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Science and Technology for Sustainable Development

1. Introduction

This note was prepared as an input to the ongoing discussion on priority issues for Rio+20. It provides an overview of global trends in science and technology[1] for sustainable development since the Earth Summit in 1992, and reviews the related UN debate, global commitments and their achievement since. Only four time-bound targets were identified and overall delivery on these and related general technology commitments has not been encouraging.

2. Recent global trends

The landscape of science and technology issues and institutions has changed significantly since 1992. Emerging economies have become leaders not only in manufacturing and trade of technologies, but also increasingly in research and innovation.[2]

Governments call for accelerating clean technology change

Technology has greatly shaped society and the environment. While technology progress has addressed many problems, it has also added new problems.[3,4] To varying degrees, all technologies consume resources, use land and pollute air, water and the atmosphere. While increasing eco-efficiency of technology use has greatly reduced the amounts of resources consumed and pollution produced *per unit of output* over the long run, *absolute* amounts of consumption and pollution have continued to increase unsustainably.

Governments have called for concerted actions to accelerate change towards cleaner technology. Many technology optimists believe such acceleration is essential and call it the *technology innovation imperative*[5]. The World Economic and Social Survey 2011 called for a "*global green technological transformation, greater in scale and achievable within a much shorter time-frame than [in the past]*" that "*must enable today's poor to attain decent living standards, while reducing emissions and waste and ending the unrestrained drawdown of the earth's non-renewable resources.*"[6]

Global technology progress is too slow to compensate for increasing consumption

Actual progress in technology performance at the global level has fallen far short of such ambitions.[6] For example, the declared goal of establishing a renewable low-carbon energy technology system on a global scale remains elusive, with modern renewables jointly accounting for 0.7 per cent of primary energy, compared to fossil fuels' share of 81 per cent in 2008.[7] Global CO_2 emissions have increased considerably *faster* in the 2000s than in previous decades.[8] Despite national and international efforts to accelerate and direct energy technology change, the pace of the global energy/fuel transitions has *slowed* significantly since the 1970s.[9]

Prevailing "solutions" are insufficient to achieve the technically feasible factor of 4 to 5 increase in global eco-efficiency

It is *technically feasible to increase global eco-efficiency by a "factor 4"* or even 5 until 2050.[10,11,6] This would allow more than doubling global wealth while halving resource and energy use. It could also mean providing the present level of services while reducing resource and energy consumption by 75 to 80 per cent.[12] Such global eco-efficiency goal is highly ambitious. It illustrates what could be done, if all organizational, socio-economic and political limits were overcome world-wide.[13]

Simplistic solutions continue to dominate present national and global debates on how to meet the technology innovation imperative. Technology optimists suggest "*big push*"-policies to scale up available technologies. Others focus on market incentives and hope that the necessary technological transformation will come about by "*getting prices right*" through internalizing environmental externalities. Several Governments in Asia are pursuing technology-focused industrial policies, with mostly positive developmental benefits.

Greater role of emerging economies in technology flows and transfer, but poorer and smaller economies marginalized

Today's patterns of technology flows and transfer differ greatly from those in 1992, a time when technology flows were mainly between developed countries and the challenge was to promote greater technology transfer to developing countries. While these flows are still important, clean technology flows among emerging economies and from emerging economies to developed countries have grown faster. Net revenue from royalty and license fees received by high-income countries was rather low until 2003 after which it increased rapidly to US$26 billion in 2007. This revenue is almost entirely due to technology transfer to emerging economies, while the participation of the poorest and smaller economies was negligible.

Large developing countries have emerged as world leaders in clean technology production, exports, and use

Not only the overall magnitude, but also the nature of cross-border technology flows has changed. They are increasingly embedded in global trade and FDI flows, thus forming an element of international production systems. In terms of manufacturing and export of clean technology, several large developing countries have become world leaders, and some are also emerging as the most important users.[14]

Increasing importance of South-South clean technology transfer despite continued high barriers

South-South clean technology transfer has become increasingly important. Highly publicised examples include ceramic cook-stoves, biogas digesters, cement board, and jatropha biofuel, and a range of Chinese and Indian FDI activities in Africa. Yet, a number of policies continue to hinder South-South technology transfer. A recent survey found tariff and non-tariff (equivalent) barriers in large developing countries for solar PV products to range from 12 to 18 and 41 to 63 per cent, respectively.[14]

Increases in RD&D investment only in large emerging economies

Mirroring the changing patterns of technology flows, RD&D stocks and flows have changed, illustrating a much more important role for large, emerging economies. Overall investment in R&D as a share of GDP in middle and low income countries doubled from 0.5 to 1 per cent from 1996 to 2007, whereas in high-income countries it remained fairly stable at 2.2 to 2.4 per cent over the same period.[15] Anecdotal evidence suggests that this share has remained at much lower levels in the poorest and/or most vulnerable countries. For example, it was about 0.1 per cent of GDP in the Caribbean Region.[16]

Today's level of public spending for energy-related research and development in developed countries is still well below that of the 1970s and early 1980s, even though overall RD&D budgets have doubled since the 1980s.[17] Public spending on RD&D of nuclear, fusion, fossil fuels and renewable energy technologies is lower in each case than in 1980. Energy RD&D in Brazil, the Russian Federation, India, Mexico, China and South Africa was about US$19 billion, which is more than that of all IEA countries combined (US$12.7 billion).[18] This challenges the conventional wisdom that most new technologies are created in developed countries and transferred to developing countries. Energy RD&D investments in emerging economies focus on fossil fuel and nuclear energy, with renewables and energy efficiency underrepresented.

Strategic patenting and increased patent quantity over quality

The rise of strategic patenting and a series of legislative changes to expand monopoly rights has led to a very complex system of patents which is increasingly geared to support the rights of incumbent, large firms over new, smaller, innovative firms. Strategic patenting arguably has become the single most important reason for the increased number of patents. Arguably, the system in many countries has moved from its original objective to stimulate innovation through providing incentives to innovators, to preventing new domestic and foreign market entrants, an increasing number of which are from developing countries. Some characterize the IPR system and its enforcement in some countries as "excessive".[19] Against this background and related public criticism, some patent offices are exploring ways to improve patent quality over quantity.[20]

Patenting rates for clean technology are faster than for other sectors, including in large emerging economies

In a matter of only a few years, several large emerging economies have created strong patent offices. China's patent office is expected soon to become the world's largest. However, poorer and smaller economies have remained at the receiving end.

Patenting rates for clean energy technologies have increased faster than for other sectors, at about 20 per cent per year since the adoption of the Kyoto Protocol in 1997. The leading six countries patenting clean technologies (Japan, USA, Germany, Republic of Korea, UK, France) account for almost 80 per cent of all patent applications in clean energy technology, but large emerging economies are rapidly emerging as leaders in clean technology patents in their own rights. India features within the top five countries for solar PV, while Brazil and Mexico share the top two positions in hydro/marine.[21]

Rise of free and open-source collaborations and solutions

Web-based technologies have made new forms of science and technology collaboration possible. In particular, free and open-source collaborations and solutions have emerged as alternative forms to the conventional IPR systems of patents and copyrights. Yet, technology policy and legislation routinely disregard or even discriminate against open-source despite its public benefits.

Willingness for licensing of clean technology to developing countries, but capacity barriers to overcome

Information on licencing of clean technology is sparse. However, a recent survey[21] found relatively low levels of out-licensing of clean technology towards developing countries. Scientific infrastructure, human capital, favourable market conditions, and investment climate were considered more important factors than IPR protection in the country of the licensee. The willingness to out-license was found to be much higher than the actual level of licensing. 70 per cent of respondents said they were prepared to offer more flexible terms when licensing to developing countries with limited financial capacity. Most respondents favoured collaborative R&D activities, patent out-licensing and joint ventures over patent pooling and cross-licensing.

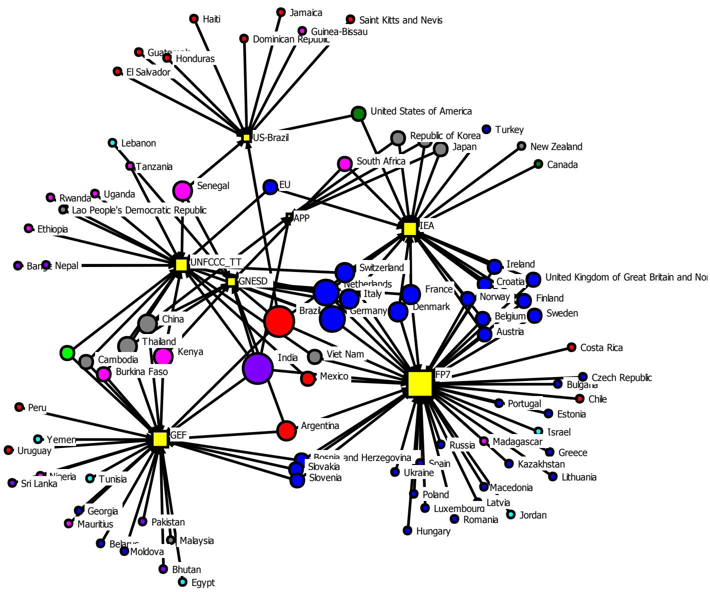
Table 1. Importance of decision factors for licensing agreements with recipients in developing countries [in % of survey respondents][21]

	Protection of IPRs	Scientific Capabilities and infrastructure	Favourable market conditions	Favourable investment climate
Not a factor	18	13	16	15
A basic precondition for doing business, but not a driving factor	28	37	26	27
Significantly attractive condition, would encourage negotiation	29	37	44	42
Compelling reason toward an agreement	25	13	14	16

Increasingly open international networks of RD&D collaboration

The global RD&D network of clean technology cooperation has become almost universal, whereas it involved essentially only developed countries in 1992. Today, entities in 182 UN Member States participate in some form of international clean technology cooperation, with potential knowledge flows between all of these.[22] However, the structures of technology cooperation networks differ greatly between technology clusters, reflecting national policy priorities, resource endowments, and political considerations. Figure 1 shows the global technology cooperation network on bioenergy. A number of multilateral frameworks, such as the EU's framework research programmes, and bilateral ones, such as that on biofuels between Brazil and the USA, have been opened to external participants, including from developing countries. Such trend to open collaboration provides new opportunities to poorer countries and improves the efficiency of global RD&D cooperation on clean technology. Making all future technology cooperation frameworks "open" might prove the cheapest option to improving RD&D to the benefit of all.

Figure 1. Participation network in technology cooperation on bioenergy[22]



Notes: Squares: cooperation frameworks; circles: participating countries; circle size: number of participations. GNESD: Global Network on Energy for Sustainable Development; FP7: EU's 7th Framework Programme.

Increased emphasis on market instruments instead of technology mandates and standards

In line with a general trend, today's technology policy in many countries emphasizes market and price instruments as levers of choice, with much less focus on technology mandates and standards than in the past. Various forms of taxation, subsidies, feed-in tariffs, and permit trading systems have been introduced to stimulate green technology. For example, government support for renewables was US$57 billion in 2009 and is expected to quadruple in the next 20 years.[23] Oil price spikes, high gasoline taxes, subsidies and permit trading schemes are natural experiments which provide insights into the limitations of technology policy approaches based on price incentives alone. For example, in most countries carbon tax equivalents of gasoline taxes are much larger than carbon prices generally considered necessary from a climate change perspective, but only regulatory measures have significantly impacted efficiency and emissions.

Fragmented system of capacity building mechanisms

Over the past twenty years, a system of capacity building mechanisms on clean technology has emerged that is increasingly fragmented. In particular, the fragmented nature of UN system support for technology and sustainable development is apparent in a recent survey of UN system activities[24] which illustrates the wide range of capacity building activities. However, these activities remain largely uncoordinated and ad hoc, in terms of both content and country coverage. In particular, activities typically fall under specific issue-based programmes with relatively narrow objectives. There is no global framework, agreement, assessment or monitoring mechanism of progress in terms of science, technology, and development.

3. History of UN debate on technology and development

It is useful to recall the changing role of technology in the UN debate on sustainable development (Table 2), in order to appreciate the contrasting paradigms on technology that are prominent in the UN preparatory process for Rio+20. Each decade since 1960 had a dominant paradigm with its preferred solutions which played out in major global meetings, modified the role of the UN and triggered institutional change. Alternative assessments of the causes of the poverty of nations and associated paradigms multiplied, so that by the 2000s, reaching consensus in the UN on technology issues has become increasingly difficult. Government statements are typically based on either one of the present or past paradigms, consequently offering different and even contradictory solutions. Hence, the broad appeal of today's common approach that defines the overall objective but does not prescribe the means beyond references to technology, financial resources and capacity.

Table 2. Stylized overview of changing dominant paradigms in the UN debates on technology since the 1960s

		1960s	1970s	1980s	1990s	2000s
Dominant perceived	Causes of poverty	Lack of science and technology to increase production	Lack of capacity to benefit from technology	State intervention	State intervention, protectionism	Implementation gaps in terms of capacity, funds, technology; low political commitment
	Paradigms, solutions	Big push, technology transfer; techno-optimism; stages of development.	Technology gaps, equitable access; indigenous capacity; NIEO, Neo-Keynesianism, dependency theory.	Neoliberalism and self-regulating markets.	Washington consensus (globalization, liberalization), sustainable development (intergov. agreements, global funds)	Global problems approach: international cooperation to set goals and raise resources
UN	Approach	Scientific-technical level. Authoritative content provided by UN staff and experts.	Political level. Strictly intergovernmental process. Global and regional plans of action.	Increased involvement of public and private stakeholders.	Intergovernmental Summits. Global Forum of stakeholders. High-level panels.	High-level political panels. Expert assessments with stakeholder participation. Transnational alliances, public-private partnerships.
	Meetings	UN Conference on S&T for Development (Geneva, 1963).	UN Conference on S&T for Development (Vienna, 1979).	None	Earth Summit (Rio, 1992)	UN MDG Summits (2000 and 2010), Rio+20 (2012)
	Institutional change	ECOSOC established Advisory Committee (ACAST)	World Plan for Action (1971). Vienna Program of Action (1979). GA created Inter-governmental Committee	IPCC	Rio Conventions; GEF, UN CSD. Donor funding through UN programmes and funds.	Millennium Task Force, IIASTD. Global funds. CDM and emissions trading; "One-UN"; Global Compact.

4. Existing commitments

In view of its purpose to inform discussions on possible outcomes at Rio+20, the preferred emphasis of this note would be on goals with time-bound targets. But only four time-bound targets were identified, two of which with delivery dates that have already passed (table 3). Hence, we also consider qualitative commitments that are not time-bound or well defined. The following documents were consulted: Agenda 21 (1992); JPOI (2002); MDGs (2000, and 2008 update); the "UN Summit on the Millennium Development Goals" (2010); the World Summit for Social Development (WSSD, Copenhagen, 1995); WTO's TRIPS agreement; and the Copenhagen Accord (Copenhagen, 2009). The emphasis here is on Agenda 21 and the JPOI, and technology commitments in the sustainable development context only.

Table 3. Time-bound commitments on science and technology. Those relating directly to "green technology" are highlighted in green.

Source	Goal and Target	Date
MDG Goal 8	8.F "In cooperation with the private sector, make available benefits of new technologies, especially information and communications"	2015
Agenda 21 ch. 21 "Environ-mentally sound management of solid wastes"	21.18(a) "Governments….should: (a) By the year 2000, promote sufficient financial and technological capacities at the regional, national and local levels… to implement waste reuse and recycling policies and actions;"	2000
Agenda 21 ch. 35 "Science for sustainable development"	35.21(b) "A substantial increase by the year 2000 in the number of scientists - particularly women scientists - in those developing countries where their number is at present insufficient"	2000
Convention on Biological Diversity, COP10, Decision X/II	Target 19: "By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied."	2020

Environmental impacts can conceptually be seen as the consequence of driving forces in the areas of population, affluence, and technology. While the aim of affluence associated with ever higher levels of consumption has been a non-negotiable aspect of international relations, population aspects have been highly contentious and often linked to religious beliefs. Thus, technology drivers have been the levers of choice, explaining the prominence of technology in international debates.

It could be argued that most UN commitments of the past twenty years follow the technology-centric perspective, which aims to facilitate technology transfer from developed to developing countries for which it is considered crucial to raise financial resources and build capacity. Often these three elements have been referred to as "*means of implementation*". In this perspective, technology is something the developed countries possess, as illustrated in the Rio principle 7: *"…The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view …. of the technologies and financial resources they command."* It is clear that by 2011 the simple dichotomy among developed and developing does no longer reflect the disparities between countries that are considered as developing by the UN. Rio principle 9 more generally called on *all* Governments to cooperate on technology development, diffusion and transfer.

Table 4 summarizes global commitments on science and techno-logy for sustainable development, only 25 per cent of which specifically address "green" technology.

In Agenda 21, technology is referred to more than any other issue. It is prominent in every single chapter. Due to space limitations, it is impossible to list all relevant 691 references in Agenda 21 in this brief note. Four of the 40 chapter headings of Agenda 21 refer to science or technology, which is more than for any other issue: ch. 16 (Environmentally sound management of biotechnology), ch. 31 (Scientific and technological community), ch. 34 (Transfer of environmentally sound technology, cooperation and capacity-building), ch. 35 (Science for sustainable development). Technology-relevant commitments contained in these chapters and others throughout the text are of a rather general nature and their scope is wide.

Elements of Agenda 21 that are representative of its overall science and technology commitments include the following. Paras §16.1 and §35.3 outline programme areas for biotechnology and science for sustainable development. Ch. 31 calls for building technology capacity (§34.20, §34.26) and suggests the creation of international information systems (§34.15), regional and international clearing-houses to facilitate partnerships (§34.16, 34.17), networks of green technology research centres (§34.21) and technology assessment centres (§34.26). It also calls for long-term collaborative arrangements between enterprises of developed and developing countries, multinationals (§34.27), and for joint ventures between suppliers and recipients of technologies (§34.28). Notably, §34.18(e) calls on Governments and int.'l organizations to "*purchase… patents and licences on commercial terms for their transfer to developing countries on non-commercial terms as part of development cooperation*".

Ten years later, JPOI contained 140 references to science or technology on its 62 pages. The JPOI did not include any chapter specifically focusing on technology, but the topic was highlighted in a chapter on "*means of implementation*" together with capacity building and finance. The JPOI does not include any time-bound, quantifiable targets. Science and technology continue to be considered too important and contentious by Governments to be captured in terms of time-bound, quantifiable commitments.

The JPOI (ch.X §105-113) restates many of the technology commitments contained in Agenda 21. Its wording illustrates the apparent effort to bridge the divide between various paradigms in the UN debates (table 2). For example, §105 calls for enhancing "*existing national institutional capacity in developing countries to improve access to and the development, transfer and diffusion of environmentally sound technologies*". JPOI elaborates on technology transfer (§105, §106), access to global R&D programmes (§107) and publicly funded R&D (§113), networks of centres of excellence (§108), collaboration between scientists and policy makers (§109, §111), assessment models (§110), and ICT (§112).

Table 4. Issues, global commitments, and their delivery to date. "Green technology"-specific elements are highlighted in green.

		Issue	Global commitments	Delivery
Knowledge sharing	Capacity building	Build national financial, scientific and technological capacities to develop, assess and use technology	A21 (21.18a, 34.20, 35.4d), Rio principle 9, JPOI (X.105, 108, 110), CA (3)	*Partial.* Progress in middle and high-income countries only.
		Build technology assessment capacity and use it	A21 (34.26, 35.4c), JPOI (X.105, 109, 110)	*Partial.* Progress in high-income countries only.
		Technical assistance and scientific-technical knowledge exchange	Rio principle 9, JPOI (X.106, 109, 110)	*Yes*, but uneven benefits
		Training on technology ethics	A21 (31.10c)	*No.*
	Information	Cooperation between scientists and policy makers for science-based decision-making	JPOI (X.109, 111)	*No,* only few examples of systematic collaboration.
		Scientific-technical input to intergovernmental processes, policies, and the UN	A21 (31.4c,d)	*Partial*, for particular issues only (e.g., IPCC)
		Disseminating research results	A21 (31.4e, 35.4b), JPOI (X.106, 109)	*Yes.*
		UN to create inventory of technology clearing-houses	A21 (34.17)	*No.*
	Networks	Regional cooperative mechanisms	A21 (31.4b), JPOI (X.106)	*Partial.* EU and ASEAN only.
		Create network of clearing-houses of technology information	A21 (34.15)	*No,* but information is available in patent registers.
		International network of technology assessment centres	A21 (34.26)	*No*
RD&D	Public support	Enhance green technology development, including with publicly funded R&D	Rio principle 9, JPOI (X.105, 106), MDG2010 (60), JPOI (X.113)	*Partial.* Only selected clusters and countries. Decreased public R&D in OECD countries.
		Improve science and technology for SD, incl. for biodiversity and agriculture	CBD COP10, A21 (16.1, 35.4a), MDG2010 (60)	*Yes.*
		Increased number of women scientists	A21 (31.4g, 35.21b)	*Yes.* 17% more women science graduates than ten years ago.
	Partnerships	Collaborative network of research centres (and others)	A21 (34.21), JPOI (X.106, 108)	*No.* EU only.
		Support developing countries to access international R&D programmes	JPOI (X.107)	*Partial.* Primarily EU and ASEAN.
		Promote long-term, international partnerships between multinational and other enterprises	A21 (34.27)	*Yes*
		Promote partnerships between public and private sectors	JPOI (X.106, 109)	*Yes*
Technology transfer	Facilitation	Enhance green technology transfer (incl. on mitigation, adaptation, early warning, biodiversity and agriculture)	Rio principle 9, JPOI (X.105, 106, 113), MDG2010 (60), CBD-COP7, CA (3)	*Yes*, but the scale not commensurate with challenge
		Promote green technology transfer to developing countries on concessional and preferential terms	JPOI (X.105)	*No*, at least not systematic or at a significant scale.
		Promote access to green technology	JPOI (X.105)	*Yes*
		Technology Mechanism to accelerate climate-relevant technology development and transfer	CA (11)	*Yes*
	Partnerships	Partnerships with the private sector on ICT	MDG 8.F	*Yes.*
		Network of clearing-houses	A21 (34.16)	*No*
		Promote joint ventures and FDI in line with developing countries' priorities	A21 (34.28)	*Yes,* but benefits limited to a few countries.
Technology mandates	National	Enabling environment for green technology and biotechnology	A21 (16.1), JPOI (X.105)	*Partial.* For selected renewable techs, not biotech
		Cooperation on codes of practice and guidelines	A21 (31.10a)	*Yes*
		Improve agricultural technology performance	MDG2010 (60)	*Yes*
		National advisory groups on technology ethics	A21 (31.10b)	*Partial.* Mainly in Europe.
	Int'l	International cooperation on codes of practise and guidelines	A21 (31.10a)	*Yes.*
		Changes to international legal instruments	A21 (31.10d)	*Yes,* TRIPS, TRIMS, CDM, etc.
Market incentives	Diffusi	Enhance green technology diffusion	Rio principle 9, JPOI (X.105, 106), MDG2010 (60)	*Partial.* Example feed-in tariffs, but limited impacts.
		Develop and deploy ICTs	A21 (31.4h), JPOI (X.112)	*Yes*
	Transfer	Governments to encourage private sector to transfer green technology	A21 (34.18)	*Partial.* Many initiatives, but limited impact.
		Governments to purchase patents and licenses for transfer to developing countries on non-commercial terms	A21 (34.18(e)iii)	*No*

Notes: A21 := Agenda 21. Paragraph numbers provided in brackets. CBD=Convention on Biological Diversity. CA= Copenhagen Accord 2009.

Table 5. Summary of proposals on science and technology, contained in official submissions of Member States, intergovernmental organizations, and major groups for the Rio+20 preparatory process. "Green technology"-specific elements are highlighted in green.

	Proposal	By*	Is it "new"?
Green technology transfer and diffusion	Create an enabling environment that aims to remove barriers to technology transfer and adaptation, especially to developing countries, in accordance with international obligations.	G77, Egypt	A21 (16.1), JPOI (X.105)
	Consider green technology transfer to developing countries on concessional terms, especially in the context of publicly-funded technologies, and consider expansion of the scope of technologies in the public domain.	G77, India, Egypt, Brazil	A21 (34.18(e)iii), JPOI (X.105, 106, 113), MDG2010 (60)
	Establish a global technology mechanism [or 'technology sharing facility' or 'technology clearing house' or 'Global Green Innovation and Technology Partnership'] to facilitate technology transfer and sharing.	G77, Belarus, Bolivia, UNEP, AP Youth, ICTSD	Partly, A21 (34.15, 16, 26), CA (11)
	Support development of public-private knowledge sharing infrastructure, voluntary patent pools and other collaborative IP mechanisms, including open-source and General Public Licenses.	ECE regional meeting, OECD	New
	Exchange renewable energy technologies between countries, regions and different sectors.	IRENA	JPOI (X.105, 106, 113), CA (3)
	Provide universal access to broadband Internet service, and develop and diffuse social technologies.	Brazil	A21 31.4, JPOI X.112
Research, development and demonstration	Establish a global mechanism for research cooperation on sustainable development by 2013, in order to provide scientific knowledge, report progress, and promote research and innovation programmes in partnership with the private sector and others.	EU	**Partly**, A21 (34.21), JPOI (X.106, 108), JPOI (X.107), CA (11)
	Create an international, regulatory body on technology development.	Kazakhstan	New
	Identify and support centres of excellence as nodal points for technology research and development.	India Delhi meeting	A21 (34.21), JPOI (X.106, 108)
	Build a global, cross-sectoral information/data network, based on the Global Earth Observation Network.	Japan, EU, AGEDI	**Partly**, A21 (31.4e, 35.4b), JPOI (X.106)
	Promote basic and applied RD&D in the areas of energy, environment, chemistry, material sciences, and engineering	OECD, Europ. Students Forum, ECE meeting	New
	Promote RD&D on technologies related to renewable energy; marine and coastal areas; drylands; forest resources; and green local technologies based on traditional knowledge.	IRENA, IOC, CGEE Brazil, Brazil, Egypt	JPOI (X.105, 106, 113), A21 (16.1, 35.4a)
	Create an "Intergovernmental Panel on Sustainable Development" to provide scientific advice.	Indonesia, Stakeholder Forum, Children/Youth	**Partly**, JPOI (X.109, 111), A21 (31.4c,d)
Capacity building and stakeholder participation	Provide international support to countries to further develop their scientific, technological, professional and related capacities.	G77, Boston University, Pardee Center	Rio principle 9, JPOI (X.106, 109, 110)
	Implement the Bali Strategic Plan for Technology Support and Capacity Building without further delay.	G77, India, APRN, PDMA	Bali Strategic Plan
	Establish a global capacity development mechanism to provide country-, region- and sector-specific advice to Governments on the transformation to a green economy, and to assist them in accessing funds.	EU, ECE regional meeting	**Partly** (regional), A21 (31.4b), JPOI (X.106)
	Consider economic partnership agreements on capacity building for green technology transfer and deployment.	India	New
	Consider a global version of the Aarhus Convention.	Pardee Center	New
Policy environment and market incentives	Pursue science-based decision making and integrated policy, where science, technology, and innovation policies are aligned with sectoral policies and national sustainable development strategies	Botswana, UNESCO	JPOI (X.109, 111)
	Consider an International Convention for the Evaluation of New Technologies and create an intergovern-mental mechanism to provide resources and capacity building for impact assessment of new technologies.	ETC Group, DPI/NGO conf., ICENT, APRN	New
	Institute carbon and resource prices to stimulate green innovation, and financial/economic instruments for renewable energy technology deployment.	OECD, IRENA	JPOI (X.105, 106)
	Consider a Sustainable Energy Trade Agreement, with a view to enable the scaling-up of innovation, diffusion, and use of goods, services, and technologies in the non-fossil fuel energy sector.	ICTSD	New
	Promote international markets of hi-tech goods and services, in order to accelerate major innovations.	Kazakhstan	New
	Promote green patents, to provide fair incentives to innovators of environmentally sound technologies.	Canada, G77, Brazil	New
	Develop responses to the needs of developing countries in the area of patent protection and intellectual property rights, and explore the concept of assured access.	G77, Brazil	**Partly**, A21 (34.18(e)iii)
Global goals and targets	Consider a target share of financial resources to be committed to science, technology and innovation.	Brazil	New
	Consider green technology roadmaps.	IRENA	New
	Consider globally coherent, national goals and targets for 2020, 2050, 2070 and 2100, to be backed up by the Astana "Green Bridge" Initiative and related frameworks.	Kazakhstan	New
	Consider the global goal that, by 2020, Governments promote production processes using best technology for eco-efficiency, recycling, manufacturing, reuse of materials, product durability and longevity.	DPI/NGO conference	New
	Consider the global goal that, by 2020, the majority of the world's goods and services are procured by Governments from sources certified by objective third parties as sustainably produced.	DPI/NGO conference	New
	Consider long-term, global technology performance goals for key sectors, such as energy, water and waste.	Colombia, Guatemala	New

Notes: *= The wording of the proposals follows the text contained in the sources mentioned first in each row.
A21 := Agenda 21. Paragraph numbers provided in brackets. CBD=Convention on Biological Diversity. CA= Copenhagen Accord 2009.

The Copenhagen Accord in 2009 called for technology, finance and capacity building support (§3), to be registered (§5) and provided through a new "*Technology Mechanism to accelerate technology development and transfer*" (§11). Details of this mechanism are still being discussed.

In 2010, the "UN Summit on the Millennium Development Goals" resolved to "*promote the development and dissemination of appropriate, affordable and sustainable technology and the transfer of such technologies on mutually agreed terms*" (§60).

In contrast to certain public perceptions, WTO's TRIPS Agreement states that *"…the protection and enforcement of intellectual property rights should contribute to… technological innovation and to the transfer…of technology, to the mutual advantage of producers and users … and in a manner conducive to social and economic welfare, and to a balance of rights and obligations*" (Art. 7).

5. Delivery on commitments

Judgment is needed to assess delivery against the not-so-well defined commitments listed above. Yet, evidence is strong for the following conclusions. All global time-bound commitments listed in table 3 have been (or will most likely be) achieved. Overall delivery on the commitments that were not time-bound has been relatively good, with 16 types of commitments fully and 10 partially achieved. Yet, some glaring gaps remain with no significant progress reported for 9 types of commitments (table 4). Overall progress towards the agreed objectives has been better in the areas of technology transfer, mandates and market incentives, than in RD&D and knowledge sharing. Technology-oriented intergovernmental agreements might be considered essential in a multilateral world, but they remain under-developed compared to transport, trade, investment, and environment agreements. It is impossible to say whether delivery of commitments specifically relating to "green technology" has fared better or worse than those generic to technology.

6. Science and technology-related proposals for Rio+20

Table 5 provides an overview of the science and technology-related proposals contained in the official submissions of Member States, intergovernmental organizations, and major groups, including NGOs and the private sector.[25] The wording of the proposals closely follows the text in the submissions.

Fifteen of the 31 proposals are "new" suggestions (highlighted in red in table 5), in the sense that at present there are no agreed international commitments. They are primarily in the areas of policy environment, market incentives, global goals and targets.

Six proposals are elaborations on existing commitments, primarily in the form of institutional suggestions (indicated as "partly new" in table 5). Examples include the creation of global mechanisms on technology, research cooperation, and capacity building, as well as an Intergovernmental Panel on Sustainable Development and an enhanced Global Earth Observation Network.

The Rio+20 submissions did not cover 12 science and technology-related issues for which there are already existing global commitments. Eight of these are deemed to be already fully achieved and four of them at least partly. The submissions for Rio+20 are focussing primarily on those issues and commitments where insufficient progress has been made since 1992 (table 4).

In view of the strong interest by delegates in sustainable development goals, we provide additional details on the science and technology-related goals that have been put forward to the Rio+20 preparatory process (table 6). It should be noted, however, that numerous other proposals have been made in various fora by think tanks, NGOs, and other actors.[26]

Table 6. Technology-related goals and targets proposed recently.

Proposal by Colombia and Guatemala on Sustainable Development Goals (SDGs)[27]
The Governments of Colombia and Guatemala have put forward the most comprehensive proposal of SDGs. This proposal includes one general goal on financing and technology capacity and three goals specific to the energy and water sectors (without quantifications): • Sufficient financial and technological capacities at the regional, national and local levels… to implement waste reuse and recycling policies… by 20_. • _% of national energy needs are met from renewable sources by 20_. • Energy efficiency standards are in place and under implementation at national level. • Sectoral water use efficiency plans are in place by 20_.
DPI/NGO conference[28]
The final declaration from this conference of CSOs proposed one time-bound SDG on green technology: • By 2020, governments should promote production processes that reflect the best available technologies for eco-efficiency, recycling, remanufacturing, reuse of waste materials, product durability and longevity… By 2020, the majority of the world's goods and services are procured by governments from sources certified by objective third parties as sustainably produced. and suggested several general commitments to green technology: • Improved access to information technology, especially for young people; • Governments to implement a just transition to sustainable economies as fast as possible through an unprecedented level of cooperation and policy coherence by the sharing of green technologies and know-how. • Adoption of an intergovernmental mechanism or instrument to assess the environmental, health and socio-economic impacts of new and emerging technologies, in line with the precautionary principle. We call for the outright ban on technologies that put the planet at grave risk.
Millennium Consumption Goals (MCG) initiative
This initiative is organized in the form of an open dialogue, which means the content of MCGs is not fixed but evolves as new proposals emerge. A compilation of proposed MCGs is on the initiative's website.[29] It does not contain a specific technology goal, but proposes a time-bound energy technology goal: Increase renewable energy share to 15% by 2025.
Proposal by the Republic of Kazakhstan
The following phased targets were suggested: • From 2020: to reserve carbon-bearing primary energy sources for future generations through renewable energy. • By 2050: to halve the energy intensity of a unit of Gross World Product and to provide conditions for maintaining this energy intensity. • By 2070: to build up a backlog of non-renewable energy and to achieve global capacity of renewable energy at the level of global energy sufficiency for the period through to 2100. • By 2100: to identify technological levels of energy sufficiency for each country securing high human development index.

7. Towards SDGs on science and technology

There are only two time-bound goals/targets related to science and technology for sustainable development, and their delivery date has not yet expired: MDG 8.F and CBD Target 19. Discussions might focus on accelerating progress towards these goals and on additional time-bound, measurable goals/targets (table 7).

Table 7. Potential areas to be considered for technology goals.

It needs to "add-up" globally	**(a) Global technology performance improvement by a factor 4** This goal might be elaborated in the form of eco-efficiency targets for 2030 and 2050, for example: • Increase global resource and energy efficiency by a factor 4 by 2050. This might mean doubling the level of energy services, while halving primary energy and resource use and overall pollution. • Issue-specific technology performance targets for 2030: reduce energy and resource/materials intensity by at least 40 per cent and double the use of waste water treatment and solid waste management. • Issue-specific technology performance targets for 2020: increase by 20 per cent the water efficiency in agriculture and energy, as well as food supply-chain efficiency.
Need for equity	**(b) Universal access to sustainable technology** This goal might be elaborated in the form of universal access targets for modern, clean and affordable energy and transport services; clean water, sanitation, waste water treatment, recycling, solid waste management, and modern information and communications technologies, etc., by 2030.
Institutions need to be up to the challenge	**(c) Global green innovation system for sustainable development** This goal might be elaborated in the form of institutional and inputs targets by 2030, for example: • Global RD&D cooperation system that is open for participation by entities from all countries. • Global IPR system which promotes technology development, innovation, access and transfer. It would value quality over quantity; support new forms of licensing, voluntary patent pools, and free and open-source collaboration. • Combined public and private investment of at least 2 per cent of GDP in RD&D in all countries, and at least 3 per cent in technologically advanced economies. • Publicly-funded technology, scientific discoveries and creative works made freely available for sustainable development.

The purpose of the Rio 2012 Issues Briefs is to provide a channel for policymakers and other interested stakeholders to discuss and review issues relevant to the objective and themes of the conference, including a green economy in the context of sustainable development and poverty eradication, as well as the institutional framework for sustainable development.

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[1] Following Dobrov (1979), "technology" comprises not only material inputs and equipment, but also software (i.e., explicit and tacit knowledge and human skills) and "orgware" (institutions, regulations and cultural norms). In the long-run, there cannot be progress in technology without progress in science and vice versa.
[2] In addition to the energy technology examples provided here, similar statements apply to other technologies, in particular biotechnology and nanotechnology.
[3] Grübler, A., (1998). *Technology and Global Change*. Cambridge, United Kingdom: Cambridge University Press.
[4] Diamond, J., (2005). *Collapse: How Societies Choose to Fail or Succeed*. New York: Viking Press.
[5] Holdren, J.P., (2006). *The energy innovation imperative: addressing oil dependence, climate change, and other 21st century energy challenges*. Innovations: Technology, Governance, Globalization, vol. 1, No. 2, pp. 3-23.
[6] *World Economic and Social Survey 2011*, United Nations, http://www.un.org/en/development/desa/policy/wess/wess_current/2011wess.pdf
[7] Key World Energy Statistics 2010. International Energy Agency, 2010.
[8] van Vuuren, D. P., Riahi, K. (2008). *Do recent emission trends imply higher emissions forever?* Climatic Change, vol. 91, No. 3, pp. 237-248.
[9] Marchetti, C., Nakicenovic, N. (1979). *The dynamics of energy systems and the logistic substitution model*. IIASA, RR-79-13, cesaremarchetti.org/abstract.php?id=23.
[10] von Weizsäcker, E. U., Lovins, A.B., Lovins, L.H. (1998). *Factor Four: Doubling Wealth-Halving Resource Use-The New Report to the Club of Rome*. Earthscan.
[11] von Weizsäcker, E., et al. (2009). *Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity*, ISBN 9781844075911.
[12] Cullen, J., Allwood, J.M. (2010). *Theoretical efficiency limits for energy conversion devices*. Energy, vol. 35, No. 5 (19 January), pp. 2059-2069.
[13] The most ambitious global sustainable development scenarios (e.g., IPCC-B1 scenario) illustrate pathways toward a factor 3 improvement.
[14] Source: Brewer, T.L, (2008). *Climate change technology transfer: a new paradigm and policy agenda*, Climate Policy 8 (2008) p. 516-526.
[15] Data sources: World Bank, UNESCO Institute for Statistics.
[16] *Five-year review of the Mauritius Strategy…"*, United Nations, Report of the Secretary General, 5 July 2010, A/65/115.
[17] Nemet, G., Kammen, D. (2007). *U.S. energy research and development: declining investment…*. Energy Policy, vol. 35/1, p. 746-755.
[18] in PPP terms
[19] There is a large body of literature suggesting an increasingly "excessive" nature of IPR systems since the 1990s. Examples include: (a) National Research Council (1993). *Global dimensions of intellectual property rights in science and technology*, National Academy Press; (b) Louwaars et al. (2005). *Impacts of Strengthened Intellectual Property Rights Regimes on the Plant Breeding Industry in Developing Countries*, World Bank; (c) Kur and Levin (2011). *Intellectual Property Rights in a Fair World Trade System – Proposals for Reform of TRIPS*, Edward Elgar.
[20] EPO (2009). *Quality over quantity: on course to raise the bar*, http://www.epo.org/about-us/office/annual-report/2008/focus.html
[21] *Patents and clean energy: bridging the gap between evidence and policy*. UNEP, EPO and ICSTD (2011), www.epo.org/clean-energy
[22] Zhang, X., (2011). *A Network Analysis of Clean Technology Cooperation Programmes*, background research paper, United Nations DESA, 2011.
[23] International Energy Agency (2010). World Energy Outlook 2010. Paris: OECD.
[24] *Technology development and transfer of technology for Climate Change: A Survey of Activities by UN organizations*, Working Paper, UN DESA/UNIDO, 2010.
[25] The full text of official submissions to the preparatory process for Rio+20 are accessible here: http://www.uncsd2012.org/rio20/index.php?menu=115
[26] Additional proposals for goals and targets and their attainability are being reviewed by UN DESA in the context of the EU-funded project "*Sustainable Development in the 21st Century*", referred to as SD21 project, http://www.un.org/esa/dsd/dsd_sd21st/21_index.shtml.
[27] Rio+20: Sustainable Development Goals – Proposal by the Governments of Colombia and Guatemala for consideration by the participating countries, September 2011; http://www.eclac.org/rio20/noticias/paginas/9/43799/2011-613-Rio+20-Note_by_the_secretariat-Rev-1-30-08_Prop._Col_Guat.pdf
[28] http://www.uncsd2012.org/rio20/index.php?page=view&nr=273&type=230&menu=38
[29] http://www.mcgforum.org/wp-content/uploads/2011/08/Table-MCG-Summary-v2.pdf