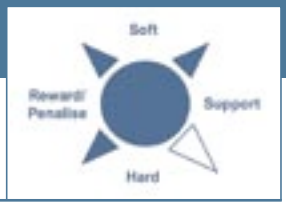

1. Research and Development

Definition & objectives

Research and development (R&D) can be defined as "systematic investigatory work carried out to increase the stock of knowledge and the use of such knowledge to devise new products and processes". R&D includes basic research, applied research and experimental development conducted by governmental departments, universities, research institutes, private companies, and non-governmental research bodies, in many cases forming the first stage of the development and application of new technologies and organisational innovations (SciDev.net, 2006).

R&D is an essential part of economic and social development in any country. New technologies realised through R&D can help raise the productivity and competitiveness of companies and create employment by producing new products as well as improving production processes. Even though many developing countries may be able to acquire knowledge and technologies needed for development from industrialised countries, they still need to nurture 'indigenous' capacities to adapt and utilise technologies within the local conditions. They may also need new technologies different from those of industrialised countries (e.g. utilisation of biomass energy). To realise resource efficiency, R&D is particularly relevant not only to make the existing products and processes more efficient but also, more fundamentally, to innovate new ways of delivering products and services in a less resource-consuming manner (Dormann and Holliday, 2002).

Business may drive the development of new products and processes, but many of the key innovations that society takes for granted have their origin in publicly funded research. It often takes time to convert a scientific discovery into practical applications, but the private sector tends to focus its R&D investments on short-term incremental changes to existing technologies for obtaining a quick financial return. This may result in not only underinvestment in basic research but also sacrificing environmental and social performance of new technologies for immediate private commercial success. The government therefore needs to intervene in order to support R&D activities whose initial financial return may be low but long-term public benefits are potentially significant. (OECD, 2004; Jefferson, 2000).

The government can help through a coherent 'R&D policy' to foster domestic R&D activities needed to build a comprehensive national scientific and technological capacity on resource efficiency. It is becoming increasingly important for such a policy to support the whole process of innovation that is created by a diverse range of organisations rather than focus on individual R&D activities, by encouraging collaboration within and between the public and private sectors, sometimes beyond national boundaries (SciDev.net, 2006).

Mode of operation

Governmental agencies can provide both financial and non-financial incentives to promote R&D in the public and private sectors. The following table provides a list of R&D policy measures that can be taken on governmental incentives:

Type of policy intervention		Explanation
Financial	**Direct financing**	The government can directly finance R&D efforts at public scientific bodies such as universities, government research institutes and science parks.
	Grants	The government can directly fund private R&D efforts through awarding financial grants (both for-profit and not-for-profit). Grants allow the government to target the projects with high social returns.

	Tax incentives	Tax incentives represent an indirect form of support to private R&D efforts by providing tax relief that lowers costs. This measure gives more autonomy to the private sector but makes it difficult to target projects.
	Removing subsidies	The government can also remove subsidies for environmentally harmful products (e.g. fossil fuels) to create a level playing field for R&D on resource-efficient technologies.
	Long-term investments	The government can provide R&D for resource-efficient technologies with long-term, low-rate investment in companies or encourage loans by venture capital and other financial organisations.
Non-financial	**Protection of intellectual property rights**	The creation of a legal environment that protects patents and relaxes anti-trust activities can increase the likelihood of generating an acceptable return from R&D investment.
	Demonstration projects	The trials of new technologies are essential to prove technical viability at a commercial scale for technologies for which it is difficult to attract private sector financing. Demonstration projects are also needed to tailor developed technologies to fit specific contexts.
	Human resources development	The availability of university graduates influences the potential number of research scientists and engineers. Education policies lead to a match with the requirements of industry (see also instrument 'Education and Training').
	Industrial standards	The provision of standardisation in products and processes can not only reduce the costs of production by providing clearly specified requirements but also speed up competition for upgrading of products (see also instrument 'Eco-labelling').
	Co-ordination bodies	The creation of co-ordinating agencies or advisory councils can improve the flow of information between government departments, research organisations and industry, fostering learning processes, indigenous innovation and technological diffusion (see also instrument 'Information Centres').
	International collaboration	The government can facilitate the formation of international joint ventures and other international collaborative efforts to encourage resource-efficient technology transfer and innovation. Some development aid has been allocated to encourage international co-operation in R&D.

Table 1: Types of policy intervention for research and development

Financial incentives are only likely to be successful in stimulating domestic innovation if the government treats non-financial incentives as complementary supporting measures. R&D policies need to be adapted to the needs of a country at its particular stage of technological development. For developing countries that are users and adapters of imported technologies, more emphasis should be placed on non-financial measures (SciDev.net, 2006).

The focus on resource efficiency in R&D can be incorporated into the overall R&D policy framework. For example, the EU has placed "sustainable development, global change and ecosystems" as one of seven priority thematic areas in the Sixth Framework Programme for Research and Technological Development (2002-06), allocating approximately 12% of the total budget of 17.5 billion euros. The other way round, the Canadian government's Sustainable Development Strategies 2000-03 identified "capacity building in R&D and skills" as one of three key measures to raise Canadian industry's productivity through resource efficiency.

Strengths & weaknesses

R&D policy has certain strengths and weaknesses as an instrument promoting resource efficiency as summarised below:

Strengths	Weaknesses
Provide innovative solutions R&D can lead to identifying new leapfrogging technological solutions to resource efficiency, not only improving efficiency in the existing production processes.	**Free riders** Imitators of new products may prevent R&D investors from enjoying the full benefits of their efforts. Others may claim a tax credit by classifying routine costs including quality control and testing as R&D expenditures.
Increase national competitiveness New products and processes developed through R&D can create a significant competitive advantage for the country. The ability to adapt the latest technologies can also ease access to international markets.	**Risk of failure** R&D efforts do not always result in successful applications. The government needs to be prepared for the risk that it may be criticised as wasteful diversion of taxpayer's money from more urgent or productive uses.
Build up capacities for further development The technological capacities and human resources developed through R&D can create a virtuous cycle that leads to further new innovation.	**Difficulty in prioritisation** It needs time for the government and the private sector to find out the outcome and effectiveness of R&D activities. The government frequently lacks appropriate information about the market and new technological developments. This may lead to misdirecting the country's technological development and adaptation.

Table 2: Strengths and weaknesses of research and development for resource efficiency

The costs incurred for implementing R&D policy are relatively significant. However, developing countries may be able to mitigate costs by focusing their resources on non-financial measures and inducing effective technology transfer (see the table below).

Category	Description	Faced by
Formulation	…for building up R&D policy to co-ordinate a system of innovation in the country	Government
Capacity building	…for educating and training people to gain professional knowledge and skills needed for R&D	Government/Industry
Investment	…for providing financial means to encourage public and private R&D efforts	Government/Industry
Co-ordination	…for providing a legal framework to encourage innovation and co-ordination between sectors	Government/Industry

Table 3: Costs associated with research and development for resource efficiency

Success factors

Success of R&D policy depends on a variety of factors that capitalise on the strengths and minimise the weaknesses identified above. The following factors are drawn from experiences of existing practices:

Success factor	Explanation
Education	The tertiary education needs to ensure creating a large number of environment-minded quality scientists and engineers. The government needs to pay attention to not only quantity but also quality of education to achieve better results in R&D. The students also need other competences such as foreign languages than the expertise, while the infrastructure and equipment in schools play a key role of improving quality of education.
Balanced protection of intellectual property rights	Intellectual property rights give innovators market power over competitors, but at the same time, access to basic or essential products needs to be secured for poor populations. The government needs to ensure a balance between commercial and public interests, as well as keep research outcomes resulting from publicly funded R&D widely available.
Define performance	The development of resource-efficient technologies would be encouraged by setting clear goals that specify efficiency and emission characteristics of technologies.
Public-private partnerships	It can be more appropriate for the government to remain in the role of defining broad objectives and timetables for technological innovation and back up these objectives with incentives. The private sector can play the major role in exploring the main technological choices and making the investments needed to meet these objectives. Such an arrangement not only encourages the exchange of information but can also facilitate risk sharing and enhance administrative flexibility.

Table 4: Success factors of research and development for resource efficiency

Key References and Case Studies

Dormann, J. and Holliday, C. (2002) ***Innovation, Technology, Sustainability and Society,*** World Business Council for Sustainable Development (WBCSD), Geneva.

www.SciDev.net (August 2006)

UN Millennium Project (2005) ***Innovation: Applying Knowledge in Development,*** a report of the Task Force on Science, Technology and Innovation, Earthscan, London.

UNDP (2001) Human Development Report 2001: Making new technologies work for human development, UNDP, New York.

Name	Link
Science and Development Network: News, views and information about science, technology and the developing world	http://www.scidev.net/
The Earth Institute – Mobilizing the Sciences and Public Policy to Build a Prosperous and Sustainable Future	http://www.earthinstitute.columbia.edu/research/index.html
Wuppertal Institute on Environment, Climate, Energy - FACTOR FOUR - Doubling Wealth, Halving Resource Use	http://www.wupperinst.org