# Module 1 Resource Efficiency

This module is arranged to address four main questions around the role of resource efficiency in environmentally sustainable economic development:

- **What is Resource Efficiency?**
- **Why is Resource Efficiency important for Asia Pacific economies?**
- **How can Resource Efficiency be measured?**
- **How can it be achieved?**

## What is Resource Efficiency?

All economic activity depends on the availability and use of natural resources, including materials, energy and water. In order to provide goods and services, natural resources are extracted, transformed, used and finally discarded at the end of their lifetime. Natural resources underpin construction and housing, transport and mobility; they provide energy and food and are embedded in all consumer goods that support our standard of living.

The utilization of natural resources to enable social and economic activity has been referred to as Industrial Metabolism (Ayres and Simonis, 1994) and Social Metabolism (Fischer-Kowalski and Haberl, 1997). In their seminal work, these authors addressed the inter-linkage of our socio-economic systems with the natural environment in terms of material, energy and water use, land use, waste and emissions. Throughout human history, resource use has increased as people have adopted new technologies to advance their standard of living. This had led to exaggerated material flows, energy consumption, and intensive land use, which are the primary drivers behind most environmental stresses such as climate change, ozone depletion, and loss of biodiversity, waste generation, acidification and eutrophication.

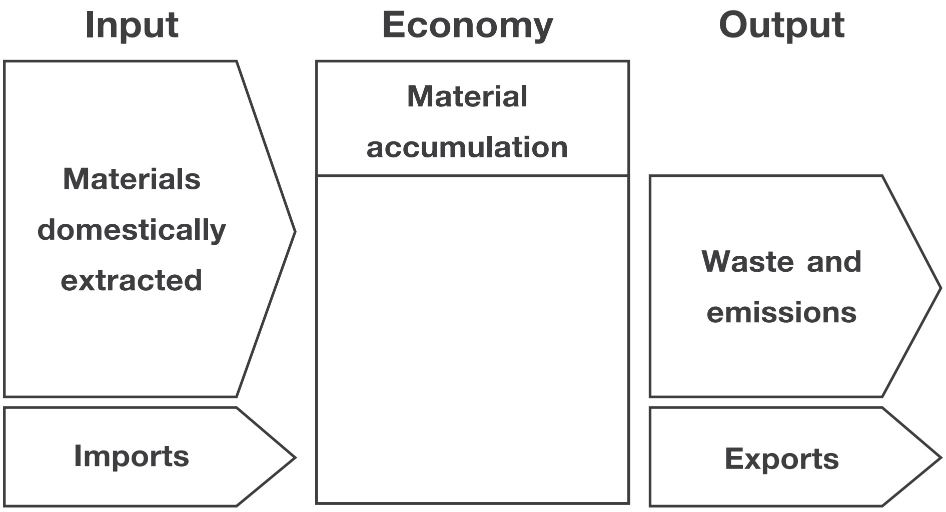
Total resource use is one core measure of long-term environmental disturbance potential, and its reduction would contribute reliably, although not proportionally, to a de-escalation of most environmental problems. Resources, however, can be used more or less efficiently, i.e. the amount of resources (materials, energy and water) that are required to produce a unit of product or service may vary considerably in regard to the technologies and processes employed.

The notion of resource efficiency addresses that economic growth and resource use and environmental pressure can be decoupled by well-designed public policies. The philosophy of resource efficiency and dematerialization outlines a path to achieving economic growth and wellbeing, while using fewer resources and generating fewer emissions in meeting our demands for food production, transport, construction and housing and energy.

Definitions:

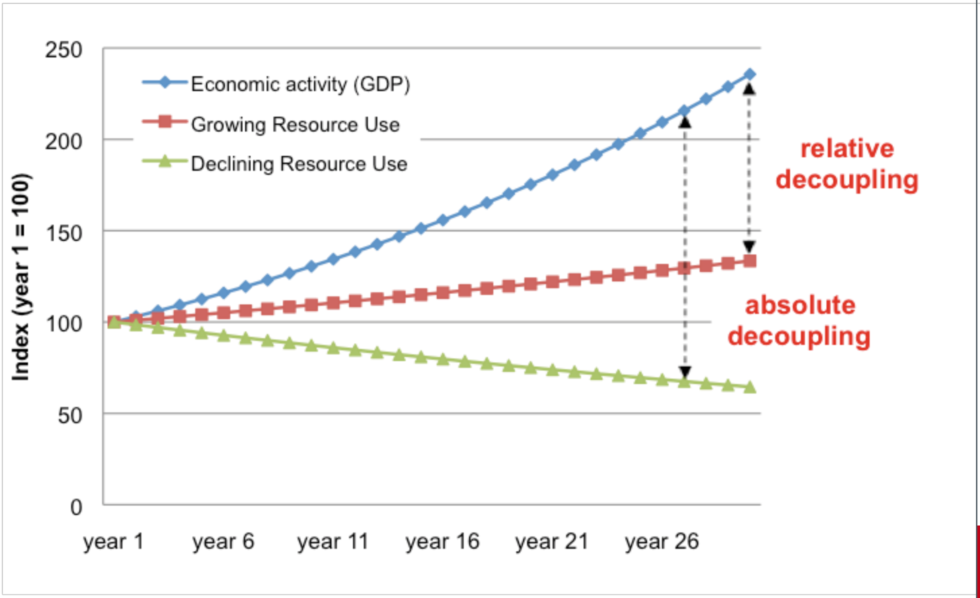
Industrial Metabolism: Societies intentionally establish and maintain a flow of materials and energy with nature within the labour process and by applying technologies. The notion of metabolism originates from biology, where it refers to the need of any organism to interact with its environment in order to survive. 'Industrial metabolism' by analogy describes all physical processes that convert raw materials and energy into finished products (Ayres and Simonis 2004). Economies extract materials from the domestic environment and import materials and goods, they transform materials in manufacturing and use them in production and consumption. Some materials are accumulated in the economy in the form of buildings, infrastructure and long lived goods. Eventually, all materials are returned to the environment in the form of waste and emissions.

Figure 1 Scope of material flow accounts



Resource Efficiency refers to the quantity of resources (materials, energy and water) that are required to produce a unit of a product or service. Resource efficiency may be expressed as Resource Intensity, i.e. resource use per unit of economic output or as Resource Productivity, i.e. economic output per unit of resource input. At the national level, efficiency is measured as materials use per unit of economic output (GDP). If resource use is growing at a slower rate than gross domestic product we speak about relative decoupling. If resource use is declining, we speak about absolute decoupling, which is equivalent to dematerialization.

## Figure 2 Relative and absolute decoupling of economic activity and resource use



Relative decoupling of material and energy use from economic activity at the national level has occurred in many economies. Absolute decoupling at the national level is very rare and usually only occurs in a situation of economic crisis (such as the breakdown of planned economies in Eastern Europe in 1989) or as a result of very successful environmental policies (such as in Japan in the 1980s).

Related concepts:

### *IPAT*

There is obviously a positive relationship between environmental impact (of any kind) and the size of a population and its affluence (i.e. consumption), which may be mediated by technological improvements. In the early 1970s, Paul Ehrlich and John Holdren addressed this relationship with their famous 'IPAT' formula suggesting that environmental Impact (I) may be estimated by Population (P) times Affluence (A) i.e. income per capita times a Technology factor (T) resulting in I = P x A x T. The IPAT approach has increasingly been used to identify the relative contribution of population, consumption and technology to environmental impact.

### *Strong and weak sustainability*

Natural resource economists have argued that sustainability could be measured by adding natural, human and man-made capital which would be substitutable. Sustainability would occur when the sum of these capitals grows. This has been referred to as weak sustainability. In contrast, strong sustainability refuses the substitutability between different types of capital and insists that sustainability requires the integrity of natural capital, which should not be reduced over time.

### *Dematerialization*

The notion of dematerialization addresses the fact that economic growth could be achieved at different levels of resource use. Relative dematerialization occurs when GDP grows faster than resource use. Absolute dematerialization would imply that resource use decreases over time.

### Cleaner production and eco-efficiency

The concept of resource efficiency originates from the notion of eco-efficiency which refers to the capacity to make industrial processes less resource intensive by applying resource saving technologies, recycling and end-of-pipe technologies for reducing emissions.

### Sustainable consumption

Overall resource use depends to some extent on the lifestyles and consumption behaviours of households. As the global population grows and a new middle class and new consumers emerge in many developing countries there is a greater urgency for more sustainable consumption, i.e. enabling a decent standard of living at much lower environmental costs.

### Environmental Kuznets Curve

The EKC hypothesis states that environmental impact would increase as national per-capita income grows but that there would be a turning point when societies become more prosperous and new demand for cleaner environment services emerges. Beyond a certain level of income a national economy could afford to invest in clean technologies and such services, and therefore environmental impacts would start to decrease. This relationship though has proven viable only for some air pollutants but has not been empirically established for overall material and energy use.

### Ecological Rebound Effect

The notion of rebound refers to the fact that gains in resource efficiency often result in lower prices for resources, goods, and services, enabling more people to purchase those goods and services. Thereby, efficiency would contribute to growth in resource use and contradict efforts to save resources via greater efficiency. While some systems theorists would argue that efficiency is an inappropriate strategy to save resources, there is a competing view and empiric evidence that accompanying demand side management policy measures would help to avoid rebound.

## Why is Resource Efficiency important for the Asian and Pacific economies?

Since the 1950s, all OECD countries have experienced rapid growth in economic activity and standard of living. This has come at some cost, however, with the increased use of resources, resulting in greater environmental pressures, greenhouse gas (GHG) emissions, and consumer waste. While growth in global resource use and emissions was until recently driven by wealthy industrial countries, today's main drivers are the rapidly developing economies of China, India and Brazil.

This has ratcheted up the scale and speed of global resource use, with today's patterns of production and consumption hitting the limits of what the planet can offer and sustain. Pressure points including climate change, water and food availability, price surges for strategic raw materials, and peaking global oil supply are converging rapidly in an unprecedented manner.

The evolution of the human economy has passed from an era in which manmade capital was the limiting factor in economic development to an era in which remaining natural capital has become the limiting factor. Herman Daly, 1992

In a recent book 'Socioecological Transitions and Global Change' (Fischer-Kowalski and Haberl, 2007) a group of researchers has empirically shown that the current transition in developing Asian economies from an agrarian-biomass based resource use pattern to an industrial resource use pattern involves a major increase in material and energy flows, corresponding to a two- to four fold increase in the demand for materials and energy. Despite rapid economic growth during the last decade, the Asia-Pacific region still shows relatively low material and energy consumption per capita, suggesting that major growth may follow. Infrastructures that are closely coupled with bulk material flows (transport, energy and housing) will be critical to future development.

At the same time, many Asian developing economies are already approaching their limits in terms of domestically available resources and the environmental carrying capacity, and have become net importers of raw materials, especially fossil fuels and metals. Future economic development will rely increasingly on their capacity to purchase those strategic resources on the world market, and prices for many strategic resources may increase.

While the economic development of many OECD countries was enabled by resources acquired from other countries, today's developing nations will not have the opportunity to utilize cheap resources from elsewhere. According to Herman Daly, we are moving from an empty to a full world, which changes the economics of all production and consumption activities. In order to remain competitive and to allow for increases in the standard of living of its people, the Asian and Pacific region will have to massively invest in infrastructures and technological innovation to foster resource efficiency, as well as in its biggest asset – human capital to support and develop societal ingenuity. In a more general sense, energy generation, mobility and transport as well as housing will require dramatic improvements. The objective is to invent, design and create new industrial infrastructures that use less energy and are less dependent on a stable supply of energy, that use fewer materials and allow for higher flexibility and lower risks in the face of global environmental change and resource scarcity. This needs to be enabled by a well developed system of education and investment into science and innovation to create a knowledge base for green economic growth. It also will require massive investment into the relevant skills for existing and new employees in the high environmental impact sectors such as manufacturing, construction, and transport to equip the workforce with green skills to foster efficient resource management practices. Because the Asian and Pacific developing economies are already planning to establish new infrastructure over the next decade there is a short window of opportunity to invest in resource efficiency and that development of appropriate human resources that will have a lasting effect over the next 20-30 years to come.

## How can Resource Efficiency be measured?

Resource efficiency, as discussed earlier, establishes a relationship between an economic indicator (usually gross domestic product, GDP) and a resource use indicator. For this purpose, indicators for resource use need to be highly aggregated (covering all resource flows of a national or regional economy), are ideally based on sound conceptual foundations, are feasible, and policy relevant. They cover all aspects of resource use including materials, energy, water and land use, as well as waste and emissions resulting in indicators for material efficiency, energy efficiency, carbon and emission intensity, water use efficiency and land use efficiency.

### Material Efficiency

A national material intensity indicator depends on a data set and high level indicators for material flows. Important multi-national organisations such as the OECD and EUROSTAT have invested in establishing methodological guidelines for material flow indicators in a participatory process involving statistical offices and major scientific institutes. We are therefore in a favourable situation for establishing material flow accounts and indicators for national economies based on the standardised set of rules and methods provided in the 'MFA Compilation Guide' (EUROSTAT, 2007). See also the reports by the OECD (2008) on measuring material flows and resource productivity.

Material flow accounts take stock of all relevant natural resource inputs from domestic or imported sources, covering biomass, fossil fuels, metals and industrial and construction materials and exports, as well as waste and emission outputs. The most basic accounts treat the national economy as a black-box and focus on inputs and outputs, as well as changes in physical stocks of infrastructure. A set of high level national material flow indicators is based on such basic accounts including Domestic Extraction (DE), Imports (IM), Direct Material Input (DMI), Exports (EX), the Physical trade Balance (PTB), and Domestic Material Consumption (DMC).

Basic accounts may be established using the well-accepted international data sets of the Food and Agriculture Organization (FAO), the International Energy Agency (IEA), the United States Geological Survey (USGS) and the United Nations Trade database (COMTRADE). Ideally, international data should be complemented by data available from within countries, which often offers more detail and allows specific characteristics of a country's material flows to be addressed.

The basic accounts are usually complemented by data on further aspects of material use such as

- flows within the economy (using physical input/output tables),
- embedded (upstream and downstream) flows related to imports and exports, calculated by accounting for the raw material equivalents (RMEs) of imports and exports
- unused extraction covering material flows that do not enter the economic process but have nevertheless considerable environmental impact (such as overburden in mining or by-catch and by-harvest in fishing and agriculture)
- detailed accounts of physical stocks

National material efficiency is expressed as material productivity (GDP per DMC) or material intensity (DMC per GDP) based on real GDP and exchange values.

## Energy Efficiency

A national energy intensity indicator depends on energy flow accounts and energy balances, and takes into account all relevant aspects of energy conversion from primary energy sources to final energy use in economic activities, to useful energy. The level of data harmonization for energy flows is much greater than for material flows, courtesy of the impressive dataset available from the International Energy Agency (IEA) which is complemented by a comprehensive guidebook 'the Energy Statistics Manual' (OECD/IEA 2005).

Energy flow accounts and balances take account of all relevant energy flows starting from primary energy sources (coal, natural gas, oil, nuclear, wind and water), allocating those energy sources to major users including the primary sector, manufacturing, transport, construction, services and households. There is further and more complicated data work involved in establishing useful energy accounts, as has been demonstrated by Ayres and Warr (2009) whose work covers the United States and Japan.

National energy efficiency is expressed as energy productivity (GDP per TPES) or energy intensity (TPES per GDP) based on real GDP and exchange values. Sectoral energy intensities may be calculated based on final energy consumption by economic sectors and the added value of those sectors, and these may complement national indicators by explaining the effect of different sectors' energy intensities on national results.

## Water Use Efficiency

Calculating national water use intensity is difficult because of large data gaps. Water use statistics usually distinguish water supply from different sources such as ground water and surface water, and the water demands of major economic sectors such as agriculture, manufacturing and households. Combined with economic data, national and sectoral water intensity indicators may be constructed.

## Land Use Efficiency

The assessment of national land use intensity is far from being a straightforward process. Firstly, statistical datasets and data from areal assessment need to be harmonised to identify different land use categories such as agriculture, forestry or urban industrial land. There is little data available on urban/industrial land and no consistent dataset for other land use categories. In a next step, it is required to identify intensive land use categories such as cropland, plantations, managed forests, and urban/industrial land to account for total land in use. Combined with national GDP a land use intensity indicator may be derived. Subsequently, sectoral indicators for agriculture, forestry and manufacturing and service sector activities may be established. Despite many conceptual issues, the availability of data will be a main constraint.

### Table 1 Overview of national and sectoral indicators

| Eco-efficiency | Pollution intensity |
|---|---|
| Energy intensity (MJ/GDP) | $CO_2$ intensity (t/GDP) |
| Water intensity ($M^3$/GDP) | GHG intensity (t/GDP) |
| Material intensity (t/GDP) | Waste intensity (t/GDP) |
| Land use intensity ($km^2$/GDP) | Emissions to air intensity (t/GDP) |
|  | Emissions to water intensity (t/GDP) |

## National Indicators

- Energy intensity measured as Total Primary Energy Supply - TPES/GDP (data available at IEA database for most countries worldwide). Highly feasible indicator.
- Water intensity measured as surface water and groundwater use/GDP (data available in national statistics for most countries worldwide). Highly feasible indicator.
- Material intensity measured as Domestic Material Consumption - DMC/GDP (data available for some countries; capacity building required for those countries that have not yet collected such information). Feasible indicator.
- Land use intensity measured as intensivley used land /GDP (data available in national statistics for most countries worldwide). Indicator requires further methodological effort.
- Emissions to air intensity measured as $CO_2$, GHG, or total emissions to air/GDP (data available in national statistics for most countries worldwide). Highly feasible indicator.
- Emissions to water intensity measured as BOD/GDP (data availability uncertain). Indicator requires further methodological effort.
- Waste intensity measured as total waste land filled (industrial and residential)/GDP (data availability uncertain). Indicator requires further methodological effort.

## Sectoral Indicators

- Energy intensity measured as final energy use of a sector/sectoral added value. Aim for disaggregation for activities that have the greatest share in total final energy consumption of the focal sector and activities that have very high energy intensity. Candidates are iron and steel, cement, etc. Data is available at the IEA database and national energy statistics of most countries. Highly feasible indicator.
- Water intensity measured as sectoral surface water and groundwater use/sectoral added value. Aim for disaggregation for activities that have the greatest share in total water use of the focal sector and activities that have very high water intensity. Candidates are textile industry, food industry, pulp and paper, etc. Data will be available in national water statistics for most countries. Highly feasible indicator.
- Material intensity measured as sectoral material use/sectoral added value. Disaggregation of national material flow data to economic sectors is a difficult task and usually requires a physical input output table (PIOT) that does not exist for most countries. One way forward would be to report a bundle of 5-10 strategic materials. Indicator requires further methodological effort.
- Land use intensity measured as intensively used land by sector/sectoral added value. Data will be available in national statistics in a number of countries. Feasible indicator.
- Emission intensity measured as sectoral emissions to air and water for specific substances such as $CO_2$, $SO_X$/sectoral added value. Data will be available in countries that have established a national emission monitoring. Aim for disaggregation for activities that have the greatest share in total emissions of the focal sector and activities that have very high emission intensity. Candidates are iron and steel, cement, textiles, chemical industry, etc. Feasible indicator.
- Waste intensity measured as waste by sector/sectoral added value. Data will often not be available or of insufficient quality. Indicator requires further methodological effort.

## How can it be achieved?

Fostering resource efficiency is usually driven by high level policy initiatives. An example of such an initiative would be the G8 summit at Sea Island in 2006, which led to a council recommendation at OECD level to promote material flow and resource efficiency indicators. Many national and supranational bodies have agreed on high level policy goals such as the Sustainable Use of Natural Resources strategy of the European Union, the sound material cycle society initiative of the Japanese government or the Circular Economy Law enforced by the Chinese government. Even if such high level policy objectives require implementation within the administrative systems of nation states to become effective, they signal a certain political will and hence enable more concrete sectoral policies fostering resource efficiency and sustainable resource use.

It is largely agreed that enabling resource efficiency will depend on a useful mix of existing policy instruments including regulation, market based instruments, education and transition management.

> Comprehensive policies comprising both regulatory and market-based tools are needed to achieve greater resource productivity. G8 Environment Ministers Meeting, Kobe, Japan, 2008

### Regulatory Instruments

Regulatory instruments set legal standards in relation to environmental performance, pressures and outcomes. They have traditionally been favoured by governments to carry out environmental policy. They work best when a problem is well defined and technologies for problem solving are readily available. Regulatory instruments have several benefits, the setting of a standard is inexpensive and the goals for policy achievement are clear as they impose minimum performance requirements and mandate compliance. They are often criticised, however, for being inflexible, costly to enforce and providing incentives to avoid penalties rather than fostering a more general interest in improving a situation.

Regulatory instruments to enable resource efficiency improvements include standards for emissions or technologies, environmental liability, extended producer responsibility via product take-back and environmental control and enforcement through permits and inspection by authorities. Technical and emission standards refer to required technical equipment or maximum levels of emissions from specific sources of pollution, and can thus promote technological innovation.

## Economic and Market Instruments

Economic instruments work by encouraging certain behaviours through economic incentives. They change the evolutionary environment of businesses and households and thereby generate different behaviours depending on each actor's specific circumstances and capabilities. This flexibility can often reduce overall compliance costs quite significantly compared with uniform regulation. The two most notable advantages of economic instruments over traditional regulation are their cost effectiveness and their ability to provide incentives for innovation and improvement beyond a certain level of performance. They often require, however, sophisticated institutions to implement and enforce them in order to generate the desired effects. Charges and taxes need to be collected and monitoring is required to avoid free-riding. Tradeable permits are particularly challenging because the creation of a well functioning market can require a fairly large administration. Their effects on resource consumption and emissions are not as predictable as under a traditional regulatory approach.

Economic instruments include subsidies (including the removal of environmentally harmful subsidies), taxes (on resources, products or emissions), rebates (when purchasing environmentally friendly products), cap and tradable permits and deposit-refund schemes.

## Green Tax and Budget Reform

Green Tax and Budget Reform (GTBR), entails a modification of existing tax systems within a broader budget reform and a flexible system of budget redistribution (budget recycling). It seeks to use revenues from environmental taxes to reduce the tax burden on beneficial economic activities, such as investment or employment in a flexible and fast responding manner. It thereby shifts the tax burden towards the 'bads' (such as pollution, waste and resource depletion) and away from the 'goods' (such as employment, income and investment). The goal of GTBR is a zero net increase in the tax burden, but a positive impact on employment and polluting behaviour through the market forces by incentivising cleaner, and more resource efficient production and consumption.

Von Weizsäcker et al. (1997) proposed a 'revenue-neutral, slowly progressing long-term tax shift' in their seminal report to the Club of Rome 'Factor 4: Doubling Wealth – Halving Resource Use' so that resource prices reflect externalities. Revenue neutrality could be achieved by reducing other taxes, such as income taxes or corporation taxes, to ensure that the overall tax burden does not increase but is merely redirected to more resource efficient activities. Advantages of GTBR include (i) changing perverse incentive structures, (ii) reducing undesirable taxes and (iii) achieving environmental deregulation.

Bernow et al. (1998) developed a general outline of a nearly revenue-neutral GTBR package with the aim of reducing pollution, creating jobs, boosting wages and increasing the progressivity of the tax structure. Key components of their GTBR package include:

- Levy taxes on polluting or resource depleting activities
- Rebate this revenue to the taxpayers by reducing payroll taxes
- Phase the tax shift in gradually and predictably over a number of years
- Provide transitional assistance for communities, workers and industries that are strongly affected by the tax
- Address the implications for international competitiveness of those industries that are most affected by the tax

Today, many consider GTBR to be a powerful policy tool that creates the potential for a 'double dividend' – an environmental improvement coupled with an economic benefit. It can lead to enhanced economic growth, greater employment, more efficient resource use and a cleaner environment.

## Cap and Trade Systems

The first step in creating a market based mechanism/demand side management tool for reducing the use of common environmental goods, or reducing emissions, is to set a cap for the use of the resource (the amount of emissions) at a level deemed environmentally sustainable. The cap, or quantity of use, may be set at the source or the sink end of a certain resource, whichever is closer to scarcity or easier to control. Despite cap and trade systems being considered as market based instruments, setting the quota is really a social-ecological and not a market decision.

Since the resource (or the emission) is now limited and no longer a free good, it becomes associated with an opportunity cost and a price. After regulating the ownership of the newly created asset, permits for users may be issued and traded on the market. Resource users and emitters are then bound by their capacity to purchase permits to legitimate resource use or emissions, and can trade their permits whenever their quota is undersubscribed. In theory, cap and trade systems are able to achieve set levels of use and to agree on a market price per unit of use.

It should be noted that social constraints on scale (sustainability) and on distribution (fairness) must be politically imposed before markets are allowed to trade permits and determine prices. There are several possibilities to roll out a cap and trade system in regard to how permits are distributed. Yearly quotas may be auctioned to the highest bidder and the resulting income could enter public treasury. On the other hand, rights could be given to historical private users for free (such as the high emitting sectors) for a period of time at no price. In practice, we may see a combination of these strategies. One main argument in favour of a trading system is the idea that it can be designed to be cost neutral. A stumbling block commonly experienced is that large businesses can use their market power to influence the price of permits, and there is a related problem of distributional fairness when permits are distributed to users for free.

## Information based measures

Information based policy instruments provide information about the environmental performance of certain products, services or systems in a standardised manner so that consumers and investors can make more informed decisions. They include public information campaigns, eco-labelling schemes, research and development and public disclosure of a company's environmental performance to distribute information about the adoption of resource conserving practices. Information based measures can be mandatory or voluntary.

One advantage of information based measures is that implementation costs are low. In addition, they help raise public awareness and changes in consumer behaviour where the consumer becomes an active player in the societal pursuit of more sustainable consumption opportunities. It can also provide direct incentives by sensitizing the individual investors how to exercise their stock holders rights to companies for reducing their environmental burden to avoid competitive disadvantage.

## Voluntary initiatives

Voluntary initiatives do not enforce participation, and seek to bring about desired change by directly influencing decisions on resource efficiency. Voluntary initiatives include partnership projects, voluntary codes of practice, voluntary environmental management standards or audits, and voluntary agreements. Such agreements aim to promote environmental improvements through the development of clear voluntary goals. Voluntary agreements are defined as schemes where firms make commitments to improve their environmental performance beyond legal requirements and in time demonstrate the economic and market benefits for operations and revenue of the companies.

## Targets, monitoring, benchmarking

When developing national resource efficiency policies governments may wish to enable the quantification of problems and the setting of targets, and to monitor progress towards achieving them through benchmarking. Quantitative targets and indicators are useful in determining the level of change required while also allowing for comparisons between companies or different government initiatives. Furthermore, indicators can help in measuring the progress of specific actions to improve resource efficiency against predefined targets.

## Modelling and Scenarios

The establishment of a sound record of the history of natural resource use and resource productivity, which can be updated on a yearly basis, could provide a useful set of information to policy makers for planning policies and evaluating their outcomes. In that sense, establishing these accounts and using them for analysis will improve public policy making and inform and enable integrated economic-environmental policies.

Nonetheless, policy makers are dealing with very complex systems whose behaviour is often not fully understood, and therefore scenarios may be seen as useful tools to better understand our economic systems and their relationship to natural resource use, and perhaps to enable the recognition of constraints to certain economic developments early on in a laboratory setting. Scenarios are stories about possible futures, which help us to explore trade-offs and synergies. Natural resource accounts covering stocks and flows of resources serve as an important input to environment-economic models, which may take different forms.

## Summary

Measuring and monitoring resource use and emissions as well as resource efficiency and emissions intensity of economic activities is an important tool to underpin the policy planning process, which enables the evaluation of existing and new policies ex post and ex ante. Starting with a set of baseline information enables benchmarking, helps establish best practice, and allows for targets to be set, which in turn informs the necessary effort and achievements of public policy in regard to resource use and environmental sustainability.

Driven by greater concerns about resource use and environmental quality, multi-national organisations such as the OECD and the United Nations have invested in strategies to foster green economic development and have driven the development of assessment tools to plan for and evaluate the success of 'Green Growth'.

Indicators for resource use and resource efficiency offer ways to operationalize the policy objectives of Green Growth. They are a first step towards satellite accounts to the System of National Accounts, and hence speak to economists and politicians alike. They are based on sound conceptual (scientifically credible) knowledge, are constructed to be policy relevant, and are feasible, i.e. timely data are available at a viable cost.

There is a triple dividend of greater wellbeing, cost saving (leading to enhanced competitiveness) and reduced environmental impact to be earned if measures are taken to support green economic development required for a low-carbon, environmentally sound society and improved investment in natural and human capital. Well designed public policies to enable greater resource efficiency are an important stepping stone for achieving this.

# For further reading

## Scientific literature

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International Energy Agency (IEA) 2005. Energy Statistics Manual. OECD/IEA, Paris.

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OECD 2008. Measuring Material Flows and Resource Productivity. 3 Volumes and a Synthesis Report. OECD, Paris.

## Websites

The United Nations Environment Program (UNEP) Resource Panel http://www.unep.fr/scp/rpanel/

The International Panel for Sustainable Resource Management, or Resource Panel, provides independent scientific assessment of the environmental impacts of the use of resources over the full life cycle, and advises governments about how to reduce these impacts.

The United Nations Economic and Social Commission for the Asia Pacific (ESCAP) Green Growth Strategy http://www.greengrowth.org/

To assist policy and decision makers, ESCAP is focussing on Green Growth to support sustainable development in the Asia-Pacific region. Policy measures include sustainable consumption and production, greening of businesses, sustainable infrastructure, green tax and budget reform as well as indicator development to operationalize Green Growth.

The United Nations Environment Program (UNEP) Green Economy Initiative http://www.unep.org/greeneconomy/

The Green Economy Initiative (GEI) is designed to assist governments in 'greening' their economies by reshaping and refocusing policies, investments and spending towards a range of sectors, such as clean technologies, renewable energies, water services, green transportation, waste management, green buildings and sustainable agriculture and forests.

The CSIRO and UNEP Asia-Pacific Material Flow Database
http://www.csiro.au/AsiaPacificMaterialFlows

The online database provides material flow and material intensity data and indicators for most countries in Asia and the Pacific for 1970 to 2005.