ASIA PACIFIC ENERGY RESEARCH CENTRE

ENERGY EFFICIENCY INDICATORS AND POTENTIAL ENERGY SAVINGS IN APEC ECONOMIES

A STUDY OF ENERGY EFFICIENCY AND SAVINGS IN APEC ECONOMIES

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FOREWORD

This report, *Energy Efficiency Indicators and Potential Energy Savings in APEC Economies*, is part of a long-term effort to improve energy efficiency - a component of a sustainable energy system - in APEC member economies.

The first and second phases of this project were completed in March 2000 and March 2001, respectively.

These studies have contributed to the construction of an APEC Energy Efficiency Indicators Database. However, much work still needs to be done in building on these achievements. It is our hope that APERC will continue to receive strong support from member economies for this initiative.

This report is published by APERC as an independent study and does not necessarily reflect the views or policies of the APEC Energy Working Group or of individual member economies.

Tatsuo Masuda
President
Asia Pacific Energy Research Centre

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ADEME	Agency for Environment and Energy Management (France)
AEEMTRK	ASEAN-EC Energy Management Training and Research Centre
APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
AUS	Australia
BD	Brunei Darussalam
bln	billion
C	carbon
CCE	cost of conserved energy
CDA	Canada
CHL	Chile
CHP	combined heat and power
CO_2	carbon dioxide
CT	Chinese Taipei
DOE	Department of Energy (USA)
EC	European Commission
EDMC	Energy Data and Modelling Center (Japan)
EGEDA	Expert Group on Energy Data and Analysis
EGEE&C	Expert Group on Energy Efficiency and Conservation
EIA	Energy Information Administration (USA)
EMM	APEC Energy Ministers Meeting
EPA	Environmental Protection Agency (USA)
FEC	final energy consumption
FY	fiscal year (Japan)
GDP	gross domestic product
GVA	gross value added
HKC	Hong Kong, China
HVAC	heating, ventilation and air-conditioning
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
IMF	International Monetary Fund
INA	Indonesia
IT	information technology
JPN	Japan

kgoe	kilogram of oil equivalent
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory (USA)
MAS	Malaysia
MEX	Mexico
mln	million
NRCan	Natural Resources Canada
NPV	net present value
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía (Latin American Energy Organization)
PE	Peru
PNG	Papua New Guinea
PPP	purchasing power parity
PRC	People's Republic of China
R&D	research and development
ROK	Republic of Korea
RP	Republic of the Philippines
RUS	Russian Federation
SEC	specific energy consumption
SIN	Singapore
SPP	simple payback period
tce	tonne of coal equivalent
TFC	total final consumption
THA	Thailand
TPES	total primary energy supply
UN	United Nations
US or USA	United States of America
VN	Viet Nam
WB	World Bank
WEC	World Energy Council

EXECUTIVE SUMMARY

ENERGY EFFICIENCY INDICATORS AND POTENTIAL ENERGY SAVINGS IN APEC ECONOMIES

The summary presents the major findings of APERC's study on Energy Efficiency Indicators and Potential Energy Savings in APEC Economies. This study had the following objectives:

- Construct and update for APEC member economies the basic energy efficiency indicators covering the whole economy, major energy end-use macroeconomic sectors and selected industrial and transport sub-sectors. Improve data quality.
- Produce energy intensities and output/energy elasticities as an intermediate result in order to provide APERC Energy Outlook project with important forecasting variables.
- Develop methodology and identify economic energy savings potentials in major end-use sectors of APEC economies – industry, transport, residential and commercial.
- Identify and produce an overview of successful energy efficiency policies and programmes in APEC economies.
- Develop and maintain a network of energy efficiency experts and agencies in APEC member economies. Disseminate an energy efficiency indicators database through relevant APEC organisations.

The study provides a methodological framework for energy savings assessment. Energy savings assessment methodology comprises technological energy savings in absolute values, penetration rates of new technologies, and re-aggregation to the sectoral level. Four types of energy savings potentials are distinguished: theoretical, technical, economic and market. Potential savings can be achieved only if they are economically feasible. The main economic feasibility parameter for energy savings measures should be implementation cost compared with average end-use energy price.

Energy efficiency policies in selected APEC economies have also been reviewed and successful cases of energy efficiency improvements identified. However, the relevant information is fragmented and not easy to obtain with the few quantitative evaluation figures available. Evaluation and analysis of energy efficiency policies is intended to be the emphasis of the next study by APERC.

REPORT CONTENT

The report comprises five chapters. Chapter 1 is an introduction to the problems of energy savings assessment and indication of energy efficiency improvements. The main question this study addresses is to what extent the potential energy savings on the demand side could represent an alternative to incremental energy supply.

Chapter 2 describes a methodological approach to assessing energy savings. Energy savings have two components: structural changes and improvements in energy efficiency.

Structural changes to less energy-intensive activities in a national economy reduce final energy demand. Economic development policies should be implemented that will consciously achieve such savings. A case study of Russia's energy policy illustrates the role of structural shifts.

Energy efficiency improvements are mainly due to technological progress and can be realised by implementing new, more efficient technologies.

Quantitative assessment of energy savings is two-fold – technical and economic. We distinguish between theoretical, technical, economic and market energy savings potentials. Theoretical and technical estimates are usually derived from physical and technical analysis of energy flows in end-use. Economic and market energy savings can be identified when additional monetary parameters are incorporated.

The parameters of economic feasibility for energy savings measures are their implementation costs compared with the average end-use energy price. This is a microeconomic problem, and it was hard to find adequate ways to evaluate energy-saving measures. Gaps exist in terms of information and methodology between macroeconomic and microeconomic assessments of energy savings.

A general energy savings assessment methodology comprises technological energy savings in absolute values, penetration rates of new technologies, and re-aggregation to the sectoral level. That requires detailed information about the age of physical capital, old and new technologies in operating industrial facilities, transport and buildings, and amortisation rates. A case study on the US iron and steel industry by the Lawrence Berkeley National Laboratory gives an example of such an approach and provides a valuable methodological background.

The only meaningful way to carry out this assessment is through national sector/technology specific surveys based on a large number of on-site energy audits. We looked at a collection of available national energy savings assessment studies providing quantitative estimates.

Chapter 3 identifies energy efficiency indicators (EEI) for macroeconomic sectors – industry, transport, residential and commercial. Trends in energy efficiency were analysed based on measurable parameters/indicators. They are constructed as ratios between energy consumption variables and corresponding economic activity variables.

The approach of our study is top-down, starting from the level of the whole economy down to disaggregated levels of major sectors. On these levels, the energy efficiency indicators are the most meaningful within each economy, comparing past and present levels of energy end-use.

Cross-country comparisons were able to be made on the basis of purchasing power parity estimates of economic activity.

In each sector we have compiled results of available potential energy savings assessments in some APEC economies.

Here we should explain the structure and content of the APEC Energy Efficiency Indicators database. It covers all 21 APEC economies and the time span is from 1980 to 1999. Technically, it is a 2 Mb file in 'Excel' format comprising raw data and automatically calculated indicators. The database has been put into the care of the EDMC department of IEEJ, and will be inserted into the APEC Energy Database as a special section.

Chapter 4 offers an overview of energy efficiency policies in selected APEC economies. Information is available mainly for OECD economies. The overview covers energy efficiency policies and measures in industry, transport and buildings.

Chapter 5 provides conclusions and recommendations.

CHAPTER 1

INTRODUCTION

BACKGROUND AND JUSTIFICATION

The project is an extension of the APERC studies 'Energy Efficiency Indicators for Industry' and 'Energy Efficiency Indicators for APEC Economies'. Previous phases highlighted the need to build and maintain a database of energy efficiency indicators for APEC economies.

The database comprises economic activity and energy consumption data in the agriculture, industry, transport, residential and commercial sectors. Intermediate results of energy efficiency trend analysis – energy intensities – were also used in energy demand/supply forecasting.

Potential energy savings estimates are important for energy demand planning because they point to the share of final demand that could be met by improving energy efficiency. Cost-effective energy savings need to be identified in order to obtain realistic values.

Energy efficiency policies aim to realise existing opportunities for energy savings. There is a significant need to improve policy collaboration among APEC economies and disseminate successful practice.

RATIONALE FOR THE PROJECT

This project was supported at the following APEC Energy Ministers Meetings:

- Third Meeting of APEC Energy Ministers, Okinawa, Japan, 9-10 October 1998

> *"Ministers … agreed that energy efficiency should continue to be a priority of the Asia Pacific Energy Research Centre, encouraging the Centre to advance its work on energy efficiency indicators."*

- Fourth Meeting of APEC Energy Ministers, San Diego, USA, 10-12 May 2000

> *Encouraged APERC to advance its work on energy efficiency indicators and to continue to have energy efficiency as a priority.*

- The project also elaborates on policy issues Nos. 2, 11 and 13 of the APEC 14 Non Binding Energy Policy Principles, respectively:

> *# 2: "Pursue policies for enhancing the efficient production, distribution and consumption of energy.";*
>
> *# 11: "Encourage energy research, development and demonstration to pave the way for cost effective application of new, more efficient and environmentally sound energy technologies."; and*

 # 13: "Promote cost effective measures which improve the efficiency with which energy is used but reduce greenhouse gases as part of a suggested regional response to greenhouse gas reductions."

PROJECT OBJECTIVES

Construct and update basic energy efficiency indicators of APEC member economies, covering the whole economy, major energy end-use macroeconomic sectors, and selected industrial and transport sub-sectors. Improve data quality.

As an intermediate result, produce energy intensities and output/energy elasticities in order to provide the APERC Energy Outlook project with important forecasting variables.

Develop methodology and identify economic energy savings potentials in major end-use sectors of APEC economies – industry, transport, residential and commercial.

Identify and overview successful energy efficiency policies and programmes in APEC economies.

Develop and maintain a network of energy efficiency experts and agencies in APEC member economies. Disseminate an energy efficiency indicators database through relevant APEC organisations.

SCOPE OF RESEARCH

The geographical scope is the 21 APEC member economies.

The time span is from 1980 to 1999 (2000 in some cases).

Energy efficiency indicators are considered for the whole economy and for major energy end-use sectors – industry, transport, residential and commercial.

Energy efficiency policies are considered in industry, transport and buildings.

DATA

- Data sources: WB, IMF, UN, OECD for economic activity, and APEC and IEA energy databases. More national statistical data needed for disaggregated levels.
- APEC EEI Database has been constructed in a simple 'Excel' format with initial data and built-in automatically calculated indicators.
- Purchasing power parity (PPP) is used as a monetary measure of output to produce cross-economy comparable EEI.

METHODOLOGY

- Energy efficiency indicators (EEI) monitor energy use as a productive factor for economic activity (output).
- Top-down approach.
- Structurally adjusted energy intensities are rough estimates of energy efficiency trends.
- Decomposition methods have been used to explain trends in energy intensity by identifying structural and energy efficiency changes.
- Complementary use of monetary and physical unit-based indicators. Unit-based indicators are relevant in energy-intensive industries (iron and steel, cement, pulp and paper) and transport.
- Weather adjustments in services and residential sector.
- Energy savings assessment methodology uses technological energy savings in absolute values, penetration rates of new technologies and further re-aggregation to the sectoral level.

COOPERATION

Continue cooperation with APEC EGEE&C, EDMC, IEA, and ADEME on energy efficiency projects.

Complete the joint ADEME-APERC study on 'Energy Efficiency Policies and Indicators' under WEC supervision.

CHAPTER 2

ENERGY SAVINGS ASSESSMENT

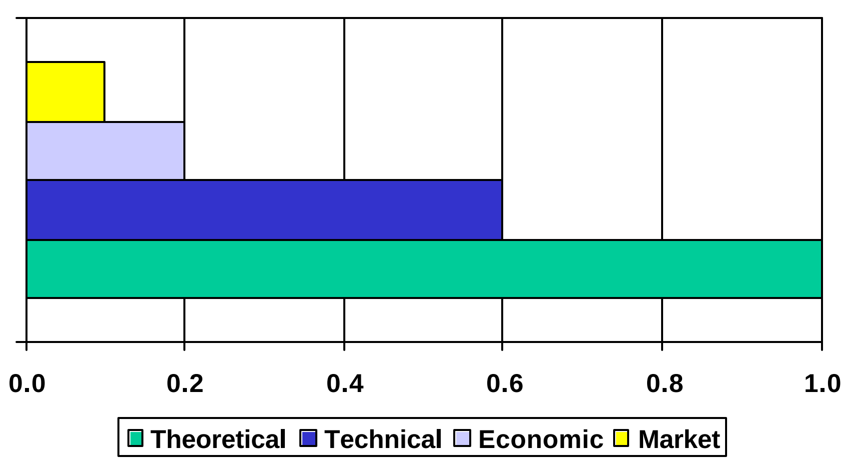
TYPES OF ENERGY SAVINGS POTENTIALS

Assessment of potential energy savings should be based on two main parameters – technical and economic. When considering the potential for increased energy efficiency, it is essential to distinguish between four types of potentials (Figure 1).

The theoretical potential represents achievable energy savings under theoretical considerations of thermodynamics, where final energy consumption is kept constant, and energy losses can be minimised through process substitution, heat and material re-use, and avoiding heat loss.

The technical potential represents achievable energy savings that result from implementing the most energy-efficient commercial and near-commercial technology available at a given time, regardless of cost considerations and reinvestment cycle. This can be expressed as a phased-in potential that reflects the total replacement of existing energy – converting and using capital stocks.

Figure 1 Types of energy savings potentials



The economic potential is the energy saving that would result if during each year of the period in question, all replacements, retrofits and new investments were shifted to the most energy-efficient technologies that are still cost-effective at given energy market prices. It also includes all organisational measures such as maintenance, sensitive operation and control, and timely repairs. The economic potential has sub-definitions depending on the economic perspective being used: the business (or project) perspective, the macroeconomic perspective, or the societal (or welfare-based) perspective. The economic potential implies a well-functioning market, with competition between investments in energy supply and demand. It also assumes that the barriers to such competition have been corrected by energy policies. It is assumed that as a result of such policies, all users have easy access to reliable information about the cost-effectiveness and technical performance of existing and emerging options for energy efficiency. The transaction cost for individual investors and the direct costs of policies associated with implementing these options are assumed to have been lowered to an irreducible minimum.

The market potential or expected potential is the efficiency improvement that can be expected to be realised for a projected year and given set of conditions (such as energy prices, consumer preferences and energy policies). The market potential reflects obstacles and market imperfections that keep efficiency potential from being fully realised [WEC, UNDP, UNDESA, 2000].

STRUCTURAL COMPONENT IN ENERGY SAVINGS

Structural changes in an economy directly affect energy demand. The shift from energy-intensive industries, such as mining and quarrying, basic metals, chemicals and petrochemicals to less energy-intensive manufacturing and/or services decreases energy consumption even without more effective energy end-use technologies being implemented.

The most important driver for energy end-use is the shift of economic activity to services at the expense of industry and agriculture, which started in the 1950s in developed economies and emerged in the 1980s-1990s in developing economies. This is a long-term trend now experienced by most countries. Services are much less energy-intensive than industries and every structural change of economic activity towards services yields energy savings. Table 1 represents actual values of energy intensities in these two macro-sectors in APEC economies in 1999.

Table 1 Energy intensity in industry and services, selected APEC economies, 1999

Economy	Energy Intensity of Industry, [kgoe/$1990]	Energy Intensity of Services, [kgoe/$1990]
Australia	0.252	0.017
Canada	0.364	0.063
Chile	0.245	0.020
China	1.067	0.146
Hong Kong, China	0.173	0.034
Indonesia	0.366	0.033
Japan	0.110	0.020
Korea	0.278	0.091
Malaysia	0.302	0.080
Mexico	0.337	0.018
New Zealand	0.492	0.037
Peru	0.260	0.017
Philippines	0.510	0.104
Singapore	0.096	0.017
Chinese Taipei	0.234	0.014
Thailand	0.420	0.042
United States	0.186	0.036

Source: APERC, IEA, DRI-WEFA

Energy intensity of services is about 5-30 percent of that of industry. So every shift in creation of value-added from industry to services (in relative terms, meaning shares) results in savings of 70-95 percent of energy in end-use, compared to the previous structure.

Shifts within industries to less energy-intensive activity, such as in machinery, electronics and textiles, also decrease overall energy demand in industry and yields energy savings compared with the higher share of heavy industries. A detailed consideration of the industrial structure in each APEC economy is beyond the scope of this study, and should be conducted on the national level, supported by specific national statistics.

The 'light' industrial structure and/or more service-based economy represents an opportunity for energy savings. Such economic development can be treated as a kind of energy policy. Structural changes play an important role in national energy planning. Box 1 represents an illustrative case of Russia's Energy Outlook 2020 [Energy Ministry of Russia, 2001].

Box 1. Energy savings in Russian Energy Outlook 2020

Dramatic growth of energy efficiency in the economy is one of the major pre-requisites for the social and economic revival of Russia. Unless this is addressed, the fuel and energy complex will decelerate economic recovery and growth. On the other hand, the growth rate and, what is more important, the speed of the national economy's restructuring will, together with technological progress, determine energy efficiency growth: with a higher GNP growth rate and higher share of services and high technology industries, demand in domestic energy consumption will go up.

According to the energy strategy parameters for long-term social and economic development, the economy's restructuring should provide savings that will offset more than half the growth in energy consumption (400 mln tce, or tons of coal equivalent, by 2010 against 1,020 mln tce in 2020).

Alongside structural change, the Energy Strategy envisages organisational and technological measures to achieve more efficient use of fuel and energy by implementing energy efficiency policies. Russia has a large potential for such measures. Implementation of domestically applied (lower value) and world (higher value) organisational and technological actions aimed at more efficient use of energy resources may lower annual consumption by 40-48 percent or 360-430 mln tce. The energy industry accounts for approximately 33 percent of these potential savings, another 33 percent comes from other industrial sectors and construction, over 25 percent comes from housing and utilities, 6-7 percent from transport and three percent from agriculture.

Approximately 20 percent of the energy efficiency potential or 70-85 mln tce per year may be implemented for a maximum US$15 per tce, which is the current price for heating fuel. The most costly activities (at over US$60 per tce) account for approximately 15 percent of the energy efficiency potential.

The implementation of measures in the price range US$15-60 per tce, which account for the remaining 66 percent of energy saving potential (220-280 mln tce per year) and which are comparable to the estimated structural energy savings, will require considerable dedicated investments of US$7-17 billion in the period ending in 2010 and US$25-50 billion during the following decade.

The Energy Strategy envisages the creation of economic, organisational and administrative conditions for the quickest possible implementation of measures that are economically justified to achieve higher energy savings. The size of this part will be determined by price and tax policies.

Table 2 summarises the energy savings targets for the Russian economy in 2000-2020.

Table 2 Russia. Energy savings forecast (against 2000)

Year	Total mln tce	Including electricity bln kWh
2005	30-55*	20-40
2010	105-140	60-130
2015	185-200	130-230
2020	300-420	190-300

**: minimum*

Source: Energy Ministry of Russia (2001)

TECHNICAL ASSESSMENT

Technological progress is the main driver of energy efficiency improvements and the main tool to achieve energy savings. The difference in energy consumption between existing equipment and new efficient equipment represents a technical potential for energy savings.

First, the new energy efficient technologies should be identified. An APEC-wide study on energy conservation technologies has been carried out by the Energy Conservation Center, Japan [ECCJ, 2000]. It has identified technologies available to retrofit existing equipment in various industries to make it use less energy. Technical parameters of energy savings have been reported.

But the practical implementation of these technologies requires an on-site assessment in each case. The main problem is to assess the technical and economic characteristics of existing physical stock and to find opportunities for renovation. Such a task is nationally and sector-specific and requires detailed bottom-up studies.

The general tool for a technical assessment is an energy audit. Energy audits estimate the current status of energy consumption and identify a range of measures to reduce energy demand. These measures can be either mandatory or voluntary, depending on national regulations. On-site energy audits in factories are usually carried out for this purpose. In residential and commercial sectors, energy audits in buildings provide similar information.

But in transport (with the focus on road transport, accounting for 80-90 percent of total sectoral energy demand) the actual working approach is to set up fuel use standards for newly produced cars and trucks. A good example here is the US CAFE standards.

ECONOMIC EVALUATION OF ENERGY EFFICIENCY MEASURES

Energy savings can be practically achieved only if they are economic. Therefore, economic feasibility is a necessary component in assessing energy savings.

Installing new energy-efficient equipment provides an opportunity to minimise operating costs related to fuel and electricity consumption. This can be included in the same initial capital investment needed to replace the existing equipment. Overall economic feasibility of energy efficiency measures can be determined by conventional cost-benefit analysis. Such analysis weighs benefits against costs over the life cycle of the measure.

For energy efficiency projects, commonly used indicators of economic feasibility are net present value (NPV) and simple payback period (SPP) of proposed measures.

Net present value represents the sum of all discounted annual benefits less costs over the life cycle of a project implementing energy-saving measures:

$$NPV = \Sigma^{N}_{i=1} (B_i - C_i) / (1 + d)^i \quad (1)$$

where:

B_i is project benefits in year “i” mainly the price of the saved energy,

C_i is capital, operation and maintenance costs in year “i”,

“d” is a sector-specific discount rate, reflecting the cost of capital,

N is the lifetime of the project.

Positive NPV indicates the project is economically viable.

The simple payback period is defined as the number of years required to cover initial investment costs (I_0) by average discounted revenues (R_{av}) generated in the project:

$$SPP = I_0 / R_{av} \quad (2)$$

The benchmark SPP should be set up according to specific conditions in a national economy and the sector where the project is being implemented. In practice, values usually vary from two to five years.

ENERGY CONSERVATION SUPPLY CURVE

Identification of the ‘cost of conserved energy’ is a useful variation of the NPV approach. Here, the overall costs of the saved energy are compared with the average price of fuels or electricity. Energy savings are cost-effective (or economic) when their unit cost is less than the price of energy. Such a criterion provides a more visible comparison with the cost of alternative additional energy supply options.

Box 2 illustrates this approach with a sector-wide study by LBNL [Worrell *et al*, 1999] analysing energy savings in US steelmaking.

Box 2. Energy conservation supply curve for US steelmaking

A conservation supply curve ranks energy efficiency measures by their ‘cost of conserved energy’ (CCE), which accounts for both the cost associated with implementing and maintaining a particular technology or measure and the energy savings associated with that option over its lifetime.

$$CCE = \frac{\text{Annualised Investment} + \text{Annual Change in O\&M Costs}}{\text{Annual Energy Savings}}$$

$$\text{Annualised Investment} = \text{Capital Cost} \times d/(1-(1+d)^{-n})$$

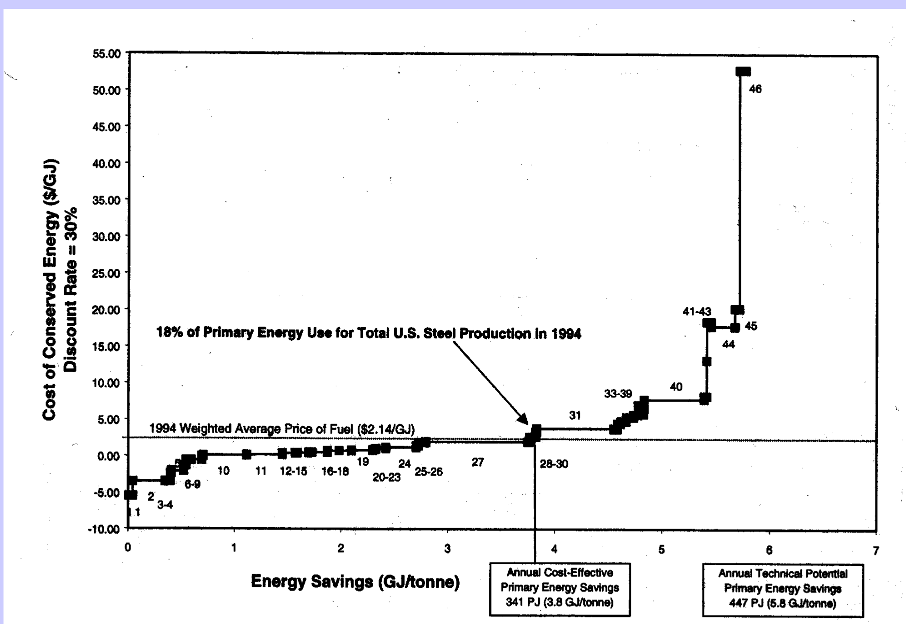
where ‘d’ is the discount rate and ‘n’ is the lifetime of the conservation measures.

CCE are calculated for each measure that can be applied in a particular sector or sub-sector and then ranked in order of increasing CCE [Koomey et al., 1991]. Once all options have been properly ranked, a conservation supply curve can be constructed. Defining 'cost-effective' involves choosing a discount rate that reflects the desired perspective (such as customers, society). Then all measures that fall below a certain energy price, such as the average price of energy for the sector, can be defined as cost-effective.

The CCE are plotted in ascending order to create a conservation supply curve (Figure 2). This curve is a snapshot of the total annualised cost of investment for all efficiency measures being considered at that time. The width of each option or measure (plotted on the x-axis) represents the annual energy saved by that option. The height (plotted on the y-axis) shows the option of CCE.

The energy conservation supply curve for total steelmaking in the US shows that the cost-effective energy saving was 341 Petajoules in 1994, which represents 18 percent of primary energy use for total US steel production. Some of the largest cost-effective energy savings appear possible with measures such as: preventive maintenance, coal injection into blast furnaces and improved monitoring and control systems for blast furnaces and rolling mills.

Figure 2 Energy conservation supply curve for total steelmaking



Source: Worrell et al, 1999

As we have seen, the energy savings potential assessment for the iron and steel industry was the result of a nationwide survey and analysis covering dozens of technological measures. It is essentially a bottom-up study, summarising information about commercial implementation of new technologies and then aggregating it to the whole sector level.

The ideal for each measure is that the full life cycle assessment should be carried out in energy and monetary terms. That is, a financial assessment of all capital costs, as well as operating and maintenance costs, accompanied by an energy audit.

SECTORAL ENERGY SAVINGS POTENTIALS

An energy savings assessment in macroeconomic sectors, such as industry, transport, residential and commercial, requires one more step up in the aggregation level. In order to cover the whole range of emerging technologies it should be based on wide bottom-up surveys.

Selective energy audits represent the necessary action at the bottom level, but the data collected is fragmented and should be aggregated to the sectoral level. That is a general approach to estimate the energy-efficiency component of energy savings in macro-sectors.

Within sectors, changes in structure can be analysed based on detailed statistical data on economic activity. Potential savings from a less energy-intensive structure can be estimated if an explicit economic development policy has been formulated.

There is a big difference between energy audits in factories or buildings and energy savings in macro-sectors (or even sub-sectors). It is determined by the different nature of micro-economic and macro-economic assessments. To bridge this gap, specially designed studies are needed on a national level.

Here we present some results of sectoral bottom-up studies on potential energy savings assessment. They are estimates of cost effective energy savings, that is, economic savings.

In Korea, the Council on Energy and Environment estimated potential energy savings in industry of 25 percent, transport 28 percent, residential and commercial 35 percent up to 2020 [CEE, Korea, 2001].

In Russia, the Energy Ministry estimated potential energy savings in industry of 31-33 percent, transport 6-7 percent, residential 26-27 percent of current energy consumption [Energy Ministry of Russia, 2001].

In Thailand, the National Energy Policy Office estimated potential energy savings in industry of 30 percent, transport 56 percent, and residential and commercial 6-7 percent [NEPO, 2000].

Chapter 3 provides more specific examples of energy savings estimates in different sectors of APEC economies.

CONCLUSIONS

Energy savings can be achieved by structural changes to less energy-intensive activities in a national economy and by energy efficiency gains.

Energy efficiency improvements are mainly due to technological progress and can be realised by implementing new and more efficient technologies.

Potential energy savings can be assessed through national sector/technology-specific surveys. Energy audits represent a microeconomic basis for such studies. They should be accompanied by financial audits in order to determine economic parameters. Economic feasibility parameters for energy savings measure net present value compared with average end-use energy price.

Energy savings assessment methodology comprises identification of technological energy savings in absolute values, penetration rates of new technologies, then re-aggregation to the sectoral level.

A gap of information and methodology exists between the macroeconomic and microeconomic assessments of energy savings.

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CHAPTER 3

INDICATION OF ENERGY EFFICIENCY

OVERVIEW

There is no standardised set of data or indicators used widely for monitoring the progress of energy efficiency. Generally, the indicators chosen depend on the specific phenomena to be reviewed by analysts. Studies made by international organisations on energy efficiency have used indicators that allow useful comparisons of energy use trends between different countries. APERC conducted and published such a study in 2001. The selection of indicators used, however, is not consistent and changes from study to study. This is due in part to the fact that the dependencies among key drivers or policies and actual energy use vary greatly between regions or countries. Analyses have also shown that the factors or drivers influencing energy efficiency change over time as a result of technology, historical events, and changes in regional conditions and general human behaviour.

The purpose of this chapter is to review the data and indicators generally used to assess energy efficiency in the major sectors of economic activity: residential/commercial, industry and transport. The information that can be derived from their use will also be discussed. Recommendations on which indicators are best-suited to monitor efficiency in the APEC region will be made in each of the sections discussing individual sectors.

INDICATORS OF ENERGY EFFICIENCY

Energy use can be quantified using 'extensive' quantities, such as total energy consumed, or total consumption of a given fuel. 'Intensive' quantities, which are extensive quantities divided by a normalising factor or data number, are more useful for comparison purposes. Energy intensity, or energy use in a sector divided by gross domestic product (GDP), is such a quantity and is widely used to investigate differences in the efficiency of final energy use by sector, country or period.

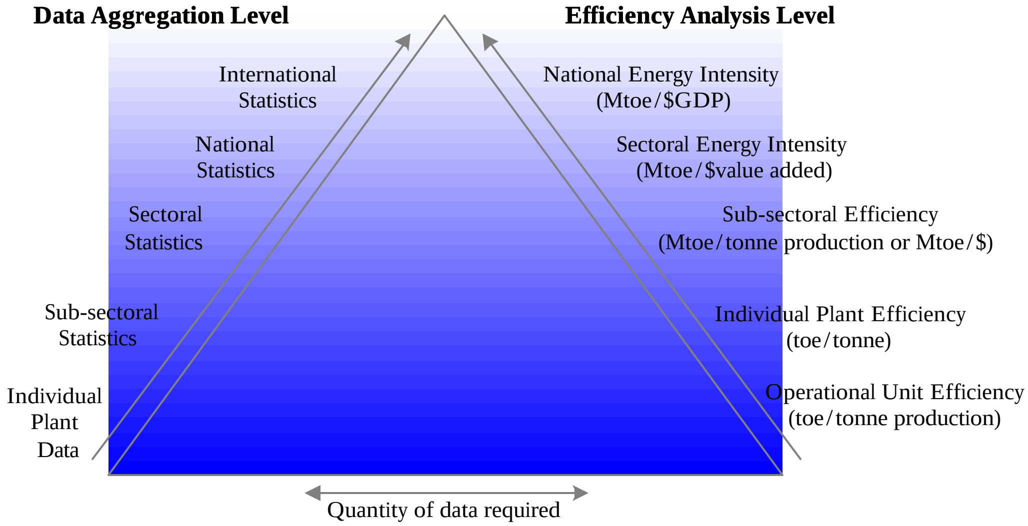
As explained in 'Chapter 2: Methodology' of APERC's Energy Efficiency Indicators 2001 report [APERC, 2001], indicators of energy efficiency can be constructed from a complete range of data that can go from aggregated international or national statistics all the way to output data from individual operating units within a plant. A pyramid diagram, Figure 3, explains this methodology.

The pyramid portrays a hierarchy of energy indicators, from least detailed on top to most detailed at the bottom. The top element might be the ratio of energy use to GDP. The second row of elements might be the energy intensities of each sector. The bottom layer can be data as specialised as energy output from individual units of a power plant.

At the highest levels of aggregation, few indicators of energy intensity can be constructed. Here it is difficult to isolate a particular effect from a given cause, due to the aggregation of both causes and effects.

This hierarchy is important because it permits the analyst to relate very small elements from below, which may be the direct object of policies, technological progress, structural reform, or behavioural change, with higher-order, more aggregate quantities, showing how changes in the former are related to changes in the latter. With this hierarchy one can better explain more aggregate changes in energy use in terms of components, and more carefully choose the depth of analysis required. That choice depends on the questions that need to be asked.

Figure 3 Energy efficiency indicator pyramid



Source: Phylipsen *et al*, 1998

When using the energy use/GDP ratio, however, the limits to its application for a particular situation should be understood. The inappropriateness of using this ratio for analysing the impact of changing energy use over time is made clear by the IEA in its energy use and efficiency study [IEA, 1997]. This particularly applies when analysing the impact of changing technology, efficiencies and energy intensities over energy use. The difference in the ratio among countries and over time is a complex function of many components. The study, which was conducted on data only from IEA countries, shows that for some countries the change in the ratio is dominated by structural changes, while in others changes in individual energy intensities dominate. In one-third of the countries shown, both kinds of change contribute, and the ratio is also influenced by fundamental changes in the way electricity is supplied in each country [IEA, 1997].

A sector's energy use, divided by gross domestic product (GDP), is the starting point for understanding differences in the efficient use of final energy by sector, country or period. With few exceptions, such analyses have been carried out over long periods only in OECD countries. These ratios are instructive for what they say about energy use in different economies at a given point in time. They can also be used to measure changes in energy efficiency and other components of energy use, such as changes in the structure and consumption of a given sector or sub-sector. Changes in energy efficiency are driven by higher prices, technical improvements, new technologies, cost competition and energy conservation programmes [UNDP/UNDESA/WEC, 2000].

Another issue to take into consideration when defining the use of specific efficiency indicators is that traditional relationships among key factors do not behave in the same manner over time.

With the development of new strategies to reduce the use of energy, new indicators can be defined which are better suited to describe the results of their application.

New indicators can be defined that will better show the results of present strategies to reduce the use of energy.

3.1 INDUSTRY

ENERGY EFFICIENCY INDICATORS FOR THE INDUSTRY SECTOR

Indicators of energy efficiency in industry can be constructed by comparison of energy end-use and corresponding economic activity data in monetary and physical units. Time series ratios between these two variables identify the trend in energy efficiency. For each individual economy they provide an indication of an improvement or deterioration in energy efficiency.

Comparisons among countries can be made by using purchasing power parity. This reflects (to some extent) the general price level and peculiarity of value-added composition in each economy [APERC, 2001].

Recommended energy efficiency indicators for industry include the energy intensity of industry and manufacturing, specific consumption of steel, cement and paper, the energy intensity of industry in a constant structure, and the energy intensity of industry in a reference structure.

- **ENERGY INTENSITY OF INDUSTRY AND MANUFACTURING**

The energy intensity of industry or manufacturing is defined as the ratio between the final energy consumption of the branch being considered (measured in energy units: toe, Joule, etc) and the value added, measured in US dollars at 1995 purchasing power parity. Table 3 illustrates the dynamics of industrial energy intensity in APEC economies.

Table 3 Energy intensity in industry, APEC economies, [kgoe/$1995ppp]

	1980	1990	1995	1999
Australia	0.211	0.190	0.187	0.185
Canada	0.320	0.302	0.312	0.298
Chile	0.129	0.126	0.127	0.135
China	0.643	0.404	0.219	0.140
Hong Kong, China	0.059	0.058	0.065	0.056
Indonesia	0.235	0.235	0.201	0.210
Japan	0.166	0.116	0.113	0.110
Korea	0.227	0.152	0.165	0.175
Malaysia	0.128	0.126	0.113	0.115
Mexico	0.201	0.221	0.229	0.175
New Zealand	0.168	0.238	0.256	0.260
Peru	0.046	0.052	0.034	0.055
Philippines	0.040	0.040	0.054	0.050
Russia	n.a	n.a	0.465	0.382
Singapore	0.060	0.158	0.124	0.160
Thailand	0.080	0.074	0.092	0.075
United States	0.298	0.255	0.256	0.235

Source: APERC, IEA, DRI-WEFA, WB

- **SPECIFIC CONSUMPTION OF STEEL, CEMENT AND PAPER**

This unit consumption is calculated as the ratio between the final energy consumption of the industries and their output measured in tons.

Energy savings potentials in iron and steel and cement industry

Potential energy savings can be directly estimated in industries with bulk homogenous output, such as iron and steel and cement. The key feature here is that there is an international 'best practice' level in unit energy consumption. Comparing actual unit consumption with such a benchmark enables us to obtain the difference value which in relative terms (related to a benchmark level) means the amount of energy that could be saved in percentage terms.

This kind of estimate has been reported in APERC's 2000 study 'Energy Efficiency Indicators for Industry in the APEC Region' [APERC, 2000].

- **ENERGY INTENSITY OF INDUSTRY IN A CONSTANT STRUCTURE**

The intensity in a constant structure of industry or manufacturing reflects the variation of energy intensity, assuming a constant structure of value added, between the various branches or sub-branches, for a reference year, so as to leave out the influence of structural changes.

The Divisia method is the usual method to separate out what is due to structural changes from what is due to changes in sectoral intensities in the variation of energy intensity of an industrial or manufacturing sector (or of an aggregate branch).

The Divisia method is applied on a yearly basis and decomposes the growth rate of the intensity of manufacturing between year t and t-1 into two growth rates. The first measures the influence of structural changes, and the second measures the influence of changes in sectoral intensities.

Changes in intensity in a constant structure result from variations in sectoral intensities; they provide a good indicator of the overall energy efficiency trend in industry or manufacturing (or within a branch).

Differences in variations of intensity and intensity in a constant structure are due to intensity changes: the larger the discrepancy, the greater are the intensity effects.

- **ENERGY INTENSITY OF INDUSTRY IN A REFERENCE STRUCTURE**

The final energy intensity of an industry in a reference structure represents a fictitious value of final intensity of the industry, which is calculated by taking the actual sectoral intensity for mining, construction and manufacturing and the structure (meaning the share of mining, construction, and manufacturing in the value added of industry) of the reference economy (the EU average for instance). For manufacturing, intensity is taken to mean the intensity of a reference structure.

ENERGY SAVINGS POTENTIALS IN APEC ECONOMIES IN THE INDUSTRY SECTOR

The Economic Potential of Energy Efficiency (Selected Economies)

1. North America

The United States and Canada have higher energy consumption per capita than any other region. They share several characteristics (large size, low energy prices) but differ substantially (climate). In both economies, studies have assessed the potential for increased energy efficiency by 2010.

Table 4 provides a summary of bottom-up technology explicit studies assessing economic energy savings potential in various industries in Canada and the United States (WEC, UNDP, UNDESA 2000).

Table 4 Economic energy efficiency potentials in North America, 2010

Sector	Economic potential (percent)		Energy price level assumed	Base year	Source
	United States	Canada			
Iron and steel	4-8	29	United States: scenario for price development Canada: price scenario by province	United States: 1995 Canada: 1990	United States: Interlab, 1997; Brown and others, 1998; Romm, 1999 Canada: Jaccard and Willis, 1996; Bailie and others, 1998
Aluminium (primary)	2-4				
Cement	4-8				
Glass production	4-8				
Refineries	4-8	23			
Bulk chemical	4-9	18			
Pulp and paper	4-8	9			
Light manufacturing	10-18				
Mining	n.a	7			
Industrial minerals	n.a	9			

Source: WEC, UNDP, UNDESA (2000)

2. China

In 1995, the iron and steel industry consumed 3,740 PJ, accounting for 13 percent of China's final energy use with 46 percent energy efficiency. Energy consumption per tonne of steel will likely fall from 44 PJ in 1995 to 35 PJ in 2010, which is a little higher than the level in industrialised countries in the 1970s. Potential efficiency savings in some other energy-intensive branches are higher – construction materials could achieve 20 percent and chemicals up to 30 percent, with particular savings in production of basic chemicals such as ammonia, sulphate, soda and carbide.

Table 5 provides estimates of cost efficient energy savings in China's industries (WEC, UNDP, UNDESA 2000).

Table 5 Economic energy efficiency potentials in China, 2010

Sector	Economic potential (percent)	Energy price level assumed	Base year	Reference
Iron and steel	15-25	Today's price	1995	Hu, 1997
Cement	10-20	Today's price	1995	Hu, 1997
Foundries	8-14	Today's price	1995	Hu, 1997
Pulp and paper	20-40	Today's price	1995	Hu and Jiang 1997
Textiles	15-28	Today's price	1995	Hu, 1997
Fertilisers	10-20	Today's price	1995	Hu and Jiang 1997
Aluminium	20	Today's price	1995	Hu and Jiang 1997
Brick kiln	32	Today's price	1995	Hu and Jiang 1997
Refineries	5-10	Today's price	1995	Hu and Jiang 1997
Ethylene	10-30	Today's price	1995	Hu and Jiang 1997
Calcium carbide	10-22	Today's price	1995	Hu and Jiang 1997
Sulphate	14-25	Today's price	1995	CIECC, 1997
Caustic soda	10-30	Today's price	1995	CIECC, 1997

Source: WEC, UNDP, UNDESA (2000)

3. Thailand

In 1995, the industrial sector consumed 16 Mtoe of energy annually, equivalent to 32 percent of total national energy consumption. By 2025, industrial sector energy demand is forecast to reach 64 Mtoe, or 41 percent of the total Business as Usual (BAU) national forecast for energy demand. This represents a three-fold increase in 1995-2025.

The three commercial energy sources together accounted for 64 percent of industrial energy consumption in 1995. Traditional biomass fuels account for another 27 percent of industrial fuel. These values are projected to shift only slightly to 65 percent and 24 percent respectively by 2025.

Energy efficiency potential

The Conservation Case was defined to include efficiency improvements beyond those assumed for the BAU Case. The analysis revealed that the industrial sector would account for the second-largest source of demand-side efficiency after transport, with industry representing 30 percent of the additional conservation identified for the Conservation Case. Table 6 presents the sources of the industrial Conservation Case savings, which occur primarily with electricity, coal, and traditional fuels. These account for 54, 100 and 61 percent, respectively, of Thailand's entire energy savings for each of those energy sources.

Table 6 Thailand, industrial sector projected demand and conservation case savings, 2025

Fuel	Industrial BAU Demand (ktoe)	Industrial Energy Savings – Conservation Case (ktoe)	All-Sectors' Conservation Savings (ktoe)	Industrial Share of Total Efficiency (%)
Coal	16,814	1,873	1,873	100
Fuel oil	14,191	728	836	87
Traditional fuels	15,466	1,315	2,159	61
Electricity	11,173	2,828	5,242	54
Gas	3,541	142	142	100
Motor fuel	1,768	0	0	0
LPG	1,189	52	(287)	n.a.
Other (mostly transport)			13,017	0
TOTAL	**64,141**	**6,938**	**22,982**	**30**

Source: NEPO, Thailand, 2000

Table 7 presents a summary of industrial energy savings in the Conservation Case by industrial sub-sector. This indicates that the sub-sectors contributing the greatest conservation opportunities are cement (28 percent of industrial efficiency potential), food (25 percent), and textiles (11 percent). Combined, these three industries account for 65 percent of the Conservation Case potential savings in the industrial sector.

Table 7 Thailand, energy conservation projections in industrial sector (by subsector, business-as-usual case minus conservation case, for the years 2015 and 2025)

Usage Type	2015 (ktoe)	Percent of Total Efficiency (%)	2025 (ktoe)	Percent of Total Efficiency (%)
Subsector				
Food	1,088	29.3	1,742	25.1
Textile	392	10.6	769	11.1
Paper	85	2.3	152	2.2
Chemicals	263	7.1	553	8.0
Equipment	284	7.7	600	8.7
Other	519	14.0	862	12.4
Energy-intensive				
Cement	945	25.5	1,976	28.5
Steel	131	3.5	282	4.1
Total - All uses	3,706	100.0	6,938	100.0
BAU Base demand	39,571		65,249	
Eff. as percent of base	*9.4%*		*10.6%*	

Source: NEPO, Thailand, 2000

4. Viet Nam. Energy Efficiency Programmes in Industry

The Energy Conservation and Efficiency (EC&E) programme in Viet Nam was started in 1995 by the Project Office for Master Plan for EC&E under the Ministry of Science, Technology and Environment (MOSTE).

Major opportunities for energy conservation in Viet Nam were identified for short-term improvements (15 percent savings), and for the long term, mainly in the cement industry (50 percent), the ceramics industry (35 percent), and coal-fired power stations (25 percent). Long-term improvement measures of similar magnitude are identified in most branches of the larger state-owned industries, where the average efficiency of old boilers is only 50 percent and could be up to 90 percent.

In the electric power sector, big opportunities were identified for energy conservation and for reduction of the peak load, better known as demand-side management. Primarily, replacement of incandescent lighting with fluorescent lighting will bring about a substantial reduction in the peak load in the early evening. Implementing the demand-side management programme will delay or avoid investment in the equivalent of a 200 MW power station. Further improvements are identified in industry, where 50 percent of electricity is used in the 88 largest factories, with savings potential of an average 30 percent.

Table 8 provides national estimates of energy efficiency potentials in industry.

Table 8 Energy efficiency potentials in Viet Nam's industrial sector

Sub-sectors	Short term Investment		Medium Term Investment		Long term Investment	
	Fuels (%)	Electricity (%)	Fuels (%)	Electricity (%)	Fuels (%)	Electricity (%)
Steel sector	6-8	3-5	3-4	2-3	15-20	2-3
Coal sector	3-5	2-3	5-7	2-3	15-20	2-3
Cement sector	15-18	4-6	12-15	4-6	50	15-17
Construction materials sector	15-18	-	15-20	-	30-40	-
Light manufacturing	10-12	5-7	11-13	3-4	10-12	5-7
Coal fired power plants	8-10		12-15		20-25	
Total industry	10-12	2-3	15-17	3-4	25-30	5-7

Source: Energy Conservation and Efficiency Use in Vietnam, MOSTE 1997

3.2 TRANSPORT

ENERGY EFFICIENCY INDICATORS FOR THE TRANSPORT SECTOR

In APEC, transport is the second-largest energy-consuming sector after the industrial sector, accounting for 29.8 percent of final energy consumption in 1999. Oil products dominate consumption in the sector, with a share of 96.2 percent, followed by natural gas with 2.3 percent.

In the latest Outlook produced by APERC in 2002, transport is expected to show the fastest growth among final consuming sectors, increasing its energy demand by 76 percent (2.7 percent per annum) in 1999-2020. The strongest growth is expected in developing economies, as a result of accelerated economic growth and improving living standards.

Given the importance of transport as a large oil-consuming sector and as an influential industry in APEC economies, it is important to follow its trends in energy consumption. Decision makers are focusing attention on energy consumption trends in this sector. In terms of energy efficiency, any gain that can be achieved in consumption in this sector will have a significant impact on overall energy consumption.

TECHNICAL AND BEHAVIOURAL EFFICIENCY MEASURES

Efficiency in the transport sector can be achieved in two forms: technically and by the application of management measures.

Technical efficiency of transport vehicles is related to their engine performance in terms of energy consumption, to the aerodynamics of the vehicle, to its weight and power, and to any other technical characteristics of the vehicle that influence its specific consumption, such as its tyres.

Overall efficiency represents the amount of energy required to move a vehicle: it depends, in addition to the technical efficiency, on the driver's behaviour, the speed, the pattern of use of the vehicle (number of stops, distances) and the load, among other things.

At the macro level, for all vehicles in a country, another factor affects overall efficiency. This is the relative share between different types of vehicle. An increasing share of more powerful cars or larger cars in the total number of cars will, all other things being equal, decrease overall efficiency, and vice versa. Therefore, at the macro level, the overall efficiency of cars depends on their technical efficiency, on behavioural variables in the use of vehicles, and on consumers' preference for certain types of car, in terms of size, engine power, comfort, and equipment such as an air cooler. For trucks and light vans, the way the fleet of vehicles is managed, traffic congestion or the road situation, are additional variables in explaining the difference between overall and technical energy efficiency. Knowing whether an increase or decrease in energy efficiency stems from a technological or a behavioural change is important for the following reasons:

- Energy efficiency programmes aimed at modifying technologies and behaviours are different; therefore, dissociating these two factors gives a clearer picture of how effective the programmes are.
- To understand why energy efficiency is improving or worsening, it is important to know which factors are behind the trend, in order to define future actions and programmes more precisely [ADEME/ENERDATA, 1999].

Energy policies have focused principally on technology to reduce fuel use per km in new cars or improve traffic flows to reduce fuel consumption per km. Some transport and environmental policies have addressed ways of encouraging people to use cars less and other means of transport more. Energy planners have looked at these choices, but the measures adopted appear to have had relatively little impact in most economies.

To measure changes in energy use (or differences among economies) requires examination of the components of energy use: characteristics of vehicles, their utilisation, travel patterns, and energy use itself, all by mode. Technologies, behaviours, energy policies, and macroeconomic policy instruments (such as taxes on cars and fuel) all make changes in how people travel and how much energy is used, so indicators highlighting those components are necessary elements of policy analysis and formulation. Careful examination of non-technical parameters is important because of the likelihood that factors such as congestion, noise, fiscal policies, and parking problems will affect travel and in turn be affected by transport-related policies that do not address energy directly yet have a great impact on its use.

Although many transport and environmental policies are implemented locally or regionally, lack of data means most of this analysis must focus on national-level indicators. Any analysis of transport requires disaggregation into urban and non-urban transport, travel patterns of individual households, and utilisation patterns for certain types of cars and for buses or rail [IEA, 1997].

ENERGY INTENSITY OF TRANSPORT

There is no single, good indicator to grasp the overall efficiency trends in the transport sector, mainly because of the difficulty of separating out the energy used by the different modes of transport, especially road transport.

The indicator usually considered to provide the best overall picture is the energy consumed in the transport sector per unit of GDP. This energy intensity does not have the same status as for other sectors, as transport activities take place in all sectors and it is not possible to define a macroeconomic indicator of activity that is characteristic of the sector.

AVERAGE UNIT CONSUMPTION PER EQUIVALENT CAR

The drawback of evaluating average road transport consumption on a simple per vehicle basis is that all types of vehicles are put on the same level. Motorcycles, cars, pickups, trucks and buses are added together, with one motorcycle counting the same as one car. If, for example, the number of motorcycles is increasing more rapidly than the number of cars, the average unit consumption will decrease rapidly, since a motorcycle uses much less fuel than a car (by a factor of between 50 and 100). Any change in the composition of the stock of vehicles will affect the unit consumption, even if the vehicles do not change from a technical point of view (meaning there is no technical progress).

To understand how much of the variation in unit consumption can be attributed to structural changes in the composition of the stock of vehicles, a better indicator of energy efficiency is the unit of consumption per equivalent car. This relates the total composition of motor fuel to a fictional stock of vehicles, measured in terms of a number of equivalent cars.

The conversion of the actual stock of vehicles to the stock of equivalent cars is based on coefficients reflecting the average yearly consumption of each type of vehicle relative to that of cars. If a motorcycle consumes on average 0.2 toe/year and a car 1 toe/year, one motorcycle is considered equal to 0.2 equivalent cars. These coefficients can be derived from surveys (or estimates) of distances travelled and specific consumption (litres/100 km).

AVERAGE UNIT CONSUMPTION PER EQUIVALENT CAR AND AVERAGE PRICE OF FUEL

A comparison of unit consumption of gasoline or diesel per equivalent car to the average price of that fuel will show a definite influence of price over vehicle efficiency. However, price differences do not explain all the differences: lifestyles (such as size of cars, driving habits) and the degree of use of cars (average distance travelled per year) also play a key role.

In the case of diesel, the differences observed in unit consumption are mostly non-technical. The factors behind these differences are numerous: fleet management, the average size of vehicles (a higher share of diesel cars will decrease unit consumption), and in some cases the refuelling of vehicles in transit between economies (which is included in domestic consumption). These factors can be influenced by different levels of diesel prices, as well as by different regulations and practices.

In the case of combined gasoline and diesel consumption, differences observed could be due to other factors not directly linked to prices, such as different degrees of use of vehicles (behavioural/managerial factors), and different mixes between gasoline and diesel [WEC, 2000].

FREIGHT TRANSPORT

The structure of the freight sub-sector is made up of the same kinds of elements as travel: stock of vehicles, their characteristics and the distances they travel, the characteristics of freight (analogous to the purposes of trips in travel), the quantity of freight (in tonnes lifted), and utilisation measured as freight haulage in tonne-km. Also important are modal choice (ship, air, rail, truck), fuel choice, fuel intensity and model intensity. As with travel, all these elements serve to explain both changes in freight energy use over time and differences among economies.

Freight haulage is the level of activity or volume, or literally the 'output', of each freight transport mode, usually measured in tonne-km, which indicates both the weight of freight and the distance it is moved. Further division into piece goods (such as packages) and bulk goods (such as coal, or ore) is important, since the latter are more likely to fill a vehicle to capacity.

Vehicle activity is an indirect indicator of freight activity. Truck vehicle-km, or railcar-km, coupled with average capacity in tonnes, gives important indicators of the capacity to haul freight. While train-km and even ship-km can be defined, they are usually not important indicators of energy use because of the wide variation in how much of a train's or ship's capacity is used. Tonne-km of capacity tells more about what could have been hauled for the vehicle movements that actually occurred. Vehicle-km or tonne-km of potential haulage is more closely related to efficiency of energy use because of the direct relationship between a vehicle's characteristics and energy use.

'Tonnes lifted' measures the weight of freight hauled, regardless of distance. The drawback with tonnes lifted is that energy use is related to both weight and distance. As an indicator it is also ambiguous: if two modes are involved in sending a shipment, that shipment is 'lifted' twice. But knowing tonne-km and tonnes allows an estimate of the average distance a tonne is shipped by a given mode. This indicator can show the role of different modes in shipping different kinds of goods. It also shows how much bulk is actually moved in any economy.

Haulage distance can be estimated as the ratio of tonne-km to tonnes by mode and type of goods. Although there is much overlap, trucks haul goods the shortest distances, ships usually the longest, and rail in between, depending on the country's geography. Similarly, different kinds of goods are hauled different distances [IEA, 1997].

RECOMMENDED ENERGY EFFICIENCY INDICATORS FOR TRANSPORT

Following is a list of indicators suggested for a basic analysis of efficiency trends in the transport sector. An elemental analysis of energy efficiency in the transport sector should, at a minimum, include indicators similar to these. The sophistication of the analysis will suggest the need for other more specific indicators to be developed. An example would be an analysis of the results of a specific implemented policy.

Vehicle use and capacity

The following indicators are for evaluating vehicle use or traffic in terms of distances travelled and hauled capacity. ADEME/ENERDATA, in their joint study 'Energy Efficiency Indicators: The European Experience' [ADEME, 1999], suggest that indicators should allow the analysis of the technology effect, which measures the energy savings from a technical origin, and of the behavioural effect, which measures energy savings due to modifications in the use pattern, such as the driver's behaviour, annual car use or fleet management. For this reason, traffic should be expressed in terms of capacity offered and in terms of capacity utilisation. The first indicator (seat-km, tonne-km) represents technical efficiency. The second, consumption per actual traffic unit, will in addition reflect the influence of capacity utilisation and of organisational and management factors. 'Offered' or 'gross' refers to the available traffic capacity in the fleet. 'Demanded' and 'hauled' refer to the capacity actually used. The indicators for 'air freight ton-km offered' and 'marine freight ton-km offered' are not included as these are usually unavailable. Units are as indicated.

Km travelled - Small vehicles (motorcycles, motor tricycles)
Km travelled - Cars
Km travelled - Light trucks (pickups, SUVs)
Freight trucks ton-km offered
Freight trucks ton-km hauled
Passenger bus seat-km offered
Passenger bus actual passenger-km demanded
Air passenger seat-km offered
Air passenger actual passenger-km demanded
Air freight ton-km hauled
Rail passenger seat-km offered
Rail passenger actual passenger-km demanded
Rail ton-km offered
Rail ton-km hauled
Marine passenger seat-km offered
Marine passenger actual passenger-km demanded
Marine ton-km hauled

Energy use by mode

The indicators that follow are for analysing the total amounts of energy used in each mode in a year. Units will usually be energy units such as litres or Joules.

Small vehicles annual energy consumption
Cars annual energy consumption
Light trucks annual energy consumption
Freight trucks annual energy consumption
Passenger buses annual energy consumption
Airlines passenger domestic and international annual energy consumption
Airlines freight domestic and international annual energy consumption
Rail passenger annual energy consumption
Rail freight annual energy consumption
Marine freight annual energy consumption
Marine passenger annual energy consumption
Pipeline annual energy consumption

Energy efficiency

These indicators use the information obtained in the previous lists to calculate the specific consumption per type of vehicle and activity, allowing an analysis of efficiency trends in every type of transport activity. Units similar to those indicated are used.

Small vehicles specific consumption in km/litre
Cars specific consumption in km/litre
Light truck specific consumption in km/litre
Freight trucks specific consumption in km/litre
Passenger buses specific consumption in seat-km offered/litre
Passenger buses specific consumption in seat-km demanded/litre
Air passenger specific consumption in seat-km offered/litre
Air passenger specific consumption in seat-km demanded/litre
Air freight specific consumption in ton-km /litre
Rail passenger specific consumption in seat-km offered/Joule
Rail passenger specific consumption in seat-km demanded/Joule
Rail freight specific consumption in ton-km hauled/Joule
Marine freight specific consumption in ton-km hauled/Joule
Marine passenger specific consumption in seat-km/Joule
Fuel transport by pipeline specific consumption in quantity transported/Joule

Carbon emissions

Growing awareness of global emissions dictates that greenhouse gas emissions generated by transport activity be quantified, and that the trends be followed closely in the future. Detailed emissions information is not readily available from a number of economies. In some cases, emission factors can be used for their calculation using the total energy consumption data above. The following list is for total annual emissions per type of transport activity in units of carbon.

Emissions from small vehicles in tons of C
Emissions from cars in tons of C
Emissions from light trucks in tons of C
Emissions from freight trucks in tons of C
Emissions from passenger buses in tons of C
Emissions from air in tons of C
Emissions from rail in tons of C
Emissions from marine in tons of C
Emissions from pipeline in tons of C

Macroeconomic indicators

This is the suggested disaggregation for macroeconomic indicators to determine energy intensity relative to total GDP.

Road personal (small vehicles, cars, light trucks) energy per GDP
Road commercial (trucks) energy per GDP
Road passenger (buses) energy per GDP
Air passenger energy per GDP
Air freight energy per GDP
Rail passenger energy per GDP
Rail freight energy per GDP
Marine passenger energy per GDP
Marine freight energy per GDP

ENERGY SAVINGS POTENTIAL IN APEC ECONOMIES IN THE TRANSPORT SECTOR

Following are tabular summaries (Tables 9-13) of potential savings in the transport sector in different countries presented in the World Energy Assessment prepared jointly by the UNDP, the UNDESA and the WEC. Those shown are the regions that include APEC economies. Other regions, such as Western Europe, are also shown for reference due to their leadership role in the future technology and management of traffic matters.

Table 9 Economic energy efficiency potentials in Western Europe, 2010 and 2020

Item	Economic potential (%)		Price level assumed	Base year
	2010	2020		
Cars	25		Year 2000 prices	1995
Door to door integration	4			1995
Modal split of freight transport		3*		1995
Trains and railways		20	Year 2000 prices	1999
Aircraft, logistics	15-30	25-30	Year 2000 prices	1998

* Refers to final energy use of the entire sector

Efficiency improvement in cars shown will be due to technological measures agreed to by the association of European car manufacturers. Door-to-door integration refers to efficiency improvements brought about by the integration of railways and transport companies across borders in Europe. Modal split refers to an expected shift of freight from road to rail due also to railway integration. In the aircraft business, logistical changes are expected to improve traffic, although this is not expected to compensate for the growth in air transport mileage.

Table 10 Economic energy efficiency potentials in the US and Canada, 2010

Item	Economic potential (%)		Price level assumed	Base year
	US	Canada		
Passenger cars	11-17		US: scenario for price developments*	US: 1997
Freight trucks	8-9			
Railways	16-25			
Airplanes	6-11		Canada: price scenario	Canada: 1990
Overall	10-14	3		

* The scenario assumes a 1.2 percent annual increase in oil prices from 1997 levels

For the United States, the lower overall limit corresponds to the efficiency that will be achieved in a business-as-usual scenario, and the higher limit is the result of a higher efficiency/low carbon scenario according to an Interlaboratory Working Group in 1997. In Canada, large transport demand growth and the high price of efficient technologies combine for poor savings.

Table 11 Economic energy efficiency potentials in Japan and Southeast Asia, 2010 and 2020

Item	Economic potential		Price level assumed (US cents/kWh)	Base year
	Japan 2010 (%)	Southeast Asia 2020 (PJ/year)		
Transport		2,275		1992
Compact cars	1.8		0.044	1990
Buses	0.2		0.196	1990
Trucks	2.8		0	1990
Compact cargo vehicles	13.7		0	1990
Within cities:				
Vehicles	7		0.01-0.06	1990
Buses, trucks, cargo vehicles	14		0.01-0.06	1990
Passenger cars	0.3		0.06	1990

Transport is the largest consumer of energy in Japan and Southeast Asia. Demand continues to grow due to a shift to larger cars. Policies are in place to raise efficiency and subsidise hybrid vehicles. An electric mass transit system under construction in Thailand, a switch to natural gas in city buses and the use of fuel cells after 2010, are policies considered in the rest of Asia.

Table 12 Economic energy efficiency potentials in Russia, 2010

Item	Economic potential	Price level assumed	Base year
Transport	967-1,172 PJ/yr	1995 levels of EU	1995
Trains	10 – 15%	1995 levels of EU	1997

Ambitious programmes for safe, comfortable and more efficient transport in Russia will be difficult to achieve unless the necessary financial support is obtained.

Table 13 Economic energy efficiency potentials in China, 2010

Item	Economic potential (%)	Price level assumed	Base year
Trains (diesel)	5-15	Year 2000 prices	1995
Trains (electric)	8-14	Year 2000 prices	1995
Cars	10-15	Year 2000 prices	1995
Vessels	10	Year 2000 prices	1995

Transport is a large and fast-growing energy consuming sector. By 2010, consumption will almost double. Transport has a low end-use efficiency of around 30 percent. Programmes include the following: increase the share of diesel vehicles, rationalise the weight of cars, increase road construction, improved propellers in ships and better ship shape design.

Economic energy efficiency potentials in Latin America

Two-thirds of Latin America's transport demand is concentrated in Brazil and Mexico, where road use represents 90 percent of the sector's consumption. Specific consumption of cars and freight transport in Mexico has decreased in the last 15 years, and this trend will continue. Subway systems have not grown at the same rate as passenger demand.

3.3 RESIDENTIAL AND COMMERCIAL

RESIDENTIAL ENERGY EFFICIENCY INDICATORS

For this sector, the main objective is to measure efficiency of energy end-use in buildings.

The residential sector is a final consumer of goods; output measures are not relevant to this sector. Therefore, energy efficiency indicators are constructed by comparison of energy and/or electricity consumption with the number of residents. Energy consumption in dwellings requires special statistical information and is available only for some OECD countries.

For services, energy and/or electricity consumption is related to the number of employees, the office floor area and value-added by the services. Floor area data is mainly unavailable, except for economies such as Japan and the USA.

Electricity consumption in the residential and commercial sector is characterised by special dynamics and the relevant indicators describe the efficiency of electricity end-use in buildings.

RECOMMENDED ENERGY EFFICIENCY INDICATORS FOR RESIDENTIAL AND COMMERCIAL SECTORS

- Energy consumption per capita, per unit of floor space
- Electricity consumption per capita for lighting and electrical appliances
- Energy consumption per dwelling adjusted to reference climate (time series in average temperature needed for each particular economy)
- Energy consumption of service sector per employee, per unit of floor area, per unit of value-added in services
- Electricity consumption of services per employee

ENERGY SAVINGS POTENTIAL IN APEC ECONOMIES IN THE RESIDENTIAL/COMMERCIAL SECTOR

Table 14 provides some quantitative estimates of energy efficiency potential in residential and commercial sectors in APEC economies [WEC, UNDP, UNDESA, 2000].

To realise potential energy savings, special targeted programmes should be implemented in residential and commercial sectors. Boxes 4 and 5 provide practical examples of practice in Thailand and Singapore.

Table 14 Economic energy efficiency potential in residential and commercial sector

Electricity by Sector	Potential for Saving (%) or petajoules (PJ)		Energy price assumption (US cents per kWh)	Base Year
	2010	2020		
Electricity in Residential				
USA	10 –53%		US scenario for price development	1995
Canada	13%			1990
Japan	20 – 75%			1995
Southeast Asia		20 – 60%	2.0 – 8.5	1995
China	10 – 40%		2.0 – 8.5	1995
Mexico	20 – 25%			1996
Electricity in Commercial				
USA	25%			
Canada	9%			
Mexico	40%			
Japan	240-280 PJ		2-5	
Southeast Asia		290 PJ	2-5	

Box 4. Energy conservation in Thailand's residential and commercial sector

One of the main objectives of Thailand's energy policy is to promote energy conservation. It has been intensively implemented since 1992 through the Energy Conservation Promotion (ECP) Act. This includes specific targets and strategic procedures.

The main end-users in Thailand's residential sector are divided into cooking, and lighting, cooling and other electrical uses. LPG, kerosene, charcoal, biomass and electric stoves are used for cooking. Lighting needs are met by electric and kerosene lamps. Cooling is powered by electricity, which is also used for appliances including refrigerators, water heaters, television, washing machines and clothes irons.

The end-users in the commercial sector are hotels, hospitals, banks, public buildings and public lighting. Activities in the commercial sector are identified as cooling, lighting, thermal use and other electrical appliances, and the demand energy is mainly electricity and fuel oil to produce hot water in hotels.

Energy conservation in the residential sector is measured based on efficient lighting and cooling, and higher-efficiency cooking stoves and electrical appliances. The same set of options regarding efficient lighting, cooling and electrical appliances can be applied to the commercial sector.

Based on the energy use described above, the potential for energy savings in the residential and commercial sector are as follows:

Lighting. Possible energy savings of more than 40 percent:

- Promoting replacement of 20 watt and 40 watt fluorescent tubes by more efficient 18 watt and 36 watt fluorescent tubes.

- Replacing less efficient 60 watt incandescent lamps with 11 watt compact fluorescent lamps.

Space heating and cooling systems. Possible energy savings 10-50 percent:

- Improving building structures.

- Using efficient space heating systems.

- Using efficient electric air conditioning. The present air conditioners have an average power rating of 1,667 watts, while the new efficient systems have 1,127 watts.

Other electrical appliances:

- Energy savings could be achieved through increased penetration of more efficient appliances. At present, the standard refrigerator has an energy rating of 485 kWh/year while efficient ones have a rating of 377 kWh/year.

Box 5. Singapore. Energy conservation in buildings

In 1994, Singapore conducted a technical programme through energy surveys and audits in order to:

- Collect information on energy use patterns of different consumer groups.

- Identify the energy efficiency potential of these groups.

- Formulate energy efficiency indicators, for example energy per square metre of air-conditioned area or energy use per guestroom for hotels.

The programme has identified the following levels of potential energy savings (Table 15).

Table 15 Potential savings in electricity use in the residential sector in Singapore

Electric appliances	House Development Board (HDB)	Private dwelling
Air conditioners	8%	33%
Refrigerators	37%	28%

Equipment identified for energy efficiency target:

- Air conditioning: Replace existing devices, improve chill operation, better insulation.

- Refrigeration: Target could be reached through replacement with water-cooled systems.

- Lighting: Replace incandescent light bulbs and use compact fluorescent lamps (CFL) or fluorescent tubes.

3.4 APEC ENERGY EFFICIENCY INDICATORS DATABASE

The APEC Energy Efficiency Database was constructed at the start of the APERC/ADEME /WEC collaboration to help APERC in its various studies of energy efficiency indicators, particularly in the industrial sector. It is now being updated to include 1999, so it will be a time series from 1980 to the year before the current year, and is to be updated continuously.

The work of updating in future years can hopefully be passed on to EDMC of IEEJ, so that APEC matters can be handled by staff who have the expertise and resources to improve it further if so desired. EDMC may also wish to incorporate it into the APEC Energy Database.

The objective of this exercise is:

1. Report on the Database.
2. Prepare or update it for handover to EDMC for their safe keeping as a contribution by APERC to APEC/IEEJ.

STRUCTURE OF DATABASE

Time series/Excel

The basic structure of the database is a time series beginning in 1980 to the year before the current year, and to be updated every year. Each economy is on a spreadsheet in Excel format.

Sources of data

Most data is sourced from IEA, APEC, the World Bank, ADB, AEEMTRC, other well-known data sources, and in some instances economy source where particular data is lacking.

Indicators

A remarkable feature added to the database is the generation of indicator calculations, which appear from row 122. These are vital to studying each economy's growth trends in the industrial sector, as well as agriculture, mining, quarrying and the power sector, where a lot of emphasis is concentrated in the drive for energy efficiency.

Size of database

The database occupies more than 2Mb of memory and can increase over time and with new requirements.

Accuracy of data

If there is a question as to any data's accuracy it should be reported at once to EDMC for verification.

CONCLUSIONS

The energy efficiency database has to be a tool that can be expanded and improved as we move ahead. APEC does not have many years of study in energy efficiency as compared with the European countries, therefore it is vital that the database be maintained and continuously improved.

The energy database currently being used at APERC does not include all data required for analysis of the evolution of efficiency trends in different economic sectors. A proposal has been made to include the identified indicators in the database and to solicit APEC economies provide information that will allow better analysis of efficiency trends. APEC economies are encouraged to provide this information and to expand the capabilities of the available data system.

Use of better fuel-efficient machinery, prime-movers for power generation and equipment, and cleaner and more efficient fuels are choices depending on the ability of an economy. Being aware of environmental concerns is vital to policy-makers in the APEC region.

It is also encouraging that APERC will carry on its collaboration with ADEME, OLADE and World Energy Council for future studies of energy efficiency.

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CHAPTER 4

OVERVIEW OF ENERGY EFFICIENCY POLICIES AND MEASURES IN SELECTED APEC ECONOMIES

The main drivers of energy efficiency policy are political or industrial, or a combination of both. In political policy, as each country understands its obligations in efforts to protect the global and local environment, it attempts appropriate measures to reduce its emissions of greenhouse gases (GHG). UN efforts on global climate conditions such as the Kyoto Protocol have contributed significantly to this process and will do so more in the future if the protocol is ratified. Regarding industrial policy, many governments are promoting innovative ideas and equipment to enhance energy efficiency. Many have begun using financial incentives such as rebates to ensure a greater impact in their economies.

Subsidies or incentives offered by government to involve key players in emission reduction efforts have also generated energy efficiency gains, such as through industries opting for more fuel-efficient or technologically improved equipment. Perhaps the end-use sectors which yield high gains or derive the greatest energy efficiency savings are the Industrial, Power Generation, Transport and Commercial sectors, because of a desire - for political reasons - to meet global environmental concerns.

Many economies have adopted energy efficiency policies and measures, but systematic information is only available for OECD economies. Since the oil shocks of the 1970s economies belonging to the International Energy Agency have gained significant experience in implementing energy efficiency programmes. Progress has also been made by several APEC non-OECD economies.

The good practice they have accumulated provides valuable lessons for other economies. The following is an overview of the current status of energy efficiency policies in Australia, Canada, New Zealand, Japan and the USA. Also included is a review of energy efficiency programmes and measures in Chile, Malaysia, the Philippines, Chinese Taipei and Viet Nam.

ENERGY EFFICIENCY POLICIES IN THE INDUSTRIAL SECTOR, DEVELOPED APEC ECONOMIES

The main target of energy efficiency in this sector has been renovation of technological equipment. Old equipment needs to be replaced in order to improve performance, leading to higher productivity. Some of the equipment may be regarded as too expensive to replace if the decision is left to companies alone. However, with financial incentives provided by government, companies are cooperating to enhance product improvements or technology and achieve higher energy efficiency. This seems to be a better solution for industry.

Table 16 summarises the efforts by each economy in its industrial sector. It is apparent that most of the economies have ongoing Energy Audit Programmes with continuous information dissemination systems using training and distribution of brochures, media and so on. Some have industries carrying out demand-side management in order to conserve energy and maximise output. Most have concerns about environmental safeguards.

The table shows how Japan is promoting energy savings by offering financial incentives or tax rebates. Furthermore, technological advances made by Japan (and other economies) may be transferred to developing economies that need to save energy by retrofitting more cost-effective equipment. In Japan's case there seem to be no clear indication of savings achieved so far, but these should become more apparent as policies already implemented have an effect.

Table 16 Energy efficiency policies in the industrial sector, developed APEC economies

Program Type	Australia	Canada	New Zealand	Japan	USA
Energy audits	X	X	X	X	X
Information dissemination	X	X	X	X	X
Demand side management	X	X	X	X	
Environmental concerns	X	X	X	X	X
Industrial concerns	X	X	X	X	X
Financial incentives				X	
Regulatory requirements				X	
Innovative incentives				X	
Possible drivers	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political
Duration results expected	Long term	Long term	Long term	Long term	Long term

Source: IEA (2001)

Australia and New Zealand follow closely in energy savings achievements. The USA is continuing many of its programmes despite its reluctance to ratify the Kyoto Protocol. It could be argued that it should maintain cooperation with the international community to reduce its GHG emission levels even if it disagrees with Kyoto targets, because safeguarding the global environment is largely the responsibility of industrial nations, which produced a major part of the accumulated GHG emissions in past industrial development.

ENERGY EFFICIENCY SAVINGS POLICIES IN THE RESIDENTIAL/COMMERCIAL SECTOR, DEVELOPED APEC ECONOMIES

The main opportunities for energy savings can be identified in the commercial rather than the residential part of this sector. Energy savings options in the residential sector are specific to household income levels. For economies with low to moderate income per capita, the concept of energy saving will be ingrained. For those with high income per capita, energy savings may not be of major concern, because it is easier to meet energy costs. This means that energy savings go along with income – if incomes are low, ways to save energy will be sought, but if incomes are high, savings will be less.

Table 17 summarises efforts by each economy in the residential and commercial sector. It is apparent from the table that most economies have building codes or standards for residential and commercial buildings. Energy labelling of consumer goods and household appliances may become common practice in the immediate future if mandatory standards are agreed by economies. There are also ongoing programmes to continuously disseminate information.

Table 17 Energy efficiency policies in the residential and commercial sector, developed APEC economies

Program Type	Australia	Canada	New Zealand	Japan	USA
Energy audits	X	-	-	-	-
Building codes/laws/standards	X	X	X	X	X
Energy labelling	X	X	X	X	X
Information dissemination	X	X	X	X	X
Environmental concerns	X	X	X	X	X
Residential/commercial concerns	X	X	X	X	X
Financial incentives			X		
Regulatory requirements					X
Innovative incentives					
Possible drivers	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political
Duration results expected	Long term	Long term	Long term	Long term	Long term

Source: IEA (2001)

For Australia in the Residential/Commercial sector, there are no indicative figures in terms of actual savings or savings potential to date as the programmes are still being evaluated, just started or are nearly due for evaluation. For New Zealand only Residential is considered, as Commercial is combined with Industrial.

NEW JERSEY STATE (US) ENERGY EFFICIENCY PROGRAMMES, CASE STUDY

CONSTRUCTION OF COMMERCIAL/INDUSTRIAL FACILITIES

There is a strict building code for developers, designers, engineers and contractors in any commercial/industrial construction.

Through the Building Operation & Maintenance (O&M) code, New Jersey hopes to create sustainable, market-driven improvements in the resource efficiency of operation and maintenance practices in existing commercial buildings and industrial facilities. To this end there is wide awareness and demand for resource-efficient building and O&M practices.

The Compressed Air programme is aimed at achieving significant energy savings from optimising compressed air systems in industrial facilities. The programme is geared towards small to medium-sized enterprises.

RESIDENTIAL SECTOR PROGRAMMES

The Residential HVAC-Electric programme promotes energy-efficient heating, ventilation and air conditioning (HVAC) equipment and is designed to transform the market to one in which quality installations of high efficiency equipment are commonplace. It promotes both the sale of high efficiency equipment and improvements in sizing and installation practices that affect operating efficiency. Rebates are offered for high-efficiency central air conditioners and heat pumps, and the programme is geared towards high gains in energy efficiency in central air conditioners and heat pumps.

The Residential HVAC-Gas programme is another example where use of energy-efficient HVAC equipment is encouraged based on energy labelling programmes, with financial benefits/incentives to attract wider community participation. Information dissemination is carried out by way of training offered to technicians and contractors for furnaces, boilers, programmable thermostats and efficient gas water heaters. Results are expected in the long term, and it is possible that energy labelling may become mandatory for many household appliances.

The Residential Low Income programme is directed at making achievement of energy efficiency affordable for low-income groups.

The Residential New Construction programme aims to ensure that new homes meet gradually improving energy efficiency standards in the long term.

The Residential Retrofit programme increases public awareness of energy end-use and energy efficiency. This will be accomplished in two ways. First, utilities will provide software tools to help customers assess both the efficiency of their energy use and opportunities for improving efficiency. Second, utilities will operate call centres to take questions from consumers on energy efficiency issues and refer them to other relevant programmes.

OTHER ENERGY EFFICIENCY PROGRAMMES

Through the Residential Air Conditioning Cycling Load Control Programme, certain utilities will continue to use air conditioner cycling strategies to free capacity on days when usage peaks.

Through the Schools Energy Efficiency & Renewable Education programme, utilities will make available to learning institutions resources and support for energy efficiency and renewable education initiatives (grants, materials, curriculum content, teacher instruction and services).

At present, more than a dozen programmes are being administered by New Jersey's seven investor-owned electric and gas utilities. They collaborate with the Natural Resources Defense Council to design, develop and implement programmes.

EVALUATION OF RESULTS

As of September 30, 2001, implementation of approved efficiency programmes had resulted in annual energy requirements for homes and businesses in New Jersey being cut by 35,429 MWh and 149,415 million Btu (23,000 ktoe). CO_2 emissions have been reduced by 17,714 metric tons annually. Additional savings of 31,528 MWh and 68,150 million Btu (14,000 ktoe) are projected based on commitments to 13 additional projects under the Residential HVAC programme, 3,257 new homes to be constructed under the Residential New Construction Programme, 944 commercial and industrial construction projects in line with the Commercial & Industrial Construction Programme, four more Compressed Air projects and 39 Customer Sited Clean Energy Generation projects.

ENERGY EFFICIENCY SAVINGS POLICIES IN THE TRANSPORT SECTOR, DEVELOPED APEC ECONOMIES

The transport sector is encountering rapid growth as more people travel, largely due to increases in population and income levels. Various energy efficiency programmes aim to curb the rising demand for transport energy (Table 18).

Table 18 Energy efficiency policies in the transport sector, developed APEC economies

Program Type	Australia	Canada	New Zealand	Japan	USA
Transport policy framework	X	X	X	X	X
Fuel efficiency standards	X	X	X	X	X
Efficient public transport planning	X	X	X	X	X
Information dissemination	X	X	X	X	X
Environmental concerns	X	X	X	X	X
Transport concerns	X	X	X	X	X
Financial incentives					X
Regulatory requirements					
Innovative incentives					
Possible drivers	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political	Industrial and Political
Duration results expected	Long term	Long term	Long term	Long term	Long term

Source: IEA (2001)

It is apparent from Table 18 that most of the economies have strong transport policy frameworks, public transport planning, fuel efficiency standards and transport concerns. Some highly developed economies tend to have policies that encourage road users to favour the best vehicles – those that make less noise and cause less pollution. There is also ongoing dissemination of information by training and distribution of brochures, media and so on for transport equipment purchasers. Road infrastructure, railway lines, airports, wharves and supporting construction tend to be developed and operated taking into account environmental issues.

ENERGY PRICING AND FISCAL ISSUES IN THE TRANSPORT SECTOR

Energy pricing is a key element in good public policy for promotion of energy efficiency. Such pricing means establishing consumer prices for energy products that reflect the cost of energy supply, whether they be fuel-based or electricity. Lessons can also be learned from economies that have implemented efficiency programmes without adjusting energy prices and have had disappointing results.

Fiscal measures on cars and motor fuels could be effectively implemented because some estimates show around 15 percent of household spending is for vehicle use. Typical policy targets here are level of ownership, annual usage and specific fuel consumption level.

ENERGY EFFICIENCY POLICIES IN SELECTED APEC NON-OECD ECONOMIES

CHILE

Except for the upstream oil sector, the energy market in Chile is completely privatised and open to competition, providing a development stimulus to energy producers. Initiatives in demand-side energy efficiency include the following:

- Monitoring energy efficiency indicators for energy-intensive industries: copper mining, sugar production, etc.
- Energy standards have been defined for appliances (twelve items), lighting (six items), air conditioning and thermal equipment (seven items), motors and pumps (four items) and transformers and cables (two items).
- Voluntary agreements on energy consumption in the copper mining sector.
- Thermal regulations for houses and buildings have been applied since 2000, with a final target to establish an energy certification system in 2006.

No quantitative evaluation is available for these programmes, however.

MALAYSIA

National energy policy includes promoting efficient utilisation of energy. As in many developing economies, particularly those well-endowed with energy resources, promoting energy efficiency has been that much more unattractive and difficult. Though the Ministry of Industry and Trade is very committed to promoting energy efficiency in all sectors, programmes and projects continue to be limited in scope and coverage.

Industry

The National Industrial Energy Efficiency Improvement Programme is the most ambitious the ministry has been implementing since 1999, targeting the industrial sector as a whole. This project is being implemented over a period of four years and is estimated to cost 79 million ringgit. Adequate funds have already been secured for it. The ministry has secured funding support of US$7.6 million from the Global Environment Facility and the United Nations Development Programme. Both Japan and Denmark have offered technical support for some of the baseline activities of this programme. The Malaysian Electricity Supply Industry Trust Account (or MESITA) will be contributing more than 20 million ringgit.

Pusat Tenaga Malaysia (or PTM) has been entrusted with implementing the programme, and is expected to work in partnership with industry, both end-users and energy service providers. Briefly, this programme aims to address the main barriers to wider adoption of efficient energy technologies and practices by industries. It incorporates eight major projects, each designed to address specific barriers to energy efficiency:

- Energy-use benchmarking for major industrial processes,
- Energy auditing, training and performance,
- Energy rating (labelling and test facility upgrading),
- Energy efficiency promotion and development,
- Energy Service Companies (ESCO) industry development and support,
- Technology demonstration projects,
- Local energy-efficient equipment manufacturer support, and

- Promoting participation of financial institutions.

The programme offers vast opportunities to industry and is designed to become self-sustaining after a four-year implementation period.

Residential and commercial sector

The commercial and residential sector accounts for about 12 percent of energy consumption in Malaysia. The sector has not been subject to the same attention regarding energy efficiency as the industrial sector, so less data is available.

However, a study conducted by JICA in 1998 on hotels, hospitals and shopping complexes showed huge potential for energy savings. One example was a shopping complex, where one of five energy-efficiency measures showed potential annual saving of 2.2 million ringgit in its electricity bill. In the case of a hotel one of four recommended energy measures showed a potential annual saving of 140,000 ringgit on its electricity bill, and a hospital showed similar savings potential.

As the Industrial Energy Efficiency Improvement Programme is expected to provide sufficient coverage and opportunities for the industrial sector, a gap clearly exists for projects focusing on the commercial and residential sectors.

PHILIPPINES

The Philippines Department of Energy coordinates and monitors implementation of various energy efficiency programmes such as introduction of new technologies, promotion of energy-efficient appliances, 'best practice' information programmes, technical assistance and auditing. Energy import dependence and relatively high energy and electricity prices are the main drivers for energy conservation in the Philippines.

Actual energy savings achieved through various programmes in 2000 reached 0.3 million toe, about 45 percent of projected savings for that year.

A government energy efficiency plan has the following targets:

- Enhance consumer understanding of energy use
- Lower consumer energy expenditures without constraining productivity
- Reduce capacity/transmission expansion requirements
- Reduce greenhouse gas emissions.

Policy measures to meet these targets include enhancement of private-sector involvement in energy efficiency programmes through energy service companies (ESCO). Establishment of ESCOs is considered one of the main ways to realise potential energy savings. Implementation and expansion of energy standards on appliances and a labelling programme is an important element of national energy efficiency policy. The government has initiated an 'Enercon' programme in which all government offices must reduce their electricity and fuel consumption by 10 percent in a 10-year period.

The Department of Energy is setting up measurable sectoral energy savings targets as part of broader energy planning. Energy management services (including ESCOs) represent about 60 percent of the overall energy savings target. Among those making up the rest will be information and education campaigns, labelling and standards, the governmental 'Enercon' programme, and cogeneration in power plants.

The programmes are expected to generate total energy savings of 4.5 million toe in the 10-year period 2001-11, with an equivalent cumulative deferred plant capacity of about 3,000 MW.

The lack of an effective monitoring and evaluation system is recognised as a major impediment to energy conservation.

CHINESE TAIPEI

Chinese Taipei is implementing energy efficiency and conservation programmes with a target of 28 percent in total energy savings by 2020 compared with 2000. In absolute values that would be 41.87 million tonnes of oil equivalent.

It is compulsory for 1,800 major consumers to report their energy use every year, representing 30 percent of Chinese Taipei's total energy consumption. A nationwide energy audit programme supports entities aiming to set conservation targets, implement energy efficiency measures and review the results.

Industry

The majority of large users (1,384) are in the industrial sector, which accounts for approximately half of total energy consumption. Monitoring of progress includes setting an energy-efficiency index for major products of energy-intensive industries and establishing energy efficiency reviews and an approval system for new factories.

The iron and steel, chemicals, cement, pulp and paper, and fibre industries are helped in formulating voluntary energy-saving action plans. Long-term low-interest loans and investment tax credits encourage industrial equipment upgrades and replacement.

Cogeneration schemes are being promoted. Conversion of waste heat into power is considered the major focus. Waste heat recovery directly increases the efficiency of final energy use.

Establishment of energy service companies is aimed at providing services related to energy saving, including technical consulting, inspection and diagnosis, planning and design, new engineering solutions and technology transfer to small and medium-sized enterprises (SME).

Transport

Energy conservation measures in transport include the following:

- Implementation of gradually stricter energy efficiency standards for cars and motorcycles
- Introduction of alternative fuels: natural gas and hybrid fuel buses, electric motorcycles and buses, LPG fuelled cars.
- A new transport blue-print aims to construct high-speed railway and mass rapid transit systems.

Residential and Commercial

Raising energy efficiency standards for electrical appliances such as air conditioners, refrigerators, fluorescent lamps and induction motors. This is aimed at improving energy performance by stages.

The energy-saving design code specifies energy consumption requirements for six classes of buildings. Energy consumption indexes measure progress. An inspection and test system aims to monitor energy performance of buildings.

General issues on energy efficiency in Chinese Taipei

Measures are in place to establish an energy audit, impose energy efficiency controls on electrical appliances and motor vehicles, and provide technical services for the industrial and commercial sectors.

Demand-side measures being implemented include time-varying pricing of electricity and favourable pricing for interruptible electricity supply.

The focus is on energy-intensive industries, which account for about one-third of total final energy consumption. The main impediment to conservation is relatively low price of energy for end-use.

VIET NAM

Legal provisions on energy conservation are now being considered in Viet Nam. A draft government decree on 'Energy Conservation and Efficiency', prepared by the Ministry of Industry, is designed to cover industrial products, buildings and building equipment, energy-intensive machinery and processes, residential energy use and public services.

A national research programme called 'Master Plan for Energy Conservation and Efficiency' drawn up by the Ministry of Science, Technology and Environment (MOSTE) in 1995 shows that:

1) Short-term energy conservation measures, requiring little or no expenditure such as enhancing awareness, improvement of housekeeping, small repairs and upgrading could generate energy savings of 12-15 percent of total industrial energy consumption.
2) Implementing medium-term energy conservation measures (with a payback period of less than three years) could bring savings of 18-21 percent of total industrial energy consumption.
3) Long-term conservation measures (with a payback period of more than three years), such as replacement of technologies and equipment, could result in savings of 30-37 percent of total industrial energy consumption.

The most significant energy conservation opportunities have been found in the cement, steel, ceramics and porcelain, and pulp and paper industries, and in industrial boilers and transport.

Within the framework of a nationwide government-coordinated Viet Nam Energy Conservation Programme (VECP), energy auditing in industry and buildings was carried out on a demonstration basis followed by discussions with concerned enterprises/buildings management and staff.

Energy conservation centres have been established in five major cities – Hanoi, Ho Chi Minh, Hai Phong, Da Nang and Can Tho. Information programmes include numerous workshops and training courses, as well as TV and radio broadcasts to raise public awareness of energy efficiency issues.

Demand Side Management (DSM) assessment in Viet Nam, completed in 1997 with World Bank assistance, has identified potential for 770 MW generation capacity savings and 3,550 GWh/yr electricity savings, and recommended a phased approach in implementation. A phase I DSM programme was launched in 2000 with support from SIDA (Sweden's International Development Agency). It aims to: 1) establish DSM cells and develop energy efficiency pilot programmes, 2) develop load research, load management and energy auditing capability, 3) establish standards for equipment such as lighting and motors, and 4) develop a building code for energy-efficient commercial buildings. It should be followed by phase II in 2003-2005.

Energy standardisation is an important part of VECP aiming to apply standards as a benchmark for production and harmonising national and international standards. Consumer product labelling is at the initial stage.

A process for developing energy efficiency standards has been established, overseen by technical committees in industries. Test standards and minimum efficiency performance standards (MEPS) for incandescent bulbs, linear fluorescent lamps, ballasts and electric motors have been developed in draft form. These are being circulated for public review before adoption as mandatory national standards.

Standards will be used to qualify products for inclusion in incentives, rebates and financial assistance programmes. The Ministry of Industry and MOSTE are to create and manage a public fund to provide financial support for energy-efficient consumer products.

Energy conservation activity in Viet Nam is being strongly supported by international cooperation. The EU gave financial support to set up energy conservation training courses. The project 'Viet Nam promoting Energy Conservation in SMEs (small and medium enterprises)' is being carried out with technical and financial support from UNDP/GEF. The Swedish International Development Agency (SIDA) has funded a project on demand-side management.

CONCLUSIONS

Good public policies on energy efficiency are vital for our livelihood because they promote technological progress and serve as an environment protection measure. Sound policies also encourage us to achieve better standards and a better quality of life.

POLICY CATEGORIES

Energy efficiency policies overviewed here can be divided into eight broad categories:

1) Labels and Standards,
2) Energy Audits,
3) Demand Side Management (DSM),
4) Voluntary Agreements,
5) Financial Incentives (subsidies, soft loans),
6) Fiscal Incentives (accelerated depreciation, tax rebates),
7) Environmental Incentives (carbon tax, CDM framework),
8) Information Programmes ('best practice', training).

EVALUATION

To monitor implementation of energy efficiency programmes, quantitative assessment is needed. The following evaluation parameters are relevant to monitor the progress of programmes:

- Programme budget,
- Amount of energy saved,
- Cost of energy saved,
- Payback period,
- Internal rate of return on investment,
- New generation capacity avoided,
- Jobs created,
- Penetration rate of new products/technologies.

Our current overview of energy efficiency policies shows that usually few quantitative figures are available for consideration. The major issue here is data availability. Project assessment figures are often confidential, especially in deregulated energy markets.

Non-OECD economies provide more opportunities for energy savings than developed economies, offering significant scope for technology transfer and international trade in consumer products.

We have not covered two APEC non-OECD economies most actively implementing energy conservation programmes – China and Thailand. An energy efficiency policy overview and assessment may form part of the next phase of APERC energy efficiency studies.

The energy efficiency programmes currently implemented in developed APEC economies show that a government commitment to support targeted energy efficiency programmes is crucial to realisation of potential energy savings.

The energy efficiency programmes presented here for Australia, Canada, Japan, New Zealand and the US could provide an example for other economies in designing national policies.

SECTORAL POLICIES

In the industrial sector the programmes are mainly targeted at introduction and dissemination of new technologies – processes and equipment. The drivers here are reduction of energy bills, environmental concerns and fast capital renovation to achieve competitive advantages. In the transport sector the main direction is a mandatory requirement in average fuel consumption for new cars. That means introduction of standards for automobile producers. Transport planning and design is especially effective in urban areas. Energy labelling and standards programmes for consumer products and new buildings are effective policy tools to achieve energy efficiency improvements in the residential and commercial sector.

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The Asia Pacific Energy Research Centre (APERC) has completed three consecutive studies in energy efficiency and savings. The main issues addressed by this study are: what is the place of energy saving as an alternative to conventional energy supply, and what part of final energy demand could be met by energy savings.

Significant options for economic energy savings have been identified in the industry, transport, residential and commercial sectors of APEC economies. These are savings that can be realised in the case of full implementation of cost-effective energy conservation measures.

Thus, for instance, they comprise: 1) For Korea, industry 25 percent, transport 28 percent, residential and commercial 35 percent up to 2020, 2) Russia industry 31-33 percent, transport 6-7 percent, residential 26-27 percent of current energy consumption, 3) Thailand industry 30 percent, transport 56 percent, residential and commercial 6-7 percent up to 2025.

Energy pricing is a key factor determining feasibility of energy-saving measures. For instance, in developing Asian economies, one of the fundamental government actions benefiting energy-efficiency activities involves reductions in price subsidies for electricity. While the movement away from subsidised prices towards market-based ones can be a difficult transition from the social and political perspectives, it is crucial to the implementation of end-use efficiency measures.

The main deliverables of the present project are:

1) APEC Energy Efficiency Indicators (EEI) Database

The EEI database has been presented to EDMC in IEEJ for further maintenance and publication of major indicators in the framework of APEC Energy Database.

2) Energy savings assessment methodology

A general energy savings assessment methodology comprises the following: 1) national sector/technology-specific surveys and energy audits, 2) technological assessment, 3) estimates of penetration rates of new technologies and 4) re-aggregation to the sectoral level.

An appropriate evaluation of energy efficiency policies and measures is based on: 1) calculating actual energy savings in absolute values, and 2) determining economic feasibility using a net present value approach based on average end-use energy prices. These evaluation tools need to be applied at the project level.

3) Energy Efficiency Policy Overview

Currently it covers APEC OECD economies, where information on energy efficiency policies is available. Broader coverage will be an objective for the next APERC study on energy efficiency.

The final target of energy efficiency policies should be the creation of a market niche for energy-efficient technologies/measures. Governments should create incentives to invest in energy efficiency, including tax breaks and easier access to capital markets. A variety of financing and tax schemes, such as soft loans, subsidies, accelerated depreciation and tax credits, are already used to improve the economic feasibility of energy-efficiency projects. In APEC economies, the most dynamic factor in the creation of a special energy efficiency market niche is the emergence of ESCO (Energy Service Companies) activity, supported by governments.

The basic messages that this study intends to convey are:

- There is a need for quality data collection (both energy and economic) in order to monitor the efficiency of energy end-use;
- There is a gap between top-down constructed sectoral indicators and bottom-up national assessments of energy savings potentials. Scales and objectives are not comparable;
- Sectoral surveys of energy end-use are the main tool to estimate energy savings potential;
- Government commitment to develop targeted energy efficiency programmes is crucial to realise potential energy savings;
- Elimination of market imperfections and a bias towards traditional energy supply could facilitate implementation of energy-efficient technologies;
- Energy efficiency is a necessary component of national energy policy, contributing to energy security, providing insurance to traditional energy supply, and acting as an environment protection measure.

RECOMMENDATIONS

Data collection is the basis of research – more detailed and consistent data on energy end-use and economic activity is required to derive quality energy efficiency indicators. Formally, this process is supervised by national statistical services. There is a need for better access to data through collaboration with relevant energy-efficiency agencies in APEC economies.

Evaluation and analysis of energy-efficiency policies should be the focus of the next study in APERC.

APERC will continue cooperation with international organisations: 1) ADEME and OLADE (in the framework of WEC project), 2) APEC EGEE&C and 3) IEA in:

- Monitoring energy efficiency trends
- Quantitative evaluation of energy efficiency policies/measures