IRENA
International Renewable Energy Agency

RESOURCE

YOUR SOURCE FOR RENEWABLE ENERGY INFORMATION

DATA METHODOLOGY

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Introduction to IRENA REsource Data and Statistics Page

IRENA REsource

IRENA, as the global voice of renewable energy, has launched REsource, a freely accessible online knowledge platform that dynamically captures and illustrates renewable energy growth patterns. By linking to IRENA's full knowledge library, REsource provides information on renewable energy market statistics, potentials, policies, finance, costs, benefits, innovations, technologies, education and other topics.

REsource aims to improve decision-making, increase public awareness, promote investor confidence, and accelerate the overall deployment of renewable energy technologies.

The data and statistics page displays the latest renewable energy data available at IRENA. Data is currently aggregated under four different topics, each of which is presented on a different 'data dashboard':

1. Renewable Energy Capacity
2. Renewable Energy Education
3. Renewable Energy Employment
4. Renewable Energy Levelised Cost of Electricity

This document provides information about the methodology behind the data dashboards in IRENA REsource.

Download of Data

IRENA collects data from different sources, including member states, international organisations, local and regional organisations, specialized data providers such as associations, etc., or makes informed estimates based on analysis. Since some of the information is collected from external sources, IRENA does not own the rights to distribute all the data in raw format. Therefore, the data is only available in aggregated graphical format.

Frequency of Data Update

The last date of the data update is specified in the respective dashboard methodology section. The Renewable Energy Capacity and Renewable Energy Education dashboards read from IRENA's internal databases and will be updated on an ad-hoc basis during the year. The Renewable Energy Employment and Levelised Cost of Electricity dashboards are created as a result of intensive research and analysis and data updates are tied to IRENA's publication cycle.

Methodology: Renewable Energy Power

Scope

The Renewable Energy Capacity data in IRENA REsource represent the maximum net capacity of power plants and systems that use renewable energy sources to produce electricity.

According to the *International Recommendations for Energy Statistics*, maximum net electrical capacity is the maximum active power that can be supplied continuously, with all plants running, at the point of outlet (i.e., after taking the power supplies for the station auxiliaries and allowing for the losses in those transformers considered integral to the station). This assumes no restriction of interconnection to the network. It does not include overload capacity that can only be sustained for a short period of time (e.g., internal combustion engines momentarily running above their rated capacity). The maximum net electricity-generating capacity represents the sum of all individual plants' maximum capacities available to run continuously throughout a prolonged period of operation in a day.

A power plant with an installed capacity of 1 megawatt (MW) produces 1 megawatt-hour (MWh) of electricity if running at full capacity for one hour.

For most countries and technologies, the figures reported reflect the cumulative capacity installed at the end of the calendar year and include only those projects that are connected. In some cases however, the reported capacity may also include projects that are completed but not yet connected.

Technology and Sub-Technology Notes

- **Hydropower** refers to the potential and kinetic energy of water converted into electricity in hydroelectric plants. Hydropower capacity data include p*umped storage*.
- **Bioenergy** covers the energy derived from organic, non-fossil material of biological origin (biofuels), which can be used for the generation of heat or electricity. Bioenergy is generated from three types of biofuel - solid biomass, biogas and liquid biofuels - where these are defined as follows:
    - *Solid biomass* includes products such as wood or agricultural waste, as well as municipal waste. It also includes any solid biomass used in co-firing with fossil fuels.
    - *Biogas* incudes gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes). It includes landfill gas, sewage sludge gas and other biogases.
    - *Liquid biofuels* are liquids derived from biomass and used as fuels. They include bioethanol, biodiesels and vegetable oils used directly as fuel.
- **Solar energy** is solar radiation exploited for electricity generation and hot water production. Solar capacity data include *solar photovoltaic (PV)* and *concentrated solar power (CSP)*.
- **Wind energy** is the kinetic energy of wind exploited for electricity generation by wind turbines. Wind capacity data include *onshore wind* and *offshore wind*.
- **Geothermal energy** is the energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. Geothermal capacity data do not include heat pumps.

- **Tide, wave and ocean energy** is mechanical energy derived from tidal movement, wave motion or ocean current and exploited for electricity generation. Ocean energy capacity data include devices used for testing purposes whose lifetime ranges from a few months to a few years.

Geographical Notes

Data for countries do not include data for associated overseas territories unless specifically noted below:

- "Rest of the world" includes countries and territories that are not members of the United Nations.
- France excludes the following departments and territories: Guadeloupe, French Guiana, Martinique, New Caledonia, French Polynesia, Réunion, and St. Pierre and Miquelon.
- Japan includes Okinawa.
- Norway includes Svalbard and Jan Mayen Islands.
- Portugal includes the Açores and Madeira.
- Spain includes the Canary Islands.
- China excludes Hong Kong Special Administrative Region of China (China, Hong Kong SAR), Macao Special Administrative Region of China (China, Macao SAR) and Chinese Taipei.
- Israel includes East Jerusalem.
- Serbia includes Montenegro until 2006.

Data for regions are aggregated as follows:

- Africa includes Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cabo Verde, the Central African Republic, Chad, Comoros, Congo, Democratic Republic of the Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, the Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, the United Republic of Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.
- Asia includes Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Kazakhstan, Democratic People's Republic of Korea, Republic of Korea, Kyrgyzstan, Lao People's Democratic Republic, Malaysia, the Maldives, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Tajikistan, Thailand, Timor-Leste, Turkmenistan, Uzbekistan and Viet Nam.
- Central America and the Caribbean includes Antigua and Barbuda, Bahamas, Barbados, Belize, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.
- Eurasia includes Armenia, Azerbaijan, Georgia, Russian Federation and Turkey.
- Europe includes Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Republic of Moldova, Monaco, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine and the United Kingdom.

- The Middle East includes Bahrain, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates and Yemen.
- North America includes Canada, Mexico and the United States of America.
- Oceania includes Australia, Fiji, Kiribati, Marshall Islands, Micronesia (Federated States of), Nauru, New Zealand, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.
- South America includes Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela (Bolivarian Republic of).

Data Collection

The data presented here come from a variety of sources. Most of the data are official statistics submitted by countries to IRENA using the IRENA renewable energy statistics questionnaire during its annual data collection cycle or taken from official publications.

Where official statistics are unavailable, the statistics are supplemented with IRENA estimates or third party data such as that from industry associations.

Comments on the data and suggestions for additional data sources should be sent to statistics@irena.org.

Last data update: April 2015

Methodology: Renewable Energy Education

Background

The IRENA Renewable Energy Learning Partnership (IRELP) was established in April 2012 to raise awareness of, and access to, renewable energy educational opportunities and resources worldwide. IRELP contains four databases, available through www.irena.org/irelp, including renewable energy courses and programmes, webinars, training guides and manuals, and internships.

Data Collection

The IRELP databases contain over 2,500 renewable energy courses and degree programmes, 120 internship opportunities, 700 webinars and 220 training guides as of December 2014. Approximately 70 percent of the information found within IRELP has been gathered through IRENA desk research. Approximately 20 percent of the content has been sourced through IRELP's 22 partner organisations, including regional centres, training institutes and industry associations. The remainder of the content on IRELP has been added by volunteer members of the IRELP Global Network, who have been trained to search and upload related content to the IRELP databases.

Data Verification

All data that is sourced externally is verified by IRENA prior to being published on the IRELP website. When a course or programme is added to the IRELP database, an automatic email will contact the training provider. This email includes the record link on the IRELP website and invites training providers to send comments or feedback on their respective records. While IRENA makes all efforts to ensure the accuracy and completeness of content shared through IRELP, content is provided "as is", without any conditions, warranties or other terms of any kind.

Data Content

Education data that is referenced on REsource only includes records currently published on IRELP. The information in the IRELP databases is updated regularly, however, IRENA is not liable should the content be incomplete or out of date. Suggestions for inclusion may be sent to info@irelp.org.

Liability

IRENA is not responsible for any kind of loss or damage resulting from use of the information provided on IRELP or through links to third-party content. IRENA does not endorse and shall not be held responsible or liable for any content, products or services on or available from such websites or material. Any dealings between IRELP users and third party training providers found on or via IRELP are made between the user and the relevant provider. Therefore, IRENA is not responsible or liable for any loss or damage of any kind incurred as the result of any such dealings.

Last data update: April 2015

Methodology: Renewable Energy Employment

Content

Employment data in IRENA REsource depicts the status of renewable energy employment at the time of the publication of IRENA's latest Renewable Energy and Jobs – Annual Review, which is released in May and updated every year. The database includes direct employment, indirect employment when available and induced employment is excluded[1]. This may lead to underestimation since some of the data sources only report direct employment, with indirect employment excluded. Please see the section below on *Key Definitions* for explanation of *direct*, *indirect* and *induced* jobs.

Data Collection and Validation

The renewable energy employment data consists of a mix of primary and secondary data. **Primary data** are collected through government entities (*e.g.* ministries, statistical agencies) and industry representatives. **Secondary data** are referenced from a wide range of regional and global studies (see section on *Sources of Data* below). The underlying methodologies in these studies vary; inevitably, the different sources are often uneven in detail and quality.

Once data are received, a process of judgment and validation involving both IRENA staff and external experts takes place. If there are differences between the data reported by government entities and secondary sources, priority is usually given to the former. Judgement on which numbers to choose also depends on available information from the industry and relevant trends in policy, deployment or investment in different countries.

Limitations

The datasets provide an initial estimate of renewable energy employment at a global scale. However, gaps remain in data for certain countries and certain technologies within countries. A major cause for these gaps is that renewable energy is not singled out as a sector in the national economic, trade or labour statistics, mainly because: 1) it is still a relatively new industry and 2) it is a cross-cutting industry that encompasses different economic subsectors.

In addition, the availability of up-to-date information on renewable energy employment is an important limiting factor. The figures included in this database range primarily from 2011 to 2013. It should also be noted that the lack of data reported on any one technology/country is often indicative of a data gap rather than the absence of renewable energy jobs.

In an effort to continuously improve the employment database, comments and suggestions for data sources should be sent to revalue@irena.org. In parallel, IRENA is also working on various estimation methodologies to improve the quality of the employment figures to generate a more uniform data set. Finally, it should be noted that while IRENA strives to ensure the accuracy and completeness of the data, content is provided "as is", without any conditions, warranties or other terms of any kind.

[1] Exclusion of induced employment can sometimes be difficult due to lack of clear and consistent boundaries between different types of employment.

Notes on Specific Technologies

Some general notes on the employment data for renewable energy technologies are given below.
Notes on specific country data for each technology are shown on each graph.

- **Geothermal Energy:** Includes power and heat applications. Geothermal employment data is only available for the United States and the European Union. The figure for "All World" is estimated using employment factors. For Europe, it is assumed that what EurObserv'ER reports as "heat pumps" is entirely geothermal energy.
- **Hydropower:** Employment information for large-scale hydropower is incomplete, and therefore the data relates only to small hydropower. Although 10 MW is often used as a threshold, definitions are inconsistent across countries. In addition, employment data for small hydropower has not been found for major countries such as China, Malaysia and Indonesia etc.. Therefore the global total for small hydropower is based on a simple employment factor estimate based on data from United States and Europe.
- **Solid Biomass:** The data includes power and heat applications. Though traditional biomass accounts for a large number of people employed, it has not been included due to the predominantly informal[2] nature of the jobs involved and the related poor and scattered data.
- **Ocean Energy:** Very little information is available for this technology. Employment numbers remain small in comparison with other renewable energy technologies.

The global employment for "All World" is calculated by adding the individual totals of the technologies.

Key Definitions

The definitions for *direct*, *indirect* and *induced* employment are included here. For more details please refer to the Renewable Energy and Jobs report.

- **Direct employment** refers to employment that is generated directly by core renewable energy activities, without taking into account the intermediate inputs necessary to manufacture renewable energy equipment or construct and operate facilities.
- **Indirect employment** includes the employment in upstream industries that supply and support the core activities of renewable energy deployment. Usually, these workers produce steel, plastics or other materials, or they provide financial and other services.
- **Induced employment** encompasses jobs beyond the renewable energy industry and its upstream industries, such as jobs in the consumer goods industry. When people who are employed directly or indirectly in the renewable energy sector spend their incomes on a variety of items in the broader economy, the expenditure could result in induced economic activity and associated employment effects. Similarly, changes in energy costs for final consumers due to higher/lower costs of renewables could also give rise to induced employment impacts as the disposable income of the consumer changes.

Last data update: May 2014

[2] Employees are considered to have informal jobs if their employment relationship is, in law or in practice, not subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits (advance notice of dismissal, severance pay, paid annual or sick leave, etc.).

Sources of Data
The source of each data point is indicated in REsource. A bibliography is provided below:

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Methodology: Levelised Cost of Electricity

Scope

The Levelised Cost of Electricity (LCOE) of renewable energy technologies varies by technology, country and project, based on the renewable energy resource, capital and operating costs, and the efficiency/performance of the technology. The approach used in the analysis presented here is based on a discounted cash flow (DCF) analysis. This method of calculating the cost of renewable energy technologies is based on discounting financial flows (annual, quarterly or monthly) to a common basis, taking into consideration the time value of money. Given the capital-intensive nature of most renewable power generation technologies and the fact that fuel costs are low, or often zero, the weighted average cost of capital (WACC), often also referred to as the discount rate, used to evaluate the project has a critical impact on the LCOE.

Modelling Approach

There are many potential trade-offs to be considered when developing an LCOE modelling approach. The approach taken here is relatively simplistic, given the fact that the model needs to be applied to a wide range of technologies in different countries and regions. However, this has the additional advantage that the analysis is transparent and easy to understand. In addition, more detailed LCOE analyses result in a significantly higher overhead in terms of the granularity of assumptions required. This often gives the impression of greater accuracy, but when it is not possible to robustly populate the model with assumptions, or to differentiate assumptions based on real world data, then the "accuracy" of the approach can be misleading.

The formula used for calculating the LCOE of renewable energy technologies is:

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

LCOE = the average lifetime levelised cost of electricity generation;
I_t = investment expenditures in the year t;
M_t = operations and maintenance expenditures in the year t;
F_t = fuel expenditures in the year t;
E_t = electricity generation in the year t;
r = discount rate; and
n = life of the system.

	Economic life	Weighted average cost of capital, real	
		OECD and China	Rest of the world
Wind power	25	7.5%	10%
Solar PV	25		
CSP	25		
Hydropower	30		
Biomass for power	20		
Geothermal	25		

Data Collection

All costs presented are real 2014 USD; that is to say, after inflation has been taken into account unless otherwise stated. The LCOE is the price of electricity required for a project where revenues would equal costs, including making a return on the capital invested equal to the discount rate. An electricity price above this would yield a greater return on capital, while a price below it would yield a lower return on capital, or even a loss. The data required for the calculation of the LCOE are based on real-world projects contained within the IRENA Renewable Cost Database. The database contains around 9 000 utility-scale projects for which good data are available and a further 6 000 projects, where some data is missing (i.e. capacity factor) and is calculated or assumed based on location or the weighted average in the database for that location. In addition, the database contains around 740 000 data points for small-scale residential solar PV systems.

Different cost measures are useful in different situations, the LCOE of renewable energy technologies is a widely used measure by which renewable energy technologies can be evaluated for modelling or policy development. It is, however, not the only metric that can be used to evaluate and compare the costs of renewable energy technologies. Importantly, the LCOE is not an evaluation of the tariff required, as a more detailed DCF approaches taking into account taxation, subsidies and other incentives would be required by renewable energy project developers to assess the profitability of real world projects. This depends on their individual circumstances and market and are beyond the scope of any analysis by IRENA.

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