Is the Big Blue Marble Getting Greener?

By Janet S. Hendrickson

Intellectual property rights are a necessary incentive for investment in the development of green technologies. Additionally, there are several treaties and regulatory regimes around the world that create incentives to develop and disseminate clean energy technologies (CETs) or green technologies. These treaties and regulatory regimes provide incentives for companies to develop cleaner technologies and, consequently, for innovators to file patent applications in various countries. For example, when considering the trend in claimed priority applications (e.g., patent families) directed to CETs, the number of applications in the CETs identified by the European Patent Office (EPO) (e.g., solar photovoltaic (solar PV), solar thermal, wind, geothermal, hydro/marine, biofuels, carbon capture and storage (CCS), and integrated gasification combined cycle (IGCC)) showed a marked increase since 1997 when the Kyoto Protocol[1] was initially adopted. (See Figure 1.) The Kyoto Protocol has a goal of stabilizing greenhouse gas concentrations in the atmosphere. This data shows that political decisions can stimulate development of green technologies. This article provides a picture of the green technology patent landscape and the factors that affect development and dissemination of green technologies.

While intellectual property rights are an important incentive for development of green technologies, they also are a source of contention when considering how best to mitigate climate change trends. It is widely believed that widespread reduction of greenhouse gas concentrations is needed and that various mitigation and CETs must be adopted quickly in order to reduce the greenhouse gas concentrations in a time frame that will affect the global climate. There is a tension between the interested parties because developing countries and some nongovernmental organizations believe that intellectual property rights are a hinderance to this dissemination of green technologies. Instead, these countries and organizations advocate compulsory licensing of these technologies, while many developed countries and business associations argue that stronger intellectual property rights would help dissemination of technologies. Against this backdrop, it is important that intellectual property policy is developed using the best empirical data available. To that end, several studies were undertaken to determine the state of the green technology landscape and to analyze the best path forward for dissemination of these green technologies.

Transferring technology is a complex process, and intellectual property rights, the size of the domestic market, and a number of other factors that predominantly rely on the assimilating country's knowledge system play a role in the viability of technology transfer from technology holder to developing countries. It has generally been found that healthy competition between patent holders in green technology areas means that one or a few actors cannot dominate the technology, and thus, intellectual property rights are not the only factor necessary for successful technology transfer. Further, for the least developed countries, there is typically a low rate of patenting for green technologies so intellectual property rights are not a barrier at all. For many of the developing countries, stronger intellectual property laws are necessary to attract investment by companies active in green technology. In sum, while intellectual property rights are an important factor for successful technology transfer, they are not the only factor.[2]

Green Technology Patents

The amount of worldwide energy generated by renewable energy sources in 2006 was 15.4% of the total energy, and most of the renewable energy came from hydropower (12.3%). The percentage of renewable energy generated is highest in Europe, followed by North America (Canada, United States, and Mexico), and then the Pacific region (Japan, Korea, New Zealand, and Australia). High growth rates in solar and wind power have occurred in the last two decades, but have not kept the growth of renewable energies on par with the growth rate of total electricity generation. To encourage growth of renewable energy sources, many countries have enacted policies favorable to renewable energy production. To evaluate the success of these programs, accurate studies of the development activities in technology areas is essential, and one way to analyze the strength of development activities is by measuring patent counts.

When considering the patenting rates for various CETs, the rate of increase per year is about 20%. Since 2001, the patent activity for CETs is about the same as the patenting activity in other technical areas. When considering specific green technologies, patenting rates in solar PV, wind, and carbon capture technologies has shown the most activity since 2000, and hydro/marine and biofuels have shown the second most activity since 2000. The level of patenting in solar PV and wind show that these technologies are commercially deployed while hydro/marine energy is not quite to the stage of commercial deployment.[3]

The countries with the most patent activity in CETs are Japan, the United States, Germany, France, South Korea, and the United Kingdom. While these countries have the highest number of claimed priority applications in the CETs, all of these, except South Korea, have a higher number of claimed priority applications in fossil fuel and nuclear energy. While Japan has the highest number of claimed priorities in CETs, Japan is dominant in solar PV technologies, and the United States has its patent activity more evenly spread across all fields. (See Figure 2.) Germany leads all countries in wind technology, and South Korea's patenting activity is concentrated in solar PV technologies.[4]

Of the emerging economies, China has the highest number of claimed priorities in CETs, mostly in the solar PV field, but most of these patents are not held by Chinese companies. Thus, China may be a large manufacturer of clean energy, but is not a significant holder of technology.[5]

Moreover, when considering the patenting activity between countries, most patenting activity occurs between the top

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patenting countries of Japan, the United States, Germany, South Korea, France, and the United Kingdom. Inventors from the United States and Japan have the largest number of claimed priority applications filed in China, followed by inventors from Germany, South Korea, France, and the United Kingdom. Chinese inventors do not have a large number of patents filed first in China and then filed in the leading patenting countries, reflecting the general trend in other technical areas that Chinese patenting activity stays at home.[6]

This study of patenting trends for various technologies also provided information about the concentration of clean energy patenting efforts as compared to total patenting efforts in various countries. This analysis provided a somewhat different picture of development activity around the world. When normalizing the data in this way, countries that were not at the top in total numbers of claimed priority applications showed significant activity as innovators in CET. For example, Thailand, Greece, Taiwan, and South Korea are top innovators in the solar PV technologies, Denmark leads in wind technologies, and Ukraine has the highest percentage share in biofuels. The data also shows that many countries have concentrated efforts in one CET field and have little activity in other fields. Of note, China has become an innovation hub in the fields of geothermal, solar PV, wind, carbon capture, and IGCC since 1998, and if these trends continue, is likely to emerge as a top patenting country in these fields in the future. In contrast, solar PV is the only field where India shows significant activity, otherwise India does not show the same level of activity as China.[7]

Another aspect for analysis of the patent landscape is the maturity of the various CET areas. For example, the data regarding the percentage of claimed priority applications from the top 10 applicants is indicative of the development cycle and the breadth of activity in the field. Typically, a higher percentage of patent consolidation indicates a less mature technology. The most consolidated CET area is in carbon storage with 36% of inventions held by 10 applicants, with carbon capture, wind, and IGCC technologies having more than 20% of inventions held by 10 applicants. Solar thermal, a known mature field, has only 5% of inventions held by 10 applicants.[8] The International Energy Agency has identified three generations of green technologies. Hydropower, biomass combustion, and geothermal energy are mature technologies. Solar energy, wind power, and bioenergy are rapidly developing technologies. Concentrating solar power, ocean energy, improved geothermal, and integrated bioenergy systems are in the development stages.[9]

As can be expected, various political decisions have had an effect on patenting activity in various technologies because innovators and investors respond to such decisions. In particular, when the patenting data was normalized to the activity in 1997, the year the Kyoto Protocol was initially adopted, it showed a significant increase in patenting activity occurred from 1997 to 2006. For example, the largest increase in patenting activity since 1997 was in wind, solar PV, and hydro/marine, with biofuels and geothermal technologies also showing an increase. In contrast, the number of claimed priority applications directed to fossil and nuclear fuels has declined since about 2000.

The effects of political decisions depend on the level of maturity of the technology area, the type of decision (e.g., research and development (R&D) budgets, feed-in tariffs, renewable energy credits, tax credits, etc.), and the particular country. Research and development investment by countries had a more widespread positive effect on development of green technologies than other more specific incentives such as feed-in tariffs (i.e., a payment to generators from utilities to provide price parity for renewable energies as compared to other sources of energy) or renewable energy credits (i.e., tradable energy commodities that provide a production subsidy to renewable energy sources). In order to have a portfolio of incentives, it is important for policymakers to consider the best incentive for the particular purpose.

For example, when comparing wind and solar power, the base cost of the technology is a determining factor for whether particular incentives are effective to encourage development. Since wind power is a more cost-competitive technology, renewable energy credits that are not technology specific encourage consumers to use wind power because it is a cheaper form of renewable energy. Since the consumer is likely to choose the most economical form of renewable energy, these certificates encourage more development in cost-competitive renewable energies. However, feed-in tariffs for cost-competitive technologies do not induce a higher rate of development. In contrast, renewable energy credits do not encourage development of solar power since solar is not as cost competitive as wind, but feed-in tariffs specific to solar do encourage increased development of solar technologies.[11]

Also, in some areas, the market conditions for competitor technologies are the best predictor of activity in the CET field. For example, when considering biofuels, the patenting activity grows with increasing oil prices. Thus, depending on the market price of oil, the urgency for alternative fuels can increase or decrease.[12] General market conditions can also play a role in developing CETs since a drive to improve processes by reducing energy consumption or reducing waste streams improves economics of a process while consequently making the process greener.[13]

Licensing Survey

A survey of various types of entities that are holders of CET was designed to investigate the licensing attitudes and practices of organizations. The results showed that out-licensing (where the owner of the technology licenses it out for monetary gain) was important to 73% of all organizations and 84% of organizations having CETs as a substantial portion of their patent portfolio. A greater importance for out-licensing was seen for public organizations and universities, whereas private companies attached less importance to out-licensing as part of their business activities. In-licensing (where an entity gets access to proprietary technology to use for its own purposes) was not as important as out-licensing. Also, engagement in patent pools

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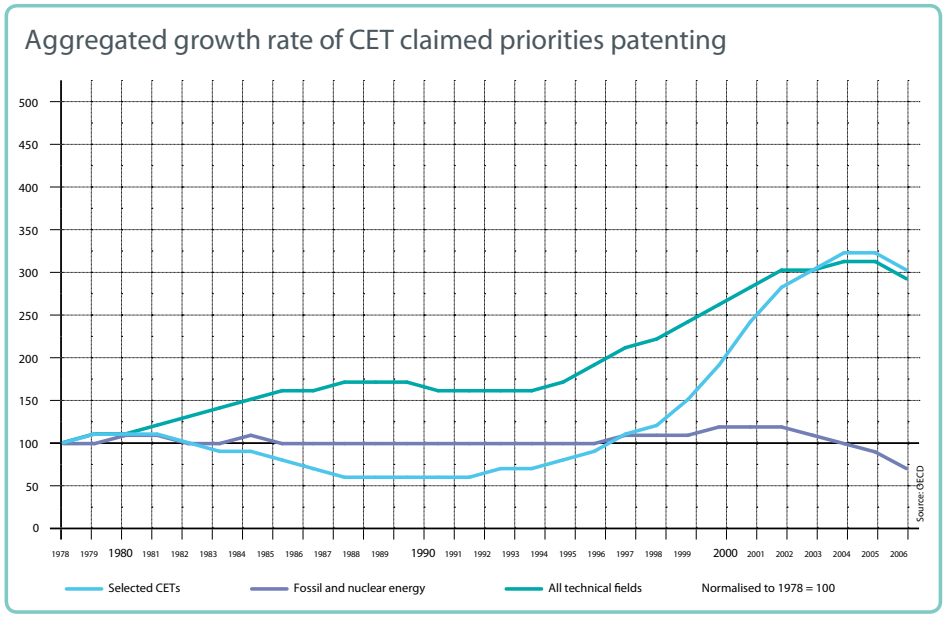
Figure 1 Aggregated Growth Rate of CET Claimed Priorities Patenting[10]



and cross-licensing arrangements was less common than entry into cooperative R&D arrangements.[14]

While only 17% of organizations stated that they had frequently or occasionally entered into licensing agreements with developing countries, this figure must be analyzed in context. There are many reasons why an organization may or may not enter into a licensing agreement, including transaction costs, identifying a partner, and licensing terms. Other studies have found that the willingness of an organization to out-license technology does not correlate well with the level of licensing.[15] While organizations believed that intellectual property rights were very important to licensing, other factors were also important, and 70% of organizations were willing to offer more favorable licensing terms to parties in developing countries. This willingness to license varied by type of organization, with universities most willing to license, followed by public institutions, small businesses, and large businesses.[16]

Policy Efforts by Patent Offices

As described above, a wide range of policy initiatives have been advanced to encourage development and dissemination of green technologies. Once green technologies are developed, patent systems can encourage innovators by providing mechanisms for improved examination and notice of patent rights. These mechanisms range from accelerated examination for green technologies to a new classification system for green technologies. The accelerated examination for green technologies was designed to help applicants develop green technologies and receive granted patents in a shorter period of time in order to more easily attract investors and other collaborative partners to maximize the potential for the technologies to reach the development stage. Further, the EPO developed a new classification system for green technologies due to the wide range of fields to which green technologies could be classified to make it easier and more transparent to determine the state of development of various green technologies. The new classification system allows for easier identification of competitors and opportunities for development.

Advanced Examination for Green Technologies

Several countries have instituted advanced or accelerated examination for green technologies.[17] Typically, such green technologies are broadly defined, and the applicant must indicate how the disclosed invention meets the particular green technology standard. As seen below, many of the programs for accelerated examination have similar requirements, but may have procedural differences. Also, many practitioners warn of the disadvantages of accelerated examination; particularly, that the full range of prior art pertinent to the claimed invention may not be known before the examination concludes. However, depending on the length of time to grant and the situation of the applicant, the disadvantages may be outweighed by the advantages of having a patent in hand for fundraising or licensing purposes.

Australia

Typically, in Australia, examination of patent applications process in the order that examination requests are received. However, expedited examination in Australia can be requested in writing, and "green technology" is one reason for requesting such expedited examination. If granted, the application receiving expedited examination would move to the front of the line, and examination would begin within four to eight weeks after filing the request. There is no additional fee. "Green technology" in Australia is undefined but seems to broadly include technologies from clean energy to green cleaning products.

Canada

In Canada, an application can be examined outside of its routine order if the applicant states that the application "relates to technology the commercialization of which would help to resolve or mitigate environmental impacts or conserve the natural environment and resources." As in Australia, no government fee is required. If the request is granted, the application is considered as under a special order procedure, and if an extension of time or abandonment of the application occurs while under special order, the application will be returned to examination in its routine order.

Israel

For applications filed on or after December 27, 2009, green patents in Israel receive priority from the patent office without a request from the applicant or additional fees. For green patents filed before December 27, 2009, a request may be made to enter into the program. If making a request to enter the green patent program, the applicant must describe why the technology advances environmental protection. The definition appears to be quite broad, and many technologies would likely fit into Israel's green patent program.

Japan
On November 1, 2009, the Japanese Patent Office started a pilot program for accelerated examination for green-related applications. "Green-related applications" are applications related to green inventions that contribute to the environment by conserving energy, reducing carbon dioxide emissions, saving resources, or reducing the environmental burden.

South Korea
The Korean Intellectual Property Office (KIPO) has a "super speed examination system" for green technology patent applications. Green technologies are those that reduce pollutant discharge or that have received funding or authentication for green growth. To request super speed examination, a prior art search from an agency authorized to conduct searches on behalf of KIPO and submission of the search results to KIPO are required.

United Kingdom
The United Kingdom Intellectual Property Office has a "Green Channel" for requesting accelerated processing of an application. The invention must relate to a "green" or environmentally friendly technology, and the applicant can accelerate search, combined search and examination, publication, and/or examination.

United States
The United States Patent and Trademark Office (USPTO) Green Technology Pilot Program started on December 8, 2009, was expanded on May 21, 2010, and has been extended to December 31, 2011. Under the USPTO's Green Technology Pilot Program, patent applications that meet program eligibility requirements will be advanced out of turn (i.e., accorded special status) for examination. The invention must pertain to green technologies including environmental quality, energy conservation, development of renewable energy, or greenhouse gas emission reduction. The first 3,000 petitions to make special new patent applications that meet program eligibility requirements will be accepted into the program. As of April 4, 2011, 1,595 petitions had been granted and 250 patents having a green technology petition had been issued. If the requirements are met, the application will be accorded special status and advanced out of turn for examination.

EPO Green Technology Classification System
Patent classification systems are used by patent offices to systematically classify patent documents and nonpatent literature to assist with administration and searching. The International Patent Classification (IPC) is the most commonly used classification system, and patent offices may supplement the IPC to add subclasses. For accurate information regarding the patenting practices in a particular technology area, the patent classification scheme is an important tool to search the technology landscape. Thus, the driving force for a new classification system for green technologies was to provide the information needed to support policy development.[19]

The EPO developed a new classification system for climate change mitigation technologies that takes into account the industrial sector as well as the applications of a technology. This required definition of hundreds of new categories. To that end, the EPO identified approximately 50 technical fields related to CETs, which are listed in Figure 3. This new classification system attempted to establish a way to search all the world's patents and produce patent technology landscapes without significant outlay of resources. The classification data is included in the EPO's Worldwide Patent Statistics Database (PATSTAT) and will be regularly updated. These technology landscapes provide vital information about the state of the green technologies, competitors, and opportunities for further development.

Conclusion

There is a great deal of information about green technology patents. Several studies of patenting activity were undertaken and provide a variety of perspectives regarding the importance of intellectual property rights to the development and dissemination of green technologies throughout the world. Generally, intellectual property rights are considered to be important for development of green technologies and one of several factors for dissemination of these technologies. Many governments and patent offices around the world have enacted regulatory and procedural regimes to encourage development of green technologies, and many of these regimes seem to be doing just that. The patenting activity of green technologies is expected to increase at the same rate that it has since the initial adoption of the Kyoto Protocol. Moreover, the patenting activity of green technologies may increase in the future if further agreements to reduce greenhouse gases are adopted. ■

Figure 2 Ranking of Top Patenting Countries in Selected CETs (1988–2007)[18]

	Selected CETs	Solar PV	Solar thermal	Wind	Geo-thermal	Hydro/ marine	Biofuels	Carbon capture	Carbon storage	IGCC
Japan	1	1	3	3	3	3	3	2	3	2
US	2	2	2	2	1	1	1	1	1	1
Germany	3	3	1	1	2	2	2	3	4	3
S. Korea	4	4								
France	5	5	4			5	4	4	2	
UK	6					4	5	5	5	4
Italy	7		5							
Canada	9				5				5	
Denmark	12			4						
Spain	13			5						
Austria	15				5					
Sweden	16									5
Norway	17								5	
Finland	19									5
Israel	19				4					

Endnotes

1. The Kyoto Protocol, adopted in Kyoto, Japan, in December 1997 and entered into force on February 16, 2005, is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing emissions of greenhouse gases (GHGs) (i.e., carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons (HFCs), and perfluorocarbons, (PFCs)). These reductions amount to an average of 5% against 1990 levels over the five-year period 2008–2012.

2. United Nations Env't Programme, European Patent Office & Int'l Ctr. for Trade & Sustainable Dev., Patents and Clean Energy: Bridging the Gap Between Evidence and Policy 18–19 (2010).

3. *Id.* at 30.

4. *Id.*

5. *Id.* at 31.

6. *Id.* at 49.

7. *Id.* at 32–34.

8. *Id.* at 43.

9. Nick Johnstone et al., *Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts*, 45 Envtl. Resource Econ. 133, 134 (2010).

10. Reproduced from Figure 3 of United Nations Env't Programme, European Patent Office & Int'l Ctr. for Trade & Sustainable Dev., Patents and Clean Energy: Bridging the Gap Between Evidence and Policy 29 (2010).

11. *See* Johnstone, *supra* note 9.

12. United Nations Env't Programme et al., *supra* note 2, at 37.

13. *Id.*

14. *Id.* at 54–57.

15. *Id.* at 54–59.

16. *Id.* at 60.

17. *See* 4 John Gladstone Mills III et al., Patent Law Fundamentals § 21A:17 (2d ed. 2011); Japan Patent Office, Annual Report 2010, 55–56, http://www.jpo.go.jp/shiryou_e/toushin_e/kenkyukai_e/pdf/annual_report2010/part2.pdf; *The Examination Process—Expedited Examination*, IP Australia, http://www.ipaustralia.gov.au/patents/process_expedited.shtml (last visited June 13, 2011); *Expedited Examination of Patent Applications Related to Green Technology*, Canadian Intellectual Property Office, http://www.cipo.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr02462.html (last modified Mar. 16, 2011); *Green Technology Pilot Program*, USPTO, http://www.uspto.gov/patents/init_events/green_tech.jsp (last modified June 1, 2011); *Patents Fast Grant Guidance,* Intellectual Property Office, http://www.ipo.gov.uk/p-fastgrantguide.pdf (last visited June 13, 2011).

18. Reproduced from Figure 6 of United Nations Env't Programme, European Patent Office & Int'l Ctr. for Trade & Sustainable Dev., Patents and Clean Energy: Bridging the Gap Between Evidence and Policy 32 (2010).

19. United Nations Env't Programme et al., *supra* note 2, at 65.

20. Reproduced from Annex 4 of United Nations Env't Programme, European Patent Office & Int'l Ctr. for Trade & Sustainable Dev., Patents and Clean Energy: Bridging the Gap Between Evidence and Policy (2010).

Figure 3 CETs Identified by the EPO[20]

SECTOR	SUB-SECTOR, APPLICATION, APPARATUS, COMPONENT
Geothermal energy	• Earth coil heat exchangers • Systems injecting medium directly into ground (hot dry rock system, underground water) • Geothermal heat pump (for buildings) • Pipes and other hardware
Hydroenergy	• Conventional (e.g., with dams, turbines, and waterwheels) • Ocean thermal energy conversion (OTEC) • Oscillating water column (OWC) • Salinity gradient • Tidal stream and damless hydropower (e.g., sea flood and ebb, river, stream) • Wave energy (e.g., Pelamis)
Solar thermal energy	• Dish collectors • Fresnel lenses • Trough concentrators • Tower concentrators • Heat exchange systems • Mountings or tracking
Photovoltaic (PV) energy	• Amorphous silicon PV cells • CuInSe2 material PV cells • PV systems with concentrators • Dye-sensitized solar cells • Solar cells from Group II-VI materials • Solar cells from Group III-V materials • Microcrystalline silicon PV cells • Polycrystalline silicon PV cells • Roof systems for PVC cells
Thermal-PV hybrids	
Wind energy	• Blades or rotors • Components or gearbox • Control of turbines • Generator or configuration • Nacelles • Offshore towers • Onshore towers
Biofuels	• Combined heat and power (CHP) turbines for bio-feed • Gas turbines for bio-feed • Biodiesel • Bio-pyrolysis • Torrefaction of biomass • Cellulosic bioethanol • Grain bioethanol • Bio-alcohols produced by means other than fermentation
Carbon capture	• Capture by absorption • Capture by adsorption • Capture by biological separation • Capture by chemical separation • Capture by membrane diffusion • Capture by rectification or condensation
Carbon storage	
Combined combustion	• Integrated Gasification Combined Cycle (IGCC) • IGCC combined with CCS