Methodology for a Diagnostic Study on a National Cleaner Technology Strategy for Countries in the Central and Eastern Europe and Former Soviet Union Countries region

Cleaner Technology Strategy for CEE and NIS region
United Nations Division for Sustainable Development
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I. INTRODUCTION

The following is the draft of a methodology for a diagnostic study on national cleaner technology strategies (NCTS) for countries in the region of Central and Eastern European (CEE) and Former Soviet Union (NIS) Countries.

The methodology is being developed in cooperation with the Division for Sustainable Development (DSD) of the United Nations, the Slovak Cleaner Production Centre, the Ministry of Environment of Slovak Republic, the Ministry of Economy of Slovak Republic, UNEP, and a group of selected experts.

The methodology has, whenever possible, drawn from existing technology needs assessment methodologies including, but not limited to, those developed by the Kansas Technology Enterprise Corporation, Richard A. Bendis, and those presented to the United Nations Commission on Sustainable Development (CSD) by the Governments of the Netherlands and Switzerland in 1995, taking into account also the suggestions done within the Colombian NCTS project of DSD/DESA in 1999.

Countries in the region are often mentioned as countries in transition. The end of twentieth century and start of a new one has been unusual turbulence in developments and a variety of actual status of national economics, as well as in collecting and maintaining national data. Some countries are already members or on the way to OECD (Czech republic, Poland, Hungary, Slovak Republic), most of CEE and some NIS countries are working towards EU membership.

The proposed methodology aims to provide guidance for countries in the region to develop their own diagnostic studies for NCTS and for this reason has to take into account the variety in situations.

The basic approach changed from the original proposal by applying SWOT analysis techniques to incorporate more factors and enable more flexible adjustments to the situation in particular countries. This decision was taken mainly with regards to different standards and culture in collecting and maintaining data on national level in the region.

II. PROJECT GOAL

The purpose of the document is to present a broad methodology that could be used by countries in the region to analyse capacities and opportunities for research, development and commercialisation of cleaner technologies in the country. With the results from the diagnostic study of Slovakia, proposals for a National Cleaner Technology Strategy will be developed with a manual of guidelines and recommendations for the development and implementation of this NCTS for Slovakia as well as broad policy options which could be used by other countries in the CEE and NIS region.

Cleaner technologies for the purposes of this methodology are intended to be technologies that:

- Conserve raw materials and energy, reduce the toxicity (or hazard) of the materials used in a process, reduce the quantity and/or toxicity (or hazard) of industrial processes' wastes and emissions.
- Produce products (and their packaging) that consume less materials and less energy during use, generate less emissions and waste, are more easily reusable, recoverable or recyclable after use, and have less impact if deposited in the environment.
- Produce services that consume fewer materials and less energy during their deployment and/or generate less emissions and waste during their deployment.[1]

Technologies for the purposes of this methodology refer to "not just individual technologies, but total systems, which include know-how, procedures, goods and services, equipment as well as organization and managerial procedures"[2]. So we do not refer only to the hardware part of technology. In EU the term “techniques” is often used.

New technologies must be generated and defined for the purpose of achieving progress in the development priorities of each country. Economic and social development continues to be the priorities in countries of this region. However, this emphasis on the economic and social aspects of development must be reconciled with concerns over the impacts that these development goals may have on the environment and thus on the country’s ability to maintain development in the long term

The purpose of the methodology is to provide strategic planning tools for policy makers in these countries. These tools are aimed to aid policy makers in merging all three priorities, social, economic and environmental, into policies which will use science and technology to achieve an organic linkage between research and production to improve the country’s ability to use its natural resources efficiently and protect the environment, while raising living standards and promoting exports to achieve economic development.

[1] UNIDO
[2] Agenda 21

III. TECHNICAL BACKGROUND

Long-term studies in many countries suggest that advances in technology have been responsible for at least half of long-term economic growth, through improvements in capital and labour productivity, and the introduction of new processes, products, and services. "Studies also show that a high percentage of the technologies used in the region are not generated domestically. Not one of the countries in the region can be said to have maintained sufficient internal capabilities for scientific development and technological change to sustain capital formation and managerial skills; to link knowledge and production; and, most importantly, to penetrate international markets by systematically increasing the ability to compete. While accepting the universality of scientific knowledge, we must recognize that world advances in science are driven mainly by economic objectives. The fundamental directive of policies in the areas of science and technology must be geared to the region's current and future needs.

Some countries have started to develop national technology strategies in order to promote technological advances and sustainable economic growth together with environmental protection. Such National Cleaner Technology Strategies (NCTS) could be an important component of development policies.

NCTS generally focus on three complementary goals:

(i) To build industries that are competitive in both domestic and global markets, as well as environmentally sustainable;

(ii) To establish business conditions attractive to domestic and foreign investments in cleaner technology, and bringing in international technology, finance, and managerial know-how; and

(iii) To promote public-private R&D partnerships aimed to encourage spin-off, adaptation and commercialisation of cleaner technologies, through investments in productive assets that remain within the countries.

The development of market-oriented NCTS is an important complement to market reforms, promoting adaptation of R&D institutions and publicly owned and private industrial enterprises toward new domestic and global market opportunities as well as EU accession.

Because of lack of resources for R&D activities, countries need to attract foreign investment and foreign companies as partners. Private sector spending, including foreign participation, can be leveraged by modest but well-targeted government support. Work in the area of cleaner technologies is relatively recent in developing countries, in part due to the fact that environmental protection is often seen as limiting economic growth. **In fact cleaner production often increases productivity and reduces waste, contributing to long-term economic growth**.

IV. OBJECTIVES

This methodology is intended as a starting point for a continuing process of study and practical testing of national cleaner technology strategies.

The objective of the methodology is to encourage governments to develop and implement National Cleaner Technology Strategies aimed at promoting research, development, transfer and commercialisation of cleaner technologies on the basis of partnerships with domestic and foreign private companies to promote the modernization of national industries. A national case study will analyse the situation in Slovakia and provide policy options, as a practical example of the application of the methodology.

These policies should aim to strengthen the country's research and development capacity, to improve the competitiveness of key industrial sectors and to integrate technology policies into overall sustainable development plans.

A National Cleaner Technology Strategy should provide technology policy options to promote the development of sectors where a country's "opportunities" and "capacities" meet. These policies should aim to:

- Stimulate the creation and commercialisation of cleaner technologies
- Establish institutional arrangements to improve the effectiveness of public investments in R&D returns on public investment, as well as the commercialisation of publicly-owned technologies
- Improve the research and development capacity of the country's universities, public research institutions and industries
- Improve the application and commercialisation of existing research results
- Create new high-wage, high-skilled job opportunities
- Make national industries including small and medium-sized producers and recently privatised enterprises competitive in the global economy as well as environmentally sustainable
- Build a financial-technical network willing to invest in and support technology-based enterprises at each stage of development
- Provide incentives for foreign and domestic investment in national R&D and for improving the existing industrial base

Partnerships between public and private, and national and international actors must be strengthened.

Government agencies can promote these objectives by:

- Establishing processes to make partnership opportunities more accessible and easier to identify for both national and international participants
- Establishing efficient and reliable access to information
- Establishing mechanisms to match projects and cleaner technologies with sources of capital, both domestic and foreign, and other technical and commercial support to facilitate the commercialisation process
- Improving cooperation among government entities, the private sector and potential foreign investors
- Using public funds to leverage increased inter-sectoral coordination or research activities
- Promoting the use of consortia and other umbrella organizations to multiply efforts and offer firms of all sizes opportunities to participate in R&D
- Ensuring the effective protection of intellectual property and investor rights
- Promoting simple, clear, transparent and predictable procedures for royalty and licensing agreements
- Ensuring that public-private partnership agreements are responsive to private sector needs and easy to negotiate
- Increasing private sector participation in policy making and project selection
- Developing a system for measuring programme results

V. PRIMARY ACTIVITIES

The methodology is a part a NCTS Project to develop implementable strategies for countries in the region. There are five key activities necessary to accomplish this goal:

1. Prepare a methodology for a Diagnostic Study of cleaner production capacities and opportunities for countries in the region, as a basis for developing national cleaner production strategies.

2. Prepare a regional study of policies and other incentives for cleaner production

3. Organize a regional Expert Meeting on Development of National Cleaner Technology Strategies for CEE and NIS Countries. To be held in Bratislava, Slovakia, 27-30 June 2000.

4. Conduct a Diagnostic Study for Slovakia using the methodology.

5. Develop a strategic plan for cleaner technology development for countries in the region and a more detailed strategic plan for cleaner technology policies for Slovakia, based on the Diagnostic Study.

6. Create a Manual of Guidelines and Recommendations for the design and implementation of cleaner technology policies, the promotion of public and private R&D activities in selected areas, and the commercialisation of these cleaner technologies.

This report is the methodology referred to in step 1 and national study referred in step 4.

VI. METHODOLOGY FOR THE DIAGNOSTIC STUDY

1. Introduction

Efforts to integrate with the European Union, during a transition period of economical, political, and social changes, mean unusual challenges for countries in the region. Companies are under increasing competitive pressure of market economy, while faced with shortage of capital, tougher environmental legislation and limited access to information.

Nations have to address many problems including legal systems; brain drain, unresolved environmental problems from the past, new social issues and many other problems.

The need to compete in one of the most advanced markets – the European Union - and in the same time withstand its pressure; efforts to join international organisations - OECD, European Union, NATO, etc.; consequent demand to harmonise country's internal conditions with international standards; mean further pressures on governments and state budgets.

A continuing challenge is how to use national resources to support technology-related development. Global competitiveness requires the establishment of strategic advantage through specialisation. By focusing on those areas in which there is a good match between global opportunities and a country's strengths in science and technology, resources can be deployed where they can make the greatest impact.

The diagnostic study will assess sectors on which a country could focus its attention for technology related economic development in an increasingly environmentally conscious world. This is the first step toward the development of an action plan identifying specific technologies for priority development. The study relates global and national opportunities in specific technologies to the capacities of businesses, government, and research institutes and universities in the country to capitalize on these opportunities. International and national data are to be collected on a range of variables related to selected sectors and where possible to technology areas. Each of these variables will be evaluated by means of performance scores for each sector and potential technology area. The study will conclude with a summary assessment of where the best matches lie between high opportunity sectors and technologies and high domestic capacity.

2. Sectors and Technologies

2.1 Critical Technologies

Every two years, the National Science and Technology Council of the United States updates its list of "Critical Technologies". This list encompasses technologies which are significant either for reasons of **economic prosperity or national security**, often both. The 1999 list encompasses 7 technology categories, with 27 specific technology areas and a total of 94 technology sub-areas. The list resembles those of Japan, Germany and other countries.

As world economies become more intertwined, technologies to support the marketable opportunities of the future should be expected to become more similar. The 1999 list of Critical Technologies, which provides a possible structure against which a country's strengths can be analysed, is shown in Table 1.

However, lists of critical technologies or similar documents have not been published in countries in the region, yet.

The ability of the country to cope with the most advanced technologies also depends on tradition and technical and economic strengths. It is expected that the national lists of sectors and technologies significant to economical and technological development will reflect this, e.g. not all of them would be the most advanced[1].

2.2 Sectors and Technologies to be considered

For the purpose of the diagnostic study a list of sectors and technologies for consideration has to be created. The list of critical technologies in Table 1, can be used as a starting point to identify technologies that are most relevant to the country.

Those sectors/technologies, which:

- have either high rate on the country's GDP or
- are an important employer or
- are important within the country from other point of view (c.f.e.: high received investments during last few years), or
- are already seen as priorities in official policies

should be included in the analysis.

[1] *Kotler´s theory of competitor strategy (leaders, challengers, followers and niches..) can be applied for countries as well as for companies.*

Table 1 - United States Critical Technologies, 1999

CATEGORY	Technology Area	Technology Sub-Area
Energy	Energy efficiency	building technologies, non-IC propulsion systems
	Energy storage, conditioning distribution and transmission	advanced batteries, power electronics, capacitors
	Improved generation	gas turbines, fuel cells, next generation nuclear reactors, power supplies, renewable energy
Environmental Quality	Monitoring and assessment	integrated environmental monitoring, remote assessment of biosystems
	Pollution Control	pollution control
	Remediation and restoration	remediation & restoration, bioremediation, nuclear waste storage/disposal
Information & Communication	Components	high density data storage, high definition displays, high-resolution scanning technologies
	Communications	data suppression, signal conditioning & validation, telecom/data routing
	Computer Systems	interoperability, parallel processing
	Information management	data fusion, large scale info systems, health systems and services, integrated navigation systems
	Intelligent complex adaptive systems	autonomous robotic devices, artificial intellligence
	Sensors	physical devices, integrated signal processing
	Software and toolkits	education/training software, network and system software, modeling and simulation software, software engineering tools, pattern recognition, software production, neural nets
Living Systems	Biotechnology	bioprocessing, monoclonal antibody production, protein engineering, recombinant DNA technologies, vaccines, genetics, combinatorial chemistry
	Medical technologies	health info systems/services, biocompatible materials, functional diagnostic imaging, bacterial/viral defect screening, medical device and equipment
	Agriculture & food technologies	sustainable agricultural production, food safety assurance, aquaculture and fisheries
	Human systems	advanced human-machine interfaces
Manufacturing	Discrete product manufacturing	CIM support software, equipment interoperability, intelligent processing equipment, robotics, auto systems for facilities ops, net shape processing, rapid solidification processing
	Continuos material processing	catalysts, surface treatments, ultrapure refining methods, pollution avoidance, predictive process control
	Micro/nanofabrication and machining	microdevice manufacturing techs, artificial structuring methods
Materials	Materials	alloys, ceramic materials, composites, electronic materials, photonic materials, high energy-density materials, highway/infrastructure materials, biocompatible materials, stealth materials, superconductors, polymers
	Structures	aircraft structures
Transportation	Aerodynamics	aircraft aerodynamics, surface vehicles aerodynamics
	Avionics and control	aircraft/spacecraft avionics, surface transport controls
	Propulsion and power	aircraft turbines, spacecraft power systems, electrically powered vehicles
	Systems integration	intelligent transportation systems, aircraft/spacecraft integration
	Human interface	human factors engineering, spacecraft life support

Source: Office of Science and Technology Policy, National Critical Technologies Report, March 1999.

2.3 Proposed procedure to create a list

1. Start with sectors. Decide the criteria which will be used to include a sector into the list. Some of possible criteria are:
    - share of the sector in GDP higher than 5%
    - growth of the sector during last 3 years - top 5
    - growth of sector exports - top 5
    - share of the sector in national exports is higher that 15%. Latest year available
    - number of foreign investors in the sector - top 5 sectors, latest year available
    - total amount of investment during last 3-5 years, top 5 sectors
2. Decide on relevant sectors from the available lists of critical technologies
3. Identify the relevant sectors ID (Sector Classification of Economic Activities). This will help in data collection
4. Collect data on sectors. Based on data prepare the list of sectors for consideration
5. Prepare a list of technology and sub-technology areas. Involvement of technology research institutions, universities, Academy of Science, grant agencies and industry associations is recommended.

Example of the list suggested for Slovak republic is in Table 2.

Table 2

CATEGORY / Sector	***Technology Area***	***Technology Sub-Area***
Energy		
	Energy efficiency	building technologies
	Energy storage, conditioning distribution and transmission	advanced batteries, power electronics, capacitors
	Improved generation	gas turbines, fuel cells, reactors, power supplies, renewable energy
Environmental Quality		
	Monitoring and assessment	Integrated environmental monitoring, remote assessment
	Pollution Control	pollution control
	Remediation and restoration	remediation & restoration, bioremediation
Information & Communication		
	Communications	data suppression, signal conditioning & validation, telecom/data routing
	Computer Systems	interoperability, parallel processing, image processing
	Information management	data fusion, large scale info systems, health systems and services

	Intelligent complex adaptive systems	autonomous robotic devices, artificial intellligence
	Sensors	physical devices, integrated signal processing
	Software and toolkits	education/training software, network and system software, modeling and simulation software, software engineering tools, pattern recognition, software production, neural nets
Living Systems		
	Biotechnology	bioprocessing, monoclonal antibody production, protein engineering, recombinant DNA technologies, vaccines, genetics, combinatorial chemistry
	Medical technologies	health info systems/services, biocompatible materials, medical device and equipment
	Agriculture & food technologies	sustainable agricultural production, food safety assurance advanced processing and products
	Human systems	advanced human-machine interfaces
Manufacturing		
	Discrete product manufacturing	CIM support software, equipment interoperability, intelligent processing equipment, robotics, auto systems for facilities ops, net shape processing, rapid solidification processing
	Continuos material processing	catalysts, surface treatments, ultrapure refining methods, pollution avoidance, predictive process control
Materials		
	Materials	alloys, ceramic materials, composites, electronic materials, photonic materials, high energy-density materials, highway/infrastructure materials, biocompatible materials, stealth materials, superconductors, polymers
Transportation		
	Control	surface transport controls
	Propulsion and power	electrically and gas powered vehicles
	Systems integration	intelligent transportation systems, systems integration
Production Sectors		
	Car production	
	Light chemistry	specialities, efficient separation processes pharmaceutics components and medicines
	Wood and furniture	sustainable forestry, ecological products
	Pulp and paper	non-chlorine processes, advanced materials
	Polygraphy	image processing, advanced products, computerised systems

3. Analysis

3.1 Basic Approach

The systemic business approach is to examine the current situation in through analysis of past data and future projections. To identify which technologies may be priorities for a country, one must understand both external and internal environments: in economic (including market), environmental and social dimensions.

The internal environment describes the country's *"capacity"* or capabilities to take advantage of these opportunities in scale of "**S**trengths" and "**W**eakness", whereas the external environment is viewed as a range of "**O**pportunities" and "**T**hreats", in further text referred as "*opportunities*".

Technologies in which both *capacity* and *opportunities* are judged to be high would be candidates for further study as strategic technologies.

3.2 Indicators

A set of indicators should be designed which would reflect the most important facts Three groups of indicators would apply:

- national - indicators which are not specifically related to the sector or technology, but are expected to have important impact to the final development and rate of sector specific value to the national one would be of interest. GDP and GDP growth, usual interest rates of mid- and long-term investments, energy prices, infrastructure indicators are few examples;
- sector specific - indicators specifically related to and/or evaluated for the sector;
- technology/technology area specific - indicators specific to the certain technology area/sub-areas. Technology specific raw material pricing, typical investments per employee, specific resources (water f.e.) consumption per unit of production, are few examples.

Some indicators would apply to more than one sector, for example in cases when several sectors/technologies share the same specific resources.

To the extent possible, data collected and analysed should apply to particular sectors so that the analysis will be consistent. Technology specific indicators are typically available in limited extent, though it would be desirable to have an opportunity to collect them. Mot of them are not part of statistics.

Some indicators will apply in both internal "capacities" and external "opportunities" categories, depending if they are evaluated for the country or environment external to it.

3.3 Rating Opportunities and Capacities

"Opportunities"

The external environment represents "opportunities" for a country.

Financial forces, such as international and national investment can prove to be either important opportunities or threats. International market demand and developments create another aspect of external environment. Trade, subsidies, social and environmental policies and priorities of international organisations in the region have to be considered.

Technologies viewed as offering good returns on investment will be among the first to be commercialised. Government policies can also affect chances for obtaining R&D funding, through explicit or implicit research priorities.

One might also consider the actions of industry, venture capitalists, government, and universities in other nations with respect to particular technologies, in that such actions may indicate their judgements on expected market returns.

Since chances refer to the country's external environment, data should be collected and compared from countries that influence sustainable technological development. In order to evaluate the country's capacities, we should compare them to other CEE and NIS countries, the EU and selected European countries (for example: Ireland, UK, Germany, France), OECD, the United States. Since it is important to compare the country's strength with its peers, we should collect data for key CEE and NIS countries and compare the data with those of the leading developed economies such as identified above. Comparison with selected "Asian tiger" economies can help to learn from their experience.

"Capacities"

A country's technology "capacities", or its ability to capitalise on its opportunities, are shaped by many factors including: the composition of its economic base; academic research strengths; the institutional network for commercialisation and technology transfer; and the activities of technology related businesses and universities with respect to venture capital; patent awards, and receiving grant awards for co-operative technology programs; environmental requirements; human resources availability and cost; size of national market; management culture.

Scoring

A standardised rating system has been developed. The objective of the rating system is to determine, through an aggregate index, whether capacity or chance is high for each sector/technologies in the technologies list.

Most of aspects represented by an indicator can be viewed as either external - "opportunity" or internal - "capacity"; and can be considered in positive or negative for further development.

Positive internal facts - "capacities" represent **S**trength, negative mean **W**eakness; positive external facts -"opportunities", represents **O**pportunity, negative mean **T**hreat. Positive evaluation gets score 1, negative -1. If it is not clear or the team cannot search agreement, the scoring is 0

Decision for assigning indicators as external or internal and ratings should be explained after the data collection and analysis is complete.

Determination of weights

After a score has been assigned to each element of opportunity and capacity, a weighted index for the technology is calculated.

The proper selection of weights can be crucial for final decision and might become problematic especially if there are many categories/areas/indicators. In such cases, weights selected on the pair comparison of importance of single indicators proved to provide reasonable results. Example is given in Table 3 in Chapter 4.

4. Developing the Scoring Scheme - Slovak Example

This section explains, as an example, how the rating was determined. For illustration and explanation purposes, limited number of criteria is presented. Relevant indicators (Annex X) are referred in brackets.

"Opportunities" (External) Elements

Op1 - Research and Development – Growth of Spending (2)

- Where money has been committed for research and development increasingly, there is a larger opportunity. Due to existing situation, this growth can be achieved only from international resources. Continual growth indicates wider interest in the area. If there was a continual growth in spending during last 3 years - assigned "1". If no money were reported for the specific technology/sector research the scoring was "-1", otherwise "0". National resources and growth of spending is considered a capacity.

Op2 - Research and Development – Level of Spending by international projects/programs in the country (7)

- Where money has been committed by international and foreign resources for research and development, there is a larger probability of leading edge developing science. Where there was spending higher than 1 million US$ - assigned "1". If no money were reported for the specific technology/sector research the scoring was "-1", otherwise "0".

Op3 - Foreign Capital Funding (30)

- Sectors receiving 10 % or more of foreign capital funding were rated "1"; other technology areas with 1 % or more received a "0"; others were rated "-1".

Op4 - Licences sold (14)

- Sectors where more than 10 licences were sold during last 3 years received "1". Sectors which reported at least 1 license sold were scored "0", no licence "-1".

Op5 - Patents registered nationally or internationally in Slovakia (15)

- Sectors where more than 30 patents were registered during last 3 years received "1". Sectors which reported at least 1 patent sold were scored "0", for no patent reported assigned score "-1"

Op6 - Exports growth (24)

- Sectors where the reported latest year export growth is higher than 20% were considered opportunity and received "1". Areas which reported export growth at least 5% were scored "0", the rest was scored "-1"

Op7 - Sector Research Institutions (6)

- Sectors where the national technology research institution was involved in international projects continually for at least last 3 years were considered opportunity and received

"1". The rest were scored "0", unless the institution disappeared during last 3 years - scored "-1"

Op8 - Average consumption of water per unit of production by sector as a % of the best ones identified by World Bank guide (44)

- Those sectors where consumption of primary resources (water in this case) is close to the recommended values will not have to invest so heavily into environmental compliance measures and their resource utilisation is more efficient. Environmental efficiency is desirable. If the sector value is equal, better or worse by max. 20% than recommended - assigned "1". If sector value is within 20-50% worse than World Bank's value or no data available – "0", otherwise "-1". This is considered an opportunity due to actual situation in CEE and NIS countries related to EU consumers requirements.

Table 3 - Weights assignment *(refers to "opportunities" in case example)*

	Op1	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	*number*	*level*	*weight*
Op1	-					x	x		2	III	1
Op2	x	-	x	x		x	x	x	6	I	3
Op3	x		-	x		x	x		4	II	2
Op4	x			-		x	x	x	4	II	2
Op5	x	x	x	x	-	x	x	x	7	I	3
Op6						-	x		1	III	1
Op7							-	x	1	III	1
Op8	x		x			x		-	3	II	2

Notes:

1. The entry in each cell indicates the row criterion considered more important in the comparison of each pair (column). The unshaded cells indicate that the column criterion is more important
2. Number indicates how many times the criterion is considered more important. It is a sum of shaded cells in the given row.
3. Areas above and below the diagonal are complementary and must match.

The weights used represent the judgement of the relative importance of each element prior to others based on pair analysis for an opportunity. Levels and consequently weights are given by intervals in number obtained: 7-5, 4-3, 2-0.

After collection of relevant data, a panel judges the relative importance. The entry into cell was introduced only if consensus was reached. In cases where consensus was not reached, the criterion was reconsidered.

For example: Op3 – Foreign Capital Funding was considered:

- to be more important than Op1 because of actual problems and week position of research during last 10 years;
- to be less important than Op2. If a research institution is able to receive high foreign funding this points potential competitiveness and leading edge involvement

- more important than Op4. Licences sold does not necessary mean development in the country. Frequently lack of capital is the reason for the policy of selling licences
- less important than Op5. Interest in patent registrations in the country mean either competitors in the country or interesting domestic market
- more important than Op6. Foreign capital funding is a primary reason for exports growth in many sectors
- more important than Op7. The same consideration applied as with Op1
- less important than Op8. Resource efficiency and water availability is becoming a limiting factor for further development.

An example of the decision criteria used for Slovak Republic follows. All rating elements should be adapted for each country.

A summary of the opportunity assessment matrix is provided below.

Table 4 - Opportunities Assessment

	Op1	*Op2*	*Op3*	*Op4*	*Op5*	*Op6*	*Op7*	*Op8*	*Global scoring*	*Average scoring*
Weights assigned	***1***	***3***	***2***	***2***	***3***	***1***	***1***	***2***	***15***	
Technology Area										
Energy efficiency	1	1	0	-1	1	-1	1	0	5	0,33
Energy storage, conditioning distribution and transmission	0	0	1	-1	0	-1	1	-1	-2	-0,13
Improved generation	1	1	1	-1	1	-1	1	0	7	0,47
Monitoring and assessment	0	0	-1	-1	0	-1	0	0	-5	-0,33
Pollution Control	-1	-1	-1	-1	-1	-1	0	0	-12	-0,80
Remediation and restoration	-1	-1	-1	-1	-1	-1	0	0	-12	-0,80
Communications	0	0	1	0	1	0	0	1	7	0,47
Computer Systems	0	0	0	0	1	-1	0	0	2	0,13
Information management	0	0	0	0	1	-1	0	0	2	0,13
Intelligent complex adaptive systems	0	0	-1	-1	1	-1	0	0	-2	-0,13
Sensors	-1	-1	-1	-1	0	-1	0	1	-7	-0,47
Software and toolkits	0	0	-1	0	1	-1	0	1	2	0,13
Biotechnology	0	1	-1	1	1	1	0	0	7	0,47
Medical technologies	-1	-1	-1	-1	0	-1	-1	-1	-12	-0,80
Agriculture & food technologies	0	0	-1	0	1	0	0	-1	-1	-0,07
Human systems	-1	0	-1	-1	0	-1	-1	0	-7	-0,47
Discrete product manufacturing	0	1	0	1	1	0	0	0	8	0,53
Continuous material processing	0	1	0	1	1	-1	0	0	7	0,47
Materials	0	0	-1	-1	1	-1	0	0	-2	-0,13
Control	0	0	-1	-1	0	-1	0	0	-5	-0,33
Propulsion and power	0	-1	-1	-1	-1	-1	0	0	-11	-0,73
Systems integration	0	-1	-1	-1	-1	-1	0	0	-11	-0,73
Car production	1	1	1	-1	1	1	1	0	9	0,60
Light chemistry	1	1	0	1	1	1	1	-1	9	0,60
Wood and furniture	0	0	-1	-1	0	0	0	0	-4	-0,27
Pulp and paper	0	0	-1	-1	0	0	1	1	-1	-0,07
Polygraphy	0	0	-1	0	0	0	1	1	1	0,07

"Capacity" (Internal) Elements

C1 - University degree employees (20)

- Areas in which 15% or more of the employees possess a university degree were scored a "1"; others received a "0" rating, unless the rate of university degree was lower than 5%.

C2 - Employment size (17)

- Where a sector has high employment, the sector received a "1"; where no significant employment was noted, a "0", others were rated a "-1".

C3 - Specific Research Institution (6)

- Areas where the specific technology research institution exists were considered opportunity and received "1". The rest were scored "0", unless the institution disappeared during last 3 years - scored "-1"

C4 - Research Strengths –Technology Area(12)

- In technology areas with research funded by industry, technologies with more than 50 thousands US$ received "1". Rating of "0" was assigned to technologies with research funded by industry but less than given amount. The rest received "-1".

C5 - Capital Investments (29, 30, 31)

- Technologies with $0,5 million or more in investment during last 3 years received "1". "0" values were given to those with some funding. All others were rated "-1".

C6 - Patents submitted to other countries (15)

- Technologies with at least 10 patents submitted to foreign offices during last 3 years were rated "1". Those with less but with at least one were rated "0". All others were rated "-1".

C7 – Environmental activity and experience of sector (40,41)

- Own activity and CP experience of sector on cooperative basis is considered a capacity – indicate preventative approach and support to sector. Sectors with specific environmental activities within associations and demonstrated CP projects were rated "1". Those with less but with at least one were rated "0". All others were rated "-1".

Weights assignment procedure was analogical to “opportunities” process. The determining intervals were: 6-5, 4-3, 2-0

Table 5 - Weights assignment *(refers to "capacities" in case example)*

	C1	C2	C3	C4	C5	C6	C7	*number*	*level*	*weight*
C1	-	x	x					2	III	1
C2		-						0	III	1
C3		x	-				x	2	III	1
C4	x	x	x	-	x	x	x	6	I	3
C5	x	x	x		-	x		4	II	2
C6	x	x	x		x	-		4	II	2
C7	x	x			x	x	-	4	II	2

A summary of the capacity assessment matrix follows on the next page.

Table 6 - Capacities Assessment

	C1	*C2*	*C3*	*C4*	*C5*	*C6*		*global scoring*	*average scoring*
weights assigned	***1***	***1***	***1***	***3***	***2***	***2***	***2***	***12***	
Technology Area									
Energy efficiency	1	-1	1	1	1	-1	-1	2	0,17
Energy storage, conditioning distribution and transmission	0	-1	1	1	0	-1	-1	-1	-0,08
Improved generation	1	0	1	1	0	0	0	5	0,42
Monitoring and assessment	0	0	1	0	0	-1	-1	-3	-0,25
Pollution Control	0	0	1	0	-1	-1	-1	-5	-0,42
Remediation and restoration	-1	-1	0	0	-1	0	0	-4	-0,33
Communications	1	1	1	1	0	0	0	6	0,50
Computer Systems	1	1	1	0	1	1	1	9	0,75
Information management	1	1	1	1	1	1	1	12	1,00
Intelligent complex adaptive systems	0	1	0	0	-1	0	0	-1	-0,08
Sensors	0	0	0	0	-1	-1	-1	-6	-0,50
Software and toolkits	1	1	0	1	0	0	0	5	0,42
Biotechnology	0	0	-1	0	0	1	1	3	0,25
Medical technologies	0	-1	-1	-1	-1	-1	-1	-11	-0,92
Agriculture & food technologies	-1	-1	0	0	1	-1	-1	-4	-0,33
Human systems	0	-1	0	-1	0	-1	-1	-8	-0,67
Discrete product manufacturing	0	-1	0	1	1	0	0	4	0,33
Continuos material processing	0	-1	0	1	0	0	0	2	0,17
Materials	0	0	1	0	0	-1	-1	-3	-0,25
Control	0	0	1	0	-1	-1	-1	-5	-0,42
Propulsion and power	0	0	1	1	-1	-1	-1	-2	-0,17
Systems integration	0	0	0	0	0	-1	-1	-4	-0,33
Car production	-1	1	1	1	1	0	0	6	0,50
Light chemistry	1	0	1	1	1	1	1	11	0,92
Wood and furniture	0	-1	1	0	0	0	0	0	0,00
Pulp and paper	0	-1	-1	1	1	1	1	7	0,58
Polygraphy	1	0	0	0	1	1	1	7	0,58

Matching Opportunities and Capacity- Slovak. Example

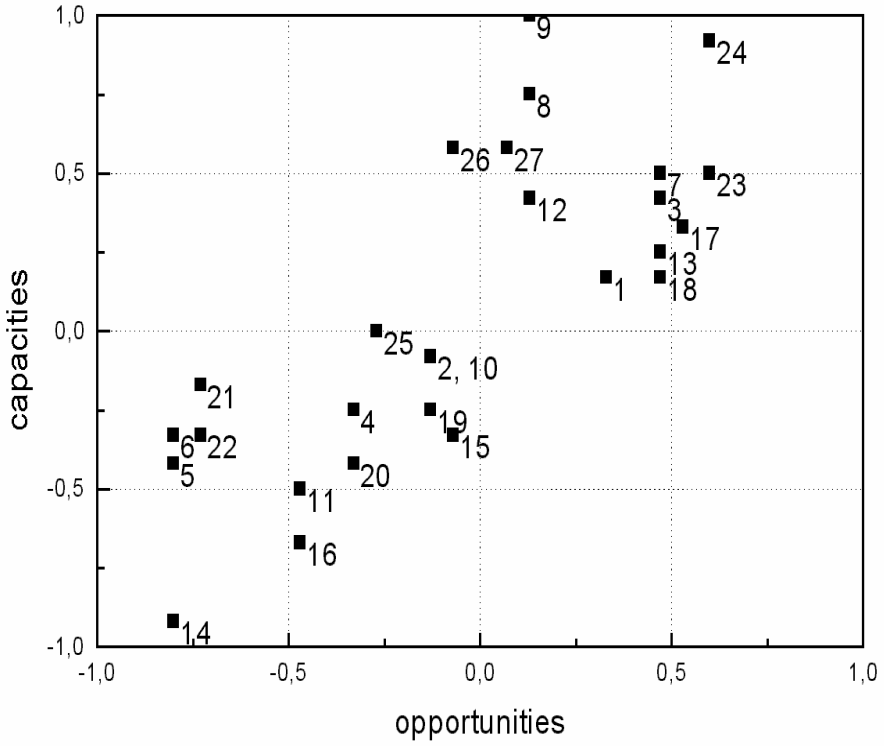
The results of the assessments, Table 7, just completed become clearer once they are viewed graphically.

Table 7 – Opportunities and Capacities

Technology Area	***opportunities***	***capacities***
Energy efficiency	0,33	0,17
Energy storage, conditioning distribution and transmission	-0,13	-0,08
Improved generation	0,47	0,42
Monitoring and assessment	-0,33	-0,25
Pollution Control	-0,80	-0,42
Remediation and restoration	-0,80	-0,33
Communications	0,47	0,50
Computer Systems	0,13	0,75
Information management	0,13	1,00
Intelligent complex adaptive systems	-0,13	-0,08
Sensors	-0,47	-0,50
Software and toolkits	0,13	0,42
Biotechnology	0,47	0,25
Medical technologies	-0,80	-0,92
Agriculture & food technologies	-0,07	-0,33
Human systems	-0,47	-0,67
Discrete product manufacturing	0,53	0,33
Continuos material processing	0,47	0,17
Materials	-0,13	-0,25
Control	-0,33	-0,42
Propulsion and power	-0,73	-0,17
Systems integration	-0,73	-0,33
Car production	0,60	0,50
Light chemistry	0,60	0,92
Wood and furniture	-0,27	0,00
Pulp and paper	-0,07	0,58
Polygraphy	0,07	0,58

Those areas, where both numerical values are positive show potential for further considerations within the process of preparation of NSCT. Those technology categories, where both numbers are higher than 0,5 should be considered as first priority.

In the chart below, the cells in the upper right show those technology areas with the most promise for Slovakia. A similar chart can be prepared for each country. The reader should keep in mind that this chart is intended as a guide to thinking about these technologies rather than a definite statement about the prospects for that technology.



1 Energy efficiency
2 Energy storage, condition
3 Improved generation
4 Monitoring and assess.t
5 Pollution Control
6 Remediation and restorat.
7 Communications
8 Computer Systems
9 Information management
10 Intelligent complex adap
11 Sensors
12 Software and toolkits
13 Biotechnology
14 Medical technologies
15 Agriculture & food techn.
16 Human systems
17 Discrete product manufac.
18 Continuous material proce.
19 Materials
20 Control
21 Propulsion and power
22 Systems integration
23 Car production
24 Light chemistry
25 Wood and furniture
26 Pulp and paper
27 Polygraphy

VII. SUMMARY AND RECOMMENDATIONS

The final analysis will consider a broad range of variables and develop an overall assessment of technologies, talking into account, where necessary, factors not considered in this methodology.

The results of methodology applied will depend on selection of factors and criteria and their weights. For this reason, the team-work of experts involved, as well as valid data are crucial for results.

This methodology needs to be recognized for what it is, a preliminary framework for an overview assessment. The assessment will be a diagnostic study of cleaner technology capacities and opportunities for commercialisation in the country. The next step will be to develop a broad strategic plan utilizing this assessment and implementing the plan through strategic technology policies for the country.

VIII. STEPS FOR ORGANIZATIONS USING THIS METHODOLOGY

1. Gather opportunity and capacity data as outlined in the methodology.

2. Develop a rating system and assign values and weights to the opportunity and capacity elements.

3. Format data into representative tables that organize the data into a useful structure.

4. Build an opportunities versus capacity matrix that identifies high potential critical and strategic technologies for the country.

5. As an ongoing process, review and update data and matrices.

6. Make final assessment of priority technology areas, taking into account all relevant information.

7. Develop a draft strategic plan for cleaner technologies for the country.

8. Conduct a consultative review to evaluate the draft plan.

9. Prepare a manual of guidelines and recommendations.

IX. SOME DATA SOURCES

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X. ANNEX 1

Examples of indicators which could be considered in the study.

The two types of indicators are seen: sector specific (S) and common (C).

ID	*Description of indicator*	*Type*	*Note*
1	Research and development spending as a percentage of GDP per sector.	S	1,2 3
2	Sector annual growth rate in total R&D expenditures.	S	1,3
3	Total R&D personnel (science and engineering) per 1000 labour force.	C, S	1
4	Sources of R&D expenditures at public universities: national government, local government, industry, institutions and others. Latest year available. Total $ and %.	C	1
5	Share of total R&D expenditures by government, industry and academia..	C	1, 3
6	Sector research institutions involvement in national and international projects	S	1, 2
7	Level of R&D spending by international projects/programs in the country by sector	S	
8	Total national investment in R&D by sector.	S	1, 3
9	Ranking of the country's and other regional R&D universities. Latest year available. Rank by total of all R&D expenditures.	C	1
10	Dollars invested in nationally designated university research.	C	1, 2, 3
11	The country's industry R&D investments by sector.	S	1, 3
12	Intellectual property protection number of inventions, patents, licences awarded by category/sector	S	1, 3
13	Leading technology classes/sectors on patent awards. Totals and ratio of national patents by	S	1, 3
14	Leading technology classes/sectors among licences. Totals by category/sector.	S	1, 3
15	Patents registered, by sector, for the last 5 years, with percentage breakdown per category.	S	1,2
16	Science and engineering graduate students per million inhabitants for	C	1, 2

1 national data

2 EU, OECD, selected countries, USA data

3 latest year, comparative changes for the last 3-5 years, depends on data availability

ID	Description of indicator	Type	Note
	the latest year available.		
17	Employment and job creation in manufacturing and other selected technology sectors. Comparative analysis of the last 5 years. Share of total employment and net job creation.	S	1
18	Employment structure and wages in manufacturing and other selected industries. Latest year available.	S	1
19	Sectoral strengths and key industries. Employment and number of firms. Latest year available.	S	1
20	Number of scientists and engineers working by sector.	S	1, 2
21	Unemployment, inflation, national savings, and investment trends and growth for the last five years, as well as estimates for the future.	C	1
22	Rate of university degree employees speaking at least one foreign language	C	1, 2[1]
21	Rate of households having access to Internet	C	1, 2
22	Per capita GDP growth for the last 5 years.	C	1
23	Sector growth as a percentage of GDP	S	1, 2
24	Total exports in dollars and as a percentage of GDP by export category for the latest year available.	S	1
25	Evolution of the budget deficit (last 5 years).	C	1
26	Venture capital invested in companies, by sector, for the last 5 years.	S	1, 2
27	Total capital investments by technology category/sector; in percentages and local currency.	S	1, 2
28	Capital investments – machinery and equipment - by category/sector, in local currency and in percentages of total capital investment by sector	S	2
29	Capital investment – nonmaterial investment – by category/sector, in local currency and in percentages of total capital investment by sector, for last 3 years	S	2
30	Participation of foreign capital in sector in % of foreign capital in country	S	1, 2
31	Average interest rate development	C	1, 2
32	Number of ISO 14001/EMAS compliant firms and ratio of ISO compliant firms to potential registrants for the latest year available.	C	1
33	Number of ISO 14001/EMAS certified companies, by sector.	S	1, 2

1 national data

2 EU, OECD, selected countries, USA data

3 latest year, comparative changes for the last 3-5 years, depends on data availability

ID	Description of indicator	Type	Note
34	Government data on mineral and natural resources production capacity (i.e. tons of cement per year, m^3 of natural gas per year, etc.).	C	1
35	Average energy, water prices by sector	S	1, 2
36	Wastes and emissions fees collected by sector	S	1, 2
37	Primary resources consumption (energy, water, etc.) by sector	S	1, 2
38	Presence of subsidies on water, gas, electricity, heat, etc. for sector	S, C	1
39	BCL (Basic capacity level defined by OECD) for CP reached in the country	C	1
40	Direct support to CP by sector	S	1
41	Sector specific environmental best practice experience (guides, CP case studies, environmental performance benchmarks recommended, etc.) acquired nationally	S	1
42	Presence of environmental WG or other activity within the sector industry association	S	1
43	Sector regulated by IPPC Directive	S	1
44	Average consumption of natural resources per unit of production (water, energy, gas) by sector as a % of those identified by BAT/sector guide or World Bank guide	S	1
45	Sector specific environmental regulation and enforcement by sector	S	1

1 national data

2 EU, OECD, selected countries, USA data

3 latest year, comparative changes for the last 3-5 years, depends on data availability