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UNIDO and the World Summit on Sustainable Development

Technology Needs Assessment (TNA) for Developing Countries

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

economy environment employment

UNIDO and the World Summit on Sustainable Development

Technology Needs Assessment (TNA) for Developing Countries

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Executive Summary

Technology needs assessments (TNAs) are frameworks designed to help identify the technology needs and priorities of developing countries (DCs) in order to ensure technology transfer can occur successfully. Because successful technology transfer depends crucially on the existence of local abilities to assess and acquire technology ('acquisition capability'), the TNA frameworks developed in this report focus on needs, strengths and weaknesses *from a local DC capability point of view*.

There are two major dimensions of technological capability. First, is the capability to develop strategies and manage technological acquisition, use and further development (sometimes called 'techno-managerial' capabilities). Second, is the detailed engineering (or scientific) capacity needed to acquire and develop specific technologies.

The report argues that the most important of the two capabilities is the techno-managerial dimension. These 'strategic' capabilities are essential for managing the processes of technological acquisition, adaptation and development successfully. Without strong and effective techno-managerial capabilities it is highly unlikely that the specific technologies required for economic development can be absorbed and mastered. Conversely, with the necessary strategic and management capabilities in place, it is far more likely that the specific technologies necessary for environmentally sustainable development can be acquired and absorbed.

The TNA frameworks presented are one of UNIDO' s contributions to the World Summit on Sustainable Development (WSSD) in Johannesburg (26 August to 4 September 2002). Because the transfer of modern technologies is central to sustainable development and poverty reduction, a central part of the WSSD agenda is concerned with ensuring the successful technology transfer from developed to developing countries. However, before technology transfer issues can be addressed, it is necessary to examine the technology needs of specific DCs as these differ considerably, as do the capabilities of different countries.

Therefore, this report offers a framework and specific tools for DC technology needs analysis. This will constitute one of the inputs into UNIDO's initiative on 'Technology Transfer: Assessing Needs - Promoting Action' to be launched at the WSSD.

Three versions of the TNA are developed which deal, in turn, with capabilities at the national, sector and enterprise levels. The report focuses mostly on the national level, a major focus of the WSSD and an area where UNIDO can make a major direct contribution. However, the three TNAs are complementary:

- The national TNA focuses on technology policy formulation and execution at the policy level;
- The sector level TNA takes a similar approach at the industrial sector level and for generic technologies which cut across specific sectors;
- The enterprise level TNA examines needs from the perspective of firms, as ultimately business enterprise is responsible for most technology acquisition in DCs.

Each of the three TNAs is designed to involve key stakeholders in a consultative process so that they can together identify the main barriers to capability development and successful technology transfer. The report also provides guidance on the use of the TNA tools as well as examples of successful policy initiatives for capability development from successful DCs and the developed nations. The TNAs can be used both to audit capabilities and to identify paths for improvement in capability building within DCs.

At the national level, the TNA identifies a ‘staircase’ of four stages of technological development, suggesting ways of building on strengths and overcoming weaknesses. At sector level, the TNA offers a similar approach, concentrating on the needs of particular sectors. Leading sectors often play a key role in economic development and, as such, it is important to build up sector capabilities to achieve national goals towards employment, poverty reduction, export growth and the acquisition of environmentally sound technologies (ESTs).

UNIDO is able to play a major role in articulating and defining national technology strategies through the use of the TNA and a wide range of other instruments. To illustrate the experience of UNIDO in this area, the report provides concrete examples of how UNIDO has assisted with technology transfer of ESTs from the North to the South and, equally importantly, from South to South in support of poverty alleviation, import reduction and environmentally sound development.

Traditionally, TNA approaches have often been highly complex activities, carried out in a ‘top down’ manner (often by technical specialists). By contrast, the TNAs presented here take a bottom up ‘self-assessment’ approach. They are designed to be simple and practical so that the actual process of needs analysis can be carried out quickly, based on the knowledge of DC policy representatives.

The tools can be applied by a DC independently or in partnership with UNIDO. They are designed: to benchmark existing DC technological capabilities against other countries’ capabilities; profile the capabilities of the DC showing strengths and weaknesses; assess the effectiveness of current mechanisms for technology acquisition; and provide necessary information to help select technology priorities within a coherent strategy for technology acquisition and upgrading.

The TNA frameworks provide one mechanism for UNIDO-DC partnership at the government, sector and enterprise level and can facilitate targeted action by national- or sector-level agencies. Hopefully, the TNAs will be a useful input to the process of assisting developing nations to overcome technological weaknesses and build up the capabilities they need for sustainable economic development.

Introduction

Following UNIDO guidelines, technology needs assessments (TNAs) are country-driven activities which support the identification of technology priorities of developing countries (DCs) and assist in the implementation of technology strategies for DCs.[1] TNAs involve key stakeholders in a consultative process which is able to identify the barriers to technology transfer and provide guidance, measures, and actions to overcome any barriers. TNAs should also provide support for the development of a coherent national technology strategy in support of competitiveness, economic growth and environmentally sustainable development.

As Part 1 shows, the TNA frameworks developed in this report are one of UNIDO' s contributions to the World Summit on Sustainable Development (WSSD) in Johannesburg (26 August - 4 September 2002). As the Chairman's report on the second Preparatory Committee for the WSSD points out, "Globalisation, if appropriately managed, has the potential to promote sustainable development for all. However, there are increasing concerns that globalisation has led to the marginalisation of a number of developing countries" (Salim 2002, p11).

The above report goes on to point out that the transfer of modern technologies is central to sustainable development and poverty reduction. Technology can be a powerful tool for bridging the gap between those countries that are benefiting from globalisation and those currently marginalised from the globalisation process. Therefore, a key part of the WSSD agenda focuses on how to ensure technology transfer from developed to developing nations.

Unfortunately, many DCs face major challenges in acquiring, developing and using modern technologies. Clearly, before a technology transfer strategy can be developed, the specific technology needs and difficulties of individual DCs have to be analysed and understood. The purpose of this report is therefore to offer a framework and specific tools for DC technology needs assessment (TNA). This will form one of the inputs into UNIDO's initiative on 'Technology Transfer: Assessing Needs - Promoting Action' to be launched at the WSSD.

Three versions of the TNA are developed which deal in turn with the national level, the sector level and the enterprise level.[2] The report focuses mostly on the national and sectoral levels, which is where UNIDO can make the greatest direct contribution. However, the three TNAs are complementary:

- The national TNA focuses on technology policy formulation and execution at the macro level;
- The sector level TNA takes a similar approach for the industrial sector level and for technologies which cut across specific sectors;

[1] In this report technology is assumed to include any scientific needs, although scientific capabilities are probably less relevant in the short term for most poorer DCs. The terms 'technology' and 'science and technology' (S&T) are used interchangeably to represent all S&T needs.

[2] The TNA frameworks are based upon research on successful technology transfer and acquisition in both developed and developing nations (e.g. Rush et al, 1996; Bessant et. al, 2000; Hobday et al, 2001).

- The enterprise level TNA provides a detailed approach to auditing the capabilities of business firms, as ultimately firms are responsible for most technology acquisition in DCs as elsewhere.

Part 2 provides a working definition of technology and technology transfer, arguing that in a DC, technology transfer from an advanced country can only occur successfully when some or all of the capability related to a specific production process, product or service has been acquired.[3] This applies to as much to environmentally sound technologies (ESTs) as to any form of technology. *Without the capability to acquire technology, technology transfer cannot occur*. Capabilities are made up of human skills, knowledge and accumulated experience within the DC. Because capability is so important to successful technology transfer, the report focuses on TNA from the DC local capability point of view.

Part 3 presents the national TNA tool. This provides a systematic method of asking the following questions: Does the DC in question have the capability to acquire the necessary ESTs? How strong is that capability? Are there any crucial weaknesses which must be addressed? How do existing capabilities compare (or benchmark) against those in other DCs? This technology 'audit' is needed to develop an action plan to ensure that specific priority technologies can be identified and transferred as quickly as possible.

Part 4 presents a similar tool for addressing sector level issues, recognising that leading sectors often play a central role in the overall development of a nation. A more detailed enterprise level tool is presented in Annex 1, for those countries wishing to undertake an in depth audit of micro level capabilities.[4]

Finally, Part 5 provides details of UNIDO's activities in support of DC technology capability building, as well as several concrete examples of how UNIDO has assisted with technology transfer of ESTs both at a North-South and a South-South level.[5]

It should be noted that traditionally TNAs are often carried out in a 'top down' manner, often by specialist experts in lengthy documents. By contrast, the TNAs presented here deliberately take a bottom up 'self-assessment' approach. They are designed to be

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[3] This is essentially a 'techno-managerial' or strategic capability, rather than a specific scientific or engineering competence. Without the strategic capability to manage technological acquisition, adaptation and development, it is highly unlikely that specific technologies will be acquired effectively or in ways which promote economic development. By contrast, with the managerial and policy capabilities in place to create and implement technology strategies, it is much more likely that individual DCs will be able to identify and acquire the priority technologies needed to promote sustainable economic development on an ongoing basis.

[4] This tool has been applied, for example, to firms in Korea to identify the necessary policies needed to help upgrade firms from one level to another (Hobday, et al, 2001).

[5] Other UNIDO contributions which relate to these issues include Bennet and Vaidya (2002), which provides both a general framework for understanding sustainable industrial development as well as an action plan for UNIDO to promote the development of the 49 least developed countries (LDCs) based on the UN Classification. Also, the CAPTECH Manual (2001) provides a comprehensive firm-level expert TNA for SMEs; the firm-level TNA presented in Annex 1 of this report complements the CAPTECH approach with a shorter, self-assessment tool.

simple for rapid use. They are based on the view that DC policy representatives are best informed about their particular circumstances and best able to use the TNA to develop and implement a programme of action.

The tools can be applied by a DC independently or in partnership with UNIDO. They are designed to:

1. Benchmark existing DC technological capabilities against other countries' capabilities;
2. Provide a 'capability profile' of the DC, along with key areas of strength and weakness;
3. Examine the effectiveness and efficiency of current mechanisms for technology acquisition;
4. Provide the necessary data to help choose technology priorities and implement a strategy for technology acquisition and upgrading.

In addition to the TNA, other services provided through UNIDO's Industrial Promotion and Technology Branch (the Service responsible for implementing UNIDO's technology transfer strategy) can help ensure the subsequent implementation of the strategy, including partnership building, S&T support and assistance with fund-raising.[6]

[6] For example, Bennett and Vaidya (2002) show how the poorest DCs can envision catch up strategies based on their starting position and the paths followed by more successful DCs (e.g. from East Asia).

Part 1: The TNA - A UNIDO Contribution to the WSSD

1.1 Technology and the WSSD

The international community is in the process of engaging governments, business and civil society in actions to promote industrial and economic growth, social development and environmental protection. During the second session of the Preparatory Committee (PREPCOM 2) for the World Summit on Sustainable Development (WSSD), held from 28 January to 8 February 2002, it was confirmed that the UN Conference on Environment and Development held in Rio de Janeiro in 1992 provided the international community with both the fundamental principles and the necessary programmes of action for achieving sustainable development.

A key part of this agenda involves technology transfer to developing countries (DCs). As noted in the introduction, the Chairman's report on PREPCOM 2 argues that, if well managed, globalisation has the potential to promote sustainable development in the DCs. However, at the present time many countries have effectively been marginalised from the march of globalisation.[7] This report points out that promoting sustainable development in a globalising world requires actions to ensure the transfer and diffusion of environmentally sound technologies to DCs. This includes actions on technical advisory and consultancy services, technology banks, marketing support, legal advice, research and development (R&D) and laboratory facilities, as well as assistance in project formulation and negotiation, technology sourcing and match-making (Salim, 2002, pp18-19).

1.2 Technology Transfer and the Rio Process

Since the transfer of modern technologies is central to sustainable development they have a crucial role to play in achieving the Millennium Declaration Development Goals and, in particular, to alleviate poverty. Technology can be a powerful tool to narrow the gap between those countries that are benefiting from globalisation and those for which globalisation has led to increased marginalisation.

Unfortunately many developing countries face major challenges in acquiring, using and developing modern technologies. In order to overcome these challenges, national strategies and international assistance have to work hand in hand. Through UNIDO, the UN system can encourage and support concrete steps to help DCs at all levels of development.

In the context of international endeavours for sustainable development, technology transfer has been recognised as a key 'means of implementation' for the recommendations of Agenda 21. Several meetings of the Commission on Sustainable Development have adopted recommendations on technology transfer. Indeed, the major multilateral environment agreements all contain significant clauses dealing with technology transfer. The Special Session of the General Assembly for the 5-year-

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7 See for example MAP/OMEGA (2001) which documents the extreme poverty and marginalisation of much of Africa and provides a vision for sustainable growth and development, incorporating the role of environmental and information and communication technologies.

review of the Rio commitments in 1997 reiterated the importance of technology transfer. The Report of the Secretary General for the preparatory process of the WSSD, 'Implementing Agenda 21', identifies technology transfer as one of the ten key areas in which progress is needed.

1.3 The G-77 Summit

Successful technology transfer depends crucially on the capability of each developing country to acquire and implement the technology in question. *Technology acquisition is the other side of the coin of technology transfer: without the local capabilities to acquire technology, technology transfer cannot occur*. Therefore, it is essential that N-S cooperation enables the poorer developing nations gain the capabilities needed to acquire modern, sustainable technologies.

In addition to N-S co-operation, in some areas greater S-S co-operation could be an effective means of facilitating technological transfer and acquisition. The UNIDO Initiative described here seeks to create synergies with the aspirations of the Tehran Consensus with a view to preparing specific input to the High Level Conference on South-South Co-operation foreseen for 2003. In support of this, Part 5 below provides concrete case examples of how UNIDO has promoted poverty reduction through the transfer of ESTs.

1.4 The UNIDO Initiative and Methodology

Since UNIDO's mandate is uniquely suited to play a key role in technology transfer, the UNIDO Director-General, Carlos Alfredo Magarinos, has decided to mobilise a special effort to assess needs in the area of technology transfer and to promote action. UNIDO wishes to undertake this Initiative with interested and suitable partners (from international organisations, NGO's, private business, interested governments and academia). The idea is to combine high quality assessment tools with a global, regional and sectoral outreach effort geared at initiating concrete co-operation endeavours.

The methodology of the UNIDO Initiative. combines national technology needs analysis with a process for exploring national and sectoral priorities for building the capabilities to acquire modern technologies and to ensure technology transfer occurs rapidly. The UNIDO Initiative also includes a process for 'match-making' (or alliance building) for concrete co-operation endeavours, based on its previous experiences in this area.

1.5 Technology Needs Assessments

TNAs are frameworks and tools designed to identify and determine the capabilities needed to implement the technology priorities of developing countries. They involve major stakeholders in a consultative process in order to identify national and sectoral priorities and overcome the barriers to technology transfer at three key levels: (a) nation; (b) sector; and (c) enterprise. The UNIDO Initiative focuses mainly on the national and sectoral levels, where major gaps currently exist, but it also provides detailed tools for assessing needs at the business firm level (See Annex 1).

The Commission on Sustainable Development has explicitly recommended the use of TNAs in order to identify priority needs. The TNA methodology here, is designed to enable countries to rapidly assess their own capabilities and to develop viable technology strategies for the nation and leading sectors. The methodology can also help countries build up the capabilities to implement technology projects quickly to meet local needs.

1.6 TNA Action Process

As a first step, a short questionnaire (described below in Part 3) will be made available to interested delegations/government entities. The questionnaire is simple and straight forward, having 30 or so questions which can be answered by one or more country representatives. The tool assesses the key local capabilities needed for successful technology transfer, including policy objectives formulation, technology transfer mechanisms and the performance of existing policy machinery.

The questionnaire also has a built in 'benchmarking system' which shows where a country currently is on a 'staircase' of technological capabilities ranging from very weak to very strong. Partner countries in the Initiative will be able to quickly self-assess their existing capabilities against the simple staircase model and identify the next step on the capability staircase to aim for.

The TNA will allow countries to self-assess their overall national technological capabilities in areas such as policy making, research and technology organisations, the links between government and firms and the effectiveness of current national technology strategies and programmes. The self-assessment phase should be completed by the end of June.

The questionnaire (or 'tool') covers the three key features of national technological capability:

(a) the ability to formulate policies and strategies correctly (i.e. policy making capability);

(b) the mechanisms and institutions required to carry through policy;

(c) the performance of current policies and mechanisms in meeting targets (i.e. implementation capability).

The tool captures data on ESTs at each of these levels as well as all other key areas of technology transfer. It can be used to rapidly build a profile of the strengths and weaknesses of the overall national technological capability, which can then form the basis of a DC strategy for technology transfer with key priorities. This process, if necessary, can be assisted by UNIDO.

Those countries that decide to participate in the self-assessment, will be invited to regional (and possibly sub-regional) consultation meetings, facilitated through the UN Regional Commissions. These consultation meetings will discuss (and possibly tailor and up-grade) the questionnaire and exchange views on success-stories and engage in shared learning. Since it is not possible to deal with all technologies in the same way, the UNIDO Initiative proposes to identify and focus on sectoral priorities that are of particular relevance to a given region or sub-region.

1.7 Exploration of Sector and Technology Priorities

Technology can offer solutions to deal with environmental, employment and poverty problems affecting the developing world. The above series of workshops, carried out in a regional or sub-regional setting, will bring together key decision makers from national governments, international organisations and the private sector to develop action programmes to address those challenges that are perceived as most pressing by the regions or sub-regions concerned. The challenges to be addressed can be identified through a similar questionnaire (presented below in Part 4) that can be used by interested countries to self-assess sector capability needs.

The issues initiated by the questionnaire process might well include some of the key environmental questions identified by UNEP's Global Environment Outlook as particularly severe problems for a given region or sub-region, including:

For Africa, e.g. GEO-2000 identifies as the major challenges:

- increased food insecurity resulting from rapid population growth, degradation of agriculture and arable lands, mismanagement of available water resources;
- deforestation (pointing to a need for energy alternatives to firewood);
- biodiversity loss;
- acute and worsening fresh water problems;
- coastal and marine resources degradation
- air-pollution as major problem in most African cities;
- high urbanisation requiring more effective urban management systems;

For Latin America and the Carribbean, GEO-2000 highlights:

- nutrient depletion and soil erosion;
- groundwater contamination and depletion;
- heavy metal contamination;
- urban waste disposal problems.

More info on GEO can be found on the web at *www.unep.org/geo2000/english/0092.htm*

The national and sector level tools will help guide participants to an understanding of what capabilities need to be in place at the country and sector level to address these problems.

Once the key capabilities are identified and put in place, resolving these problems though technology transfer then becomes a real possibility, as long as sufficient support, especially financial, can be made available. UNIDO can assist in the identification of possible funding sources (see Part 5).

Sectors may include key employment and export generation industries (e.g. manufacturing). They may also include generic sets of technology that are of particular interest to a given region (e.g. biotechnology for Latin America). They could also include key environmental technology fields (e.g. air pollution controls) which cut across traditional industrial sectors. The workshops could be facilitated by various partners in the Initiative (e.g. the International Center on Biotechnology and Genetic Engineering could take the lead on biotechnology issues). The international organisations involved in these workshops would pledge to bring seed money to start implementing the action-programmes and would actively work to raise additional money from donors or international financing entities.

Following the national and sectoral assessment phases, UNIDO, together with its partners in the Initiative, would facilitate the start up of task oriented, multi-stake-holder coalitions that would facilitate actual technology transfer according to the modalities most suitable to each case.

Experience with existing institutions for technology transfer is highly uneven, partly because DCs often lack the capabilities to assess the technologies on offer and acquire them effectively, at low cost. The participants in the UNIDO Initiative will have an opportunity to exchange views on the most effective modalities for regional and sub-regional support.

1.8 Timing of the Initiative and Links with Other International Processes

The national self-assessment phase will be initiated in May 2002. The subsequent phases of the Initiative will be finalised in dialogue with those countries and entities expressing initial commitment and taking into account the relevant priorities identified in the preparatory process for the WSSD.

The finalised version of the Initiative will be launched at the WSSD as one specific alliance for implementation. The execution of the regional consultations will be planned for 2003, the building of alliances and initiation of the regional or sub-regional programmes of action will commence in 2004.

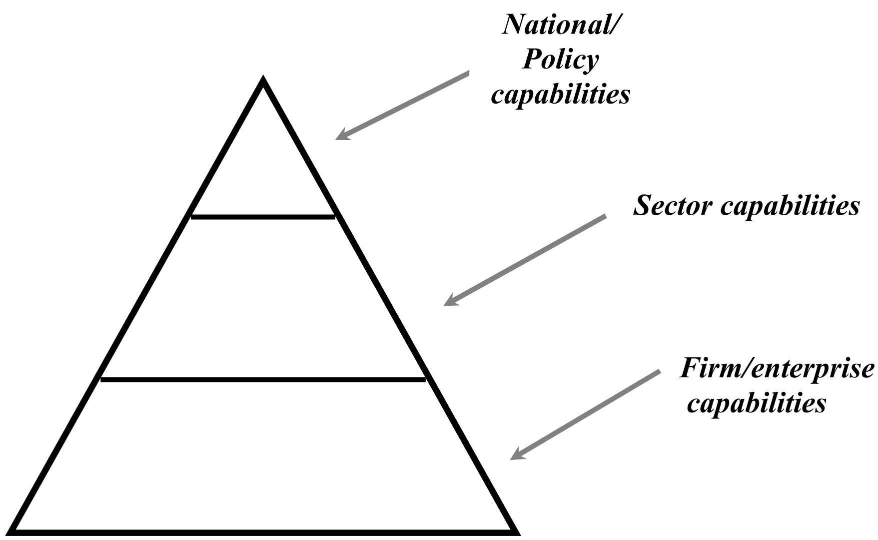
The UNIDO Initiative take as its point of departure, the global consensus reached at Johannesburg. It seeks to link with the ITU Summit, the World Conference on Biotechnology (Chile, 2002), the 2003 S-S-Summit and other relevant regional and global events.

Part 2: Technology Transfer and Technology Capability

There are many ways of defining technological capability. To avoid any misunderstandings and to provide concrete definitions based on research, Annex 2 presents definitions of all the technology terms used in the report.

As the Annex shows, technological capabilities can be seen as all those abilities needed to carry out production related activities, ranging from planning, the purchasing of equipment, plant start-up and operation, the adaptation of inputs, improvements to production processes, changes to product specifications, product-process interface engineering (e.g. design-for-manufacture), incremental improvements to processes and products, new product design, applied R&D and basic research.

Figure 1: Technology Needs Assessment Framework:
Three Strategic Levels of Technological Capability



For the purposes of this paper it is also helpful to define capability according to nine constituent components:[8]

1. Awareness: being aware of technology issues and the need to acquire technologies;
2. Search: the ability to seek out and identify technologies to solve particular problems;
3. Core capability: the building of a distinctive capability in some area of technology;

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[8] This is based on Bessant et al. (2000), which provides a tool for auditing firm level capabilities (see Annex 1).

4. Strategy: the development of a technology strategy, including a framework with priorities and an action plan;
5. Assess and select: the ability to assess and select cost effective technology solutions;
6. Acquire: the acquisition and absorption of specific technologies;
7. Implement: the skill involved in making effective use of technology
8. Learn: the ability to learn from and accumulate experience in order to continuously improve capabilities;
9. Linkage: the ability to form and exploit linkages with networks of technology suppliers and others involved in technology.

As Figure 1 shows, these capabilities need to be built up at three strategic levels for a DC to acquire technology effectively: (a) the nation; (b) the sector; and (c) the firm or business enterprise.

As noted in the introduction, rather than any specific S&T capability, the crucial capabilities for DCs (and developed countries) is the managerial/strategic capability needed to select, acquire, absorb and implement specific technologies. With this strategic capability in place, it is far more likely that specific technologies can be acquired and developed successfully. By contrast, even if the country has specific ‘hard’ S&T resources, if the techno-managerial capabilities are weak or absent, then the nation will, in all probability, not be able to develop the strategies needed to absorb and exploit the specific technologies in a way which fosters economic development.[9]

The following section takes national level capabilities and discusses the key components of the tool used to provide a TNA, suggesting how to audit, benchmark and improve policy level capabilities.

[9] For example, it is often the case that hardware (e.g. advanced IT equipment) is purchased and then not utilised properly, due to insufficient local abilities. This kind of ‘technology transfer’ (i.e. the transfer of equipment rather than knowledge) can be very expensive and highly ineffective. By contrast, with IT management skills in place (e.g. in systems specification, overall design, project management, recruitment skills, operational capability) the costs of genuine technology transfer can be reduced substantially.

Part 3: Technology needs assessment at the national level

3.1 Understanding and Using the Tool

This section discusses the national level TNA tool in detail. At the present stage it is a prototype tool which can easily be extended or tailored for particular country needs. It is also designed for rapid use, having no more than 30 key questions. The section is structured as follows:

- *3.2 Describes the aims and purpose of the tool;*
- *3.3 Presents a simple DC capability 'staircase' model, which enables a country to use the tool to quickly 'benchmark' itself against other countries and to see potential next stages in the national policy development of the country;*
- *3.4 Describes typical conditions facing DCs at the four levels of the staircase model and how policies could help governments move up to the next level;*
- *3.5 Presents the tool itself, a simple structured questionnaire which can be completed by one or more country representatives;*
- *3.6 Explains the structure of the tool, showing how it is able to address policy formulation, policy mechanisms and the policy performance of a DC (as well as key environmental issues);*
- *3.7 Provides guidance on how to use the tool, explaining how each question addresses a particular TNA issue;*
- *3.8 Shows how to use the tool to develop a capability profile, including strengths and weaknesses;*
- *3.9 'A Strategy Workshop': Points the way to using the evidence from the tool to develop a strategy and action plan, including key priorities for the country (Part 5 shows how UNIDO is able to assist with follow up processes).*

In addition, Annex 3, provides examples of 'best practice' technology policies programmes from the developed and developing countries, showing how these countries intervene to improve local technological capabilities.

3.2 Purpose of the TNA

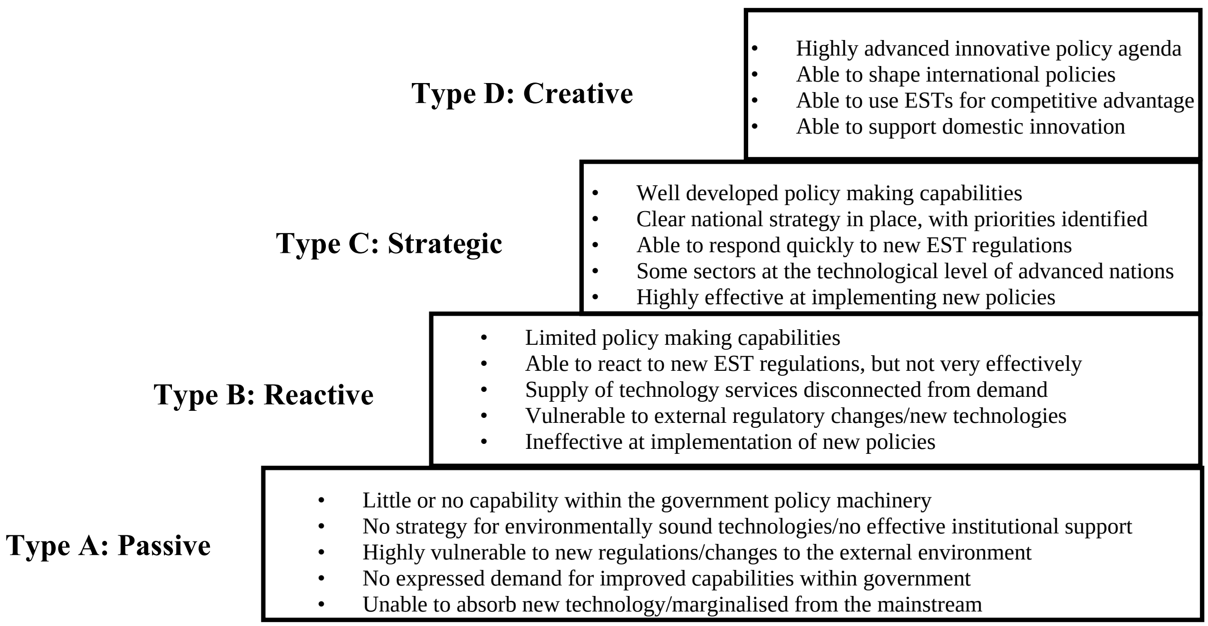
The national level TNA needs to address policy level questions concerning the country's technological capability: what is the overall level of capability relative to other countries? how well do existing technology transfer mechanisms function? which key resources does the country have to build upon? what are the country's critical weaknesses? does the country have the appropriate policy-making bodies to ensure technological development?

Broader strategic questions include: what is the overall national strategy for technological development? How well does this strategy fit in with and support wider economic and environmental goals? Which technology capability 'gaps' need to be filled? Does the 'policy machinery' link up well and do the various players communicate with each other, and with private sector firms?

The national TNA also needs to assess the existence (or not) of:
(a) a national technology strategy;
(b) a base of existing capable firms;
(c) appropriate research and technology organisations;
(d) effective policy making bodies.

With strong policy capabilities in place, the specific technologies required to fulfil a national strategy (e.g. in areas such as clean water, environmental pollution, agriculture, manufacturing industry, bio-technology and information technology) can be arrived at through consultation between the various actors involved and the deployment of managerial and S&T resources.

Figure 2: Staircase Model of National Policy Capabilities in DCs



Notes: The above capability staircase model builds on the work of Baden-Fuller and Stopford (1994), Bessant et al (2000) and Arnold et al (2000). However, these latter studies are applied at the level of the firm, rather than at the national policy level.

The aim of the TNA is not only to identify areas of weakness and difficulty which need to be addressed. It also needs to capture the potential 'dynamic comparative advantages' or, put another way, distinctive fields of technological strength which can either: (a) meet pressing existing economic needs; (b) resolve environmental problems

(c) create new competitive advantages for the economy; or (d) a mixture of all of the above. Where key weaknesses are identified, technology policies and programmes may need to be established by government, which can be led either by government agencies or private sector companies.[10]

By facilitating in depth analysis of national goals, government responsibilities with respect to technology can identified and shared with the relevant stakeholders, and specific national technology priorities can be clarified using the TNA. Once articulated, these priorities can be used to inform educational policies (including managerial education, technical training and S&T education), as well as infrastructural policies (e.g. transportation, energy and communications). Government may need to consider how to regulate or provide incentives for specific goals (e.g. in relation to environmental pollution or employment creation) and ensure, through its macroeconomic management, that technology transfer has the necessary stable macroeconomic conditions to occur.

3.3 A Staircase Model for Benchmarking National Technological Capabilities

One key objective of the TNA is to provide a rapid benchmark (i.e. comparison) of the capabilities of a country compared with others, so that the DC can envision the next steps on the ladder of progress. Research shows that there are considerable differences in the capabilities of DCs to formulate and execute national technology policies, and the 'staircase' model is a simple device for capturing these differences.

The staircase model depicted in Figure 2, describes four 'ideal types' of national governments according to their degree of capability. The four categories are represented on a staircase of capability levels, from Type A (very weak) to Type D (very strong). Countries, of course, do not remain in a single position over time. They may well progress over time through the various stages, depending on how successful they are. They may also slip backwards if governments for some reason lose their skills or competencies. Also note that, within each category, there is a fairly wide band of capabilities with considerable differences within each type.[11]

In principle, the framework can be applied to an entire country, a government, or to a ministry or department. There is likely to be significant differences between departments of government, depending on size, power and resources available. For example, ministries of S&T are often low down in the 'pecking order' of ministries, with less influence than ministries responsible for finance and industry.

In what follows we focus on governments as the chief representatives of countries at the national level. Taking each of the four country types in turn, it is possible to broadly characterise governments according to their capability levels.

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[10] It is important to point out that the national TNA does not imply centralised 'planning' or extensive or intrusive government co-ordination. On the contrary, the TNA is a simple analytical instrument for examining the current position of a country and deciding where it might wish to get to in the future. The primary technology actors within the country are private sector firms without which technology acquisition cannot occur.

[11] More 'fine tuning' is offered with sector and micro level TNAs (see Part 4 and Annex 1 below respectively).

3.4 Typical Conditions Facing DCs at the Four Levels of Development

Type A Governments: Unaware/Passive

Type A governments can be characterised as being 'unconscious' or unaware of the need for technology transfer or environmental improvement. For one reason or another, they do not recognise the need for technology capability building and may well exist in an environment of crisis, where other needs take priority over technology for good reasons (e.g. health or education). These countries are unlikely to have policies for sustainable technology and are probably marginalised from the mainstream of international trade and discussions over pollution, ESTs and so on.

These governments do not know where or what they might improve, or how to go about the process of building policies for technology upgrading. As such, they are highly vulnerable to external forces. For example, if lower cost competitors enter their traditional markets with higher quality products or services, they may not realise this until damage is done to local industry. Even if they do recognise a problem, they may waste scarce resources by analysing the situation incorrectly and focusing on the wrong kinds of improvement. If a new environmental regulation is agreed at the international level it is likely that these countries will be unable to respond and may be damaged competitively, leading to further exclusion from exports, and lower employment generation.

Because these nations are ill-prepared in all major areas of S&T, a thoroughgoing improvement programme is urgently needed, unless other priorities (e.g. basic human needs, including food, health and education) rule out any technology considerations. Assistance may be required to enable these governments to understand technological challenges and to develop strategic national frameworks for manufacturing and other key sectors. Help may also be needed to identify appropriate changes and to acquire and implement specific technologies.

These governments will probably require assistance in sustaining this process of improvement over the longer-term. In very poor countries, the manufacturing sector will tend to focus on the assembly of simple products for the local market and will not yet have developed production engineering skills, export or R&D capabilities. The immediate need is to enhance assembly capabilities and begin to develop technical and engineering skills in order to improve efficiency and open up more higher value added opportunities by improving manufacturing processes.

Type B Governments: Reactive

Type B governments recognise a need for improvement in technological capabilities for environmental purposes, growth and exports. However, they are unclear about how to go about the capability building process systematically. Since their internal resources are limited (they may lack key skills and personnel experienced in technology) they tend to react to technological threats and possibilities, but are unable to shape and exploit events to their advantage.

These governments may well be threatened by new EST regulations devised in the developed countries. They may depend heavily on technology transfer from dominant foreign suppliers and may bargain ineffectively for technology, because of a lack of knowledge and experience. Overall, these governments have poorly developed capabilities in most areas of technology assessment and strategy. However, there are some strengths upon which to build.

These countries probably need to begin by developing a strategic framework for technological capability building, including key priority areas and a series of steps for improvement. Governments in this category need to be able to search more effectively for S&T solutions, to explore new technology options, and to acquire and implement specific technologies (e.g. new products and processes for manufacturing). As capabilities are mastered, these countries should progressively develop an internal capability for strategic analysis for upgrading needs, and require less and less support as time goes by. In manufacturing, these countries will typically have moved on from assembly and already have technician and engineering skills upon which to build. Their next stage of development could well be to develop the capabilities to innovate with process technology and gradually move to Type 'C' on the staircase.

Type C Governments: Strategic

Type C governments will have a sound knowledge of how to upgrade technological capabilities within their country. They are highly capable of implementing national technology projects and take a strategic approach to capability building (e.g. Republic of Korea or Province of Taiwan). In Hong Kong, for example, (see Annex 3.1) the government set up a very effective organisation, the Hong Kong Productivity Council, for supporting and diffusing technology among SMEs in order to overcome 'market failures' (e.g. a lack of information on overseas markets).

As they have a clear view of priorities, Type C governments are able to formulate strategies and build up their internal capabilities incrementally in technical and managerial areas. Unlike Type A or B governments they will be able to implement technology programmes with skill and speed. These governments benefit from a consciously developed strategic approach to technology transfer, absorption and improvement. However, they probably lack the capabilities to re-define policy agendas with respect to new technology. They are comfortable within the boundaries of existing technologies and industries but may become 'trapped' in mature or slow growth sectors.

Although Type C governments are able to respond quickly and effectively to new EST regulations, local industry may need policies in order to increase the rate and depth of innovation in leading sectors. They may also need better access to capital goods and services. Type C governments may benefit from strategic advice concerning the latest sustainable technologies needed for the medium- and long-term. They may also require government-led initiatives and institutions for technology development among SMEs, and other less advanced sections of industry (as provided, for example by IRAP in Canada, see Annex 3.2). Although, these countries may be behind the international technology frontier in some areas, they have important foundations upon which to build and are able to aim towards becoming a Type D, highly innovative country.

Type D Governments: Creative

There are very few Type D governments in the developing world. By definition, most will have graduated to middle income or high income status (e.g. Province of Taiwan and Singapore). Type D are the international leaders within the developing world and, as such, are able to act swiftly to improve their nation's technological capabilities. Domestic governments support their leading industries in their efforts to upgrade and define environmental technology standards and can help advance the overall international technology frontier (e.g. Republic of Korea in semiconductor and nano-technology). These governments take a pro-active approach to exploiting technology for competitive advantage. They are familiar with modern strategic frameworks for technological acquisition and innovation and take it upon themselves to contribute to the new technologies (e.g. in genomics and bio-informatics).

Type D government departments typically enjoy a high degree of techno-managerial capability. They understand the need for industry to diversify into new sectors and know where their nation's skills and capabilities may bring new competitive advantages. Their substantial resources enable them to remain abreast of new technological opportunities and threats. Policy makers keep closely in touch with industry in their joint efforts to shape and exploit the frontiers of technology to their advantage. Much can be learned from these countries and they may also be helpful in advising less developed countries on how to overcome the barriers to development, that they themselves have overcome.

Climbing the technology staircase

To summarise, one of the main challenges facing policy makers in DCs is to build the capabilities required to 'climb the technology ladder' to help the nation as a whole become more capable and competitive.[12] With a good understanding of how to acquire technology, policy makers can help remove barriers to technological progress (e.g. shortages of technical education or inefficient R&D institutes) and build on local advantages (e.g. in natural resources or skilled labour). However, policy objectives differ widely according to where the government is positioned on the technology staircase outlined in Figure 2. Therefore, the TNA below is designed to situate a country on the staircase.

3.5 The TNA: a Tool for Benchmarking and Profiling Policy Capabilities

Figure 3 presents the self-assessment capability audit tool for national governments. One or more government S&T representatives are asked to answer the following questions according to the scale below by entering 1, 2, 3, or 4, for each question.[13] The four point scale corresponds directly to the four categories of country in Figure 1 (Types A, B, C and D).

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[12] It is also important to stress that technology policy-making bodies need to take into account other important factors which impact on national technological performance and opportunities for the future. These include the impact of indirect or 'implicit' technology policies (e.g. educational, trade, competition, economic and industrial policies). Sometimes these are more important than direct S&T policies in encouraging or discouraging firms and sectors to improve capabilities. Furthermore, governments need to consider the appropriate *mode* of support for technology (e.g. private sector sponsorship, other market-led mechanisms, direct government support, and indirect government support mechanisms).

[13] Ideally, staff from various different departments and various levels of seniority should fill in the questionnaire to compare views and arrive at a representative view for the country.

Figure 3: Self-Assessment Capability Audit Tool: for National Governments

Key technology capability area	Audit Questions	Disagree Strongly	Disagree Some-what	Agree Some-what	Agree Strongly	N/A [14]
	Assessment Score	***1***	***2***	***3***	***4***	
Policy making						
1 Technology plays an important part in our national development strategy						
2 Our government's technology policy priorities are clear and coherent						
3 Our technology policy is agreed and understood by key national actors						
4 Our government can assess technology threats and opportunities rapidly						
5 We are able to evaluate the effectiveness of our environmental policies						
6 Environmental issues are given a very high priority						
7 Technology policy responsibilities are delegated to the correct bodies within government						
8 We are able to revise our policies quickly in the light of new environmental (EST) demands						
9 Most of our initiatives are driven by industry needs						
10 We contribute to international technology groups and forums						
Policy machinery						
11 We are able to support leading sectors in the acquisition of technology from abroad						
12 We are able to help our leading sectors form technology strategies						
13 We are able to help industry implement EST projects effectively						
14 Our technology institutes are effective at meeting industries' needs						
15 We have a wide range of technology acquisition mechanisms to meet industry needs						
16 Industrialists believe our technology representatives are highly skilled						
17 Our technology acquisition mechanisms help us catch up with advanced countries						
18 Our policies help us to shape environmental technologies to our advantage						
19 We have specific groups responsible for ESTs						
20 Our technology groups gain valuable knowledge and experience from working with international agencies						
Policy performance						
21 Our technology acquisition mechanisms change rapidly according to new external EST regulations						
22 We are able to adjust our technology priorities rapidly						
23 We can point to several major government-led technology achievements						
24 We met our environmental technology targets last year						
25 We know our EST priorities for the next five years						
26 We regularly ask firms for their views on our technology performance						
27 We are able to charge companies for participation in our programmes						
28 Our technology programmes are run efficiently						
29 Our EST initiatives are generally low cost but high value						
30 Our technology initiatives contribute directly to export generation						

[14] N/a = not applicable or not known (in which case an average of other scores is to be used to complete the audit).

3.6 The Structure and Rationale of the Tool

The tool covers three key areas of policy capability:[15]

- first, the ability to formulate policy;
- second, the mechanisms and organisations needed to implement policy;
- third, the performance of existing policy mechanisms (i.e. the implementation effectiveness and efficiency of policies and policy machinery).

In addition, within each area specific questions deal with environmental issues (see section 3.7 below). Taking each of these in turn, it is useful to describe what an advanced Type C or D country would typically be capable of.

Policy Making Capability

An advanced developing country (Type C or D) will be able to point to a coherent national S&T policy which embodies EST targets. The policy will typically be agreed with, and understood by, the major actors (e.g. firms, technology institutes, energy ministries and so on) within the country, and responsibilities for enacting the policy will be clear and unambiguous. The policy will be integrated into the country's wider development, growth and environmental strategies, and form an indispensable part of this wider agenda. The government will be aware of its leading sectors in terms of exports and industrial potential and much of its development strategy will be enacted through these sectors.

Policy mechanisms and machinery

Policy mechanisms or machinery refer to the organisations of government responsible for formulating and executing the S&T policy. An advanced DC will typically have various groups within government who are expert in the formulation of strategy, search and acquisition of technology, project implementation and forming linkages with international groups (e.g. IS09000 standards bodies and environmental groups). The machinery may include national institutes for S&T, environmental programmes and other mechanisms (e.g. temporary projects for technology transfer) for ensuring policy is implemented. A Type C or D economy will be able to show that its various mechanisms and institutes are 'demand driven' (i.e. driven by the needs of local users) and not 'supply push' (e.g. driven by the desire to conduct S&T research). Note that many government S&T organisations are indeed supply push, dedicated to research but dislocated from the real needs of industry (Rush et al, 1996).

Policy performance

Impressive policies mean little if they are not carried out in a timely and efficient manner. Policy performance refers to the effectiveness and efficiency by which policies are enacted, executed and evaluated. Performance includes the ability of the policy machinery to respond quickly to new problems and opportunities, including new environmental regulations. An advanced Type C or D country will conduct evaluations

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[15] The three dimensions of policy are derived from a series of major S&T policy and programme evaluations carried out over many years in both developed and developing countries (e.g. Guy et al, 1991; Hobday, 1997, Rush et al, 1995; Rush et al, 1998). However, in contrast to these and other 'expert' evaluations, the current questionnaire is a 'bottom up' self assessment tool, designed to help groups improve their policy capability. Because it is a self-assessment, rapid approach, it does not deal with all technology issues in great depth, but concentrates on a wide band of important issues. The main aim is to obtain sufficient data to rapidly initiate a programme of technology upgrading.

of policy achievements and regularly assess the appropriateness and effectiveness of the existing policy machinery. Performance includes the cost-benefit ratio of public S&T investments, focusing on the outcomes of policy as well as the costs to the government. High performing policies will, by definition, be demand driven and policy institutes may well have been restructured and revitalised in order to meet the changing needs of industry through time. As one of the principle 'customers' of S&T policy, industry should play a major part in assessing the performance of the policy machinery and the reputation of policy departments.

3.7 Using the Tool to Assess a Nation's Technological Capability

An input into strategy

The tool is designed to cover the three dimensions of national policy above. After completion by one or more policy representatives, by using the scoring system government officials can:

- Step 1: calculate the overall technology capability level (or 'benchmark' the country against the four categories);
- Step 2: identify key strengths and weaknesses according to various sub-categories of technology capability;
- Step 3: convene 'a strategy workshop' which uses the data to develop a strategy to address major problems, build on identified strengths and identify key priorities for the country.

The purpose of steps 1-3 is arrive at a strategy so that an action plan can be developed to carry through policies efficiently and effectively. Although the tool provides important inputs into policy making it does not define the implementation plan. However, in this area UNIDO is capable of supporting DCs through its various programmes, described in Part 5 below. Through its initiatives, UNIDO can assist with both the completion and implementation of the tool and the execution of a follow on action plan.

Guidance notes for using the tool

Each question is designed to address specific areas of policy formulation, machinery and performance and, in addition, environmental performance:

<u>1. Policy Making (Q1-Q10)</u>

- Q1 indicates the degree of awareness of technology within government and the degree of integration of technology issues into wider strategy. Without a fairly strong degree of awareness and integration, it is highly unlikely that government will be effective in formulating and executing policy. Low scores in this area are likely to be followed by low scores in all other areas;
- Q2 and Q3 are concerned with the clarity of technology priorities and how well the policy is communicated to the key actors involved (e.g. industry, academia and sector specialists);
- Q4, Q5 and Q6 deal with the issue of how well government is able to assess external threats and opportunities in technology in general (Q5) and in the area of ESTs in particular (Q6);
- Q7 and Q8 refer to how well responsibilities for technology activities are delegated, and the ability of government to respond to new changes in environmental regulations.

- Q9 indicates how responsive the government is to the needs of local industry or how demand driven (as opposed to supply push) policies actually are in practice;
- Finally, Q10 points to the ability of policy makers to form linkages with international agencies concerned with technology (e.g. standards bodies, evaluation groups and other policy makers). Highly advanced countries are well represented in these bodies and gain advantages from participation. By contrast, Type A and B countries probably see these bodies as an external threat.

2. Policy machinery (Q11-Q20)

- Q11 and Q12 focus on how well the technology policy machinery is able to support industry in its efforts to acquire foreign technologies in order meet the goals of growth and development;
- Q13 and Q14 deal with the existence of practical mechanisms for implementing EST projects and other industrial technology needs, respectively;
- Q15 looks at the diversity of policy approaches and whether these are linked into industry needs;
- Q16 assesses the quality and skill of government officials from industry's viewpoint;
- Q17 asks whether the organisational mechanisms are sufficient to keep up technologically and, in advanced cases, to help industry catch up and narrow the gap between themselves and the leaders;
- Q18 and 19 assess how innovative the policy machinery is in relation to ESTs and the priority and focus given to environmental technology issues within government;
- Q20 looks at how effectively policy groups exploit working linkages with international agencies concerned with technology.

3. Policy Performance (Q21-Q30)

Regarding how well the policies perform in achieving their goals and building up the nation's overall capability:

- Q21 and Q22 assess the degree of flexibility of government in response to new EST regulations and the speed of responsiveness to new technology needs in general (e.g. for growth and employment purposes);
- Q23 and Q24 examine the direct impact and the long term effectiveness of government policies;
- Q25 deals with government's ability to set policies to address likely future EST regulations;
- Q26 and Q27 assess how well leading firms are 'plugged in' to the process of assessing policies and the value that firms place on government's activities;
- Q28 and Q29 pick up efficiency and value for money issues in S&T programmes and in ESTs in particular;
- Q30 deals with the impact of policies on export generation and, by implication, employment creation and industrial growth.

4. Environmentally Sound Technologies (ESTs)

Within the three above areas, the tool includes 10 questions (three in sections 1 and 2 and four in section 3) directly concerned with environmental issues.[16]

- **Policy making for EST** (Q5, Q6 and Q8); these questions deal specifically with the ability to assess the effectiveness of EST policies (Q5), the priority given to the environment (Q6) and the ability of government to respond to new EST needs (Q8);
- **Policy machinery**: (Q13, Q18, Q19), these questions refer to the ability to implement new EST projects (Q13), the ability to contribute (not just react) to new EST regulations (Q18) and the allocation of resources and priority to EST issues (Q19);
- **Policy performance**: (Q21, Q24, Q25 and Q28); these four questions assess, in turn, the flexibility and responsiveness of government to EST regulations (Q21), the ability to set and meet achievable short-term goals, and long-term priority targets (Q24 and Q25), and value for money in the area of EST projects and programmes (Q28).

3.8 Using the Tool to Develop a Capability Profile

As noted above, the first step is to calculate the overall technology capability level (or 'benchmark' the country against the four categories). Figure 4 overleaf provides a fictional example of a completed questionnaire.

Step 1: Calculating the Government's Overall Capability Level

Simply add up the total score (the total possible score is 120) and enter in the table below, where the overall capability level is described:

Capability Levels (1-4)	Score Range	Enter Your Score	Overall Audit Result
1 Passive	1-30		Your government performs poorly and is ill-prepared in all major areas of technology policy formulation and implementation; it is highly ineffective at acquiring and using technology; the government is also unaware of EST needs; a major improvement programme is urgently needed and key technology and environmental priorities addressed
2 Reactive	31-60		Your government has poorly developed capabilities in most areas of policy formulation and execution; it is lagging behind other countries in the ability to formulate policy and ensure the acquisition of necessary technologies for growth, exports and environmental standards. However, there are some strengths upon which to build and awareness of the problems exists
3 Strategic	61-90		Your government has strong in-house policy making capabilities and takes a strategic approach to technology acquisition. In some areas, the country is behind the international technology frontier but has many important strengths upon which to build; the government reacts effectively to changing environmental needs
4 Creative	91-120		Your government has a fully-developed set of technological capabilities and is able to shape the international technology frontier to its advantage. In many areas the government takes a creative and pro-active approach to exploiting technology for competitive advantage. Other countries can benefit from your experience and may wish to engage in technology transfer with you

[16] Note that indirectly, all the above questions also deal with ESTs, because EST capability is a sub-set of the capability of government to address technology issues in general. Put another way, without strong local technological capabilities ESTs cannot be transferred.

Figure 4: National Technology Capability Profile of Country X

Key technology capability area	Audit Questions	Strongly Disagree	Disagree Some-what	Agree Some-what	Strongly Agree	N/A
	Assessment Score	*1*	*2*	*3*	*4*	
Policy making						
1 Technology plays an important part our national development strategy			X			
2 Our government's technology policy priorities are clear and coherent				X		
3 Our technology policy is agreed and understood by key national actors			X			
4 Our government can assess technology threats and opportunities rapidly		X				
5 We are able to evaluate the effectiveness of our environmental policies		X				
6 Environmental issues are given a very high priority			X			
7 Technology policy responsibilities are delegated to the correct bodies within government				X		
8 We are able to revise our policies quickly in the light of new environmental (EST) demands			X			
9 Most of our initiatives are driven by industry needs			X			
10 We contribute to international technology groups and forums		X				
Policy machinery						
11 We are able to support leading sectors in the acquisition of overseas technology		X				
12 We are able to help our leading sectors form technology strategies		X				
13 We are able to help industry implement EST projects effectively			X			
14 Our technology institutes are effective at meeting industries' needs				X		
15 We have a wide range of technology acquisition mechanisms to meet industry needs			X			
16 Industrialists believe our technology representatives are highly skilled		X				
17 Our technology acquisition mechanisms help us catch up with advanced countries		X				
18 Our policies help us to shape environmental technologies to our advantage		X				
19 We have specific groups responsible for ESTs			X			
20 Our technology groups gain valuable knowledge and experience from working with international agencies			X			
Policy performance						
21 Our technology acquisition mechanisms change rapidly according to new external EST regulations		X				
22 We are able to adjust our technology priorities rapidly		X				
23 We can point to several major government-led technology achievements			X			
24 We met our environmental technology targets last year			X			
25 We know our EST priorities for the next five years				X		
26 We regularly ask firms for their view on our technology performance			X			
27 We are able to charge companies for participation in our programmes		X				
28 Our technology programmes are run efficiently		X				
29 Our EST initiatives are generally low cost but high value		X				
30 Our initiatives contribute directly to export generation		X				

Step 2: Assessing a Governments Particular Strengths and Weaknesses

To arrive at a profile of specific technology policy strengths and weaknesses, the country in question can relate the answers given to the three sets of questions, dealing with policy making, policy machinery, policy effectiveness and environment. Figures for case X show the following:

1.Policy Making- refers to the ability of senior policy makers to recognise the technological needs of the economy and the environment; it also refers to the ability to formulate strategies for upgrading, recognising the dangers of 'standing still' in today's highly competitive, increasingly global economy.

Questions 1 to 10

A: Total possible score best practice = 40	B: Your score	
		Passive 1-10
	19	Reactive 11-20
		Strategic 21-30
		Creative 31-40

2. Policy machinery - policy machinery refers to the existence of mechanisms for formulating and executing S&T policy. It refers to the government structures responsible for implementing projects and forming linkages with international groups; it includes national institutes for S&T, environmental programmes and mechanisms for industrial technology transfer.

Questions 11 to 20

A: Total possible score best practice = 40	B: Your score	
		Passive 1-10
	16	Reactive 11-20
		Strategic 21-30
		Creative 31-40

3. Policy performance - refers to the effectiveness and efficiency by which policies are enacted, executed and evaluated; performance indicators include speed of reaction within the policy machinery (e.g. to new environmental regulations), the overall effectiveness of the existing policy machinery, the costs *vs* benefits of public S&T and the extent to which S&T investments are demand driven (i.e. capable of meeting the needs of industry and the environment).

Questions 21 to 30

A: Total possible score best practice = 40	B: Your score	
		Passive 1-10
	15	Reactive 11-20
		Strategic 21-30
		Creative 31-40

4. Environment: Strategy, Machinery and Performance[17]

This section concerns all aspects of the countries approach to environmental technology transfer and capability building: strategy, machinery and performance. Fill in the scores from: Q5, Q6, Q8, Q13, Q18, Q19, Q21, Q24, Q25 and Q28.

Questions 11 to 20

A: Total possible score best practice = 40	**B: Your score**	
		Passive 1-10
	17	Reactive 11-20
		Strategic 21-30
		Creative 31-40

The Example of Country X

Having scored 50 in total, the overall position of 'country X' is towards the upper end of the 'Reactive' category 2. Looking at the results in the areas of policy making, policy machinery, policy effectiveness and environment, we see a relatively high score on policy formulation (19) nearly in the strategic range (an important strength on which to build). However, with policy machinery and mechanisms score only 16; reforms may be needed, especially given the inability of the government to support leading sectors and industry (Q11), and the low scores against environmental mechanisms. In fact, policy machinery, performance and environment all have major problem areas to consider.

Looking at the detailed scores on the questionnaire, even though country X is 'reactive' overall, it has four major areas of strength (marked in the 'strategic' category) upon which to build. The country has a clear and coherent technology policy and responsibilities are properly delegated. Technology institutes are very effective in country X and there is a clear EST plan for the next five years.

However, in terms of weaknesses, there are major deficiencies in 14 areas which are holding the country back and preventing it from moving forward to the next stage of development. These weaknesses (or 'hot spots') can form the basis of a workshop designed to explore the problems in depth, to rank the problems in order of priority for improvement.

The workshop can then explore the causes of the problems (sometimes there is one underlying cause for many problems, for example a lack of finance), and then explore solutions to the problems. This should culminate in a properly resourced action plan with priorities, next steps and clear responsibilities for action (i.e. a technology strategy).

The next section offers a possible workshop process which UNIDO can offer as part of its Initiative.

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[17] Total figures must be calculated from the questionnaire (rather than the four categories here), otherwise there is double counting (i.e. the environment figures would be repeated).

3.9 Step 3: A Strategy Workshop

A workshop for developing a national technology strategy

Following on from the audit

Pathways to improvement

If your country wishes to embark upon (or has begun) a technology upgrading programme, then UNIDO is able to offer workshops with managers and practitioners, to take forward the audit results and help define an improvement path.

Our workshops are conducted in a friendly, positive atmosphere by experienced facilitators: the workshop has two Parts A and B.

Part A: Resolving major problems ('hot spots')

During our workshop process, we will ask you to

- *verify that the overall results - and the results according to the specific capabilities fields - are in your view correct*
- *identify other key areas/factors which may have been missed out in the audit*
- *position the three or four most significant problem areas ('hot spots') in order of priority*

For each of the major problems we will ask you to:

- *Explain/expand on the nature of the problem*
- *Identify the main causes of the problem*
- *Brainstorm solutions to the problem*
- *Agree an improvement plan and identify the resources needed to implement it*

Part B: Identifying and building on strengths('beauty spots')

Using a similar process Part B, examines the key areas of strength (or 'beauty spots') identified in the audit as an input into strategy. In Part B we explore strengths in order to discover the key distinctive technological capabilities of the nation (forming a 'capability based' strategy). For example, you may be excellent at implementing projects, but weak at forming strategy. By investing in strategy expertise, and by then designing a portfolio of employment-creating projects with key priority targets, a rapid upgrading could begin.

Using this process, UNIDO can help your country develop a capability based strategy, which links your core capabilities to emerging new markets and new technologies in an environmentally sustainable way.

Please note that these services can only work as part of an overall national change programme fully supported by senior government officials.

Part 4: Technology Needs at the Sector Level

4.1 The Role of Leading Sectors

Leading sectors play a key role in national technology strategies aimed at export growth, employment creation and the environment. In any single DC sectors will tend to be at various levels of capability, some will be leading and others lagging behind. The framework in Figure 5, very similar to the national level framework, can be applied to different sectors within the same country – or to the same sector across different countries.

Compared with national technological capabilities, at the sector level capability needs are more 'fine tuned'. In leading Type C and D sectors, the focus will be on maximising the development and growth of environmentally sound exports through a dynamic system of technological capability development. Actors within the sector will be working together to increase the value added opportunities and to climb the technology ladder.

4.2 Institutional Support for Leading Sectors

Leading sectors within a DC often rely on sector institutions or business associations. These institutes may well deal with specific technology issues and formulate technology strategies, including programmes of support for local industry, standards, quality (e.g. ISO9000), shared technical facilities, business consultancy and so on.

The HKPC (see Annex 3.1 below), for example, carries out all of these activities for Hong Kong. As the HKPC is largely focused on electronics manufacturing technologies it therefore functions as a sector institute, as well as a national institute. Within such sector institutes, leading firms often play an important part in developing technologies and formulating technology strategies at the sector level.

Annex 3.3 shows the case of CITER which is generally considered to be one of the most effective sector-based institutes in Italy. Operating in the clothing sector, CITER works with around 500 firms (mostly SMEs) each year, not only providing technology services but also marketing, finance and management advice and consultancy.

Sector institutes and local firms may have links with TNCs (e.g. sub-contracting initiatives, joint ventures or licensing arrangements) and connections with international institutions which deal with standards, quality and specific technology developments as in the case of both the HKPC and CITER (see Annex 3).

Other such institutes dealing with sector issues include the Industrial Technology Research Institute (ITRI) in the Province of Taiwan and the Singapore Institute of Standards and Industrial Research (SISIR). Both ITRI and SISIR have strong sector programmes as well as overall national and international technology aims and objectives.[18]

At the sector level, it is important to understand how the sector fits into the overall competitive advantage of a particular country and how sector organisations intend to

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[18] For a detailed examination of SISIR, HKPC, ITRI and other leading technology institutes around the world, see Rush et al. (1996).

acquire and develop technology. Effective sector level S&T institutes often contribute to sector strategies and bring together firms and government bodies in a consultative processes similar to those which take place at the national level.[19]

Figure 5: Sector Level Technological Capabilities in DCs

Type D: Creative

- Able to gain advantages through innovation
- Distinctive sector strategy, imitated by others
- Creative approach to ESTs
- Sector plays key role in national strategy
- Highly effective, demand-driven services

Type C: Strategic

- Clear sector strategy in place; aware of mainstream EST issues
- Highly capable within technological boundaries of sector
- Able to keep up by acquiring and absorbing foreign technologies
- Firms served well by demand-led technology mechanisms
- Unable to catch up, but highly effective at implementing projects

Type B: Reactive

- Some elements of a strategy in place, but no clear priorities
- At the mercy of new EST regulations formulated in developed countries
- Supply of capabilities disconnected from demand for services
- Firms poorly serviced (e.g. with information, training, consultancy)
- Ineffective at implementation of new strategies; unable to keep up

Type A: Passive

- Little or no capability within the sector; unable to absorb new technology;.
- No coherent technology strategy for environmentally sound technologies
- Focus of firms and policy makers on crisis management;
- Highly vulnerable to technological advances and new EST regulations
- No expressed demand for technology, unaware of threats or opportunities

4.3 Benchmarking Sector Level Capabilities

In assessing the capabilities of a particular sector, similar 'check list' questions can be posed as in the case of a nation: does the sector have the appropriate institutions for leading its development? does a strategy exist which the major government bodies, business associations and leading firms are in broad agreement with? how well are sector level issues co-ordinated? do current technology transfer arrangements contribute to the sector in the best possible way? are there important gaps or weaknesses at the sector level which need to be filled?

Using the 'staircase' approach, a sector level staircase model (see Figure 5) can be used to benchmark sector level capabilities within a nation (i.e. contrasting different sectors for capability levels) or across nations (i.e. contrasting the same sector with that sector in other countries). Again, focusing here on least developed economies, most sectors are likely to fall within bands A and B:

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[19] In the UK, for example, sector-level panels have emerged, with sector level strategies, from recent foresight exercises.

Type A Sectors: Unaware/Passive

Type A sectors are not conscious of the need for a technology improvement strategy, despite the fact that one is needed. The leading actors in these sectors do not recognise the need for technology transfer or adaptation. Other pressing needs may well appear to take priority over technology considerations (e.g. survival or financial crisis). These sectors typically do not know what they might improve or how to go about capability building and they are probably vulnerable to external market and technology changes. Even if individual companies do recognise a problem they are unlikely to gain wide support for a sector improvement programme because few others are willing or able to 'join in'.

Basic assistance is needed to help Type A sectors become aware of the necessary strategies required to acquire and assimilate specific technologies and to upgrade capabilities. These sectors are likely to require help in sustaining a programme of improvement for some time to come. In manufacturing sectors in very poor countries, the focus is probably on the basic assembly of simple products for the local market. Firms may not yet have the capability to master production engineering techniques and lack routes into export markets. In such cases, sector groups may wish to try to enhance existing assembly capabilities and set out a strategy for learning engineering skills in order to improve competitiveness and help open up export markets.

However, because these firms are unaware of technological needs they present no 'demand' for technology services and do not seek them out. In order to overcome this basic awareness/demand problem, initiatives and strategies need to actively 'reach out' to firms in these sectors. The three S&T institutes in Annex 3 all provide such services, focusing especially on upgrading SMEs.

Type B: Reactive Sectors

The key actors within reactive sectors recognise a need for improvement in technological capabilities. However, they are unclear about how to go about the process systematically. Because their internal resources are limited (they may lack skills and experienced personnel) they tend to react, effectively or ineffectively, to events including technological threats and opportunities, but are unable to shape and exploit events to their advantage. These sectors may depend heavily on technological knowhow from foreign suppliers and may base their strategies and operations on their limited prior experience, rather than sound advice based on a knowledge of market and technology needs. Reactive sectors have poorly developed capabilities in most areas of technology assessment and strategy, but have some strengths upon which to build.

Type B sectors are inherently stronger and better co-ordinated than Type A ones. However, they typically lack any kind of strategy or framework for considering technological matters and deciding on collective priorities. Priorities may include an improved supply of trained human resources and joint investments in shared technological facilities (e.g. as in the HKPC in Hong Kong, see Annex 3.1). Sector groups or institutes (or government bodies connected with the sector) need to be able to search for S&T solutions and assess new technology options. They also need to develop the capability to advise on how to acquire and implement specific technologies (e.g. new processes for manufacturing).

Figure 6: Self-Assessment Capability Audit: Sector Level[20]

Key technology capability area	Audit Questions	Strongly Disagree	Disagree Some-what	Agree Some-what	Strongly Agree	N/A[21]
	Assessment Score	***1***	***2***	***3***	***4***	
Sector strategy						
1 This sector plays a key part in our national development strategy						
2 Our sector's technology priorities are clearly defined						
3 Our sector's technology strategy is understood and shared by the key actors involved						
4 We have learned a great deal from previous sector projects						
5 We are acquiring new EST's rapidly						
6 The sector is able to diffuse ESTs rapidly to large and small firms						
7 Our strategy is geared towards increasing exports and raising wages						
8 We are able to revise our strategies quickly in the light of new environmental needs						
9 Most of our initiatives are driven by industry needs						
10 Our sector contributes to international sector bodies						
Sector support mechanisms						
11 We work with all the key players in our sector						
12 Major firms play a key role in developing our strategy						
13 Our sector is well represented in Government						
14 Our sector groups are well informed as to new EST requirements						
15 Our technology acquisition mechanisms work well at the supply chain level						
16 We know exactly 'who is responsible for what' in dealing with EST issues in our sector						
17 We have a wide range of technology acquisition mechanisms (e.g. institutes, programmes, projects)						
18 Our education/training approach ensures a goods supply of technical skilled people in our area						
19 We evaluate the effectiveness of our environmental projects						
20 Our sector groups are able to influence international agencies dealing with technology						
Sector performance						
21 The leading firms believe our technology strategy is being implemented effectively						
22 We regularly consult with industry to assess our sector's EST performance						
23 We can point to several major EST project achievements						
24 Environmental regulations pose no threat to our export targets						
25 The costs of our technology acquisition programmes are greatly exceeded by the benefits						
26 We are meeting our employment and export goals						
27 Industrial users are happy to pay for our commercial EST services						
28 Our programmes mechanisms are regularly reviewed for their efficiency and effectiveness						
29 Our technology initiatives are low cost but high value						
30 Our future sector initiatives are likely to be met						

[20] To be completed by one or more sector representatives from a relevant government department, industry association, S&T institute and/or leading firm.

[21] N/a = not applicable or not known (in which case an average of other scores is to be used to complete the audit)

Consultancy companies may fill this role, or services may be provided by government funded research and technology organisations (e.g. on standards) depending on the needs of the sector. As capabilities develop, these sectors may develop self-sustaining capabilities for strategic planning, S&T upgrading and so on. In manufacturing, these sectors will typically have moved on from Type A assembly operations and already have access to technician and engineering skills. Their next phase could well be to develop the capabilities to innovate with process technology and become more strategic in the way they approach technology threats and opportunities. With a strategy in place these sectors may well be able to expand their exports via sub-contracting (e.g. OEM) arrangements with TNCs and through other buyers, as has occurred widely in East Asia.[22]

4.4 The Self-Assessment Capability Audit: Sector Level

Figure 6 presents the sector level questionnaire which follows the same logic and structure as the national level tool. (The guide to using the sector level tool is also the same as the national level questionnaire; see Sections 3.7 and 3.8 above). Completing the sector questionnaire enables a capability profile to be built up in four key areas: (1) the ability to formulate and communicate an appropriate strategy for the sector; (2) the ability to put the structures or mechanisms in place to realise the strategy; (3) performance, which is based on management effectiveness and efficiency in meeting the sector's goals, including value for money; and (4) environmental targets and other EST considerations.

The questionnaire deals with key dimensions from each of these four areas from which a capability profile, including strengths and weaknesses, can be developed. Here we describe the logic of each of the questions.

1. Sector Strategy

- Q 1 assesses the importance of the particular sector and its integration into wider national development goals;
- Q 2 turns to the existence of a sector strategy, with goals and priorities, without which there is little hope of co-ordinating and improving sector performance and judging the value of investments;
- Q 3 looks at whether the strategy is widely communicated and shared by the key actors; by implication it also touches upon how well the various components of the sector 'work together';
- Q 4 assesses the ability of the sector's representatives to reflect upon, learn and accumulate experience in order to improve the strategy;
- Q 5 deals with the speed of acquiring particular technologies, reflecting the 'absorptive capacity' of the sector overall;
- Q 6 is concerned with the ability of the sector to spread new technologies to both large and small firms;
- Q 7 asks to what extent the strategy embodies export, wages and by implication employment objectives;
- Q 8 is concerned with the ability of the sector leaders to revise their strategies quickly in response to new needs, suggesting also the degree of flexibility of the strategy;

[22] See Bennett and Vaidya (2002) for a review of typical paths of development.

- Q 9 assesses the attention given to local business needs within the strategy and the sector's ability to incorporate industry-level needs;
- Q 10 deals with the way the sector is linked into international bodies such as standards and quality institutes.

2. Sector Support Mechanisms

- Q 11 highlights the issue of the incorporation of key actors into sector bodies, as well as linkages between firms, policy institutes and educational establishments;
- Q 12 deals specifically with the involvement and inclusion of key industrial actors in sector level activities;
- Q 13 examines the ways in which the sector is linked into government, indicating 'channels of influence' in policy matters;
- Q 14 looks at how well sector mechanisms are able to respond to new ESTs, indicating both the degree of responsiveness and flexibility of institutional arrangements;
- Q 15 assesses the ability of sector mechanisms to acquire and diffuse technology along the supply chain;
- Q16 deals with how well task delegation is understood and undertaken;
- Q 17 looks at the range of technology acquisition mechanisms, as the fixed institution approach increasingly gives way to new types of flexible, demand-driven initiatives, programmes and projects;
- Q 18 looks at the supply of relevant education and training in areas such as technicians, engineers and scientists; it also hints at the existence of processes for working with universities and government on educational issues;
- Q 19 reviews the existence of mechanisms for learning from previous projects (e.g. post-project reviews and evaluations);
- Q 20 assesses the influence of the sector in international bodies concerned with technology.

3. Sector Performance

- Q 21 assesses goal achievement from an industry perspective including a measure of relevance to firms;
- Q 22 deals with evaluation capability as well as involvement with industry;
- Q 23 examines success in implementing new technology projects;
- Q 24 looks at how well environmental goals are linked into export growth priorities;
- Q 25 turns to issues of value for money and the financial efficiency of sector interventions;
- Q 26 is concerned with how well the sector is meeting its employment and export targets;
- Q 27 provides a measure of success in providing valuable 'demand driven' services to industry, touching on fund raising performance;
- Q 28 provides an indication of variety in the approach to technology transfer, assuming that overall effectiveness depends on a plurality of approaches;
- Q 29 touches on cost efficiency and the need to provide value for money;
- Q 30 is concerned with sector performance in setting future targets and its confidence in meeting future goals.

4. Environmental Efficiency and Effectiveness

Ten questions within the questionnaire are dual purpose questions, dealing both with technology acquisition in general and with EST issues, covering strategic capability, mechanisms, and performance in the environmental area.

- Q 5 provides an indicator of the priority given to ESTs and a measure of EST acquisition capability;
- Q 6 assesses the ability of sector mechanisms to diffuse new ESTs both to large firms and small firms in the supply chains;
- Q 8 looks at flexibility in response to environmental demands;
- Q 14 is concerned with the sector's ability to deal with environmental needs quickly and effectively;
- Q 16 deals with the issue of delegation of EST issues and taking a shared approach to environmental matters;
- Q 19 is concerned both with the existence of mechanisms for learning from previous EST experiences and the importance attached to the environment in the sector;
- Q 22 assesses the sector's EST performance evaluation capability;
- Q 23 examines the sector's success in implementing environmental projects;
- Q 24 looks at how well ESTs requirements are linked into export strategy;
- Q 27 assesses the success of sector organisations in providing valuable EST services to industry.

PART 5: The Contribution of UNIDO to DC Technology Transfer

5.1 Practical Assistance to Poorer Countries

In another contribution to the WSSD, Bennett and Vaidya (2002) provide a detailed analysis of UNIDO's technology transfer initiatives, focusing on the strategy and organisation of the Industrial Promotion and Technology Branch. It also deals with UNIDO's contribution to the Montreal Protocol, Agenda 21 and other important activities in support of sustainable technology development.

This section complements the above report with (selected), recent practical examples of UNIDO's work in support of technology transfer and sustainable development dealing, in turn, with:

5.2 the range of services provided;
5.3 specific services provided by UNIDO;
5.4 the international technology centres (ITCs) and their networks;
5.5 case studies of technology transfer;
5.6 a South-South co-operation programme in housing;
5.7 revitalisation of research and technology institutes in support of SMEs

The aim here is to show how the TNA can initiate practical help with the technology priorities of DCs, especially the poorer nations. The support services can be considered as a basis of future joint DC-UNIDO partner activities. Some of the services outlined can be provided directly by UNIDO. Others can be supplied by specialist individuals, consultancy companies and policy research institutes known to UNIDO.

5.2 The Range of Services Provided

Six core elements of UNIDO's service package are presented in Annex 5. Given the wide variety of technology needs in DCs, UNIDO provides many services which can be 'mixed and matched' according to DC requirements. Sometimes, these services are built into packages to meet a structured set of objectives. Alternatively, they can be applied selectively, as and when needed.

The headings along the top of Annex 5 (A to H) describe the purpose of the services which UNIDO provides, including their aims, delivery mechanisms, target users, role of UNIDO, service suppliers and funding sources. Taking each of these in turn:

<u>A. Technology needs area</u> - refers to the S&T issue identified as important during the TNA process (e.g. improved management and the need to set up new policy mechanisms, through to mechanisms to commercialise innovations);

<u>B. Products and services</u> - refer to the specific services which UNIDO can supply to meet the particular needs of identified target users;

<u>C. Objectives</u> - refer to the particular aims of the service (for instance, to build new management capabilities, to expose local research centre managers to best practices in other countries, or to market local technology outputs internationally);

D. Delivery mechanisms - are ways in which the services are delivered (e.g. workshops, training, study tours, demonstrations, one-to-one expert advice);

E. Target users – include ministries of S&T, senior policy makers, managers of research institutes, scientists, engineers and so on;

F. Role of UNIDO - in some cases UNIDO can supply the service directly (e.g. high level policy advice) based on its in-house experience and knowhow; in other cases, UNIDO can identify international partners, co-ordinate activities, or help to seek out new sources of funding;

G. Other service suppliers – this includes organisations known to UNIDO which are competent to engage in technology support, most of which have demonstrated leading-edge capabilities. These include individual specialists, small and large consultancy firms, S&T policy research institutes and academic groups;

H. Funding sources - it is recognised that external funding will be needed to carry forward most new DC projects or programmes. In some cases, UNIDO can identify funding bodies, assist in negotiations and help put together proposals for external funding bodies to consider.

5.3 Specific Services Provided by UNIDO

The left hand column of Annex 5 presents six major examples of technology needs areas, which can be supported or co-ordinated by UNIDO (the list is not exhaustive and other services are provided). Each service can be applied to specific environmental issues, or to general technology capability building. They include:

1. Technology acquisition mechanisms

These include various types of technology acquisition and capability delivery mechanisms, including research centres, other organisations (e.g. S&T industrial users) and environmental programmes, which can be formed to address particular DC technology needs. For example, regional groups sometimes develop business innovation centres to support the commercialisation of local S&T outputs. Many 'self help' groups exist in the US and Europe which can be very effective (e.g. CITER in Italy, Annex 3.3). Some institutions incubate spin-off firms, while others support local small and medium sized enterprises (SMEs) with services and shared facilities (e.g. the HKPC in Hong Kong, Annex 3.1). Many focus on 'soft' technology services (e.g. environmental consultancy, marketing assistance, financial and investment advice and project management training) for their members. Soft services can be an important source of revenue for DC technology institutes.

Technology delivery mechanisms may be low cost and 'virtual' in nature (e.g. club arrangements and information sharing groups). Others may be high cost and/or centred on one physical location (e.g. technology institutes, science parks and business incubation centres). Most include local firms, universities and other users in their membership. To allow new mechanisms to emerge 'bottom up' to meet local needs, solve particular problems and raise revenues, it is usually necessary for government to design market friendly enabling legislation. Clubs and institutes tend also to need a charter to outlines rules, obligations, costs and benefits of membership, as well as a business plan.

To promote technology delivery mechanisms, UNIDO provides advice on the start-up and functioning of new institutions, as well as evidence on international best practices, alternative models of organisation and advice on the development of market friendly legislation (e.g. for ESTs). One of the purposes of UNIDO is to generate awareness of trends and management best practices, to explore strategies and provide information, advice and training. Users of this service tend to include managers and directors of technology institutes, officials of ministries of S&T and representatives of related ministries, including environment, energy and transport.

The role of UNIDO is also to identify consultants, assess funding sources, search for international partners and co-ordinate the supply of services. Possible service suppliers include individual experts, small and large consultancy companies, S&T policy research institutes and specialist academic groups (e.g. CENTRIM, PREST and SPRU in the UK). Possible funding sources include Tacis (EU), UNDP, UNIDO, EU, Donors' funds, EBRD, Trust funds, UK Know How Fund, and other donors.

2 Science and technology funding systems

UNIDO aims to assist DCs to develop effective funding mechanisms for S&T. This includes advice on incentive-based funding (e.g. how to encourage collaboration between institutes and local firms through project funding), how to organise programmes to meet environmental objectives, and lessons learned (good and bad) from other countries and regions (e.g. UK, EU, US and East Asia). Also included are, monitoring and evaluation, peer review assessment (ie. the review of project proposals and results by experts operating in the same or similar S&T fields). The target audience for this assistance includes senior ministry officials, managers of research centres, and interested users (e.g. industrialists, environmental officials and health sector managers) of technology outputs.

3 Management best practices

There is now a wealth of modern tools for improving the operational effectiveness and efficiency of technology related organisations (sometimes called revitalisation strategies). The aim of this set of services is to: (a) expose senior officials and managers connected with S&T to new tools and concepts (e.g. learning organisations, environmental planning, empowerment, TQM, benchmarking and user-needs assessment); and (b) impart the ability to critically assess, understand and learn by experimenting with such tools. The role of UNIDO is to provide international case examples of success and failure, identify specialists in the field, develop and supply educational packages and organise workshops to raise awareness.

4 Networking and collaboration

National and international networking has become an essential part of technology transfer worldwide, especially in the area of ESTs. For example, the use of Internet and Web Pages can provide access to foreign technology collaborators and sources of data on environmental regulations, S&T trends and new market opportunities.

UNIDO has its own network of S&T institutes worldwide (see below) and can advise on best practices in network building. Possible users of networking consultancy include middle managers in technology institutes, as well as scientists and engineers.

5. Strategy development

UNIDO is able to deploy tools such as SWOT (strengths, weaknesses, opportunities and threats) to assess the opportunities and challenges facing particular DCs. Technology strategies need to be based on a systematic analysis of the needs of individual countries (e.g. using the TNA above). Local capabilities, environmental regulations, market opportunities and user needs all need to be taken into account. As well as providing consultants to assist with strategy development, UNIDO can organise training for managers to carry out their own strategic assessments.

6. High level policy advice

Senior policy makers often find it useful to discuss high level technology issues, such as funding structures, legislation and EST regulation frameworks with experts and/or S&T counterparts in other countries (e.g. those which have reformed their own public S&T sectors such as the UK). One aim here is to present interesting examples of best practices in other countries and help develop new approaches to market friendly legislation, aimed at enabling 'bottom up' technological capability building to occur. UNIDO's overall aim is to enhance policy capability for establishing effective regulatory frameworks in technology and the environment for the future.

The importance of the funding issue

Despite the potential for useful UNIDO-DC collaboration, it is clear that any major projects and programmes will require substantial external financial support, given current funding constraints within most poorer DCs. By clarifying the specific types of collaboration which UNIDO can most effectively engage in with DCs, it is hoped that major proposals for sustainable technology development can be developed jointly by DC partner organiations and UNIDO, and that UNIDO can assist with the search for external funding sources.

5.4 International Technology Centres and their Networks

ITCs as a unique tool for technology acquisition

UNIDO is recognised as being the only UN agency having International Technology Centres (ITCs) for promoting technology acquisition *via* international collaboration, and technological knowledge sharing. The four main ITCs are described in detail in Annex 4. ITCs are a unique tool for building up technology partnerships and thus encouraging industrial investments in the area of new and environmentally sound technologies.

UNIDO's ITCs can be seen as its 'technological arms'. The ITCs are supported by a number of tools and methodologies for building awareness in ESTs and assisting with the transfer and acquisition of technology. The ITCs, which are integrated with the work programmes of the Investment and Technology Promotion Offices (ITPO), differentiate UNIDO from other UN agencies and other organisations working in this area.

The ITCs are fully financed from extra-budgetary contributions (from both developed and developing countries). They play an important and complementary role to UNIDO programmes and act as a technology resource base for DCs.

Each ITC has networks consisting of government institutions, industrial associations, R&D institutes, universities, professional societies, consulting companies and funding agencies working in the same subject area. These provide an opportunity for work programmes of ITCs to continuously reflect the changing industrial and environmental needs of DCs.

The ITCs with their networks and sub-networks are a substantive technology resource base available in UNIDOs Investment and Technology Promotion Network (ITPN). They are able to provide decision-makers in DCs with necessary information on technology and investment trends and help them develop the required policies and business strategies to ensure effective technology transfer and commercialisation.

Mission and activities of the ITCs

The objectives of the ITCs are:

- to provide an international forum for DCs to monitor technological trends and build awareness in industry, the research community and governments on sustainable technological advances;
- to help bridge the gap between the emerging market demands and the existing DC technology base;
- to stimulate the diffusion of new sustainable technologies into industrial sectors to enable DCs to meet quality and environmental standards.

The ITCs and their networks of R&D institutes, universities and firms provide an abundant source of knowledge concerning a wide range of technologies. They are able to provide substantial inputs into TNAs as well as market trends and industrial applications *via*:

- technology monitoring and foresight;
- technology forums;
- online expert group meetings;
- knowledge dissemination and diffusion (e.g. periodical publications and annual Global Technology Reports, on-line Virtual Libraries and on CD-ROM).

ITC platforms for exchange of knowledge and experience involve a range of Technology Acquisition Functions including**:**

- frameworks for public/private and research/industry partnership and North/South and South/South co-operation;.
- facilitation of access to new technologies;
- data base on innovations, technological solutions, competence and knowledge, expertise, tools, services and partnership opportunities;
- search for a technology required to meet strategic objectives;
- technology needs assessment support (e.g. for supporting the tool in Parts 3 and 4);
- advisory services and training in a range of technological areas;
- support for technology acquisition *via* UNIDO tools and methodologies;
- design of appropriate institutional mechanisms for technology acquisition;
- diffusion of best international practice and expertise.

Figure 7: ITP: Technology Transfer & Commercialisation Case Studies

Case 1. Fund Mobilisation for Technology Acquisition Projects.
Through the International Centre for the Advancement of Manufacturing Technology (ICAMT, see Annex 4.4) UNIDO has signed Trust Fund Agreements (TFAs) for US$1,825,000 with various partners. In addition, the Government of India has located US$300,000 from IDF, thus bringing the total fund mobilisation to US$2,125,000 in the 1st year of operation. Two more TFAs for US$100,000 are under preparation. The ICAMT-led project has been successful in fund-raising at the ratio of 1:30. Each US$1.0 spent on new project development has brought around US$30,0, as a co-funding share of counterparts from governments, private industry and banks.

Case 2. Technologies for the Poor in Africa (South-South Co-operation)
Again within ICAMT, UNIDO and the Indian Government have launched a technology transfer and investment promotion project for production of cost effective building materials for low cost housing in Africa (see Section 5.6 for details). These products are manufactured locally from recycled agro-industrial wastes and local materials resources. The machinery already sold to Africa after one exhibition in Dar-es-Salam (July 2000) generated employment of 100 skilled, 220 semiskilled and 600 unskilled workers. By now, orders for procurement of equipment account for over US$0,5 million. The project is being converted into a large-scale South-South programme between India, Asian, African, Latin American and Caribbean countries.

Case 3. Technologies for the Future Through Partnerships
In November 2000, UNIDO established an International Center of Medicine Biotechnology (ICMB) in Obolensk, Russia, with the main aim of creating a framework for promoting a range of future, high impact technologies for progress in the 21st century. It will also build up public, private and research-industry partnerships (both North-South and South-South) and link commercialisation of high-tech to investment promotion and partnership development using UNIDO tools and methodologies of UNIDO. The 1st Partnership Meeting (in December 2000, Moscow) brought together senior officials & leading industrialists from Russia, Brazil, China, & India and laid the basis for ongoing technological partnerships.

Case 4. Bringing R&D Results to the Market with Capital
On 25th November 2000, the Governments of the Republic of Belarus and the Xandong Province of China signed a set of agreements to set up in Jinan the Belarus-China Technopolis, as an affiliated institution of the National Center of Technology Transfer being established in Belarus with UNIDO assistance. The initial contacts between the counterparts took place in June 2000. At present, more than 100 research projects are being considered by the Chinese side for initial commercialisation. In this case, UNIDO is helping to bring research results to a potentially huge marketplace with start up capital.

5.5 Case Studies of UNIDO Technology Transfer Activities in Action

Although UNIDO has been involved in a huge number of projects and programmes for technology transfer to DC, far too numerous to mention here, it is helpful to point to a few recent projects and programmes of the Investment and Technology Promotion Branch (ITP) to illustrate how UNIDO can assist in capability building. Figure 7 shows four recent examples dealing, in turn, with: (1) fund mobilisation; (2) technologies for alleviating poverty in Africa (discussed in more detail below); (3) generating new technologies *via* partnerships; and (4) exploiting the results of local R&D in the market place.

5.6 An Example of UNIDO South-South Cooperation in Housing

Case 2 above is an especially relevant example of a UNIDO project on South-South co-operation, designed to promote the transfer of ESTs to resolve problems of poverty and housing. The project is entitled: 'Investment and Technology Promotion and Transfer of Manufacturing of Composite Materials for Low Cost Housing in Africa'.[23]

The housing problem in DCs

Fast changing demographic and migratory trends in many DCs are exerting pressure on domestic construction industries to improve efficiency, productivity and delivery systems to meet housing needs for the poor. However, materials for low-cost housing for most of the countries in Africa, Asia and Latin America are scarce and relatively high cost.

The consequences of the materials shortage are evident: imports have increased across the board in practically all DCs imposing additional strains on the balance of payments, particularly in Sub-Saharan Africa. In some Sub-Saharan African countries, prices of basic materials for construction have increased up to eight-fold during the last 15 years, far in excess of any rise in income levels. One of reasons for the price rise is that local industry has increasingly become dependant on high technology, high cost imported components and materials. It is estimated that Africa alone spends US$3.0 billion annually on imports of materials and products.

High technology conventional products require huge capital investment and depend on imported inputs such as fuel, spare parts and even skilled personnel for their operation. The 'high technology solution' is both expensive and inaccessible to the majority of the population in the DCs, especially in Africa.

UNIDO's role in creating a South-South solution

R&D efforts over the past two to three decades in several countries, especially in India, have led to the sourcing of composite materials locally. Initial efforts have demonstrated that many of these local materials can effectively substitute for traditional materials like cement, steel and wood. However, these technologies, except in a few countries, have not been supplied widely to industrial enterprises.

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[23] See ARCT/UNIDO (2002) for another important Sub-Saharan African initiative, designed to strengthen technology and management capabilities in order to promote both food security and poverty reduction in sub-Saharan Africa -

In order to respond to these needs, UNIDO, with the support of the Government of India and in cooperation with the United Nations Centre for Human Settlements (UNCHS), has taken an initiative to promote a long-term programme of technology acquisition and capability building for manufacturing alternative materials based on agro-industrial wastes and local resources for low cost housing.

The emphasis is on the development of environmentally sound and energy efficient technology capable of being absorbed by many DCs. These are not just isolated technologies but integrated systems which can reduce consumption of mineral and forest resources, help in the replacement of non-renewable raw material resources by renewable ones, save on scarce materials like cement, steel, timber and provide technical know-how, equipment, training of artisans and managerial support.

Through ICAMT (see Annex 4.4), UNIDO is providing Member States with access to these new technologies, and making relevant expertise available. In the process this is creating domestic investment opportunities and business partnerships for local firms wishing to manufacture these materials locally.

The programme hopes to achieve the following aims:

- technology acquisition and diffusion to Africa;
- creation of mechanisms for technology transfer and investment promotion.;
- capacity building for manufacturing the alternative materials and equipment;
- modernisation of manufacturing processes of composite materials by recycling agro-industrial waste using local resources;
- environmental protection and energy efficiency in manufacturing processes;
- reducing poverty through local industry development and employment generation;
- greater South-South co-operation and partnership.

This project, currently in its Pilot Phase, has generated considerable interest among some countries in Latin America and the Caribbean (e.g. Jamaica, Peru and Venezuela). It shows that in some areas, technology can be a valuable tool for achieving the combined benefits of environmental protection, energy efficiency, employment creation and poverty reduction.

5.7 The Revitalisation of Research and Technology Institutes (RTIs) in Support of SMEs

Many DC governments have invested in RTIs, but many have proved to be inefficient and have failed to match up to their initial visions and aims (Rush et al, 1996). UNIDO has therefore developed programmes to help revitalise RTIs, so that they can address the problems of technology transfer and, in particular, provide badly needed support for SMEs.

For SMEs flexible business partnerships with RTIs can be valuable, because:

- while SMEs cannot absorb all new technologies, RTIs can potentially provide relevent knowledge and training;
- SMEs are normally short of R&D facilities which RTIs can possess;
- SMEs need partners for monitoring technological advances, testing, standards, etc.

In theory, research and technology institutes could enhance the technological competitiveness of SMEs by helping to managing and implement relevant technologies. However, in practice, RTIs often face declining levels of government spending. Frequently they are disconnected from the real needs of industry. They need to develop new ways of interacting with target industry groups in order to become 'demand driven' (rather than supply push). To this end, RTIs need incentives and management capabilities to respond effectively to SME demands.

UNIDO is able to support these demands on RTIs, through its services to research providers and managers, including:

- the development of business competencies;
- assistance with translating technological needs into commercial reality;
- maintaining engineering and R&D resources to support SME needs.

In the process of revitalising RTIs it is necessary align their strategies and work programmes with the needs of industry. It is also important to strengthen managerial skills, marketing mechanisms and links to business. UNIDO is the only multi-lateral organisation able to offer an integrated package of services to strengthen RTIs so that they become market-oriented and industry demand-driven.

UNIDO has developed Guidelines on the Revitalisation of Research and Technology Institutes for improving their effectiveness. UNIDO and the ICS (see Annex 4.1) have also developed a Programme of Support Services to help RTIs improve their performance. The programme includes the introduction of new management and marketing tools, policy advice, R&D funding, project management, benchmarking, training, networking, linking the technology promotion to investment mechanisms, and building up business partnerships.

Within the framework of this programme, UNIDO is actively cooperating with the Science and Technology Policy Research Unit (SPRU of the Sussex University, England); the Research Unit on R&D Management of Manchester Business School, England; the University of Rome, Italy; the International Development Group (IDG) from England, and other national, regional and international institutions.

Annex 1: Technological Needs Analysis at the Firm Level

A comprehensive UNIDO TNA for firms is provided in the CAPTECH Manual (2001). To complement CAPTECH, this Annex presents a simple, self-assessment tool based on the nine sub-dimensions of technological capability described in Part 2 above. The questionnaire follows the same basic logic as the National and Sector level models, categorising firms according to four levels of capability.[24]

Figure 1.1 presents the questionnaire. From the scoring system, a firm can first calculate its overall technology capability level, and second identify detailed strengths and weaknesses according to the nine sub-categories of technology capability presented in Part 2.

<u>Calculating the company's overall capability level</u>

Simply add up the firm's total score (the total possible score is 96) and enter in the table below, where the overall organisational capability level is described:

Capability Level (1-4)	Firm Score	Scoring Categories	Overall Audit Result
1		1-24	Your company is weak and ill-prepared in all major areas of technology acquisition, use, development, strategy and so on; a major improvement programme is urgently needed
2		25-48	Your company has poorly developed capabilities in most areas of technology strategy, search, acquisition and capability building. However, there are some strengths upon which to build
3		49-72	Your company has strong in-house capabilities and takes a strategic approach to technology. In some areas, the firm is behind the international technology frontier but has many important strengths upon which to build
4		73-96	Your company has a fully-developed set of technological capabilities and is able to help define the international technology frontier. In many areas it takes a creative and pro-active approach to exploiting technology for competitive advantage.

[24] The firm level tool is based on Bessant et al (2000) and Arnold et al (2000).

Figure 1.1: Self-Assessment Technological Capability Audit Tool

The firm is asked to answer the following questions according to the scale below by entering 1, 2, 3, or 4, for each question.[25] *The four point scale corresponds directly to four categories of firms (Types A, B, C and D), ranging from weak (passive) '1' to very strong (creative) '4'.*

Technology activity area	**Key Questions**	**Disagree Strongly**	**Disagree Some-what**	**Agree Some-what**	**Agree Strongly**	N/A
	Assessment Score	***1***	***2***	***3***	***4***	
1 My company is well aware of the technologies most important to its business						
2 Technology plays an important part in my company's business strategy						
3 My firm is well equipped to assess technological opportunities						
4 My company can assess technology threats without difficulty						
5 My company has special technological strengths which it is able to exploit						
6 My company knows which technologies to outsource and which to develop internally						
7 Our management is skilled at formulating a technology strategy to meet business goals						
8 Our firm knows its main technology priorities						
9 Our firm has a well developed technology 'vision'						
10 Our firm knows how to select the technology needed for its business						
11 Our company knows which are the best sources of technology						
12 Our company is effective at acquiring technology from external sources						
13 Our company has good links with important external suppliers of technology						
14 Our technology activities (e.g. engineering and R&D) are organised effectively within our company						
15 We have clear processes for carrying out technology projects						
16 Our company has a good system for assessing technology projects.						
17 Our firm carries out post-project reviews						
18 We are able to learn from one technology project to another						
19 Government policies encourage us to invest in technology						
20 We use external organisations (e.g. consultancy firms) to assist us with technology assessment						
21 We use outside bodies to help us develop technology						
22 External organisations help us implement our technology strategy						
23 We work with universities in key technology projects						
24 We work with government research institutes in important technology projects						

[25] Ideally, staff from various different departments and levels of seniority should fill in the questionnaire to gain a representative view from inside the company.

Annex 2: Definitions of Terms Used

As noted in Part 2, there are many different definitions of technology, capability and related terms. To avoid confusion, this Annex provides definitions of the terms used in this report, supported by expert research. It also shows how the frameworks developed in this report relate to the national systems of innovation (NSI) approach to technology policy. The definitions here underpin the analytical perspectives incorporated in the TNA frameworks in Parts 3 and 4.

2.1 Technology vs *production capability*

Schmookler (1966, p18) defines technology as the "social pool of the industrial arts". Technology can be viewed as a dynamic resource, embodied not only in physical capital but also, and more importantly, in human skills, institutions and social structures. In contrast with the static concept of 'production capacity', technological capability represents the skills and know-how required to manage, create and extend the existing pool of technological knowledge.

2.2 Components of technological capability

Technological capabilities underpin many pre-and post-investment tasks. These include planning, the purchasing of equipment, plant start-up and operation, as well as the adaptation of inputs, improvements in production processes, changes to product specifications, product-process interface engineering (e.g. design-for-manufacture), incremental improvements to processes and products, new product design and applied and basic R&D.

2.3 Technology transfer and acquisition

In the context of DCs, technology transfer from an advanced country has occurred when some or all of the capability related to a specific production process, product or service has been acquired. Technology transfer and acquisition are therefore two sides of the same coin and occur simultaneously. Without the capability to acquire technology, technology cannot be transferred. In DCs (as in other nations), effort, investment and purposeful strategies are required to acquire, assimilate and adapt technology in order to build up the stock of technological capabilities.

2.4 Technological learning

Technological learning, another key concept, refers to *how* technological capability is acquired. As such, technological learning is one of the main mechanisms which goes on within the 'black box' of the firm. Technological learning is the mechanism by which the inputs to technology (such as R&D, training and engineering efforts) are converted to outputs (e.g. new products, more efficient processes, improved productivity and product quality).

Based on Maxwell's definition (1981, pp19-20), technological learning can be defined as the set of processes by which firms accumulate technological knowledge, skills and experience relevant to the planning, construction, operation, adaptation, improvement, replacement and creation of production processes. Production processes include both those for tangible products (e.g. computer hardware) and intangibles (e.g. telephony or electricity services and software). Although learning may not always generate technological progress (technological progress also depends on sufficient investment and efficient organisation), the normal outcome of successful learning is and should be technological progress (Bell, 1982 p39).

2.5 Sources of capability building

The sources of technological learning and capability are many, involving both formal and informal processes. Formal sources include apprenticeships, plant investment and operation, training, applied engineering and R&D investments. Informal sources include negotiation with suppliers, communication between engineering team members, learning-by-observing experts, conversations and informal meetings.

2.6 Innovation in DCs

A further concept which often causes confusion in the context of DCs is innovation. The strict developed country definition of an innovation is the successful introduction of a new or improved product, process or service to the world or the marketplace (Dorfman, 1987 p4; SPRU, 1972 p7; Kamien and Schwartz, 1982 p2). However, this definition fails to capture the important streams of minor, incremental changes which can lead to large gains in productivity, improvements in product quality, process efficiencies, structural change and economic growth in developing nations (Nelson 1959, Phillips 1966, Malerba 1992).

In the successful East Asian newly industrialising economies (NIEs), as in many other DCs, most innovation occurs from 'behind the technology frontier' defined by leaders in the advanced countries (Hobday, 1995). Therefore, following Nelson and Rosenberg (1993), Kim (1997) and many others (e.g. Myers and Marquis; 1969, Schmookler; 1966 and Gerstenfeld and Wortzel, 1977), innovation is defined in this report as a product or process new to the firm, rather than to the world or marketplace. In addition, innovation is best viewed as a *process*, involving the application of new knowledge and skills, rather than easily measurable once-and-for-all events.

In order to catch up, rather than merely ‘keep up’ with developed countries, both learning and innovation are required. Building technological capability through learning is a necessary but insufficient condition for narrowing the technology gap with developed countries. This is because the technology frontier itself is a moving target and can be shifting away from the DCs fairly rapidly in areas such as information technology, the internet, new materials, telecommunications, bio-technology and so on.

2.7 National Systems of Innovation (NSI)

Most approaches to ‘national systems of innovation’ write from and assume a developed nation context. [26] The firm in the developed country benefits from surrounding technological resources which are embedded in a sophisticated ‘national

[26] In these studies, individual companies are assumed to have access to highly advanced technological resources and capabilities through their interaction with the environment in which they compete. For example, building on the original resource-based work of Penrose (1959), the ‘dynamic capability’ approach of authors such as Teece et al (1994) and Dosi (1988) is applied to company-level innovation and new business opportunities. The main authors in this field (e.g. Utterback and Abernathy, 1975; Abernathy et al 1983; Tushman and O'Reilly, 1997; Chesbrough and Teece, 1996; Hamel and Prahalad, 1994) all assume an advanced, developed country context.

system of innovation' (NSI), which includes universities engaged in S&T, highly trained human resources and sometimes useful publicly funded research programmes and institutes. Firms draw upon these resources and the advanced, demanding markets of the developed country guide firms' decisions and influence their visions of the future (Ansoff and Stewart, 1967; Swann and Gill, 1993).

2.8 The problem of NSI in developing countries

In DCs, especially the poorer countries, this dynamic NSI cannot be assumed to exist. Firms often operate within small, underdeveloped markets and the supply of education and skills is usually deficient. There is often a lack of resources, knowledge and capabilities within policy institutions and sometimes the bureaucracies and practices of government restrain technological capability building. Even when there is efficient administration and clarity regarding development strategy, there is sometimes a dearth of investment resources for programmes to enhance the capabilities of firms and to build the institutions needed for technological development. Therefore, this report does not use the term NSI, as this can potentially be highly misleading. Instead, the report focuses on the existence of 'national technological capabilities'.

Annex 3: Examples of Best Practice Government Policies and Programmes for Technology[27]

3.1 The Hong Kong Productivity Council: Helping to Overcome Market Failures at the National Level[28]

The HKPC carries out a wide range of technology support services for SMEs in an effort to overcome some of the market failure problems prevalent in Hong Kong. Its functions include the organisation of consortia, the provision of shared technical facilities, consultancy and research. Part of its aim is to assist industry to upgrade to higher technology, higher value-added activivities. By addressing the market failure problem, the HKPC plays an important part in Hong Kong's technological progress.

Background and history

The HKPC is a statutory organisation established in 1967. The idea of the HKPC originated in 1963 when the Government joined an international organisation for productivity improvement. Previously productivity came under the Labour Department. In 1979 a significant shift occurred in the role of the HKPC. The Government had become concerned about mounting protectionism in the West and the territory's dependence on textiles and fibres. A decision was taken to try and diversify the economy. The HKPC's role was extended to include technological support to industry (e.g. it promoted the application of microprocessors in the late-1970s). During the 1980s, the HKPC extended its reach to cover many facets of technological and industrial development in Hong Kong.

Adapting strategy to changing circumstances

One of the key success factors in the history of the HKPC has been its ability to move with the times and to adapt proactively to the changing external environment and in particular the evolving technological needs of the territory (1). The strategy of the HKPC has undergone four major re-orientations during its history:

<u>Phase 1: 1967 to 1973</u>

At the time of the start up, most manufacturing firms in Hong Kong were engaged in labour intensive activities, using relatively simple production technology. The principle mission of the HKPC was to acquire and disseminate information on productivity related matters. Short courses were organised to diffuse the information both to firms and other organisations.

<u>Phase 2: 1973 to 1980</u>

During the second phase the Institute began to build up a consultancy operation in company management and in electronic data processing. Simultaneously, it began to introduce a series of technical services, including surface treatment and low cost

[27] While these organisations and programmes are generally considered to be 'best practice' in the developed and developing countries, it should be noted that few critical evaluations as to their costs and benefits exist.

[28] Details here are from Hobday (1996).

automation. Because of concerns over protectionism and growing competition, the HKPC strove to meet the increasing demands for technical support and services to enable firms to produce more complex products and to diversify into new product areas.

Phase 3: 1980 to 1990

During the third phase the HKPC grew rapidly taking on many new tasks. With the opening up of China, many firms began moving their production facilities into neighbouring Mainland provinces. Other factors, such as the competition from lower wage countries, skill shortages and the need for Hong Kong firms to move to higher technology, higher value added activities, led the HKPC into several new areas. These included setting up several industry specific technical facilities such as the Radio Frequency Laboratory and the Surface Mount Technology group to assist electronics makers improve their processes, a Textile and Apparel Division to introduce just-in-time techniques and a Metals Division to promote component production technology.

Phase 4: the 1990s

During the first half of the 1990s, in response to rising wage costs and the economic integration of the Territory with Southern China, the HKPC focused its efforts on increasing value added activities by raising the innovative potential of companies. Its services became more sophisticated, including product design support, research and development, quality enhancement programmes and automation support facilities. The Institute launched a major initiative in cooperation with Oxford University in the UK to provide a competence based management development programme in Hong Kong. It also developed a new strategy for providing support for manufacturing related service activities. Another important move was to set up an office in Mainland China in Guangzhou to support firms operating in South China.

Sharing technology facilities

During the 1990s, the Council was well-equipped with up-to-date facilities. These included a large display area, an auditorium, a technical reference library, electronic data processing facilities, a computer-aided design service centre, a surface mount technology laboratory, a radio frequency and digital communication laboratory, photo-chemical machining, metal finishing and industrial chemical laboratories, an environmental management laboratory, sheet metal processing, and precision machining and die casting laboratories.

Conclusion

During the 1990s the HKPC dealt with around 4000 firms per annum. It offered consultancy services in industrial technologies, product design and development, production management, personnel recruitment, market research, EDP and environmental control. The Council ran around 500 training courses each year dealing with technology issues, computer technology, management and industry supervision. It also organised industrial exhibitions, feasibility studies, overseas study missions and a technical information service. HKPC has a total staff of around 500 including professional consultants with practical experience in engineering, science, economics, business administration, electronic data processing and metallurgy.

3.2 IRAP Canada: an Example of a Nation Wide Programme to Assist SMEs

IRAP[29]

The Industrial Research Assistance Programme (IRAP) is the National Research Council's (NRC) award-winning innovation assistance service for small and medium sized enterprises (SMEs). More than 260 Industrial Technology Advisors (ITAs) work within Canada's innovation system to assist firms access key players who have the facilities and expertise firms need to carry out technology development and research activities. The ITA network provides access to the tools firms need for: technical assistance; resources and facilities; as well as financial, marketing or management services. SME's with under 500 employees, and industrial associations, aiming to enhance their technological capability are eligible for support.

Advisory Services

IRAP's advisory services strengthen SME's capacity to innovate through personal delivery of services. ITAs are located in 90 communities across Canada and work with some 12,000 firms a year, in all regions of the country and in all industrial sectors. From product design and material selection to production methods and project management, IRAP assists firms tap into sources of specialised expertise. ITAs help firms identify what is needed and how to locate it, at each stage of the development process. IRAP also helps firms access expertise in areas such as marketing, financing, and production through the Canadian Technology Network (CTN).

Financial Assistance for Research Activities

Cost-shared financing of research and pre-competitive development projects is available through IRAP in two areas:

- Smaller Scale Projects These projects are often preliminary in nature and funding is available for up to 40-50% of eligible project costs, depending on the province and the project (e.g. costs associated with labour, travel, sub-contracting and consultant fees). Contributions to these smaller scale projects are limited to a maximum of $15,000.
- Larger Scale Projects These are more complex research and development activities carried out over a longer period. Funding is available for up to 40-50% of eligible project costs, depending on the province and the project. Contributions for these larger scale projects range from $15,000 up to $200,000-$350,000 maximum, depending on the province, over a period of up to 36 months.

Assistance with products, processes and services

IRAP and Technology Partnerships Canada (TPC) (a special operating agency of Industry Canada), joined forces to support innovative small and medium-sized enterprises (SMEs) by investing in projects developing new or significantly improved technological products, processes or services.

Youth Internship Programmes

Two internship programmes managed by IRAP give more than 500 (per year) recent college and university graduates who are unemployed or underemployed a chance to assist small and medium-sized enterprises' R&D projects. IRAP participates in the

[29] See Hoffman et al (1997) for further details.

Youth Employment Strategy of Human Resources Development Canada through the Science and Technology Internships Programme with SMEs and the Science Collaborative Research Internships Programme.

Best Practices

Sustainable Development: IRAP helps firms look for ways to enhance product design and reduce costs, use of materials and waste. They show that it makes good economic and environmental sense for companies to apply the principles of sustainable development.

Innovation Insights and Technology Visits Programme

NRC-IRAP co-sponsors, with the Alliance of Manufacturers & Exporters Canada, two programmes to provide an opportunity for SMEs to benefit from exposure to the latest innovation technologies and best practices across Canada:

Innovation Insights (ii) provides an opportunity to explore the applications of trend setting best practices and experience real life situations, from real companies which are open about the problems they have faced and how they overcame them.

The Technology Visits Programme (TVP), provides senior executives with a hands-on opportunity to see in operation the latest manufacturing technologies and innovative methods proven successful by leading-edge companies across Canada.

International Technology Transfer

Technology Inflow Programme (TIP) The Technology Inflow Programme (TIP) has a domestic and international component and is designed to assist Canadian SMEs access Canadian or foreign technology and help develop R&D partnerships.

Strategic Alliances The Strategic Alliances office has been established to enhance IRAP's abilities to assist Canadian SMEs in developing collaborations. Their mandate is to provide SMEs and ITAs with effective and timely access to:

- International expertise
- Technologies
- Strategic technology alliances
- Joint activities

International Projects

NSERC (the Natural Sciences and Engineering Research Council), IRAP/NSERC University-SME Projects: Collaborative Research and Development Programme. NSERC in partnership with IRAP has created a pilot initiative to facilitate the joint participation of Canadian industry and university researchers in international projects.

Using an existing Research Partnership Programmes mechanism, the Collaborative Research and Development (CRD) Programme, IRAP and NSERC hope to increase the level of joint Canadian university-industry participation in international projects/collaborations and secure greater benefits to Canada.

Industrial Technology Advisors (ITAs) are located in IRAP regional offices and are contactable on a toll-free number which will automatically connect firms with the appropriate regional office.

3.3 CITER[30] Italy: an Example of a Sector Support Mechanism for the Clothing Industry

CITER[31]

CITER is one of Italy's 'Centres for Real Services' set up to support industry. In Emilia Romagna, the fastest growing of Italy's 20 regions in the 1980s and 1990s, CITER is generally seen as the most successful Centre. CITER, which was formed in 1980, arose out of a training course for small industrialists which ran from 1976 to 1980, sponsored by the local community, the employers' association and the trade union and funded by the European Social Fund. CITER was set up as a consortia (Society Consortile) between six associations of final and sub-contracting firms and of artisans in the clothing industry, together with ERVET. The aims of CITER were to help firms progress from quantity to quality; diversify their market outlets, improve distribution channels and enable the use of electronic technology. There is a strong representation of users of the service and the regional government although the principal initial funder was the only public sector representative on it.

Finance

Finance has come from the following sources:

- ERVET and the regional government is today the only source of public funds. CITER receives no direct finance from the national, state or from international institutions.
- The regional association of local chambers of commerce.
- The sponsorship of three local credit institutions (it being one of the features of the industrial districts that they have a wide range of local and regional banks).
- Subscriptions and the sale of services and publications to members.
- The sale of services and research studies to non-members plus affiliation fees from organisations outside the region.

Membership

In its founding year CITER had 95 members. By 1985 this had risen to 500, and has remained close to this level since then. In 1994 there were 460 members, of whom 57 percent were in knitwear and 43 percent in clothing. Two thirds of the members are from the Capri area. This means that of the 2,600 local clothing firms in and around Capri, 13 percent are members of CITER. In spite of their small size, artisans still account for a majority (56 percent) of CITER's membership, the remainder being industrial companies. In the past few years membership has expanded to firms, design studios, technical colleges and joint business organisations throughout Italy, and this widening geographical coverage is also reflected in CITER's sales of services.

Staffing and Services

The Centre is managed by a president's office of three, and 15 other staff members. The core staff can call on over 40 consultants for specific projects. CITER operates at three levels: the micro level, addressing the needs of specific firms; the sector level; and a level it calls the `industrial system', which deals with the relations of competition and co-operation within the sector as well as other sectors linked to the textile industry.

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[30] Centro Informazione Tessile di Emilia Romagna

[31] Information from Murray (1996).

CITER provides constantly updated information on new technology; in relation to machinery, materials, work processes; and to problems of pattern making in hosiery and garment making. It draws extensively on an international network, and on expert clothing technicians. It is also concerned with technology transfer. In co-operation with ENEA (the Italian Atomic and Alternative Energy Agency Italy which possesses a wide range of high-technology expertise).

Means of Technology Transfer

CITER holds regular meetings and seminars in which it reports back the intelligence gained by its front-line staff. It produces reports and purchases written and other printed material which is held in the Centre's library. It produces fashion videos and a quarterly technological bulletin, which is circulated to members. It also has a showroom of threads, fabrics and stitches, as well as a collection of videos. As well as these general forms of dissemination, CITER runs an information line to answer specific queries. It also provides consultancy and specific training (for example in the use of CAD equipment).

Finance and Charging

Many firms are not aware of the value of the service until they have received it. CITER believes that the social value of their receiving it may exceed its value to the firm alone. This is the argument for the continued level of state support, particularly where full auto financing limits the impact of the Centre on the industry as a whole. CITER's directors have argued that substantial public funding is important, for it allows charges to be kept to a modest level which encourages diffusion, particularly among small firms. Public support also provides long-term funds for new projects.

Initially CITER geared its policies towards the model of a club (subscriptions) rather than individual service pricing. Subscription charges encouraged a sense of belonging to the Centre and of open access to its facilities. As the range of services has increased, the emphasis has switched to service charges, including training fees. This has served to act as a discipline on the nature of the services provided, and ensure commitment to the firms and artisans purchasing them.

Annex 4: UNIDO International Technology Centres (ITCs)

Presently, ten UNIDO International Technological Centres are being operated as its projects at different levels of development.

4.1 International Centre for Science and High Technology (ICS), Trieste, Italy

ICS is an autonomous UNIDO institution with an annual budget of approximately US$4.5 Million. ICS's areas of competence cover a wide spectrum of new technologies, including:

- pure and applied chemistry;
- earth environment and marine sciences and technologies;
- high technology and new materials;
- institutional, management, interdisciplinary and networking activities.

The main activities of ICS aim at building up national capability in technology promotion, commercialisation, transfer and management. These activities include:

- expert group meetings and workshops on technology development and commercialisation issues;
- training courses on technology management and strategic business alliances;
- study tours and fellowships;
- short-term consultancy services;
- monitoring technological advances through publications;
- establishing and strengthening the links between the research community and industry;
- networking.

At present, UNIDO and ICS are reviewing the strategy of ICS in order to strengthen its role in the transfer of technology to DCs and in building up technological capabilities in developing nations.

4.2 International Centre for Advancement in Manufacturing Technology (ICAMT), Bangalore, India

The Pilot Activities Programme of ICAMT started in October 1999. The main aim of ICAMT is to enhance technological performance in manufacturing, productivity, and quality of goods in DCs through the transfer of advances in manufacturing technologies and techniques. Its 3-year Operational Phase started in April 2002.

The centre provides a wide range of services including individual project engineering, training courses, demonstrations, and assistance in selecting and using technologies, software and equipment. The establishment of ICAMT is encouraging new investments in manufacturing industry and promoting the creation of joint ventures, including both South-South and North-South co-operation.

ICAMT is also able to provide SMEs with an extensive selection of state-of-the-art systems with which they can gain hands-on experience, allowing them to make more informed investment decisions. It can also act as a partner in UNIDO's sub-regional, field and Investment Promotion Services Offices, as well as with other members of its partnerships' network.

4.3 International Materials Assessment and Application Centre (IMAAC), Rio de Janeiro, Brazil

IMAAC began its Pilot Activities in May 1998 and since then has established an initial network consisting of R&D institutes and technology centres, universities and national authorities dealing with materials related issues in 12 countries (Argentina, Brazil, Canada, Chile, China, Germany, India, Italy, Mexico, Portugal, Puerto Rica and United Kingdom). The mission of IMAAC is to provide an international forum to serve the materials community with more effective management and utilisation of traditional as well as new materials suitable for sustainable industrial development.

The main objective of IMAAC is to address the issues of materials technology having a major trans-sectoral impact on economic growth and competitiveness, and foster sustainable development of materials sector of industry that would lead to major qualitative changes in the production cycle – from processing of raw materials to obtaining of finished products.

Its functions to build up awareness in industry and governments in the development of local EST materials and related human resources and assist the developing economies to absorb and apply rapidly emerging knowledge of materials to enable them to cope with he demands of competitive global markets as well as meet quality and environmental standards.

The programme aim is to accelerate the application of new materials technologies in the developing economies through transfer of knowledge and expertise on sustainable development of materials sector of industry with the support of a global network of R&D institutes, universities, professional and industrial associations and individual experts.

4.4 International Centre for Materials Evaluation Technology (ICMET), Taejon, the Republic of Korea

ICMET is currently implementing Pilot Activities focusing mainly on capability-building activities through training and collaborative programmes in selected areas of new materials. The mission of ICMET is to develop international guidelines, codes of practice, and standards on testing and characterisation of new materials which can be accepted across national boundaries.

The development, verification and application of common (for both producers and users) methodologies for materials testing and evaluation speed up the application of new materials in the market place and promote further development of new products and processes, thus encouraging new industrial investment.

One of the main roles of ICMET is to bridge the gap between R&D organisations, enterprises and the market place in DCs in order to stimulate the application of new materials and processing technologies to materials related sectors of industry. ICMET is also fostering collaboration between developed and developing countries in this important area of industrial development.

4.5 International Centre for Small Hydro Power (ICSHP), Hangzhou, People's Republic of China

ICSHP is dedicated to promote sustainable development of water resources worldwide in the form of small hydropower plants, as a clean and environmentally sound means of rural electrification, which will lead to poverty alleviation, economic development, increase of employment opportunities and living standards.

Dependence on fossil fuels will accentuate the green house gas emissions, increase transmission and distribution losses in energy transfer and make it unaffordable for the majority of populations, especially those living in rural areas. ICSHP assists the developing countries in promotion and transfer of small hydropower, as environmentally friendly, small in size and the densest among the renewable sources of energy technology, utilizing established North-South and South-South cooperation mechanism.

ICSHP operates at the Headquarters of the International Network on Small Hydro Power, a member-driven organization with over 100 members from 49 countries and is backed by the experience of over 100 equipment manufacturers in this area. The programmes focus is on capacity building, technology transfer and fostering strengthening North-South and South-South cooperation.

4.6 International Centre of Medicine Biotechnology (ICMB), Moscow, Russian Federation

The mission of newly established ICMB is to act as global focal point for developing countries in the field of medicine biotechnology by tracking the latest worldwide developments in leading-edge technologies and bridging the gap between the emerging market demands for medicines and the existing technology base.

Today, the majority of countries in the world have turned to healthcare programmes as a cornerstone in their plans and strategies for socio-economic development and sustained growth. The main objective of ICMB is to transform the existing knowledge and expertise into concrete industrial products to solve the health problems.

The programme, based on international networks of government agencies, researchers, producers, will be focused on accelerating the development and application of new technologies for production and certification of new gene-engineered medicines, vaccines and substances for diagnostic, prophylaxis and treatment of infectious diseases (AIDS, hepatitis, tuberculosis, etc.) for human and veterinary use.

ICMB will provide a springboard for leading-edge emerging technologies and act as a catalyst through services in awareness building, industrial application of new technologies and bridging the gap between the market demands and the existing technology base through development of partnership and regulatory mechanisms.

Annex 5: UNIDO - Science and Technology Support Services

A.Technology Needs Area	B. Products and Services	C. Objectives	D. Delivery Mechanisms	E. Target Users	F. Role of UNIDO	G. Other Service Suppliers (Examples)	H. Funding Sources
1. Technology Acquisition Mechanisms	*Advice on start-up/functioning *International comparisons *Models of organisation *Advice on market friendly legislation and regulation	*Generate awareness *Explore options and strategies *Providing training	*Workshops *Study Tours *Written reports/surveys *Educational material	*RC Managers *MOST *Other ministries *Industry managers	*Identify consultants *Fund raising *Partner search	*International consultants *S&T policy institutes (e.g. Nomisma, Italy) *OPM (UK) *CENTRIM (UK) *UNIDO	*Tacis (EU) *UNDP *UNIDO *Trust funds *UK Know How Fund
2. Technology Funding Arrangements	*Alternative international models *Incentive-based approaches *Project and programme funding *Peer Review	*Provide advice on: -Principles and guidelines -Monitoring of programmes -Evaluation methods	*Workshops *Written advice *Training	*Ministry Officials *RC managers *Industry managers *Other users of S&T outputs	*Identify consultants *Develop networks *Provide information *Assist in fund raising	*Specialist consultants *Institutions (eg Sichelgaita, Italy) *Technopolis (UK) *UNIDO *SPRU (UK)	*EU *Donors' funds *UNDP *UNIDO *EBRD
3. Management Best Practices	*Advice on state-of-the-art guidelines *International reviews *Tools and methods	*Awareness building *Experimentation/ learning *Capability building *Change management *Negotiation skills *Marketing skills *Project management skills	*Training *Self-assessment *Coaching (one-to-one) *Educational material *'Training trainers'	*MOST *Other ministries *Users of S&Toutputs *RC managers	*Co-ordinate *Identify consultants *Partnership building	*A.Andersen *KPMG *Ernst&Young *CENTRIM (UK) *OPM (UK)	*EU *Donors *UNDP

UNIDO Science and Technology Support Services (Cont'd)

A. Technology Needs *Area*	B. Products and Services	C. Objectives	D. Delivery Mechanisms	E. Target Users	F. Role of UNIDO	G. Other Service Suppliers (Examples)	Funding Sources
4. Networking and collaboration	*Introduction to S&T networks *Internet/Intranet trends *Introduction to network building *Negotiation (e.g. on technology transfer)	*Awareness building *Generating business opportunities *Introduction to international collaborators	*Training *Software *Seminars	*RC scientists and engineers *RC middle managers *MOST officials *S&T users	*Introduction to UNIDO Research Centre Network *Advise on other networks *Identify consultants *Technology transfer (guidelines and advice)	*International consultants *S&T policy institutes *UNIDO	*EU *Donors *UNDP
5. Strategy Development	*Competency analysis *Market positioning *User needs analysis: *Competitor analysis *Business planning *Case studies	*Identification of RC strengths/weaknesses *Tools for strategy development *Visions for the future *Responding to change	*Training *Guidelines *Software *Workshops *Self-assessment *Training of trainers	*Senior managers of RCs and industrial users	*Identify consultants and networks *Advise/coordinate	*International consultants *S&T policy institutes *UNIDO	*EU *Donors *UNDP
6. High Level Policy Advice	*Legislation and regulatory framework *International comparisons *Policy design *Market friendly legislation	*To enhance capabilities of Government agencies *Policies which enable 'bottom up' innovation *Introduce 'market friendly' legal frameworks *Information on other countries	*One-to-one advice *Workshops *Seminars	*Ministry officials *RC directors	*Identify individual specialists *Provide direct advice *Search for counterparts *Co-ordinate services	*International specialists *UNIDO *World Bank	*EU *Donors *UNDP

RC = Research Centre
S&T = Science and Technology

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UNIDO is responding to the challenge of sustainable industrial development by serving as a global forum and providing technical cooperation services. In its global forum function, UNIDO generates and disseminates knowledge relating to industrial matters and provides a platform for the various actors to enhance cooperation, establish dialogue and develop partnerships. As a technical cooperation agency, UNIDO designs and implements programmes to support industrial development efforts.

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