Working Paper

IRENA
International Renewable Energy Agency

Intellectual Property Rights

The Role of Patents in Renewable Energy Technology Innovation

June 2013

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
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List of Acronyms

ARIPO	African Regional Intellectual Property Organization
CCMT	Climate Change Mitigation Technologies
CPC	Cooperative Patent Classification
DIN	German Institute for Standardisation
EAPO	Eurasian Patent Organization
ECLA	European Classification
EPO	European Patent Office
F-I/F-terms	Japanese Classification
IPC	International Patent Classification
IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
JPO	Japan Patent Office
KIPO	Korean Intellectual Property Office (South Korea)
OAPI	African Intellectual Property Organization
OECD	Organisation for Economic Co-operation and Development
OFF	Offices of First Filing
PATSTAT	EPO Worldwide Patent Statistical Database
PCT	Patent Cooperation Treaty
R&D	Research and Development
RD&D	Research, Development and Demonstration
RET	Renewable Energy Technology
SIPO	State Intellectual Property Office of the People's Republic of China
TRIPS	Agreement on Trade Related Aspects of Intellectual Property Rights
USPC	United States Patent Classification
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Executive Summary

Accelerating the development and deployment of renewable energy technologies (RETs) requires innovation throughout the whole technology life cycle, from basic research to commercialisation. The International Renewable Energy Agency (IRENA) has been assessing different instruments that promote RET innovation, focusing in particular on patents, standards, technology transfer, and cooperation in research, development and demonstration. Efficient use of such instruments will benefit RET innovation.

This brief working paper focuses on patents and describes the basics of what patents are and how they work, as well as presenting some ideas of how patents and their information can be used to encourage RET innovation. Some examples of the use of patent information to indicate the trends of technology developments, technology transfers and knowledge generation are assessed.

Through the literature review, collaboration activities with key patent organisations, and an expert workshop, some insights have been drawn on the roles of patents in technological innovation. Key insights include the following:

- Patents play a key role throughout the technology life cycle and act as an engine for technological innovation.
- Patent trends can be analysed to identify technology progress and innovation as well as to forecast innovations. For example, RET patent information can provide valuable insights into: 1) which countries and innovators are active in inventing technologies; 2) which countries are the potential markets where technologies need to be protected; 3) the trends in technology developments for a particular fields of technology over time; 4) the trends in technology transfers from one country to another; and 5) international research and co-operation as indicated by co-invention and co-ownership.
- It is also important to understand that patents have their limitations when used as information sources, as not all inventions are patented.

This process has also identified the next steps for IRENA in the field of patents in the context of RET innovation:

- The role of patents in RET innovation is not well understood by many policy makers. In cooperation with relevant partners, IRENA should continue to develop a better understanding of the role of patents in RET innovation.
- Making patent information more accessible may help accelerate innovation. Patent information can be made more accessible and easy to understand, for example through a user-friendly information platform.
- Based on the studies carried out so far, IRENA will continue to look into patents as one of the instruments to assess patterns of RET innovation.

Introduction

Innovation is essential for the accelerated deployment of renewable energy technologies (RETs) that will play a key role in addressing the issues of energy security, energy access and climate change. Technological innovation is achieved through a mix of various demand factors and technology supply factors. Various modes of innovation operate within different contexts at different stages of technology development, involving various players over different timescales.

Innovation can occur at all stages of the technology life cycle of RET, ranging from breakthroughs in basic technology inventions and improved research, development and demonstration (RD&D) systems, to improved market development and commercialisation. RET innovation is a multifaceted issue with different contexts in each region or country.

As part of the efforts by the International Renewable Energy Agency (IRENA) to strengthen its Member States' technology and innovation strategies, the IRENA Innovation and Technology Centre (IITC) has initiated an assessment of enabling technology frameworks, including RD&D trends and status information. The information ranges from patents and reduction of technology risk through streamlined standardisation and quality management, as well as assessments of criteria for RET innovation policy frameworks. This activity will bolster IRENA's role as a global voice and advisory resource for renewables, through pooling knowledge, disseminating relevant information and providing practical advice and guidelines on promoting RET innovation. IRENA can support RET innovation and contribute significantly to renewable energy deployment by providing guidance on various instruments, such as standardisation, patent information, RD&D frameworks and technology cooperation.

Since 2012, IITC has been looking into Intellectual Property Rights (IPR) protection and utilisation, in particular patents, as one of the relevant instruments to support technological innovation. IPR protection plays an important role throughout the entire technology life cycle, from RD&D stages through to the commercialisation and diffusion of technology. To better understand the functioning of IPR in technology development and deployment, IRENA has consulted on the use of patent information for RET deployment through various workshops and meetings with experts in the field, developed a concept of the portal system providing access to RET patent information in collaboration with the World Intellectual Property Organization (WIPO) and the European Patent Office (EPO), and conducted an overview of patenting activity and innovation in the field of desalination technologies run by renewable energy.

This paper outlines the discussions and findings to date on the possible role of patent information to encourage innovation in RET development and deployment – a role that is not well understood. This paper sets out to explain the use of patents in renewable energy innovation, assess their status, and make suggestions as to how this information can be used for policy-making.

1. How patents encourage innovation in technological development and deployment

Innovation is crucial for the development and deployment of technologies. A widely deployed model to understand technology builds on the concept of the technology life cycle. The life cycle of technologies can be divided into a number of steps – from invention, through RD&D and market development, to commercial diffusion. Different processes can be discerned at each stage of the life cycle and different instruments can be deployed to promote innovation.

One group of such instruments relates to IPR. IPR refers broadly to the ownership of intellectual findings in the industrial, scientific, literary and artistic fields. IPR grants inventors certain exclusive rights over their creations to encourage creative activity for the benefit of society by allowing the inventors a fair return on their investments. Traditionally, IPR is divided into two groups: industrial property rights and copyright. In general, copyright is a legal term describing rights given to creators for their literary and artistic creations, such as for example, music and paintings, while the term "industrial property rights" is used as a denomination for certain exclusive rights regarding innovative ideas or distinguishing signs or designations in the industrial or commercial field. Industrial property takes a range of forms and includes, among others, patents to protect inventions, trademarks, industrial designs, and commercial names.

Patents can play a prominent role in the entire technology life cycle, from initial RD&D to the market introduction (demonstration to diffusion) stages, where competitive technologies can be protected with patents and licensed out to third parties to expand financial opportunity (Figure 1). The global patenting activity is growing. *World Intellectual Property Indicators* reported that in 2011, the total number of patent filings worldwide exceeded 2 million for the first time, with a growth rate of 7.8% over 2010 (WIPO, 2012).

A patent is the right granted to a patent holder by a state, or by a regional office acting for several states, which allows the patent holder, for a limited period, to exclude others from commercially exploiting his invention without his authorisation. A procedure for patent granting is described in ANNEX I. By granting such rights, patents provide incentives for innovators, offering them recognition for their creativity and enabling them to appropriate the returns of their investment. A patent may be a powerful business tool allowing innovators to gain exclusivity over a new product or process, develop a strong market position and earn additional revenues through licensing.

Patent protection is usually sought at the research and development (R&D) stage of the technology life cycle. Various departments in companies, including research units and specialised lawyers, play a key role in the development of inventions, as well as in the process of preparing and filing patent applications and obtaining, maintaining and exploiting patents.

In return for exclusive rights, the inventor must sufficiently disclose the patented invention to the public, so that others can access the new knowledge and can further develop the technology. The disclosure of the invention is an essential consideration in any patent-granting procedure. In this way the patent system is designed to balance the interests of inventors and the general public.

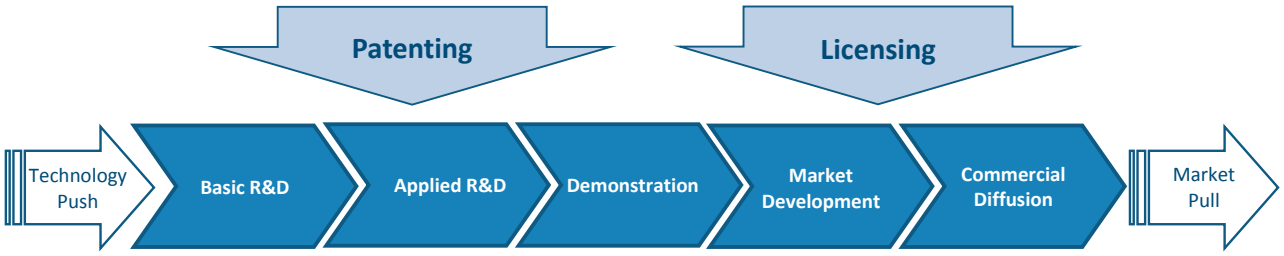


Figure 1: Patents facilitate advances throughout the technology life cycle

Patents are unique in the way that they award time-limited rights of exclusive use of ideas or concepts that can be used to provide useful products and services. Patents are rights protecting the outcomes of an innovation process (commonly called "inventions"). Inventions can relate to the creation of an entirely new device, product, method or process, or may simply be an improvement to a known product or process. A single product can be covered by a range of patents, while on the other hand an individual patent is often part of a larger technology solution, requiring crucial know-how to execute a complex technology deployment.

Not all inventions are patentable. An invention must meet several criteria to be eligible for patent protection. These criteria include, most significantly, that the claimed invention:

- Consists of *patentable subject matter*: An invention must fall within the scope of patentable subject matter as defined by the applicable national law, which varies from one country to another. Many countries exclude certain subject matters from patenting, such as scientific theories, mathematical methods, plant or animal varieties, discoveries of natural substances, methods for medical treatment (as opposed to medical products), and any invention where prevention of its commercial exploitation is necessary to protect public order, good morals or public health.
- Is *new*: An invention must show some new characteristic that is not known in the body of existing knowledge, referred to as "prior art", within the same technical field. While the definition of prior art may differ between countries, many countries consider any information disclosed to the public anywhere in the world in written form, by oral communication, by display or through public use, to constitute prior art.
- Involves an *inventive step (non-obviousness)*: An invention is considered to involve an inventive step when, taking into account the prior art, the invention would not have been obvious to a person having ordinary skill in that art. This requirement is meant to ensure that patents are only granted in respect of truly creative and inventive achievements, and not to inventions that could be easily deduced by a person with average knowledge in the technical field from what already exists.
- Is capable of *industrial application (utility):* An invention must be of practical use, or capable of some kind of industrial application. An invention cannot be a mere theoretical phenomenon; it must be useful and provide some practical benefit.
- Is fully *disclosed*: A patent application must disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the relevant technical field. In some countries, the "best mode" known to the inventor for practicing the invention must also be disclosed.

Patents are crucial for technological innovation in the context where they apply. They can be used to generate revenues (from licences), encourage synergistic partnerships, or to create a market advantage and be the basis for productive activities. As such they create strong incentives for innovation in market-based economies. An alternative approach would be to keep inventions confidential, limiting public access to crucial technology advances. However, this would have advantages and disadvantages for both inventors and for society as a whole, which can benefit from the inventions.

The protection conferred by patents is time-limited. Generally it lasts for 20 years from the filing date of the application (provided the renewal or maintenance fees are paid on time), but can be abandoned (invalidation) or revoked before the expiration of this period [1]. Once the patent has expired or abandoned in a given country, third parties are no longer required to obtain the consent of the patent holder for the exploitation of the formerly patent-protected invention, and so in those countries, the invention can be freely used by the public. It should be noted that there is a typical time lag of 5–10 years between granting of the patents and market uptake.

Patent rights are territorial in nature and are governed by national patent laws. This means that a patent is valid and enforceable only in the territory of the country in, or for which, protection is granted, in accordance with the applicable law of that country. Therefore, if a patent is issued in Japan, it only protects the invention in Japan. If the invention needs to be protected in another

1 *The time between patent filing and granting, which is called pendency, typically ranges from two to five years but varies from office to office. Although in most countries, the term of protection for patents is 20 years counted from the filing date of the patent application, patents of addition or patents of improvements may be available in some countries, covering further developments of the invention. In addition, in some countries, and in very specific circumstances, protection may be extended beyond 20 years, or a Supplementary Protection Certificate (SPCs) may be granted. For example, SCPs can be granted in the area of pharmaceuticals, due to delayed commercialisation resulting from the time required to obtain marketing approval from the appropriate government authorities. Generally, SPCs do not exceed five years.*

country, such as China, the owner needs to file another application for a patent in China. At present, there is no system that grants patents with global, worldwide effect. Therefore, in principle, an application for a patent must be filed in each country of interest in accordance with the law of that country.

Filing a patent application for an invention in many countries at the same time may incur enormous costs, because each application must comply with different rules, including different language requirements. Therefore, inventors typically limit filing their patent applications to those countries where they see a potential market for their inventions.

In order to help an applicant from one country to obtain protection in other countries, the Paris Convention for the Protection of Industrial Property provides the so-called "right of priority"[2]. This provides practical advantages in that, when applicants seek protection in several countries, they are not required to present all their applications at the same time, but have 12 months at their disposal to decide in which countries they wish to obtain protection. This allows applicants to organise the steps they must take to secure protection in foreign countries with due care.

Although it is not possible to obtain a patent protection with a global, worldwide effect, the Patent Cooperation Treaty (PCT), an international treaty administered by WIPO, makes it possible to seek patent protection for an invention simultaneously in each of a large number of countries by filing a single international patent application instead of filing several national or regional applications. A single international patent application under this treaty has the same effect as regular national or regional applications filed in each Contracting State of the PCT designated in the international application. The PCT international applications may be filed by anyone who is a national or a resident of a Contracting State of the PCT. After going through certain procedures at the international level, each national and regional patent office of the countries in which an applicant seeks patent protection decides whether or not to grant a patent with respect to an invention contained in a PCT international application.

In addition, when a number of countries are members of a regional patent system, a patent application may be filed with effect in the territories of all or some of these countries with the relevant regional office. The regional patent offices are: the African Intellectual Property Organization (OAPI), the African Regional Intellectual Property Organization (ARIPO); the Eurasian Patent Organization (EAPO); the EPO; and the Patent Office of the Cooperation Council for the Arab States of the Gulf (GCC Patent Office).

As stated above, people or companies in countries where the patent has not been granted or has no legal effect are free to use an invention, even for business purposes. In developing countries, where not many patents have been granted, there may be many opportunities of using such inventions. However, lack of skills, inadequate investment capital supply chains, and economies of scale make it difficult for developing countries to use available inventions for their own technology development and/or development of manufacturing capacity for the inventions within their countries.

A patent can also be licensed to another party (a licensee), which permits that party to use, sell or manufacture the invention. In return, the licensor usually receives royalty payments from the licensee. While patent information is public, licensing information is generally kept confidential.[3] If available, an analysis of licensing activities, showing which patents are licensed by whom and where, could be used to indicate the commercial value of patents and the trends of technology diffusion geographically and among companies. The unavailability of such information is unfortunate from an analytical perspective, since that information could be used to identify the usefulness of patents and the networks of patent information diffusion and application.

Patents can be owned by governments or government organisations, although the majority are owned by private sector organisations and individuals. Governments, in principle, cannot grant licences to third parties for use of patents that are privately owned, nor can they force patent owners to share their rights with third parties, except in some specific cases, such as in the event of abuse of the patent rights and/or in the public interest through "compulsory licence"[4].

2 *As provided by Article 4 of the Paris Convention, on the basis of a regular first patent application filed in one of the Contracting Parties, the applicant can enjoy, for the purpose of filing in the other countries party to this Convention, a right of priority during the period of 12 months from the date of the filing of the first application. Any subsequent filing in any of the countries party to the Paris Convention before the expiration of the 12-month period shall not be invalidated by reasons of any acts accomplished in the interval, such as another filing, publication or sale of the invention.*

3 *National laws differ on the issue of recordation of licensing agreements; some national laws may require that the licensing agreements or transfer of patent rights be registered in a specialised registry in order to make such transactions effective, and others may not require such a registration. In countries where such recordation is a mandatory requirement, the scope of the recordation vis-a-vis the content of those agreements, and its accessibility by public may also differ.*

4 It refers to the use of a patent without the authorisation of its owner only under a certain conditions aimed at protecting the legitimate interests of the patent holder.

Advocates of patenting argue that patents act as a strong incentive for innovation, while others are concerned that they restrain innovation. To some extent the role and impact of patents depend on the specific technology involved. While some patents may temporarily limit the use of specific technologies to the patent's owner and licensees in some jurisdictions, such innovations often spur the development of competing technologies. For technologies requiring considerable financial and technical resources, and a long period to develop marketable products that are then relatively inexpensive to reproduce, patent protection is critical. For pharmaceuticals, for example, patents are important both in terms of spurring innovation of new medicines and ensuring access to new medical technologies.

National and regional patent offices, such as the United States Patent and Trademark Office (USPTO), the Japan Patent Office (JPO), EPO, the Korean Intellectual Property Office (KIPO) and the State Intellectual Property Office of the People's Republic of China (SIPO) play a critical role in ensuring that patents are granted only to inventions that are genuine contributions to the state of the art and comply with procedural, as well as substantive requirements prescribed under the applicable patent law of the country or region in question. In particular, while the steps taken by the offices to grant patents vary, broadly speaking the patent office's examine the applications to ensure that they comply with formal requirements, *e.g.*, that all relevant documentation is included and the filing fee has been paid. Furthermore, in many countries, the patent office will conduct the prior art search and a substantive examination, aiming to ensure that the application satisfies patentability requirements, such as novelty, inventivenessand industrial applicability, and that the invention is clearly and completely disclosed in a patent application. If the examination leads to a positive conclusion, the patent office grants a patent and issues a certificate of grant. In addition, many patent offices provide a period during which third parties may oppose the grant of a patent. In addition, in most countries the patent office publishes patent applications, normally 18 months after the first filing date and again when patents are granted. In practice, patent offices are often understaffed, resulting in mounting backlogs and challenges in maintaining quality standards. High-quality patents help increase certainty in the market place and enhance technological innovation.

Moreover, IPR protection (including patents) has become an important aspect of trade. While WIPO is the key international organisation that promotes innovation and creativity through use of IPR, the World Trade Organization (WTO) also plays a key role in the area of IPR. Under the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), the WTO establishes the minimum levels of protection that each of its Members has to give to IPR, which should contribute to innovation and transfer of technology in a way that benefits both technology suppliers and recipients.

Use of patent information for planning and monitoring of innovation

Patents (and usually also patent applications) are published for public inspection, to fulfil the "social contract" inherent in the patent system; the applicant receives a temporary exclusive right in return for disclosure of the invention. Patent information, namely the information included in public documents, such as patent applications and granted patents constitutes an important source of technical, legal and business information. Such information plays an important role in the process of innovation by, for example, stimulating new ideas and inventions through disseminating known technology. Patent information can also be used to assess RD&D trends, emerging technologies, whitespace, innovation patterns and relevant markets of competitors. The public nature of patent information also helps to avoid duplication of efforts and unnecessary investments or infringement on patent owners' IPR. When patent ownership and inventor data are public, competitors, as well as partners for collaboration, licensing and technology transfer, can be identified more easily.

The broad range of technical, business and legal information available from patents can be used for a number of different purposes including;

- Prior art searches to establish a baseline for technical research and development activities;
- Avoiding patent infringement;
- Planning investment, commercial and R&D activities; and
- Identifying key patenting trends and innovation patterns.

Patents are also used as an indicator for monitoring the innovation of technologies, the technology competitiveness of a country or the economic performance of a company or country. The patent landscape report prepared by WIPO in cooperation with IRENA on *Desalination Technologies and the Use of Alternative Energies for Desalination* (November 2011), which explored the use of patent information to assess trends in deployment of renewable energy for desalination, is an example of this use.

Patent citations, namely references to prior patent documents and the state of the art included therein, and their frequency are also often used as indicators for the

technological and commercial value of a patent, and to identify "key" patents, something that varies depending on the nature of the technology. In pharmaceutical technologies, for example, a patent on one important substance can be determined as a key patent. However, for more complex technologies, such as those used in renewable energy, patents are usually further developments of existing technologies. In these cases, it can be difficult to identify a clear-cut key patent.

Patent data can also be used to indicate global trends for technology transfer. A patent that is granted in many countries suggests that the inventor foresees wide applicability. A study by the OECD developed a proxy measure of technology transfer from the fact that protection for the invention may be sought in several countries (Hascis, *et al*., 2010). This is due to the fact that inventors are unlikely to file patent applications in more than one country unless there is a potential market for the technology covered by the original patent in those countries.

In a study on the impacts of standards on economic growth by DIN, the German institute for standardisation, three indicators – patents, licences and standards – are used to model technical progress in Germany. While patents are taken to indicate knowledge generation within Germany, licence payments from other countries are considered the indicator for knowledge imports, with standards used as an additional indicator for knowledge diffusion. The study found that patents were particularly important with highly R&D-intensive technologies, while standards were more widely applied for low to medium R&D-intensive technologies (Blind, *et al*., 2011). On the national level, econometric analysis for France suggests that patents are more significant than standards for economic growth. Growth in the stock of patents by a single percentage point yielded 0.37% gross domestic product (GDP) growth, while the equivalent growth in standards only yielded 0.12% GDP growth (Miotti, 2009).

Although a combination of various indicators may be utilised as an indicator for economic impact assessment of patents, there are a number of reasons why patents have limitations as indicators for innovation.

Patents alone do not reflect all inventive activities and technology transfers directly, because not all technical inventions lead to patent applications. Some businesses seek to protect their ideas by keeping them confidential. Also, the propensity to patent varies over time in different technology fields, companies and countries, and there are other complicating factors, such as social and economic conditions related to inventions and transfer of technology.

- Published patent applications and patents may not always contain the full information necessary for business activities, and they do not guarantee the commercial value of the inventions, since patent information is designed for the specific legal and technical purposes of the patent system.
- There are other means to protect intellectual property, such as the copyrights and designs mentioned above.
- Not all inventions are patentable.
- Although published patent applications and patents are an important source of technical information, information disseminated through the patent system alone is usually not sufficient "to build a widget", as certain types of other knowledge, such as know-how and market information, may be also required to build the widget to the extent that it is economically profitable.
- "Non-technical" aspects of innovation can also be useful, such as business organisations and methods, financial instruments, marketing, suitably skilled personnel and other knowledge transfer.

In summary, patents can be used in several ways to support and monitor RET innovation:

- The basic role of patents is to create temporary and geographically limited exclusive rights that act as a strong incentive for innovation through protection of investments and resulting inventions, and to support dissemination of innovation outcome. Patents never have a global coverage. Once patents have expired, the information is freely available for others to use.
- Patents play a key role as an incentive for innovation in market-based economies. They allow technology investors to capture the value of inventions.
- Numbers of patent applications are growing rapidly. They can be considered a core component of an information-based society.
- Because patent information is public, patent databases constitute an important source of technology knowledge. At the same time individual patents are often only part of a larger technology solution and written in such a way that know-how and other specific knowledge are required to fully deploy the invention to an economically profitable extent.
- Patent trends can be analysed to identify RD&D trends and forecast innovations. The number of patent filings in a certain field, the location of patent filings, the name of filing organisations and inventors, the referencing of patents and the patent families are used as indicators of innovation. Just as patent filings are often relevant to market formation, patent analysis can generate valuable

information about market development, such as which fields of technology current businesses intend to enter in the years ahead.

- At the same time patents have their limitations as information sources. Not all inventions are patented. Not all patents have the same relevance and the same value. Unfortunately the usefulness of certain patents in innovation is not self-evident and will often only show over time. While information on patent families can be collected, licensing information may not always be available.
- Patenting is an indicator of RD&D progress, but the fact that many patents are filed does not guarantee that a key technology will emerge or be successful in the market.
- Assessments of patent information in combination with other information such as GDP and RD&D investments can indicate the technology competitiveness of a country or the economic performance of a company or country, thus monitoring technological innovation.
- Quality patents help increase certainty in the marketplace and will help enhance technological innovation. In addition, they ensure that exclusive rights are only granted for valid inventions, preventing unwarranted exclusion of competitors from a particular marketplace. Governments, through their patent offices, must be stewards of patent quality.

2. Global patenting trends in RET

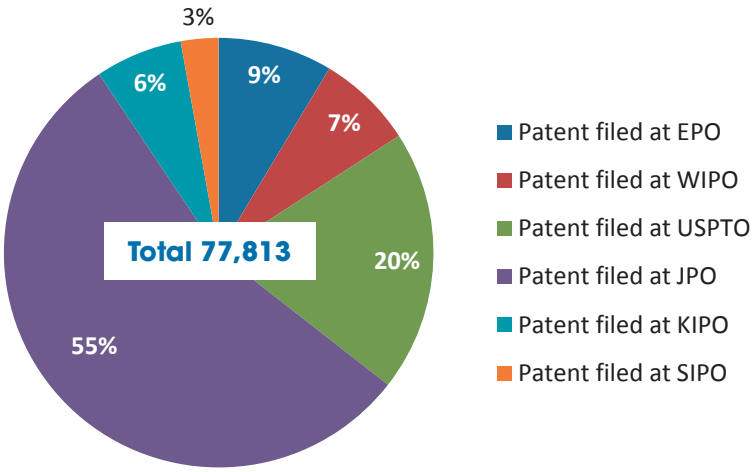
How many patents exist in the renewable energy field depends on how we define renewable energy. While the definition is evident for production of solar PV, it is less clear in the area of information technology (*e.g.*, smart grids) or biotechnology (*e.g.*, genetically engineered crops). Estimates suggest that there are around 215,000 existing patents with a main focus on renewable energy applications (Copenhagen Economics, 2009).

Patenting activities in RET have increased significantly since the 1990s. WIPO has conducted a patent landscape analysis on alternative energy technologies (solar, wind, bioenergy, hydropower, geothermal, wave and tidal power, as well as hydrogen and fuel cell, carbon capture and storage, and waste-to-energy) to examine the developments in the number and character of patent applications at several patent offices (the USPTO, JPO, EPO, KIPO, and China's SIPO) and international applications under the PCT.

The WIPO study looked into 77,813 filed patents relevant to renewable energy at the different patent offices. Of these 55% were filed in Japan, followed by the US and Europe (Figure 2). However, the dominance of Japan is not reflected in the market shares of equipment supply, which again indicates the limited value of patents as a proxy for commercial success.

The analysis showed that the annual rate of patent filings increased by 10% starting in the 1990s and by 25% from 2001 to 2005. Based on the patent activities seen in different patent offices, Europe and Japan showed a steady increase in patent applications, while patent applications increased exponentially in the US, the Republic of Korea (South Korea), and under the PCT system (WIPO, 2011).

Another patent mapping study was conducted by the United Nations Environment Programme (UNEP), the



**Note: The year of the patent publication at each patent office varies as follows.*
EPO: 12/1978–04/2008
WIPO: 10/1978–03/2008
USPTO: 01/1976–04/2008
JPO: 10/1976–12/2007
KIPO: 07/1979–04/2008
SIPO: 01/1991–11/2006

Figure 2: Renewable energy-related patents filed at different patent offices around the world

(Source: Patent-based Technology Analysis Report – Alternative Energy Technology, WIPO, 2009)

EPO and the International Centre for Trade and Sustainable Development (ICTSD) and presented in the report *Patents and clean energy: Bridging the gap between evidence and policy*[5]. The study used PATSTAT, a worldwide patent statistics database managed by EPO, to look at six main RETs – solar energy, wind energy, ocean energy, geothermal energy, hydropower and bioenergy. It found that the leading countries in terms of patent activities in these technologies were Japan, the US, Germany, South Korea, the UK and France. These countries together accounted for almost 80% of all patent applications in the RETs reviewed. At the same time, some emerging economies were showing specialisation. China, for example, showed notable patent activity in the area of solar PV (UNEP, EPO and ICTSD, 2010).

The study also showed that, between 1978 and 2006, the annual number of patents increased by a factor of between two and six. For hydro and geothermal, the patenting rate doubled. For biofuels it increased four-fold. For wind it increased five-fold and for solar it increased six-fold. This across-the-board growth shows the rising interest in renewable energy and the acceleration of innovation in this field between 1995 and 2006. Most patents were filed in the area of solar PV, followed by wind. A steady growth was discernible in the field of biofuels and solar thermal, which suggests that these may be fields where rapid market growth may be expected in years to come. Hydropower, ocean technology and geothermal seem to be at an earlier stage of innovation, where patenting is just picking up.

Looking into the trends of specific technologies, high patent growth rates (such as for wind, for example), have resulted in a very significant increase in the rate of deployment of these technologies. Figure 3 illustrates a similar correlation between patenting growth and the rate of deployment for wind energy technology. In this case the time lag between the growth of patents and the market growth seems to be 5–10 years. A steep increase in patenting predates the take-off of deployment by a few years, indicating that growth in patent activities can be an indicator for market prospects. At the same time it should be kept in mind that fossil fuel prices rose significantly during the period covered by Figure 3 and significant efforts to curb CO_2 emissions began.

It should also be noted that such correlation varies in different technologies. In other areas, such as hydrogen fuel cell vehicles, patenting does not result in significant uptake – a number of factors, including the policy environment, may have significant effects on adoption.

A look at patent filing patterns for most RETs shows that the technology market is largely dominated by industrialised countries, and developing countries have been latecomers. A report by Copenhagen Economics (2009) stated that only 0.1% of the 215,000 patents in the areas of waste and biomass, solar, fuel cell, ocean, geothermal and wind power technologies, during the

5 *Report available at www.unep.ch/etb/events/UNEP%20EPO%20ICTSD%20Event%2030%20Sept%202010%20Brussels/Brochure_EN_ganz.pdf*

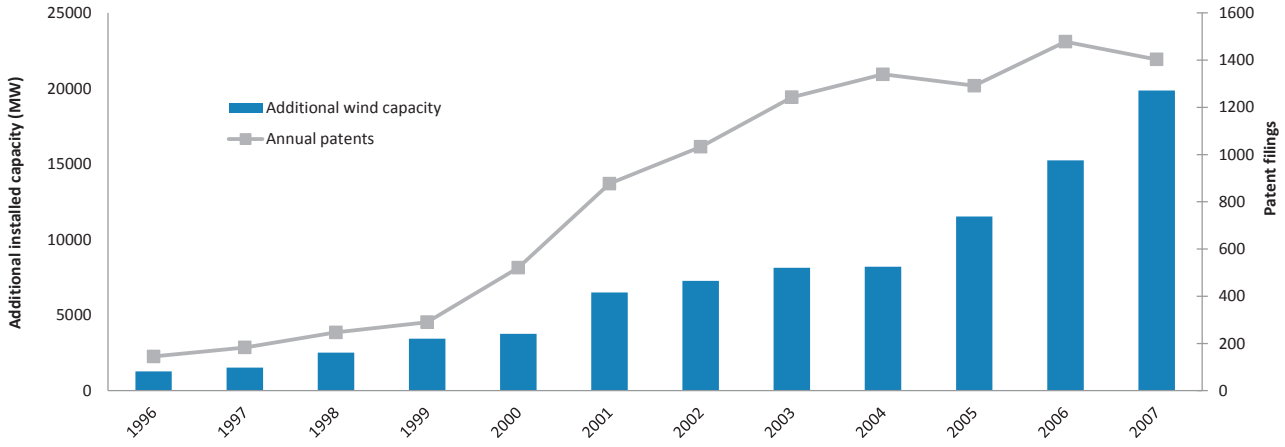


Figure 3: Patent filings and deployment of wind energy technology (Source: Lee, et al., 2009).

period 1998–2008, were registered in low-income developing countries.

Although patenting activities for RET are low in developing countries this does not imply that these countries have no access to the technologies. Technology users in countries where patent protection does not exist can use products, protected by patents in other countries, for commercial purposes without infringing the exclusive rights of respective patent holders.

The low patenting rate in some developing countries is changing. Growth of domestic ownership of patents by emerging market economies is evident, especially in China. About 92% of the 7,400 climate change technology patents owned by residents of emerging economies in 2008 were owned by China (Copenhagen Economics, 2009).

In terms of patent ownership concentration, a study by Chatham House (*Who Owns Our Low Carbon Future: Intellectual Property and Energy Technologies*, 2009)[6] found considerable variation in different RETs. For example, in the wind energy field, the top four patent owners collectively own 13% of all wind patents. These four industries (Enercon, General Electric (GE), Vestas Wind Systems, Mitsubishi) have a 57% share of the global market for wind turbines. In contrast, for solar PV, many of the top ten manufacturers are not patent holders (Lee, *et al*., 2009). The fact that patents are so dispersed suggests that no single company is in a position to monopolise the market based on ownership of patents.

Several studies have used patent data to develop a proxy measure for technology transfers. A study by Hascic, *et al*. (2010) found evidence of significant climate change mitigation technology equipment and knowledge flows across countries in the field of solar PV, wind power, biofuels and CO_2 capture. Hascic, *et al.*, used the count of patent applications filed with different patent offices, namely duplicate applications, as a proxy measurement for technology transfers. Given the significant expense in procuring patents, applicants tend to file only in markets where they plan to manufacture or sell their products, or are the location of significant competitive activity. The most important recipient countries seem to be China, South Korea, Brazil and South Africa (Figure 4). For example, in solar PV, although the original inventors are mostly seen in Japan and US, China was the biggest recipient country, receiving 2,071 patents in total, out of which 1,067 were from Japan and 663 from the US (Hascic, *et al*., 2010). This finding can be interpreted in several ways. It may suggest that US and Japanese patent owners think that these are important markets for RETs, or it may suggest that they regard producers in those emerging countries as potential competitors. Either way, it suggests that China, South Korea, Brazil and South Africa can play an important role in RET innovation. In the case of PV, most patents originate in Japan and the US. In the case of wind, most patents originate from Europe and, to a lesser extent, from the US.

6 *Report available at www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/r0909_lowcarbonfuture.pdf*

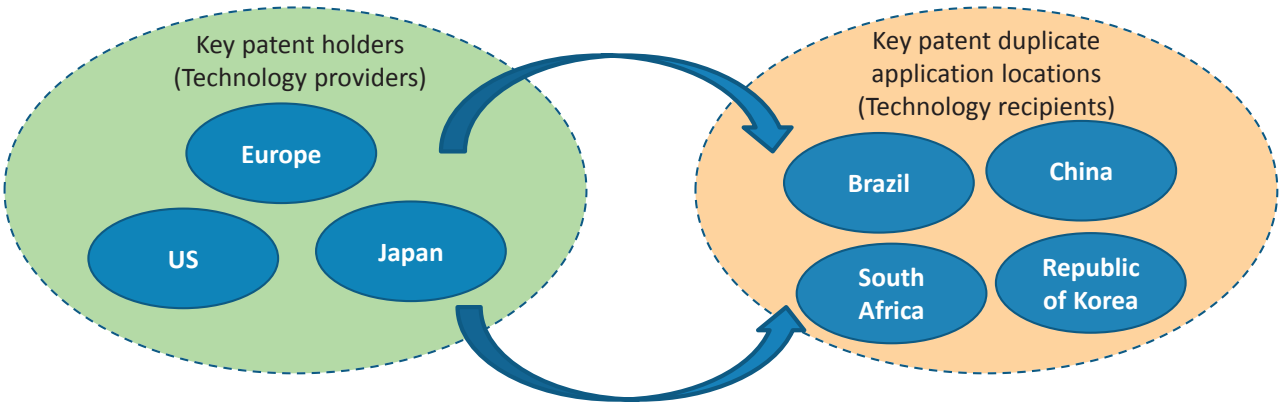


Figure 4: Trends of technology transfer of solar PV and wind energy from OECD countries to developing countries by looking into the same patents applied in different countries

(Source: Adapted from Hascic, et al., 2010)

One success story where patents played an important role in accelerating the development of PV cells may be seen in the Chinese company, Suntech Power Co., Ltd. The founder and CEO of the company, Dr. Zhengrong Shi, obtained a PhD from the University of New South Wales, Australia and worked in many research positions. He himself holds numerous patents in solar PV technology. Dr. Shi returned to China to start Suntech Power, which grew quickly through acquiring other businesses, including a Japanese PV company, MSK, which became one of the world's leading companies producing PV cells (Barton, 2007). Key patents, technological capacity gained through technology transfer (in this case by acquiring companies), and the growing global market for PV all enabled rapid innovations in PV technology in China.

Looking into a number of studies, overall it can be concluded that patents play a relevant role in the innovation system for renewable energy and the lead times and breadth of technology development in this industry are such that no player in the market has been able to gain exceptional advantages over others.

3. Use of patent information for RET assessments – existing databases and challenges

Assessment of RET requires the identification of key technologies and an accurate understanding of those technologies among policy makers and investors. Although patent information alone cannot determine the technology options, it can serve as an indicator for policy makers who want to assess technology solutions. Patent documents constitute a rich source of state-of-the-art technology information as well as legal and business information. They can provide important insights regarding trends of technology development across countries and by inventors. This can help policy makers assess technology trends and potential options for investment.

Much of the patent information is publicly available through a variety of patent databases around the world (Table 1). Patent database services differ in terms of geographic and historical coverage, as well as in the type

Table 1. Major patent databases available

(Information as of March 2013)

Key Database	Collection of filed patents	Data coverage	Legal status	Classification	Patent analysis tools	Language
PATENTSCOPE (WIPO)	18 million, including 2.2 PCT and 2.5 million from EPO	28 countries, plus EPO, ARIPO (African Regional Intellectual Property Organization) and PCT	Yes	IPC (International Patent Classification)	Statistical, Graphical analysis	AR, CN, DE, EN, ES, FR, HE, JP, KR PT, RU, VN (Multilingual search available)
Espacenet (EPO)	88 million	more than 90 countries	INPADOC legal status tab	CPC (Co-operative Patent Classification-replaced ECLA), IPC Note: Y classification for clean energy technologies	-	DE, EN, FR, JP, CN, KR (EPO Member Countries use Espacenet platform with access to documents in 22 additional languages)
IPDL (Japan)	77 million	Japan	Yes	F-I /F-terms	-	EN, JP
SIPO (China)	1.7 million	China	-	IPC	-	EN, CN
PatFT (USPTO)	More than 6.5 million	USA	Yes (separately through PAIR)	USPC (US Patent Classification), IPC	-	EN
KIPRIS (South Korea)	4.4 million	South Korea	Yes	IPC	-	EN, KR
Google Patents (Google)	8 million (provides full-text search including for period prior to 1976)	USA	-	IPC, USPC	-	EN
PatentLens (Cambia)	80 million	Australia, US	INPADOC legal status	IPC, ECLA, USPC	-	EN, CN, FR, ES, DE, KR, JP, RU

Key to languages: AR (Arabic), CN (Chinese), DE (German), EN (English), ES (Spanish), FR (French), HE (Hebrew), JP (Japanese), KR (Korean), PT (Portuguese), RU (Russian), VN (Vietnamese)

of documents available (patent applications, granted patents, etc.) and the elements of these documents that are available (titles, abstracts, description, claims, etc.). In addition, many databases offer various tools designed to facilitate the retrieval of relevant search results as well as for the visualisation and analysis of these results. There are three main types of patent databases: public sector databases (provided by national and regional patent offices), free-of-charge private sector databases, and fee-based private sector databases (WIPO, 2010b). In this paper, the first two types of databases will be discussed in more detail.

Although the patent search procedure has been improved by using classification schemes to retrieve relevant information, the different classification schemes developed by specific patent offices has made it difficult and complicated to obtain consistent data when looking into global patent activities. If a patent is filed in many patent offices, it will probably have multiple classification codes.

In order to improve patent searching, in 2010 EPO and USPTO jointly initiated the harmonisation of their two different classifications into a single system with a similar structure to the IPC. This is called the Co-operative Patent Classification (CPC) and will develop a new classification scheme based largely on ECLA, ensuring compliance with the IPC standards administered by WIPO. The CPC will be an important step towards harmonising the various classification schemes around the world. (For more information: www.cooperativepatentclassification.org/index.html).

Also in 2010, EPO worked with UNEP and ICTSD to develop a new classification scheme for clean energy and climate change mitigation technologies called the "Y02 classification". The new Y02 classification code is titled "Climate Change Mitigation Technologies (CCMT)" with subcategories of "Y02C: Capture, storage/sequestration or disposal" and "Y02E: Emissions reduction technologies related to energy generation, transmission of distribution", the latter including RETs (UNEP, EPO and ICTSD, 2010). This dedicated classification allows users to search by CCMT, not only by *technology*, but also by *applications* of the technologies such as power generation. EPO has further extended this scheme with new areas in CCMT Buildings (Y02B), and CCMT relating to Transport (Y02T) in 2012, as well as a new scheme dedicated to Smart Grids (Y04S). To date, this system has been used to identify and "tag" some 1.5 million patent documents relating to climate change mitigation technologies, making them readily accessible through the patent information system as well as patent statistics analysis tool. This can assist policy makers in retrieving relevant information quickly and accurately to facilitate their decision-making (EPO, 2012).

RETs are often a combination of different technology elements, extending over various sectors. As the quantities of RET information available to the public have grown, so too have the challenges of finding relevant information from which useful knowledge can be extracted. Also, effective searching of patent information often requires a solid knowledge of the technical field to which an invention belongs. (WIPO, 2010a) Different classification systems may also result in different results of patent search. These constraints make it difficult, especially for policy makers and investors, to easily access relevant technology information when searching the existing patent databases. Furthermore, the current patent classification schemes often do not correlate with the type of information sought by policy makers (UNEP, EPO and ICTSD, 2010). Policy makers and investors in developing countries in particular often look for technology solutions from end-use applications such as power generation, heating/cooling, transportation, water supply, etc. In contrast, most of the existing patent classification schemes are based on technology.

In order to fill the gap of access to information and knowledge for RET patents, IRENA has begun development of a web-based information platform intended to integrate existing RET patent information and enhance the knowledge of the roles and benefits of patents in promoting RET innovation. The details of this activity are described in the next section.

4. Renewable energy patents – IRENA activities

IRENA is mandated to assist governments in energy planning for more efficient and effective RET and innovation strategies. In order to fulfil its mandate, IRENA needs to play an important role in providing accurate and up-to-date technology information including patent information. IRENA can help disseminate patent information so that it can be used by policy makers for the assessment of RET, especially in developing countries.

IRENA has been working with WIPO and EPO since 2011 to explore ways of enhancing the use of patent information in order to assist RET assessments for policy makers, in particular those in developing countries. The following three activities have been carried out so far.

4.1 Patent landscape report on renewable energy desalination technologies

As a case study to show the use of patent information, a patent landscape report was developed in collaboration with WIPO on desalination technologies and the use of renewable energies (the report is available at: www.wipo.int/export/sites/www/freepublications/en/patents/948/wipo_pub_948_2.pdf). The report provides the latest overview to date of patenting activity and innovation in this area, in order to support policy makers and investors in assessing technological solutions for renewable energy deployment.

The study found that there were 4,551 patent families related to desalination of water, of which more than 20% represented the combination of desalination technologies with the use of renewable energy. For 80% of the RET, integration occurs with solar thermal energy (Figure 5).

The study also found that Japan had historically been the leading location for patent filing, although some German and US companies have shown increased patenting activity over the last five years, while South Korea and China have also become important locations for patent filings. Interestingly, only 1% of the total offices of first filing (OFF) were in Middle Eastern countries, where desalination has become one of the most impor-

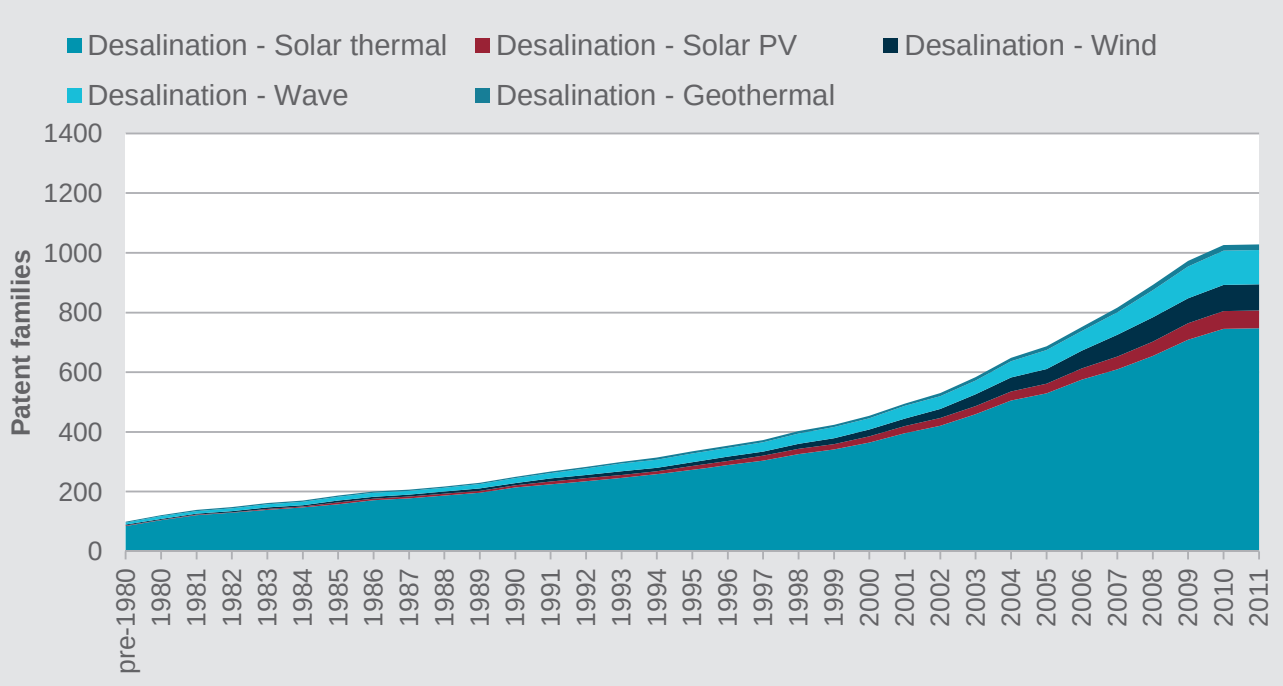


Figure 5: Cumulative patent families in desalination and renewable energy

(Source: WIPO, 2011)

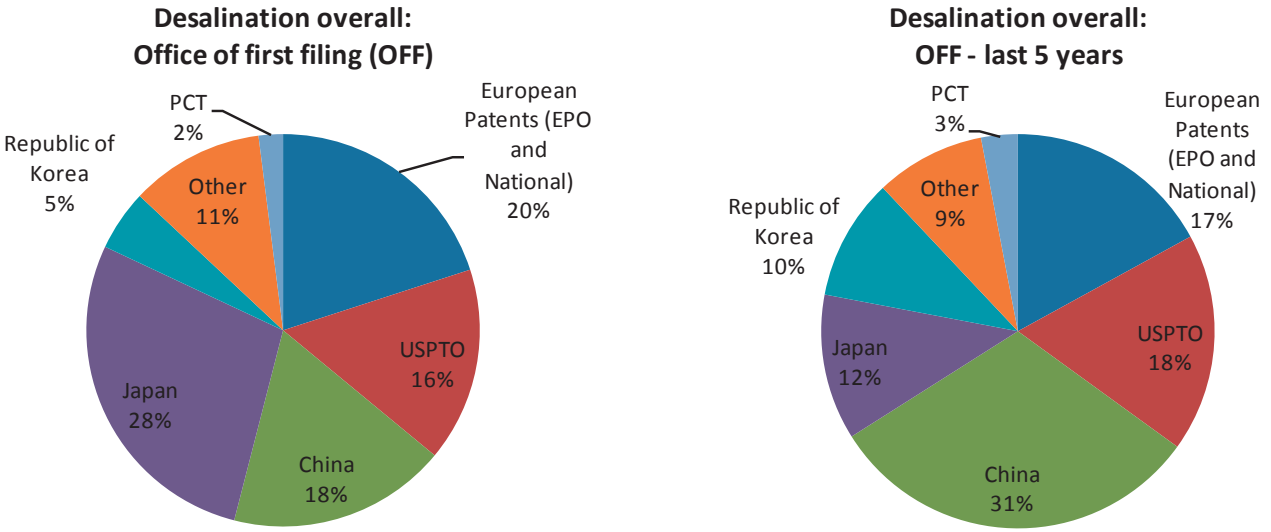


Figure 6: Patent activities for desalination by countries (Source: WIPO, 2011)

tant sources of water supply and where solar energy is abundant (Figure 6).

To date the use of renewable energy for desalination has been low. With the rapid decrease of renewable energy costs, technical advances and increasing number of installations, renewable energy desalination technologies are expected to further reduce their costs in the near future and become an important source of water supply for all regions affected by water scarcity.

Further elaboration of patent information on the key technologies, granted patents, cost of licensing the technology, and technical criteria to implement the patented technologies, would provide further insights for policy makers and investors for technological assessments.

Based on the patent landscape assessment for renewable energy desalination, IRENA will further extend the assessment to emerging technologies, such as ocean technology, in order to better understand the up-to-date trends of technology development. This will provide IRENA Member Countries and investors with insights, including which countries and innovators are active in inventing technologies, and which countries are the potential markets.

4.2 Development of the IRENA patent information platform concept

In order to promote technological innovation in RET, patent information can be used as one of the technology supply factors. Patents can provide useful information for policy makers and investors on the state-of-the-art technology information and identify R&D trends, allowing them to forecast innovation. However, obtaining such patent information can be challenging. As a first step towards making full use of patents, initial access should be made easy and comprehensive for policy makers and investors.

IRENA can act as a platform by providing relevant and easily accessible patent information on RET, not only for policy makers and investors, but also for researchers and industry stakeholders. The platform should be able to guide users in searching for RET, and also show them how to use the information (Figure 7).

In this context IRENA, working in collaboration with WIPO, developed a concept for a new search portal system for RETs in 2011. This portal will enable users – mainly policy makers and investors in developing countries – to easily search facilities for relevant technology patents. The portal is intended not only to provide a comprehensive technology-oriented search, but also to allow end-use application for RETs without the need of profound expertise in patents and technologies (Table 2). The search portal will build on WIPO's PATENTSCOPE, which has data coverage of 18 million patents from 29 countries including 2.2 million PCT (Patent Co-operation Treaty) patents and 2.5 million EPO patents . In order to design the portal in a way that makes it easy to search for the technological domains that are especially important to developing countries, new search queries need to be developed by WIPO for each RET.

A prototype of the WIPO-IRENA search portal can be found at http://patentscope.wipo.int/search/Irena/IRENA.html. WIPO's PATENTSCOPE system (http://pat-

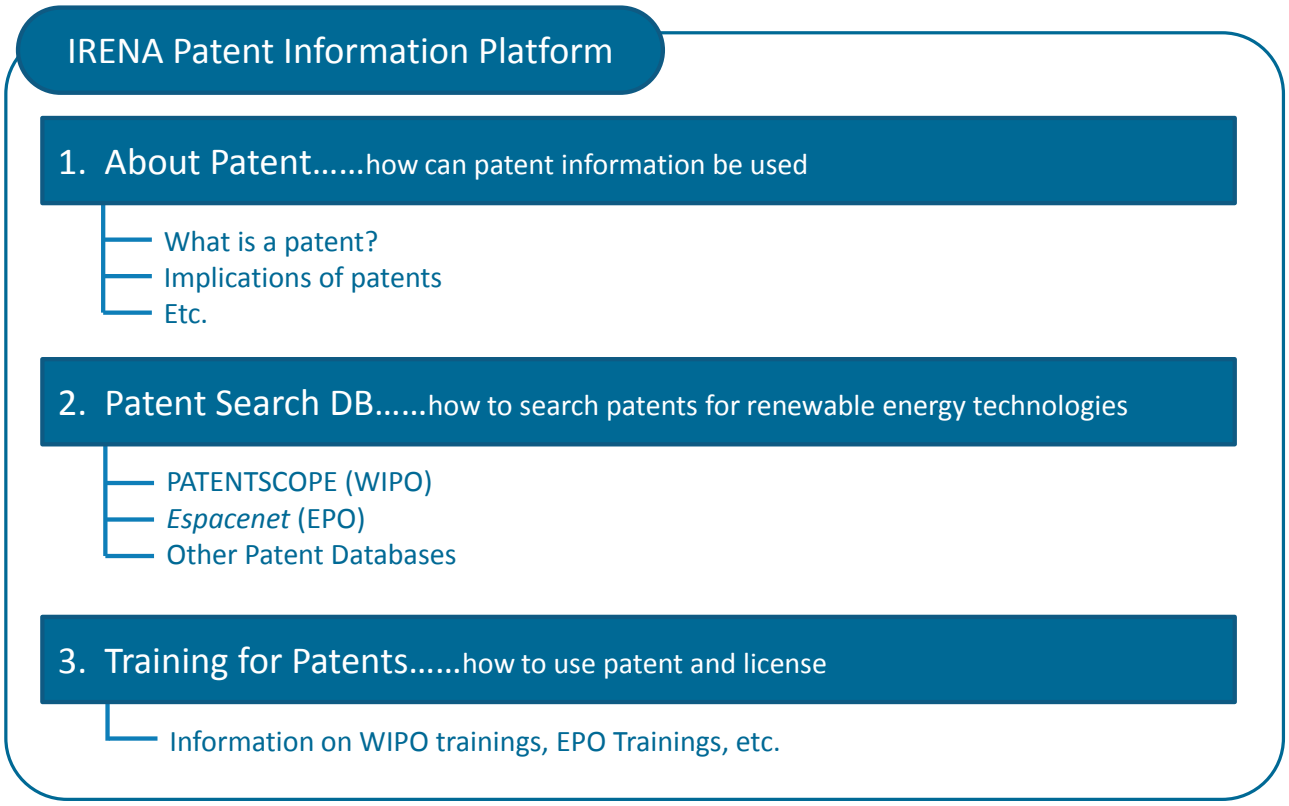


Figure 7: Concept of the IRENA Patent Information Platform

Table 2. End-use application and technology matrix

	Power Generation	**Energy for Heating**	**Energy for Cooling**	**Energy for Cooking**	**Energy for Water Supply (Water pumping, Desalination)**	**Energy for Transportation**	**Energy for Rural areas (Decentralized)**
Solar Energy	X	X	X	X	X		X
Wind Energy	X	X	X		X		X
Hydroenergy	X						X
Bioenergy	X	X	X	X		X	X
Geothermal energy	X	X	X		X		
Ocean Energy	X						
Other Enabling Technologies (Storage systems, Transmission and distribution issues, Smart Grid)	X						

entscope.wipo.int/search/en/search.jsf) system has the particularity to support very complex Boolean queries containing up to several hundred keywords in different languages. Combined with the fact that, at the time of writing this document, PATENTSCOPE gives access to around 11 million full texts (description and claims) among the total 14 million patents and that this coverage is expected to rise to more than 20 million by end of the first quarter of 2013 when the US collection will be indexed, this offers powerful search capabilities that IRENA users can tap into. WIPO has also defined a methodology for building complex search queries tuned to specific user needs, the queries being saved in the proposed search portal so that they can be used by end-users who have not mastered the intricacies of patent searching or the syntax and capabilities of the PATENTSCOPE system. Technical details of the methodology of the system development using PATENTSCOPE's search strategy, called the Cross Language Information Retrieval (CLIR), are described in ANNEX II.

IRENA information platform for renewable energy patents and standards

Based on the learning from this exercise and further feedback from experts and discussions with IRENA Member Countries, a need was identified for further exploration of the most effective ways to make full practical use of patent information for policy makers and investors. IRENA can play a key role in pooling existing efforts and information by various patents databases into a single global platform rather than developing its own patent search system. In this way IRENA can guide users to different sources of patent information, including various patent databases, information on licensing, and case studies from around the world on how patents can be used to enhance innovation for RETs. Moreover, understanding of the role of patents in innovation for the development and deployment of RET was identified as a gap by policymakers.

In order to optimise the access and effective use of the relevant information for RET innovation, IRENA plans to extend its concept of the patent information platform to include information on international and national standards for RETs as another important set of instruments for promoting RET innovation. Standards also play a key role in promoting technological innovation throughout the whole technology development stages. Proper access to such standards information is also important for policy makers to better plan and invest for accelerated RET deployment. A study which provides better understanding of the roles of standardisation for RETs is presented in the report *International Standardisation in the Field of Renewable Energy* available on the IRENA website (www.irena.org).

The IRENA information platform aims to facilitate easy access to patent and standards information on RETs and provide better understanding of the benefits of standards and patents among policy makers and relevant stakeholders as important instruments for decision-making to promote RET innovation. Such a platform will act not only as a pooling of knowledge and information, but also as a means of encouraging co-operation on RET development among different countries and regions.

In 2013, IRENA will develop a web-based prototype of the information platform that contains collective information for existing RET patents and standards including patent activities for different RETs in various countries and regions, international and national RET standards, information and case studies on benefits and effective use of patent and standards information. Based on the approach developed for the patent information platform, the new platform will also allow users to access the information from the end-use application (*e.g.*, power generation, energy for heating/cooling, cooking, water supply, transportation and rural areas) for each RET for their effective use in decision-making and investments.

4.3 IRENA's Workshop on Assessment of Intellectual Property Rights for Promoting Renewable Energy, 25 October, 2012 (Bonn)

IRENA organised a workshop, *Assessment of Intellectual Property Rights for Promoting Renewable Energy* on 25 October 2012 in Bonn, Germany. More than 20 participants, including experts and representatives from patent, trade and research organisations, along with energy associations, gathered to discuss the role of IPR in technological innovation for renewable energy, as well as the potential role of IRENA in IPR to promote renewable energy.

The workshop highlighted the importance of better understanding by policy makers of IPR in relation to RET. Participants noted that IRENA can facilitate access to patent knowledge and translate such information in practical ways to promote innovation for RETs. For patent information to be used to assess trends in innovation, indicator methodologies need to be further improved.

The outcome of the workshop will be incorporated into IRENA's future activities in the area of innovation. The proceedings, including the summary of the workshop, are available on the IRENA website (www.irena.org).

5. Conclusions and next steps

This paper serves to provide the background for further activities by IRENA in the field of renewable energy innovation. Some key conclusions from this background study include the following:

- The role of patents in RET innovation still needs to be better understood. They can support the development of national policies and regulations, but this requires further clarification and understanding about the positive role they can play, the effectiveness of their use and the information they contain.
- It has been observed that patents can play a key role as an engine for innovation and as a source of information regarding innovation trends in R&D intensive sectors, such as pharmaceutics. In the case of RET, further analysis is still required to assess the impact of patents on the innovation and commercialisation rate of technologies.
- Renewable energy accounts for only a small proportion of total patenting activities.
- The characteristics of RET, notably the rate at which the market develops in comparison to the 20-year term of patents and the global activities of many equipment suppliers, mean that patents do not create a major barrier for the deployment of RET.
- Patents are a measure for research output. They can contain valuable information for the development of new technologies before a market takes off. However, there are some limitations to patent information. Licensing may be a better proxy for technology transfer and dissemination, yet information on licensing is often kept confidential.
- Different patent databases based on different classification schemes provide different results in searching. The users of patent information need to be informed of, and understand, these limitations.
- There are more than 200,000 patents in the area of renewable energy. Only in hindsight is it usually possible to identify which ones are key patents. Patenting in most renewable energy areas has increased more than five-fold in the last two decades.
- Making patent information more accessible may help to accelerate innovation. Patent information can be made more accessible and easy to understand, for example through translations and a user-friendly information platform.
- Many patents in solar PV and wind were filed 10-15 years ago and are reaching the end of their terms, unless they have not been abandoned or revoked in the countries where they applied. This means the information can soon be freely used, and may already be available for use in locations where patent protection was not sought. In any case the filings were usually limited to key markets, and very few renewable energy patents have been filed outside OECD countries and China. This means that patents in the renewable energy sector should be considered as a source of innovation for developing countries, not as a constraint to innovation.
- Increasing patent quality will enhance the utility of patents as a source of technical information. Governments should ensure that applications examined by their patent offices are of the highest possible quality.
- Renewable energy patent information can provide valuable insights into: 1) which countries and innovators are active in inventing technologies, 2) which countries are the potential markets where technologies need to be protected, 3) the trends of technology developments in certain technology fields over time, 4) the trends of technology transfers from one country to another and 5) international research and co-operation as indicated by co-invention and co-ownership.

IRENA's next steps to further work on the role of patents in renewable energy technology development and application include:

- IRENA will continue working with relevant stakeholders, including WIPO and EPO, to develop a better understanding of the role of patents in RET innovation and explore ways of tapping into patent information as a rich information source for RET, in order to help countries use this information to stimulate technological innovation.
- IRENA can play a role through the provision of a pilot information platform to promote innovation in RETs. Together with its partners, IRENA can develop a pilot information platform aiming at providing accurate and up-to-date information, including information on patents and relevant

publications, to enhance access for RET innovation. The pilot platform can be expanded and refined based on the demand for information services from users.

- The analysis of renewable energy patent information in specific application areas will be expanded in order to better understand the latest overview and innovation in RET application. The case study on renewable energy desalination has provided valuable insights and will be expanded to other innovative technology fields such as ocean energy technology.
- Work related to patents will be part of a larger framework of innovation for RETs, which includes other supply factors and enabling frameworks including standards, technology value chain, and technology co-operation.
- Based on the studies already conducted, and in collaboration with key partners, IRENA will extend the concept of the patent information platform development in 2013 to a larger framework to include other information on innovation instruments, in particular standards for RETs.

References

Copenhagen Economics (2009), "Are IPR a barrier to the transfer of climate change technology?", Copenhagen Economics A/S and the IPR Company Aps, Copenhagen,

http://trade.ec.europa.eu/doclib/docs/2009/february/tradoc_142371.pdf (Accessed: March 2013).

Barton, J.H. (2007), "Intellectual Property and Access to Clean Energy Technologies in Developing Countries – An analysis of Solar Photovoltaic, Biofuel and Wind Technologies", ICTSD (International Centre for Trade and Sustainable Development), Switzerland,

http://dspace.cigilibrary.org/jspui/bitstream/123456789/28398/1/Intellectual%20property%20and%20access%20to%20clean%20energy%20technologies%20in%20developing%20countries.pdf?1 (Accessed: March 2013).

Blind, K., *et al*. (2011), "The Economic Benefits of Standardization", DIN German Institute for Standardisation, Berlin, available at

www.din.de/sixcms_upload/media/2896/DIN_GNN_2011_engl_akt_neu.pdf (Accessed: March 2013).

Pottelsberghe de la Potterie B. van and D Francois (2006), 'The cost factor in patent systems', CEB Working Paper 06/002 (2006), available at

www.uni-lj.si/files/ULJ/userfiles/ulj/razis_razv_projekti/intelektualna_lastnina/%25C5%25A0tudija-The%20cost%20factor%20in%20patent%20systems.pdf (Accessed: March 2013).

EPO (European Patent Office) (2012), "Finding sustainable technologies in patents", Munich, available at

http://documents.epo.org/projects/babylon/eponet.nsf/0/6e41c0df0d85c0acc125773b005144de/$FILE/sustainable_technologies_brochure_en.pdf (Accessed: March 2013).

Hascis, I., *et al*. (2010), "Climate Policy and Technological Innovation and Transfer: An Overview of Trends and Recent Empirical Results", *OECD (Organisation for Economic Co-operation and Development) Working Papers*, No. 30, OECD, available at

www.oecd-ilibrary.org/environment/climate-policy-and-technological-innovation-and-transfer_5km33bnggcd0-en (Accessed: March 2013).

Miotti, H. (2009), "The economic impact of standardization. Technological change, standards growth in France". Afnor, Paris, available at

www.sis.se/pdf/Economic_impact_of_standardization_France.pdf (Accessed: March 2013).

Lee, B., *et al*. (2009), "Who Owns Our Low Carbon Future: Intellectual Property and Energy Technologies", A Chatham House Report, London, available at

www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/r0909_lowcarbonfuture.pdf (Accessed: March 2013).

UNEP (United Nations Environment Programme), EPO and ICTSD (2010), "Patents and clean energy: Bridging the gap between evidence and policy", available at

www.unep.ch/etb/events/UNEP%20EPO%20ICTSD%20Event%2030%20Sept%202010%20Brussels/Brochure_EN_ganz.pdf (Accessed: March 2013).

WIPO (World Intellectual Property Organization) (2009), "Patent-based Technology Analysis Report – Alternative Energy Technology", Geneva, available at

www.wipo.int/export/sites/www/patentscope/en/technology_focus/pdf/landscape_alternative_energy.pdf (Accessed: March 2013).

WIPO (2010a), "Guide to Using Patent Information", ISBN: 978-92-805-2012-5, Geneva, available at *www.wipo.int/freepublications/en/patents/434/wipo_pub_l434_03.pdf.*

WIPO (2010b), "Guide to Technology Databases", WIPO, ISBN: 978-92-805-2172-6, Geneva,

available at *www.wipo.int/export/sites/www/freepublications/en/patents/434/wipo_pub_l434_11.pdf* (Accessed: March 2013).

WIPO (2011), "Patent Landscape Report on Desalination Technologies and the Use of Alternative Energies for Desalination", in cooperation with IRENA (International Renewable Energy Agency), WIPO, Geneva, available at

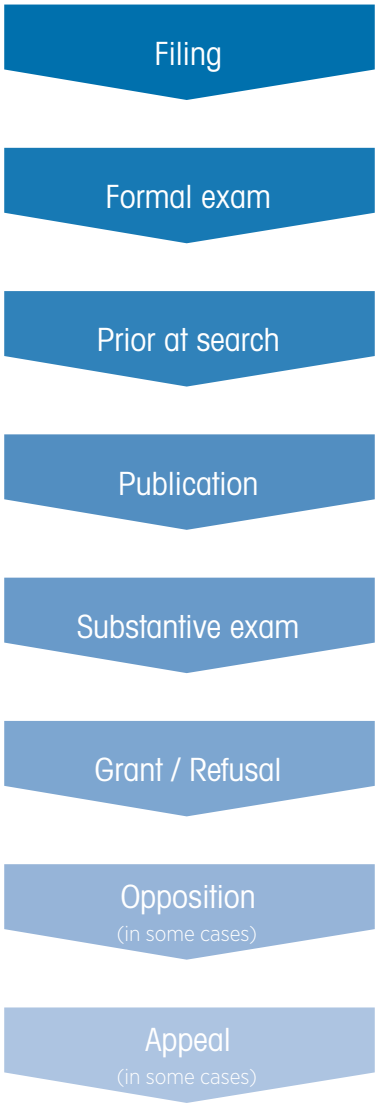
www.wipo.int/export/sites/www/freepublications/en/patents/948/wipo_pub_948_2.pdf.

WIPO (2012), "Economics and Statistics Series 2012", World Intellectual Property Indicators, Geneva, available at

www.wipo.int/export/sites/www/freepublications/en/intproperty/941/wipo_pub_941_2012.pdf (Accessed: March 2013).

ANNEX I
Patent granting procedure

(Source: WIPO, 2010a)



- **Filing.** An applicant chooses a filing route, *i.e.*, national, regional or international, and files an application. The initial filing is considered the "priority filing" from which further successive national, regional or international filings can be made within the "priority period" of one year under the Paris Convention for the Protection of Industrial Property.
- **Formal examination.** The patent office ensures that all administrative formalities have been complied with, *e.g.*, that all relevant documentation is included in the application, and that all filing fees have been paid.
- **Prior art search.** In many countries, but not all, the patent office carries out a search of the prior art, *i.e.*, of all relevant technological information publicly known at the time of filing of the patent application. Using extensive databases and expert examiners in the specific technical field of the application, a "search report" is drafted, which compares the technical merits of the claimed invention with that of the known prior art.
- **Publication.** In most countries, the patent application is published 18 months after the priority date, *i.e.,* after the first filing date.
- **Substantive examination.** If a prior art search report is available, the examiner checks that the application satisfies the requirements of patentability, *i.e.*, that the invention is novel, inventive and susceptible to industrial application, compared to the prior art as listed in the search report. The examiner may either grant the patent application without amendments, may change the scope of the claims to reflect the known prior art, or may refuse the application.
- **Grant/refusal:** The examiner may either grant the patent application without amendments, may change the scope of the claims to reflect the known prior art, or may refuse the application.
- **Opposition.** Within a specified period, many patent offices allow third parties to oppose the granted patent on the grounds that it does not in fact satisfy patentability requirements.
- **Appeal.** Many offices provide the possibility of appeal after the substantive examination or after the opposition procedure.

Note: Patents granting procedures differ from one patent office to another. Patent applications are filed with relevant national or regional patent offices and applicants pay filing fees as prescribed by respective offices. The process of patent application can be time-consuming and expensive. The cost of patenting consists of various expenses including procedural fees (filing fees, grant fees, validation fees, etc.), translation costs (especially when filed at EPO), and external fees such as patent attorney and maintaining costs (annual renewal costs). In a comparison study on patenting costs in three patent offices, namely EPO (Europe), USPTO (US), and JPO (Japan), the total costs of the filing procedure from intial filing to 20 years of maintaining the patent varied from USD 22,701 to USD 169,113, with Europe showing the most expensive patent system. (Pottelsberghe de la Potterie and Francois, 2006)

ANNEX II

The prototype of WIPO-IRENA search portal is based on the WIPO's PATENTSCOPE system. The system's methodology consists in defining atomic multilingual search concepts that, optionally combined with IPC codes, can be further assembled to create elaborated search strategies. PATENTSCOPE also puts an extension called the Cross Language Information Retrieval (CLIR) at the disposal of its users and assists them in finding relevant synonyms as well as translation of search keywords into 12 other languages (see http://patentscope.wipo.int/search/clir/clir.jsp). This extension greatly facilitates the work of creating search strategies.

The logic that led to the construction of the PATENTSCOPE multilingual search strategy for the following topic supplied by IRENA is as follows:

For example, when searching for the relevant patents for water supply by desalination run by solar energy, two atomic multilingual search concepts are necessary, one for solar technologies and the second for desalination technologies (which implies the concept of supplying water).

Using the CLIR system and synonym brainstorming and research, the two following atomic concepts have been drafted (showing here only the English, French, German, Chinese and Japanese keywords for brevity):

+Solar[English]=(solar OR sun)

+Solar[German]=(Solar OR Sonnen OR Sonnenenergie OR Sonnenlicht OR Solarzelle)

+Solar[French]=(solaire OR soleil)

+Solar[Japanese]=("太陽" OR "太陽光" OR "日射" OR "日射" OR "日光")

+Solar[Chinese]=("太阳" OR "孙氏" OR "太阳能")

+Desalination[English]=("desalination" OR "demineralizing" OR "demineralisation" OR "desalinisation" OR "desalting" OR "desalinization" OR "desalinating" OR "desalinizing" OR "desalinising" OR "salt removal")

+Desalination[German]=(„Entsalzung" OR „Entsalzungsanlage" OR „Wasserentsalzung" OR „Entmineralisieren" OR „Entsaltzung" OR „desalinating" OR „Demineralisierung" OR „entsalztes" OR „Demineralisation" OR „Aussalzen" OR „Mineralsalzentziehung")

+Desalination[French]=("dessalement" OR "dessalage" OR "désalinisation" OR "désalination" OR "déminéralisation" OR "déminéraliser" OR "dessalinisation" OR "dessaleur" OR "dessalinée" OR "désalage" OR "éliminer le sel")

+Desalination[Japanese]=("淡水化" OR "脱塩" OR "塩処理" OR "脱塩器" OR "脱塩工法" OR "淡水化処理" OR "式脱塩" OR "造水")

+Desalination[Chinese]=("脱盐" OR "除盐" OR "淡化机" OR "脱盐剂" OR "除盐水" OR "脱盐器" OR "除盐器" OR "进行淡化处理" OR "式淡化器")

Each atomic concept is searched independently in PATENTSCOPE against abstracts to assess the quality of the selected terms and synonyms in all languages (in terms of recall and precision). Potential noise problems are noted so that they can be lessened or eliminated at the building strategy step. The corresponding sets of IPC codes are noted and their descriptions are checked to see if one or several IPC code(s) do(es) not exist for the searched atomic concept that can also be used when building the final search strategy.

The query strategy is then built by successive attempts to merge the atomic search concepts with proximity (NEAR), AND, OR, ANDNOT operators and with IPC codes, and applying the criteria on indexed text fields in PATENTSCOPE (any combination of title TI, abstract AB, description DE and claims CL).

At each iteration, the results list is checked and the search strategy further refined until it is satisfactory. In first runs, target search fields usually do not include descriptions and claims in order to ensure that search results are obtained quickly.

The obtained final search strategy for solar desalination is as follows:

[+solar AND +Desalination]TIABCL ANDNOT IC:"A61K"

Interpretation: The concepts "solar" and "desalination" are searched together without proximity restrictions. They should appear both either in the title or/and in the abstract or/and in the claims of the retrieved patents. The results are then filtered to remove the patents classified under the IPC code A61K (Human Necessities: Medical or Veterinary Science; Hygiene). It is to be noted

that it is also possible to search in patent descriptions. This is used only in infrequent difficult cases because the claims section of a patent is supposed to cover all the inventive matter, which means that searching in descriptions as well usually produces more noisy results than relevant results, and at the penalty of a longer execution of the queries. However, searching in descriptions may sometimes pay off for technical fields where patent claims are drafted in generalised terms using lengthy noun or verbal constructions that do not use the frequent denominations.

The advantages of the proposed methodology are as follows:

1. Universality: All patents contain a textual description and claims, but not all patents are classified. If patents are available in PATENTSCOPE, they become searchable by multilingual queries.
2. Timeliness: As soon as a patent application is published it becomes searchable, even if it only becomes classified months later.
3. Evolutivity: If a given multilingual search strategy is found not to retrieve a particular relevant patent, it can be amended to improve its recall.
4. Affordability: It is estimated that building a new search strategy requires half a day's work for a person skilled in the art and versed in the PATENTSCOPE search capabilities.
5. Search versability: Any search subject or decomposition that is of interest to IRENA users can be addressed, irrespective of the existence of a corresponding classification entry.

However, this methodology is not a universal panacea as cases exist where query strategies based on keywords are inefficient (notably when the search matter is difficult to describe with words or does not explicitly appear in the descriptive text of the patent, although it can be derived from it) and where the IPC does not provide enough help. Other, more thorough classifications may help retrieve more relevant results in some of these cases (CPC; FI/F Terms).

To build the WIPO-IRENA search portal prototype, WIPO engaged a PhD student for two months during the summer of 2012, trained her on the PATENTSCOPE search capabilities and supplied her with search topics of interest on renewable energies selected by IRENA. Some search topics were discarded, as they did not particularly lend themselves to multilingual keywords search. In the cases that were retained, the prototype portal provides the retained query strategy as complimentary information, as well as when available, a short report of the discussions that occurred between IRENA and WIPO concerning the searchability of the matter and the agreed assumptions.

As an outcome of the efforts, the "Solar Energy" and "Wind Energy" domains have been covered, with 129 different query strategies built and more than 100 atomic queries. In developing such a new patent search portal, it is critical to define the ways to validate whether the search results are precise enough to provide the information needed. This would require extensive assessments by experts, not only in the field of RET, but also in patent queries. Assessments by actual end-users, including policy makers, investors and researchers, are also necessary. This will require extensive resources and time. Another point in developing such a search portal is that a systematic structure is needed to operate and maintain the search portal by fine-tuning the search queries based on the progress of technologies. These are challenges that need further discussion if this work is to advance.

The IRENA/WIPO collaboration was extended to EPO, which has already developed extensive classification on renewable energy-related technologies, *i.e.*, the Y02 classification system, as described in Section 3. This classification was developed as a collaborative effort by EPO, UNEP and ICTSD who worked with many experts in patents and RET over a period of years. Their efforts are reported in the document *Patents and clean energy: Bridging the gap between evidence and policy* (UNEP, EPO and ICTSD, 2010). Y02 classification is unique to EPO's efforts, while WIPO's database is classified based on the IPC. Therefore, a single patent search in both WIPO and EPO databases will result in two different search results, one from each database.

As the Y02 classification covers most of the major RETs and also allows end-use application, WIPO and IRENA explored the possibility of building the search queries based on the EPO's Y02 classification scheme. However, the different classification system methodologies made it difficult to construct exactly the same search queries.

As a trial, a search was made for six technologies from solar energy (three types of thin-film cells – amorphous silicon PV cells; microcrystalline silicon; polycrystalline silicon) and wind energy (three key components of horizontal-axis turbines – blades and rotors, nacelles, generator and configuration). EPO provided WIPO with the classification structures behind the Y02 for each technology and WIPO developed similar queries based on the query structure of Y02 classification and ran them through the PATENTSCOPE. The search results are shown in Table I-1.

The results are obviously different as the collections of the patents in each database are different: Espacenet having 80 million patents and PATENTSCOPE having 14 million patents. For the PCT patents, PATENTSCOPE usually found more patents results than Espacenet. However, although there should have been a close

Table I-1. A trial of patent search results using the Y02 query structure in different patent databases (as of October, 2012)

	Espacenet (EPO)	PATENTSCOPE (WIPO)
PV cells		
Amorphous silicon PV cells	5,617 (321 PCT)	1,046 (571 PCT)
Microcrystalline silicon	1,057 (71 PCT)	1,221 (680 PCT)
Polycrystalline silicon	1,814 (113 PCT)	600 (113 PCT)
Wind energy		
Blades and rotor	10,862 (1 058 PCT)	600 (113 PCT)
Nacelles	2,075 (279 PCT)	1,386 (706 PCT)
Generator and configuration	8,781 (795 PCT)	50,457 (12 812 PCT)

correlation in the numbers from the Espacenet results and PATENTSCOPE, there are some differences in the PCT collection seen in each database. This may be because some keywords were missing or omitted in the search query construction by WIPO, may be due to misclassified or unclassified patents within the EPO database at the time of execution of the queries, or may reflect differences of interpretation on the subjects being searched.

Although the adequacy of the results has not been validated, this case search comparison showed the complexity of the construction of patent search queries as well as the interpretations of search queries among different patent databases. Although the trial did not show what the differences were between the two databases and how each database complements the other, it is important for users to understand the strength and weakness of each database. One assumption is that the Y02 classification in Espacenet allows more precise searching on specific clean energy technologies, including renewable energy, while PATENTSCOPE catches broader terms of technologies. One could use Espacenet to look into the patent information on specific technology while using PATENTSCOPE to understand the trends of the global patenting activities and trends through PCT. Or, one could use both systems to look into overall trends and specific technology information. In that sense, because of the different patent collection and database construction, there is no one perfect patent search to meet all users' needs.

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