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Determination of the framework conditions and research–development needs for the dissemination of cleaner (sustainable) production applications in Turkey

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The term cleaner production has been used in policy and strategy documents of top agencies/institutions on science, technology and development in Turkey for over 10 years. However, cleaner production is not sufficiently understood and applied, except in terms of energy efficiency. To overcome this deficiency, the Ministry of Environment and Forestry supported a project ‘Determination of the Framework Conditions and Research–Development Needs for the Dissemination of Cleaner (Sustainable) Production Applications in Turkey’, which was carried out in 2009 by the Technology Development Foundation of Turkey (TTGV) with Goksel Demirer as consultant. The objective was to determine national capacity, assess Turkish regulations in terms of cleaner (sustainable) production (C(S)P) and compare it with related European Union (EU) regulations, report existing incentive mechanisms, perform a sectoral analysis to determine high-priority sectors for C(S)P implementation, determine the research and development and other needs and provide recommendations. The project used a participatory approach. Sixty-six and thirty-seven stakeholder institutions contributed to the determination of existing institutional capacity and sectoral priorities regarding C(S)P, respectively, through questionnaires. Moreover, 125 participants from 62 stakeholder institutions participated in the project workshop in which the draft report of the project was finalised with feedback from the participants. This paper communicates the main outcomes of the project.

Keywords: cleaner technology; sustainable production; research and development

Introduction

Cleaner production was defined by the United Nations Environment Programme (UNEP) as ‘decreasing risks on humans and environment by continuous application of an integrated and preventive environment strategy on products and processes’. It aims to prevent/minimise pollution, contrary to common pollution control approaches. Pollution control approaches accept the production and design phases as unchanged factors; therefore pollution is seen as an inevitable result of these phases, and solutions are sought after pollution occurs. Consequently, these approaches lead to additional costs for the institutions by focusing on waste treatment facilities. On the other hand, cleaner production approaches accept pollution as a result of deficiencies and inefficiencies during design, raw material use and production processes and aim to find solutions through necessary developments during these processes (UNEP 1996). Cleaner production has a close relation with sustainability, besides development of new products, processes, systems and services (Glavic and Lukman 2007).

UNEP–Division of Technology, Industry and Economics (UNEP-DTIE) took the first significant step by launching a cleaner production programme in 1989. The main aim was to raise awareness regarding this subject, form a structure and generalise sustainable development by stressing its benefits. The cleaner production concept adopted by many countries, agencies and institutions has obtained global qualification since then (UNEP 2002). It then evolved into ‘sustainable production’ (Narayanaswamy and Stone 2007). Sustainable production is defined as ‘the creation of goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically viable, safe and healthy for employees, communities and consumers, and socially and creatively rewarding for all working people’ (Veleva and Ellenbecker 2001). The cleaner production concept is still used by many institutions while the sustainable production concept has been rapidly adopted (Veleva and Ellenbecker 2001; Glavic and Lukman 2007). Therefore, the term cleaner (sustainable) production (C(S)P) is adopted in this study.

The C(S)P concept was first considered in Turkey by the Scientific and Technological Research Council of Turkey (TUBITAK) and the Technology Development Foundation of Turkey (TTGV) in 1999 (Science–Technology–Industry Discussion Platform 1999). The cleaner production concept is a priority area of the Supreme Council for Science and Technology (BTYK), which determines the national science and technology policies. This concept has also been emphasised in the Environment and Sustainable Development Panel in the scope of the TUBITAK’s Vision 2033 Project (http://www.tubitak.gov.tr/home.do?ot=1&sid=472&pid=468 [cited 2011 Feb 21]). Moreover, it was among the main themes in the 8th Five-Year (http://ekutup.dpt.gov.tr/plan/viii/plan8.pdf [cited 2011 Feb 21]) and 9th Seven-Year Development Plans (http://ekutup.
C(S)P has been cited in many other policy and strategy documents of top-level agencies/institutions on science, technology and development in Turkey for over a decade; however, it is not sufficiently known and applied except in energy efficiency aspects because there is a lack of capacity on the subject.

In order to overcome this deficiency, two national projects are being executed in Turkey since 2008. The first is the United Nations Industrial Development Organisation (UNIDO) Eco-Efficiency (Cleaner Production) Programme of TTGV (since 2008) as a sub-programme in the scope of ‘Enhancing the Capacity of Turkey to Adapt to Climate Change’ United Nations Joint Programme (http://www.undp.org.tr/Gozlem2.aspx?WebSayfaNo=1392 [cited 2011 Feb 21]). The second is the ‘Determination of the Framework Conditions and Research–Development Needs for the Dissemination of C(S)P Applications in Turkey’ (http://www.cygm.gov.tr/CYGM/AnaSayfa/tumProjeler/10-04-27/Temiz_S%C3%B3k%C3%B6r%C3%B6r%C3%B6r%C3%B6r%C3%B6r%E3%81%97retim.aspx?sfang=tr [cited 2011 Feb 21]), supported by the Ministry of Environment and Forestry and carried out by TTGV, with Goksel Demirer as consultant. One of the specific objectives of this project is to evaluate the research and development needs for adoption of C(S)P in Turkey.

This paper communicates research and development needs for wider C(S)P implementation in Turkey during the EU accession period. With its Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan, the EU strives to develop C(S)P policies that will help provide sustainability worldwide to develop low carbon and sustainable technology, product and services; and change consumer behaviours through providing development of such concepts as resource efficiency, product performance and eco-innovation (European Commission 2009). Therefore, the findings of this study might prove important not only for countries in the EU adaptation process but also for new member states.

**Methods**

As a major output of the ‘Determination of the Framework Conditions and Research–Development Needs for the Dissemination of C(S)P Applications in Turkey’ project (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]), a draft report was prepared. The participation of public bodies, universities, research agencies, non-governmental organisations, chambers of commerce and industrial zones, sectoral institutions, press, media and financial institutions as stakeholders was sought during report preparation. The following stakeholders were included in the process (Figure 1):

- 37 stakeholders (A) for criteria evaluation in the determination of priority sectors for C(S)P;
- 128 stakeholders (A + B) for the determination of existing institutional capacity for C(S)P; and
- 151 stakeholders (A + B + C) for opinions and contribution for the draft report.

Questionnaires were sent to 128 institutions to determine institutional capacity. The questions included existing and planned activities, publications, research and development and training needs related to cleaner production, eco-efficiency, sustainable production and consumption, energy efficiency and life-cycle evaluation tasks. A total of 66 institutions provided feedback. All information from the institutions was considered. Received information was analysed and the areas not directly or indirectly related to cleaner production, eco-efficiency, sustainable production and consumption, energy efficiency and life-cycle evaluation concepts and tasks were excluded in the evaluation.

The draft project report was discussed in a 1-day workshop on 29 December 2009. All stakeholders were invited to the workshop. Invitee list included 128 institutions to which the questionnaire was sent and an additional 23 institutions. The total number of agencies and institutions invited to the workshop was 151, the number of agencies and institutions represented was 62 and the number of participants was 125. In order to provide effective access...
to the draft report, it was made accessible via the Internet 1 week before the workshop date. This was emphasised in the invitation letters. Feedback from participants was recorded, and participants were asked to provide further feedback until 20 January 2010.

Results and discussion
Evaluation of the existing capacity

Ozbay (2005) evaluated a study on determination of necessary policies, strategies and suggestions conducted by Organisation for Economic Co-operation and Development (OECD) (2000) for the dissemination of C(S)P in developing countries. She indicated that it could be useful to take experiences of other countries into consideration in establishing a cleaner production centre in Turkey, regarding the determination of duties and activities (Ozbay 2005). The OECD report underlined one of the most important constituents affecting the widespread application of C(S)P is the existing capacity in developing countries. Capacity building can be achieved through training related staff in government, companies, managers and employees of financial institutions and so on, as well as establishing databases to disseminate best available techniques and success stories (OECD 2000).

When the outcomes of the project are considered, even though there have been limited capacity-building activity studies in the last decade, there is no nationwide activity covering different sectors, enterprise scales and stakeholders (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]). The evident advantages of C(S)P (waste reduction, increased efficiency, legal compliance, etc.) were not sufficient to be readily adopted by industry. Capacity-building activities, along with other measures, will help all stakeholders, including industry, to realise the related benefits and thus accelerate the adoption process. The Eco-Efficiency (cleaner production) Programme (http://www.ecoefficiency-tr.org/ [cited 2011 Feb 21]; appendix 2, table 1) carried out by TTGV since 2008, in the context of the UN Joint Programme, Enhancing the Capacity of Turkey to Adapt to Climate Change (http://www.undp.org.tr/Gozlem2.aspx?WebSayaFaNo=1392 [cited 2011 Feb 21]), is an important step towards capacity building in Turkey. The Eco-Efficiency Centre that will be established as one output of this programme may provide many services directly or through universities, accredited consulting firms and so on to enhance C(S)P capacity in Turkey.

When responses to the questionnaires are considered, the difference between end-of-pipe approaches and C(S)P is not clearly understood by many stakeholders. This is a solid indication that priority should be given to capacity-building activities in Turkey. There are notable human resources in almost all the institutions that responded to the questionnaire; however, most of these experts possess education and expertise in the environmental sector, but do not have formal training and/or experience in C(S)P. Middle East Technical University, Bogazici University and Istanbul Technical University are the leading universities and have several activities on the subject. However, the existing capacity based on quantitative performance criteria (publications in citation index journals, research and development, implementation and consulting projects, technology development and patent applications, etc.) is far from sufficient for the needs of the country. A limited number of projects have been implemented in public institutions but most of them were not carried out directly to enhance C(SP) capacity in the country. They were implemented to comply with commitments regarding international agreements, adoption by the EU and so on, and mainly by international consultants. Thus, they did not create significant capacity. However, even though it is not systematic and nationwide, the limited capacity created through these projects in some public institutions (Ministry of Environment and Forestry, Ministry of Industry and Trade (MOIT), Ministry of Public Works and Settlement, National Productivity Centre, TUBITAK, Small and Medium Enterprises (SMEs) Development Organisation, Izmir Development Agency, etc.) should be used in future activities in Turkey. The competencies of the institutions (environment, industry, infrastructure, efficiency, R&D, SMEs, etc.) and their networks should be used for effective coordination and planning. Similarly, training and dissemination activities conducted in Turkey on C(S)P (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]) have had limited impact due to a lack of coordination and planning. Even though raising awareness in the industrial sector is of utmost importance, it is believed that organised industrial zones and the chamber of commerce in Turkey have a limited understanding of the subject. Most of their related activities aim at EU adoption, health and safety issues and environmental management systems, and lack an integrated vision. There are many NGOs working on environmental issues in Turkey, however they do not possess significant capacity on C(S)P. On the other hand, various national/international projects on C(S)P as well as financial support programmes, for example, TTGV, should be considered. Moreover, some sectoral organisations (e.g. cement, food) are prominent in carrying out transnational cooperation in these fields (Ulutas et al. 2010).

Evaluation of existing legislation

When existing legislation in Turkey is evaluated, it is observed that concepts related with C(S)P are frequently cited. Moreover, it is indicated that the development of cleaner technologies and approaches is needed. However, Turkey does have legislation that directly addresses C(S)P, as in other countries, such as the EU SCP SIP Action Plan (http://ec.europa.eu/environment/eussd/escp_en.htm [cited 2011 Feb 21]) or Cleaner Production Promotion Law of China (http://www.npc.gov.cn/englishnpc/Special/CombatingClimateChange/2009-08/25/content_1515203.htm [cited 2011 Feb 21]). While the national
 programme of Turkey for adoption of the EU (http://www.abgs.gov.tr/index.php?p=42260&l=i=2 [cited 2011 Feb 21]) is considered, it is foreseen that adoption regarding waste management and other legislation will mostly be completed in the future. The critical issue is to support the legislation with the necessary infrastructure and capacity needed for implementation.

It is of imperative importance to adopt the sustainable consumption and production (SCP) Action Plan of the EU as an example by taking into consideration the integrated parts of this action plan, such as eco-labelling and eco-design, along with life-cycle assessment, the regulations for which are not yet in force in Turkey. The concept of C(S)P must be considered in the context of legislation. The development of framework legislation similar to the Energy Efficiency Law in Turkey or legislation in other countries on C(S)P is very important. This should have links to all the related legislation. Meanwhile, it is very important to inform industry about the best available techniques (BATs) and provide best reference documents (BREFs) defined in the EU’s Integrated Pollution Prevention and Control (IPPC) directive, which is being adapted to the Turkish legislation. This should be done with active involvement of all stakeholders through the use of BREFs as well as other related sectoral guides, handbooks and so on.

**Evaluation of existing incentive mechanisms**

Based on research from many countries, incentives are among the most important parameters influencing promotion of C(S)P (OECD 2000). Incentive mechanisms available in Turkey for C(S)P are quite limited and not comparable to those in the EU, in terms of variety and amount. Some projects supported in Turkey, although limited, constitute examples for financial resources that can be used for C(S)P activities. In addition, general incentives have not been used for C(S)P so far and will be applicable in time as the interest in C(S)P increases in Turkey; especially bank loans for industries that stress renewable energy and energy efficiency concepts. Even though there are some developments providing SMEs with loans for small investments, SMEs might have difficulty in accessing loans for C(S)P investment. This is mainly due to assurance requirements, high interest rates and so on. With mechanisms like a credit guarantee fund, it is hoped that these difficulties will be overcome and bank loans will efficiently be used for C(S)P activities.

Similar to energy efficiency, providing industry with financial support to conduct C(S)P audits to determine feasibility options is very important. Possibilities of agreements and cooperation between TUBITAK, TTGV, the Small and Medium Enterprises Development Organisation (KOSGEB) and the General Directorate Electric Power Resources Survey and Development Administration (EIE), which already provide support in the area of energy efficiency, should be explored in terms of setting up specific funding programmes for C(S)P projects. The EU funds available to Turkey (EU accession funds, Instrument for Structural Policies Pre-accession (ISPA), Special Accession Program for Agriculture and Rural Development (SAPARD), and Poland and Hungary: Action for the Reconstruction of the Economy (PHARE), as well as Competitiveness and Innovation Framework Programme/Entrepreneurship and Innovation Programme (CIP/EIP) and Framework Programme (FP 7) are very important for future C(S)P activities in Turkey. Providing national or regional risk/venture capital for C(S)P activities including energy efficiency and renewable energy using funds managed by regional and international funding institutions should be investigated.

There are several incentive mechanisms that can be used for C(S)P activities in Turkey. It is imperative that legal and financial tools are used in harmony with technical aid, dissemination and so on. Progress in C(S)P activities can be accelerated by creating a fund based on a new legislation, a national programme and priorities of the country.

**Evaluation of sectoral priorities**

One of the most important factors leading to success of a national C(S)P strategy is a sector-focused approach (Ashton et al. 2002). Due to limited resources, it is necessary to prioritise between sectors for C(S)P practices. Simple C(S)P tools such as good housekeeping are developed only for the implementation in SMEs regardless of sector, and these practices can provide improvements only in very general issues (prevention of water or raw material losses). Significant gains in large enterprises are only possible using more comprehensive and sector-specific C(S)P tools. Due to the requirement for more resources and higher expertise, use of this kind of tool without sectoral prioritisation could lead to significant loss of time and resources. In this context, sectoral prioritisation has an important role in C(S)P practices.

The sub-sectors of the manufacturing industry in Turkey have been subjected to prioritisation for C(S)P practices in this study. The parameters used are water and energy consumption, amount of wastewater discharged, solid waste and hazardous waste generated, air emissions, sectoral employment, export share and eligibility for C(S)P. This prioritisation was accomplished with the multi-criteria decision-making (MCDM) method using recent available data and taking feedback from relevant institutions and organisations (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]). According to the results, the top five high-priority industrial sectors are the basic metals industry, food products and beverages, chemicals and chemical products, other non-metallic mineral products and textile products. These sectors coincide with the priorities of other national and international institutions. For example, textile products, food products and chemical and chemical products industries are among the sectors prioritised in the framework of the UNIDO Eco-Efficiency Programme based on water use.

Although priority sectors were identified based on the C(S)P approach, our results significantly overlap with the priority lists of other institutions with different objectives.
and criteria (MOIT 2008). Following the top five high-priority sectors, secondary priority sectors (between the 5th and 10th on the list) include coke and refined petroleum products and nuclear fuel production, motor vehicles, trailers and semi-trailer manufacturing, machinery and equipment manufacturing not elsewhere classified, clothing manufacturing, metal goods, manufacture of electrical machinery and apparatus industries. It is stated in the Industrialisation for Continuous and Balanced Development Section of the National Agenda 21 Report prepared by the Ministry of Environment and Forestry that SIP will especially affect industries having high intensity of water, raw material and energy consumption, such as paper, packaging, chemical and petrochemical industries and/or industries having high pollution loads. Ranking of these sectors varies according to the method used and changes in the order. As mentioned earlier, within the scope of this evaluation, nine data sets were used for nine criteria (see section 6.2 of the project report; http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]). To perform a more precise and more detailed prioritisation for these sectors, an analysis with more data sets is required. However, this study based on the most recent and available data and the feedback of relevant stakeholders forms a basis for

- prioritisation of industrial sectors of Turkey for C(S)P activities;
- providing important input to the relevant policies that will be developed in future; and
- similar studies using more comprehensive data sets and feedback of stakeholder institutions/organisations (Bogurcu et al. 2010).

Research and development and other needs
The research and development needs were determined based on

- existing capacity, legislation, incentive mechanisms and sectoral priorities evaluated in the context of the project;
- scientific literature, case studies and other references used during preparation of the project report;
- needs of the Ministry of Environment and Forestry on the subject provided to the project team; and
- feedback provided by stakeholders, given during and after the workshop.

Research and development needs

- Repeating capacity and related need assessment performed in this project (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]) on a regional, sectoral, scale and so on, for the entire country with a wider stakeholder list
- Repeating sectoral priority assessment performed in this project (http://www.ttgv.org.tr/content/docs/cleaner-production-final-report.pdf [cited 2011 Feb 21]) on a regional, sub-sectoral scale for the entire country with a wider stakeholder list and more detailed data sets
- Conducting case studies to reveal financial revenue for C(S)P (OECD 2000)
- Conducting in-depth research on innovative C(S)P applications and products in high-priority sectors (Zapata and Nieuwenhuis 2010)
- Exploring the applicability of specific C(S)P tools (Almeida et al. 2010)
- Formation of databases for application of specific C(S)P tools (Ribeiro and Silva 2010)
- Research on possible exploitation of emerging fields such as nanotechnology, biotechnology, information technology and so on in C(S)P activities (Hall and Crowther 1998; Zweck et al. 2008)
- Research on possible exploitation of existing waste management facilities towards C(S)P (Dilek et al. 2003)
- Establishing the necessary infrastructure for environmental performance assessment studies in different sectors (Lundberg et al. 2009)
- Development of a systematic approach to evaluate the environmental dimension of new technologies before they are adopted and integrating it into legal procedures (Kunnari et al. 2009)
- Conducting research on relating C(S)P to popular environmental problems and international agreements (Mestl et al. 2005)
- Evaluation of cleaner technology transfer on a sectoral basis (Cagno and Trucco 2008)
- Investigating effects of adopting C(S)P techniques on industrial processes, product quality and cost in all sectors (Fratila 2009)
- Research on impacts of adopting EU directives related to C(S)P on industry (Silvo et al. 2009)
- Research on increasing environmental performance in different sectors (Bouwer-Utte 2009)
- Determination of best available techniques for C(S)P applications on a sectoral basis (Dijkmans 2000)
- Adoption of life cycle assessment as a tool for decision making in industry (Huntzinger and Eatmon 2009)
- Assessment of C(S)P potential of companies in advance to avoid wasting resources (Doniec et al. 2002; Ozbay and Demirer 2007; Avsar and Demirer 2008)
- Investigating the substitution potential of hazardous chemicals with non-hazardous equivalents in industry (Oztürk et al. 2009)
- Conducting research on bio-energy and bio-products formation from wastes (Catarino et al. 2007; Dogan et al. 2008)
- Conducting research and development activities on potential application of industrial symbiosis concepts in Turkey
• Investigation and development of alternative financial models used in C(S)P suitable to the conditions of Turkey

Effective implementation
• To enable establishment of an eco-efficiency centre as one output of the Eco-Efficiency Programme funded by UNIDO and carried out by TTGV and to implement capacity-building activities on a nationwide basis
• To establish an advisory board consisting of representatives of stakeholders so that this centre will incorporate all existing capacity in the country when forming national action plans and strategies
• Conducting ‘train the trainer’ programmes on C(S)P (Huisingh and Mebratu 2000)
• Using demonstration projects in dissemination and as training tools
• Developing/adapting C(S)P guidelines and manuals tailored to local needs
• Through a webpage prepared and managed by the eco-efficiency centre:
  o introduce tools and methods of C(S)P and related concepts,
  o disseminate results of related projects,
  o provide training tools, guides, manuals and so on for widespread use,
  o provide links to national/international web resources, databases and so on.
• Developing tools for public awareness raising
• Organise training events, workshops and so on to disseminate results of the implementation projects ‘success stories’ to all stakeholders
• Determine the roles of sectoral institutions and unions in policy making (Chappin et al. 2008)
• Form a better cooperation between decision-makers and universities (Mickwitz and Melanen 2009)
• Form web-based databases for the best available techniques
• Implement demonstration and eco-innovation projects with different tools and strategies of C(S)P in companies of high-priority sectors to form examples of efficient resource use and pollution prevention (Dakwala et al. 2009)

Conclusions
C(S)P has been on the agenda of many countries for over three decades. When the country cases are examined, it is seen that C(S)P is carried out by raising awareness, forming capacity and cooperation and making necessary policy reforms. National cleaner production centres have critical importance for carrying out this process. The number of national cleaner production centres (NCPC) reached 42 in 2004 as a result of the UNIDO resource-efficient and cleaner production programme (http://www.unido.org/index.php?id=04460 [cited 2011 Feb 21]). Moreover, there are other cleaner production centres established using national initiatives and sources, particularly in developed countries.

The project ‘Determination of the Framework Conditions and Research–Development Needs for the Dissemination of C(S)P Applications in Turkey’ was conducted by TTGV in 2009. One of the main objectives was to determine the research and development needs regarding a wider application of C(S)P. This objective is in full agreement with the UNIDO Eco-Efficiency (cleaner production) Programme (http://www.ecoefficiency-tr.org/ [cited 2011 Feb 21]) executed by TTGV since 2008 in Turkey. It is a sub-programme in the scope of ‘Enhancing the Capacity of Turkey to Adapt to Climate Change’ UN Joint Programme, which is the only national programme being implemented on C(S)P in Turkey. The existing capacity, legislation, incentive mechanisms and research and development needs determined in the context of the above project will provide a basis for the Ministry of Environment and Forestry and other related stakeholders for further actions. The proposals generated in the context of this project should be transformed into a roadmap through a multi-objective cost/benefit and prioritisation analysis. It is imperative that this process be realised with the contribution of all stakeholders, starting with decision-making, funding, expertise-owning of institutions. It is well known that cleaner production centres provide significant input to many activities, as well as directly leading new ones. In this context, establishment and sustainability of an eco-efficiency (cleaner production) centre as an output of the UNIDO Eco-Efficiency Programme carried out by TTGV is very important. All stakeholders in Turkey, starting with the beneficiaries of this programme, namely, the Ministry of Environment and Forestry and MOIT, should support this centre and contribute to its activities.

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