DISCUSSION PAPER OF THE S&T COMMUNITY ON CSD-18 ISSUES

1. INTRODUCTION

As co-organizing partners of the Scientific and Technical (S&T) Community Major Group, the World Federation of Engineering Organizations (WFEO) and the International Council for Science (ICSU) are presenting this paper on Sustainable Consumption and Production, Transport, Chemicals, Waste Management and Mining for consideration at CSD-18. While the paper discusses particular sustainability issues as they relate to these topics separately, none of these areas functions within isolated silos. For example, mining clearly relies on transport and waste management. By the same token, mining impacts transport and waste management. Sustainable consumption and production is discussed as a cross-cutting and overarching issue of sustainable development.

Agenda 21 and the *Johannesburg Plan of Implementation* call for numerous science and technology based actions relating to the themes under review. This paper presents information on some progress that has been made, and discusses the obstacles that still exist in implementing such actions. The paper also outlines major new challenges and opportunities in harnessing science and technology for a more sustainable path to development in the five areas.

In preparing this paper, ICSU and WFEO consulted their members worldwide, which include expertise across the relevant scientific, engineering and technological disciplines (e.g. respective international scientific unions) The International Social Science Council (ISSC) also provided very valuable input. In fact, the two co-organizing partners of the S&T Community major group have each a large network of national and international scientific and professional partners. Cooperation and information exchange with these partners contributed significantly to the development of the ideas presented in this paper. Examples of these partners include the Academy of Sciences for the Developing World (TWAS), the Stockholm Environment Institute and the global environmental change research programmes, co-sponsored by several UN system organizations and ICSU.

Science and Technology are major driving forces that impact change and development generally, including in the CSD-18 topical areas. Through the application of science, engineering and technology, the S&T Community has a direct and vital impact on the quality of life for all people. Generally, science and technology, are striving to serve the public interest by promoting the health, safety and welfare of all in a sustainable manner. The pressing challenge is now to expand science, engineering and technology, innovation and application, towards the goals of sustainable development.

In July 2009, in Lausanne, Switzerland, several prominent Engineering Societies, representing over 350,000 members worldwide, hosted a workshop dealing with "Engineering Solutions for Sustainability: Materials and Resources", focusing on the engineering answers for cost-effective sustainable pathways, the strategies for effective use of engineering solutions, and the role of the global engineering community.

The operational definition of "sustainability" developed on this occasion is multi-dimensional and encompasses the following issues and objectives:

1. economic, the engineered system needs to be affordable;
2. environmental, the external environment should not be degraded by the system;
3. functional, the system has to meet users' needs over its life-cycle, including users' needs for functionality, health and safety;
4. physical, the system should endure the forces associated with its use and accidental, willful and natural hazards over its intended service life;
5. political, the creation and existence of the system needs to be consistent with public policies; and
6. social, the system has to be and continues to be acceptable to those affected by its existence.

Engineering organizations, at both the international and national levels, have examined the roles and responsibilities which the engineering profession has and will have in achieving sustainable development. For example, the recently published (September 2009) *Future Climate Engineering Solutions – Joint Report* focuses on climate-change and contains many observations on engineering and sustainability, made with the input of 13 engineering associations from 12 countries.

Climate, life-style, macroeconomic, political, and social changes will alter demands and resources for infrastructure systems. Therefore, engineered systems must meet today's needs and be adaptable to changes in future needs. The concept of resilience has been developed for engineering to resist natural, accidental and willful hazards; it means the system must possess the power of recovery. Similarly, a resilience definition of sustainability is now being developed. It recognizes the need to enable current and future generations of society to be resistant to anticipated and unanticipated changes in economic, environmental, political and social systems. This means that engineered systems and practices should be adaptable to unforeseen demands and technical capabilities. For a multi-dimensional, resilience-oriented understanding of sustainability to be operational, we need life-cycle assessment methods -covering all dimensions of sustainability- that provide for transparent weighing of incommensurate effects.

The concept of resilience is also central to a systems science approach of understanding sustainability and a holistic approach to sustainable development. The goal of sustainable development is to create and maintain prosperous social, economic and ecological systems. These systems are intimately linked. Humanity depends on services of ecosystems (such as clean water and air, food production, fuel, and others) for its wealth and security. Moreover, humans can transform ecosystems into more or less desirable conditions. Negative shifts in ecosystem conditions, with consequences for human livelihoods, vulnerability, and security, represent loss of resilience of both ecosystems and socio-economic systems.

Research undertaken during the last decade has revealed the tight connection between resilience, diversity and sustainability of interconnected social-ecological systems. Resilience, for social-ecological systems, is related to (a) the magnitude of shock that the system can absorb and remain within a given state, (b) the degree to which the system is capable of self-organization, and (c) the degree to which the system can build capacity for learning and adaptation. "Management" of the system can destroy or build resilience, depending on how the social-ecological system organizes itself in response to management actions.

Global imbalances in societal and economic development mean there is uneven access to the material and human resources required to develop and implement sustainable solutions. Achieving a balance among economic prosperity, environmental health, and social equity will require significant changes in business strategies, operating technologies, personal behaviors, and public policies. The engineering and the scientific community can engage with communities of interest in the process of improving quality of life by helping to balance the need for resources, including minerals, metals, and fuels against the need to protect the environment and society from unnecessary adverse impacts. Communication and understanding between the policy domain and the engineering and scientific communities must be improved.

One major challenge lies in the lack of research and development funds, as the development of science and engineering will be essential for adaptation to a changing world. Sustainability requires building solid awareness both by political leaders and the general public of the need to support forward-looking policies that encourage well-coordinated investment to develop and apply scientific and technological innovations. At times, engineers' responses to the challenges of sustainability might be to propose cutting-edge technology. In other cases, the solutions may have existed for a long time but implementation may require the will, the means and the diffusion of knowledge to make it happen. In other words, answers may lie in combining new and old tools.

2. SUSTAINABLE CONSUMPTION & PRODUCTION

There are huge differences between the per-capita consumption levels of wealthy and poor societies around the world. In many countries, in particular in the developing regions, there are similar great differences of consumption between different social groups within nations. In developed countries, consumption of energy, household goods, and other materials has reached very high aggregate levels which are placing tremendous stresses upon the environment and natural resource bases, and ultimately affect negatively our life support systems. In contrast, in many developing countries, large segments of the population struggle with poverty, often including under-consumption of food and other basic needs, posing serious health concerns and limiting prospects for productive livelihoods. Neither of these two extreme consumption patterns can be regarded as sustainable.

During the last 20 years, scientists have accumulated clear evidence that human actions have become the main driver of global environmental change and that the current aggregate trends and patterns of consumption and production are unsustainable. The list of the global environmental change problems is becoming longer and the consequences of these changes are becoming more and more severe:

- There is scientific consensus, documented in the assessment reports of IPCC, that the increase in greenhouse gases in the atmosphere due to human activities (largely because of the still growing reliance on fossil fuels) is altering the Earth's climate, bringing about a general global warming. Non-discriminatory and inefficient energy consumption is an important part of this problem.

- Similarly, the Millennium Ecosystem Assessment (MA), the first state-of-the-art scientific appraisal of the conditions and trends in the world's ecosystems and the services they provide- such as food, forest products, clean water, and natural resources-, found that 60% of the ecosystem services are being degraded or used unsustainably. The major changes that have been made to ecosystems, mainly over the last 50 years, have contributed to net gains in human well being and economic development. However, these gains have been achieved at ever increasing costs: the degradation of many ecosystem services. These problems, unless addressed rapidly, will substantially diminish the benefits that future generations obtain from ecosystems.
- There is also scientific consensus that due to human impacts other subsystems of the Earth system are about to leave their "safe operating space". They are: human interference with the nitrogen cycle; humans increasing the rate of biodiversity loss; people now using almost 50% of all available freshwater running off land (water withdrawals have doubled over the past 40 years) which has led scientists to agree that humanity is faced with a looming global water crisis.
- Chemical pollution at global scale has become another area of great concern expressed by scientists. No comprehensive quantification and scientific assessment of the planetary impact of chemical pollution has so far been undertaken. Consequently, research efforts must be increased to quantify the amount emitted to, or concentration of persistent organic pollutants (POPs), plastics, endocrine disrupters, heavy metals in, the global environment and to better understand the effects of this pollution on the world's ecosystems and the functioning of the Earth system.

As the Scientific and Technological Community major group, it is our responsibility to bring to the deliberations of CSD-18 this clear message that the current consumption and production patterns in many countries are unsustainable and that a major shift of direction of human development is urgently required. We welcome that the document entitled "Proposed Input on a 10 Year Framework of Programmes on Sustainable Consumption and Production (SCP)", to be tabled at both CSD-18 and CSD-19, defines as an ambitious objective of the Framework of Programmes a decoupling of economic growth and social development from environmental degradation but it is not made clear whether the programmes to become part of the Framework will be commensurate with the huge tasks. A true strategic approach will be needed to engage humanity with a sense of urgency in a transition to sustainable models of consumption and production.

A Framework of this kind is at heart an effort to organize major social change. This change is considered a consequence of policies primarily in three fields, information and awareness raising, regulation, and international agreement. It has to be stressed that the Framework should also include programmes which address the economic, financial, (consumer and producer), behavioral, and cultural obstacles to change. For instance, not valuating ecosystem services has become an economic obstacle to a transition towards sustainability.

Governance institutions need to be part of the change, as well as drivers of fostering change towards sustainability. Effective governance institutions must be able to: (a) lengthen the time horizons for which societal and individual decisions are made; (b) broaden the orientation of governments to the needs of the many over the long term; (c) enable the private sector, governments, individuals and entire societies to consider short-term sacrifices that offer long-term improvements, and, (d) include the capacity for rapid, constructive response to evidence of unsustainability of a certain course of action. Furthermore, a strategic framework of action would include addressing the role of international business and industry in shaping demand, issues of conflict of priorities and directions, social movements of different kinds, and questions about what drives personal behavior.

Issues around the concept of consumer choice are of great importance in this context. Hence, a Ten Year Framework of Programmes on SCP should clearly spell out what is the underlying understanding of consumer choice and what is the role of government in "editing" that choice. For instance, strict product norms are a good tool to protect human health and the environment.

It must be acknowledged, however, that even when effective institutional arrangements and incentives are in place, a successful transition to sustainability requires citizens that place a high priority upon meeting such goals. This is why issues of understanding sustainability, consumer and producer behavior, culture and values must be considered as of high importance. Social science research has already provided numerous insights about many of these issues.

Moreover, engineering and technology will be critically important for achieving transitions to sustainability. The challenges that current consumption and production patterns pose to sustainable development point to the questions of what materials and resources will be required and how these materials and resources are produced and used in a sustainable manner. The use of specifically recyclable materials (e.g. alloys) is one of the current means to address such questions. This will require:

1. Engineering solutions for enhancing recycling rates and recovery, such as integrated sorting systems;
2. Designing for recyclability prior to manufacturing, for example, standardized alloys;
3. Developing new recycling processes for products that are made today; and
4. Optimizing existing technologies and new technologies to recover small amounts of rare metals present in many products.

For the success of these measures, it is important to disseminate among all production and consumption sectors two main concepts:

1. Knowledge of product life cycle; and
2. True cost of a product that includes the recycling costs.

Another area where engineering and technology will be key in transitions to sustainable consumption and production patterns relates to energy. There is progress within the global community in agreeing to transform our energy systems towards sustainable pathways and to move to a low-carbon economy. Meeting the world's rapidly growing energy demands in a sustainable manner will, during the coming decades, require utilizing a diverse mix of energy resources and technologies, while increasing efforts to enhance the implementation of existing clean energy technologies and to spur further scientific understanding, and engineering design aimed at the development of new clean energy technologies.

Enhancing energy conservation and efficiency are key for decoupling economic growth from increased energy use, and thus for driving sustainable development worldwide. The World Energy Council estimates that nearly two thirds of all primary energy is lost before it is converted to useful energy. There is a clear need to continue making advances in areas such as: the efficiency of various energy conversion systems (burners, turbines and motors, for example); low-energy designs for electrical appliances and for heating, cooling and lighting of buildings; the dematerialization and recycling of energy-intensive material, and designing land-use and transportation systems that minimize demand for personal vehicle travel. Moreover, there is the equally important and vast field of necessary behavioural changes in terms of energy consumption.

In an increasingly globalized economy, the location of product manufacturing and the goods end-users are sometimes widely dispersed. Increasingly, products that once may have been produced locally or at least domestically are made aboard and shipped to consumers half-way around the world. Goods not only travel further to market but, in some cases, once used, they make the return journey as recycled material. While diversified trade and such recycling can be seen in a positive light, in the absence of more efficient transportation, such trade expends more energy. This can be mitigated through engineered actions to improve handling and shipment of goods.

One specific example relates to trade in agricultural commodities. Combined with available infrastructure to process, store and move food products, global agricultural trade has allowed many parts of the world to enjoy a more varied diet and higher levels of nutrition.. However in addition to the high energy intensity of global food trade, many other shortcomings remain in domestic and international food distribution networks. The result is that enormous amounts of food with the potential to sustain large human and livestock populations are wasted or spoiled before reaching end users. Engineering technology applied to harvesting crops; in preserving and refrigeration; and in warehousing and transporting food products can reduce such wastage. In many cases, the technology to safeguard food exists, but the knowledge and resources to apply that know-how are not readily accessible.

Promoting greater technological efficiency is one way forward but it is not sufficient, and is sometimes problematic. For instance, efforts to promote efficiency often suppose and reproduce unsustainable forms of consumption. Freezers can be made efficient but expanding the current system of global frozen food transport networks to cover the aspirations of consumption of billions of more people should not be the goal, as this particular pattern of consumption does not seem sustainable.

Infrastructure is a critical area in an engineering and technology-oriented approach to reducing environmental degradation and increasing efficiencies of material and energy use.

Infrastructure includes the manufactured products, constructed facilities and natural features that shelter and support most human activities: buildings of all types, communications, energy generation and distribution, natural features, transportation of all modes, water resources, and waste treatment and management. Manufactured products can be part of infrastructure, just as automobiles are an element of transportation infrastructure. Infrastructure needs not be confined to the "built or engineered environment." Natural features are part of infrastructure, such as a wetland that contributes to waste treatment or a lake that contributes to a water supply.

Not only does the design of infrastructure change over time, so does the inventory of what is included in infrastructure. A century ago, few would have envisioned the airlines infrastructure that circles the globe. Mere decades ago, only visionaries could have foreseen the information and communications technology infrastructure that today extends to so many facets of life in developed and developing countries. Even at this moment, engineers and scientists are shaping new visions into new realities. In perhaps just a few years, these realities may be taken for granted and contribute significantly to sustainability.

For the very reason of its importance to safety, health, quality of life and the economies of developed and developing countries, sustainability of infrastructure must be a major focus of national and international activities. Infrastructure improvements can take many forms and just some areas where they are needed include:

1. quantitative performance objectives for infrastructure systems, including the dimensions of sustainability and integration of infrastructure systems;
2. infrastructure products such as intelligent vehicle-highway systems and smart grids for electrical power generation, transmission and distribution, and
3. engineering tools and practices such as integrated data systems, modeling-simulation-visualization tools, integrated project delivery systems, and performance-based standards with streamlined systems for acceptance by multiple regulatory authorities.

The wider debate on climate change involving public, government and specialists has focused attention on the vulnerability of certain public and private infrastructure to long-term climatic changes. Responses have included making buildings, transportation and sanitation systems "smarter." Recommendations that engineers and others have advanced to make infrastructure more sustainable in the face of a changing climate may also prompt other improvements to infrastructure. It could make the infrastructure more durable and adaptable in terms of function, economics or other factors. So, for example, installing heat pumps, solar power, higher-efficiency appliances, enhanced building envelopes, district heating and energy management systems – besides reducing carbon footprints – also may yield lifecycle savings.

From the viewpoint of the scientific community (natural, social and economic sciences), the 10 Year Framework of Programmes on Sustainable Consumption and Production should reflect both, be more science and engineering based and include support to internationally coordinated research efforts aimed at a more holistic understanding of production and consumption systems. For instance, questions about consumer decisions (including the role of both individuals and institutions) require far greater attention. Research on this issue has thus far been highly fragmented and hampered by disciplinary barriers.

The current CSD cycle should be used to promote further interesting interdisciplinary research approaches that have been developed over the last 10 to 20 years, such as: analyzing what sustainable lifestyles mean in different parts of the world and for different social groups; impact of specific consumption and production patterns on poverty reduction in different parts of the developing world; measuring the resources consumed to support people's lifestyles in terms of "ecological footprints"; evaluating the values and attitudes that drive consumption-related behavior and lifestyle; studies focusing on households and settlements as primary units of analysis, since this is the level at which most consumption decisions are made; systems analyses that are place-based, but at the same time, that consider the globalization of production./consumption cycles (for instance, that examine how consumption patterns of developed countries are linked to the export of natural resources from developing countries); and studying production/ consumption systems through a life-cycle approach, from the extraction of raw materials through processing, distribution, use and disposal. Such a much enhanced body of knowledge in these areas would benefit policy makers, governments, the private sector, civil society, and practitioners in general.

Most countries distinguish between R&D policies that focus on the generation of new knowledge, and industrial policies that focus on building manufacturing capabilities. Convergence of these two approaches could foster the expanded use of existing sustainable technologies, while also building a foundation for long-term R&D efforts. Creating links between knowledge generation and enterprise development is one of the most important challenges facing developing countries. Targeted taxation regimes and market-based instruments, and a wide variety of strategies for unlocking financial capital, are needed to create and develop enterprises that contribute to sustainable production and consumption.

3. TRANSPORT

Transportation technologies are progressing on many fronts towards lower emissions of air pollutants and greenhouse gases, including for instance: cars powered by hybrid engines, electricity and fuel cells; busses and commercial vehicles powered by compressed natural gas; the use of alternative fuels derived from various biomass sources; and continued improvements in the fuel efficiency and emissions of standard gasoline and diesel-powered vehicles. These various technological innovations are all gaining commercial success in differing rates. Their continued market penetration needs to be encouraged through appropriate economic incentive programmes and ongoing research, development, and deployment efforts. Even with the aggressive implementation of cleaner vehicle technologies, there remains a strong need to reduce demand for personal vehicle transport and long-distance road transport of goods.

Not only does transport require its own infrastructure, but a transportation system also shapes the infrastructure that it surrounds and passes through. Seeking energy sustainability through shorter travel distances may lead to an urban landscape of closer-knit residential, commercial and industrial buildings.

Actions for promoting cleaner fuels and vehicles must be complemented by policies to reduce the overall demand for personal vehicle use by furthering public transport, although modifying unsustainable transportation energy consumption patterns will require cultural and behavioral adjustments. The current global economic crisis has created a favorable framework to implement such adjustments in many key countries.

Currently, many governments are developing policies that foresee:

1. Diversification of mobility means;
2. Emphasis on public transport in urban zones;
3. Low-fuel consumption vehicles, for example hybrid and electrical cars, and
4. Public space management in cities with new modes for car usage.

One success story in numerous developed countries is the new type of mobility services, like free-use or low-cost rent of bicycles, multi-user taxi sharing and car sharing now employed in several cities. Another partial success story is the downsizing of cars dimensions, weight, speed performance, and engine-cylinder volume in order to achieve low-fuel consumption.

There is opportunity of using the Internet for precise transfer of transportation information, such as location, safety and scheduling. Within a city or intercity, ICT allows for “Intelligent Transport Systems” with high efficiency and safety. This can lead to faster travel with less stopping and starting. Governments should encourage all stakeholders to build and maintain national information infrastructure and create information resources to make ICT tools available to all people, urban and rural, for learning and working.

Some success has been demonstrated for cars CO_2 emissions abatement. A priority area of R&D should be the development of hybrid electric/gasoline cars with regenerative braking systems, as well as electrical vehicles. Similarly, investment in R&D aimed at the development of convenient, economic and safe ways of storing hydrogen on-board motor vehicles (e.g. carbon nanofibers) must be stepped up significantly. Making automobiles lighter by using new materials, such as Aramid fiber, can reduce vehicle weight and, with it, fuel consumption.

Investment in engineering opens numerous ways to making transport more sustainable. A report from Japan notes the presence of more than 500 million cars on the road worldwide. Losses due to friction and heat account for two-thirds of their fuel consumption. If the annual fuel consumption of these cars could be cut by 10% by reducing friction, it is estimated that the conserved energy would provide electric power for all households in Japan for a year or more.

Programs for producing ethanol and bio-diesel are already in place based on different crops (e.g. cassava, castor beans, cotton seeds, jatropha, palm-oil, soybean, sunflower, and sweet-potato). Biomass production for fuels requires land resources and, in many parts of the world, may have to compete with food production. Moreover, the water footprint of biofuels is a challenge that should not be ignored. Some tropical countries have large tracts of degraded lands that could benefit from the establishment of bio-energy plantations. Planting arid, semi-arid, degraded, and marginal lands that are unsuitable for food production, with non-edible bio-fuels crops would not compete directly with current food production and could help rehabilitate the soil. For large agricultural areas, on a case-by case basis, a scientific, engineering, social, economic and sustainability analysis should be conducted on the comparative advantage of planting food or biofuel crops, especially in the face of the ongoing global food crisis.

A shift towards cellulose-based second generation biofuels using wood and grassy crops would offer greater reductions in carbon dioxide emissions and less land used per unit of energy. However, technical breakthroughs would be required to achieve this.

Increasingly, high-speed rail is emerging as an alternative to short-haul air transport and urban areas are turning to new modes of light rail transit. Sustainability would be enhanced by shifting goods movement to rail as an alternative to road transport.

The door is swinging open for innovation and improvement not only in land transportation but also in aviation and maritime transport through changes to aircraft and vessels that enhance engine performance and reduce friction. Further benefits may accrue from propelling vessels with methane fuel, improved use of waste heat from propulsion machinery, utilizing new sail technology or applying new types of paint to hulls. Adjustment to route patterns may also bring fuel savings.

4. CHEMICALS

Management of chemicals in a sustainable manner, often called sustainable or sound chemicals management, must be science and engineering based and it requires strong regulatory frameworks at national, regional and global levels. While human society generally benefits greatly from chemicals, it is essential to systematically address possible risks for human health and the environment. The S & T Community strongly supports the implementation of the Globally Harmonized System of Classification and Labeling of Chemicals, as well as adopting a global system of recognizing and communicating risks/hazards. The concept of “no data no market” should be followed requiring that a comprehensive set of data and information about a chemical is made available to regulators and to users before it can be sold. Sustainability principles will also require that chemicals industries adapt their technologies to carbon-footprint reduction for all material and processes.

In a number of developed countries, the chemical industry remains the largest manufacturing sector. The industry employs millions of people worldwide, including several hundreds of thousands of scientists, engineers, and technicians engaged in research and development. International trade in chemicals exceeds one billion tons since 2000.

Several international instruments and mechanisms to address the issue of sustainable management of chemicals at the policy level have been established during the two decades since Rio de Janeiro 1992. Negotiations for a global legally binding instrument on mercury will commence in 2010, to be completed by 2013. Mercury is traded globally, used in products and chlorine-alkali plants, and emitted from coal-fired plants, incinerators, cement kilns, and contaminated sites.

In order to overcome existing shortcomings, policies and measures should focus in particular on the following areas: risk assessment, data collection and information transparency; stepping up implementation of international instruments; strengthening of national regulatory infrastructure; support to developing countries to build up human and institutional capacity in sustainable chemicals management; and multi-stakeholder involvement at national and international levels.

To enhance the coherence of national and international activities in chemicals management and to incorporate chemical safety issues into the international and national development agendas, the UNEP-led Strategic Approach to International Chemicals Management (SAICM) has started to contribute significantly to a more rapid dissemination of relevant information and ongoing discussion of priorities and emerging issues. The second International Conference on Chemicals Management reviewed the SAICM Global Plan of Action and added five emerging issues: nanotechnology and manufactured nanomaterials, chemicals in products, lead in paint, electronic waste and perfluorinated chemicals. More scientific and engineering research is required in order to ensure that these five areas will become fully part of sound chemicals management and regulatory systems.

Management of chemicals throughout their life cycles must be made an integral part of sound chemicals management. Life-cycle producer responsibility has not yet been widely respected and sufficiently implemented. For example, much of the electronic waste created in developed countries is sent to developing countries, often illegally. This influx of toxic waste has resulted in the contamination of land, water and humans.

Another challenge is how best to ensure that for new hazardous chemicals, such as pesticides and POPs, the necessary toxicity, health and safety assessments are undertaken without delay. Scientists and engineers call for developing a mechanism of identifying emerging problems associated with new hazardous chemicals The OECD-led work on nanotechnology and nanomaterials reflects this approach.

In many countries, insufficient attention is still paid to the safe and efficient use of pesticides, as well as to environmental impact assessments of pesticides application. Special programmes to dispose of obsolete pesticides (and other chemicals) stocks and to prevent further accumulation of such stocks should be encouraged.

The best form of sustainable chemicals management is, whenever possible, the development and use of safe, environmentally benign substances (in replacement of more hazardous ones), often based on renewable raw materials. Governments and industry should encourage this “green chemistry” through enhanced research, education, incentives and favorable market conditions. There is a great need of increasing international cooperation in the development and transfer of technology of safe chemical substitutes and in the development of capacity for their production.

Among the challenges faced by developing countries in implementing and strengthening sustainable chemicals management is the lack of adequate human resources and institutional capacities for risk assessment and interpretation, implementation and enforcement of regulatory frameworks, for rehabilitation of contaminated sites and emergency response, as well as effective education, training and awareness raising programmes. Increased North-South and South-South cooperation is needed to ensure that all countries and regions have the capacity to manage chemicals in a sustainable way, in particular in light of increasing trade, use and production of chemicals in developing countries. Countries should be encouraged to take an integrated approach to chemicals management when seeking assistance and cooperation from bilateral and multilateral donors.

Both, developing and developed countries, should give greater emphasis to the involvement of the private sector, scientific research and engineering organizations, education institutions, farmers and community groups in the development and implementation of sustainable chemicals management policies and strategies, and the building of respective capacities.

5. WASTE MANAGEMENT

One of the biggest returns on investment in health is to develop sustainable clean water and waste management systems. In fact, improvements to water supply and sanitation brought on by engineering both in developed and developing countries represent the single largest contributor to improved public health and, by extension, human sustainability.

On a closely related front, scientists and engineers continue to improve and develop new means to safely release to the environment water used in agriculture and industrial processing.

Policies for progressive limitation of release of waste involve a need for implementing waste management measures and for recycling materials and equipment. Waste is one major cause for non-sustainability. In Europe, about 50% of all solid and liquid waste products are produced by human activities inside buildings. In past years, as much as one-half of the entire US GDP might have been attributable to some form of waste.

Co-generation, which allows use of otherwise “waste” heat from the residential, commercial and industrial sectors for electrical generation, makes good sense both environmentally and economically. Energy efficiency measures in the industrial sector (such as climate-ready utilities) also have some co-benefits due to reduction in fuel and material use, leading to reduced emissions of air pollutants, solid wastes and waste water.

The JPOI calls for the 3R approach to waste manage: reduction and prevention of waste; the maximization of reuse and recycling; and the replacement of products with harmful waste by environmentally friendly alternative materials. Without sustainable waste management, several of the Millennium Development Goals, in particular to halve by the year 2015 the proportion of people without access to safe drinking water and basic sanitation, will not be met.

Solid waste management should be considered an important public service. However, in many developing countries this service is wholly inadequate, due to lack of resources. In fact, waste management is often not seen a priority by local authorities and national governments, disregarding the potential public health and environmental consequences. Poorly designed and maintained landfills represent an ongoing challenge, often even in developed countries. Seepage of effluent, sometimes into water courses, and the escape of greenhouse gases such as methane are surmountable technical problems that need to be addressed. Overall, a policy of moving away from landfill use to more sustainable waste management is required. However, incinerating waste and transferring residues to the soil and fine particles to the air has its own problems of environmental sustainability.

Sustainable consumption and production policies and sustainable waste management are closely interrelated. City governments for their jurisdiction but also national governments as part of the National Sustainable Development Strategies should conceptualize and make operational “integrated sustainable waste management systems”. Such a system consists of a variety of activities, including reduction, reuse, recycling and composting, operated by a variety of stakeholders at various scales. In addition to technical and operational aspects, also financial, training, legal, institutional and economic aspects and linkages must be addressed in an integrated manner to enable the overall system to function and ensure its sustainability.

There is no globally accepted classification of hazardous wastes which should be corrected. Globally, generation of hazardous wastes is increasing alongside the accelerated increase in total waste. Special care must be applied to the management of hazardous wastes and respective national regulatory frameworks must be established, monitored and regularly updated. All countries should become parties to the Basel Convention. Its three pillars – effective and more rigorous implementation at all levels of scale, waste minimization, and capacity building waste management require strengthening in many countries and sub regions. In several parts of the world (e.g. Eastern Europe and Central Asia), there is a legacy of the past in accumulation of hazardous wastes. There exist large stockpiles of obsolete pesticides containing persistent organic pollutants and large amounts of industrial waste, mainly from resource mining and processing activities. The wastes often contain radioactive nuclides metal compounds (e.g. cadmium, lead, zinc and sulfates).

The developing international trade in electronic waste has become an issue of concern, as large quantities of e-waste are being exported to developing countries for the purpose of re-use, repair, recycling and recovery of non-ferrous and precious metals. Moreover, plastics in the marine environment have become a major problem. Plastics release toxic chemicals into the ocean.

Radioactive waste that results from numerous processes of human activity requires special management attention and its disposal must be done with special care to avoiding harming people and the environment. Low-level waste (LLW) constitutes the bulk of the radioactive waste in volume and in mass, although it contains only a small fraction of the total waste radioactivity. The origin of LLW is quite diverse: nuclear power, medicine, research, and industry. Intermediate-level waste with long-lived isotopes (LL-ILW) and high-level waste (HLW) originate almost exclusively from nuclear reactors and their fuel cycle facilities, as well as defense facilities of countries that have developed nuclear weapons. Though quite limited in volume, they constitute the bulk of the waste radioactivity.

Nearly all radioactive wastes will be placed in a storage facility for some time, with the ability to retrieve them. Thus, storage is an essential step in radioactive waste management, although the targeted duration of storage will vary hugely (e.g. radio nuclides with short half-lives will decay away rapidly, so after a few months there is essentially none left; a number of isotopes require a storage of about three centuries; plutonium with a half-life of 24,000 years can be removed beforehand by reprocessing technologies). The available technological solution to LL-ILW and HLW waste disposal is long-term containment in deep sub-surface storage facilities considered geologically stable and “water-tight”, making sure that the migration time of the radioactive particles from their original site to the biosphere will be long enough for the radioactivity to have decayed much below acceptable limits, or that they will stay fully confined in their deposit location.

It needs to be recognized that solving the problem of LL-IWL and HLW waste disposal is in some countries as much a social and political process as a technical one. In these countries, there often exists no political and public consensus of high-level waste disposal strategies and for actual waste disposal sites. In some European countries, it became clear that the past practice of deciding where deposits should be built without an extensive engagement of civil society and local community concerned have generally failed.

A lot of waste is generated when existing infrastructure (roads, buildings, etc.) is replaced. This can be averted or minimized by recycling or finding new uses for the material – for example reusing crushed concrete during road construction. The LEED (Leadership in Energy and Environmental Design) approach to building design, engineering and construction has gained increasing acceptance in recent years. LEED not only encourages capture, conservation and recycling of grey water, it also promotes life-cycle approach that considers the end of the building useful life. Where possible, consideration should be given to require all plans for new and rebuilt infrastructure to project long-term costing – including decommissioning.

6. MINING

Attention is drawn here to the important Milos Declaration, which was adopted at the first conference on Sustainable Development Indicators in the Minerals Industry (SDIMI) held in 2003 at Milos, Greece. The Declaration is a statement of contribution to a sustainable future through the use of scientific, technical, educational and research skills, and knowledge in minerals extraction and utilization that was endorsed by the leading global professional and scientific organizations and institutes representing the mineral mining professions.

Mining can contribute to sustainable development by the consistent use of leading practice for environmental stewardship and equitable benefits to local community meeting the needs of today and tomorrow. The large physical footprint of surface mines should be carefully planned to reduce environmental impacts during mining and return the land to a sustainable post-mining use. Safety guidelines and good practices for tailings management should be developed. Numerous examples of reuse and redevelopment are led by projects such as the Eden Project in England. These actions must be taken with full engagement of communities, the government and other stakeholders. Similarly, it is fundamental that environmental and social impact assessments are done, in consultation with the local communities, before the extractive activities start for both open cast and underground mining.

The 2003 Milos Statement on Contribution of the Minerals Professional Community to Sustainable Development also elaborates commitments necessary to fulfill the sustainability vision in the minerals sector through professional responsibility; education, training and development; and communication. The commitments include the following objectives that are widely endorsed within the professional engineering community:

- Employing science, engineering, and technology as resources to people, catalysts for learning, providers of increased quality of life, and protectors of the environment, human health, and safety;
- Encouraging the development, transfer, and application of technologies that support sustainable actions throughout the product and mine life cycles;
- Promoting the teaching of sustainability principles in all engineering programs at all academic levels;
- Encouraging a global exchange in academic training, as well as apprenticeship and internships programs, and
- Disseminating technical information on sustainable development and the role of the minerals, metals, and fuels in sustainable development, including information on the role of minerals in maintaining a high quality of life.

Development of new mining technologies must be encouraged by governments, with the recognition that all energy and water needs are unique to the location and to the mineral being produced. Some cutting-edge success stories include:

1. The introduction of modern techniques and particular chemicals for in situ leaching;
2. More efficient rock breaking technologies to reduce energy use;
3. Technologies that reduce water requirements:
4. Innovative transportation such as slurry pipelines vs. trucking transport, and
5. The application of enhanced robotics and remote mining technology that can improve human working conditions and save on associated ventilation and cooling systems.

One example of chemical production in mining providing multiple benefits is the coal-bed methane recovery. The methane needs to be removed to make the mining of coal safer by reducing mine explosions. Methane is a natural gas, a clean-burning fuel. Use of CO_2-enhanced coal bed methane recovery combined with sequestration is recommended when sources of anthropogenic CO_2 are available. Sub regional, regional and global cooperation and sharing of best practices in this area should be increased with special attention to countries in need of technical assistance.

The challenge for the mining sector will be to enhance social and environmental sustainability of this important segment of many national economies, as well as globally. For instance, countries should ensure that adequate environmental monitoring systems are put in place. Their absence makes it difficult to assess present and past pollution from mining activities. As a result, waste composition and volume, and the extent of soil, surface, and groundwater contamination and its effects on human health, are often not known. Corporate social and environmental sustainability and accountability is required. There should be a broader international approach to policies related to the mining sector from the sub regional to the global scale.

7. EDUCATION, TRAINING, AND INSTITUTIONAL CAPACITY BUILDING IN SCIENCE AND TECHNOLOGY

Mainstreaming "sustainability" in the transport, chemicals, waste disposal and mining sectors requires professionals with a solid training and knowledge in different fields of science, engineering and technology. Addressing the challenges of sustainable development in these sectors, as well as in the overarching field of sustainable consumption and production requires strong and focused national, regional and global science, engineering and technology systems. However, it is now clearer than ever that these challenges have thus far outstripped the capacities both of the science and technology community and of society to forge effective and comprehensive responses. Nothing less than a massive effort will be needed in order to strengthen scientific and technological capacity in all regions of the world, and, in particular, in developing countries.

The still widening North – South divide in scientific and technological capacity must be bridged. The countries of the Organization for Economic Cooperation and Development (OECD) spend annually more on research and development than the economic output of the world's 61 least developed countries. Developed countries employ 12 times the per capita number of scientists and engineers in research and development than developing countries.

Developing countries must address this problem and significantly enhance investment in higher education and scientific and technological capacity. Bilateral donors and other funding mechanisms should include science and technology capacity-building among their priority areas of development cooperation and substantially increase the funds they allocate to this sector for sustainable development. Special attention should be given to the areas of sustainable consumption and production, transport, mining; waste and chemicals. A critical mass of scientific and technical skills and infrastructure (for example laboratories, equipment and supporting institutions) is required for all countries to develop, adapt and produce the technologies specific to their needs; introduce these technologies effectively into the market; and provide the needed maintenance on an ongoing basis. Capacity building at the international, regional and sub regional levels must also be given increased attention as it is often the most cost-efficient way to build a critical mass of capacity.

Building and maintaining the quality of key national institutions of learning and research, especially universities, is critical to sustainable development. The responsibility for this capacity building lies squarely on the shoulders of national governments. However, the global development assistance community and the international S&T community should enhance collaboration and partnerships with developing countries in this field. Experience shows that international S&T cooperation through efforts such as the creation of scientific and technological networks, scientific exchanges, and establishing scientific centres of excellence among nations with weak scientific infrastructure, are excellent strategies for building up development policies. At the same time, coordinated measures must be taken to counter the negative effects of 'brain drain' upon countries that are working to develop their own S&T community and institutional capabilities.

With respect to the goals of sustainable development, it is also necessary to encourage and develop innovative new approaches to education and training. Educational curricula at all levels, but particularly in higher education, should be re-examined from a sustainability viewpoint. Educational and training efforts should encourage linkages between natural and social science disciplines, development studies, and applied engineering and technology together with a strong grounding in the basic disciplines of science and engineering.

The ongoing United Nations Decade of Education for Sustainable Development 2005 - 2014 is a major instrument for international cooperation in this field, as well as sharing of experiences, best practices and networking. Within different domains of education for sustainable development the over arching issue of sustainable consumption and production should receive particularly high attention. Education on sustainability aspects of transport, mining, waste and chemicals should also be included. The S&T community is committed to making an active and important contribution to the Decade.

8. CONCLUSION

Progress in meeting sustainable development goals in the areas under review at the CSD-18 session will require substantial innovative advances in science and technology. Science, engineering and technology must be global in its reach, yet local and national in their application. Enhanced North-South and South-South scientific and technological cooperation, knowledge networking and dissemination, and engineering know-how and technology sharing will be essential.

The science and technology community remains committed to increasing its efforts towards a better harnessing of science and technology for the necessary transition to a sustainable path of human development. To this end, our community also seeks to enhance further its cooperation with all stakeholders, including governments, local authorities, business and industry, farmers and all other major groups.