

Technical University of Denmark



Technology foresight and cleaner production in a highly polluted industrial area

Jørgensen, Birte Holst; Buckley, C.

Publication date:
2004

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Jørgensen, B. H., & Buckley, C. (2004). Technology foresight and cleaner production in a highly polluted industrial area. (Denmark. Forskningscenter Risoe. Risoe-R; No. 1490(EN)).

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Risø-R-1490(EN)

Technology Foresight and Cleaner Production in a Highly Polluted Industrial Area

Birte Holst Jørgensen¹ and Chris Buckley²

¹ Risø National Laboratory, Denmark

² Pollution Research Group, University of Natal, South Africa

Author: Birte Holst Jørgensen and Chris Buckley
Title: Technology Foresight and Cleaner Production in a Highly Polluted Industrial Area
Department: System Analysis Department

Abstract (max. 2000 char.):

This paper focuses on the potential of technology foresight to promote cleaner methods of production in the highly polluted industrial area of South Durban Basin in South Africa. It builds on the assumption that technologies are the central factor in the pursuit of sustainable development. It takes into consideration the experiences already gained within technology foresight exercises at national level in South Africa as well as various cleaner production activities at sectoral level. Most importantly, it tries to take into account the multiple localised capabilities and efforts in environmental protection and economic development in the eThekweni Municipality. The paper argues that technology foresight offers a reflexive process. This process simultaneously addresses the triple (economic, social and environmental) bottom lines of sustainability. At the same time, it creates a spiral learning process in which various stakeholders are brought together to assess both the likely impact of technologies and the interrelationship of industry, technology, regulation and civil society.

Risø-R-1490(EN)
December 2004

ISSN 0106-2840
ISBN 87-550-3394-6

Contract no.:

Group's own reg. no.:

Sponsorship:

Cover :

Pages: 17
Tables: 4
References: 20

Risø National Laboratory
Information Service Department
P.O.Box 49
DK-4000 Roskilde
Denmark
Telephone +45 46774004
bibl@risoe.dk
Fax +45 46774013
www.risoe.dk

Contents

Preface 4

1 How to eat an elephant? 5

2 The environmental challenge in South Durban Basin 7

3 Sustainable development and the choice of technology 9

4 Technology foresight as a spiral learning process 11

5 Conclusion 14

References 17

Preface

The paper is the result of a Danish / South African research exchange visit in October 2002 at the Pollution Research Group, University of Natal, Durban. Special thanks go to Manager Siva Chetty, South Durban Multi Point Action Plan; Project Manager Jessica Rich, Environmental Management, eThekweni Municipality; Chief Technical Advisor Karen Lundbo, Cleaner Textile Production Project; Manager Dave Wright, Engen Oil; and Professor Thomas G. Whiston, Roskilde University, for comments on earlier drafts of this paper.

1 How to eat an elephant?

A company representative once said that, in industry, environmental work promoting cleaner methods of production is like eating an elephant — one has to do it in small bites (Danish Council for Cleaner Products, 2002). In order not to prevent some companies from getting to the table, it may therefore be wise to check out the menu, invite in some good neighbours, and pick the most desirable dishes according to one's own choice — it may not be necessary to eat the whole elephant. This is what technology foresight is about when it is applied to a distinctive local problem of pollution.

South Africa does indeed possess solid foundations both where the design and application of technology foresight is concerned and in the research and implementation of cleaner, pollution-free production. This is a good starting point for those who wish to use technology foresight to promote cleaner production in highly polluted industrial areas in South Africa.

The concept of *technology foresight* is well known in South Africa. In 1995 a national research technology foresight exercise was undertaken by the Department of Art, Culture, Science and Technology as part of a plan to review and reform the science and technology system. The aim was to help to identify specific technologies and technology trends that would best improve the quality of life of all citizens over the next 10-20 years (DACST, information-pamphlet). Later the government's vision of an economy meeting the needs of people in a more equitable manner than it had hitherto was complemented by a Microeconomic Reform Strategy which defined more precisely the structural changes needed to achieve the identified sustainable economic targets by 2014 (DTI, 2002:4). The manufacturing sector, together with the remaining part of the national innovation system¹, is considered pivotal to the realisation of micro-economic strategy. This is reflected in two parallel strategies that have developed in 2002: the "Integrated Manufacturing Strategy" of the Department of Trade and Industry and the "National Research and Development Strategy" of the Department of Arts, Culture, Science and Technology. The National Advisory Council on Innovation (NACI) has built on these two strategies by identifying and developing the specific themes (or 'road maps') that need to be pursued for their successful fulfilment. The national technology and research organisation, CSIR, is currently assisting the NACI in developing technology road maps for four technologies across five key economic sectors in South Africa². Regional contributions to the development of the road maps partly reflect the clustering of industries across the country. The final technology road maps will contribute to the "National Advanced Manufacturing and Logistics Technology Strategy", due to be finalised in 2003.

¹ National innovation system refers to the relationships and interactions between the production system on the one hand and universities, research institutes and technological institutions on the other hand (see for example Edquist, 1997).

² The four technologies are: Advanced materials technologies, Product and process technologies, ICT and logistics technologies, and cleaner production technologies. The key economic sectors are: automotive and transport sector, metal and minerals sector, textiles and clothing sector, cultural/crafts industry, and chemicals (and biotechnology) sector (Information provided for the NACI Stakeholder Workshop 16 August 2002)

The problem of *cleaner production* has recently attracted growing interest from academics, from those working in public development programmes, and from some major industries in South Africa.

The Pollution Research Group (PRG), which is part of the School of Chemical Engineering at the University of Natal, has pioneered a number of investigations in environmental science. Since its formation in 1970, PRG has conducted research, education and development on several topics, including cleaner production, wastewater treatment and computational fluid dynamics. The PRG also provides technical assistance and training on the development and promotion of cleaner production in targeted industrial sectors as part of a national programme for cleaner production (see below). The regional aspect of pollution and environmental assessment is acknowledged in the idea of the 'waste minimisation clubs' — an idea that has been actively introduced and promoted by PRG. Cross-sectoral waste minimisation clubs currently operate in Cape Town.

'Cleaner production' was introduced in a national environmental development programme in 1993. It was formulated by the Department of Environmental Affairs and Tourism (DEAT) and the Department of Trade and Industry (DTI) in collaboration with the Danish government, and it was a natural and ambitious follow-up to previous environmental aid activities supported by the Danish Cooperation for Environment and Development (DANCED) and, since 2002, the Danish International Development Assistance (DANIDA). The cleaner production programme targets five major industries. These include fishing, textiles, metal finishing and possibly furniture making, but only the first three of these have been involved so far. Although some of these demonstration projects tend to be clustered in selected industrial locations around the country, the overall methodological assessment focuses on the specificities of the industrial sector, not on the specific characteristics of the co-location of industries.

Another major player in Cleaner Production is the Department of Manufacturing and Materials Technology in the national research and technology organisation known as the Council for Science and Industrial Research (CSIR). At the World Summit on Sustainable Development in September 2002, a UNIDO National Cleaner Production Centre was formed by an agreement between DTI, CSIR, UNIDO and the donor countries of Switzerland and Austria. In view of its previous activities — comprising waste recovery, energy audits, health risk assessment and environment management systems — the centre was established at CSIR (Interview with Dr. Rogers, 15 October 2002). The National Cleaner Production Centre will have a strong sectoral approach and will concentrate on the most industrialised areas of South Africa, where regional cleaner production focal points will be established. Later, a Memo of Understanding between the UNIDO-supported National cleaner Production Centre and the DANIDA-supported cleaner textile production project chaired by DTI was drafted. Precisely how the results from the national and sector-wide technology foresight exercises and road maps are disseminated and adapted to the specific industrial clusters around the country is yet to be decided.

This leaves us with a challenging question: how can we make use of the systematic and strategic elements of the technology foresight techniques when promoting cleaner production in highly polluted industrial areas? This complex problem may require technological solutions which are specifically tailored to the cluster of diverse industries and which interact with the local, provincial and even national environmental enforcement framework under which local industries operate. A regional perspective on technology foresight focuses on local capabilities and the role of knowledge in promoting cleaner production and long-term sustainability.

Knowledge has a strong tacit dimension, and this dimension is embedded in local institutions, skills and routines and is therefore tailor-made to suit the specific needs of the regional innovation system (OECD, 2001). Since the production and dissemination of practical knowledge is facilitated by what has been termed 'learning-by-interaction' (within and between organisations), spatial proximity matters. Thus proximity facilitates learning and innovation through mechanisms of interaction, including an intensive exchange of information between research, industry and authorities on both the short-term benefits and longer-term requirements of sustainable technologies.

This paper first describes the environmental and other challenges arising in South Durban Basin. After this, the focus turns to the role of technology in the pursuit of sustainable development. This leads to a discussion of the way in which technology foresight may be a strategic learning process in which key agents of change talk and walk the difficult path to sustainable development within a delimited area such as South Durban Basin.

2 The environmental challenge in South Durban Basin

Durban is home to Africa's busiest port and the main entry point for the import and export of oil, refined petroleum and petrochemical products. Petrochemical and chemical industries are located in South Durban and bulk chemical storage is located in the port itself (GroundWork, 2002: 35). The area is divided into five industrial belts which together house more than 120 industrial plants (chemical, textile, graphic etc.). Between and adjacent to these belts, many residential areas are located as a result, mainly, of historical segregation policies providing cheap labour for the industries.

The mix of heavy industry and residential areas in close proximity in a topographically limited area ensure that the South Durban industrial belts are an environmental 'hot spot'. At the same time, however, they form the economic heartland of the city and the second most important manufacturing cluster in South Africa (Roberts & Diederichs, 2002: vi). They are considered to have both economic and social strategic importance in the realisation of the long-term economic strategy for economic development and improved quality of life and citizenship for all people in Durban (South Durban Basin Multi-Point-Action Plan MMP Information Newsletter 1, October 2002; Monitor Group, 2000:2;5). The eThekweni Municipality has therefore opted for a path of sustainable development based on a combination of shorter-term as well as longer-term strategies involving partnerships between the private sector and civil society (eThekweni Municipality, 2001:8).

Currently, South Africa does not have effective environmental laws or standards on pollution control. Nor does it provide economic incentives to reduce pollution (GroundWork, 2002:19). Despite an overall environmental policy framework laid down in the Constitution and the Bill of Rights of 1996³, as well as in the National

3 Constitution Chapter 2 "Bill of Rights", § 24 **Environment** Everyone has the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Environmental Management Act of 1998, the regulation of air pollution is based on the Atmospheric Pollution Prevention Act (APPA) of 1965.

This raises the question how a country like South Africa — which is still suffering from the aftermath of the apartheid regime, has the highest Gini coefficient⁴ in the world, and has serious institutional capacity needs — should bridge the gap between the principles laid down in the constitutional bill of rights, on the one hand, and inappropriate environmental legislation that is poorly enforced, on the other. Just like other countries, South Africa needs to combine regulatory, economic, and voluntary instruments in order to both encourage technological innovation and assure investors that irresponsible companies do not benefit at the expense of those investing in environmental technologies (see also GroundWork, 2002:19).

As one of the pioneers of the local Agenda 21 movement in South Africa, the local government of Durban has, since 1994, striven to integrate an environmental management system into the overall planning and development processes of the city. A strategic environmental assessment has been made of South Durban Basin, and this integrates the views of several stakeholders from government, industry and local communities. The assessment suggests that South Durban Basin is likely to continue to have an industrial character well into the future, and that efforts required to address environmental issues should be linked to the encouragement of further industrial development and investment⁵ (Roberts & Diederichs, 2002: vii).

A number of initiatives that aim to assess the problem of air pollution have also been made over the years. These include the industry-managed Responsible Care Programme introduced following a toxic chlorine emission at the AECI complex of chemical industries in 1993; the stakeholder led SO₂ Steering Committee, set up to monitor and manage SO₂ pollution; and the agreement between the South Durban Community Environmental Alliance (SDCEA) and the refinery company Engen on an environmental improvement programme (GroundWork, 2002:39-63).

Each of these initiatives contributes to the situation today in which South Durban Basin is presently experiencing local implementation of a new air quality management system — the so-called Multi-Point-Action Plan (MPP).

This plan is intended to be a pilot study for national legislation and standards on air quality. It envisages a number of activities that will be jointly managed by a multi-level governance forum including all three layers of government, and industry and community representatives. As illustrated in the box below, the activities include both short-term measures to reduce industrial and traffic pollution and longer-term contributions designed to develop proper environmental standards and efficient enforcement mechanisms.

4 Gini coefficient is a measure of percentage of income distribution. 1 represents a situation where 1% of households earn all income, while 0 Gini represents an equal distribution. South Africa has recently surpassed Brazil and is now world leader in unequal distribution of income.

5 It should be noted that these strategic recommendations have never been approved politically. It has been pointed out that they fail to acknowledge that current industrial activities do impact on current health status and therefore must be addressed within the existing industrial development (Chetty, April 2003. A recent publication “A 2002 Snapshot. Comparison of Refineries in Denmark and South Durban in an Environmental & Societal Context” highlights that the number of incidents at the South African refineries is very high and is a critical indicator of environmental management. It also concludes that the government has failed to develop the capacity to regulate the industry and cannot ensure that everyone will be held to the same standards or that those who do pollute will pay for it (Danmarks Naturfredning & South Durban Community Environmental Alliance, 2003: 77 - 78).

Box 1: Components of the Multi-point Action Plan

- A Health Risk Assessment
- An epidemiological study
- Phasing out programme for the use of dirty fuels
- Establishing an Air Quality Management System
- Controlling chemical and fugitive emissions
- Strengthening the inspectorate
- Development of a local legal framework
- Reviewing of standards for priority pollutants
- Reviewing standards for vehicle emission

The path to sustainable development presents a challenge to the private companies and public agencies which must take and regulate investment decisions. While new legislation is prepared, and while proper institutions are developed to ensure effective implementation and enforcement, cleaner production may be a feasible way for industry to start walking the talk — as has been pointed out by Mr. Simioni, President of the textile company, Frame (Speech delivered at the annual Awards ceremony by Cotton SA, 17 October 2002).

This position reflects the economic interest the industry has in protecting and managing the environment, and in adopting a ‘cradle-to-grave’ approach (or life-cycle assessment) in which all stages of the manufacturing process are considered and optimised and attention is not devoted solely to the control of emissions and effluents. Choosing a technology is a far from straightforward task and indeed requires more systematic and far-sighted analysis and learning.

3 Sustainable development and the choice of technology

Sustainable development is not just a matter of how much growth/wealth is generated, but also of how this is achieved (eThekweni Municipality, August 2001). In other words, as was pointed out in the Brundtland report, “...*sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs*” (World Commission on Environment and Development, 1987).

As stated above, investments and technological development play an important role in the pursuit of sustainable development. This is illustrated in the so-called IPAT equation. This equation, which was developed by Paul Ehrlich and John Holdren in 1971, can be stated as follows:

$$I = P \times A \times T.$$

I is environmental impact; P is population; A is affluence (wealth per person); and T is technology (cited in Robinson, 2001:4). In a world with a growing population as well as rising average wealth, technology may be considered a key modifier of environmental impact (see Ibid. for further discussion).

But technology is a double-edged sword. Certainly, it can induce more intensive exploitation of resources, but it can facilitate more efficient use of resources and provide alternative solutions (Von Schomberg, 2002:2; Larsson et al., 2002:14). Environmentally sound and cleaner technologies are not just one technology, but rather a set of diverse technologies with diverse environmental impacts. As illustrated in the box below, they range from add-on technologies, to integrated technologies designed to optimise processes and replace hazardous materials, to the more radical and demanding systemic change that involves a change of values so that sustainability becomes the prevailing norm in all processes, products, and systems.

Box 2: Examples of environmentally sound and cleaner technologies

<p>Add-on technologies</p> <ul style="list-style-type: none"> • <u>End-of-pipe technologies</u> • <u>Cleansing technologies</u>, including technologies to clean up waste from the past. <p>Integrated technologies</p> <ul style="list-style-type: none"> • <u>Cleaner technologies</u> covering processes, products and services, for example, eco-efficiency, eco-design, and environmental management systems at company level (through the ISO 14001), at sector level (through waste minimization clubs in specific industries) or at local level (through waste minimization clubs in industrial zones). • <u>Improved energy efficiency</u>, for example, included in the eligible projects subject to the Cleaner Development Mechanism (CDM) of the Kyoto Protocol: end-use energy efficiency improvement, supply-side energy efficiency improvements, fuel switching, etc. (UNEP, 2002) • <u>Sustainable raw materials and natural materials</u>, including biopolymers and biologically degradable plastics, natural fibres and colours, natural detergents and Cleaning agents. • <u>Substitution of hazardous materials</u>, for example, through the 'Score System' which substitutes hazardous or polluting materials by more environmentally friendly ones, making the final score acceptable to clients as well as fulfilling environmental standards. As part of the Cleaner Production project for textile industry, a Score System has been introduced for some textile companies in Durban and is currently being evaluated. • <u>Optimisation of processes and materials</u>, including recycling and reuse. An example is the installation of a gypsum plant in relation to the chemical industry to reduce effluent loads and concentration to the sea (Tioxide, 2002:XX). <p>Systems change</p> <ul style="list-style-type: none"> • Radical changes in production and consumption patterns
--

The choice of technology depends on the problem at hand and the time available for investment in new technologies and innovation.

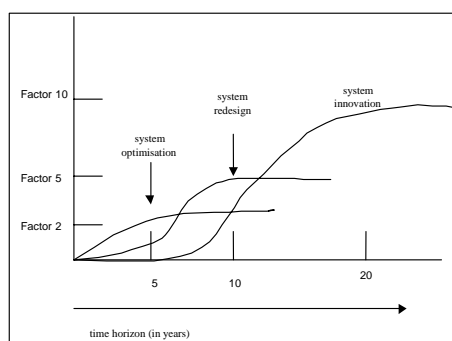
Leading experts estimate (as is illustrated in the figure below) that current resource productivity must be increased by a factor of ten in order to cope with the environmental problems in the longer run (Factor 10 club, 1994; Alliance for Global Eco-structuring, 2000). However, in the very short run, an increase by a factor of two may be attained merely through the optimisation of existing products, processes and infrastructure. Likewise, an increase by a factor of five may be achieved through more time-consuming redesign in which specific features of the system are changed — for example, by choosing to use materials that are suitable for re-use at the disposal stage.

These low-hanging fruits are all within the reach given current technologies and the potential of the private sector. The longer-term requirements, however, would require a dynamic contribution from government, industry and the research community.

As can be seen from this diagram, sustainable technologies capable of meeting the environmental challenged ahead require, on the one hand, continuous government effort to develop consistent and proper legislation and more efficient enforcement institutions, and, on the other hand, a commitment by the private sector together with

the remaining part of the innovation system to develop, diffuse and apply sustainable technologies.

Figure 1



This in turn requires a reflexive process of systemic innovation, based on the philosophy of learning-by-doing and doing-by-learning, that simultaneously addresses economic, social and environmental issues (Kemp et al. referred to in Von Schomberg:17). What is needed is a interdisciplinary, cross-sectoral approach, and a positive attitude to change at all levels and hence to new integrative and synthetic tools (Robinson 2001 draft).

Innovation theories and empirical studies of the innovation process provide useful insights into the dynamics of innovation systems. In particular, the concept of a national innovation system describes the entire network of institutions in the public and private sectors and highlights the way in which activities and interactions initiate, import, modify and diffuse new technologies (Edquist, 1997). Something similar can be said of the recent attention to regional systems of innovation, and of the role of spatial proximity in facilitating organisational learning through the mechanics of interaction (OECD, 2001). Yet these tools alone cannot adequately instruct the central players and decision-makers. They need meaningful, future-oriented information and shared visions with which they can anticipate the consequences of their choices and negotiate relevant strategies.

It is here that the highly participatory, integrative and future-oriented aspects of technology foresight come into play. Such foresight focuses on the role of technology as a means of reducing environmental impacts. It links the short-term benefits of optimisation with the longer-term requirement for redesign and systemic change.

4 Technology foresight as a spiral learning process⁶

A wide range of forward thinking tools and techniques are needed to face the challenges of sustainable development at the regional level. Continuous monitoring of new technologies, with early identification of promising areas of application, the assessment of the future impact of new technologies (social, economic, environmental, health-related, legal and ethical), and careful examination of the interrelationships of industry, technology and society — all of these add to the

⁶ This part draws mainly on Eerola & Joergensen, 2002.

‘strategic intelligence’ that is needed if choices of technology that shape the future are to be made.

In general, foresight exercises are intended to encourage better decisions, to facilitate forward thinking, and to increase preparedness for change. The strength of technology foresight lies in its ability to combine formal strategic analyses and communication processes. Thus, in a classic statement, foresight exercises are said to involve a systematic process in which an attempt is made “...to look into the longer-term future of science, technology, and economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefit” (Irvine and Martin, 1984).

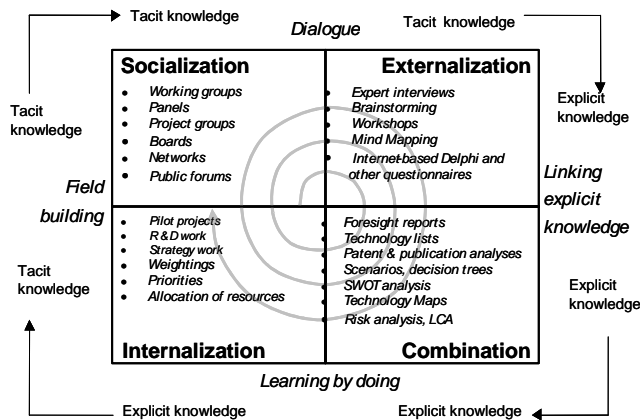
The analytic and communicative features of technology foresight exercises are stressed in a more recent definition offered by a European research network on regional foresight. Here foresight is defined as “a systematic, participatory, future intelligence-gathering and medium-term vision-building process aimed at present-day decisions and mobilising joint actions” (FOREN, 2001).

Technology foresight aiming at the promotion of cleaner production in highly polluted industrial areas may have various objectives:

- *Science and technology priority-setting and investment:* Technology foresight is used by the key players in the innovation system to direct and justify science and technology priorities. These priorities may be applied jointly or separately by private companies and public research institutes when they are deciding on investment in technologies and research.
- *The connectivity and the efficiency of the innovation system:* Technology foresight is used to ‘wire up’ the innovation system through communication, cooperation and networking among the developers, producers and users of technology, and also by highlighting the need for better framework conditions, regulation and infrastructure.
- *Shared awareness of future technologies, opportunities and strategies:* Technology foresight is used to foster shared awareness of future technologies, markets and strategies through debate about those technologies and their (beneficial and adverse) impact on society, and through better understanding of the drivers of change.

If key players from government, industry and research on the rocky road to the triple (economic, social and environmental) bottom lines of sustainability consider technology foresight as a useful tool in promoting cleaner production in South Durban Basin, a proper framework for examining and designing such processes can be derived from the following model of organisational knowledge creation (building on Nonaka et al, 1999).

Figure 2: The Technology foresight process – Useful tools and practices



Source: Eerola, 1996; Eerola et al. 2002

In this model, technology foresight is considered a locus of shared knowledge creation. It is envisaged as a spiral process in which tacit and explicit knowledge, as well as the different modes of knowledge conversion — i.e. socialisation, externalisation, combination and internalisation — play a central role.

The model also helps to explain the role of formal tools and practices in technology foresight exercises when those exercises are used to promote cleaner production in South Durban Basin. According to this model, any knowledge of future technological developments will be the result of a dynamic interaction process in which not only facts but also informed views and opinions are treated as important ingredients.

During the *socialisation* process the idea is to invite key local players from industry, environmental enforcement agencies, research institutes and community groups to participate in working groups, panels, project groups, networks and public forums. This should pool together otherwise separated tacit knowledge of these actors. South Durban Basin is already under a highly developed network governance structure designed to ensure successful implementation of the Multi-Point-Action-Plan. But additional technology focused and innovation focused networks and structures may be considered. These might include local companies and research institutes that are already engaged in cleaner production demonstrations and environmental management systems. Such companies and institutes may be good ambassadors to fellow companies and thus promote the basic idea of environmental work.

In the *externalisation* stage more formal methods are used to extract expert knowledge from key players. The tools used here depend on the time and resources available, but they may include brainstorming techniques, semi-structured expert interviews or group interviews, and/or structured questionnaires. South Durban Basin has already been subjected to a wide range of documentary work and analysis over the years. Avoiding any unnecessary duplication of that work, attention should concentrate on additional research.

The *combination* stage brings together explicit knowledge (derived from various expert judgements and analyses) of environmental policies, regulatory devices, standards, technologies and societal development. The latter judgements and

analyses can be found in national foresight reports and road maps, and in policy documents and strategies. They can be combined by the key players in the regional foresight exercise into scenarios, decision trees, SWOT analyses or risk analyses. In practice, the analytical work can be delegated to consultants and researchers who then produce the input for further discussion by the decision-makers.

Finally, in the *internalisation* process, the implications of the previous stages are given direction and sense through preparation of more specific strategies. Priorities are identified, and some of these may immediately be fleshed out in research and demonstration projects — for example, in the pilot projects on optimisation of processes and materials, cleaner technologies or the ‘good practice’ substitution of hazardous materials as it occurs elsewhere. This is a pivotal stage, as it starts walking the talk. This may have far-reaching implications for the building of trust and commitment among the key stakeholders and players, not just in the region but also in other parts of the country.

The design of the technology foresight exercise, and thus the final choice of technology foresight tools and techniques, depends on the resources available, on the time needed to conduct the exercise, and on who is to be the owner of the overall process. This requires a central decision to be made regarding who is to be the learning agent. Who, in other words, is to be the agent managing and facilitating the overall spiral knowledge creation process? In the literature,⁷ it is recommended that a learning agent should be a middle-up manager who has responsibility neither to top-down implement the decisions of government nor bottom-up represent the views of industry or civil society. This manager must be at the intersection of vertical and horizontal flows of information and knowledge.

The manager of the spiral learning process has various roles (Senge, 1990/95). First, he or she should be a *designer* of the process. This ensures that people at all stages of the exercise can deal with any critical issues they face and develop their own understanding and position in the network. Second, the manager should be a *teacher* — someone, that is, who encourages, in the participants, an interest in the future and who thereby builds strategic intelligence into people’s thoughts and actions. Thirdly, the manager is a *steward* who plays a specific role in making sense of overall goal of the foresight exercise. The bottom line here is that, through these three roles, the manager of the foresight process facilitates creative tension among the participants of the kind needed if strategic intelligence is to be built, decisions are to be taken, and joint actions are to be mobilised.

5 Conclusion

The use of technology foresight as a strategic tool for promoting cleaner production in the industrial and highly polluted area of South Durban basin need not involve starting from scratch. Instead it can build on the extensive existing experience with technology foresight at the national and scientific level, as well as practical activities within Cleaner Production. In a regional perspective, technology foresight focuses on local capabilities and the role of knowledge in promoting cleaner production and long term sustainability. Here spatial proximity plays a central role in facilitating the dynamic exchange of knowledge and learning in the regional innovation system.

⁷ See for example Nonaka et al, 1999.

South Durban Basin, with its mix of heavy industry and adjacent residential areas, has had considerable experience of efforts to deal with environmental problems: it has seen initiatives from governmental agencies, industry and local communities. Within the framework of Local Agenda 21, the local government of Durban has developed a strategic environmental assessment plan for the area, and it has done so in a consultative and participatory manner. Though its recommendations have never been approved, it contributes to the Multi-Point-Action Plan currently being implemented in the area. Other important contributions to this multi-level governance approach have come from the industry managed Responsible Care Programme, the stakeholder led SO₂ Steering Committee and the joint agreement (designed to assess the environmental problems of the area) between the local community organisation and one of the refineries. The Multi-Point-Action Plan includes both short-term measures to reduce industrial and air pollution and longer-term contributions through which, it is hoped, proper standards and enforcement mechanisms will be developed. Not only regulators, but also industry, are being called upon to contribute to both short-term, pragmatic solutions and longer-term and sustainable solutions. As technology is seen as the single most important factor in the pursuit of sustainable development, both industry and government are required to take and regulate investment decisions. It is in the interest of the industry to invest in Cleaner Production, as the benefit from such investments can be seen immediately on the bottom line. But embarkation upon on environmental work also forces industry to consider how it will cope with the environmental problem in the longer run. This requires, on the one hand, a determined effort, by the government, to develop both consistent and properly prepared legislation and more efficient enforcement institutions; and, on the other hand, a commitment, from industry and the innovation system, to investment in more radical technological solutions.

Technology foresight is a reflexive process that simultaneously addresses the triple (economic, social and environmental) bottom lines of sustainability. It creates a spiral learning process involving different modes of knowledge conversion — socialisation, externalisation, combination and internalisation — in which both tacit and explicit knowledge play a role. In this dynamic process, all key agents of change are brought together to identify plausible ways of coping with the pollution problem, to manage risk, to take decisions — sometimes tough ones — and to mobilise for action. In this way, a locally problem-driven technology foresight combines the short-term results of technical demonstration projects, environmental enforcement mechanisms and incentives with longer-term policies. It also helps to ‘wire up’ the innovation system, and it highlights any deficiencies in environmental framework conditions, access to knowledge, and access to capital and infrastructure. The foresight learning process also helps to create and maintain shared awareness of future technologies, markets and strategies.

The final design of a regional foresight exercise depends on the resources available, the time needed if the to exercise is to be undertaken, and the owner. A central decision concerns just who is to be appointed the learning agent and given responsibility for the management and facilitation of the overall foresight process. Theoretically, a learning agent should be a network manager who is both trusted by the key players and positioned in the intersection of the information and knowledge flows running between governmental agencies, industry, research institutes and community people. The network manager, on the other hand, should be a designer of the process, a teacher who brings together people in creative tension promoting strategic intelligence, and a steward capable of synthesising the overall goal of the project.

In South Durban Basin, the multi-level governance structure and the central role of the project manager are good starting points for a detailed discussion of the way in which the technology foresight should be designed in order to introduce and implement cleaner production activities (including risk management) in the industrial zone of South Durban Basin. In Siva Chetty's own words: "Opening up the analytical and contextual frame will create more obstacles but precisely those that will shape the future technology design at an elementary and systemic level" (Siva Chetty, Programme Manager, South-Durban Basin, MMP, April 2003).

References

- Danish Council for Cleaner Products. 2002. *New Paths to Competitive Advantage*. Miljøbutikken: Copenhagen.
- Danmarks Naturfredningsforening & South Durban Community Environmental Alliance. 2003. *A 2002 Snapshot. Comparison of Refineries in Denmark and South Durban in an Environmental & Societal Context*. Fishwicks.
- Department of Trade and Industry. 200x. *Accelerating Growth and Development: The Contribution of an Integrated Manufacturing Strategy*. Pretoria.
- Edquist, Charles (ed.). 1997. *Systems of Innovation. Technologies, Institutions and Organizations*. Pinter: London.
- Eerola, A. 1996. Creating and communicating technology foresight. In *Innovation Systems and Competition*", O. Kuusi (ed.), ETLA Series B 125 & VATT Series A 22. Taloustieto: Helsinki.
- Eerola, Annele and Joergensen, Birte Holst. 2002. *Technology Foresight in the Nordic Countries*. Risoe National Laboratory: Roskilde. Risø-R-1362(EN).
- Eerola, A. and Väyrynen, E. 2002. *Developing Technology Forecasting and Technology Assessment Practices on the basis of European experience*. VTT Research Notes (in Finnish).
- FOREN. 2001. *A Practical Guide to Regional Foresight*. FOREN network, European Commission Research Directorate General, STRATA programme.
- GroundWork. 2002. *Corporate Accountability in South Africa: the petrochemical industry and air pollution*. The groundWork Report.
- Irvine, J. and Martin, B.R. 1984. *Foresight in Science: Picking the Winners*. Pinter Publishers: London.
- Larsson, Allan et al. 2002. *Technology and Policy for Sustainable Development*. Paper prepared for the European Commission by a team from the Centre for Environment and Sustainability, Göteborg, Sweden, 5 February 2002.
- Monitor Group and the Durban Unicity. 2000. *Durban at the Crossroads*. Prepared for the Durban Unicom December.
- Nonaka, I., Toyama, R. and Byosiere, P. 1999. A Theory of Organizational Knowledge Creation: Understanding the Dynamics Process of Creating Knowledge. In *Handbook on Organizational Learning*.
- OECD. 2001. *Cities and Regions in the New Learning Economy*. OECD publications: Paris.
- Roberts, D. & Diederichs, N. 2002. *Durban's Local Agenda 21 Programme 1994-2001. Tackling Sustainable Development*. Natal Printers Ltd.

Robinson, John. 2001. *Squaring the Circle? On the Very Idea of Sustainable Development*. Sustainable Development Research Institute, Canada, Oct. 23.

Senge, P.M.. 1990/95. *The Fifth Discipline. The Art and Practice of The Learning Organization*. US: Currency Doubleday.

UNEP Collaborating Centre on Energy and Environment. 2002. Risø National Laboratory: Roskilde.

World Commission on Environment and Development. 1997. *Our Common Future*. Oxford University Press: Oxford.

Vollenbroek, F.A.; Weterings, R.A.P.M.; Butter, M. 1999. *Technology options for sustainable development*. In *Technology foresight and sustainable development: Proceedings of the Budapest workshop 11 Dec 1998, DSTI/STP/TIP*.

Mission

To promote an innovative and environmentally sustainable technological development within the areas of energy, industrial technology and bioproduction through research, innovation and advisory services.

Vision

Risø's research **shall extend the boundaries** for the understanding of nature's processes and interactions right down to the molecular nanoscale.

The results obtained shall **set new trends** for the development of sustainable technologies within the fields of energy, industrial technology and biotechnology.

The efforts made **shall benefit** Danish society and lead to the development of new multi-billion industries.