IRENA QUARTERLY
Q1 2017

ONSHORE WIND INDUSTRY LEARNING FAST

Governments, policy makers, regulators and energy and climate modellers all recognise onshore wind as an increasingly competitive option for new power generation capacity.

In recent decades, wind turbines have become a familiar sight in many countries. Onshore wind projects around the world now consistently deliver electricity for USD 0.04 per kilowatt-hour (kWh), with some projects achieving as low as USD 0.03/kWh. Yet up-to-date cost data and reliable projections of future costs remain limited.

The "learning curve" – a concept borrowed from manufacturing – assesses the rate at which production costs fall as deployment grows due to manufacturing and technology improvements. As an analytical tool, the curve captures past evolution and is a useful tool for assessing potential future cost trends for a given technology. In short, it provides a useful estimate of how future costs will fall as deployment (measured in some kind of physical units) grows.

Learning curves work by identifying the average percentage reduction in costs for each cumulative doubling of deployment. For the energy sector, learning curves have become an essential input to models that estimate the potential contributions of different technologies in the future energy system.

The existing literature for onshore wind, however, is out-of-date, largely failing to cover the period since 2009, when wind turbine prices have declined by 30-40%. Without comprehensive data for the entire period of onshore wind deployment, the learning curve literature may not be yielding realistic model results, potentially misleading policy makers. This is a very real risk, as almost 70% of installed capacity at the end of 2014 originated after 2007, while learning-rate estimates mostly pre-date 2010 and even include pre-2007 data.

To address this uncertainty, International Renewable Energy Agency (IRENA) has updated the onshore wind learning curve, taking into account the latest data.

Improved learning curves should help the growth of wind projects worldwide.

IRENA's **Renewable Energy Cost Database** *provides up-to-date costs for today's projects. Last year, IRENA analysed the prospects for key technologies future in* **The Power to Change: Solar and Wind Cost Reduction Potential to 2025.**

IRENA's onshore wind learning curves

IRENA compiled a database that has allowed updated calculations of the learning rates of onshore wind for both investment costs and levelised cost of electricity (LCOE), filling the knowledge gap and eliminating the uncertainty that has existed around the validity of previous learning rate analysis for onshore wind.

The project examined 12 countries (Brazil, Canada, China, Denmark, France, Germany, India, Italy, Spain, Sweden, the United Kingdom and the United States) over the period 1983-2014. These 12, accounting for over 87% of global installed capacity for onshore wind power at the end of 2014, represent a robust view of industry learning. The dataset covers more than 3 200 individual wind farms, representing 47% of global cumulative installed capacity at the end of 2014. To ensure a complete view on costs, this was complemented when necessary with additional data from reliable secondary sources for each country in each year.

The preliminary results show learning rates of 7% for investment costs (Figure 1) and 12% for LCOE (Figure 2) between 1983 and 2014, highlighting significant improvements in wind technology over the period. Final updated results are expected to be published in 2017.

Still, uncertainties remain, particularly in relation to the LCOE learning curve. Notably, the data for operation and maintenance costs over the whole period are not as robust as installed cost data, while data on actual project financing costs are almost completely absent. Yet financing costs for onshore wind have undoubtedly decreased. The 12% learning rate must therefore be considered a lower-floor finding, with the true learning rate likely to be somewhat higher.

Figure 1: Learning rates for investment costs

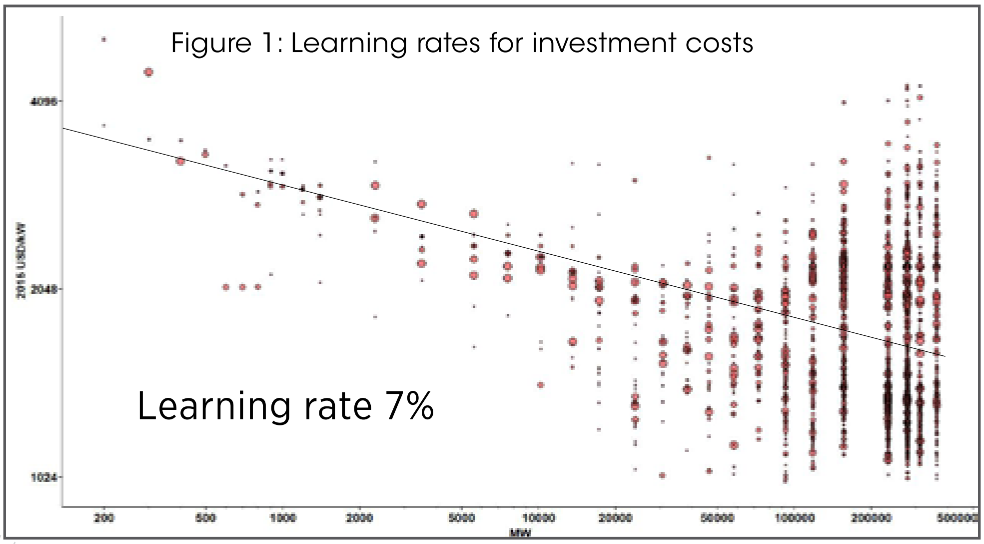
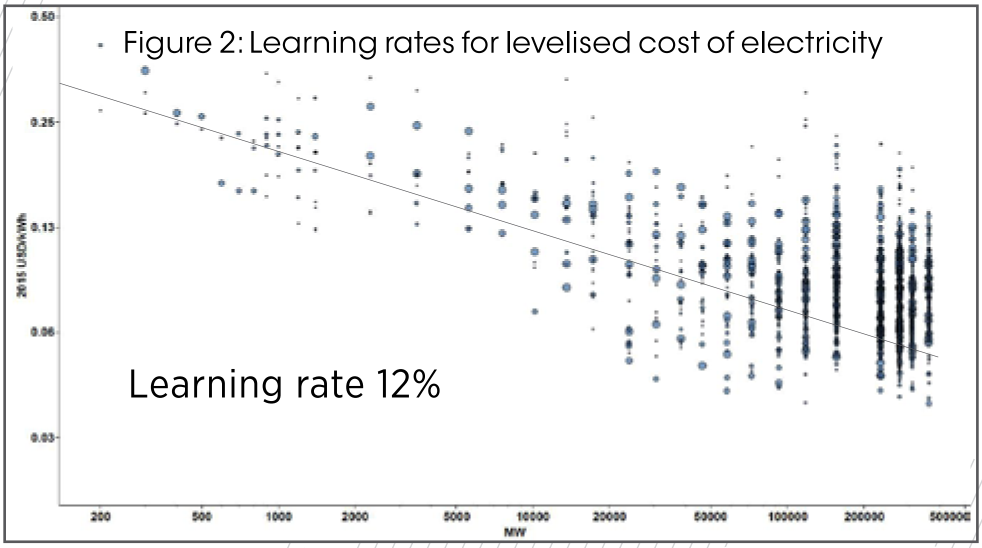


Figure 2: Learning rates for levelised cost of electricity



Better numbers needed to advance renewable energy

“Sound policies rest on good information,” said Frederick Mosteller, one of the most eminent statisticians of the 20th century. This is especially true in the rapidly growing world of renewable energy. Amid fast-changing technologies and evolving policies, collecting data is essential to monitor processes, ensure cost-effectiveness and make course corrections.

Energy development, particularly in power grids and large-scale generation tends to be long term. This requires serious statistics for planning and investment analysis. Demand has also grown for indicators of social and environmental impact, partly in relation to the seventh of the Sustainable Development Goal (SDG 7) adopted by the United Nations in 2015.

Yet the challenges of collecting and compiling renewable energy statistics are numerous. Some types of renewable power generation tend to be decentralised and may go unregulated and unreported. This is the case for small off-grid installations, as well as for traditional biomass uses. The continual emergence of new technologies, combined with a lack of clear definitions and standards, puts additional pressure on statisticians trying to capture changes and keep up with trends in the sector.

Data collection can involve numerous institutions and government departments – energy, forestry, agriculture, statistics and others. Limited staff capacity, lack of experience with renewable energy statistics and insufficient budgets for surveys can all pose hurdles.

To help regularise the process, IRENA has established annual statistics for installed power capacity and electricity generation from renewable sources. These time series (covering nearly all countries around the world) run from the year 2000 onwards and are disaggregated by type of technology. They are freely available online and support customised searches.

Recently, IRENA has published renewable energy balances for selected countries. Energy balances offer a systematic way of presenting energy supply, transformation and use in comparable energy units. Energy sources are classified as primary products (e.g. wind, solar, primary biofuels) and secondary products (e.g. electricity, heat, charcoal), which flow through a sequence from generation to final use.

> “Sound policies rest on good information”

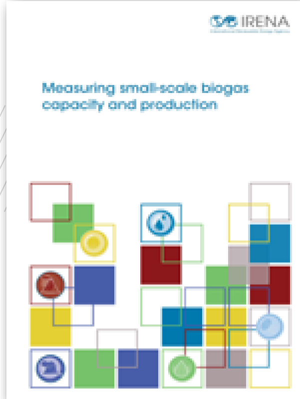
For example, a certain amount of firewood (sometimes known as “fuelwood”), grows in a country’s forest as primary biofuel. A portion of this fuelwood may be exported and another portion transformed into charcoal.

The remaining fuelwood may be burned for residential heating, but also used for electricity generation in local industry.

A national energy balance captures the origin, transformation and fate of such energy products and represents these in a systematic and understandable way.

Renewable Energy Statistics 2016 *is available on the IRENA website.*

Biogas use rising, but by how much?



The promotion of affordable, reliable and modern energy services is a major global development concern. In people's day-to-day lives, clean fuels and appliances for cooking are central to sustainable, healthy domestic energy use. Today 42% of the world's population lacks access to clean fuels and technologies for cooking, says the United Nations Economic and Social Council.

Many countries, in response, are promoting household biogas digesters for cooking and lighting.

Biogas offers numerous socio-economic and environmental benefits, including reduced firewood and kerosene consumption, lower emissions of greenhouse gases and lessen indoor air pollution, as well as added income and useful by-products. But biogas calls for specific monitoring and measuring methods.

In addition to tracking progress towards targets, such as SDG 7, such data is useful for national energy statistics, project and policy monitoring, and measuring the environmental impact of a switch to biogas.

The adoption of biogas at the farm or household level is tricky to monitor. Many households are unaware of their actual daily gas production capacity, leaving enumerators to make estimates based on visible dimensions of the biogas digester. But the digester may be buried underground or may not operate at full capacity. For example too little waste or too much water means less gas is produced.

However, such obstacles can be overcome. For instance, if the diameter of the plant can be measured, knowledge of standard specifications allows estimates of dimensions and volumes.

Daily biogas consumption can be estimated by asking survey respondents about their typical use of appliances, such as biogas stoves and lamps. The household's use of other fuels, including fuelwood, liquefied petroleum gas, kerosene and charcoal, before and after switching to biogas, can also provide clues. More directly, biogas production can be calculated by gathering data on the type and amount of waste added to the digester on a daily basis.

IRENA has produced a guide, **Measuring small-scale biogas capacity and production**, *to assist with data collection.*

What is a biogas digester?

A biogas digester is an airtight container in which bacteria break down organic waste through a process of anaerobic (no oxygen) fermentation. This generates a gas (biogas) consisting mostly of methane and carbon dioxide (CO_2). This gas can be used for cooking, heating and lighting, or it can be used to generate electricity. As more material is added to the digester, a liquid waste (slurry) is also produced, which can be used as a fertiliser.

Biogas digesters vary greatly in capacity, ranging from small-scale units used by households to larger communal and industrial digesters. Feedstocks added to the digester can include animal, food and agricultural waste. But materials such as wood, which are difficult for the bacteria to digest, should be avoided. The amount of biogas produced depends on a range of factors, including the type and amount of biomass fed in, the size of the digester and the temperature.

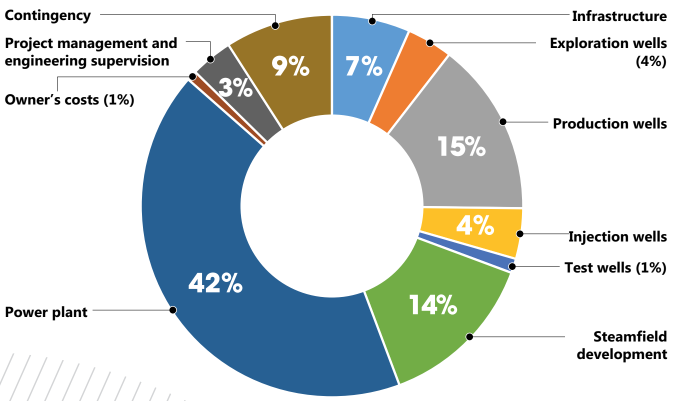
Guarantors take on geothermal resource risk

Recent statistics put the world's total installed capacity for geothermal power generation at only 13 gigawatts (GW) – less than 1% of all renewable energy capacity. Huge geothermal potential, spread across 90 countries, remains untapped.

But geothermal projects are expensive to initiate and, like oil wells, carry the risk of costly exploration failure. The high cost of locating and confirming underground heat sources, combined with long project development times, makes financial backers hesitant. Exploration wells, test wells, production wells, injection wells and steamfield development total around 40% of installed costs, nearly as much as capital expenditure. This, in turn, pushes up electricity costs from the power plant.

Installed costs from two recently built geothermal plants in Indonesia, for example, reached around USD 3 830 per kilowatt (kW). This is considerably higher than for other renewable power sources — around USD 1 800/kW for utility-scale solar photovoltaics and USD 1 560/kW for onshore wind power.

Total installed costs of two 110 MW flash geothermal power plants in Indonesia (estimated breakdown)



Fortunately, new kinds of financial instruments have emerged to mitigate the risks and address risk perceptions for geothermal energy projects.

Grants can cover high-risk exploratory probes. African and European institutions, for example, have established the Geothermal Risk Mitigation Facility (GRMF), which provides grants for surface studies, exploration drilling and further project needs in East Africa.

Germany and the European Union are similarly active in Latin America, where their Geothermal Development Facility (GDF) offers contingency grants for exploratory drilling. These transform to loans only if a project is successful, with no repayment obligation if drilling fails.

Regional grant schemes, along with other dedicated guarantee and insurance measures, will improve the chances of finding and tapping viable geothermal resources. National governments can help further by providing a stable policy framework and contributing to investment funds for geothermal projects. Risk mitigation facilities can cover multiple drilling sites, effectively spreading and reducing financial risks.

For more information, see **Unlocking Renewable Energy Investment: The role of risk mitigation and structured finance.**

GEOTHERMAL RISK MITIGATION TOOLS

Guarantee funds, exploration insurance and portfolio guarantees transfer risks to third parties.

- Guarantee funds are widely used by development finance institutions and national governments, to provide a safety net for developers in the case of unsuccessful drilling results. For example, Indonesia has set up a USD 300 million fund to develop geothermal financial structures and risk mitigation instruments.
- Exploration insurance via a public-private partnership allows governments to share the burden of potential failure in geothermal exploration drilling with private insurers. Turkey has formed such a partnership with the International Finance Corporation (IFC) and Munich RE. The insurer covers drilling costs for exploration, modelling and well development.
- Portfolio guarantees can cover part of the losses on a group of projects, diversifying exploration risks across different wells. For instance, Munich RE provides multi-well exploration risk cover for Kenya's Akiira project. This has eased the project's financing, with the premiums paid as instalments, as drilling progresses.

Romainia's Fântânele-Cogealac Wind Park

Photograph: CEZ

Investments in renewables set to grow across South East Europe

Renewables have long provided energy in South East Europe, whether as fuelwood for heating or hydroelectric power generation. But the region also relies on ageing conventional power infrastructures, which aims to phase out to reduce carbon-dioxide emissions. Clean, sustainable power sources are needed to drive future economic growth.

South East Europe, encompassing the newest European Union (EU) member states and others in the EU-led Energy Community, is committed to the deployment of renewables with binding targets. It also aims to align itself broadly with long-term EU commitments by 2030.

South East Europe's energy markets:

EU members: Bulgaria, Croatia, Romania and Slovenia

Contracting Parties of the Energy Community: Albania, Bosnia and Herzegovina, Kosovo*, Montenegro, Republic of Moldova, Serbia, the former Yugoslav Republic of Macedonia

* *Under Security Council UN Resolution 1244 (1999)*

Renewables today amount to 29 gigawatts (GW) or nearly half the region's total power capacity. But three-quarters of those renewables are from large hydropower dams.

Bulgaria and Romania are the only countries in the region with significant installed capacity for solar photovoltaic and wind, reaching 6.3 GW so far. Favourable support systems and falling technology costs spawned a short-lived investment boom in 2010–2014. This produced Europe's largest onshore wind park, the 600 megawatt (MW) Fântânele-Cogealac in Romania. But revisions to support schemes prompted investors to withdraw, and the resulting uncertainty dampened expectations for renewables around the region.

Non-hydro renewables continue to be treated with caution. Even so, steadily improving economics and growing understanding of renewable energy technologies have made governments take notice. In Serbia, a new Power Purchase Agreement (PPA) model is expected to unlock renewable energy investments, particularly in the wind sector. While 800 MW of wind projects have been planned since 2013, only 0.5 MW were installed by 2015. The new PPA could help meet the country's indicative target of 500 MW by 2020. New investments are also expected in Bosnia and Herzegovina, Montenegro, the Republic of Moldova and the former Yugoslav Republic of Macedonia.

The region possesses vast renewable energy potential. Some 88 GW could already be exploited cost-effectively today (or nearly 127 GW if Ukraine is included). The cost competitive potential by 2030 will be far greater.

See the new report: **Cost-Competitive Renewable Power Generation: Potential across South East Europe**.

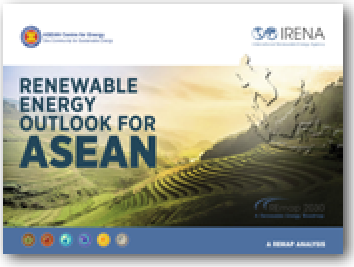
Recent publications

Renewable Energy Market Analysis: Latin America

This report offers a comprehensive review of the status and trends in the region's renewable energy development. It goes on to highlight Latin America's wealth of knowledge, draws key lessons, and outlines findings to support the continued expansion of renewables for power generation, transport and other end-uses.

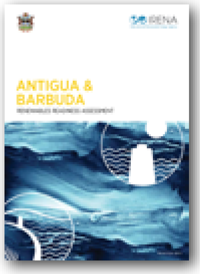
Innovation Outlooks

The series analyses emerging developments making renewable energy technologies increasingly competitive in the world's energy markets and systems.



Renewable Energy Outlook for ASEAN

The Association of Southeast Asian Nations (ASEAN) aims to rely more on renewables to support a sustainable, secure and prosperous future. This report indicates ways to accelerate renewable energy deployment and goes into depth on the technologies required for this ambitious transition.



Renewables Readiness Assessment: Antigua and Barbuda

Antigua and Barbuda possesses abundant renewable energy resources, including considerable solar, wind, biomass and ocean potential. This report presents a set of clear and practical steps for the island country to maximise renewables in the energy mix.

www.irena.org/publications

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.