WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ÉNERGIE
For sustainable energy.

ENERGY SECTOR ENVIRONMENTAL INNOVATION: UNDERSTANDING THE ROLES OF TECHNOLOGY DIFFUSION, INTELLECTUAL PROPERTY RIGHTS, AND SOUND ENVIRONMENTAL POLICY FOR CLIMATE CHANGE

I. Introduction

Addressing climate change and energy security presents extraordinary environmental, social, and economic challenges requiring national and international action by not only governments, but also the private sector and civil society. Greenhouse gas (GHG) emissions must be reduced and we must transform the way energy is produced and used. Massive and robust enabling environments will be required toward these ends, including appropriate technology mechanisms and a global trade and investment regime that enables and leverages investment, innovation, and technology uptake. Existing and new technologies are needed both to achieve climate change goals and to do so at the lowest possible economic cost (indeed, if properly implemented, climate change-related measures and economic growth can very well go hand-in-hand).

Engaging the private sector is critical in all of these efforts. Today, a significant amount of climate-related investments are paid for, and technology is advanced, by the private sector already. Certainly, these efforts are even more important in light of existing global economic conditions and the constrained budgets of developed countries in particular. As such, private investment and technology development needs to be facilitated and encouraged but to do so requires appropriate and effective enabling environments and political will.

Intellectual Property Rights (IPRs) are a key instrument. Private sector engagement requires strong and predictable IPR protection as a pre-requisite to invest in low carbon and energy efficient technology[1] innovation and diffusion. In addition, patent protection, specifically, supports the dissemination and advancement of technology itself, by providing notice of new technology solutions and assets through which to exchange expertise and giving innovators and companies the confidence they need to invest in, trade and share their technological knowhow with business partners, customers and others. By contrast, proposals to allow compulsory licensing or otherwise weaken or eliminate existing IPR protections for climate-related technologies are fundamentally detrimental to tackling climate change and development goals. They are also at odds with economic and policy research which confirms the critical, positive role the protection of clean energy technology IPR actually plays, and would create conflict and confusion with existing global IPR rules. Instead, a productive, positive agenda should be pursued.

This paper discusses these issues in greater detail. Section II discusses the importance of advancing technology to address climate change. Section III provides insight into how technology diffuses as a natural consequence of market expansion and discusses the environment necessary to support further diffusion. The discussion explores the wide variety of pathways through which technology may disseminate, including mechanism beyond typical patent licensing arrangements.

Sections IV and V examine how IPR helps support technology diffusion and why patents specifically are not a barrier to that goal. Then in Section VI, this paper clarifies why calls to erode or eliminate IPR protection fail to accomplish their objective to provide broader access to climate-related technologies. The evidence shows that they will in fact be counterproductive. Not only will policies like compulsory licensing of climate-related technologies block access to technology, but they may ultimately harm the growth of emerging and developing economies. Finally, in Section VII, the discussion closes by considering the broader context that pervades the climate change negotiations. While IPR plays an important role in technology dissemination, resolving finance and capacity building concerns may be even more vital. Technology simply cannot diffuse without appropriate infrastructure and the capacity to absorb it. It is these and other positive goals that the authors urge we should actually focus on.

II. New technology and private sector support are critical to addressing global climate change and energy challenges

The sheer volume of investment needed to address climate change challenges is staggering, but the cost of stabilization may be reduced dramatically by improving technology.[2] One study finds that if limited to currently available technologies, the present value cost of achieving stabilization at 550 ppm CO_2 would be over $20 trillion greater than with expected developments in energy efficiency, hydrogen energy technologies, advanced bio-energy, and wind and solar technologies.[3] Other studies have found that advancing technology development offers the potential to reduce costs of stabilization by over 50 percent.[4] While there is a wealth of technology available now[5], significant advances are still required. Therefore, managing climate change requires driving technology investment.

Even with the aid of advanced technology, however, the required investments are sizable. The private sector will have to be engaged. Yvo de Boer, former UNFCCC Secretary General, estimated cutting emissions will cost an *additional* $200 billion (USD) in global, annual investment.[6] The IEA predicts even greater capital expenditures will be required – specifically $750 billion (USD) annually from 2010 to 2030 and over $12.6 trillion (USD) between 2030 and 2050.[7] While the exact level of investment depends on a variety of factors, the total amount necessary is massive. The private sector has been and will continue to be a significant source of the required funds.[8]

Clean energy technology, in particular, relies heavily on private sector investment. In 2009, nearly $25 billion (USD) was spent on clean energy technology R&D alone, sixty percent of which was privately financed[9]. Among OECD countries, private companies account for almost two-thirds of R&D investment.[10] Europe exhibits an even higher dependence on industry investment, providing nearly seventy percent of the region's clean energy R&D funding.[11] Private sources supplied seventy-two percent of R&D spending in China over the same period.[12]

Support from the private sector provides additional clean energy investments, beyond R&D as well. Despite overall declines in venture capital and private equity investment, for example, private equity and venture capital alone financed nearly $7 billion (USD) in renewable energy and clean energy technology globally in 2009.[13] Leveraging private sector investment is all the more urgent in the current economic climate, where many countries are under budgetary pressure. Smart, targeted policies aimed at encouraging and leveraging private sector investment and trade are essential. In addition to providing financial support, an increase in private sector activity will aid in economic recovery by providing new jobs and exports. The private sector, therefore, is expected to make significant advances in improving clean energy technology[14] and encouraging and enabling such investment is of absolutely central importance. Facilitating the spread of these technology developments will make tackling climate change considerably more affordable.[15]

III. Understanding and facilitating the global diffusion of technology

The United Nations Framework Convention on Climate Change (UNFCCC) has long recognized the need for these critical advances to be deployed globally.[16] In its charter, the UNFCCC explicitly required its Parties to "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technology and know-how to other Parties, *particularly developing country Parties*."[17] However, it is imperative that technology be allowed to flow freely within and between *all* markets. An increasing volume of innovation originates from the emerging economies,[18] a function of increasing GDP growth and R&D spend in countries like China, India, and Brazil[19].

The wealth of innovation taking place in emerging economies is not surprising as they are able to adopt breakthrough technology[20] unhampered by the legacy infrastructure of the developed world.[21] Due to larger populations and lower per capita incomes, emerging economies are able to tackle many environmental challenges more quickly and at a lower cost than the rest of the world.[22] The most effective solutions may therefore originate from the emerging and developing world.

Confronting climate change effectively requires implementing solutions adapted to local environments and circumstances.[23] Local innovators are best positioned to design solutions tailored to local conditions.[24] As a result, many private firms spend significant R&D budget outside their home countries to access local talent and the ideas they generate.[25] Clearly, advances in emerging and developing countries create technical solutions of global benefit that need to be disseminated as rapidly as possible.[26]

A. Technology sharing arrangements and other methods of gaining access to innovation

Since embracing innovation from all sources and disseminating the results is vital to addressing climate change, appreciating how technology flows is equally critical. Technology diffusion – in the sense of technologies being adopted locally, know-how being shared, and the local population and workforce using and learning how to use new and innovative technologies – is not something that occurs overnight or that can be forced upon participants. It takes many forms, with varied approaches generally tailored to the parties and their particular circumstances. There are three principal avenues for technology sharing: trade, cooperative agreements, and assignments of rights.

One of the most basic means for sharing technology is through trade, e.g., a product sale, where the purchaser acquires an embodiment of the innovation.[27] The sale gives the purchaser the right to use the technology. And the purchaser gains an understanding of how the technology functions, by operating the equipment. The sale of more complex machinery results in an even broader dissemination of knowledge. Here, the seller provides information to enable the purchaser to install and operate equipment.[28] Such transfers include technical diagrams, instruction manuals, and frequently the training of personnel.[29] In both cases new technical knowledge derived from installing and operating equipment enables follow on inventions, which can result in new intellectual property.[30]

Often, parties engage in transactions specifically designed to transfer or generate technology. For example, cooperative agreements such as joint ventures or equivalent partnerships enable parties to obtain complementary skills or resources. In such transactions, knowledge is shared between partners to develop new products or services.[31] Similar relationships are forged between manufacturers and suppliers. The manufacturer provides design specifications and the knowledge to execute them to its supplier. In both these relationships, there is a substantial incentive to share information openly between partners. Generally the more forthcoming the firms are able to be, the more fruitful the collaboration.

Licensing or actual sales of a patent are typically considered the quintessential example of technology transfer. These assignments of rights however, absent provisions to the contrary, involve little, if any, transfer of knowledge. The transaction simply provides the licensee or owner the right to practice the technology. Typically, the patent's publication is a matter of public record prior to any transaction. An additional transfer of know-how may be negotiated, but the sharing of knowledge that is likely protected as a trade secret does not occur as a matter of right. Outward Foreign Direct Investment (FDI), or the purchase of foreign firms that own technology not available domestically, is often a more direct mechanism to obtain technology and the requisite know-how.[32]

Other models, while not sharing arrangements per se, can promote technology uptake in new markets. For instance, a subsidiary of a multinational company may set up service or manufacturing centers in a new country, sharing its know-how with the local workforce.[33] Employees trained in the new technologies gain knowledge that can be used within the multinational firm and in other ventures.[34] A local population can also gain access to technologies through the wealth of publicly available knowledge. With numerous online patent and journal repositories, countless sources of technical information can be gleaned. While reviewing literature may not be the most efficient means of absorbing new technologies, it is nonetheless a useful source of technological information, especially in regions where the associated patents are not registered.[35]

B. Encouraging firms to develop and share technology

Given that the principal mechanisms for a country to access new technologies are through trade and FDI,[36] private firms play a vital role in introducing scientific breakthroughs to new markets[37]. FDI is especially significant in the emerging and developing world, where it accounts for over twenty five percent of GDP.[38] Private firms enhance technology diffusion by financing new machinery, equipment purchases and even R&D.[39] In addition to providing financial resources, these firms are also the best source of know-how and experience necessary to deploy carbon reduction and clean energy solutions in a cost effective manner.

Encouraging private sector participation in technology diffusion requires a clear understanding of what motivates private enterprise. The private sector is focused on enhancing the value and long term sustainability of their enterprises. Therefore, private firms must be able to profit by introducing their innovations to the market in order for technology to flow.[40] And while the private sector is well suited to deal with typical business risk, the *ability* to profit does not imply uniformly successful investments.[41] Rather, it requires a strong likelihood that profits will be realized from an investment upon meeting success in the market. In other words, the ability to profit requires predictable returns.

Patent protection specifically and IPR generally are pre-requisites for investment in technology.[42] Many firms simply will not commit R&D funding without effective protection in place.[43] Robust IPR brings clarity and certainty to the market. Without it, the private sector has nothing to sell, license, or even give away.[44] Regions with predictable and meaningful IPR encourage firms to disseminate technology more quickly since it provides industry a means to recoup its investments. It enables the introduction of technology to new markets through partnering with the individuals and institutions that have the best ideas and access to resources. By contrast, countries with weak IPR regimes are often denied access to innovation[45], and to the detriment of both consumers and their economies. Ultimately, strong IPR generally results in faster technology dissemination.[46]

IV. Patents and other forms of Intellectual Property Rights enable broad based clean energy technology diffusion

Patents provide a mechanism to share technology advances on a global basis. By requiring and incentivizing the publication of key research results and scientific data through the patent system, IPR regimes support further innovation and development of new, derived products and technologies. Frequently, the discovery of one inventor's solution can drive other inventors to find new and more efficient ways to solve the same problem. Entities interested in a particular technology domain tend to closely monitor patent publication activity as it provides valuable data about who is doing what and how to achieve the next step in the technological evolution. Thus, publication of clean energy technology patent applications can serve as a catalyst for technology-centric transactions like acquisitions, partnerships, and licensing. With the extensive availability of online patent databases, these technology advances efficiently reach the entities best able to realize their commercial potential.

Patent publication also acts as a notice of unperfected rights. There is no such thing as an international patent.[47] Patents are local assets. And relatively few, if any, patents are registered in every country with a patent regime. As a result, they can be used freely by parties in jurisdictions where patent protection was not sought. In these circumstances, copying the relevant technology is a legitimate use of these innovations.[48] Similarly, the publication requirement is designed to enable widespread use of a technology after the patent expires and in those jurisdictions where protection has not been sought. This mechanism is especially relevant for clean energy technology, since many of the basic approaches involved have long been off-patent.[49]

Patents also help convert innovation into "tradable economic assets".[50] At the most basic level, they allow innovators to capture the value of their R&D activity, stimulating investment that might otherwise not occur.[51] However, there are numerous other examples where patents, in and of themselves, support technology dissemination. Firms often license their patents to suppliers to produce the individual components of a larger product. As a result, the supplier obtains access to a new technology that promotes further innovation. In small firms lacking the financial wherewithal to commercially develop breakthrough technology, obtaining an issued patent can facilitate securing capital. Here, an issued patent provides some security to potential investors that the proposed technology is actually new and useful. As a result, a product that would otherwise never have existed now has a path to market. Patents are also employed by academic and research institutions to transform their innovations into licensing income streams, which in turn may be used to support further research.[52] Accordingly, patents serve as a vital trade asset and a driving force behind innovation based economies.

IPR not only provides a means to disseminate technology, but it also enables faster technology development and diffusion through partnerships. In a partnership, parties generally provide each other access to both the relevant patents and related know-how. Such communication can be critical when it comes to clean energy technology. Clean energy technology often presents itself in the form of complex machinery, where a single technology might require hundreds of patents to be useful. Many parties may have the right to use the related patents based on licenses, a lack of local patent protection, or because the basic technology is already off patent. However, the right to practice the technology does not provide the *ability* to use it.

To truly speed up technology diffusion, partners need to feel comfortable sharing information with each other, as openly as possible. When firms do invest in regions with less than robust IPR regimes, they often rely on self-help to protect their investments.[53] As a result, firms may restrict access to competitively important information, limiting the amount of diffusion that can take place. Without the free flow of information, the advantages of partnership are greatly diminished. Not only do these limitations slow the whole process down, but it can also prevent or hamper follow-on innovation.

On the other hand, strong and predictable IPR both supports and drives partnerships. It helps potential partners clearly identify what each party brings to the relationship to better understand the value collaboration may bring. Where it is clear that meaningful trade secret protection exists, parties are more likely to broaden the disclosure of relevant know-how. As a result, technology develops faster since parties can capitalize on each other's expertise. Patents also provide a mechanism to build on a partnership's success. Innovation resulting from these ventures may be patented, resulting in further information sharing. And as information becomes more widely shared, ownership of technology solutions diversifies, encouraging collaboration and competition. Thus partnerships, reinforced by IPR, enable faster technology development and diffusion in a dynamic innovation environment.

V. Patents are not a barrier to technology diffusion for clean energy technology

In the context of clean energy technology, many have claimed that patents are a barrier to technology diffusion.[54] However, evidence of actual cases where costs relating to IPR have been restrictive in the adoption of these technologies has been sorely lacking. Two economists, Daniel Johnson and Kristina Lybecker, exhaustively reviewed the literature on environmental innovation, technology dissemination, and financing, in addition to empirical experience, objectively considering the role IPRs play in technology diffusion.[55] Their study found broad agreement that IPRs play a positive role in low-carbon technology markets. Significantly, they concluded that criticisms of IPRs as a barrier to technology not only lack economic and analytical foundation and rigor, but ignore the essential character of IPR protection in promoting innovation and enabling technology uptake, both generally and specifically in the case of clean energy technology.[56] Their findings, moreover, are consistent with numerous other analyses and studies performed by Barton, Newell, Copenhagen Economics, the OECD, the UNFCCC, the WTO and others[57].

The evidence shows that Intellectual Property Rights are a key driver of innovation, deployment, and dissemination. As discussed above, effective IPR protection encourages innovators to publish their discoveries and designs while allowing them to capture the value of R&D activity, thus stimulating in innovation that might otherwise not occur.[58] Moreover, particularly in the case of many of the least developed countries, inventors have often chosen to forgo local patent protection.[59] Less than 1% of climate related technologies are patented in these regions.[60] Thus, patent protection cannot possibly be a barrier to technology dissemination in these locales since no relevant rights exist in those regions.[61]

A. Experiences with patents in Ozone Depleting Substances technology are not appropriate comparisons to clean energy technologies as a whole

A small group of countries and non-governmental organizations (NGOs), such as the Third World Network and South Centre, nonetheless maintain that IPR protection limits the dissemination of low-carbon and renewable energy technologies, particularly with respect to the emerging and developing world.[62] In what appears to be a concerted approach, negotiators from several major emerging economies, and representatives of these and other influential NGOs, have asserted – in the UNFCCC[63], WTO[64], and WIPO[65] – that IPRs are a key barrier to technology transfer and must, therefore, be weakened. However, as discussed above, these viewpoints and proposals generally lack a basis in existing scientific and economic consensus on the subject.

Many of the NGO positions in particular, appear to draw heavily on two studies – "Technology Transfer for the Ozone Layer: Lessons for Climate Change,"[66] and a UNCTAD case study.[67] These studies consider the role of IPR in the transfer of a narrow subset of technologies, in the specific context of the Montreal Protocol.[68] With respect to the Ozone Depleting Substances (ODS) discussed, the technology environment bears more similarity to the pharmaceutical innovation than clean energy technology. Specifically, for many ODS solutions, the entire patent estate is owned by just a few actors.[69] By contrast, the technologies necessary to address climate change are varied[70] and ownership is widely distributed among numerous parties. For example, the top ten applicants in carbon capture technology and integrated gasification combined cycle (IGCC) own less than half of all patents related to that technology. [71] There is no basis for asserting, based on conclusions from these targeted studies, that IPR is a key barrier to accessing *all* types of clean energy technologies.[72]

B. Patents in the pharmaceutical industry play a fundamentally different role than patents in the clean energy technology space.

For many emerging and developing nations, understanding of the role of patents has been shaped by their experience obtaining access to medicines. However, patents play a profoundly different role in their support of clean energy technologies compared to the pharmaceutical sector.[73] As research progresses into the underlying functions of the human body, entirely new drugs for a wide variety of physical ailments are constantly discovered. In other words, the core scientific principles to cure a disease are constantly evolving. Treating diseases generally requires focusing on a specific biological mechanism, effectively limiting the number of substitute drugs.[74] As a result, an individual patent may have a substantial impact, giving its owner a strong market position where it is registered.[75]

By contrast, most of the basic technology approaches to address climate change have long been off-patent[76] and are already widely used[77]. For example, wind power was used to generate electricity in the late 19th century.[78] Similarly, the photovoltaic effect, which serves as the basis for solar technology, was discovered around the same time frame and solar cells emerged by the mid-20th century.[79] Instead of unearthing entirely new approaches, clean energy technology patents usually relate to specific improvements or features of existing solutions.[80] Thus, today's patents address efficiency and other incremental improvements of technology. Even without access to these improvements, many countries could benefit from employing publically available clean energy technology.

Competitive dynamics within clean energy technology sectors also differ dramatically from the pharmaceutical industry. Patent ownership within clean energy technology segments themselves is generally distributed amongst numerous owners, limiting the impact of any one asset. Competition exists not only within clean energy technology segments, but across sectors as well.[81] As a result of the considerable competition, patents do not contribute significantly to the cost of deploying clean energy technology solutions.[82] Given the competitive dynamics, a firm charging high prices for its IPR would simply price itself out of the market.

VI. The weakening of patents, especially compulsory licensing, is generally a poor mechanism to diffuse technology.

Some countries advocate compulsory licensing to enable broader access to critical technology solutions. Providing free or reduced cost access may yield benefits in the short term, but such a result is far from certain. Addressing climate change requires producing more complex offerings, which generally necessitates access to a combination of patented innovation and know how. Essentially, FDI is required to implement technologies that are currently non-existent in a region.[83]

Even if a country somehow achieves access to a desired technology through compulsory licensing, it will severely damage the incentive for the further innovation necessary to achieve improved efficiency and lower price points or to develop more tailor-made solutions specific to local demands and needs. As discussed above, private companies require predictable investments which are generally facilitated by robust IPR.[84] Granting licenses to entities outside the innovation chain prevents participating entities from recouping their investments. It cuts off long-term access to technology improvements as it discourages private sector investment. As a policy tool, compulsory licensing should only be applied in extraordinary circumstances and as narrowly as possible to limit its economic impact. This is precisely how it was foreseen in the carefully negotiated provisions on compulsory licensing contained in the WTO Agreement on trade-related intellectual property rights (TRIPS).

VII. The growing importance of Intellectual Property Rights to emerging and developing economies

Emerging economies haven already begun to invest heavily in clean energy technology innovation and deployment.[85] They have large populations, modest per capita GDP, and legacy energy-inefficient manufacturing. Each faces important adaptation challenges, including sustaining economic growth while dealing with global threat of climate change.[86] At the same time each of the major emerging economies has significant and increasing financial and economic clout and a proven track record of technological innovation. They are increasingly competitive and continue to attract Western research and technology investment. China is already ranked as the world's third leading R&D investor, fueled by ambitious policy goals.[87] Others, such as Brazil, Russia, and India, are similarly engaged.[88] These R&D investments are critical in raising absorptive capacity for new technology, to further advance technology diffusion. [89]

As emerging economies enhance their technical foundations, many of these countries are rapidly rising in global patent and innovation rankings.[90] China ranks fourth among patent applicants under the international Patent Cooperation Treaty

(PCT), with strong annual growth rates indicated intensive innovative activity.[91] In fact, two Chinese companies are in the top five PCT filers worldwide.[92] And while there is still a gap in patent protection between developed and emerging countries, it is narrowing fast.[93] As that gap shrinks, emerging market firms are being increasingly recognized as innovators. For example, in a recent survey of business executives, twenty percent of the top fifty innovative companies are based in emerging markets, including two companies from India and four from China.[94] The emerging markets continue to grow their innovative capacity in many domains, including in those technologies necessary to address climate change.

With respect to clean energy technologies, patent registration in emerging markets has grown dramatically, far outpacing the developed world.[95] A large and growing percentage of these patents are owned by domestic entities.[96] In these markets, patent estates are building in niche technology areas.[97] For example, India has concentrated on solar and carbon capture technologies while Brazil and Mexico focus on hydro/marine and biofuel technology.[98] Similarly, China's filings in geothermal technology match those of other top filers such as the UK, Sweden and Italy.[99] This specialization reflects the wealth of local resources available as well as growing domestic expertise. In many instances, emerging economies can use entirely "homegrown" technology instead of accessing solutions from the developed world.[100] In fact, in many of the related industries, emerging market firms are world leaders in their fields.[101]

China is home to the world's fourth largest PV producer, Suntech Power Co., Ltd., which exports the majority of its production to other markets.[102] At China's current production levels and with over 400 solar companies, the country is the leading global manufacturer of solar panels.[103] Government initiatives to increase solar technology have helped both India and China enhance local production of PV equipment.[104] Similarly, emerging markets host important leaders of wind technology as well. In 2010, India became the fifth biggest producer of wind power in the world.[105] Suzlon, India's first "homegrown" wind firm, has enjoyed rapid international growth especially due to its ability to deliver to clients faster than its main competitors.[106] As early as 2003, the company was exporting significant portions of its production to the US and continues to grow.[107] Chinese domestic wind companies such as Goldwind, Sinovel, and China Wind Systems also lead the industry.[108]

As emerging market firms continue to grow and solidify their market positions, meaningful IPR will be critical to their ongoing success. It will help attract foreign investors to partner with local firms, introducing them to new technologies. Many emerging market firms have used or will use IPR to seek proprietary protection of their own technology.[109] As discussed above, patents themselves provide a means for companies to recoup their investments in developing new technology and bringing it to market. Building patent portfolios will aid emerging market firms, not only in their continued supply of domestic markets, but in their potential to export to other markets. The growth of emerging market industry leaders such as Suntech and Suzlon has been fueled by their ability to serve customers outside their home markets. At this stage in development, patents can greatly help domestic innovators and pushing for flexible IPR regimes only undermines their growth potential. Robust IPR protection is essential from a competitiveness, employment and economic development perspective.

VIII. The protection of patents and trade secrets alone is insufficient to solving climate change challenges

Without strong and stable IPR regimes, technology diffusion will be difficult at best. While accessing the relevant technology itself is important, many countries, especially the world's poorest and most vulnerable developing countries face greater challenges to addressing climate change. The Bali Action Plan and other climate change frameworks recognize that developing countries are in a different position from industrialized and emerging economies. According to the UNFCCC, between $28 and $67 billion will be required annually to help developing countries adapt to climate change.[110] Estimates for total funding needed for both adaptation and mitigation efforts are in the range of $65 to $90 billion a year. Estimates for total funding needed for both adaptation and mitigation efforts are in the range of $65 billion to $90 billion a year.[111] While these numbers include both emerging economies and developing countries, the International Energy Agency estimates that Africa alone needs to spend approximately $560 billion by 2030 for additional energy generation,[112] much of which will need to be directed towards clean energy. Dealing with adaptation challenges in the poorest and most vulnerable developing countries and helping them join the new green economy of the twenty-first century will add billions more. A multi-part agenda should therefore be pursued.

Financing is of course critical as the poorest and most vulnerable developing countries lack the economic and financial means that industrialized and emerging economies can direct to clean energy technology innovation and deployment. As such, these countries cannot rely on their domestic resources alone; a combination of government funding and investment by private industry will be necessary.

Effective capacity building and the creation of functioning enabling environments provide another pillar. The poorest and most vulnerable countries must be supported in their efforts to develop robust enabling environments and thus gain the benefits of technology, innovation, investment and trade.[113] Technology diffusion – in the sense of technologies being adopted locally, know-how being shared, and the local population and workforce using and learning how to use new and innovative technologies – is not something that happens overnight or that can be forced upon participants. It requires substantial financing, real investment in physical infrastructure, incentive policies and legal safeguards to investment. It requires education and training of human capital to form a strong local knowledgebase, without which there would be no resources to absorb the new technologies.[114] Finally it requires local investment, trade, the presence of informed engineers or management who work with the local workforce or local business partners, and a receptive regulatory environment.[115] Only when these key "enablers" are in place, will active private sector commitment be sustainable and will actual technology diffusion occur.

IX. Conclusion

While addressing climate change requires significant levels of investment, that burden can be significantly eased through technology and firm, private sector support. Promoting low carbon and energy-efficient technology development and diffusion on a global basis is critical. Today, a sizeable percentage of the necessary investments, in terms of both financial support and technical expertise, originate from the private sector. Government policies must nurture appropriate enabling environments that allow and *encourage* their continued engagement.

When determining the most efficient means for technology to diffuse, it is important to consider the many ways it naturally flows. Product sales and service arrangements serve as the foundation for further dissemination. Without a basic understanding of the underlying technology, more complex transfers of knowledge are practically impossible. It is equally important to recognize that technology advances come from developed, emerging and developing countries, especially with respect to clean energy technology. Since the effectiveness of clean energy technology is often a function of the local environments and circumstances, innovators needs to understand more than pure technical aspects. Innovators need to equip themselves with a broader context.

However, few actors possess both technical and local expertise. As such, the fastest way to promote climate-related innovation is through partnership. By connecting local and technical experts, solutions can be discovered much more quickly. The ongoing negotiations at the UNFCCC, especially with respect to setting up a Technology Mechanism, may help foster these connections. However, what may be more vital is to ensure robust IPR protection to both support continued investments and to give private businesses the confidence they need to trade and invest in and to share their know-how and knowledge alike.

Patents and other forms of IPR enable broad based technology diffusion. When patent applications are published, they serve as a window to new solutions and a catalyst to generate technology transactions. Patents can also help secure funding for start-up firms and define what technologies different parties can bring to a venture. Meaningful trade secret protection also supports innovation, by allowing more open sharing between parties. And with the free flow of information comes new ideas and technology advances.

IPR most certainly does not act as a barrier to diffusion, especially with respect to clean energy technology. In fact, the opposite is true. Much off the basic technology is already off patent and ownership of patents regarding the most recent advances is widely distributed. While patents serve to help innovators recoup their investments, they generally do not contribute significantly to the costs of deploying clean energy technology solutions.

IP is already sufficiently well regulated at the international level; there is no need to add new, potentially conflicting mandates into UNFCCC negotiations or elsewhere and doing so may be counterproductive.[116] Importantly, calls to erode IPR protection will not aid in technology diffusion or to achieve overall climate change goals. Compulsory licensing does not provide the critical know-how required to deploy what are often complex clean energy technology solutions. Further, such polices will also impede any follow-on innovation. And as emerging and developing economies enhance their technical foundations, they have the most to lose by not robustly protecting IPR. Their future economic growth depends on their ability to develop and export "homegrown" technology solutions and become a true part of global supply chains. Reliable IPR supports those goals.

IPR protection is a critical enabler of innovation, and the development and diffusion of technology around the world, both today and in the future. However, protection of these rights alone is insufficient to solving climate change challenges. Building the right foundations, by establishing a stable, long-term and transparent policy framework and ensuring adequate financing, infrastructure, and absorptive capacity, are equally, if not more critical, especially for the poorest and most vulnerable countries. Without these key enablers, technology diffusion generally, and sustainable private sector engagement specifically, is unlikely to occur.

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[1] Henceforth referred to as clean energy technology

[2] Edmonds JA, Wise MA, Dooley JJ, Kim SH, Smith SJ, Runci PJ, Clarke LE, Malone EL, Stokes GM "Global Energy Technology Strategy: Addressing Climate Change," Global Energy Technology Strategy Program, May 2007. (Edmonds), pg. 39; Newell R. "A U.S. Innovation Strategy for Climate Change Mitigation" Discussion Paper 2008-15. Hamilton Project, Brookings Institution, Washington D.C. (Newell), pg. 14-15

[3] Edmonds, pg. 39

[4] Newell, pg. 14

[5] UNCED. Agenda 21. Available at: http://www.un.org/esa/dsd/agenda21/res_agenda21_00.shtml¶ 34.9

[6] UNFCCC. "Investment and Financial Flows to Address Climate Change." Bonn 2007. (UNFCCC 2007) pg. 92; UNEP Press Release. 17 Aug 2007. Available at: http://www.unep.org/climatechange/adaptation/informationmaterials/news/pressrelease/tabid/6710/default.aspx?documentid=594&articleid=6270&. This in in addition to the $100 billion (USD) annual costs required to cope with adaptation.

[7] IEA. "Executive Summary" in "Energy Technology Perspectives 2010: Scenarios & Strategies to 2050." 2010, pg. 53. The estimates are based on the Blue map scenario which sets the goal of halving global energy-related CO_2 emissions by 2050 compared to 2005 levels. *Id*. at 47

[8] IEA. "Global Gaps in Clean Energy R&D. Update and Recommendations for International Collaboration." 2010, pg. 9

[9] UNEP, SEFI and New Energy Finance. "Global trends in Sustainable Energy Investment 2010." 2010. (UNEP SEFI), pg. 25 based on Figure 20. Another source estimates clean energy R&D spending closer to $20 billion (USD*). World Economic Forum. "Green Investing 2010. Policy Mechanism to bridge the Financing Gap."* January 2010, pg. 13

[10] Based on 2010 figures. OECD. "Main science and Technology Indicators, 2010/2". 2011, pg. 18

[11] Europe's private sector contributed $8.1 billion (USD) of $11.6 billion (USD) spent on clean energy R&D in 2009. UNEP SEFI, pg. 26

[12] *Id*. at 18

[13] *Id*. at 27. Note that this reflects a 42% decline from the previous year and activity increased in 2010. *Id*.

[14] World Bank."Global Economic Prospects: Technology Diffusion in the Developing World" 2008. (World Bank 2008), pg. 2

[15] Edmonds pg. 39; Newell, pg. 14-15

[16] For example, *See generally* UN. "United Nations Framework Convention on Climate Change" 1992.

[17] *Id*. at Article 4.5, *emphasis added*

[18] For example, the highest volume of Patent Cooperation Treaty (PCT) applications in 2010 came from East Asia . *See* WIPO. "PCT: The International Patent System: Yearly Review." 2010. (WIPO 2010), pg. 3, 7. World Bank 2008, pg. 61 One study finds that within emerging economies, the major patent owners for most carbon abatement technologies are within the emerging economies themselves. •

Copenhagen Economics. "Are IPR a Barrier to the Transfer of Climate Change Technology?" 19 January 2009. (Copenhagen Economics), pg. 36

[19] WIPO 2010, pg. 8, Table 1

[20] World Bank 2008, pg. 5

[21] Immelt JR, Govindarajan V, Trimble C. "How GE is Disrupting Itself". Harvard Business Review. Volume 87. Issue 10. October 2009, pg. 56-65, Reprint (Immelt) pg. 4

[22] *Id*.

[23] *See* Idris K, Arai H. “The Intellectual Property-Conscious Nation: Mapping the Path from Developing to Developed” WIPO. 2006. (WIPO 2006), pg. 28 *See also* GE Reports. GE Innovation Barrometer. January 2011. Available at: http://files.gereports.com/wp-content/uploads/2011/01/GIB-results.pdf, pg. 20. Some technologies can only be applied in particular conditions. Johnson DKN, Lybecker KM. “Innovating for an Uncertain Market: A literature review of the constraints on environmental innovation” Colorado College Working Paper 2009-06. July 2009. (Johnson 2009), pg. 4. For example, wind technology is only appropriate in locations that experience regular high wind patterns. Similarly, solutions requiring access to an electrical grid may be ineffective areas lacking this type of infrastructure.
[24] *See Id*. at 4
[25] Jaruzelski B, Dehoff K “Beyond Borders: The Global Innovation 1000” Strategy & Business Magazine. Issue 53. Winter 2008. pg.56-57
[26] Immelt pg. 5;World Bank, pg. 54-55
[27] Copenhagen Economics, pg. 18
[28] UNCTAD. “Transfer of Technology” 2001. Available at: http://unctad.org/en/docs//psiteiitd28.en.pdf (UNCTAD 2001), pg. 7
[29]. *Id*. at 6-7
[30] WIPO 2006, pg. 26.
[31] *See* UNCTAD 2001, pg. 7
[32] World Bank 2008, pg. 120
[33] UNCTAD 2001, pg. 12
[34] World Bank 2008, pg. 117
[35] In jurisdictions where patents are not registered, the technology may be freely copied. Copenhagen Economics, pg. 18
[36] World Bank 2008, pg. 106; WIPO 2006, pg. 27;
[37] UNCTAD 2001, pg. 12; OECD. “Research and Development: Going Global” 2008., pg.2
[38] UNCTAD. “Foreign Direct Investment in LDCs: Lessons Learned from the Decade 2001-2010 and the Way forward.” 2011, pg. 41-42
[39] World Bank 2008, pg. 116
[40] pg. *Id*. at 109
[41] While firms strive to pick winning technology solutions, there is no guarantee that the chosen approach will work for the market.
[42] Johnson 2009, pg. 15, 21
[43] UNEP/EPO/ICTSD. “Patents and Clean Energy bridging the gap between evidence and policy, Final Report.” 2010. (UNEP/EPO/ICTSD),pg. 58; Johnson 2009, pg. 12
[44] *See* WIPO 2006, pg. 18
[45] World Bank 2008, pg. 121; *See also* Copenhagen Economics, pg. 29
[46] See generally Johnson 2009; Atun R, Harvey I, Wild J. “Innovation, Patents and Economic Growth” Imperial College Discussion Paper 5, 2006. pg. 3
[47] While the Patent Cooperation Treaty (PCT) allows the filing of a patent application in multiple jurisdictions simultaneously, separate patent protection must be secured and more importantly paid for in each jurisdiction.
[48] *See* WIPO 2006, pg. 28
[49] Barton JH. “Intellectual Property and Access to Clean Energy Technologies in Developing Countries” ICTSD. Trade and Sustainable Energy Series. Issue Paper 2. 2007. (Barton 2007), pg. 4
[50] WIPO 2006. pg. 18
[51] *Id*. at. 37; *See also* Copenhagen Economics, pg. 9
[52] *See* WIPO 2006, pg. 27
[53] Copenhagen Economics, pg. 29
[54] *e.g.* ICTSD. “Climate Change, Technology Transfer and Intellectual Property Rights” ICTSD Background Paper, Trade and Climate Change Seminar, June 18-20, 2008, Copenhagen Denmark, pg. iv and Center for American Progress. “Breaking Through on Technology Overcoming the barriers to the development and wide deployment of low-carbon technology” July 2009. pg. 2
[55] Johnson 2009; Johnson DKN, and Lybecker, KM. “Challenges to Technology Transfer: A Literature Review of the Constraints on Environmental Technology Dissemination” July 2009. Colorado College Working Paper 2009-07; and Johnson DKN, and Lybecker KM. “Financing Environmental Improvements:

A Literature Review of the Constraints on Financing Environmental Innovation", July 2009 Colorado College Working Paper 2009-08.

[56] Johnson 2009, pg. 11

[57] *See, e.g.*, Barton 2007; Barton JH. "Mitigating Climate Change Through Technology Transfer: Addressing the Needs of Developing Countries", Chatham House, Energy, Environment and Development Programme: Programme Paper 08/02, October 2008; Newell R, "International Climate Technology Strategies", Discussion Paper 08-12, Harvard Project on International Climate Agreements, October 2008, p. 25; Copenhagen Economics; "'Research and Development: Going Global" OECD Policy Brief, July 2008; UNFCCC, "Enabling Environments for Technology Transfer", 4 June 2003; World Trade Organization, "Trade and Transfer of Technology", Background Note by the Secretariat, WT/WGTTT/W/1, 2 April 2002.

[58] [UNCTAD 2001] pg. 18-19

[59] Copenhagen Economics, pg. 18

[60] *Id*. at 4-5,

[61] *Id*. at 15-16

[62] *e.g.,* Khor M. "Challenges of the Green Economy Concept and Policies in the Context of Sustainable Development, Poverty and Equity" in UN-DESA/UNEP/UNCTD. "The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective." 2011 (Khor 2011), pg. 88, Third World network comments on WIPO. "Report on the International Patent System." 2009. SCP/12/3 Rev. 2. Annex III. Available at: http://www.wipo.int/edocs/mdocs/scp/en/scp_12/scp_12_3_rev_2-annex3.pdf (TWN 2009), pg. 11-12

[63] *e.g.,* Ad Hoc Working Group on Long-Term Cooperative Action, Sixth session, Bonn, 1–12 June 2009, Doc. FCCC/AWGLCA/2009/INF.1, 22 June 2009, Revised Negotiating Text at p.185; UNFCCC.FCCC/CP/2011/INF.2/Add.1(India, 7 October 2011)

[64] *e.g.*, WTO document TN/TE/W/79 (China and India, 15 April 2011)

[65] TWN 2009, pg. 11-12

[66] Andersen SO, Sarma KM, Taddonio KN. "Technology Transfer for the Ozone Layer: Lessors for Climate Change" 2007 (Anderson 2007).

[67] Watal J. "Case Study 3 India: the Issue of Technology Transfer in the Context of the Montreal Protocol" in Jha V, Hoffman U (eds.). "Achieving Objectives of Multilateral Environmental Agreements. UNCTAD/ITCD/TED/6, (Watal), pg. 45-55.

[68] Both studies discuss the transfer of Ozone Depleting Substances (ODS). *See* Anderson 2007, pgs 105-254 and Watal 1998

[69] *See* Watal

[70] *See* Copenhagen Economics, pgs. 19-20; *See also* UNEP/EPO/ICTSD, pg. 15

[71] For example, the top ten applicants in carbon capture technology and IGCC own less than half of all patents related to that technology. UNEP/EPO/ICTSD, pg. 45.

[72] In fact, a large amount of technology required is already in the public domain. *See* Agenda 21, para. 34.9.

[73] Barton 2007, pg. 4

[74] *Id*.

[75] *Id*.

[76] Agenda 21, para. 34.9; Khor 2011, pg. 87

[77] UNFCCC. "Technologies for Adaptation to Climate Change." Bonn. 2006, pg. 9

[78] The first wind turbines used to produce electricity appear in 1887. The concept was patented in 1891 by James Blyth in the UK. "Renewable energy and role of Marykirk's James Blyth" The Courier. Available at: http://www.thecourier.co.uk/Community/Heritage-and-History/article/2332/renewable-energy-and-role-of-marykirk-s-james-blyth.html; Barton 2007, pg. 15

[79] The first patents for solar cells in the US were issued to Edward Weston in 1888 (US389124 and US389125), though the invention of modern solar cells are credited to Bell Labs in the 1950s. Chapin DM, Fuller DS, Pearson GL. "A New Silicon p-n Junction Photocell for Converting Solar Radiation into Electrical Power". Journal of Applied Physics 25 (5): 676–677. (May 1954)

[80] Barton 2007, pg. 4

[81] *Id*. at 4

[82] *See* Copenhagen Economics, pg. 4

[83] *See Id*. at 29
[84] *See* World Bank 2008, pg. 121
[85] *See generally* UNEP SEFI
[86] *See, e.g.* Ministry of Science and Technology, et al. (2007), 'China's Scientific and Technological Actions on Climate Change', at p. 1, available at http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File199.pdf ("Due to global climate change, the climate in China has experienced significant changes in recent years. . . . . [T]here was a marked increase in the frequency and intensity of extreme weather/climate events and associated disasters all causing increased losses, such as shortage of water resources and a sharp imbalance between regions, a deterioration in ecology and environment, a tremendous loss in agricultural production, a heavier pressure on food security, a rising sea level, and a threat to coastal economic and social development."); Prime Minister's Council on Climate Change, Government of India (2008), National Action Plan on Climate Change, at p. 1, available at http://www.pmindia.nic.in/Pg01-52.pdf ("India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. . . . . With an economy closely tied to its natural resource base and climate sensitive sectors such as agriculture, water and forestry, India may face a major threat because of projected changes in climate.").
[87] Global Markets Institute. "The New geography of Global Innovation" September 2010 (GMI), pg. 3, 5 China has targeted investing 2.5% of its GDP on R&D by 2020, which would translate to roughly $300 billion annually. *Id*. at 5
[88] *See* Battelle. "2011 Global Funding R&D Forecast" December 2010 Available at: http://www.battelle.org/aboutus/rd/2011.pdf (Battelle), pg. 24
[89] GMI, pg. 9
[90] WIPO 2010, pg. 12; UNEP/EPO/ICTSD, pg. 30-31
[91] WIPO 2010, pg. 12
[92] ZTE Corporation and Huawei Electronics with 1,868 and 1,528 applications respectively, in 2010 *Id*. at 20
[93] Copenhagen Economics, pg. 4
[94] Boston Consulting Group. "Innovation 2010: A return to Prominence – and the Emergence of a New World Order." 2010. Available at: http://www.bcg.com/documents/file42620.pdf, pg. 16
[95] Based on comparing the periods between 1998-2001 and 2005-2007, in emerging market economies, patent registration has increased by 545% compared to the global average of 120%. Copenhagen Economics, pg. 18
[96] *Id*. at 22
[97] UNEP/EPO/ICTSD, pg. 33
[98] *Id*. at 31, 33
[99] *Id*. at 34
[100] *See* Copenhagen Economics, pg. 25
[101] The Climate Group. "China's Clean Revolution" 2009. Available at: http://www.theclimategroup.org/_assets/files/Chinas_Clean_Revolution.pdf (TCG 2009), pg. 5, 10; Earnst & Young. "Renewable Energy Country Attractiveness Indices" 2011. Available at: http://www.ey.com/publication/vwLUAssets/Renewable_energy_country_attractiveness_indices_-_Issue_29/$FILE/EY_RECAI_issue_29.pdf (EY 2011), pg. 17-18
[102] Barton 2007, pg. 11, citing Lacoursiere C., "Clean Energy: Peering Down China's IPO Pipeline" RnewableEnergyAccess.Com March 2006
[103] Green World Investor. "China Solar Booming- Chinese Solar Panels Prices,Cost,Review,Best Manufacturers(Trina,Suntech)" 17 March 2011. Available at: http://www.greenworldinvestor.com/2011/03/17/china-solar-booming-chinese-solar-panels-pricescostreviewbest-manufacturerstrinasuntech/
[104] e.g. India's National Solar Mission (NSM). EY 2011, pg. 18; 21; Barton 2007, pg. 11 and China's 12th five Year Economic Plan which announced the intent to build 5 GW of new solar farms by 2015.
[105] EY 2011, pg. 21
[106] The Climate Group. "India's Clean Revolution" March 2011. Available at: http://www.theclimategroup.org/publications/2011/3/23/indias-clean-revolution/, pg. 9
[107] Barton 2007, pg. 17
[108] TCG 2009, pg. 5.

[109] Barton 2007, pg. 17
[110] UNFCCC 2007, pg. 117
[111] *See* Keane, Jodie, and Jessica Brown (2009), 'A Green Stimulus to Help Developing Countries Cope with Economic Turmoil and Climate Change', http://blogs.odi.org.uk/blogs/main/archive/2009/03/26/green_stimulus_financial_crisis_climate_change.aspx , accessed 8 July 2011, citing McKinsey & Co. (2009), Pathways to a Low-Carbon Economy.
[112] Holland, Hereward (2008), 'Kenya Looks to Geothermal Power to Fuel Development', Available at: http://www.reuters.com/article/2008/08/11/us-kenya-geothermal-idUSL1714781120080811
[113] World Bank 2008, pg. 107
[114] *See* Copenhagen Economics, pg. 6
[115] WIPO 2006, pg. 10
[116] UNFCCC negotiations are already complex enough as they are without the "contamination" of a spill-over of issues which are rightfully the mandate of the WTO - particularly where there is little or no evidence that a change from the status quo would be advantageous to the global effort to address climate change and significant evidence that it would be detrimental to such efforts.