund, which delivers benefits to poor communities.

Carbon finance is now emerging into the mainstream of the Bank's traditional lending business. This will facilitate movement from current, short-term, project-by-project approaches in developing countries to include sectoral and investment programming approaches, resulting in larger scale and more efficient reduction of carbon emissions and greater revenues.

The World Bank carbon funds are supporting low-carbon investments in a wide variety of sectors, ranging from the destruction of industrial gases to the capture of methane in landfills, improved energy efficiency in steel production, bagasse cogeneration, renewable energy (wind, geothermal, hydropower) and land use change and forestation. To date, almost 430 million $MtCO_2e$ have been contracted from 60 projects.

The Asian Development Bank has the Clean Energy and Environment Program, which is consistent with the Investment Framework for Clean Energy and Development and other regional initiatives. The Program includes (a) the Energy Efficiency Initiative with a regional strategy for promoting greater investments and activities in energy efficiency; (b) the Carbon Market Initiative to provide upfront financing and technical support for Clean Development Mechanism projects; (c) an initiative for Energy for All to establish strategic approaches that are scalable and replicable for providing greater access to modern forms of energy for the rural and urban poor; (d) the Sustainable Transport Initiative to improve energy efficiency in the transport sector, which is growing as a serious challenge in Asian mega-cities; and (e) the establishment of knowledge hubs on clean energy in Asia.

ADB lending for clean energy projects was $705 million in 2006 and is expected to exceed $900 million in 2007. The pipeline of lending for 2008-2010 is $1.9 billion and includes installation or retrofitting of facilities to use energy-efficient technologies, generate renewable energy and use clean fuels as well as electricity transmission and distribution facilities.

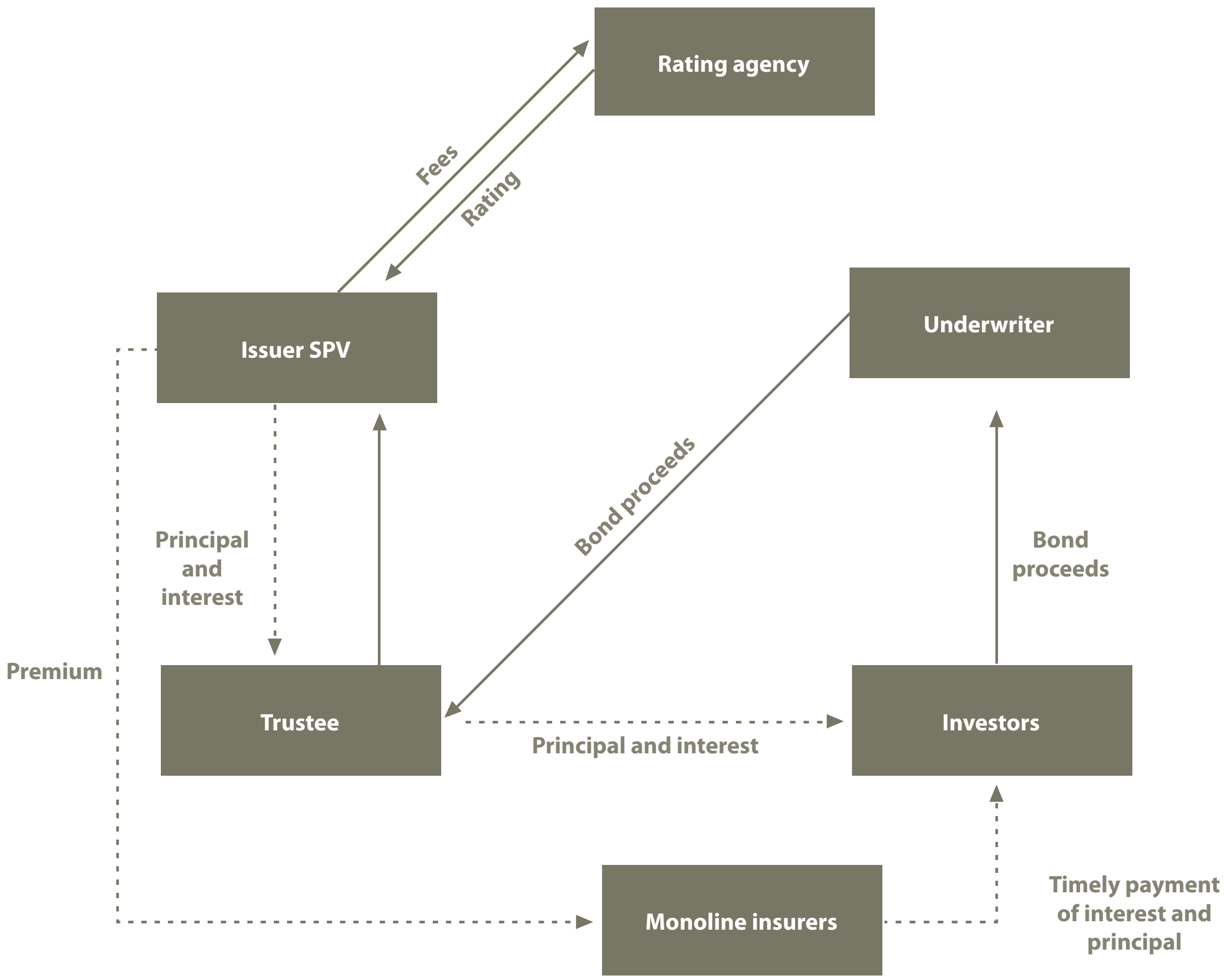
Sources: The World Bank Group Action Plan, March 2006; Asian Development Bank President Haruhiko Kuroda's statement at the Development Committee, Washington, D.C., April 2007.

A regional revenue bond initiative

Infrastructure investment requires long-term financing but can also offer attractive rates of return. One option is to issue "revenue bonds", which can combine disciplined efficiency with marketability. Revenue bonds operate in a way similar to regular bond issues. Their mechanics are illustrated in figure 3-14.

"One option is to issue "revenue bonds", which can combine disciplined efficiency with marketability"

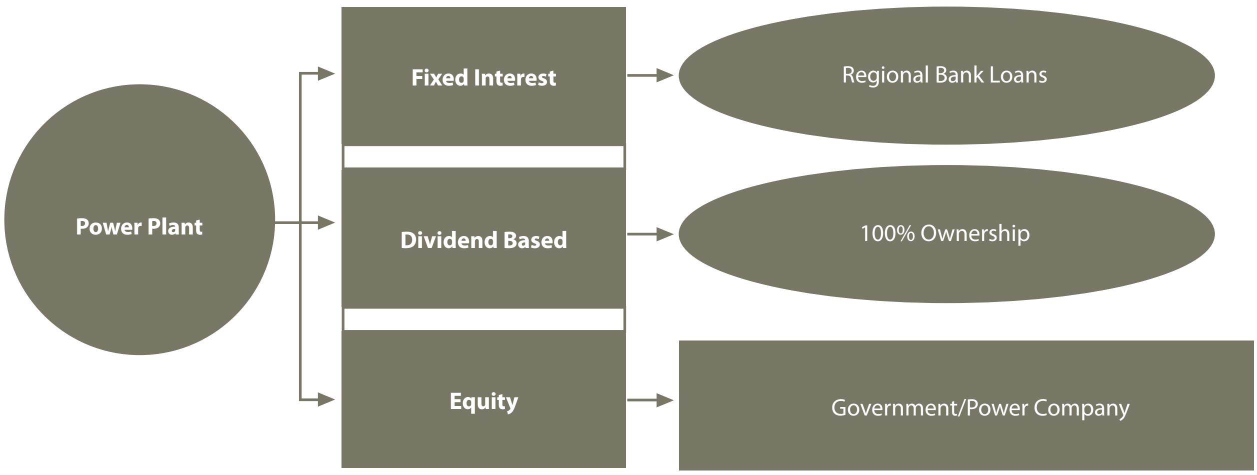
Figure 3-14—Mechanisms of a typical revenue bond



Source: Policy Research Institute for Land, Infrastructure and Transport, Research on the Effective use of the Revenue Bond, October 2005.

The principal and interest payments associated with such bonds depend on the revenue stream from the project. However, the funds raised by revenue bonds can also be supplemented with traditional borrowings and equity participation, which will make the instrument more attractive. An example of how these resources could be blended is shown in figure 3-15.

Figure 3-15—Blending revenue bonds with equity and loans



Source: Naoyuki Yoshino, "Bond market development in the Asia-Pacific Region", a paper presented at the Regional Workshop on Capacity Building for Development of Bond Markets in ESCAP Members Countries organized by ESCAP in February 2007.

The main problem in many countries is that local bond markets remain underdeveloped. One way to address this is to establish a regional revenue bond initiative, either through the existing mechanisms, such as the Asian Bond Market Initiative, or as a separate mechanism. Given a supportive institutional, legal and regulatory framework, this could be a platform for Asia-Pacific countries to issue revenue bonds and mobilize the required resources at market rates.

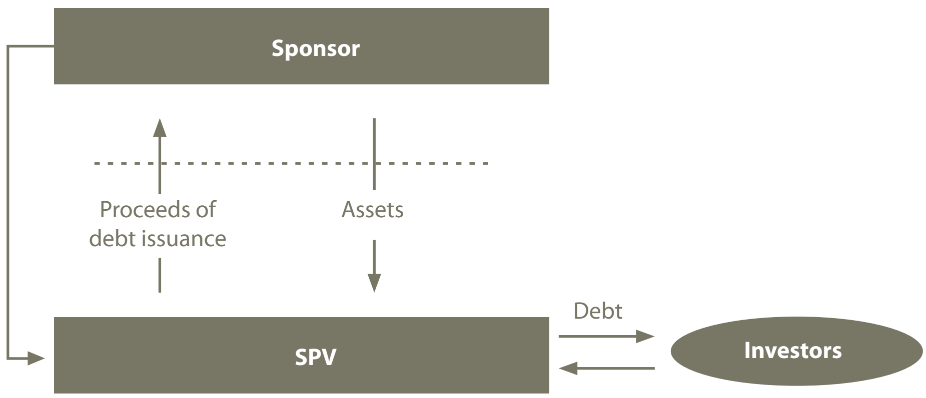
"Another instrument, the 'special purpose vehicle' is a legal entity created by a sponsor by transferring assets to it to carry out a specific purpose"

A regional special purpose vehicle for energy infrastructure development

Another instrument that is gaining popularity is the "special purpose vehicle" (SPV) for project financing. This is a legal entity created by a sponsor by transferring assets to it to carry out a specific purpose. The rules governing an SPV are set in advance and built into its activities. An SPV is a form of securitization, which offers higher-quality assets to investors by insulating them from the risk of bankruptcy either of the sponsor or the originator.

Figure 3-16 illustrates the basic parameters of an SPV. The sponsor of the project sells its assets to the SPV. The SPV is responsible for financial re-engineering of the underlying cash flows and the sale of securities to the investors. The sponsor or the originator usually makes a "true sale" of assets, which allows the sponsor to remove the assets from its books and obviates the need to hold capital against them. The securities issued to investors are asset backed since the assets of the originating firm are used as collateral.

Figure 3-16—Parameters of a special purpose vehicle



The India Infrastructure Finance Company Limited, an SPV to finance infrastructure projects on a long-term basis, was recently created in India using this concept. This could be broadened to make a regional initiative so that all countries in the region could benefit.

“A regional SPV could make use of the region's excess savings to help finance the energy infrastructure financing gap”

A regional SPV could make use of the region's excess savings to help finance the energy infrastructure financing gap.[102] It could be established with an authorized capital and a certain portion could be paid up by resource-rich countries. It could also borrow from them at a given rate. The SPV could then lend to developing countries for the undertaking of energy infrastructure projects.

One advantage of this approach, particularly in the energy sector, is that most energy projects carry high economic returns—so investors have limited exposure. However, the pricing of energy products, such as electricity, gas and fuel oil, could become a social or political issue, particularly when the global prices of fuel oil are high. Countries will therefore want to establish transparent rules and regulations on pricing so as to avoid social unrest without compromising the operational viability of energy sector projects.

CONCLUSION

Economies in the Asia-Pacific region depend upon reliable, affordable, adequate and environmentally sound supplies of energy. At present, the rising cost of energy is hurting consumers, who must spend a greater percentage of their income on energy, and affecting industries, which face shrinking profits. Moreover, the region is increasingly dependent on natural gas and petroleum fuels—and thus vulnerable to supply disruptions and painful price spikes.

> **"The region should design strategies to reduce energy demand, secure additional energy supplies, move towards more sustainable technologies and fuel types, and build the necessary infrastructure"**

To meet these challenges, the region should design strategies to reduce energy demand, secure additional energy supplies, move towards more sustainable technologies and fuel types, and build the necessary infrastructure. This would protect against future supply disruptions and high prices, while also ensuring that their citizens have adequate, affordable, reliable and environmentally sound energy services.

POLICIES AND INSTITUTIONAL MECHANISMS

Photo : StockXpert

“National energy policies are rarely comprehensive and need to be more integrated”

4

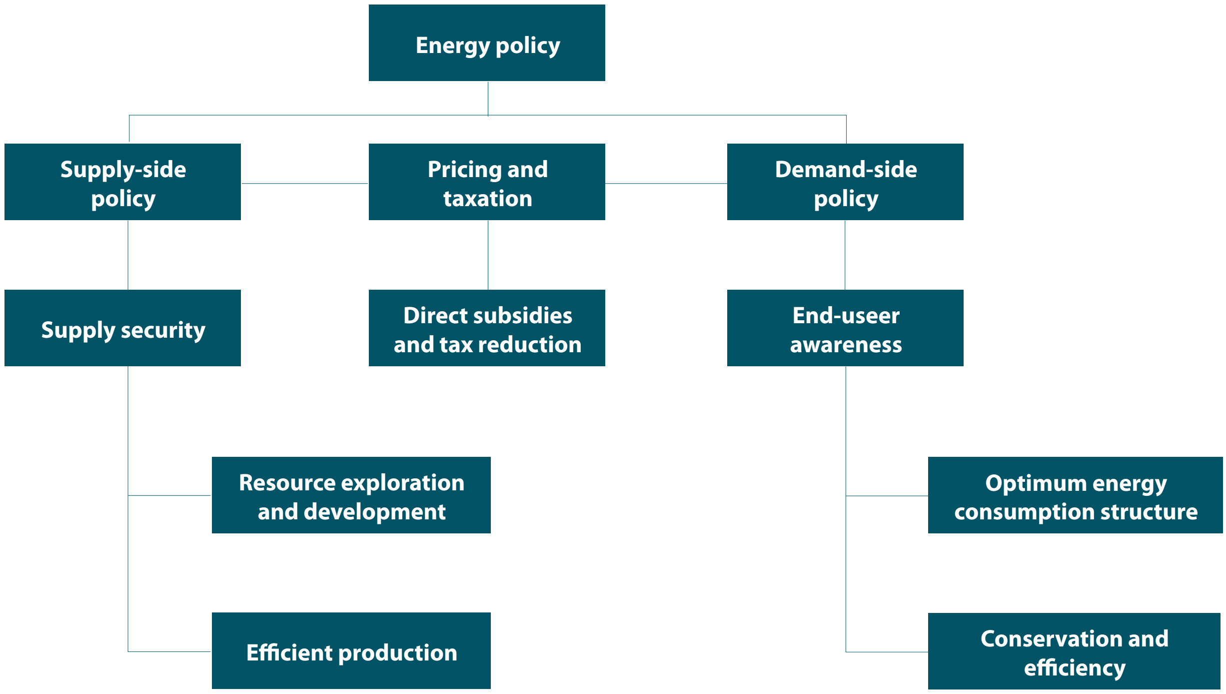
POLICIES AND INSTITUTIONAL MECHANISMS

What form should a new set of energy policies take? This chapter focuses on the potential for legislation, regulation, changing the institutional setting and providing economic or fiscal incentives. It also points out that, in a rapidly globalizing world, most countries will want to look beyond national action and seek partners through regional and subregional cooperation.

When setting energy policies, Governments face many complex issues—trying to balance concerns about energy supply and demand with social and environmental considerations. Most countries in Asia and the Pacific have such policies, but in the developing countries especially, they are rarely comprehensive, typically designed on a sector-by-sector basis.

Instead, these policies can be more integrated—combining a series of interlocking measures that help regulate the market, widen access, mobilize private-sector investment and encourage research and development. A common way of achieving this synthesis is to prepare a strategic document that defines government objectives in energy management and security and serves as an overarching basis for sectoral policies. Figure 4-1 illustrates a potential energy policy framework.

Figure 4-1—An energy policy framework



NATIONAL ENERGY POLICY

In the past, energy policy has been concerned with supply and demand within countries. Except for imports of oil and, to some extent, coal, most other forms of energy, such as biomass and hydropower, have traditionally been supplied largely from domestic resources, although the four largest oil importing countries—China, India, Japan and the Republic of Korea—are in the Asia-Pacific region. Energy policies have thus been dominated by exploration and production. The situation is, of course, different for countries that are comparatively rich in energy resources. Policy in Australia, China, the Islamic Republic of Iran and the Russian Federation, for example, aims to secure domestic supplies while increasing international exports.

Australia—Energy policy has been focused on achieving economic efficiency, energy security and environmental sustainability. Policy is heavily influenced by the country's extensive domestic fuel resources: in 2005, coal accounted for 41 per cent of the total primary energy supply, followed by oil (35 per cent), natural gas (19 per cent) and renewables (5 per cent).[103] In 2004, the Government issued a White Paper, "Securing Australia's energy future", which, among other things, aimed at attracting investment in Australia's energy resources, along with offering incentives for petroleum exploration in frontier offshore areas, developing energy markets and minimizing disruptions in supplies. The White Paper also called for a biennial review of the energy security outlook. Other recent major energy policies are related to energy market reform and institutional changes.

> "Policy in Australia, China, the Islamic Republic of Iran and the Russian Federation, for example, aims to secure domestic supplies while increasing international exports"

China—Demand for energy is surging along with the country's strong economic growth, so the Government has called for increased domestic production of alternative and renewable energy resources. According to a white paper on mineral resources released in 2003, China relies mainly on the development of its own mineral and energy resources. The Government encourages overseas capital and technology and has also been developing policies on renewable resources. It has recently established the Wind and Solar Energy Resources Assessment Center, which will, among other things, identify wind farm locations, monitor wind and solar resources and provide meteorological support services.

India—With limited domestic reserves of fossil fuels, India has to import most of its gas, crude oil and petroleum products, and recently has also had to import coal. A 2006 Planning Commission report, "Integrated energy policy", aimed at reducing India's energy requirements and import dependency by increasing efficiency in production, transmission and distribution and expanding the domestic resource base, as well as using commercial or near-commercial technologies.[104] There are also measures to acquire energy assets overseas so as to diversify sources of fuels.[105]

Islamic Republic of Iran—As one of the world's top three holders of proven oil and natural gas reserves, and the fourth largest exporter of crude oil, the country's energy policies are aimed at maintaining its oil and gas exporting capacity without compromising current energy consumption patterns and, for electricity generation, replacing oil with natural gas. Oil accounts for half of domestic energy consumption, and natural gas the other half. A key part of the energy sector development plan is continued exploration and production of the offshore South Pars natural gas field in the Persian Gulf.[106]

Russian Federation—The economy is heavily dependent on oil and natural gas exports. In August 2003, the Government confirmed the country's energy strategy. The main objectives are to improve quality and boost competitiveness on the world market—concentrating on energy safety, budget effectiveness and ecological energy security. The strategy also stresses the need to increase energy efficiency, reduce the impact on the environment, improve competitiveness and strengthen infrastructure. Taking advantage of its geographical location, the Russian Federation aims to boost exports to the fast-growing Asian energy markets, particularly China, Japan and the Republic of Korea, while being a reliable supplier of oil and gas to European countries. At the same time, the Russian Federation has broader global concerns and, during its G8 presidency in 2006, led the G8 to commit itself to increasing transparency, predictability and stability in global energy markets.

STRATEGIC OIL RESERVES

Given their high dependency on imported oil and their vulnerability to supply disruptions, some countries have been aiming to enhance energy security by building strategic stockpiles. According to a March 2001 agreement, all 26 members of the International Energy Agency must have a strategic oil reserve equal to 90 days of oil imports for their respective country (box 4-1).

> "Some countries have been aiming to enhance energy security by building strategic stockpiles"

Another possibility is to build regional or subregional reserves, especially for the least developed countries, which lack the capacity or resources to establish reserves independently. These facilities would also act as stabilizing instruments for growth in energy demand in Asia by buffering sudden price hikes. Regional strategic oil reserves could furthermore act as confidence-building measures, enhancing intraregional stability and cooperation. Japan, for example, is considering the possibility of implementing a programme that, when shortages hit, will enable countries in East Asia to share oil reserves.[107]

Box 4-1—National strategic oil reserves

China—China began building oil reserves in 2004 with a plan to have an 800-million-barrel strategic reserve to be stored at four facilities to be fully operational in 2008. China has invested some $760 million to secure oil reserves of 10 million tons at the four sites. China's reserves would consist of a government-controlled strategic reserve complemented by mandated commercial reserves.

Japan—The country has a total of about 169 days of consumption reserve. In 2003, there were 320 million barrels of petroleum in State-controlled reserves at 10 different locations. Privately held reserves of petroleum held in accordance with the Petroleum Stockpiling Law totalled 130 million barrels.[a] The State stockpile equals about 92 days of consumption and the privately held stockpiles add 77 days.

Other countries—In India, the development of a strategic crude oil reserve has begun and is expected to be pegged at 40 million barrels. The Republic of Korea has a reported reserve of 43 million barrels, and Australia has some 90 days of reserves in addition to over 200 days held in private reserves. Among the ASEAN countries, Thailand recently increased its strategic reserve from 60 days to 70 days of consumption. Singapore has an estimated storage capacity of 32 million barrels of crude oil, with an additional 65 million barrels of oil products for a total of 96 million barrels.[b] The Philippines has begun plans for a national petroleum strategic reserve by 2010 with an approximate size of 30 million barrels. The Russian Federation has begun plans for a strategic petroleum reserve which analysts estimate at about 78 million barrels.[c] The Islamic Republic of Iran has begun plans to create a strategic reserve and the Iranian National Oil Company has begun construction of 15 crude-oil storage tanks with a planned capacity of 10 million barrels.[d]

[a] Accessed from http://www.enecho.meti.go.jp/english/energy/japan/oilinfo.html.
[b] Vijay Sakhuja, "A regional approach to strategic oil reserves?", *Opinion Asia*, 25 December 2006.
[c] Randy Kirk, "The impact of additions to strategic petroleum reserves on world oil demand", *Energy Bulletin, 2*, December 2005.
[d] Iran Energy Data, Statistics and Analysis - Oil, Gas, Electricity, Coal (http://www.eia.doe.gov/emeu/cabs/Iran/pdf.pdf).

POLICIES FOR IMPROVING ENERGY EFFICIENCY

One of the most important policy objectives is to increase energy efficiency. Some of the current barriers are legal or institutional; others are concerned with finance or the lack of awareness or information. Governments have a number of options for addressing these, including: establishing national goals, setting minimum efficiency standards, introducing energy labelling schemes, setting stringent environmental standards, pricing and taxation, raising public awareness and applying economic instruments.

Establishing national goals

In China, for example, for the first time the Government has set compulsory targets. Currently, China is only 25 per cent as energy-efficient as the European Union and in recent years its energy intensity has actually worsened. In response, the National 11th Five Year Plan, for 2006-2010, requires the entire country to reduce energy intensity by 20 per cent and includes provincial quotas for energy conservation (box 4-2). The plan includes measures on statistics, surveillance, energy conservation and pollution reduction. The Government has furthermore allocated $3.2 billion to

> "The National 11th Five Year Plan of China targets 20 per cent reduction in energy intensity by 2010"

Box 4-2—Reducing energy intensity in China

Since 2005, China has been aiming to build a "Resource-saving society". One way it hopes to improve energy efficiency from the demand side is through industrial rationalization. This has increased the proportion of services in the economy, leading to a decline in energy intensity. A shift of 1 per cent added value from industry to services is estimated to have reduced energy consumption by 25 million tons of coal equivalent (Mtoe) annually. Between January and August 2007, China replaced 253 small coal-fired generating units with high-efficiency generators—cutting annual coal consumption by 13.5 Mtoe and CO_2 emissions by 27 million tons and leading in the first half of 2007 to a 2.8 per cent drop in energy intensity and a fall in sulphur dioxide of 0.9 per cent. The table below lists the measures which aim to reduce energy intensity by 20 per cent by 2010.

Sector	Measures	Unit	Reduction 2005-2010
Power generation	Close down all small thermal power generation	MW	50,000
Iron & steel	Eliminate blast furnaces with a capacity of less than 300 cubic metres	Mtoe	100
Coking	Shut down the small coking furnaces	Mtoe	80
Cement	Replacement with more-efficient technologies	Mtoe	250
Paper	Shut down small pulp and paper making production	Mtoe	6.5

Source: Adapted from China State Council Notice, May 2007.

support energy conservation and emission reduction programmes, including a $945 million reward scheme to encourage companies to reduce emissions and conserve energy.[108]

The Russian Federation has also established energy intensity goals—in the energy strategy adopted in 2003, and in the Federal Special Programme "Energy Efficient Economy in 2002-2005 and till 2010".[109] Subsequently, in September 2006 the Government published a new energy strategy, aiming by 2015 to reduce energy intensity by 63 per cent.

Minimum efficiency standards and labelling

A good way to promote energy efficiency is to set minimum standards for manufactured products. Standards can be either voluntary or mandatory, though in recent years they have tended to be mandatory. The Philippines, for example, introduced a mandatory standard for air conditioners and within a year average efficiency had increased by 25 per cent.[110] In 1999, Australia similarly adopted standards for refrigerators and freezers; as a result, over the period 1980 to 2005, the energy consumption of new refrigerator-freezers fell by about 70 per cent. Labelling standards have also been established in India: in 2006 the Bureau of Energy Efficiency launched the National Energy

“A good way to promote energy efficiency is to set minimum standards for manufactured products”

Labelling Programme for home appliances—initially on a voluntary basis but subsequently mandatory; the first two labelled appliances, frost-free refrigerators and tubular fluorescent lamps, became available in July 2006.

Experience in the Asia-Pacific region and elsewhere has shown, however, that to stimulate technical progress and ensure steady improvements in energy efficiency, such labelling programmes and performance standards must be reviewed and reinforced at regular intervals.

Government procurement

Procurement by governments and other institutional buyers can also stimulate the diffusion of energy-efficient products—setting an example for corporate buyers and individual consumers. Governments can also exert influence through "indirect purchasing" by sending clear signals to their suppliers that they should offer energy-efficient equipment and follow energy-efficient practices.[111]

> "Procurement by governments and other institutional buyers can stimulate the diffusion of energy-efficient products"

In Japan, for example, the Basic Policy on Promoting Green Purchasing contains specific provisions for government procurement of energy-efficient and environmentally preferable products, including the use of Energy Star labelling criteria for office equipment.[112] The Republic of Korea has a similar government policy favouring purchases of appliances and equipment that are above the minimum energy performance standards.[113] China also has government procurement policies linked to energy-efficiency endorsement labels and requires government departments to give preference to products with such labels. In March 2007, the Government also introduced the Corporation Income Tax Law, which includes preferential tax rates for manufacturers of energy-efficient products. In addition, there is a set of guidelines on the implementation of government purchasing of environmentally designated products, which has a list of products whose manufacturers are certified to have followed government regulations on energy efficiency and pollution control.

Other policies include building codes and standards, and regular energy audits for such major energy consumers as industrial plants, commercial buildings and transportation companies.

Pricing and taxation

In the past, most of the energy producers in Asia were owned by Governments, which also controlled energy markets, so they could set prices and production volumes directly, generally making energy available at prices much lower than the cost of production. Even today, many countries have large cross-subsidies among customer categories: lower for households, mainly rural, and agriculture, and higher for other customer categories.

Now, these systems are steadily disappearing. Over the past decade, Governments have been liberalizing energy prices and reducing cross-subsidies. As a result, since the 1990s, final prices for most fuels, except those of renewables, have increased and better reflect the costs of production. The most significant increases have been for household oil products and electricity: prices for households in 1991 were about one third those for industry, but now in many countries household electricity prices are only about 30 per cent less than those for industry.

A useful way of adjusting prices and promoting renewable energy without undermining competitiveness is to adjust tax rates. As part of green budget and tax reform, ESCAP—under its five-track Green Growth approach—is already engaged in dialogues on the potential benefits of applying green taxes. Green tax reforms bring a double dividend—allowing Governments to reduce income taxes without cutting public spending. In Germany, for example, tax revenues collected from polluters help reduce high insurance contributions for pensions.[114]

> Green tax reforms can adjust fuel prices and promote renewable energy without raising income taxes

Progress in Asia has been more modest. Nevertheless, China, Japan and the Republic of Korea have started to shift from taxes on income to taxes on carbon-generating activities. In Japan, for example, against fierce opposition from industrial interests, parliamentarians have continued to push for an environmental consumption tax. Since 2000, the Government of the Republic of Korea has increased the petroleum excise tax by 31 per cent per annum. China, too, is considering increasing taxes on retail gasoline and diesel. However, the Asia-Pacific region still has a long way to go to match the European model.

Awareness raising

Both producers and consumers need to be well informed. Governments can therefore provide and disseminate information on energy conservation.

Table 4-1—Awareness campaigns—areas, target audience and technologies

End-user area	Target audience	Technologies
Buildings - Households - Commercial	Citizens Households Sustainable communities Property owners Architects and engineers Financial institutions Schools and universities	Energy efficient appliances Heating Cooling Lighting District heating Solar energy Others
Transport - Mass transportation - Private transportation	Decision makers Transport authorities and companies Local and regional authorities Financial institutions Citizens	Electric vehicles Biofuels Gasohol Integrated planning ICT NGV Hybrid Others
Industry - Manufacturing - Services	Decision makers Local and regional authorities Consumers Utilities ESCOs	Energy efficiency Cleaner production CHP Renewable energy Others

This will enable them to combine policy "push" with consumer "pull". Governments can encourage the emergence of energy-efficiency products and solutions, while consumers can demand more efficient devices and practices. Some of the options are shown in table 4-1.

POLICIES TO SUPPORT RENEWABLE ENERGY

Renewable energy technologies can help optimize energy consumption and widen access to energy services for poor rural populations while also bringing many environmental benefits. Markets for these technologies have been growing rapidly, but they still face a number of barriers, including high initial costs, limited awareness and a lack of appropriate technologies and institutions. To deal with these issues, Governments can provide the appropriate regulations, laws, targets and incentives.

Legislation for renewable energy development

Renewable energy laws have so far been confined to developed countries. Developing countries have been slower off the mark but are now starting to act. China, for example, enacted in 2006 a renewable energy law which stipulates the responsibilities of the Government and society in developing and applying renewable energy. For example, the law encourages the development of the renewable energy industry and appropriate technical research and has established a special fund. Recent regulations under

"Developing countries have begun to introduce renewable energy laws"

Box 4-3—The Renewable Energy Bill in the Philippines

The Philippines Renewable Energy Bill provides the framework of legal and institutional conditions necessary for the private sector to move renewable energy technologies into the market. It also paves the way for policies that create markets and ensure a fair rate of return for investors. Among other things, the Renewable Energy Bill provides for the following:

(a) A renewable portfolio standard (RPS), a market-based policy that requires electricity suppliers to source a certain proportion of their supply from renewable energy. While creating a demand for renewable energy, RPS generates competition among renewable energy developers, allowing the mandated parties to meet their targets at the lowest costs;

(b) The renewable energy market, in which renewable energy power can be traded, purchased or sold. This will be linked to the wholesale electricity spot market;

(c) The green energy option, which gives consumers the choice to use renewable energy;

(d) The net metering arrangement, which allows grid users who produce renewable energy power to be appropriately credited for its contribution to the grid;

(e) The minimum renewable energy generation mandate for power generators in off-grid areas, which is expected to widen access to energy services for rural constituents.

The Renewable Energy Bill further proposes the granting of fiscal incentives to eligible proponents. These include: (a) an income tax holiday; (b) a preferential realty tax rate; (c) an exemption from import duties; and (d) a reduction in the Government's share of royalties.

the law require power grid companies to purchase electricity generated from renewable energy for their network and also establishes that the renewable energy electricity price will either be set or guided by the central Government. The Philippines, too, is in the process of approving a renewable energy bill (box 4-3). The Islamic Republic of Iran has also been developing a new law and has started to allow the participation of independent power producers.

National targets for renewable energy

Governments can demonstrate their determination to promote renewable energy by setting national targets. This also sends affirmative signals to society, especially to the private sector. By the end of 2006, such targets existed in more than 50 countries, one third of them in Asia and the Pacific (table 4-2). Most targets are set for 2010 or 2020—usually at national, state/provincial, and municipal levels.[115]

Stimulating renewable energy in power generation

Bulk power generation from renewable energy resources—wind, biomass and hydro—is already commercially competitive with conventional sources or becoming so. Solar PV is not yet competitive for grid electricity but is showing promise. Governments can promote renewable energy generation in a number of ways, including setting feed-in tariffs and portfolio standards, guaranteeing grid access, and introducing net metering, public competitive bidding and distributed generation policies.

Table 4-2—Asia-Pacific countries with renewable energy targets

Country	Target
Australia	9.5 TWh of additional electricity from renewable energy per year by 2010. About 30 TWh each year from low-emission sources by 2020—about 15 per cent of Australia's energy consumption
Bangladesh	5 per cent of demand met by clean energy by 2010 and 10 per cent by 2020[a]
China	10 per cent of electric power capacity and 5 per cent of primary energy by 2010; 15 per cent of primary energy by 2020[b]
Fiji	Fiji Electricity Authority to become a renewable energy utility by 2013
India	10 per cent of added electric power capacity during the period 2003-12; full use of cogeneration in the sugar industry;15 per cent of power capacity; 10 per cent of oil consumption
Indonesia	> 5 per cent biofuels; >10 per cent other new and renewable energy by 2010[c]
Japan	1.35 per cent of total electricity by 2010; 3 per cent of total energy consumption by 2010
Republic of Korea	5 per cent of total primary energy by 2011
Malaysia	Add 350 MW renewable energy generation capacity by 2010[d]
Pakistan	5 per cent of power generation by 2030
Philippines	100 per cent increase in renewable energy power capacity by 2011
Singapore	50,000 M^2 solar thermal systems by 2012
Sri Lanka	7.5 per cent and 10 per cent of grid electricity using renewable energy by 2010 and 2015 respectively
Thailand	8 per cent of total primary energy by 2011
Viet Nam	2 per cent of total primary energy by 2010 and 3 percent by 2020

[a] National energy policy, August 2005.
[b] Long and Mid-Term Renewable Energy Plan, State Council, http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/2007/20079583745145.pdf
[c] Presidential Regulation No. 5/2006 on National Energy Policy, Jan 2006.
[d] Malaysia, Energy Commission, "Ninth Malaysian plan on energy" (available online at http://www.st.gov.my/images/stories/upload/Chapter19_Energy4.pdf).

> "Renewable energy power generation is increasingly becoming commercially competitive in the region"

A number of developing countries in Asia and the Pacific have shown the way. India, for example, was one of the first to establish feed-in tariffs and in early 2006 announced a new national tariff policy to promote renewable power generation, including quotas, preferential tariffs and guidelines for pricing "non-firm" power. Thailand, too, allows small private power producers using biomass to sell electricity to the State-owned power utility at feed-in tariffs. Pakistan has similarly been aiming to boost wind power development, with a 9.5 cents/kWh feed-in tariff for approved projects—and has waived import duties for wind turbines.[116]

Governments can also set renewable energy portfolio standards, requiring electricity suppliers to use a minimum proportion of renewable energy. Australia, for example, required power companies in 2001 to ensure that 1.25 per cent of all electricity generated came from renewable energy resources by 2004—a requirement that will be adjusted annually towards the national target of 9,500 GWh by 2010. In 2003, Japan introduced renewable energy portfolio standards and targeted 1.35 per cent of total energy generation by 2010.[117] Thailand started in 2004, requiring 5 per cent renewable energy electricity for all newly installed power generation capacity. And in India, a number of states, such as Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Gujarat, have renewable energy portfolio standards (table 4-3).

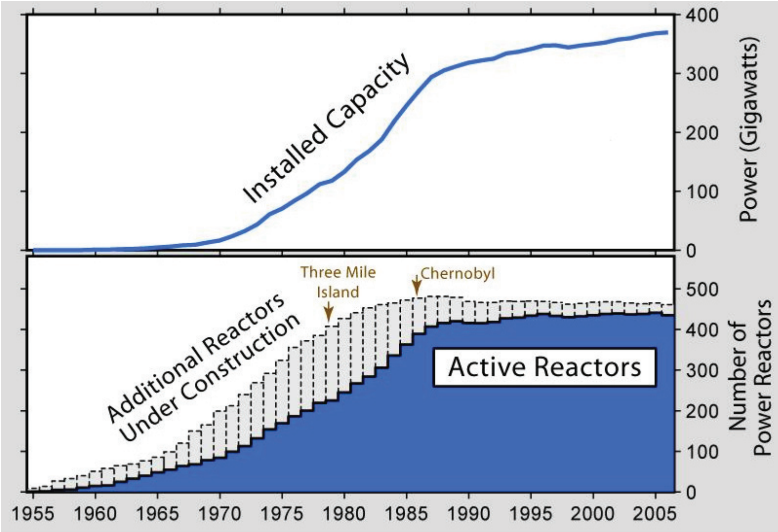
Many Governments support renewable energy power generation through direct subsidies, financial investments or low-interest bank loans. In India, for example, the Indian Renewable Energy Development Agency Limited provides loans and project financing. By March 2007, it had approved 1,816 projects and committed loans worth about $2 billion to a power generation capacity of 2,927 MW.

Table 4-3—Renewable energy portfolio standards in India

State	Renewable energy portfolio standards	Year
Andhra Pradesh	5 per cent of consumption from non-conventional energy	2005
Madhya Pradesh	Mandatory for utility to purchase 0.5 per cent of energy consumption from renewable sources	-
Karnataka	5 to 10 per cent of electricity from renewable sources	2004
Gujarat	1 per cent from 2006-07; 2 per cent from 2008-09	2005
Rajasthan	400 MW into "power purchase agreement"	2005
Orissa	To buy 200 million units of green power during financial year 2006-07 at a cost not exceeding the highest cost of thermal power in the eastern region	2005
Maharashtra	Purchase of 250 MW from biomass power projects	-
Tamil Nadu	Purchase 10 per cent of the total power consumption from renewable sources	-

Source: India, Ministry of New and Renewable Energy (http://mnes.nic.in/).

Figure 4-2—Development of the global nuclear power industry



Source: Robert A. Rohde from published data (www.globalwarmingart.com/wiki/Image:Nuclear_Power_History.png).

Policies for nuclear energy

Recently, interest in nuclear energy has surged. The most rapid growth took place during the oil shocks of the 1970s and 1980s, after which it levelled off (figure 4-2). Now, faced with increasing demand, the need to diversify the power supply, and concerns about climate change, developing countries across the world are showing more interest. According to IAEA, 16 of the 30 reactors now being built are in developing countries, and most of the recent expansion has been in Asia.[118]

Over the next 15 years, China, for example, plans to expand nuclear generation capacity fivefold from 700 to 4,500 GW.[119] India plans a sevenfold increase in capacity by 2022. Japan, Pakistan and the Republic of Korea also have plans to expand their nuclear power capacity in the near future, and a number of ASEAN countries, including Indonesia, Malaysia, Thailand and Viet Nam, have announced new plants.[120]

> "With the high oil prices, interest in nuclear energy rises as an option for diversifying power supplies"

Introducing nuclear power into a developing country presents formidable challenges—related to safety, security, waste and non-proliferation. Countries that choose the nuclear option will therefore need to develop designs and approaches that make nuclear power a safe, secure, affordable and practical solution.

Widening access in rural areas

The Johannesburg Plan of Implementation called for action at all levels to substantially increase the global share of renewable energy sources and improve rural access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources—as a major requirement for meeting the Millennium Development Goals.

A number of Governments have made great efforts to do so, by increasing the supply of conventional energy, such as electricity or fossil fuels, or introducing renewable technologies, such as solar PV systems or improved stoves. Policies for energy services need, however, to look beyond technology and be integrated

Box 4-4—ESCAP initiative for integrating energy and rural development

The provision of energy alone cannot guarantee rural development; rather it functions as a catalyst for development when other facilities and activities are in place. ESCAP has been promoting the integration of energy and rural development since 2003 by implementing the project "Capacity-building on integration of energy and rural development policies and programmes".

The project emphasizes the identification of energy needs in rural development activities in the areas of agriculture, education, infrastructure, financing and health, and the extent to which such concerns are integrated into current rural development policies and programmes. It aims to promote rural energy development through capacity-building in the integration of energy and rural development issues, stakeholder involvement and facilitation of information exchange. The project also aims to enhance national capacities to identify linkages between energy and rural development, and to promote long-term, integrated and well-coordinated rural energy policies and programmes. The participating countries were Bangladesh, Nepal and Sri Lanka along with Cambodia, the Lao People's Democratic Republic, Myanmar and Viet Nam.

Guidelines were developed on the integration of energy and rural development policies and programmes. These were extensively used for guiding the implementation of the integration concept at the national level by the national team consisting of representatives from the Governments, the private sector, NGOs and academia. At the same time, recognizing the gender bias of rural energy poverty, the projects ensure that policy interventions will benefit rural women as well as rural men.

The national teams were established as informal groups which took a leading role in mobilizing stakeholders involved in energy and rural development at the country level and in carrying out regional- and national-level project activities, such as developing national training courses and materials, building country strategies for integrating energy issues into rural development and identifying opportunities for gender-sensitive capacity development. Through this project, all participating countries developed their national strategies on the integration of energy and rural development policies and programmes.

with other efforts relating to education, health, agriculture and job creation. Box 4-4 presents some of the ESCAP region's experiences on such efforts.

Clean energy technologies usually have higher initial costs than traditional energy sources, so providing poor communities with access is a challenging task. Governments have typically addressed this by promoting locally available renewable energy resources for cooking, lighting, water pumping, heating, cooling and other productive uses. They have also adopted rural electrification policies and programmes—targeting populations that do not have access to central electric power networks.

In the Lao People's Democratic Republic, for example, the Government aims to achieve 90 per cent electrification by 2020, partly through some grid extensions but mostly through a decentralized renewable energy supply. The 1997 Electricity Law liberalized small-scale (100 kW and below) power development, allowing private companies, individuals and cooperatives to develop small-scale power plants by obtaining permission from provincial or district authorities. The Government has also incorporated energy, rural development and investment into its National Growth and Poverty Eradication Strategy.

The Government of Mongolia has also been determined to improve rural energy access. In 2002, it approved the Mongolia Sustainable Energy Sector Development Strategy Plan (2002-2010) with goals reinforced in the Poverty Reduction Growth Facility programme. In India, the Government in 2005 launched an ambitious scheme, Rajiv Gandhi Grameen Vidhyutikaran Yojana, with the goal within five years of electrifying all non-electrified villages or hamlets and providing all households with access to electricity.[121] In 2006, the Government approved the Rural Electrification Policy, which, among other things, aims to extend energy access to all households by 2009. A number of other countries in Asia and the Pacific, including Bangladesh, China, Nepal, the Philippines, Sri Lanka, Thailand and Viet Nam, have also developed rural electrification programmes based on renewable energy.

THE INSTITUTIONAL SETTING

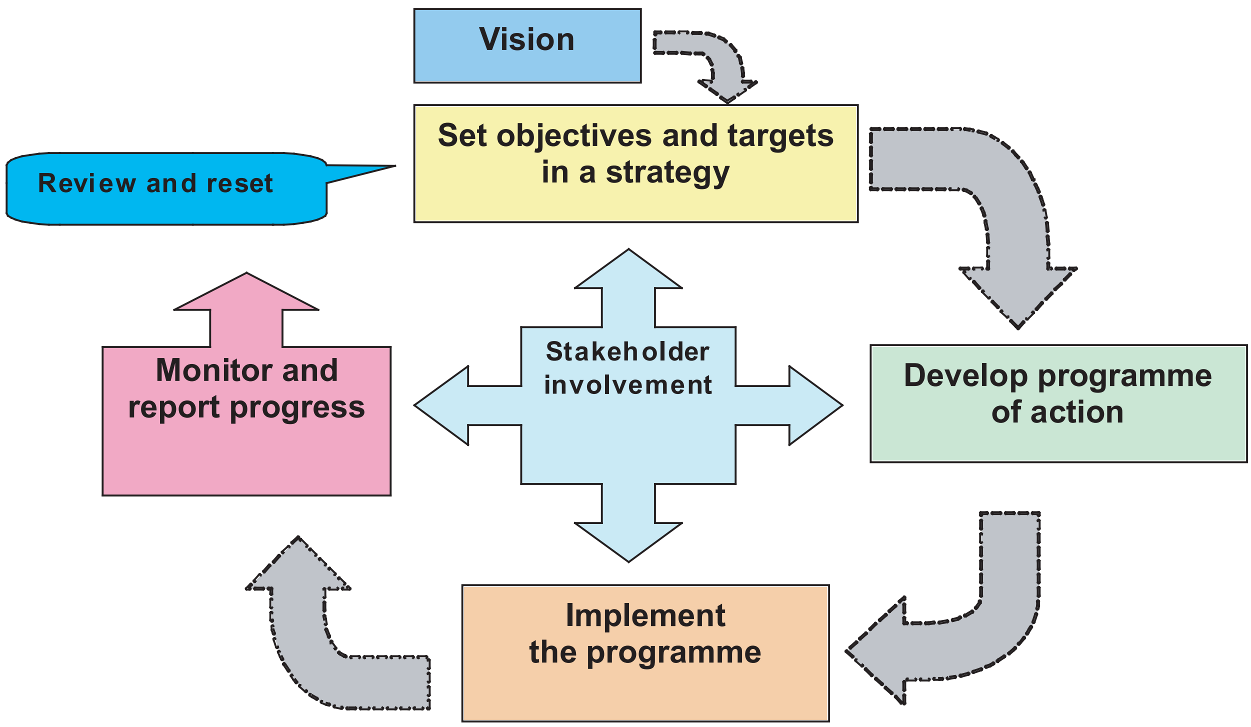
Most countries usually address issues such as energy needs, environmental protection, and poverty separately. But it is much better if these policies are integrated so that meeting the needs of one sector does not make it more difficult to meet the goals of the others. This will mean designing appropriate institutions and involving a wide range of stakeholders.

Almost all countries in Asia and the Pacific have energy agencies at the national or regional levels, or both, and more recently at the local level. Some countries have also set up agencies specifically to promote energy efficiency and renewable energy. Many, however, are held back by limited managerial skills and inadequate knowledge about available policies and technologies.

As well as integrating their activities, these institutions also need to make manageable plans—setting out the tasks, targets, timing, allocation of responsibility, funds and other resources in a manner that allows for the monitoring and evaluation of progress. In many cases, the plan can be broken down further into annual

> "Institutional arrangements are needed to involve a wider range of stakeholders to integrate sectoral policies"

Figure 4-3—Strategic planning and management—a five-step approach



operational plans. ESCAP has implemented a project and organized a series of meetings to introduce the concept of strategic planning and management. Figure 4-3 presents an overview of the relationship between vision, strategy and action plan.

INTERNATIONAL, REGIONAL AND SUBREGIONAL POLICIES

A number of other organizations are involved in regional and subregional decision-making on energy. At the regional level, these include the Asian Development Bank (ADB), Asia-Pacific Economic Cooperation (APEC), and the Asia Pacific Energy Research Centre (APERC). There are also subregional organizations that have initiated studies and programmes on energy, including the Association of Southeast Asian Nations Centre for Energy (ACE), the South Asian Association for Regional Cooperation Energy Center (SEC), and the Pacific Islands Applied Geoscience Commission (SOPAC).

The following sections provide a brief survey of various international, regional and subregional initiatives with a view to identifying options for collaboration. The list is by no means exhaustive, as these cooperative frameworks are constantly evolving.[122] At present there are at least 43 active initiatives, of which 17 are intergovernmental, 13 are programmes, nine are partnerships, and four are networks (table 4-4). The following discussion makes extensive use of acronyms. When not explained in the text, the full names will be found either in the tables or in the list of abbreviations at the beginning of this study.

Some of these initiatives, such as ACE, APEC, SAARC and SOPAC, have well-defined strategies and have established working groups while others have yet to clarify their goals or strategies, particularly on energy. Of the total, 30 deal with energy in general while 15 focus on fossil fuels, 16 on electric power, 12 on renewable energy and 16 on energy efficiency. The geographical

> "There are 43 active initiatives on energy in the region addressing different aspects of energy"

Table 4-4—International energy initiatives in Asia and the Pacific, by type

Intergovernmental	Partnership	Network	Programme
ACD	APP-CDC	ENERGIA	CAREC
ACE	BFA	GNESD	CD4CDM
ACMECS	ECO-Asia	INFORSE	CLASP
APEC	EESD	PEG (Pacific)	EUEI
BIMP-EAGA	IPHE		GMS Program
BIMSTEC	PCFV		GTI
BSEC	PEG		GVEP
ECNEA	PIESD		PIEPSAP
ECO	REEEP		RDI
ECT			SARI/E
EurAsEC			SASEC
Mekong Programme			SECSCA
PIFS			SEFI
SAARC			
SCO			
SOPAC			
SPECA			

Figure 4-4—Schematic map of energy cooperation in Asia and the Pacific

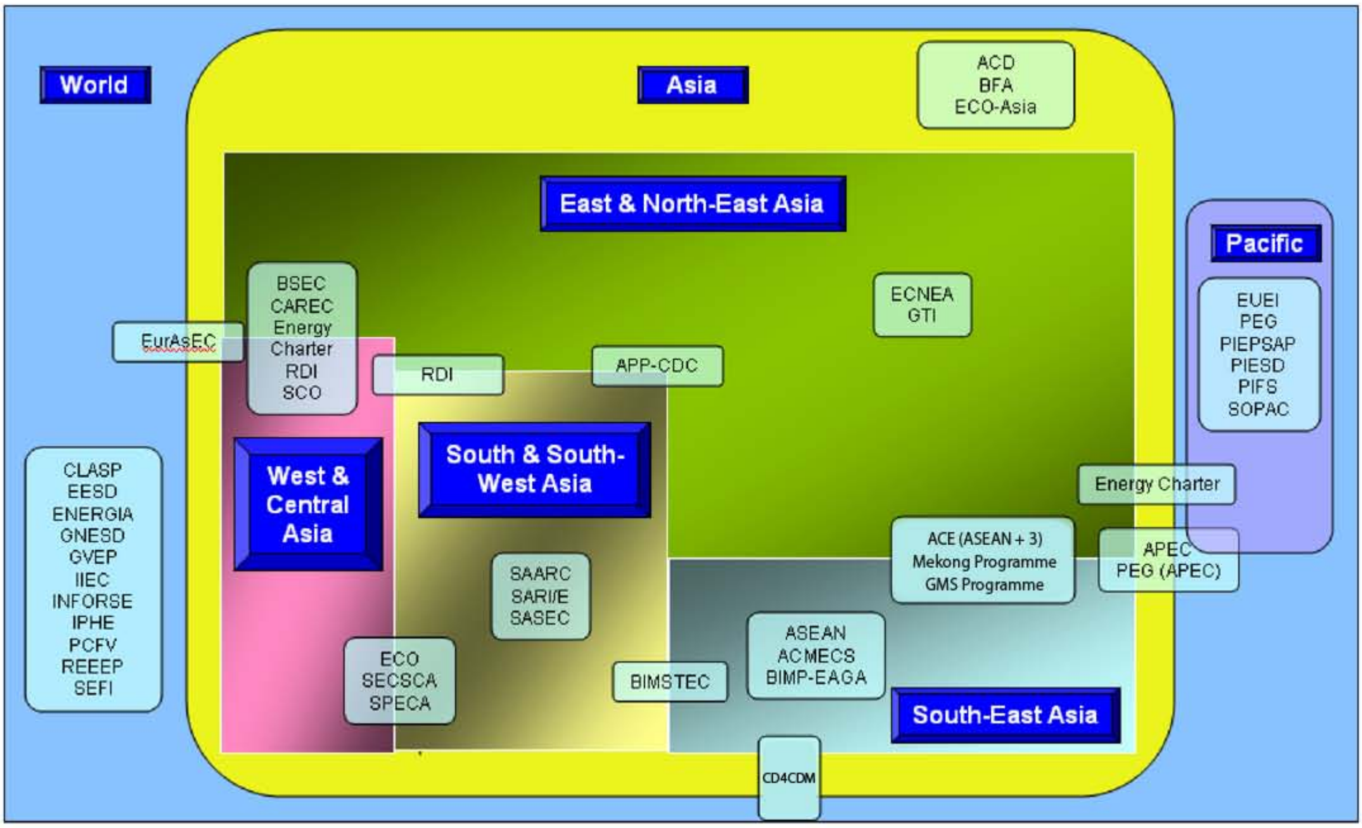


Table 4-5—International energy initiatives in Asia and the Pacific, by subsector

Energy		Fossil fuel	Electric power	Renewable energy	Energy efficiency
ACD	GMS	ACD	ACD	ACD	ACD
ACE	GNESD	ACE	ACE	ACE	ACE
ACMECS	GTI	APEC	ACMECS	ACMECS	APEC
APEC	GVEP	APP-CDC	APEC	APEC	APP-CDC
BFA	INFORSE	BIMSTEC	APP-CDC	APP-CDC	CLASP
BIMP-EAGA	IPHE	BSEC	BIMSTEC	ECNEA	ECNEA
BIMSTEC	PEG	CAREC	CAREC	GVEP	ECO
BSEC	PIEPSAP	ECNEA	ECNEA	IPHE	ECO-Asia
CAREC	PIESD	ECO	ECO	RDI	EESD
CD4CDM	PIFS	ECT	ECT	REEEP	ECT
ECNEA	SAARC	EurAsEC	EurAsEC	SAARC	GVEP
ECO	SARI/E	PEG	GTI	SEFI	PCFV
ENERGIA	SASEC	SAARC	Mekong		REEEP
EUEI	SCO	SARI/E	Programme		SAARC
EurAsEC	SOPAC	SECSCA	SAARC		SARI/E
			SARI/E		SEFI
			SPECA		

Table 4-6—Global energy initiatives in Asia

Initiative	Acronym	Type	Energy subsector
Collaborative Labelling and Appliance Standards Program	CLASP	Programme	Energy efficiency
Efficient Energy for Sustainable Development Partnership	EESD	Partnership	Energy efficiency
International Network on Gender and Sustainable Development	ENERGIA	Network	
Global Network on Energy for Sustainable Development	GNESD	Network	
Global Village Energy Partnership	GVEP	Programme	Energy efficiency, renewable energy
International Institute for Energy Conservation	IIEC	Programme	Energy efficiency
International Network for Sustainable Energy	INFORSE	Network	
International Partnership for the Hydrogen Economy	IPHE	Partnership	Renewable energy
Partnership for Clean Fuel and Vehicles	PCFV	Partnership	Energy efficiency
Renewable Energy and Energy Efficiency Partnership	REEEP	Partnership	Energy efficiency, renewable energy
Sustainable Energy Finance Initiative	SEFI	Programme	Energy efficiency, renewable energy

Table 4-7—Energy initiatives in East and North-East Asia

Initiative	Acronym	Type	Energy subsector
ASEAN + 3 through ACE	ASEAN + 3	Intergovernmental	
Asia-Pacific Economic Cooperation	APEC	Intergovernmental	
Asia-Pacific Partnership on Clean Development and Climate	APP-CDC	Partnership	
Central Asia Regional Economic Cooperation	CAREC	Programme	Electric power, energy efficiency
Energy Charter Treaty	ECT	Intergovernmental	Electric power, energy efficiency
Intergovernmental Collaborative Mechanism on Energy Cooperation in North-East Asia	ECNEA	Intergovernmental	
Eurasian Economic Cooperation	EurAsEC	Intergovernmental	Electric power, fossil fuels
Greater Mekong Subregion Programme	GMS Programme	Programme	
Greater Tumen Initiative	GTI	Programme	Electric power
Mekong Programme	Mekong Programme	Intergovernmental	Electric power
Partnership for Equitable Growth	PEG	Partnership	Fossil fuels
Renewable Development Initiative	RDI	Programme	Renewable energy
Shanghai Cooperation Organization	SCO	Intergovernmental	

distribution of these initiatives is indicated in figure 4-4 and their distribution by subsector is indicated in table 4-5.

• *Global initiatives*—Most of the 11 global initiatives deal with energy efficiency or renewable energy. Generally, they are partnerships or networks, which are also sponsored by national, international or development donors, such as the United States Department of Energy, USAID, UNEP and IIEC (table 4-6).

• *Asian initiatives*—Three initiatives cover all the subregions of Asia: Asia Cooperative Dialogue (ACD), the Boao Forum for Asia (BFA) and ECO-Asia. ACD is an intergovernmental initiative and one of the more advanced since it has the Qingdao Initiative, which defines its cooperative energy measures. The Boao Forum for Asia has similar objectives but is a partnership with public- and private-sector members. ECO-Asia, launched in 2006, is another government-business partnership that focuses on climate change and promotes activities to increase investment in clean technologies.

• *East and North-East Asian initiatives*—Excluding global and Asian initiatives, there are 12 international energy initiatives (table 4-7). Six are intergovernmental – ASEAN +3, APEC, ECNEA, ECT, Mekong Programme, and the SCO. ECNEA is the only initiative focusing on all countries in the subregion; the rest either cover other subregions besides East and North-East Asia or do not include all countries that are in ECNEA. China is more involved in programmes dealing with hydro-power, such as GTI, ADB's GMS programme and the MRC Mekong Programme. ASEAN, which is a South-East Asian initiative, has also been joined by China, Japan and the Republic of Korea (ASEAN +3),

Table 4-8—Energy initiatives in North and Central Asia

Initiative	Acronym	Type	Energy subsector
Asia-Pacific Economic Cooperation	APEC	Intergovernmental	
Central Asia Regional Economic Cooperation	CAREC	Programme	Electric power, fossil fuels
Economic Cooperation Organization	ECO	Intergovernmental	Electric power, energy efficiency, fossil fuels
Energy Charter Treaty	ECT	Intergovernmental	Electric power, energy efficiency, fossil fuels
Eurasian Economic Cooperation	EurAsEC	Intergovernmental	Electric power, energy efficiency
Intergovernmental Collaborative Mechanism on Energy Cooperation in North-East Asia	ECNEA	Intergovernmental	
Organization of the Black Sea Economic Cooperation	BSEC	Intergovernmental	Fossil fuels
Renewable Development Initiative	RDI	Programme	Renewable energy
Shanghai Cooperation Organization	SCO	Intergovernmental	
Subregional Economic Cooperation in South and Central Asia	SECSCA	Programme	Fossil fuels
United Nations Special Programme for the Economies of Central Asia	SPECA	Intergovernmental	Electric power

Table 4-9—Energy initiatives in South-East Asia

Initiative	Acronym	Type	Energy subsector
ASEAN Centre for Energy	ACE	Intergovernmental	
Asia-Pacific Economic Cooperation	APEC	Intergovernmental	
Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy	ACMECS	Intergovernmental	Hydropower, renewable energy (biofuels)
Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation	BIMSTEC	Intergovernmental	Electric power, fossil fuels
Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area	BIMP-EAGA	Intergovernmental	
Capacity Development for Clean Development Mechanism	CD4CDM	Programme	
Greater Mekong Subregion Programme	GMS	Programme	
Mekong Programme		Intergovernmental	Electric power
Partnership for Equitable Growth	PEG	Partnership	Fossil fuels

Table 4-10—Energy initiatives in South and South-West Asia

Initiative	Acronym	Type	Energy subsector
Asia-Pacific Partnership on Clean Development and Climate	APP-CDC	Partnership	
Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation	BIMSTEC	Intergovernmental	Electric power, fossil fuels
Economic Cooperation Dialog	ECO	Intergovernmental	Electric power, energy efficiency, fossil fuels
Renewable Development Initiative	RDI	Programme	Renewable energy
South Asia Regional Initiative for Energy Cooperation and Development	SARI/E	Programme	Electric power, energy efficiency, fossil fuels
South Asia Subregional Economic Cooperation	SASEC	Programme	
South Asian Association for Regional Cooperation	SAARC	Intergovernmental	
Subregional Economic Cooperation in South and Central Asia	SECSCA	Programme	Fossil fuels
United Nations Special Programme for the Economies of Central Asia	SPECA	Intergovernmental	Electric power

particularly for investment in oil and gas trades, energy efficiency and renewable energy. APEC, on the other hand, includes China, Japan, and the Republic of Korea, and is involved in intergovernmental dialogues and networking on important issues, including energy trade, energy efficiency and renewable energy.

• *North and Central Asian initiatives*—Excluding 14 global and Asian initiatives, there are 11 initiatives in this subregion, of which 6 are intergovernmental and 3 are programmes (table 4-8). APEC, ECNEA and SCO focus on energy in general and have working groups tackling specific subsectors. Others focus specifically on hydropower (CAREC, SPECA), energy efficiency (ECO, ECT), fossil fuels (CAREC, SECSA, BSEC) or renewable energy (RDI).

• *South-East Asian initiatives*—Aside from global and Asian energy initiatives, there are at least nine active energy cooperation initiatives (table 4-9). Of these, six were initiated among Governments in the subregion, two are funded by ADB and UNEP and its donor partners, and one is a partnership. Five deal with energy in general: ACE, APEC, BIMP-EAGA, CD4CDM and GMS. A number of initiatives deal specifically with electric power (ACMECS, BIMSTEC, Mekong Programme), energy efficiency (BIMSTEC), fossil fuels (BIMSTEC, PEG) and renewable energy (ACMECS). In terms of project implementation, ASEAN is the most advanced as it already has several plans for a trans-ASEAN gas and power interconnection. ACMECS and BIMP-EAGA are offshoots of ASEAN with the aim of conducting activities with a smaller number of neighbouring countries. The energy focus of ACMECS is hydropower and biofuels. CD4CDM, which could be considered a global initiative, is active in Cambodia, the Philippines and Viet Nam.

• *South and South-West Asian initiatives*—There are nine international cooperation initiatives in the subregion, of which four are intergovernmental, four are programmes and one is a partnership (table 4-10). Three deal with energy in general, while six are involved in specific subsectors: energy efficiency (ECO, SARI/E), electric power (ECO, SARI/E, SPECA, BIMSTEC), fossil fuel (SARI/E, BIMSTEC, SECSCA) and renewable energy (RDI).

• *Pacific island initiatives*—There are two intergovernmental initiatives, two programmes, one network, and one partnership initiative for regional cooperation. All deal with energy in general (table 4-11).

REGIONAL ORGANIZATIONS

Asian Development Bank

ADB is concentrating on clean energy and efficiency measures to improve energy security and to reduce greenhouse gas emissions. It also focuses on energy security and climate change through improved energy efficiency and indigenous forms of renewable energy. ADB helps countries promote clean energy technologies and services, and build capacity,[123] and in recent years has extended clean energy loans worth

Table 4-11—Energy initiatives in the Pacific

Initiative	Acronym	Type
European Union Energy Initiative for Poverty Eradication for Sustainable Development	EUEI	Programme
Pacific Energy and Gender Network	PEG	Network
Pacific Islands Energy Policy and Strategic Action Planning	PIEPSAP	Programme
Pacific Islands Energy for Sustainable Development	PIESD	Partnership
Pacific Islands Forum Secretariat	PIFS	Intergovernmental
Pacific Islands Applied Geoscience Commission	SOPAC	Intergovernmental

$717 million (2000-2005) and $1,993 million (2006-2008).[124]

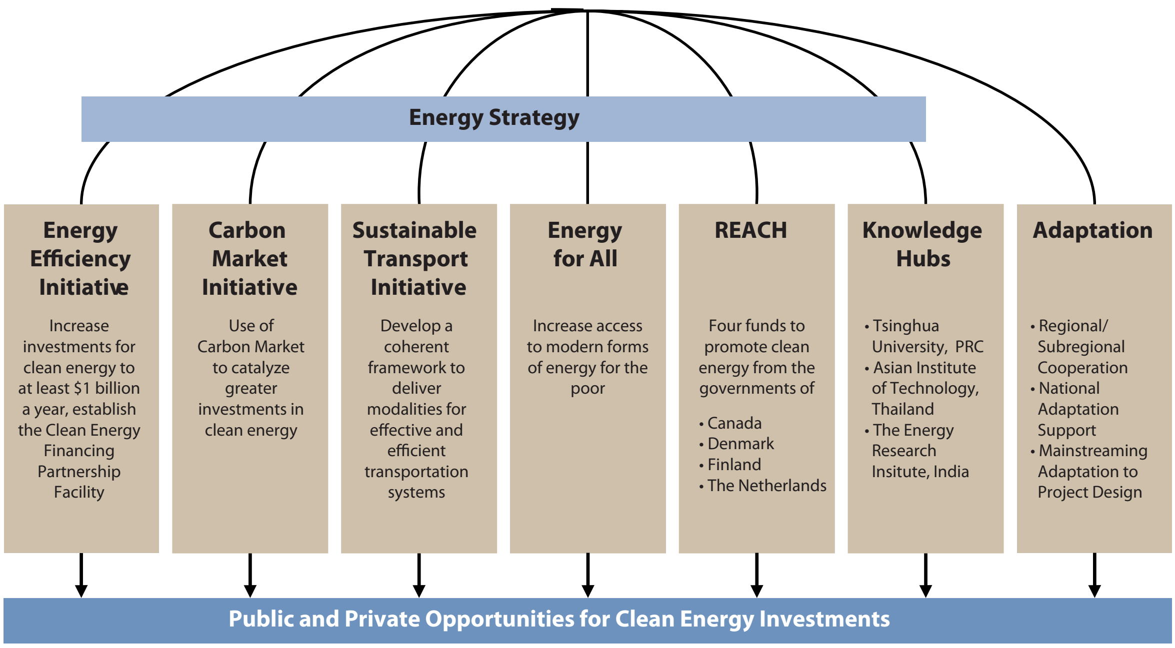
ADB recently reviewed a draft energy strategy paper (May 2007) which recommends balanced infrastructure investment and efficient financial operations for guiding future technical cooperation activities and programmes. The overall energy vision is reflected in the Clean Energy and Environment Program, which is illustrated in figure 4-5. In partnership with the economies of the Greater Mekong Subregion, ADB is also undertaking a comprehensive study to define an energy sector strategy, aiming to expand cooperation among those economies to ensure efficient and affordable access to modern energy services for all.[125]

Asia-Pacific Economic Cooperation

With 21 member economies, Asia-Pacific Economic Cooperation (APEC) is the region's premier forum for economic cooperation, trade and investment. During the annual meetings, members discuss energy issues, including the Energy Security Initiative. To implement this broad-based initiative, the APEC Energy Working Group aims at facilitating energy trade and investment and ensuring that energy contributes to the APEC community's economic, social and environmental enhancement. The current "Future directions strategic plan" focuses on strengthening the security and reliability of affordable energy, the promotion of clean and efficient technologies, the efficient use of energy, achieving environmental improvements, and the production and use of energy.[126] One initiative is a real-time information sharing system for use during energy emergencies and disruptions.

The Energy Working Group has long recognized the contribution of business and was one of the first APEC forums to establish its own public- and private-sector dialogue mechanism—the Energy Working Group Business Network—which advises on energy policy issues and facilitates regular dialogues between energy policymakers and representatives of the business sector.[127] The Energy Working Group is assisted in its work by five expert groups and two task forces—biofuels and energy efficiency, and renewable energy financing.

Figure 4-5—ADB's Clean Energy and Environment Program



PRC = People's Republic of China
Source: ADB, Second Regional Consultation Workshop on the GMS Energy Strategy, Bangkok, 28-29 May 2007 (accessed on http://www.adb.org/Documents/Events/2007/Second-Regional-Consultation-GMS/default.asp in September 2007).

The recent meeting in Sydney, Australia, concluded with the "Sydney APEC Leaders' Declaration on Climate Change, Energy Security and Clean Development". This emphasizes that economic growth, energy security and climate change are intrinsically linked and it promises to work towards clean and sustainable development. It also stresses the importance of "affordable and secure supplies of energy which are central to economic growth and sustainable development."

Prior to the Sydney meeting, the Energy Ministers, meeting in Darwin, Australia, discussed energy development and the progress of the Energy Security Initiative. They adopted the Darwin Declaration on Achieving Energy Security, in which they emphasized energy security and sustainable development through the promotion of clean and efficient energy production and use, with investments worth at least $6 trillion up to 2030 for the APEC region.

As part of the research arm of APEC on energy, the Asia Pacific Energy Research Center (APERC) was established in 1996 with sponsorship by Japan. APERC provides energy policy analysis and energy data collection and sharing, through conferences, studies, publications and workshops,[128] and has recently established a set of energy security indicators.[129]

SUBREGIONAL ORGANIZATIONS

ASEAN Centre for Energy

The ASEAN Centre for Energy was founded in 1990 as an intergovernmental organization to initiate, coordinate and facilitate energy cooperation for the ASEAN region. It has nine member countries: Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore and Viet Nam. ACE receives the mandate for its work programme from the ASEAN Plan of Action for Energy 2004-2009, which includes six programmes: (a) ASEAN power grid; (b) trans-ASEAN gas pipeline; (c) coal and clean coal technology promotion; (d) energy efficiency and conservation promotion; (e) new and renewable energy development; and (f) energy policy and environmental analysis.

At the twelfth ASEAN Summit, held in Cebu, Philippines, the heads of State of ASEAN countries, along with representatives of Australia, China, India, Japan, the Republic of Korea and New Zealand, adopted the Cebu Declaration on East Asia Energy Security on 15 February 2007.[130] In the same year, the ASEAN Ministers on Energy, meeting in Singapore, made a Joint Ministerial Statement on promoting energy security.[131]

SAARC Energy Centre

In 2005, the South Asian Association for Regional Cooperation (SAARC) established the SAARC Energy Centre (SEC) in Islamabad to replicate the vision and objectives of ACE and serve the energy interests of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.[132] Since then, SEC has conducted foundation-building activities, such as energy cooperation, between ASEAN and SAARC in which SAARC delegations were beneficiaries under the ADB Regional Technical Assistance Programme for the Capacity Building of SAARC Energy Centre.[133]

In supporting the efforts of SEC, SAARC Energy Ministers met in 2007 to exchange views and to set the course for future action with recommendations from the South Asia Dialogue on Energy.[134] To provide further political support, during the 2007 SAARC Summit meeting, the heads of State and government confirmed the need to further develop conventional sources of energy.

Pacific Islands Applied Geoscience Commission

The Pacific Islands Applied Geoscience Commission (SOPAC) has three technical programmes. One is the Community Lifelines Programme, which deals with energy issues as they relate to financial, economic and social development.[135] This aims to improve access to energy services and strengthen national capacity in the areas of solar, biomass, ocean thermal energy conversion, wave and geothermal. SOPAC has also been mandated to coordinate the Pacific Energy and Gender Network, an initiative to foster the participation of women and youth in all dimensions of energy development.[136]

In parallel to those in other subregions, the Governments of the Pacific convened a Pacific Energy Officials and Energy Ministers Meeting in Rarotonga, Cook Islands, in 2007. The theme was "Energy security for sustainable development". The Ministers adopted a communiqué on the need to take action on numerous key issues to help counter the uncertainty of energy supply.[137]

The Economic Cooperation Organization

The Economic Cooperation Organization is an intergovernmental regional organization established in 1985 by the Islamic Republic of Iran, Pakistan and Turkey for the purpose of promoting economic, technical and cultural cooperation among 10 member States in Central and South Asia. ECO adopted a plan of action for energy/petroleum cooperation which promotes the trading of power, increasing efficiency and conservation, and cooperation in petroleum refining.

The Eurasian Economic Community

The Eurasian Economic Community (EurAsEC) was established in 2000 by five countries—Belarus, Kazakhstan, Kyrgyzstan, the Russian Federation and Tajikistan—later joined by Uzbekistan. Although it functions as a forum for common issues on free trade and customs, member States are also jointly developing the hydropower complexes of Central Asia and addressing electricity supply issues. An agreement on a common oil and gas market for EurAsEC is being drafted which will allow for equal access of member States.[138]

Shanghai Cooperation Organization

The Shanghai Cooperation Organization (SCO) comprises six countries—China, Kazakhstan, Kyrgyzstan, Russian Federation, Tajikistan and Uzbekistan. Originally formed to build military cooperation and security trust across common borders, SCO has developed into other spheres, including energy. The member countries have agreed to cooperate in creating an energy market for oil and gas exports, and the Russian Federation has announced plans to develop an SCO "energy club" to regulate the flow of energy exports.

CONCLUSION

In any country, national energy policies cover important and contentious issues—and have an impact on the entire economy, on the society and on environmental sustainability. They must therefore be carefully crafted for local conditions, and as the prices of fuels have continued to rise, countries will have to cooperate regionally to find ways of reducing costs.

Many countries are looking not just to fossil fuels, but also to renewable energy and even nuclear energy, but while doing so, they can integrate their energy policies with those of other sectors, such as environment, industry, planning, rural development, taxation and transportation. Policies can also include options for strategic oil reserves, lowering energy intensity and introducing eco-taxes that provide incentives to develop energy-efficient production and end-use. For improving the lives of the poor, Governments can improve access to modern energy services by considering prices, subsidies and new and practical technologies.

The Asia-Pacific region has many energy-related initiatives and programmes at both the subregional and regional levels, dealing with such issues as fossil fuel, electric power, renewable energy and energy efficiency. The next chapter will suggest how they can further enhance energy security through more inclusive intercountry policymaking.

ENERGY TRADE AND TRANSBOUNDARY ENERGY COOPERATION

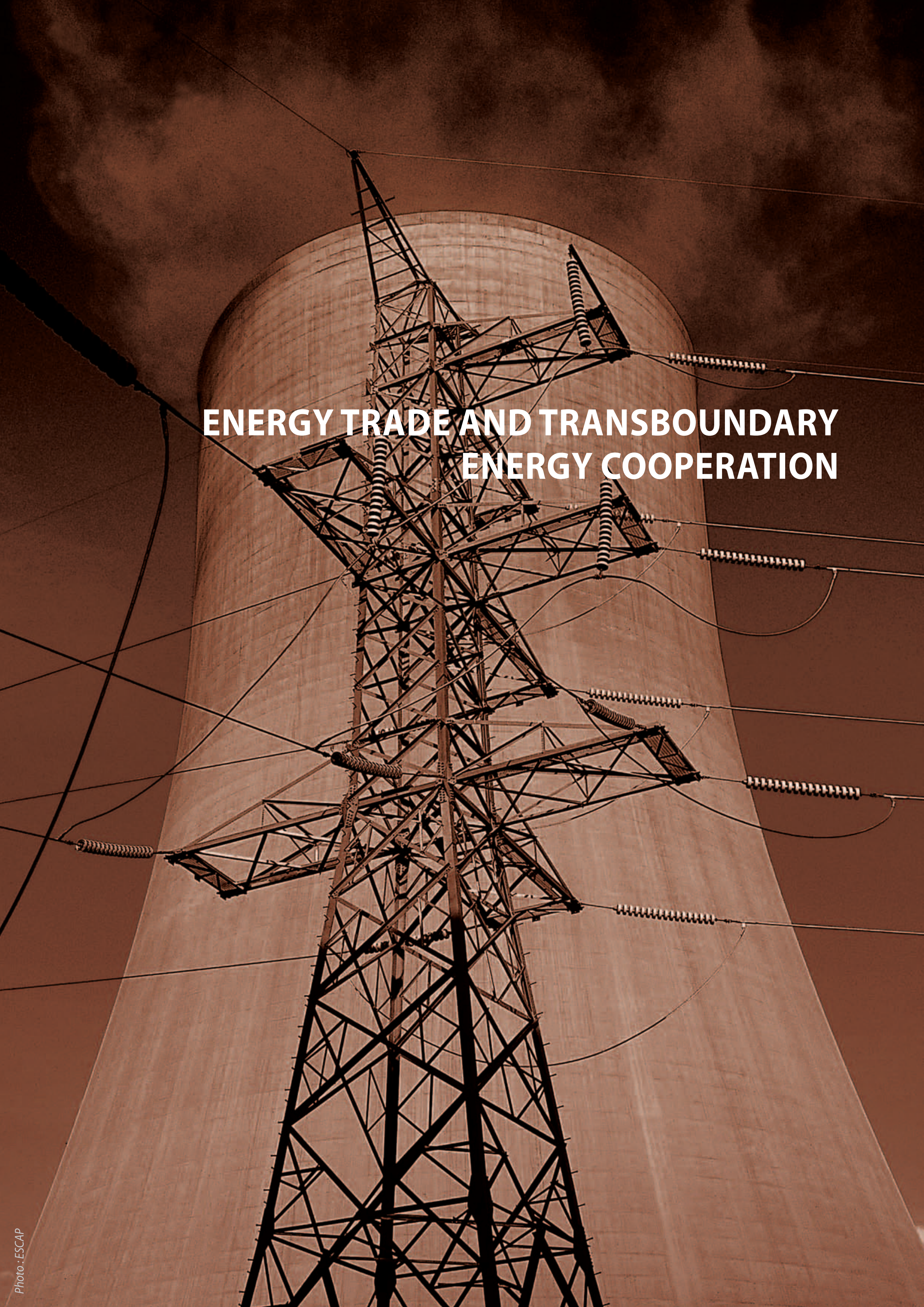


Photo : ESCAP

“Energy security and sustainable development have to be pursued primarily through national efforts, but there is also much to be gained from transboundary cooperation”

5

ENERGY TRADE AND TRANSBOUNDARY ENERGY COOPERATION

Energy security and sustainable development have to be pursued primarily through national efforts, but there is also much to be gained from transboundary cooperation, taking advantage of numerous regional and subregional initiatives. This chapter looks at the potential for expanding trade and the option of creating a trans-Asian energy system.

The Asia-Pacific region has 46 per cent of the world's total primary energy production and 40 per cent of the total final energy consumption, so, as a whole, it may appear to be self-sufficient. Nevertheless, there is significant energy trade within and beyond the region—which is responsible for 36 per cent of global energy imports and 35 per cent of exports.

Table 5-1—Proposed interconnections, the Russian Federation and East and North-East Asia

Interconnection	Length (km)	Voltage	Capacity (GW)	Output (TWh/a)
1. East Siberia (Bratsk)—North China (Beijing)	2,600	600 kVDC	3.0	18
2. Russian Far East (Bureya)—Northeast China (Harbin)	700	400 kVDC	1.0	3
3. Republic of Korea—Democratic People's Republic of Korea	-	345 kVAC	n.a.	n.a.
4. Russian Far East (Sakhalin)—Japan (Honshu)	1,800	600 kVDC	4.0	23
5. Russian Far East (Uchur)—Northeast China (Shenyang)—Republic of Korea (Seoul)	3,500	500 kVDC	3.5	17
6. East Siberia (Buryalia)—Mongolia (Ulan Bator)	500	500 kVAC	0.5	2.5

Source: Asia Pacific Energy Research Centre, *Electric Power Grid Interconnections* in the APEC Region, 2004.

East and North-East Asia

Mainland China exchanges electricity with Hong Kong, China. Moreover, electricity interconnection has been contemplated between China, the Russian Federation, Japan, Mongolia and the Republic of Korea—as proposed in the Khabarovsk Communiqué following an ESCAP expert group meeting in 2001. APEC and the Nautilus Institute have also proposed interconnections using the energy surplus in the Russian Federation to meet demand in East and North-East Asia (table 5-1).

South-East Asia

Through the GMS programme, southern China is also exporting electricity to South-East Asia. In 1993, the Yunnan Electric Power Group of China began discussing with the Electricity Generation Authority of Thailand (EGAT) the development of hydropower projects in Yunnan and the sale of electricity to EGAT. In 1998, China and Thailand signed a memorandum of understanding on a power purchase agreement.

China has also exported electricity to Viet Nam. Since 2004, three 110-kV lines have been sending electricity from Yunnan Province and Guangxi Zhuang Autonomous Region. In September 2006, a 220-kV line was installed in Yunnan's provincial capital. These four lines have transmitted 1.84 TWh to Viet Nam. This is planned to increase to 2.5-2.8 TWh per year when a fifth line is completed in 2007. Carrying 220-kV, the line will link Wenshan (Yunnan) and Ha Giang (Viet Nam), a distance of 300 km.

North and Central Asia

The unified power system of the Russian Federation exports electricity to territories of the former Soviet Union, most of which now form the Commonwealth of Independent States and the Baltic countries. The Russian Federation also exports electricity to Finland, Norway and Bulgaria. Electricity trade also occurs among the five Central Asian republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan through the Electricity Pool of Central Asia (EPCA).[139] USAID and ADB have been involved in strengthening power trade among these countries and in rehabilitating and improving the operation of EPCA.

Turkmenistan, Uzbekistan and Tajikistan also export electricity to South and South-West Asia, particularly Afghanistan. In addition, Tajikistan has signed a memorandum of understanding with Pakistan for the export of 100 MW of hydropower. ADB and other multilateral organizations, including the World Bank, are also helping these countries increase trading opportunities between the two subregions.

South and South-West Asia

In 2004, the Islamic Republic of Iran and India were the largest importers of electricity in the subregion, followed in order by Turkey, Nepal and Afghanistan. Afghanistan imported electricity from neighbouring Islamic Republic of Iran and from Turkmenistan, Uzbekistan and Tajikistan. Bhutan also exported electricity and was the subregion's highest net exporter. Turkey also exported in 2004, as did Nepal. India exported some electricity in 2004, but far less than it imported.

South-East Asia

At present, there are three electricity interconnections that facilitate trade in the South-East Asian subregion: Thailand-Malaysia, Malaysia-Singapore, and Thailand-Lao People's Democratic Republic. The Thailand-Malaysia interconnection began in February 1981 and initially consisted of an 80-MW link between EGAT (Thailand) and TNB (Malaysia)—the national vertically-integrated utilities. The transmitting capability of this interconnection, however, was too small in comparison with the size of the two systems, creating problems of synchronization. In 1988, EGAT and TNB studied the feasibility of upgrading the interconnection, and concluded that a high-voltage direct current (HVDC) link would resolve the synchronization issue. The HVDC link project started in 1994 and was completed in 2001, raising the capacity of the interconnection system to 300 MW. The Malaysia-Singapore interconnection has been in operation since 1985, with a firm capacity of 250 MVA. Under normal conditions, the interconnection is operated synchronously typically with zero-balance transactions—zero electricity exchange.

Thailand and the Lao People's Democratic Republic began to exchange power in 1968. In 1983, with the proposed development of several hydropower plants in the Lao People's Democratic Republic, Thailand signed a memorandum of understanding for the import of 1,500 MW by 2000. In 1996, the memorandum of understanding was revised to increase this capacity to 3,000 MW by 2006.

Electricity trade in South-East Asia will increase with the implementation of the ASEAN Power Grid, a flagship programme of the ASEAN energy cooperation and power interconnection projects under an ADB-sponsored GMS programme of economic cooperation. Table 5-2 shows the proposed interconnection projects for the ASEAN Power Grid. Table 5-3 lists the interconnection projects under the GMS programme.

Table 5-2—Summary of planned ASEAN interconnections

Planned interconnection	Type	Capacity (MW)	Year
1. Thailand—Lao People's Democratic Republic	HVAC (PP)	2,015/1,578	2008/2010
2. Thailand—Myanmar	HVAC (PP)	1,500	2013
3. Thailand—Cambodia	HVAC (PP/EE)	80/300	2004/2016
4. Viet Nam—Lao People's Democratic Republic	HVAC (PP)	1,887	2007/2016
5. Cambodia—Viet Nam	HVAC (PP)	80/120	2003/2006
6. Peninsular Malaysia—Sumatra (Indonesia)	HVDC (EE)	600	2008
7. Singapore—Peninsular Malaysia	HVDC (PP)	700	2012
8. Singapore—Sumatra (Indonesia)	HVDC (PP)	600	2014
9. Singapore—Batam (Indonesia)	HVAC (PP)	200/200/200	2014/2015/2017
10. Sabah/Sarawak (Malaysia)—Brunei Darussalam	HVAC (EE)	300	2019
11. Sabah/Sarawak (Malaysia)—West Kalimantan (Indonesia)	HVAC (EE)	300	2007

Source: ASEAN Interconnection Master Plan Study—Volume I, Main Report, 2003.

Table 5-3—Summary of the interconnections proposed under the GMS programme

Proposed interconnections	Year
Viet Nam—Lao People's Democratic Republic—Thailand	2008
Lao People's Democratic Republic—Thailand	2009
Thailand—Lao People's Democratic Republic—Viet Nam	2010/2012
Cambodia—Viet Nam	2018/2019

Source: Asian Development Bank/Norconsult, Indicative Master Plan on Power Interconnection in GMS Countries. 2002.

ENERGY TRADING REGIMES

Trade in energy goods is, in principle, subject the rules of the World Trade Organization. In practice, however, WTO does not deal with this area very well and energy goods are not covered by a separate agreement. This is partly because, when WTO was founded in 1995, most oil-exporting countries were not members, but the situation is changing rapidly. Saudi Arabia has recently acceded to WTO, and Iraq and the Islamic Republic of Iran have started the accession process. Another reason is that the WTO agreements deal largely with imports while the trade in energy goods also raises a number of issues concerned with exports.

> "A collective cooperation framework based on cooperation rather than competition could supplement national efforts and lead to a "win-win" solution for all"

A third reason is that there has always been an implicit understanding that energy goods are special. In the predecessor to the WTO, the General Agreement on Trade and Tariffs (GATT), energy goods were governed by GATT articles XX (general exceptions) and XXI (security exceptions) and as a result for the WTO, they enjoyed a de facto "carve-out". GATT article XXI allows a WTO member to take any action which it considers necessary for the protection of its essential security interests relating to fissionable materials or the materials from which they are derived. Article XXI (b) (iii) also allows a WTO member to take action which it considers necessary for the protection of its essential security interests in time of war or other emergency in international relations. What constitutes an emergency, however, is not clear and is thus subject to interpretation. Such action is also clearly not restricted to energy goods. Generally speaking, however, WTO members are not allowed to use quantitative restrictions, such as quotas, on their imports and have to apply trade restrictions in a non-discriminatory manner.

Trade in energy services is covered by the WTO General Agreement on Trade in Services (GATS). However, as observed above, no universal definition of energy services exists. For trade in services, GATS identifies four modes of supply:

1. Cross-border supply (e.g. hydropower transmission);

2. Consumption abroad (e.g. crossing the border to buy cheaper petrol);

3. Commercial presence (e.g. foreign investment in petrol stations or energy exploration, but not in production since FDI in energy production is not considered part of international trade);

4. Movement of natural persons (e.g. energy consultancy services delivered abroad).

For energy services, the first mode is limited by regulatory barriers and restrictive business practices by incumbent operators. In practice, the principal modes of supply are commercial presence, the movement of natural persons and cross-border supply.

Through energy trade, the region can reach untapped energy resources, strengthen existing transportation routes and develop others. To take advantage of these opportunities, however, countries will need to cooperate and harmonize policies not just on energy but also on trade and investment—and establish clear linkages between national policies and regional and international agreements. They can also work on strengthening multilateral agreements.

A TRANS-ASIAN ENERGY SYSTEM

Asia and the Pacific, as a region, is rich in energy resources, but since these resources are unevenly distributed, trade in energy is considerably imbalanced. This could be further developed. Indeed, greater regional and subregional cooperation could create a broad energy market that would make the region self-sufficient.

Governments are individually seeking and taking measures to ensure a steady supply of energy resource to sustain their economic growth. In the era of globalization, a collective cooperation framework based on cooperation rather than competition could supplement national efforts and lead to a "win-win" solution for all.

Proposed trans-Asian energy system

In addressing the energy security of the Asian and Pacific region, the Commission at its sixty-second session noted that the region had considerable potential for improving energy cooperation and creating region-wide energy infrastructure. It also noted the interest in an integrated trans-Asian energy system—and requested that the secretariat take the necessary measures, including carrying out preliminary studies, with a view to facilitating the formation and implementation of such a system.[140]

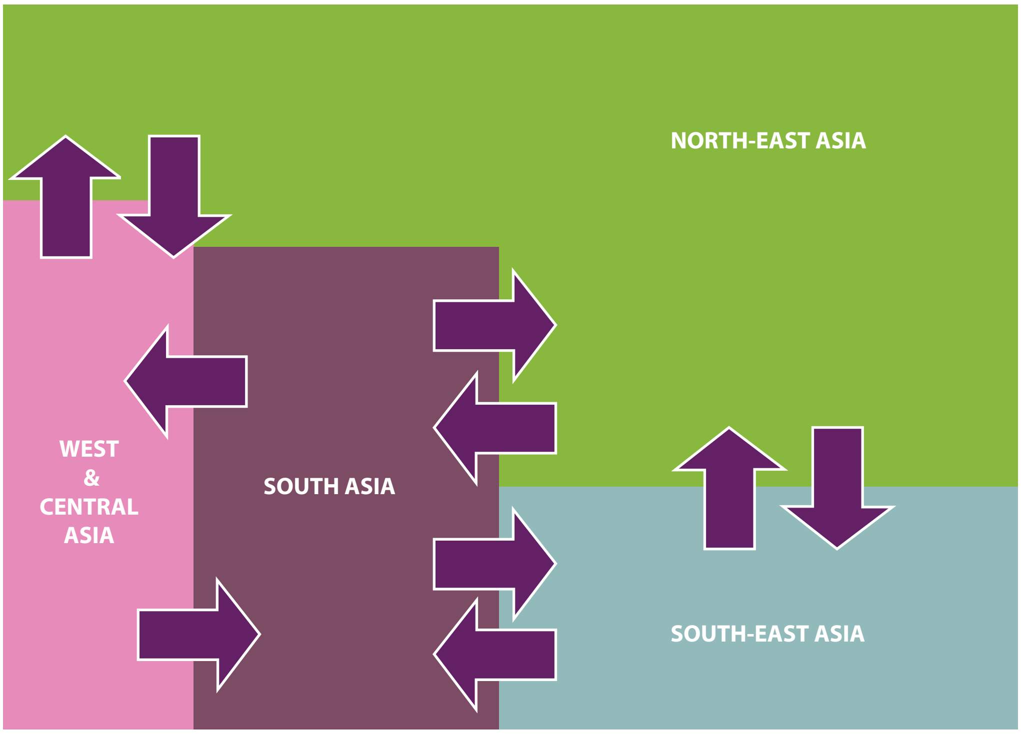
A trans-Asian energy system could be defined as an "Asia-wide integrated energy system linking and synergizing subregional energy systems". This would aim to achieve greater cooperation, coordination and integration—allowing countries to share information and expertise, leading to a system of transboundary energy trade and exchange (figure 5-1).

An integrated region-wide energy system will allow countries to balance supply and demand within the region in an efficient manner—opening up the potential for energy trade between countries that do not share borders or belong to the same subregion. This would benefit both supplying and consuming countries as well as countries of transit.

The trans-Asian energy system would inevitably encounter a number of challenges and barriers. It would be important, therefore, to build political trust among member States so that they are prepared to be interdependent and share risks and rewards. This kind of participation can be fostered by joint activities and studies.

In order to ensure commercial viability, the trans-Asian energy system would also need to engage other stakeholders, in particular the private sector. In identifying possible routes and interconnectivity, it would also be important to consider the environmental and social implications. This would require broad strategic partnerships that operate in a transparent fashion.

Figure 5-1—A trans-Asian energy system



Following the successful example of the Trans-Asian Highway, member States may therefore consider the possibility of a legal framework or an intergovernmental agreement. In absence of an existing agreement on energy, an intergovernmental agreement may be required to facilitate the implementation of the trans-Asian energy system.

A number of countries have expressed an interest in the idea. Subregional organizations, such as ACE, SAARC Energy Centre, ECO and EurAsEC, also see the advantage of intersubregional cooperation that brings economies of scale in energy infrastructure. Indeed, the main modality of the trans-Asian energy system would be intersubregional cooperation.

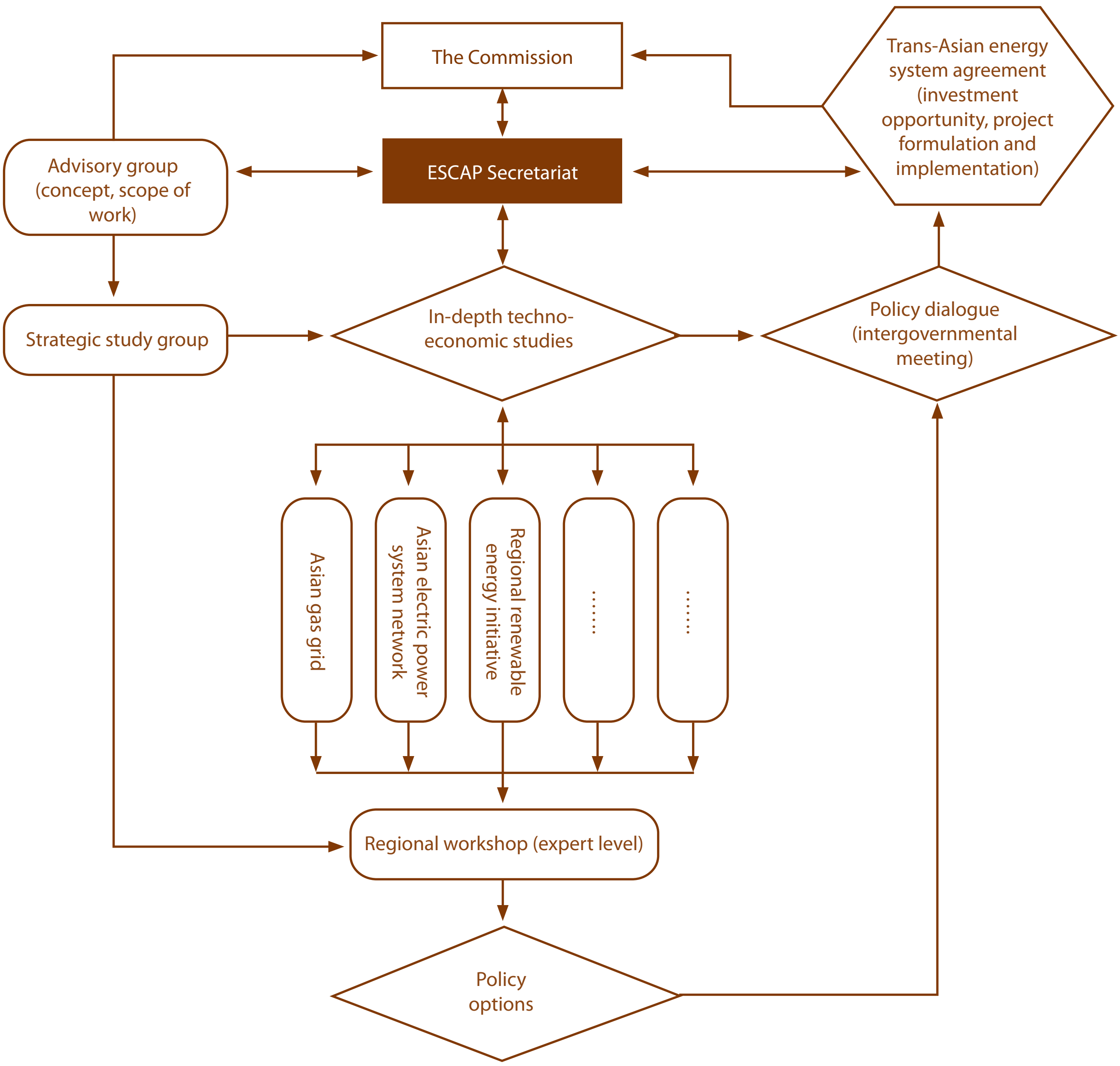
> "Subregional organizations can take advantage of intersubregional cooperation that brings economies of scale in energy infrastructure"

The concept is summarized in figure 5-2. It needs to be further developed, expanded and passed to the preparatory process for review and endorsement by member States. Moving forward would require a two-pronged approach: first, techno-economic feasibility studies on resources and transboundary connectivity and integration; second, continued intergovernmental dialogue and assessment. Figure 5-2 is a diagram of the process that could lead to the formation of the system.

As recommended by several delegations of the Commission at its sixty-third session,[141] the concept is being further refined in consultation with member States and interested international and subregional organizations. A feasibility study to clarify the concept of the trans-Asian energy system is being undertaken to form the basis for holding a policy dialogue.

On the basis of earlier consultation with selected member States and interested international and subregional organizations, it was proposed that the trans-Asian energy system would take up a mix of

Figure 5-2—A trans-Asian energy system: the way forward



> “The trans-Asian energy system would need to focus on a few key strategic priority areas where the potential for regional cooperation is high”

Box 5-1—A trans-Asian energy system

Vision

Enhanced regional energy security of Asia for sustainable social and economic development in the twenty-first century.

Objective

To achieve greater cooperation, coordination and integration of energy systems through the sharing of information and expertise, leading to transboundary energy trade and exchange.

Strategies/action

- Facilitate the establishment of an intergovernmental collaborative mechanism/agreement;
- Develop and implement a pragmatic plan of action.

Focus areas

- Hard areas: (a) natural gas pipelines; and (b) electricity grid network;
- Soft areas: energy efficiency, renewable energy including biofuel, clean coal technology, biomass, energy policy and R&D partnership.

Immediate steps

a) ESCAP to form an advisory group in consultation with the subregional organizations/initiatives and some key countries;
b) The advisory group to consider the draft preliminary concept notes, and scope of work, to be prepared by ESCAP;
c) The advisory group to form a strategic study group.

Medium term

a) The strategic study group to conceptualize and guide the in-depth techno-economic feasibility studies;
b) ESCAP to organize a regional workshop to disseminate the outcome of the studies;
c) ESCAP to convene a policy dialogue to deliberate on the policy options with a view to establishing an intergovernmental mechanism/agreement on an integrated trans-Asian energy system.

Long-term

a) To establish an intergovernmental collaboration mechanism/agreement;
b) To establish a secretariat to support implementation of the plan of action;
c) To prepare a plan of action, which could include investment opportunities and trans-Asian energy projects.

Vision for future cooperation with strategic partners—including governments, academia and the private sector

a) Cooperation and collaboration from strategic partners in the implementation of relevant activities towards the establishment of an integrated trans-Asian energy system;
b) Research and analysis work, including pre-feasibility studies and detailed techno-economic studies covering the identification of environmental and social implications;
c) Active involvement and support for policy dialogue;
d) Support in the establishment of the collaborative mechanism/agreement;
e) Sharing experiences from other regions in identifying possible challenges and opportunities;
f) Financial support
- Initial project funding for two years;
- Contribution to a trust fund;

Possible sources may include government R&D funds and contributions from private sectors.

hard and soft projects. As it would not be possible for the trans-Asian energy system to cover all the region's energy security issues, it would be necessary to focus on a few key strategic priority areas where the potential for regional cooperation is high. At this preliminary stage, under hard projects it has been proposed, therefore, to focus on natural gas and an electricity grid network, and under soft projects on energy efficiency, renewable energy (including biofuels), clean-coal technology, biomass, energy policy and R&D partnerships.

SOUTH-SOUTH COOPERATION

Compared with the number of studies on trans-boundary energy cooperation, there have been fewer studies on South-South cooperation. This is probably because the web of bilateral exchanges is complex and constantly evolving and thus difficult to track. Many of these now occur electronically through the Internet, an issue that is addressed in chapter 6.

“South-South cooperation can also help defuse tensions between countries competing for energy resources”

Many countries in the region clearly have expertise and experience that could be of value to others. South-South cooperation could allow them, for example, to work together to develop renewable energy installations and infrastructure, enhance innovation and promote technology transfer. South-South cooperation can also help defuse tensions between countries competing for energy resources. For example, the region's key energy players, China and India, could gain by cooperating on access to oil and gas (box 5-2).

Box 5-2—China and India cooperate on energy issues

To strengthen bilateral cooperation, China and India have established an annual dialogue on energy. The partnership comes at a time when the two countries are increasingly at odds in their efforts to acquire energy supplies to fuel their fast growing economies.[a]

Energy companies from both countries have also nailed down five memoranda of understanding to share information and strengthen cooperation in exploration, development, and production of oil and natural gas. Both sides agreed to seek partnerships in investments and in the construction of liquid natural gas pipelines and terminals.

The Ministry of Foreign Affairs of China hailed the agreement, saying that cooperation with India would not only benefit peoples in both countries, but also be conducive to peace and stability in South Asia and to the strengthening of South-South cooperation.

The new alliance, aimed at preventing the two nations' competition for oil assets from pushing up energy prices, symbolizes their increasingly assertive role in global energy politics. China is currently the world's second largest energy consumer, while India is the sixth.[b]

In November 2005, China and India teamed up on a joint offer to buy PetroCanada's 37 per cent stake in the largest oil company in the Syrian Arab Republic. The successful deal was the first time oil magnates in the two nations have joined forces in overseas expansion.[c]

Source: Worldwatch Institute, “China and India to build energy alliance”, by Yingling Liu (excerpts), 17 January 2006 (available online at www.worldwatch.org/node/3873, accessed in September 2007).

Note: [a] Shanghai Securities News, 13 January 2006.
[b] Financial Times, 12 January 2006.
[c] Asia Times Online, 22 December 2005.

Transfer of energy technology

One major opportunity for South-South cooperation is in sharing information on renewable energy technologies for providing remote villages or isolated islands with off-grid electricity. Some countries, such as Australia, China, India, Japan, New Zealand and the Republic of Korea, have the infrastructure and support systems for promoting and deploying renewable energy technologies, but many developing countries do not.

These technologies can be transferred in various ways, including: transferring key technical know-how; manufacturing and assembling of machinery and equipment; manufacturing components; setting up joint ventures; sharing profits and risks; and licensing production. Companies can also establish factories in other countries and keep down production costs by manufacturing locally.[142]

> "One major opportunity for South-South cooperation is in sharing information on renewable energy technologies for providing remote villages or isolated islands with off-grid electricity"

Examples of such transfers are:

Indonesia—The People Centred Economic and Business Institute (IBEKA) initially received support from ESCAP for a project entitled 5P (Pro Poor Public Private Partnerships) to generate electricity from a mini-hydropower plant with the help of the private sector. Since the completion of the project, IBEKA has been providing technical assessment and technology options to the Philippines (Barangay Electrification Programme) and the Department of Energy in Fiji.[143]

China—The International Science and Technology Cooperation Program on New and Renewable Energy, launched by the Government in 2007, has set guidelines for cooperation between China and other countries on renewable energy over the next few years. The

Box 5-3—Biomass gasifier technology transfer from India to Sri Lanka

The manufacture of lime in kilns consumes a considerable amount of fuelwood—over 180,000 tons annually in Sri Lanka. Many of these kilns employ very primitive practices, which produce poor quality products and waste a great deal of energy. The Energy Conservation Fund instituted by the Sri Lankan Ministry of Power and Energy has therefore financed the introduction of a gasifier-based lime plant using technology from India. The total investment in the plant was $23,800, but since savings on the production of lime were $4,760 per month, the payback period was only five months. The capacity of the downdraft gasifier is 300 kWh, with wood consumption of 90 kg/hour. The benefits of using the gasification technology include:

- The temperature of the firing zone can be controlled so that overfiring of limestone can be reduced and the quality of the final products improved;
- Ash contamination in final products can be eliminated completely;
- Firewood consumption can be reduced by 40-60 per cent;
- The production rate can be increased 20 times and the total production cost reduced by 40-50 per cent;
- The overall production cost can be reduced by $0.01 per kilogram of lime.

The key institutions involved were: in India, Ankur Scientific Energy Technologies Pvt. Ltd. and The Energy and Resources Institute (TERI); in Sri Lanka, the National Engineering Research and Development Centre (NERD Centre) and EnerFab (Pvt) Ltd.

Government wants to promote international exchanges via forums, seminars and joint research centres, and work with foreign counterparts to train high-level professionals.

The Government of China has cooperated with international organizations to establish a number of centres on South-South cooperation to promote technology transfer and for capacity-building in the areas of biogas, solar and small hydro technologies and policies.

Nepal—Since 1992, the Netherlands Development Agency has been working closely with the Alternative Energy Promotion Centre of Nepal on the Biogas Support Programme. With over 140,000 biogas installations, the Nepalese experience is being shared in Bangladesh, Cambodia and Viet Nam.[144]

Viet Nam—Under the Renewable Energy Action Plan of the Government of Viet Nam, scientists developed three new types of micro-hydroelectricity generators suitable for remote areas that had excellent sources of water flow. With commercial applications, the generators have become popular in other Asian countries, such as Nepal, Papua New Guinea and the Philippines. In addition, the Swedish International Development Cooperation Agency has supported the dissemination of the technology to six countries through the Regional Research and Dissemination Programme on Renewable Energy Technology for Asia.[145]

Future South-South energy cooperation

In view of the wide disparities between countries in the Asia-Pacific region, there are clearly many further opportunities for South-South cooperation. Countries such as China and India have achieved higher levels of growth in different renewable energy subsectors and could make this know-how more widely available through an effective knowledge management structure.

With the tremendous upsurge in activities, the United Nations has renewed its commitments and support for South-South cooperation as an "important element of international cooperation for development".[146] Its main decision-making body is the High-level Committee on South-South Cooperation.

"The United Nations has renewed its commitments and support for South-South cooperation as an 'important element of international cooperation for development'"

In addition, the General Assembly has mandated the UNDP Special Unit for South-South Cooperation to serve as the focal point for other United Nations entities, agencies, programmes and funds. The Special Unit addresses, in particular, the challenges and bottlenecks facing the least developed countries, landlocked developing countries and small island developing States. In addition, to explore ways of enhancing South-South cooperation, ESCAP is working with Asia-Pacific subregional organizations, such as ASEAN, ECO, the Pacific Islands Forum Secretariat and SAARC.[147]

The United Nations has also promoted South-South cooperation in Asia and the Pacific through intermediaries such as the Asian and Pacific Centre for Transfer of Technology—a regional institution under ESCAP. Another example was the establishment in 1981 of the Hangzhou Regional Centre for Small Hydro Power, with the help of UNDP, to promote exchanges, research and training in the field. UNIDO has also been instrumental in facilitating solar technology transfer by working with China to operate the Asia-Pacific Solar Energy Research and Training Centre, which has trained approximately 600 technicians from 76 countries. In 2006, UNIDO inaugurated a newly revitalized International Centre for the Promotion and Transfer of Solar Technology in Lanzhou, Gansu Province.[148]

Box 5-4—Facilitating energy technology transfer through advisory services

Since the late 1980s, APCTT has been providing advisory services to facilitate technology transfer in several areas of technology, including those relevant to the energy sector. Individual inquiries are received from firms (both large and small), research and development institutes, universities, government agencies, and individuals who wish to buy or sell technology. Energy technology transfer matchmaking efforts that were initiated in 2007 due to APCTT's advisory services involved a range of partners. An SME from Maharashtra, India, commenced discussions with a firm in Moscow to obtain technology to manufacture rice straw based gasifiers and fuel briquettes using municipal wastewater and organic waste. A large Indian firm based in Mumbai seeking technology to generate power from rice husk fly ash was introduced to a firm in Baroda, India. An SME from Haryana, India, established communication with an international university based in Bangkok to gain access to biogas-based technology for power generation. An SME based in Chittagong, Bangladesh, initiated work with a leading technology commercialization agency of the Government of India to obtain technology to manufacture solar-power-based inverters for running water pumps. Considering the intensifying interest in renewable energy technologies, in 2008, APCTT will be adding a new category showcasing renewable energy technologies on its technology4sme.net website.

CONCLUSION

Given the rising energy demand in the region, member States urgently need to develop and strengthen energy security strategies. In part, this will involve managing demand, but since many countries will be net importers, they can also look to diversify sources of supply, particularly from within the region. An Asia-wide integrated energy system linking and synergizing subregional systems could serve as a broad cooperation framework that facilitates the implementation of these strategies.

Many countries could also benefit from an expansion in South-South cooperation, which can provide some of the least developed countries with technical assistance, skills development and proven energy technologies. South-South cooperation activities are typically low cost or even free and do not usually require complex arrangements. For this purpose, the United Nations can serve as an intermediary in promoting capacity-building and the exchange of technology.

INNOVATION AND COMPETITIVENESS

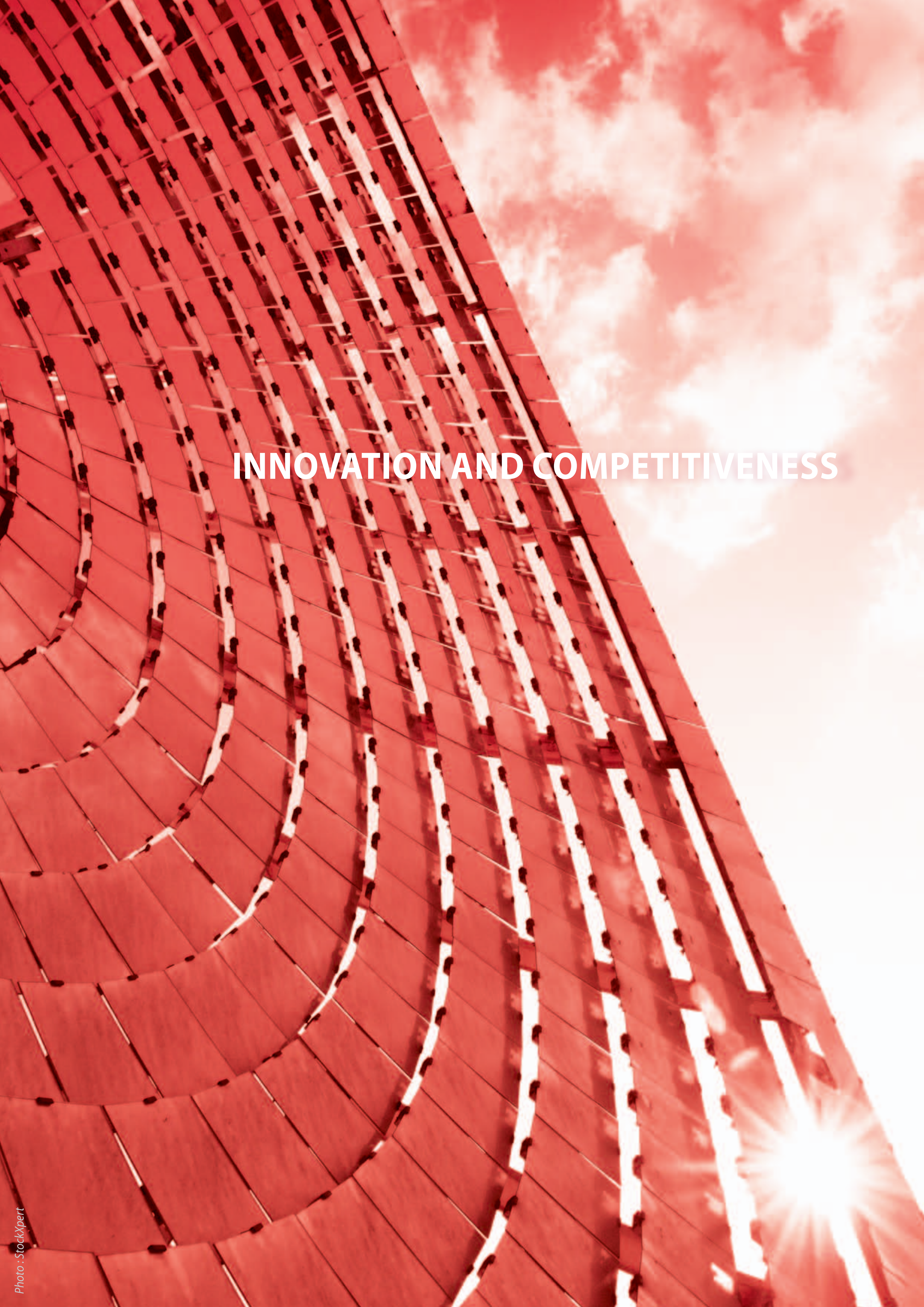


Photo : StockXpert

“Renewable energy together with other emerging technologies are now ready for use on a large scale and have the potential to meet world energy demand in a sustainable way”

6

INNOVATION AND COMPETITIVENESS

The Asia-Pacific region has fuelled economic development with a mixture of traditional biomass and more modern energy sources, typically with strong direction from the State. The next development stage, however, will demand a more complex and diverse energy mix, using a higher proportion of renewable resources, more efficient technologies and reforming the governance of the energy sector.

Meeting demands for affordable energy services will require major improvements in energy-use efficiency, greater use of renewable energy, cleaner technologies and advanced nuclear technologies. This can only be achieved with more innovation, greater competitiveness, different incentives and more ways of involving the private sector, along with technology transfer through South-South cooperation.

CLEAN ENERGY TECHNOLOGIES

Most of the increase in energy supplies in developing countries, in the short term at least, will have to come from fossil fuels. Simply burning more fuel, however, will have serious health and environmental consequences. It is important, therefore, to control pollution and adopt advanced and clean energy technologies. As indicated in table 6-1, some of these include gasification of coal and biomass, biofuels and technologies to capture and store carbon.

Table 6-1—Emerging and advanced energy technologies

Category	Technologies
Conventional	Gas to liquids, coal to liquids Liquefied natural gas Gasification of coal Hydrogen Nuclear power
Non-conventional	Biomass (densification and gasification) Biofuels (ethanol and biodiesel) Wind power Solar PV & thermal Landfill gas Geothermal
Production and conversion processes	Cogeneration Integrated gasification combined cycle Advanced-technology vehicles Fuel cells Carbon capture and storage ICT for improving energy efficiency (intelligent energy system for buildings and power grids)

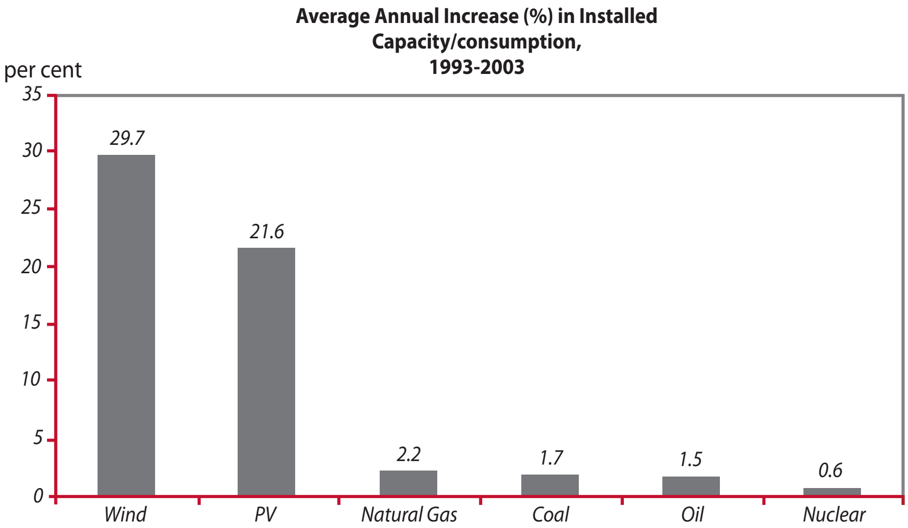
Some of the most rapid progress has been in renewable energy technologies. Wind and solar power are the world's fastest-growing energy sources, with rates of growth and technological advance comparable to that of the electronics industry (figure 6-1).[149] In many parts of the world, wind power is now cost-competitive with fossil fuel-fired power plants. As wind turbine technologies are further improved, wind power is likely to become even more competitive. Solar PV, biofuels, fuel cells, cogeneration and liquefied natural gas are also now ready for use on a large scale. By 2006 "new renewables"—which exclude large-scale hydropower and traditional biomass—were already supplying the equivalent of the residential electricity needs of more than 500 million people.

Many of these technologies are not, of course, actually new. Solar PV, wind energy, energy efficiency, bioenergy and hydrogen technologies have been under development for some time, but there have been considerable changes in recent years and many countries see them as important sources not just of energy but of technological innovation and employment.

In China, for example, by 2005 the solar water heater industry had a total production capacity of 15 million square metres with a value of about $1.6 billion and was providing jobs for 200,000 people. China has also seen a dramatic growth in solar PV and is now, after Germany and Japan, the world's third largest producer; total production in 2006 was 1,800 MW, 95 per cent of which was exported. With this rate of expansion in China, and technological advances, the price of panels seems set to fall further.

A number of countries in the region are joining with the United States in the FutureGen project (box 6-1),[150] a public-private collaborative venture to construct a zero-emissions power plant that will produce both electricity and hydrogen from coal, while capturing and storing the CO_2. India, the Republic of Korea and China have signed on as partners. Innovations are also proceeding in many other types of energy technology (table 6-2). Translating these into useful applications, however, will continue to rely on multidisciplinary, multisector and multinational cooperation.

Figure 6-1—Rates of increase in installed capacity or consumption, by technology



Source: Worldwatch Institute, *New Solar Technology Center to Promote South-South Cooperation,* 2006.

Box 6-1—FutureGen—a zero-emissions coal-fired power plant

FutureGen is an initiative to build the world's first integrated sequestration and hydrogen production research power plant. The $1.5 billion project is intended to create the world's first zero-emissions fossil fuel plant. Rather than burning coal, the approximately 275-megawatt FutureGen plant will turn coal into a gas and employ new technology to remove virtually all of the resultant air pollutants—sulphur dioxide, nitrogen oxides, and mercury. When operational in 2013, the prototype will be the world's cleanest fossil fuel-fired power plant.

Carbon capture and storage technologies will be used to separate carbon dioxide from other gases. Once isolated, the carbon dioxide will be injected and permanently trapped in deep underground formations, such as depleted oil and gas reservoirs, unmineable coal seams and deep saline aquifers.

The prototype plant will establish the technical and economic feasibility of producing electricity and hydrogen from coal, while capturing and sequestering the carbon dioxide generated in the process. The initiative will be a government-industry partnership to pursue an innovative "showcase" project focused on the design, construction and operation of a technically cutting-edge power plant that is intended to eliminate environmental concerns associated with coal utilization. This will be a "living prototype" with future technology innovations incorporated into the design as needed.

The project will employ coal gasification technology integrated with combined cycle electricity generation and the sequestration of carbon dioxide emissions. The project will be supported by an ongoing coal research programme, which will also be the principal source of technology for the prototype. The project will take 10 years to complete and will be led by the FutureGen Industrial Alliance, Inc., a non-profit industrial consortium representing the coal and power industries, with the project's results being shared among all participants, and industry as a whole.

Table 6-2—Selected areas of innovation in energy technology

	Bioenergy	Energy efficiency	Hydrogen	Solar PV	Wind energy
Application	Emerging	Practice focus in development activities	Demonstration projects	Some, but growing rapidly	Widespread application
Market dissemination	A little	Dependent on subfield; considerable in some, limited in others	No	Limited to demonstration grid-connected projects	Considerable dissemination, growing markets
Niches	Bioenergy from non-agricultural materials, such as waste and manure	Integration in other fields, such as Intelligent systems for grids and buildings	Fuel cell technology	Silicon supply, planning and installing, building integration, system integration, off-grid application	Mainstream—off-shore wind
Industrial development	Partly developed networks	Integrated in other industries	Not developed	Developing networks, subcontractor networks	Developed industry; fast-growing industry

Source: Adapted from Mads Borup, Birgitte Gregersen, Anne Nygaard Madsen, "Understanding energy technology developments from an innovation system perspective", 2007 (see http://www.risoe.dk/rispubl/reports/ris-r-1608_206-213.pdf).

BIOFUELS

Biofuels—biomass converted to liquid fuels—are simple to use, biodegradable, non-toxic and essentially free of sulphur and aromatics. Although they contain no petroleum, they can be blended at any level with petroleum fuels and used as substitutes for transportation and stationary applications.

Many countries are attracted to biofuels. Industrial countries see them as ways of reducing transport greenhouse gas emissions and diversifying energy sources. Developing countries also see them as ways of reducing dependency on oil imports but also anticipate that growing the necessary crops will create jobs and stimulate rural development. Both groups view the use of biofuels as a means of increasing energy security—especially in view of the recent surges in the world price of oil.

> "The development and use of liquid biofuels has become an important focus which has generated great public interest and has spurred debates worldwide"

With a view to increasing the contribution of biofuels to their transport fuel supplies, a number of countries in the region have adopted targets, some mandatory:

India—The Government has mandated that, from 2003, there should be 10 per cent ethanol blending (E10) in 9 out of 28 states and 4 out of 7 federal territories—all sugarcane-producing areas.[151]

Indonesia—Over the period 2005-2010, the Government is seeking a 2 per cent cut in diesel consumption through the use of biodiesel based on palm oil and Jatropha Curcas. Other raw materials, such as coconut, will also be used and it is anticipated that over the period 2016-2025, biodiesels will account for 5 per cent of diesel consumption. For bioethanol, the Government plans to introduce a 10 per cent blend with gasoline using molasses and starch. It is expected that gasoline consumption will be reduced by 3 per cent by 2011-2015 and by 5 per cent by 2016-2025.[152]

China—Since 2000, ethanol has been developed as an alternative source and by 2005 bioethanol capacity had reached 1 million tons. A number of provinces now mandate E10 blending. In its Long and Mid-term Plan on Renewable Energy Development, the Government has targeted bioethanol production of 2 million tons by 2010 and 10 million tons by 2020.[153]

Thailand—The development of biofuels is more advanced than in other ASEAN countries. In 2003, the Cabinet approved the Gasohol Utilization Strategic Plan—covering a gasoline-bioethanol blend. In 2005, it approved the Strategic Plan on Biodiesel Development, aiming to bring production based on palm oil to 8.5 million litres per day—displacing about 10 per cent of petroleum-based diesel by 2012.

Pacific—In Fiji, a biofuel development unit has been set up to support a trial of coconut methyl-ester blending for transport fuel.[154] Work has been ongoing on a number of other islands, namely Marshall Islands, Kiribati, Vanuatu, Samoa, Solomon Islands and Papua New Guinea.

Production of these alternative fuels is rising fast, particularly in South-East Asia, where Malaysia and Indonesia are the world's two largest palm oil producers, and in Indonesia and the Philippines, the largest producers of coconut.[155] There is a risk, however, that fuel crops will displace food crops and increase the price of commodities, such as sugar, maize and palm oil. Worldwide, about 14 million hectares—1 per cent of arable land—are already used for biofuel production—a share that could soon rise to 3.5 per cent or higher.[156] Biofuel production can also lead to social and environment damage. UN-Energy, the inter-agency mechanism on energy, has warned, for example, of serious consequences if forests are razed for plantations, if food prices rise and if communities are excluded from ownership.[157]

Another concern is that biofuel production may consume more energy than it produces. One study indicated that the net energy ratio (NER) of various biofuels can vary from 0.8:1 to 1.9:1.[158] An NER below 1 means that more energy is required to produce the fuel than is derived from it. When the petroleum industry started, the NERs for oil ranged between 100:1 and 200:1 depending on the oilfield. Although the ratios have since fallen—to 15:1 to 20:1—they remain far higher than those of biofuels.

Some member countries are responding to these concerns. India, for example, following poor cane crop yields in 2003-2004, imported ethanol to meet State blending targets and postponed broader targets until of sufficient supplies of domestic ethanol were available. China has capped the proportion of corn for industrial use at 26 per cent until 2010 because between 2001 and 2005 the amount of corn produced for biofuel rose by 14 per cent per year while overall production of corn rose only by 4.2 per cent. The Government decided from 2007 not to approve new projects for processing corn for biofuel.

Box 6-2—Regional forum on bioenergy sector development

With increased interest in renewable energy from biomass and issues of bioenergy development in Asia and the Pacific, ESCAP is moving forward and keeping abreast of the latest developments on bioenergy as a viable alternative source of energy for the region.

Following the United Nations Conference on Climate Change, held in Bali, Indonesia, in December 2007, UNAPCAEM, regional institution/subsidiary body of ESCAP organized a regional forum on bioenergy sector development, concentrating on challenges, opportunities and the way forward, in collaboration with the Ministry of Agriculture and Cooperatives and the Department of Agriculture of Thailand. The forum was held in Bangkok from 23 to 25 January 2008. Representatives and key stakeholders from 15 countries in Asia and the Pacific participated, along with FAO, UNDP, UNEP, UNIDO and bilateral development organizations and the private sector.

The outcome of the forum is expected to guide the formulation of capacity-building programmes for policymakers, development practitioners and the CDM projects on bioenergy. The forum also provided a platform for exchange of best practices and innovative solutions on how to foster public/private partnerships that would promote bioenergy development and bioenergy trade and investment in the region. In addition, the forum recommended the establishment of an Asia-Pacific bioenergy network to facilitate and promote bioenergy information sharing with experienced countries and through regional South-South cooperation.

NUCLEAR POWER

To increase energy security and mitigate carbon emissions, many countries are taking a renewed interest in nuclear power. In response, the industry has been preparing a new generation of reactor technologies with standardized designs that will expedite licensing and reduce construction time and cost, while maintaining high standards of protection against accidents, earthquakes and terrorist attacks. These advanced reactors will also be cheaper to operate and will produce less waste. One key innovation will be the incorporation of "inherent" or "passive" safety features—replacing active controls by the use of natural physical principles.

> "Renewed interest and rising expectations in nuclear power technology require more innovations focusing on enhancing safety, minimizing waste generation and reducing proliferation risks"

Reactor suppliers in North America, Japan, Europe, the Russian Federation and South Africa have a dozen new nuclear reactor designs at advanced stages of planning—and others are at a research and development stage. There are also "fourth-generation" reactors at the concept stage. To ensure that such developments take into account the future needs of all countries, in particular developing countries, the International Atomic Energy Agency has launched the International Project on Innovative Nuclear Reactors and Fuel Cycles.[159]

OTHER EMERGING TECHNOLOGIES

Other important technological advances can help reduce demand. For example, computers, the Internet and global positioning systems can increase transportation efficiency and lead to smart energy management systems. Satellites can also be used to asses the potential of renewable energy resources.

The need for large power grids could also be reduced by using smaller systems that generate power locally for neighbourhoods and individual residences and businesses—via micro-turbines, internal combustion engines and fuel cells. Substantial improvements are also expected in the use of solar energy for the heating and cooling of buildings and in the development of efficient photovoltaic cells. In addition, geologists have discovered rich deposits of frozen natural gas crystals on the ocean floor which could add to the production of natural gas. From the perspective of climate change, it will also be important to develop new forms of carbon capture and storage (CCS). Although the oil industry has led the way in this technology, it is of growing interest to the power sector (box 6-3).

Box 6-3—Carbon capture and storage

For many years, it was tacitly assumed that the ultimate technical solution to climate change lay in replacing fossil fuels with renewable energy, perhaps nuclear power. More recently, attention has been given to the possibility of continuing to use fossil fuels but capturing and storing the resulting CO_2.

Most interest has been in applying this approach to the power generation sector, but it could also be used with any large source, such as oil refining or steel making. If hydrogen is used by vehicles in the future, it would also be possible to capture CO_2 from the manufacture of hydrogen.

One method of capturing CO_2 is by washing the flue gas stream of a power plant with a reusable solvent. The CO_2 is recovered from the solvent and pressurized for transmission through pipelines to the storage site. Storage is most likely to make use of natural geological reservoirs, such as disused oil or gas fields, or deep salt-water-filled reservoirs. All of these technologies are already in use for other purposes—the technology for capturing CO_2 has a history of over 60 years, while CO_2 has been shipped in pipelines over hundreds of kilometres and pumped into depleted oil reservoirs for over 30 years.

No single technology can achieve the deep emission reductions needed to stabilize atmospheric concentrations; so many approaches will have to be used. Capture and storage of CO_2 will likely add $10-$40/MWh to the cost of generating electricity and reduce emissions from a power plant by 80 to 90 per cent. This cost is similar to or less than the cost of other options for making deep reductions in emissions, such as wind power or nuclear power. Modelling studies have found that overall costs would be reduced by 30 per cent if capture and storage were used.

Large-scale penetration of CO_2 capture and storage technologies will depend on assurances of political and social acceptability by demonstrating its safety and improving its economic competitiveness. The public remains largely unaware of this possibility, but environmental groups have begun at least to consider it as a serious option to complement renewable technologies and as a potential alternative to nuclear power. The first step is proving storage, with several such projects having already begun operation; the next stage will be to plan projects involving capture in power plants with transport and storage, which could be ready by 2010. Improving economic viability will require reducing the costs of capture, providing incentives for investment and setting a carbon price sufficiently high to make the option attractive.

Source: David M. Reiner, Judge Business School, University of Cambridge, United Kingdom, and Paul Freund, Special Report on Capture and Storage of CO_2, Intergovernmental Panel on Climate Change (IPCC), United Kingdom.

PRICE AND TAXATION

In the Asia-Pacific region, energy and fuel prices vary greatly from one country to another as a result of regulated policies, low taxes and subsidies which distort the market economy. Energy prices are in need of reform to make prices appropriate to the development levels as low fuel costs and heavy subsidies often lead to unsustainable energy use and therefore negatively affect the environment and energy conservation. In comparison, the European experience suggests that fuel prices can be harmonized and stabilized within a certain range where the differences between countries are smaller. In short, European countries can maintain their competitiveness in the global market and be leaders in energy efficiency because fuel prices are optimally maintained to foster innovation. The Asia-Pacific region would benefit from a long-term strategy in which government policies will close the gap further as a fundamental basis before other innovative options for R&D, infrastructure financing, energy-efficient technologies, biofuel development, etc., can be pursued.

> "Sustained energy price and taxation reforms can intervene in the market place and have a major impact on economic behaviour towards more benign resource and environment friendly patterns"

To tackle the energy pricing issue, Governments could create a regional market environment by introducing an innovative and rational pricing policy as a tool to increase market competitiveness. By stimulating the market, more incentives to develop energy-efficient and clean energy technologies could be developed, eventually leading to savings for government budget and profits for corporations. This means that Governments can support additional funding for energy infrastructure development and companies can invest more in terms of energy efficiency technologies. Overall, both economic and industrial competitiveness would be enhanced rather than retracted. Reforms for rational energy pricing could be a potential area in which regional consultation and cooperation could be realized to increase both energy efficiency and competitiveness.

In addition to fuel pricing, energy taxation could be an important instrument for promoting renewable energy and improving energy efficiency without undermining the competitiveness of member States. As part of green budget and tax reform under its five-track Green Growth approach, ESCAP is already engaged in dialogues on the potential benefits of applying green taxes by considering the environmental tax reform experience of the European Union. Often, an energy tax is erroneously viewed as an additional tax on industries and consumers, but, in fact, it is tax shifting rather than a tax increase—lowering income-related taxes while raising taxes on carbon emissions. In this regard, lessons can be learned from the European experience, in which many countries have instituted fiscal legislation, regulations and tax policies to control carbon emissions.

NEW DIRECTIONS IN ENERGY SECTOR GOVERNANCE

Governance within a sector refers to how decisions are made, implemented and enforced as well as how disputes are resolved. Currently, the energy sector in many developing countries is dominated by State-owned monopolies. These seldom operate on commercial lines and have high capital costs and long lead times. As a result, they suffer from underperformance and high costs along with petty corruption, and weak market structures and monitoring. For many developing countries, this leads to considerable economic waste and fiscal burdens.

To tackle some of these problems, a number of countries are undertaking energy sector reforms. In developed countries, the main goal of such reforms is to increase efficiency and reduce end-user tariffs. In contrast, most developing countries are carrying out reforms in order to raise finance: Governments with insufficient funds to upgrade national infrastructure are privatizing State-controlled monopolies to attract private investment.

However, the ways in which this has been done are open to question. For many countries in the region, the biggest problem is cost recovery. Consumer revenues do not even cover the cost of the energy supply, let alone the environmental costs. Private companies are therefore reluctant to invest without many concessions and subsidies, obliging Governments to assume contingent liabilities outside the normal budgetary and accountability systems. The consequence is that many countries have been burdened with hazy, opaque, unsolicited deals that expose them to extensive corruption.

Energy-sector reform has to be based rather on a shared vision of the core objectives with shared risks. These objectives typically include: a reliable, affordable energy supply; commercially viable enterprises; tariffs that reflect costs; private-sector investment; maximized competition and deregulation; and an overall structure that meets international standards, best practices and legitimate investor expectations.

> “Good governance in the energy sector requires transparent, predictable and enforceable political, social, economic rules”

Successful reform follows three basic stages:

- Comprehensive legal and regulatory reforms;
- Commercialization and development of the existing dominant utilities;
- Domestic or international private-sector investment and privatization.

The benefits include: improved service and quality for customers; more efficient use of scarce resources; technology transfer; foreign direct investment; increased trust in government institutions; macroeconomic growth; environmental improvement; and, most importantly, better living standards for people.

KNOWLEDGE MANAGEMENT

Knowledge management is a process whereby intellectual or knowledge-based assets are captured and generate value. Companies try to institute knowledge management systems to make sure that even when employees leave, the company retains all their accumulated knowledge and experience. Knowledge management aims to capture two types of knowledge: explicit and tacit. Explicit knowledge is the easier of the two since it is documented. Tacit knowledge refers to an individual’s experience and know-how and is more difficult to capture.

A degree of knowledge management already takes place in development activities though not very efficiently. For example, knowledge gained from international meetings is frequently not disseminated further within a country. Targeted knowledge management programmes could generate better, faster outcomes. Indeed effective knowledge management strategies should be incorporated into development programmes at the planning stage.

> “Knowledge management should be promoted to regional and cross-country knowledge sharing”

How can Governments improve the management of knowledge on energy security? They can, for example, hold forums with other Governments and other stakeholders, maintain information resources and knowledge portals, broker information and facilitate communities of practice. This is not just a task for Governments, however. International programmes and projects can also share information, and individuals within them can serve as points of contact.

In North-East Asia, for example, countries participating in the subregional cooperation framework regularly publish information on their energy situation, policies and programmes.[160] Many organizations also provide updates of national energy policy changes. For example, the International Energy Agency regularly releases detailed studies about individual countries as well as the outlook for specific regions.[161] Other subregional organizations, such as APEC and ASEAN, have released policy information relating to their member countries, such as the APEC *Energy Overview*. Many of these international organizations maintain databases of statistics and policy information. For example, the ASEAN Center for Energy, the SAARC Energy Centre and the Pacific Islands Applied Geoscience Commission all maintain information regarding their members on their websites. ESCAP has also been involved with electronically collecting and publishing information regarding the electric power sector. To illustrate the different networks and databases, examples are summarized in tables 6-3 and 6-4.

Other important mechanisms for knowledge management are meetings, policy dialogues and seminars. These bring together representatives from various countries, helping to maintain networks of energy professionals and bringing them into contact with other important development stakeholders. In North-East Asia and Central Asia, for example, policy dialogues have enabled countries to identify ways of working together to improve national programmes. ESCAP is supporting such dialogues, particularly in Central and North-East Asia, building on established cooperation frameworks to incorporate problem solving and intercountry collaboration and to build trust and collaboration between Governments and other stakeholders. These meetings can also ensure that the knowledge acquired at the international level is transferred to existing national programmes. International organizations and development practitioners from around the world already contribute to a number of forums, such as the online forum and website "Knowledge management for development".[162] ESCAP could also play a role in brokering information and knowledge between other international organizations and national Governments.

Table 6-3—Energy information networks

Energy Technology Network (Website address)	Summary
Climate Technology Initiative (CTI) **(www.climatetech.net)**	The Climate Technology Initiative (CTI) is a multilateral initiative, operating as an Implementing Agreement under the International Energy Agency (IEA). Its mission is to bring countries together to foster international cooperation in the accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices. CTI participating countries undertake a broad range of cooperative activities in partnership with developing and transition countries and other international bodies.
International Energy Initiative (IEI) **(www.ieiglobal.org)**	The International Energy Initiative (IEI) is a non-governmental, public-purpose international organization based in Bangalore, India, established with the purpose of promoting clean and efficient production and use of energy for sustainable development. This involves in-house analysis as well as networking regionally and globally with groups and institutions concerned with energy and development. The IEI strategy is pursued through the "information, training, analysis, advocacy and action" approach, involving information, training, analysis, advocacy and action and the systems integration of these. The Asian Regional Energy Initiative of IEI focuses on power sector, rural energy needs, the expanded provision of clean cooking fuels and environmental protection.
Renewable Energy Information Network **(www.lged.org/sre/rein.htm)**	The Local Government Engineering Department of Bangladesh has created the Renewable Energy Information Network to develop an information platform for renewable energy, utilizing modern technologies with long-term perspective. This network is designed and tailored to help energy planners, project developers, researchers and all relevant organizations develop renewable energy projects and promote renewable energy utilization in Bangladesh.
South Asia Regional Initiative for Energy Cooperation and Development **(www.sari-energy.org)**	The USAID/SARI/Energy programme facilitates more efficient regional energy resource utilization, works towards transparent and profitable energy practices, mitigates the environmental impacts of energy production, and increases regional access to energy. SARI/Energy countries include: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.
Renewable Energy Policy Network for the 21st Century (REN21) **(www.ren21.net)**	REN21 is a global policy network that provides a forum for international leadership on renewable energy. Its goal is to bolster policy development for the rapid expansion of renewable energies in developing and industrialized economies.

Table 6-4—Available energy technology databases

Database [Website address]	Description
eAccessAsia Specialist Database **(www.accessasia.org)**	NBR's AccessAsia is the world's clearinghouse for information on contemporary Asian affairs and policy-related issues. The project maintains several databases, including a specialist database. This directory of experts in Asian affairs includes energy and environment experts. Access to the database is free of charge.
Alternative Fuels and Advanced Vehicles Data Center **(www.eere.energy.gov/afdc/)**	The Alternative Fuels and Advanced Vehicles Data Center has a vast collection of information on alternative fuels and the vehicles that use them. Alternative fuels described here include biodiesel, electricity, ethanol, hydrogen, natural gas and propane. This site has more than 3,000 documents in its database, an interactive fuel station mapping system, current listings of available alternative fuel vehicles, and a great deal of information on alternative fuels, toolkits, buyer's guide, educational resources, legislation and laws, and links to other sites.
CADDET **(www.caddet.org)**	CADDET (Centre for Analysis and Dissemination of Demonstrated Energy Technologies) Renewable Energy is an International Energy Agency agreement for the exchange of information on commercial renewable energy projects and has been operating since 1993. This site contains a wide range of technical brochures and reviews covering the full range of renewable-energy and energy-efficiency technologies. In addition, CADDET hosts news, events, reports, publications, databases, and links.
China Renewable Energy Information Network **(www.newenergy.org.cn)**	This network in new and renewable energy fields covers information on solar, wind, biomass, geothermal, ocean, hydrogen and small-hydro renewable energy resources. The site is a collection of news, technology, publications, documents, and glossary of terms. It also hosts a bulletin board.
Clean Energy **(www.CleanEnergy.de)**	This is a worldwide directory of companies and products related to clean and renewable energy, with news on biomass, photovoltaic, solar thermal, hydrogen, wind, geothermal and fuel cell systems. It also provides links to other websites and information on forthcoming events.
Clean power campaign **(www.cleanpower.org)**	The clean power campaign is a non-profit organization of environmental and public interest groups, renewable energy providers, green energy marketers and energy efficiency technology companies. The centre provides news-based services and other renewable energy and technology information about clean power generation. The website covers a wide range of issues, such as sustainable electricity generation policies, clean vehicles and energy efficiency and conservation measures.
Database of Oil-Yielding Plants **(http://mnes.nic.in/list/oil-plants.pdf)**	Prepared by the Botanical Survey of India and uploaded on the website of the Ministry of New and Renewable Energy, the database provides a comprehensive listing of all plants that could provide oil.
Database of State Incentives for Renewables & Efficiency **(www.dsireusa.org)**	The Database of State Incentives for Renewables & Efficiency (DSIRE) is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy. The searchable database covers information such as tax incentives for solar electric and other renewables, alternative-fuels vehicles and energy conservation. The database is a graphical presentation of data, tables and other information.

Table 6-4—Available energy technology databases

Database [Website address]	Description
ETDE Energy Database **(www.etde.org/edb/energy.html)**	The Energy Technology Data Exchange (ETDE) Energy Database is the largest collection of energy research and technology literature in the world. With a growing total of over 4 million abstracted and indexed records in the full collection, users have access to a wealth of information contributed by ETDE member countries and international partners. ETDE began the database in 1987 but has added coverage back to 1974.
Energy Information Centre **(www.worldenergy.org/wec-geis/edc/)**	The Energy Information Centre (EIC) provides a geographic approach to the energy data and other information collected by the World Energy Council (WEC). The site emphasizes energy efficiency information, energy forecasting, energy policies, surveys, research and development, and energy technologies. International energy indicators and data series are also available from a number of other sources. In addition, the site hosts news, events, supply source directory, publications and energy-related web links.
Energy Efficiency and Renewable Energy **(www.eere.energy.gov)**	The website is a gateway to hundreds of links and thousands of online documents on energy efficiency and renewable energy. In addition, the site hosts different sections on news, technologies, events, various national programmes, renewable energy information, and a customized information centre.
Energy Ideas Clearinghouse **(www.energyideas.org)**	This website offers content-rich searchable databases for technical information on renewable energy regarding solar, biomass, geothermal, distributed generation, wind, hydro and other renewable resources. The database covers articles, documents, fact sheets, reports, etc in easy downloadable form.
Energy Statistics **(www.indiastat.com)**	Indiastat.com provides India-specific socio-economic statistical facts and figures culled from various secondary level authentic sources. The website provides access to data on the energy sector of India displaying power, coal, and petroleum statistical databases. It is a paid site, accessible only to registered members.
Greenhouse Gas Technology Information Exchange **(www.greentie.org/directory/)**	The Greentie directory of suppliers offers searchable contact details for almost 8,000 organizations and experts, covering the fields of energy and greenhouse gas mitigation technologies.
India Solar **(www.indiasolar.com)**	This informative site focuses on renewable energy promotion, awareness building and technology development in India. The website covers basic to technical aspects of renewable energy sources, such as solar thermal, solar photovoltaic, biomass, wind and geothermal energy. It hosts website directories of equipment manufacturers and suppliers, research institutes, etc. In addition, the site covers articles, surveys, statistics, events, and links to related subjects.

Table 6-4—Available energy technology databases

Database [Website address]	Description
Inforse **(www.inforse.dk)**	The International Network for Sustainable Energy (INFORSE) is a worldwide network of 200 non-governmental organizations in more than 60 countries. It aims to influence global strategies and actions in order to enable and stimulate sustainable energy development worldwide. The website provides a comprehensive source of information on sustainable energy news, network activities and publications and links to other information sources.
Renewingindia **(www.renewingindia.org)**	This site is owned and maintained by Winrock International India, covering all aspects of renewables and alternative energy generation sources, including biomass, solar, wind, hydro, tidal, ethanol and alternative fuels. The site hosts extensive information on related technologies, case studies, statistics, articles, newsletters, links, events and discussion forums.
Sustainable Alternatives Network **(www.sustainablealternatives.net)**	The Sustainable Alternatives Network (SANet), a United Nations initiative, provides advisory services for the early stages of decision-making. With a global network of information resources, local experts and financing options, it helps businesses innovate with cleaner technologies. The website brings together a useful collection of experts, case studies, funding opportunities, sustainable planning tools, and country-specific information.
Wind Power India **(www.windpowerindia.com)**	This website provides information on wind energy generation in India and around the world. It provides information on installed capacity in India by state, manufacturer and year. It also provides information on cumulative generation from wind power projects in India by state. In addition, it provides information on wind energy generator manufacturers, service providers, government agencies, and policies.

Box 6-4—Knowledge hubs

ESCAP, UNEP and the China Standard Certification Center have established the Regional Help Desk on Sustainable Consumption and Production in China. This will carry out a number of tasks: collect and disseminate information on sustainable consumption and production with specific focus on policy tools; facilitate a network of experts and institutions in the region that are specialized in issues related to sustainable consumption and production, such as energy labelling and product certification; organize training for policymakers and professionals and share good practices; build capacity to support decision-making by Governments and regional and international organizations.

ADB is also establishing regional knowledge hubs. These will act as think tanks for ADB and its developing member countries on clean energy and strengthen their capacity to generate innovative concepts, science and technology, and to manage clean energy development. Initially, three knowledge hubs have been established: (a) The Energy and Resources Institute (TERI) in New Delhi for clean energy; (b) Tsinghua University in Beijing for climate change; and (c) the Asian Institute of Technology in Bangkok for 3R (reduce, reuse and recycle).

CONCLUSION

Energy security requires continuous innovation—in exploration for fossil fuels as well as their transportation and conservation, and in the utilization of alternative renewable energy sources. These advances should, however, be accompanied by innovation and reform in the way the energy sector is governed—moving away from a highly centralized approach to one based on public-private partnerships with a free flow of information, finance and ideas across the region.

ENERGY SECURITY AND SUSTAINABLE DEVELOPMENT IN LEAST DEVELOPED COUNTRIES, LANDLOCKED DEVELOPING COUNTRIES AND SMALL ISLAND DEVELOPING STATES

Photo : Marie Ange Sylvain-Holmgren

“Half the countries in the region, however, are classified as more vulnerable, including the least developed countries, the landlocked developing countries and the small island developing States”

7

ENERGY SECURITY AND SUSTAINABLE DEVELOPMENT IN LEAST DEVELOPED COUNTRIES, LANDLOCKED DEVELOPING COUNTRIES AND SMALL ISLAND DEVELOPING STATES

In a region as vast and diverse as Asia and the Pacific, priorities will inevitably differ to some degree from one country to another—between the larger and the smaller, the richer and the poorer. This chapter looks more closely at the energy options for the more vulnerable countries—the least developed countries, the landlocked developing countries and the small island developing States.

Most of the development focus tends to be on the highly populated and rapidly growing economies, such as China and India. Half the countries in the region, however, are classified as more vulnerable, including the least developed countries, the landlocked developing countries and the small island developing States. Together, they have 6 per cent of the region's population and 3 per cent of its GDP (table 7-1).

Table 7-1—Key indicators for least developed countries, landlocked developing countries and small island developing States

	GDP ($ billion) 1990	Population (thousands)	% ESCAP GDP	% ESCAP population	Land area (thousand hectares)	Population per thousand hectares
ESCAP	9,356	3,990			5,200	768
Least developed countries	103	163	1.1	4.1	210	777
Landlocked developing countries	85	131	0.9	3.3	668	196
Small island developing States	104	14	1.1	0.3	53	260
Total[a]	277	247	3.0	6.2	497	497

Source: United Nations Statistics, 2007.

Note: [a] This is a total of all countries rather than development categories, as some countries belong to more than one development group.

Least developed countries

Although least developed countries are quite diverse, there are some common patterns. They tend to suffer from low domestic savings that do not meet their investment needs. Many have also suffered from weak governance and political instability and have often suffered from conflict which has damaged infrastructure, diverted budgetary resources and deterred foreign investment.[163] Least developed countries also tend to have limited internal markets and fewer trade opportunities. In addition, many have been seriously affected by environmental degradation and other biophysical barriers that not only weaken their access to natural resources but also undermine human health.

Landlocked developing countries

The least developed countries also include some landlocked developing countries. Without access to international waters landlocked developing countries can find it difficult to access foreign markets. Since most of their exports and imports travel via transit countries, their trade can be hampered by higher transport costs and delays. According to UNCTAD estimates based on the IMF balance of payment statistics, landlocked developing countries spent on average almost twice their export earnings for the payment of transport and insurance services in 1995 than the average for developing countries and three times more than the average of developed economies.

“LDCs tend to suffer from low domestic savings that do not meet their investment needs”

“Without access to international waters landlocked developing countries can find it difficult to access foreign markets, which can impact their development”

Small island developing States

Some of the small island developing States also belong to the least developed countries group, and although they have abundant access to international waters, they still suffer from remoteness and isolation. These countries are hampered by small domestic markets and often have limited financial, institutional and natural resources, making it difficult to diversify exports or introduce market reforms. For energy, small island developing States are often highly dependent on imported supplies, particularly oil, which becomes especially expensive since it has to be transported long distances—to and between islands. They also have limited storage capacity for petroleum resources and so are vulnerable when prices fluctuate.

> "Small island developing States have abundant access to international waters but still suffer from remoteness and isolation"

The small island developing States have significant environmental problems since economic development and the use of conventional energy sources and the resulting pollution can damage fragile marine ecosystems. Few of these countries have indigenous fossil fuels, but they often have abundant renewable resources. However, they find it difficult to develop these resources because they lack capital and suitable financing mechanisms, as well as effective institutional mechanisms, and appropriate technologies.

Many small island developing States, along with a number of least developed countries, are highly vulnerable to the impacts of climate change. Usually, a large proportion of their population and essential infrastructure are located in coastal areas that are vulnerable to inundation. As climate patterns change, some countries will also experience severe weather and sea level rise along with water shortages and declines in agriculture and fisheries. They may also be invaded by non-indigenous species in some areas, and might be susceptible to an increased risk of disease and declines in tourism. Many of these problems will also be evident in some Asian least developed countries and landlocked developing countries—while the latter will also be affected by melting glaciers.[164]

> "Many small island developing States, along with a number of least developed countries, are highly vulnerable to the impacts of climate change"

PRIMARY ENERGY SUPPLIES

Excluding Kazakhstan and Uzbekistan, the total primary energy supply (TPES) of these countries—which does not include production of secondary energy products, such as refining thermal electricity generation—is each less than 1 per cent of the region's TPES (table 7-2). This table also includes "secondary production", the definition of which differs from country to country: in many small island developing States, for example, along with least developed countries, it refers to thermal power generation, while in some central Asian landlocked developing countries, much of this is petroleum refining.

> "The total primary energy supply of many of these countries contributes less than 1 per cent of the region's TPES"

Table 7-2—Energy balance for least developed countries, landlocked developing countries and small island developing States, ktoe, 2005

	Primary Production	Imports	Export	Bunkers	Stock-changes	TPES	% of ESCAP TPES	Secondary production
ESCAP	5,302	1,632	1,587	98	6	5,242	100.0	2,339
ESCAP excluding developed	4,971	1,131	1,383	80	4	4,634	88.4	1,944
Global	11,642	4,567	4,563	294	10	11,342		5,997
Least developed countries	55	8	18	0	0	45	0.9	18
Landlocked developing countries	304	32	170	1	1	164	3.1	62
Small island developing States	4	113	68	29	-4	24	0.5	61
LDCs/LLDCs/SIDS	355	152	248	30	-2	231	4.4	134

Source: United Nations Statistics, 2007.

Table 7-3 shows the sources of primary energy for selected countries. Some landlocked countries, such as Kyrgyzstan, Armenia and Tajikistan produced significant quantities of hydroelectricity. A number of island countries also utilize hydro, along with wind energy. Other primary energy sources include natural gas for central Asian countries—Turkmenistan, Uzbekistan, Kazakhstan and Azerbaijan. Myanmar and Bangladesh also produce natural gas. Solid fuels are produced in similar amounts—in the form of traditional fuelwood as well as animal and agricultural wastes.

Some countries with fossil fuel resources are close to self-sufficiency, while others, particularly the small island developing States, are almost 100 per cent dependent on imported fuels (table 7-3 and figure 7-1). Another useful indicator is the average share of the TPES sector in GDP. In 2004, for the Pacific small island developing States, this ratio was 17 per cent—though it ranged from 60 per cent in Nauru to 2 per cent in French Polynesia. A low TPES/GDP ratio suggests that a significant amount of imported fuel may be for use by foreign aircraft or for international bunkers for shipping.

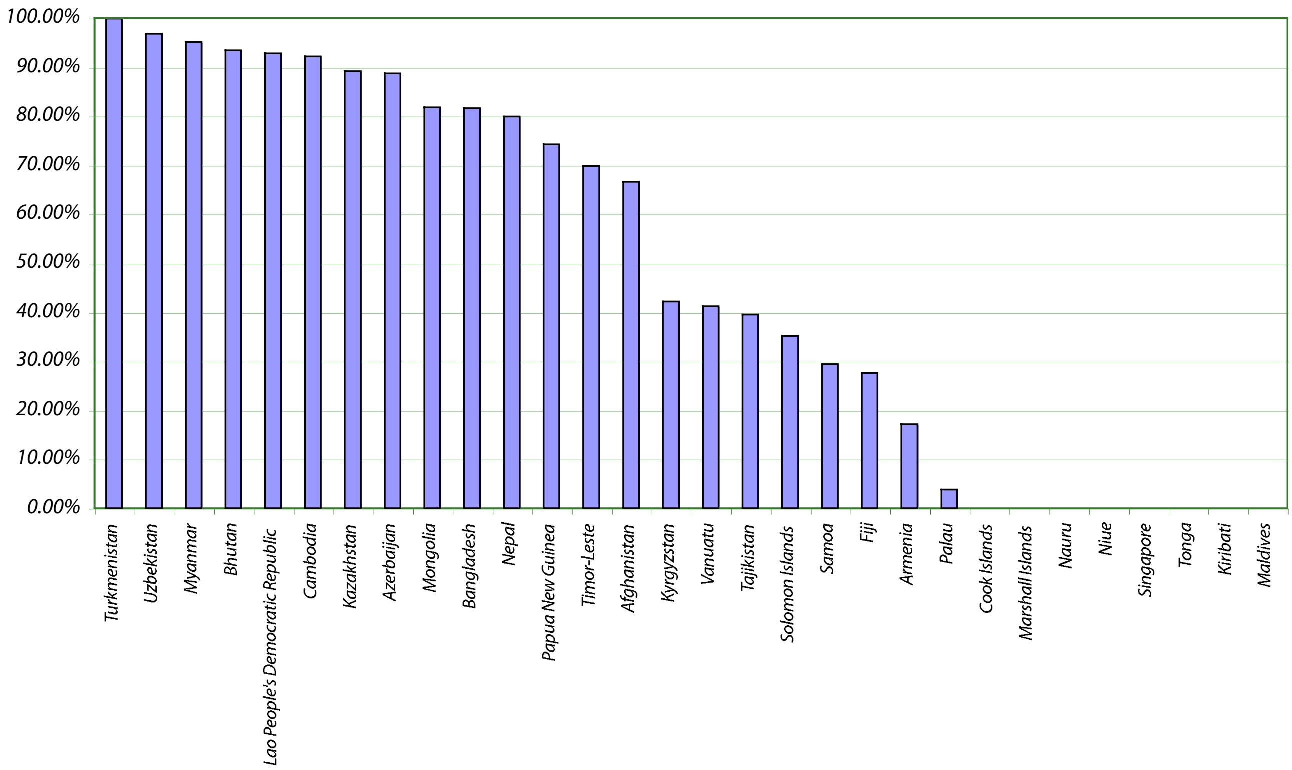
“Some countries with fossil fuel resources are close to self-sufficiency, while others, particularly the small island developing States, are almost 100 per cent dependent on imported fuels”

Table 7-3—Primary production of energy in selected countries, 2005 (ktoe)

Country	Electricity and Power			Natural gas and biogas	Primary liquid fuels	Solid Fuels		Total primary production
	Hydro	*Nuclear*	*Other electricity*			*Traditional fuels*	*Coal*	
Afghanistan	51	0	0	2	0	342	23	419
Armenia	152	234	0	0	0	9	0	395
Azerbaijan	259	0	0	5,633	22,214	1	0	28,107
Bangladesh	111	0	0	12,010	0	9,071	0	21,192
Bhutan	176	0	0	0	0	1,061	36	1,273
Cambodia	4	0	0	0	0	2,193	0	2,197
Fiji	58	0	0	0	0	193	0	250
French Polynesia	8	0	0	0	0	0	0	8
Kazakhstan	675	0	0	23,275	50,870	78	61,844	136,743
Kyrgyzstan	1,226	0	0	23	74	4	111	1,439
Lao People’s Democratic Republic	258	0	17	0	0	1,387	277	1,939
Mongolia	0	0	0	0	0	43	2,553	2,597
Myanmar	258	0	0	10,929	1,098	10,464	794	23,543
Nepal	207	0	0	48	0	3,557	8	3,820
New Caledonia	28	0	1	0	0	0	0	29
Palau	2	0	0	0	0	0	0	2
Papua New Guinea	77	0	0	119	1,900	1,317	0	3,414
Samoa	3	0	0	0	0	18	0	21
Solomon Islands	0	0	0	0	0	32	0	32
Tajikistan	1,435	0	0	27	22	0	64	1,547
Timor-Leste	0	0	0	0	135	0	0	135
Turkmenistan	0	0	0	57,013	9,100	1	0	66,114
Uzbekistan	527	0	0	54,425	3,539	4	809	59,305
Vanuatu	0	0	0	0	0	21	0	21

Source: United Nations Statistics, 2007.

Figure 7-1—Adjusted self-sufficiency for selected least developed countries, landlocked developing countries and small island developing States, 2005



Source: United Nations Statistics, 2007.

Note: Adjusted self-sufficiency is calculated by dividing the production by the total primary energy supply before subtracting exports.

Some least developed countries rely for their development on exporting energy products. The Lao People's Democratic Republic, for example, exports hydroelectricity to neighbouring countries, providing a substantial income for development. The Government has placed a high priority on developing the energy sector for this purpose as well as for meeting unmet domestic demand.[165] Similarly, Bhutan exports hydroelectricity to India and the two countries have worked together to further develop the necessary infrastructure.[166]

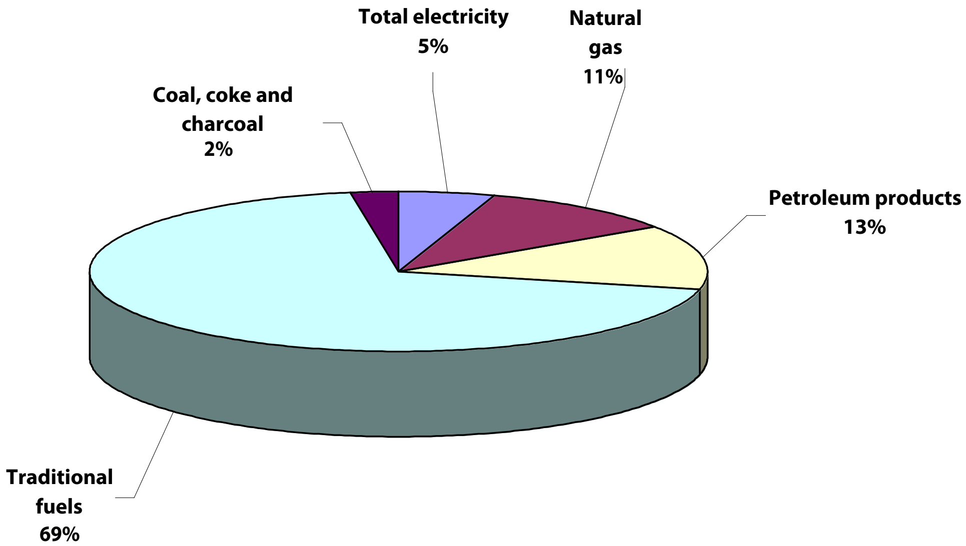
In 2005, this was just over 5 per cent of the total consumption for the ESCAP region (table 7-4). Of this, that of small island developing States is the least at 0.3 per cent. A breakdown of the forms of fuel consumed says much about the level of development. In landlocked developing countries, the major form is natural gas, followed by electricity. In least developed countries, however, the most important sources of energy are fuelwood and animal and vegetable wastes. In small island developing States, the major energy sources are electricity, diesel, jet fuel and fuelwood, indicating the combination of energy used for transport and domestic consumption. The breakdown of energy consumed in least developed countries, landlocked developing countries and small island developing States is shown in figures 7-2, 7-3 and 7-4.

Table 7-4—Total final consumption by least developed countries, landlocked developing countries and small island developing States in 2005 (ktoe)

	Least developed countries	Landlocked developed countries	Small island developing States	All LLDCs, LDCs, SIDS	ESCAP
Electricity and steam	2,413	15,227	3,321	20,604	649,971
Gaseous fuels	4,939	52,212	118	57,269	427,698
Liquid fuels	6,114	19,751	3,902	28,631	911,815
Solid fuels	33,553	17,257	1,585	46,642	1,002,049
Total energy	47,020	104,447	8,926	153,146	2,991,534

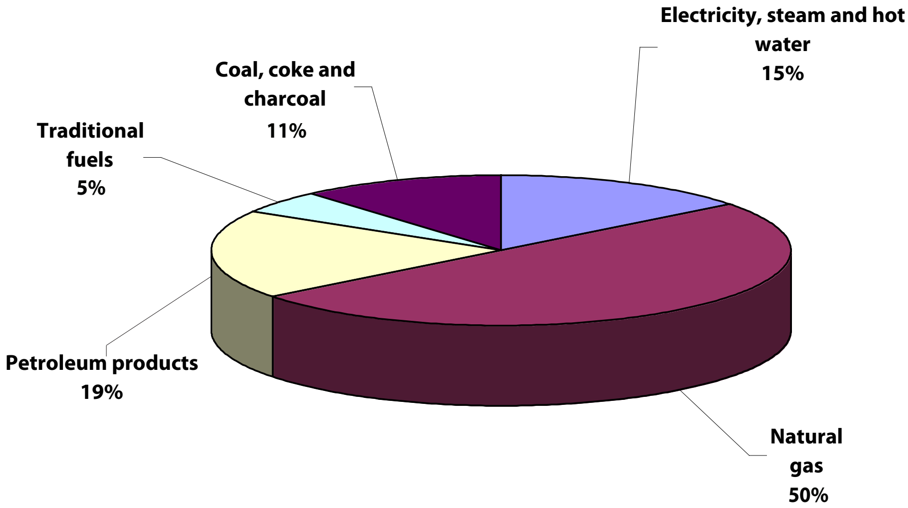
Source: United Nations Statistics, 2007.

Figure 7-2—Least developed countries, types of fuel consumed, 2005



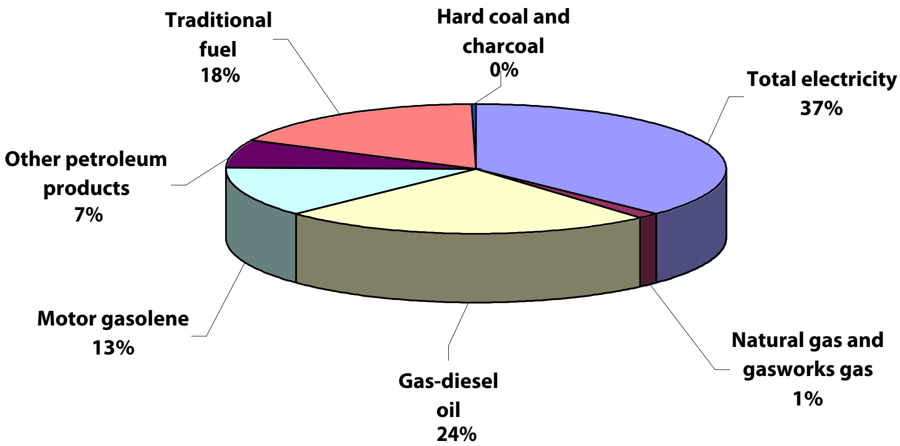
Source: United Nations Statistics, 2007.

Figure 7-3—Landlocked developing countries, types of fuel consumed, 2005



Source: United Nations Statistics, 2007.

Figure 7-4—Small island developing States, types of fuel consumed, 2005



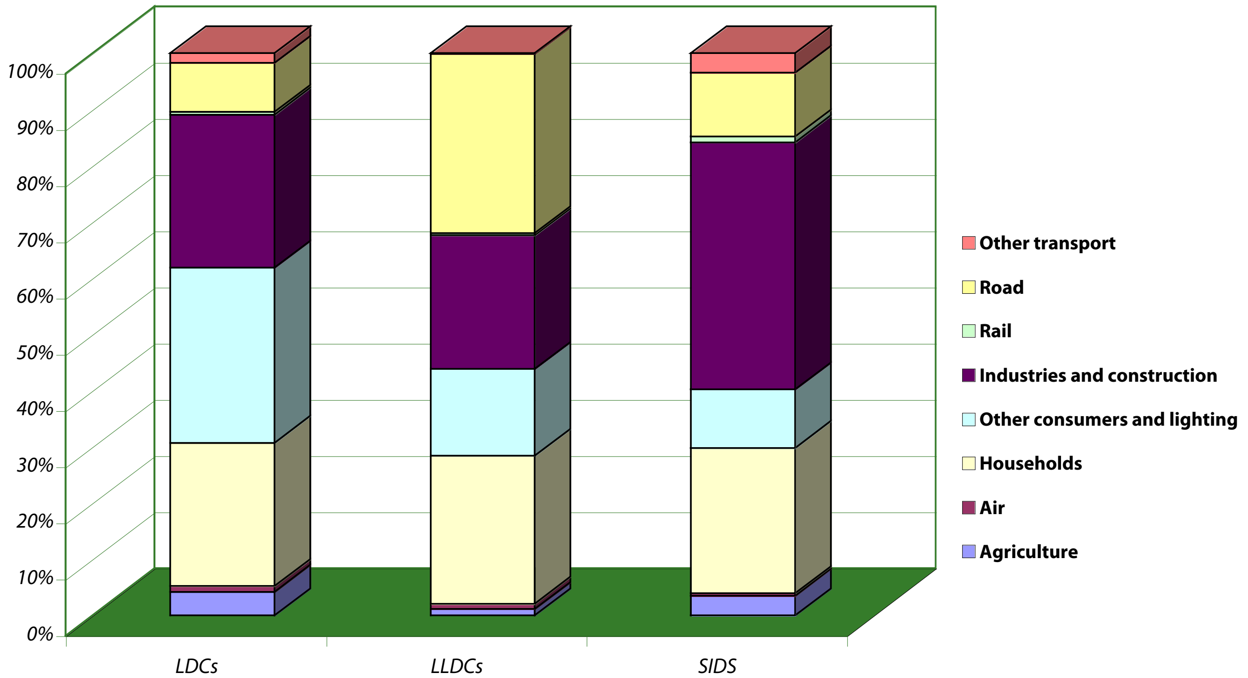
Source: United Nations Statistics, 2007.

Figure 7-5 offers a general perspective across these countries by major consumer. In the least developed countries and most of the landlocked developing countries, the main consumption is by household, while in the small island developing States consumption is more evenly balanced between roads, air travel, households, industry and other consumers, such as commercial and public services. These patterns are likely to change as countries develop.

The high proportion of traditional fuels in the energy consumption of least developed countries and small island developing States signals their inability to provide access to modern energy services—a major constraint to their economic and social development. Those with the least access are least developed countries, though some countries, particularly the small island developing States, have been quite successful in their electrification programmes. Between 1994 and

> “The high proportion of traditional fuels in the energy consumption of least developed countries and small island developing States signals their inability to provide access to modern energy services”

Figure 7-5—Energy consumption in least developed countries, landlocked developing countries and small island developing States, by sector, 2005



Source: United Nations Statistics, 2007.

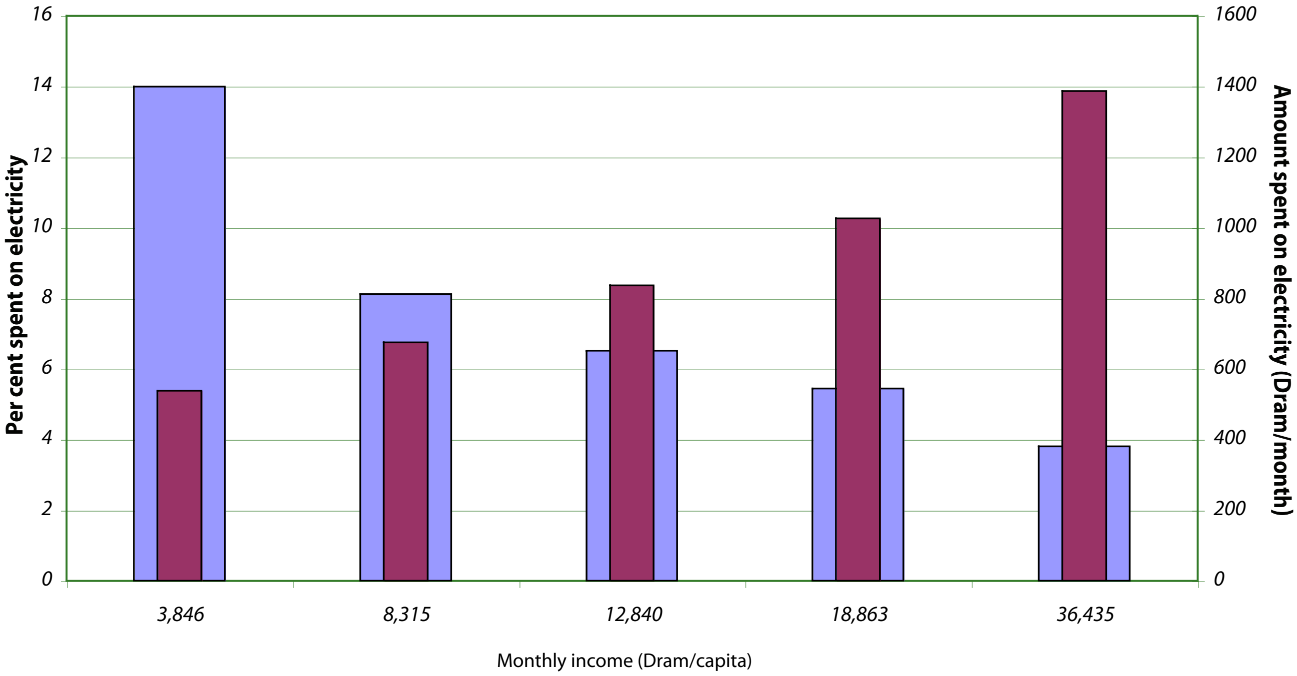
2004, the Cook Islands, for example, increased its electrification rate from 35 to 99 per cent.[167] In 2006, the Fiji Department of Energy announced that, as it had done for the previous two years, it would set aside $6 million for rural electrification—using grid extensions as well as off-grid solar and hydropower and diesel generators.[168] The Government of Bangladesh similarly aims to provide 100 per cent of the population with access by 2020.[169] In the Lao People's Democratic Republic, the Government has committed itself to reaching 90 per cent of households with electricity by 2020 through both grid and off-grid systems.[170]

Another significant limitation on energy sector development is that many consumers cannot afford to pay. Data on consumption of electricity by household is very limited. Figures 7-6 and 7-7, derived from 2005 national census data, show the amount of household income spent on electricity services by income group for Armenia and Singapore, respectively. As can be seen, the poorest consume the least amount of electricity but pay the most for it.

The poor have also been seriously affected by rising oil prices. A UNDP survey found that, between 2002

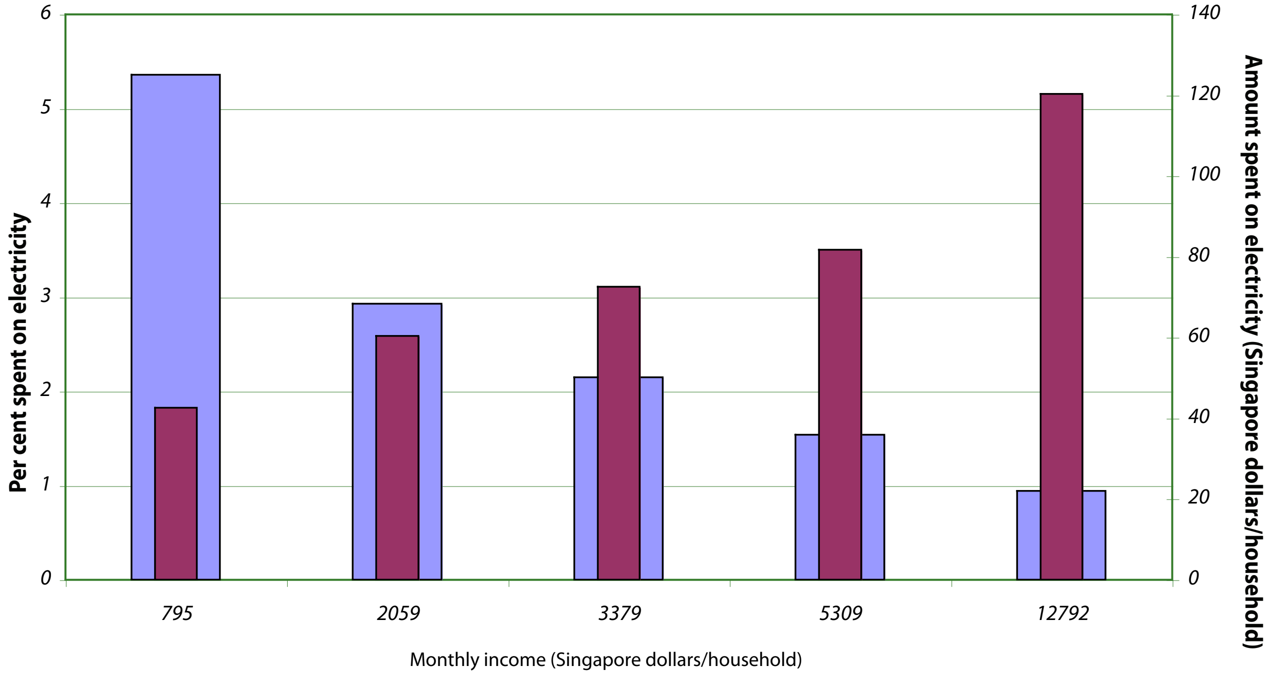
“Another significant limitation on energy sector development is that many consumers cannot afford to pay”

Figure 7-6—Armenia—household expenditure on electricity, by income group, 2005



Source: Armenia Statistics, Integrated Survey of Living Standards of Households 2005.

Figure 7-7—Singapore—household expenditure on electricity, by income group, 2005



Source: Statistics Singapore, June 2007.

> The poor have also been seriously affected by rising oil prices

and 2005, the amount poor households spent on energy needs rose by 74 per cent, and for some energy services the increases were far higher: 120 per cent for transport and 171 per cent for cooking fuels.[171] Faced with high prices for modern energy services, many of these households reverted to traditional fuels or were obliged to rely less on energy, walking instead of catching public transport, for example, or going without use of lights at night.[172]

Some Governments are helping the poorest communities afford modern energy services, for example, by providing "lifeline" tariffs. In 2004, the Energy Regulatory Authority of Mongolia introduced a lifeline tariff for the poor,[173] and in Bhutan the Electricity Authority has a tariff which is about 60 per cent lower per kWh for consumers using less than 80 kWh per month.[174] In Bangladesh, many people are being assisted with the installation of off-grid renewable energy systems through innovative microfinancing mechanisms.[175] In Nepal, the Alternative Energy Promotion Centre facilitates rural electrification through subsidies for off-grid renewable power systems and improved cooking stoves (box 7-1).

Box 7-1—Rural energy development in Nepal

In Nepal, the Alternative Energy Promotion Centre was established under the Ministry of Environment, Science and Technology to develop and promote renewable and alternative energy options. One of the most successful programmes has been for biogas development. At the end of 2005, the following achievements were recognized:

- 156,575 biogas plants had been installed
- 60 private biogas companies had been strengthened
- 15 biogas-appliance manufacturing workshops had been developed
- A comprehensive quality standards and quality control system had been developed
- 96 per cent of constructed plants were in operation
- 93,251 toilets had been constructed and connected with biogas plants
- 80 per cent of bioslurry was being utilized as an organic compost fertilizer
- The biogas programme was being developed as the first CDM project in Nepal
- BSP was an ISO 9001-2000 certification holder for its strong quality management system and subsidy administration
- 118 microfinance institutes had been mobilized for biogas lending
- 980,000 persons had directly benefited
- 11,000 people had been employed

To facilitate the development of biogas in Nepal, the Governments of Germany and Nepal funded a subsidy programme administered by APEC. Other programme mechanisms include: easily available loans from banks; operation and maintenance training along with guarantees of plant and maintenance services; and a quality assurance programme to ensure a positive public perception.

RENEWABLE ENERGY TECHNOLOGIES

Many small island developing States and least developed countries have a long history and a wealth of experience—good and bad—with energy services from renewable sources. For example, in Bhutan the solar power programme, launched in the early 1980s, has resulted in the installation of almost 62 kW of solar home lighting systems in schools and health facilities. Compact fluorescent lighting systems have also helped reduce energy usage.

> "Many small island developing States and least developed countries have a long history and a wealth of experience—good and bad—with energy services from renewable sources"

In many countries renewable energy has mainly involved small-scale remote power generation, such as PV solar home systems. While the technical issues of installation have largely been resolved there are still difficulties in maintaining the services. This is less of an issue for small-scale rural solar electrification projects—as in Tonga and Kiribati, where the implementing organizations routinely provide training for the small number of local technicians needed to operate and maintain them (box 7-2). However, it is more difficult to sustain a pool of capable designers, installers and technicians more broadly throughout the region.

If these countries are to significantly reduce their reliance on fossil fuel imports, they will also need to scale up to larger renewable energy systems to produce electricity for grids.[176] In addition, they would need to promote non-electrical energy applications, such as solar water heating combined with energy efficiency measures.

Box 7-2—Remote solar energy systems in Kiribati

As a remote small island developing State, Kiribati can take advantage of its abundant solar energy. At present, the use of solar energy is generally limited to private households in rural areas where the average demand is less than 1 kWh. However, this is sufficient for lighting at night for education purposes. Under projects funded by the Government of Japan and the European Union, while the systems are the property of the electric power company, the users pay fees. The project has therefore targeted households with a specific income level to ensure that they can afford the fees.

It is also important to have sufficient users to allow for the training and recruitment of local technicians to maintain the systems. So far, the project has created 13 full-time and 14 part-time jobs. In addition, the public perception of PV systems has improved substantially and sales of solar products have increased.

> “If these countries are to significantly reduce their reliance on fossil fuel imports, they would need to consider larger renewable energy systems and promote energy efficiency measures”

At present, however, many small island developing States have little local capacity to assess, design, develop, implement, operate or maintain large-scale renewable energy projects, or to implement non-electric power renewable energy projects. They are also short of the necessary skills. The limited existing systems for training engineers, technicians and other stakeholders in renewable energy project management and technical support are not broadly transferable to the needs of vastly more complex and locally specific large-scale developments. There is, therefore, an urgent need to support the development of local technical skills and managerial capacity.

This capacity development should be extended to women as well as men. Although women are often the primary household energy users and are more likely to be affected by shortages of energy resources, decisions on energy in many least developed countries and small island developing States are mostly taken by men. It is vital, therefore, to empower women to be involved in decision making and in managing energy services and systems—as is happening through the Pacific Energy and Gender Network and the ENERGIA network on gender and sustainable energy.

> “There is an urgent need to support development of local technical skills and management capacity that is extended to women”

Large-scale projects will need to be undertaken by diverse public and private organizations with competent managerial and technical staff who can upgrade their skills through local training institutes, minimizing the need for external technical assistance.

Biofuels

Small island developing States often provide remote areas with electricity using diesel power plants. To reduce reliance on imported energy, they can also use biofuels, such as coconut oil, from crops grown locally or imported from other islands. Feasibility studies on biodiesel are currently being undertaken in Fiji, Marshall Islands, Samoa and Vanuatu. Countries wanting to build sustainable industries will, however, need to consider the dangers of competing with other crops and of damaging already fragile ecosystems. Indeed, all programmes for introducing new forms of energy need to consider the social and environmental implications, particularly their contribution to poverty reduction and gender equity.

FINANCING ENERGY PROJECTS

Energy projects, large and small, are often more capital-intensive and have longer lead times than those in other industries and large initial investments. They are thus exposed to financial risks, such as changes in interest rates, and face the possibilities of under- or overcapacity.

Due to their long lead times and operating lives and their interdependence with other infrastructure projects, energy investments are normally financed with long-term capital. In most least developed countries and small island developing States, this has traditionally come either from domestic savings or official development assistance.[177] Another possibility is foreign direct investment (FDI), which can provide not only capital but also state-of-the-art technology as well as knowledge and skills. Countries in the region can also look to international capital markets. This has the advantage of providing cheaper capital, since it means borrowing on more efficient markets, but there are also risks: overseas capital can be volatile, and currency depreciation can increase the foreign debt burden while the revenues are generated mainly in local currency.

> “Due to their long lead times and operating lives and their interdependence with other infrastructure projects, energy investments are normally financed with long-term capital such as domestic savings or ODA”

Another option is the Clean Development Mechanism (CDM). Bhutan, Mongolia and Fiji, for example, have used the CDM successfully. This can reduce the reliance on fossil fuels through renewable energy or energy efficiency projects while also providing a good source of income.

> “The CDM has also been used successfully in several least developed countries, landlocked developing countries and small island developing States”

For smaller-scale rural electrification, a number of developing and least developed countries have successfully used microcredit financing (box 7-3). The Grameen Bank in Bangladesh is one of the most famous, but other countries, such as the Lao People’s Democratic Republic and Nepal, have similar models for financing energy programmes. Individual small-scale energy projects can accumulate large financing fees, but one way to reduce administration costs is to bundle them into a portfolio that applies the same set of procedures for all.

> “For smaller-scale rural electrification, a number of developing and least developed countries have successfully used microcredit financing”

Box 7-3—Grameen Shakti—Banking for the poor with clean and affordable energy

A common barrier to providing rural populations with energy services is the lack of finance. To help address this in Bangladesh, the NGO Grameen Shakti (Rural Energy) was established in 1996 to develop and popularize renewable energy in rural areas. Grameen Shakti has used a market-based microcredit approach for delivering solar home systems and other renewable energy technologies and products. Currently, there are 110,000 systems covering 30,000 villages.

This system is based on experiences from Grameen Bank's microcredit programme. Other key factors in its success include linking renewable energy technologies with income-generating activities and providing efficient services at the local level through renewable energy entrepreneurs. At the same time, it motivates communities through awareness-raising campaigns to establish new renewable energy businesses and create employment opportunities.

Grameen Shakti also develops and tests innovative approaches, such as micro-utility models, community-based biogas plants, and the supply of livestock on credit, as well as innovative payment methods, including payment through slurry.

Source: www.grameen-info.org/grameen/gshakti/index.html

ENERGY EFFICIENCY

Many countries have been slow to adopt energy-efficient practices and designs. Many landlocked central Asian countries have old and inefficient energy systems that use fossil fuels in large power plants—and were planned on the assumption of a considerable transfer of fuel and power between what are now independent States. After independence, many countries lost their access to fossil fuel in neighbouring countries or had to pay much more. Governments now recognize the need to boost efficiency either by retrofitting old utilities or building new ones and using alternative fuels.

The countries of the Special Programme for the Economies of Central Asia (SPECA), which include a number of landlocked developing countries, adopted in 2003 a cooperation strategy to promote the rational and efficient use of water and energy resources in Central Asia. As a result, the SPECA countries now have a work plan for improving energy efficiency and conservation through management, networking and partnerships.

Other countries, such as the small island developing States, have less-developed infrastructure. However, this also represents an opportunity since energy efficiency can be engineered in at the outset without sacrificing services. Countries can also incorporate energy conservation principles into building codes and urban and rural planning. Smart planning from the outset is far cheaper than retrofitting.

“Governments now recognize the need to boost efficiency either by retrofitting old utilities or building new ones and using alternative fuels”

“The small island developing States have less-developed infrastructure, which represents an opportunity to engineer efficient design options from the outset”

Energy efficiency measures can be initiated by any agency, including government agencies, and research and development centres, NGOs and private sector entities. The key challenge, however, is to link these strategies to the national policy framework. This can provide clear visions, strategies and action plans among the stakeholders with the active collaboration of large energy consumers and energy-intensive industries.

SUBREGIONAL COOPERATION

Many of the strategies for boosting energy security will benefit from transboundary cooperation. This can, for example, facilitate trade and transport through neighbouring countries and bulk purchasing of petroleum fuel together with common systems of storage. They can also combine to develop indigenous sources of petroleum products—as opposed to individual countries doing their own research and exploration. Regional organizations can also support least developed countries, landlocked developing countries and small island developing States through research and development on alternative fuels and energy technologies as well as by disseminating information on fuel supply and demand. Many least developed countries, landlocked developing countries and small island developing States already participate in subregional activities, as indicated below.

> “Regional organizations can also support least developed countries, landlocked developing countries and small island developing States through research and development on alternative fuels and energy technologies as well as by disseminating information on fuel supply and demand”

***Pacific islands*—**The Pacific Islands Energy for Sustainable Development partnership has developed an energy policy and strategic action plan; practically all the small island developing States are participating and many have already developed a national sustainable energy strategy. Joint initiatives include information exchange, benchmarking, standardization and capacity -building for energy officials, regulators and service providers. Further proposals include a regional energy financing facility, data exchange, harmonization of energy sector regulation, and joint procurement of fuels, goods and services, as well as systems for safe disposal of waste. The Pacific islands could, for example, use a common petroleum supplier and thus have greater negotiating power, while expanding storage facilities to reduce the costs of delivery.[178]

***South-East Asia*—**Least developed countries in the subregion have developed an “ASEAN plan of action for energy cooperation 2004-2009”.[179] This envisages an ASEAN power grid and a trans-ASEAN gas pipeline. It also covers cooperation in coal trade and clean coal technologies, in energy efficiency, renewable energy and conservation, and in regional energy policy and planning. Planned subregional activities include research, development and knowledge sharing, standardization of technical specifications, and the negotiation of transit measures, taxes and fees.

***South Asia*—**The South Asian Association for Regional Cooperation (SAARC) covers many least developed countries, landlocked developing countries and one small island developing State. Under the Regional Integrated Programme of Action, SAARC has established an energy working group which has identified a number of options for cooperation: information and knowledge sharing; the establishment of a SAARC energy centre; a review of transnational trade; and a possible regional fund for promoting non-conventional energy. It has also considered the possibility of establishing a regional power grid.[180]

POLICY SUGGESTIONS FOR SMALL ISLAND DEVELOPING STATES, LEAST DEVELOPED COUNTRIES AND LANDLOCKED DEVELOPING COUNTRIES

The Pacific Islands Energy Policy and Strategic Action Plan has many useful policy suggestions, some of which are also applicable to other least developed countries and landlocked developing countries. These with some others of particular relevance to least developed countries and landlocked developing countries are listed below. Many of these issues have been raised in earlier chapters and so are only summarized here.

Regional energy sector coordination—A central organization could coordinate energy sector plans and programmes by regional organizations, the private sector, non-governmental organizations and development partners. It could also mobilize official development assistance and international financing for national and regional energy strategies.

Policy and planning—Policymaking and planning should be open and inclusive and should strive for a better balance between the economic, social and environmental pillars of sustainable development. This would also allow countries to learn from each other.

> "Policymaking and planning should be open and inclusive and should strive for a better balance between the economic, social and environmental pillars of sustainable development"

Power sector—Countries can provide reliable, safe and affordable access to efficient power by improving the efficiency of power generation, transmission and distribution. They can also consider privatizing both management and ownership of power infrastructures to improve efficiency in pricing, quality and delivery. New and alternative energy sources should also be considered, particularly for remote and rural areas.

Transportation—Transport should be affordable and avoid harming fragile ecosystems. Achieving this will mean using emerging environmentally clean technologies and alternative fuels at prices consumers can afford, along with emission controls and more energy-efficient vehicles.

Renewable energy—The share of renewable energy can be increased by using proven renewable energy technologies and synchronizing the management of both grid-connected and stand-alone, renewable-based power systems. This can be carried out through partnerships between the private and public sector along with external financing.

Rural and remote areas—To substitute for imported fuels, countries can consider indigenous energy resources and involve the private sector in the supply of equipment and skills, and in project design, implementation, management and maintenance. Sustainable energy options can be considered for a range of purposes: electricity generation, transport, water supply, health care, education, telecommunications, food supply and income generation.

> "To substitute for imported fuels, countries can consider indigenous energy resources and involve the private sector in the supply of equipment and skills, and in project design, implementation, management and maintenance"

Environment—Energy supply and infrastructure projects should be based on detailed environmental impact assessments—on biodiversity, greenhouse gas emissions and local air quality—covering the projects' entire life cycles and including plans for waste disposal.

Efficiency and conservation—Countries can optimize energy consumption by improving their management of both the demand and supply sides of energy – organizing taxes, duties and tariffs so as to encourage efficient energy use. This will also mean raising public awareness and ensuring cooperation between governments, the private sector and energy consumers.

“Countries can optimize energy consumption by improving their management of both the demand and supply sides of energy”

Human and institutional capacity—Energy security can also benefit from better training for people working in the energy sector while also building capacity in wider communities through publicity campaigns, workshops and the school curricula. Countries can also build institutional capacity and carry out appropriate research and development—learning from each other across the region. Subregional organizations can help develop institutional frameworks for integrated energy security activities at the local, national and regional levels.

Subregional trade—For landlocked developing countries and some least developed countries, subregional cooperation can also take the form of facilitating trade in energy resources and services to and through neighbouring countries by synergizing the legal and regulatory environments and coordinating efforts to develop the necessary infrastructure. This could include, for example, assessments of the legal, physical and economic barriers to energy trade among least developed countries, landlocked developing countries and neighbouring countries.

“For landlocked developing countries and some least developed countries, subregional cooperation can also take the form of facilitating trade in energy resources and services to and through neighbouring countries by synergizing the legal and regulatory environments and coordinating efforts to develop the necessary infrastructure”

Private sector participation—Many Governments are now opening up their State-owned economic utilities to the private sector—an important source of funding for electricity systems. Globalization can extend this participation in transboundary energy trade for the benefit of all stakeholders.

Strategic alliances—Regional and subregional organizations can help countries develop strategic alliances in managing energy development and trade—for example, by identifying new sources of oil or developing alternative forms of energy.[181]

Pro-poor policies—If energy sector reforms are to benefit the poor, they need to be integrated with policies for other relevant sectors. Regional cooperation can help countries combine pro-poor energy policies with those on transport, communication, health, education services, forestry and for creating income-generating opportunities to improve the living conditions.[182]

“If energy sector reforms are to benefit the poor, they need to be integrated with policies for other relevant sectors”

Financial and economic mechanisms—Countries can also share experience on economic policies and financial mechanisms—such as oil stabilization funds, subsidies, microcredit facilities and other options, including the Clean Development Mechanism. Producing and consuming countries can also work together to moderate the effect of high oil prices by agreeing price bands within which prices can move.[183]

CONCLUSION

The least developed countries, landlocked developing countries and small island developing States have thus undertaken a considerable amount of work on a subregional basis. Now, they have a major opportunity to share these experiences across the region. Effective policies in some least developed countries and landlocked developing countries, for example, may actually be beneficial to remote small island developing States.

To facilitate this process, the Special Body on Least Developed and Landlocked Developing Countries at its eighth session recommended the establishment of a cooperation framework on energy security and stated that there was a need for a special programme on energy infrastructure for coordinated energy sector planning (box 7-4).[184] Many landlocked developing countries, least developed countries and small island developing States could benefit from such a framework. This would offer greater opportunities for energy and resource trade, and to agree policies for energy security.

Box 7-4—A framework for energy cooperation in least developed countries, landlocked developing countries and small island developing States

In its resolution 63/6, the Commission requested the Executive Secretary of ESCAP to "facilitate the establishment of a cooperation framework on energy security and widening access to energy services for least developed countries, landlocked developing countries and small island developing States…". It also requested the Executive Secretary to explore the establishment of a special programme on energy-related infrastructure and to identify the best usage of energy available in those countries. Such a programme would be aimed at the following:

(a) Strengthening national capacity for energy planning and management to enhance the sustainability of the energy sector;

(b) Promoting intercountry cooperation to exchange information, experiences and models, and good practices on renewable energy technology and its applications with a view to reducing poverty;

(c) Exploring the prospects for renewable solar and wind energy available on soft terms from international donors and non-governmental organizations for least developed countries, landlocked developing countries and small island developing States;

(d) Mainstreaming the concerns of least developed countries, landlocked developing countries and small island developing States into subregional and regional initiatives on energy trade and cooperation for the benefit of rural populations.

To initiate implementation of this resolution, the Executive Secretary is establishing a task force to work on the programme and has requested the Governments of least developed countries, landlocked developing countries and small island developing States to identify focal points to participate in or advise the task force. Two project documents are being developed: one on establishing a cooperative framework; the other exploring the options for a special programme on energy-related infrastructure.

POLICY OPTIONS FOR ENERGY SECURITY AND SUSTAINABLE DEVELOPMENT

Photo : StockXpert

“Now is the time to move beyond independent energy policies to interdependent intercountry policies for the benefit of all”

8

POLICY OPTIONS FOR ENERGY SECURITY AND SUSTAINABLE DEVELOPMENT

How should policymakers respond to the new energy challenges? How can they secure supplies, encourage industries and consumers to use energy more efficiently, and do so in ways that sustain both economic and human development while protecting the environment? This chapter summarizes the options introduced in previous chapters.

High and volatile energy prices, continuing energy-driven economic growth, heightened concerns about climate change, and the fact that 1.7 billion people still lack access to energy services across Asia and the Pacific—these and other factors demand that Governments reassess their energy strategies.

A successful overall strategy would aim at:

a. Reducing the gap between energy demand and supply;
b. Improving energy efficiency and conservation by lowering energy and resource intensity;
c. Achieving the optimal energy mix;
d. Diversifying sources of energy supply;
e. Investing in energy infrastructure development;
f. Shifting to alternative and renewable sources of energy;
g. Encouraging innovation and competition through research and development;
h. Reducing vulnerability to energy price fluctuations;
i. Achieving good energy sector governance.

To achieve these goals and meet social and environmental priorities, Governments in both energy-importing and -producing countries will need the appropriate legal and regulatory environment, along with transparent processes and consistent pricing and taxation policies that will encourage public-private partnerships in energy infrastructure development.

This chapter summarizes the options presented in previous chapters in four broad areas: sustainable energy infrastructure; investment and financing; access to modern energy supplies; innovation and governance and regional and subregional energy cooperation.

ENERGY AND SUSTAINABLE DEVELOPMENT

Countries across Asia and the Pacific can diversify energy sources, making more use of advanced and clean energy technologies while deploying conventional energy resources as efficiently as possible.

Clean and advanced technologies in coal-fired plants

Policy options could include wider application of some of the near-term and promising technologies and use of better materials.

- ***Near-term technologies***—Higher pressures and temperatures, double-reheating and reduction in condenser pressure.
- ***Promising technologies***—Supercritical pulverized fuel technology, atmospheric fluidized bed combustion, pressurized fluidized bed combustion, integrated gasification combined cycle and hybrid combined cycle systems; and carbon capture and storage technologies.

Energy resource diversification

Countries could further pursue fuel diversification in policy to reduce dependency on fossil fuels:

- ***Alternative energy***—Develop and use low-carbon and alternative energy, including natural gas, hydro and nuclear energy;
- ***Transport fuel***—Diversify fuel for transportation to liquefied petroleum gas, natural gas, biofuel and other alternatives;
- ***Renewables***—Make wider use of new and renewable energy resources to reduce dependency on fossil fuel;
- ***New technology***—Introduce innovative technologies, including clean energy technologies;
- ***Finance***—Explore innovative financing to encourage private-sector participation;
- ***Energy development processes***—Encourage innovation, competitiveness and knowledge management in all phases of energy development;
- ***Regulatory environment***—Enabling policies to create a level-playing field.

Renewable energy

Countries can make more use of renewable energy—with more inclusive energy policies, supported by a strong regulatory framework. Policy options include:

- ***Financial incentives***—Provide financial incentives, such as subsidies for renewable energy-based electricity generation, such as grid-connected photovoltaic roof-top systems with appropriate feed-in tariffs;
- ***Targeting***—Set targets for an increase in the share of renewable energy, for example, using renewable portfolio standards;
- ***Distributed systems***—Shift to smaller-scale and distributed systems by funding renewable energy-based generation in rural areas, for example, using solar home systems or hybrid systems;
- ***Research***—Promote research and development on renewable energy;
- ***Private sector***—Promote partnerships with the private sector so it can contribute capital, entrepreneurship and modern technology;

Nuclear energy

Many countries are showing a renewed interest in nuclear energy. To pursue this, they can use innovative technologies to enhance safety, reduce proliferation risks, minimize waste generation and improve economic performance.

End-use energy management

Most countries in the region have much scope for reducing the energy intensity of their economies through more eco-efficient patterns of production and consumption, buildings, transportation and electric appliances. Policies and measures in end-use energy management could include:

- ***Legislation—***Enact legislative measures for energy efficiency;
- ***Targets—***Set mandatory targets for energy efficiency—for vehicle, buildings and appliances, supported by energy labelling and monitoring;
- ***Subsidies—***Provide subsidies for energy-efficient technologies;
- ***Taxes—***Levy higher taxes for larger vehicles;
- ***Research—***Fund R&D for energy- and carbon-efficient pilot projects;
- ***Energy management—***Establish an energy service company.

Climate change

Since energy is intrinsically linked with the climate, science-based decision-making can lead to a series of measure to reduce carbon intensity:

- ***Regulations—***Strengthen rules and regulations, especially for energy-intensive industries, including rational energy pricing, taxation and subsidies;
- ***Incentives—***Provide incentives for more energy-efficient, less-polluting and low-carbon economic activities that also increase access to modern energy services;
- ***Efficiency—***Improve energy management and ensure energy conservation and efficiency;
- ***Clean technologies—***Promote cleaner production and consumption;
- ***Lifestyles—***Encourage changes in consumption pattern and lifestyles.

INVESTMENT AND FINANCING

Traditional sources of funding will be insufficient to finance essential energy infrastructure. Countries in the region can therefore look more to national and international financial markets. They will also be able to take advantage of environmental financing, such as the Clean Development Mechanism, though larger-scale financing would need to come from other arrangements, including a regional "special purpose vehicle" for energy infrastructure development.

To achieve an efficient financial market, policy options could include:

- ***Competition—***Ensure a competitive environment for both public and private institutions;
- ***Savings—***Encourage domestic savings;
- ***Financial markets—***Promote the development of financial markets and facilitate the creation of new financial instruments;
- ***Pricing—***Rationalize systems of energy pricing and taxation;
- ***Investment—***Promote domestic investment as well as foreign direct investment;
- ***Regulation—***Introduce regulatory mechanisms, including those to ensure safety of investments;
- ***Transparency—***Ensure transparency and access to information;
- ***Accounting—***Follow standard international accounting practices, with strong judicial and legal support.

MODERN ENERGY SERVICES FOR ALL

Efforts to reduce poverty should include measures to extend affordable energy supplies to vulnerable communities. These include:

- ***Integration—***Integrate policies for energy with those for rural development;
- ***Decentralized systems—***Extend services to remote areas using decentralized off-grid systems based on renewable energy;
- ***Pricing—***Combine rational pricing with innovative forms of funding and cost recovery;
- ***Participation—***Broaden decision making to ensure strong involvement from communities and the private sector.

SPECIAL NEEDS OF LEAST DEVELOPED COUNTRIES, LANDLOCKED DEVELOPING COUNTRIES AND SMALL ISLAND DEVELOPING STATES

The least developed countries, landlocked developing countries and small island developing States have unique energy security concerns that require special attention. Priorities include:

***Access*—**Widen access to energy services, using many of the policy options discussed in previous chapters;

Imports—Reduce import dependency;

***Infrastructure*—**Ensure that new infrastructure incorporates energy-efficient practices, and exploits alternative technologies;

***Energy-intensive sectors*—**As part of demand-side management, require energy-intensive sectors to apply principles of energy conservation;

***Transboundary cooperation*—**Improve regional, subregional and South-South cooperation.

INNOVATION AND COMPETITIVENESS

Achieving energy security and sustainable development can be based on new approaches whether using fossil fuels, with respect to exploration, transportation and conservation, or using alternative energy sources. Innovation will benefit from cooperation at regional and subregional levels and can include such priorities as:

***Alternative and clean energy*—**Introduce environmentally sound technologies and boost energy efficiency;

Governance—Reform structures of energy-sector governance;

***Efficiency*—**Enhance resource efficiency and reduce energy intensity;

***Knowledge*—**Improve knowledge management and sharing of experience.

REGIONAL AND SUBREGIONAL COOPERATION

In the past, most energy security issues have been considered largely at the national level. In a rapidly globalizing world, however, there is much to be gained from transboundary cooperation. Strategic and collaborative policies at the regional and subregional levels could ensure a regional energy balance.

The region as a whole has sufficient energy resources, but they are concentrated in only a few countries. All countries, either as importers are exporters, are thus engaged in energy trade with countries within and beyond the region. If Asia and the Pacific wishes to become self-sufficient, it can create a broad regional energy market. Among the options are:

***Multilateral dialogue*—**Maintain regular policy dialogues between Governments, the private sector and the financing agencies and international organizations;

***Long-term agreements*—**Seek long-term agreements on supplies and prices between producing and consuming countries;

***Strategic oil reserves*—**Coordinate the building of strategic oil stockpiles for emergency needs so as to enhance regional energy security;

Transboundary energy projects—Initiate interconnection projects to transport fuels or transmit electricity from one region or country to another within frameworks of regional or subregional cooperation;

***Trans-Asian energy system*—**Pursue the proposed trans-Asian energy system as a regional energy cooperation mechanism, building on ongoing or planned subregional energy cooperation;

***South-South cooperation*—**Build a knowledge management infrastructure to share vital information on technologies and project development as well as management and financing.

THE WAY FORWARD

Now is the time to move beyond independent energy policies to interdependent intercountry policies for the benefit of all. Although some regional and subregional energy initiatives are either in place or being contemplated, it may be useful to converge these in an inclusive package—an Asia-Pacific sustainable energy security framework. This could consist of five cluster areas (box 8-1).

The objective of the framework would be to promote energy security and sustainable development through enhanced regional cooperation in energy

Box 8-1—An Asia-Pacific sustainable energy security framework

The Asia-Pacific region could develop a framework to oversee and monitor energy supply and demand. This would also assist with efforts to accelerate research in energy efficiency and increase investment in energy infrastructure. The objective is to promote energy security and sustainable development through enhanced and closer regional cooperation in energy infrastructure development as well as in finance, energy trade, exchange and transit. The framework would consist of five overlapping cluster areas:

- Sustainable energy infrastructure development taking into account economic, social and environmental dimensions
- Investment and financing
- Access to modern energy services for all
- Innovation and competitiveness
- Greater regional and subregional energy cooperation:
  - Safeguard against energy market volatility
  - Regional energy trade, transit and exchange through a mechanism, such as a well-coordinated trans-Asian energy system
  - South-South cooperation

Implementation will require (a) further policy studies; (b) regular consultation meetings, especially at the preliminary stages, among senior officials and other relevant stakeholders; (c) the establishment of possible cooperation mechanism(s); and (d) regular policy dialogues. The framework would be realized through several multi-year programmes in phases.

infrastructure development and in finance, energy trade, exchange and transit. This could eventually lead to different forms of cooperation mechanisms.

Energy has become one of the most critical areas for government policy. The choices made now will have profound implications across Asia and the Pacific—for economic and social progress and the protection of the environment. The options are not simple and will inevitably involve trade-offs, but if they are made on a well-informed and rational basis, today's policy choices can not only help achieve the Millennium Development Goals but also ensure energy security and sustainable development for many decades ahead.

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