



CO-BENEFITS KNOWLEDGE COMMONS

Edition 2021/2022

Renewable energy, employment opportunities and skill requirements

Socio-economic assessment tools, key findings and expert contacts





Imprint

“Co-Benefits Knowledge Commons: Renewable energy, employment opportunities and skill requirements” is published by the COBENEFITS project in collaboration with the Sustainable Energy Jobs Working Group under IRENA’s Coalition for Action.

The **COBENEFITS** project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The COBENEFITS project is coordinated by the Institute for Advanced Sustainability Studies (IASS, Lead) in partnership with the Renewables Academy (RENAC), Independent Institute for Environmental Issues (UfU) and International Energy Transition GmbH (IET).

The **IRENA Sustainable Energy Jobs Working Group** addresses knowledge gaps in sustainable energy jobs and provides analysis showcasing the energy transition’s ability to increase overall employment and benefit local economies. Formerly known as the Sustainable Energy Jobs Platform (SEJP), the Group also builds capacity through knowledge exchange and the sharing of best practices for a just and inclusive energy transition.

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IRENA Sustainable Energy Jobs Working Group & COBENEFITS Factsheet 2021/2022:

Connecting policymakers with expert organisations to assess and unlock employment co-benefits

Renewable energy technologies are job boosters: in 2020, the renewable energy sector employed at least 12 million people around the globe¹.

Many governments worldwide have recognized that the energy pathway they choose will not only have an impact on combatting global warming and meeting climate goals, but also define the basis for their countries' future development. Renewables can create sustainable jobs and improve the gender balance in the future energy sector.

To harness the full potential of the social and economic co-benefits of renewables and to build the skills base needed for the energy transition, decisionmakers depend on reliable data.

With this factsheet series, we seek to present the state of the art in assessing employment co-benefits, interconnecting climate friendly power planning and sustainable job creation.

This joint factsheet edition connects policymakers in local and national government agencies with expert organisations and contact persons, to quantify specific employment co-benefits, assess policy options and unlock potentials for people and communities.

We hope that this latest edition of Co-Benefits Knowledge Commons factsheets inspires scientists to carry out further work on the multiple social and economic co-benefits of renewable energy, and policymakers to raise ambition in climate mitigation efforts by working towards a rapid transition to low-carbon power sectors.

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¹IRENA (2021): Renewable Energy and Jobs. Annual Review 2021.



About this edition

A first edition of the Knowledge Commons was launched in 2019 at the Climate Opportunity conference, hosted by the COBENEFITS project in Berlin. It presented latest assessment results, tools and policy measures to unlock the social and economic co-benefits of ambitious climate action with renewable energy.

With the 2021/2022 edition we present an update with a series of Co-Benefits Knowledge Commons factsheets, each compiling latest research and assessment tools on the co-benefits of decarbonizing the power sector:

1. Renewable energy, employment opportunities and skill requirements – in partnership with the Sustainable Energy Jobs Working Group under IRENA's Coalition for Action

2. Air quality and health – in partnership with the Climate and Clean Air Coalition (CCAC)
3. Community well-being and sustainable livelihoods

As part of the 2021/2022 edition, the factsheet Renewable energy, employment opportunities and skill requirements, published in partnership with the Sustainable Energy Jobs Working Group under IRENA's Coalition for Action, presents the state of the art in socio-economic assessment tools and recent research findings on employment effects of renewable energy and the energy transition in countries around the globe. The factsheets are accompanied by information on expert organisations and relevant contact persons.



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FUTURE SKILLS AND JOB CREATION WITH RENEWABLE ENERGY IN INDIA

ASSESSING THE CO-BENEFITS OF DECARBONISING THE POWER SECTOR

CEEW

- **Country:** India
- **Co-Benefit:** Employment (Jobs)
- **Method:** Value-chain-based analysis
- **Assessment by:** CEEW and TERI
- **Published by:** CEEW, TERI and IASS
- **Year:** 2019

Employment coefficients of renewables

India has made significant progress in utilising its abundant renewable energy resources. The country has emerged as one of the leaders of the global energy transition, with a cumulative renewable energy installed capacity of 80.6 gigawatts (GW) as of July 2019, and has recently announced plans to further expand its renewable energy sector. Total generation capacity stands at 360 GW.

Notwithstanding these targets, the employment effects of the resulting changes in the power sector needs to be properly understood.

For the COBENEFITS project, **employment effects of a shift from coal to renewable energies in the Indian electricity sector have been analyzed.**

The calculations are based on four different plans for expanding power generation in India presenting different intensities of decarbonisation in the South Asian country.

The study also provides an initial **assessment of the skill requirements, attainment levels and technical training required for India's present power sector plans and future low-carbon power sector ambitions.**

Job creation by decarbonisation

India can almost double the number of jobs through the power sector by **2030** by following an ambitious decarbonisation pathway.

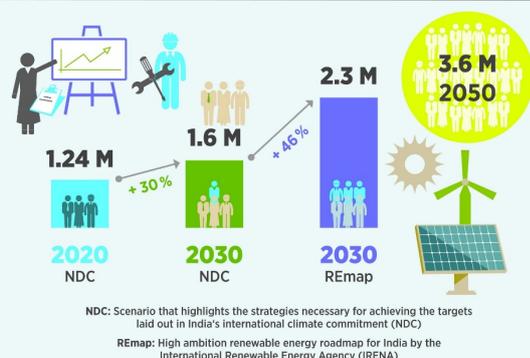


Figure:

Projection of the net employment in the power sector in India in 2020, 2030 and 2050. The first two columns show the net employment figures under the scenario of expanding renewables according to the government's NDC commitments. The third column shows the net employment that is possible if the government follows IRENA's REmap pathway. The figure for 2050 reflects the number of employees under the REmap scenario.

CEEW
THE COUNCIL



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IASS/TERI, 2019. Future skills and job creation with renewable energy in India. Assessing the co-benefits of decarbonising the power sector. Potsdam/New Delhi: IASS/TERI.

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COBENEFITS



IRENA
Coalition
FOR ACTION

Technical implementation:





Methodology

The study presents a value-chain-based approach by developing employment coefficients (full-time-equivalent jobs/MW/year) to analyze the workforce involved at various stages of the entire life cycle of different power generation technologies.

Four different scenarios for the development of employment in the power sector are assessed: Business as usual (BAU), NDC scenario, NDC PLUS scenario and the IRENA Remap scenario, all considering a consistent timeline between 2020 and 2050, but expressing different shares of renewables in the power sector.

Indicators assessed

- Full-time employment per MW per year, incl. direct, indirect and induced jobs
- Net employment in the Indian power sector from 2020 to 2050 in million full-time jobs following different scenarios
- Workforce distribution within the Indian renewables sector 2020 – 2050 and in the coal sector in million full-time jobs

Renewables as a job generator

- Renewable energy technologies tend to be more labour intensive than conventional energy technologies.
- **India can significantly boost employment through the power sector by increasing the share of renewables.** By electrifying the rural areas in the country with distributed renewable energy technologies such as small hydro, rooftop solar and biomass, the employment impact per installed capacity of these technologies is about 25 times greater than fossil-fuel based power generation.
- Skilling is the major need of the hour. Coal-sector-based employment is expected to decline by about 52% between 2020 and 2050. This transition, however, needs to be efficiently managed politically to mitigate negative impacts on displaced workers and communities.

Harnessing green jobs

- Manage the energy transition in the coal sector and coal-producing regions by the establishment of a new authority to re-skill workers from the coal sector.
- Install a system of accreditation and certification of local workers in procurement of renewable energy projects.
- Develop an online tracker to expedite skill development in the renewable energy sector to raise awareness on the urgency of skilled workforce and monitor progress.
- Improve data availability concerning employment in the RE sector.

References

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Kuldeep, Neeraj et al., 2017. Greening India's Workforce: Gearing Up For Expansion of Solar and Wind Power in India. CEEW and NRDC, Issue Paper.

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JOBS ADDED AND FUTURE SKILLS NEEDED FOR THE ENERGY TRANSITION IN SOUTH AFRICA

ASSESSING THE CO-BENEFITS OF DECARBONISING THE POWER SECTOR

CSIR

- **Country:** South Africa
- **Co-Benefit:** Employment (Jobs)
- **Method:** I-JEDI tool and SATIMGE model combined with qualitative methods
- **Assessment by:** CSIR
- **Published by:** CSIR, IASS and IET
- **Year:** 2019

Assessing employment from RE

South Africa has an abundance of renewable energy resources. This, combined with the recent drop in technology costs and the need for new power generation as coal power plants reach retirement, provides an opportunity for the country to decarbonise its electricity sector.

Managing this process will allow for a just transition in coal-dependent sectors and regions, thus opening new opportunities for current coal sector employees and other job seekers.

This study analyses the **employment impacts of different scenarios for expanding electricity generation in South Africa’s power sector**, taking into account various shares of renewables as power sources. This includes the resulting employment effects within the electricity sector, primarily focusing on coal and renewable energy sources.

It also provides an **initial assessment of the skill attainment levels required for South Africa’s energy transition**, and the potential for workers to transfer from the coal sector to the emerging renewable energy sector.

Job creation by decarbonisation

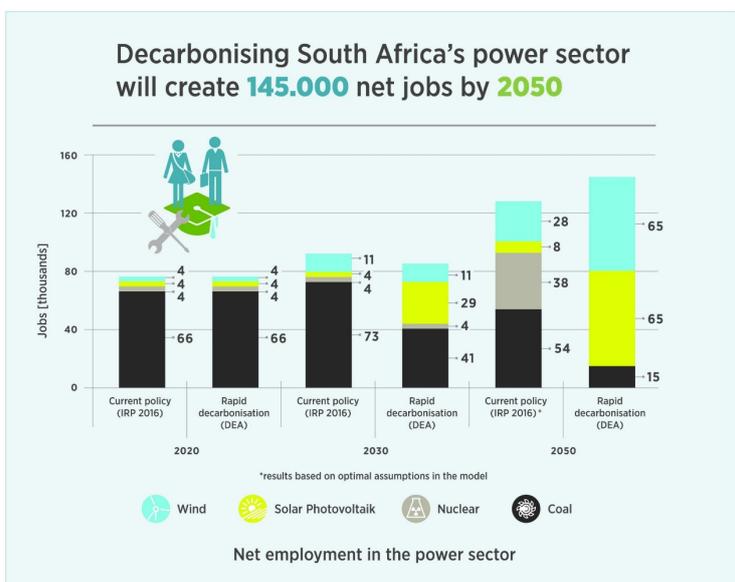


Figure: Projection of the net employment in the power sector in South Africa in 2020, 2030 and 2050. The share of different technologies is indicated by the respective colours. The „Current policy“ bar reflects the employment rate in case of the implementation of the Integrated Resource Plan 2016 (IRP 2016). Whereas the „Rapid decarbonisation“ bar reflects the employment rate in case of the implementation of the Department of Environmental Affairs (DEA) rapid decarbonisation plan. While no difference is yet observable, rapid decarbonisation is estimated to have created 17.000 more jobs than the current policy by 2050.



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CSIR/IASS/IET, 2019. Future Skills and Job Creation through Renewable Energy in South Africa. Co-Benefits Study.

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Technical implementation:





Methodology

The assessment combines a qualitative analysis of interviews with key stakeholders with a quantitative analysis to estimate the gross and net employment impacts of increased renewable energy deployment.

The International Jobs and Economic Development Impacts tool (I-JEDI) is used to assess the gross employment impacts, while the SATIMGE model is used to assess the net employment impacts.

Four electricity generation scenarios from different government analyses are considered to evaluate the employment impacts associated with different shares of renewable power in South Africa's electricity mix.

Indicators assessed

- Net employment in the power sector 2020 – 2050 by technology, following different scenarios, in FTE jobs
- Cumulative job years in various working phases created by wind and solar PV in 2018 and 2030 (direct, indirect and induced)
- Skill grade levels based on net employment impacts in the power sector (2020 – 2050), in FTE jobs (high-skilled, skilled, semi-skilled, unskilled)

Employment opportunities in numbers

- With the shift from the current policy of the Integrated Resource Plan 2016 to DEAs rapid decarbonisation path, an **additional 1.3 million jobs** are estimated to be created economy-wide and **17.000 additional jobs** in the power sector by 2050.
- Progressively over the years and in all scenarios, the net economy-wide employment gains are obtained mainly in the service based sectors.
- Across all scenarios, around **70 % of new jobs created in the power sector by RE are high-skilled jobs**, requiring at least a university degree.
- A decline in demand for South African coal can be observed across all scenarios due to global developments. Across the employment scenarios, jobs in the coal sector are predicted to decline by 35 – 40% between 2020 and 2050.

Policies for a just energy transition

Building on the study results and discussions with political partners and knowledge partners, policy and regulations could be put in place in three areas in order to benefit from potential employment opportunities:

- Create jobs along the value chain of the RE sector.
- Manage the transition in the coal sector and regions as the global demand is declining.
- Build the skills required for the future power sector in South Africa as the employment gains depend on the availability of a skilled labour force.



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EMPLOYMENT OPPORTUNITIES AND LOCAL BENEFITS OF RENEWABLE ENERGY PROJECTS IN MEXICO

CO-BENEFITS MEXICO

GIZ and IASS

- **Country:** Mexico
- **Co-Benefit:** Employment (Jobs)
- **Method:** International Jobs & Economic Development Impacts (I-JEDI) Model
- **Assessment by:** ITHACA Environmental and ICM
- **Published by:** GIZ and IASS
- **Year:** 2020

Creating employment, savings and income

The Energy Transition Law goals (LTE) and the Nationally Determined Contributions (NDC) to the implementation of the Paris Agreement require adjusting the power generation mix of Mexico and the scale up of renewable energy. This study used two scenarios considering the future development of the Mexican power system from 2020 to 2049:

1. **The Energy Transition Targets (MLTE) Scenario** using the Mexican National Program for the Development of the Electricity Sector (PRODESEN 2019).
2. **A Zero Carbon Transition (ZCT) Scenario** where at least 75% of the electricity produced by 2049 is from clean energy.

The study assesses the employment opportunities in the power sector derived from a transformation of the Mexican power matrix and the skills gap derived from shifting from fossil fuels to renewable energy, as well as potential skills that must be fulfilled to deploy solar and wind power capacity.

Additionally, it analyses the potential direct savings in energy costs and income generation at the municipal level (households and SMEs) and indirect savings for the federal government from the reduction of subsidies related to Basic Supply Tariffs.



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GIZ/IASS/Ithaca Environmental/ICM, 2020.
 Co-Beneficios: Contribución de la Transición Energética para el Desarrollo Sostenible en México

Infographic

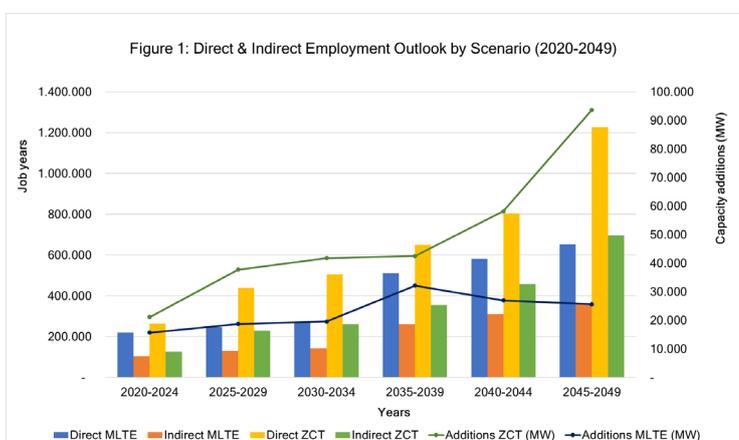


Figure: The bars indicate the direct and indirect employment years created by scaling up solar and wind renewable energy when achieving the goals traced by the LTE in the MLTE scenario and by shifting to a more ambitious decarbonisation pathway with the ZCT scenario. The lines indicate the MW additions for the MLTE and the ZCT scenarios.

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Technical implementation:





Indicators assessed

- Direct, induced and indirect job years
- In construction and O&M
- By productive sector
- Number of enrolled and graduate students
- Employment demand in the renewable sector

Methodology

This project used multiple methods to assess co-benefits and impacts from renewable energy deployment in Mexico, including literature review, interviews, workshops, data gathering and analysis, and modelling.

- The International Jobs and Economic Development Impacts (IJEDI) model from the National Renewable Energy Laboratory (NREL) was used to assess the future employment opportunities from wind and solar energy deployment.
- An analysis of the potential savings and income generation through the existing distributed generation schemes for PV.

Key findings

Employment generation from the construction and operations and maintenance of wind and solar PV capacity could generate **522,198 job years** between 2020 and 2024 and up to **1,559,328 job years** between 2045-2049. If Mexico would raise the ambition to a ZCT scenario, this numbers could raise to **638,330 job years** (2020-2024), and **3,202,505 job years** (2045-2049).

In the federal state Yucatan, it is estimated that the Industrial Medium Enterprise Sector could generate savings for **385** and **822 million pesos** under net metering and wholesale schemes. Meanwhile in the federal state Oaxaca, the business sector could generate **70 million pesos** of savings in net metering in the medium business, and **61 million pesos** under wholesale scheme in the 2020-2024 period.

Conclusion and recommendations

Mexico can enable multiple co-benefits, however, there are identified barriers that are slowing down the process, such as lack of financing and access to funding, dissemination of benefits and externalities, infrastructure (mainly distribution), technological and innovation in renewable energies, alternative schemes or models for energy generation and cogeneration, coordination in the different levels of government.

The findings of the studies show that increasing the share of various renewable energies in Mexico's electricity production mix can lead to an increase in overall employment across the economy compared to an increase in fossil fuels such as coal and natural gas.

References

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National Renewable Energy Laboratory (NREL), 2012, February.

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Secretaría de Energía (SENER), 2019, June 14.

Prodesen 2019-2033. Retrieved June 20, 2019, from <https://www.gob.mx/sener/documentos/prodesen-2019-2033>

GREEN RECOVERY AND CLIMATE ACTION

ASSESSING GREEN JOBS FROM RENEWABLE ENERGY AND FORESTRY INVESTMENTS FOR DEVELOPING AND EMERGING ECONOMIES

GGGI

- **Country:** 27 countries
- **Co-Benefit:** Employment (Jobs)
- **Method:** Emission dispersion model
- **Assessment by:** GWS, Germany
- **Published by:** GGGI
- **Year:** 2021

Assessing RE Employment of NDC targets

As a result of the economic crisis, high levels of unemployment, many developing country governments understandably have a single-minded focus on social and economic improvement. Developing economic recovery plans coincides with the first NDC revision cycle where the Parties to the Paris Agreement are currently submitting their revised NDCs. **Aligning the NDC revision process with economic recovery plans could be a great opportunity for countries to address economic, employment, and climate objectives simultaneously.** Investigating the employment implications of NDC climate actions and targets, particularly in RE, could provide important insights regarding the type of energy technologies with the highest employment creation potential. This study assessed the **employment co-benefits of implementing renewable energy (RE) targets set in the NDCs in GGGI Member developing and emerging economies.** Quantitative NDC targets related to RE were identified and reviewed for 27 countries related to five RE technologies, namely 1) solar photovoltaic (utility scale), 2) onshore wind, 3) biomass, 4) geothermal, and 5) hydropower (large and small).



Contact

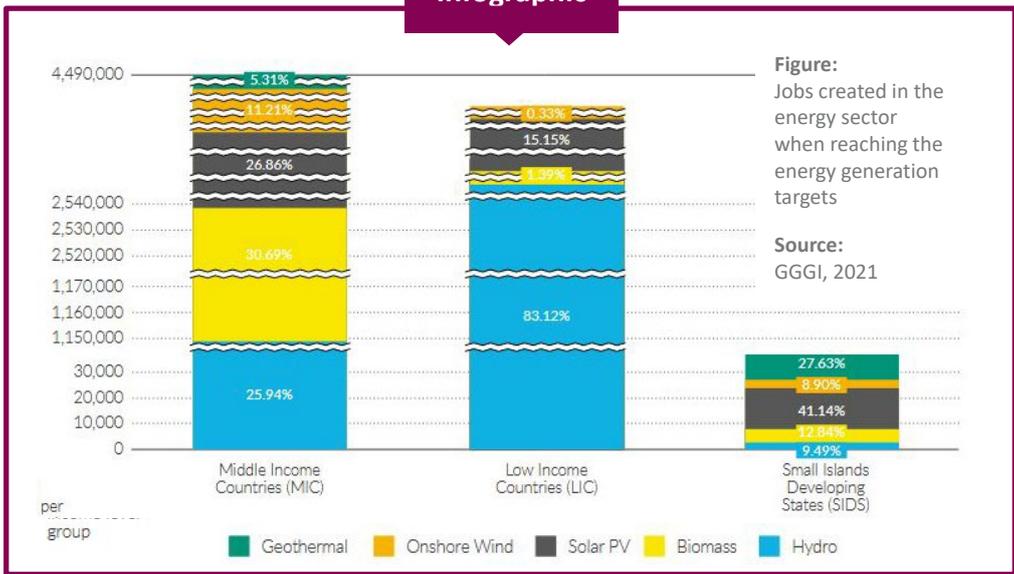
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Green Recovery and Climate Action, 2021.
Assessing Green Jobs from Renewable Energy and Forestry Investments for Developing and Emerging Economies.

Infographic



Indicators assessed

- NDC targets (in MW of installed capacity)
- Employment factors adjusted per country (job-years per MW installed)
- Employment creation potential for different stages of the value chain of renewable energy technologies (in job-years)
- Investment needs of renewable energy targets (in mil USD)

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Technical implementation:





Methodology

The assessment of the direct jobs is based on the **Employment Factors (EF) approach**. In addition, an extensive review of 30 NDCs, as well as National reports of quantifiable energy targets (additional installed capacity by 2030 in MWs) was conducted. Firstly, the study compiled EFs from the literature both for RE and fossil fuel-based energy technologies (i.e., oil, gas, and coal) for comparative purposes. Secondly, it utilized the EF approach to estimate the number of jobs that could be created if countries implement their NDC RE targets. The **employment intensity of each stage of the value chain associated with an energy technology** such as manufacturing, construction and installation and operation and maintenance, has been assessed separately. EFs were deemed apt as the indicative measure of job creation in this study, given that specific variables (e.g., labor productivity and local share) are appropriately adjusted to each country.

Key findings

- RE investments have major employment co-benefits for the green recovery of low income and emerging economies. Thus, **investing in RE, solar, and wind as part of a green recovery strategy should still be prioritized**
- For 27 GGGI Member emerging and developing economies with quantifiable RE targets in their NDCs, the **implementation of these commitments would lead cumulatively to more than 8 million job-years for the 11-year period until 2030**
- The majority of the employment co-benefits, well over 4 million job-years, are situated in just three emerging economies with large energy sectors: Indonesia, Mexico, and Vietnam
- Some LDCs have significant numbers of employment co-benefits as well—particularly Cambodia, Ethiopia, Lao PDR, Myanmar, and Nepal—but these are dominated by hydropower-linked targets that dominate job creation
- While absolute the job-year numbers are small for SIDS, employment benefits can still be significant as a share of the local labor market due to the small size of their economy
- LDCs have very low RE targets in their NDCs that are linked to solar PV or onshore wind energy, thus leading to low employment co-benefits. Given that many of these countries, particularly in Africa, currently have very low access to energy rates, **investments in RE, solar, and wind, while not driven by their current NDCs, can (or should) still be significant to achieve sustainable energy access for all**

Actions to unlock co-benefits

- Focus on **shovel-ready projects in the RE sector** to attract private sector investments and realize climate goals.
- Plan ahead and **develop skills enhancement and Vocational Education and Training Programs (VETP)**. Government sponsored VETP should address any knowledge and skills misalignments and assure that the necessary human resources are available and well equipped for private and public investments.
- **Support data collection, monitoring and reporting methods** in developing countries.



References

Grafakos et al., 2020. Employment Assessment of Renewable Energy: Power Sector Development Pathways compatible with NDCs and national Energy Plans. GGGI Technical Report

NDC Registry. The Latest Submissions.
<https://www4.unfccc.int/sites/NDCStaging/Pages/LatestSubmissions.aspx>



UNLOCKING THE JOB POTENTIAL OF ZERO CARBON

REPORT ON THE CASE STUDY HUNGARY

Green House Think Tank and Ecopolis

- **Country:** Hungary
- **Co-Benefit:** Employment (Jobs)
- **Method:** Input-Output (IO) analysis
- **Assessment by:** Green House, Ecopolis
- **Published by:** Green European Foundation
- **Year:** 2018

A zero carbon vision

This study from the Green European Foundation, working with Green House Think Tank (United Kingdom), Ecopolis (Hungary) and Green Foundation Ireland analyzed how a zero carbon vision for the economy would impact jobs in the energy; transport; buildings, waste reuse and recycling sectors in several countries. These practical impacts were calculated for the United Kingdom, Hungary and the Republic of Ireland. At this page, we have focused on the case of Hungary.

From the 8 GW capacity for power generation installed in Hungary, most of it is oil, gas, coal and nuclear. In 2015, only around 57 MW of hydro, 29 MW of solar and 300 MW of wind energy were installed, though there exists a significant potential for renewable energies. **For Hungary, the researchers calculated new jobs associated with the installation of the necessary wind and solar power to change to an energy system powered solely by renewable energy, where electricity is used for transport and heating as well as its current uses.** There have also been calculated the new full-time equivalent jobs in the NUTS2 regions of Hungary associated with wind and solar power during a transition period from 2018 to 2030, as well as full-time equivalent long-term jobs in maintenance and other.

Methodology

Based on a vision to reduce GHG emission to zero until 2030, the related job potential was calculated for all seven NUTS2 regions of Hungary. For the calculation, Eurostat data about the geographic area of interest was combined with job metrics from public sources describing hours of work and hence numbers of jobs per activity. The resulting estimates of number of jobs in each sector during a transition period from 2018 to 2030 and in the longer term are presented in total number of new, full-time equivalent (FTE) jobs in the energy sector.

Indicators assessed

- Capacity to be installed in MW (solar PV and wind)
- Transition jobs in full-time equivalent jobs (for solar and for wind)
- Long-term jobs in full-time equivalent jobs (for solar and for wind)



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Anne Chapman, Jonathan Essex and Peter Sims, 2018. Job potential of zero carbon: Report on the case studies United Kingdom, Hungary and the Republic of Ireland.

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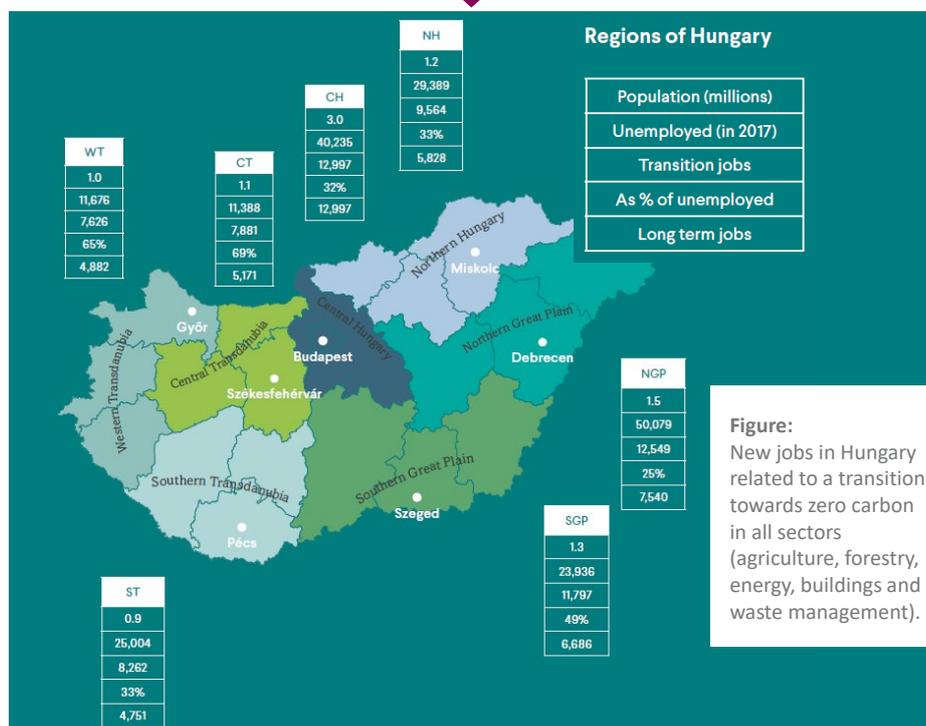


Technical implementation:





Infographic



Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA

Figure: New jobs in Hungary related to a transition towards zero carbon in all sectors (agriculture, forestry, energy, buildings and waste management).

References

Wind Power Monthly, 2010. Hungarian government overwhelmed with bids for wind energy licenses.

Key findings

- It is estimated that around 15GW of wind generation, 10 GW of solar PV capacity and 1 GW from biomass, anaerobic digestion and geothermal need to be installed in Hungary to reach the above-mentioned vision.
- In Hungary, **16200 new jobs are created in the transition period** to install the necessary wind power capacities and 1638 new jobs to install solar power. After the transition period, nearly 5000 long-term jobs will remain for the maintenance of wind turbines.
- Given the UK average values of about 100 jobs per 1 GW of electricity generation, it can be estimated that the decommissioning of 6 GW of fossil fuel power sources might lead to the loss of around 600 full-time equivalent jobs in Hungary.

Conclusion

The research shows that a transition to a zero-carbon economy is possible and is going to involve a lot of work, and thus jobs.

- It is suggested to work towards a ‘just transition’ ensuring that new jobs are of **similar or better quality** as those lost, and that workers in fossil-fuel dependent activities are able to take up new ones.
- The study also shows that the transition leads to a **shift in the location of new jobs**. In the power sector, for example, a few large-scale power stations are replaced by **more small scale renewable energy**, changing the related jobs from a small number of places to a more dispersed pattern of jobs in installation and maintenance.

RENEWABLES AND GENDER-INCLUSIVE EMPLOYMENT

STRATEGIES TO FOSTER WOMEN'S TALENT FOR TRANSFORMATIONAL CHANGE

GWNET

Objective

In order to fulfil the Paris Climate Change accords and to overcome extreme poverty, energy transitions are needed. Energy transitions demand much more than replacing polluting fuels with renewables; they entail deep societal transformations and consequently require the broadest possible participation and inclusiveness. Currently, women are representing at best one third of the labor force of the sustainable energy (SE) sector. Many women in SE work in administrative functions; in STEM jobs and at the decision-making level women's share is much lower than one third.

Since jobs in SE are expected to grow significantly in the next decades, it is imperative to ensure that women can participate on an equal footing with men in the growth of the sector. The GWNET commissioned study "Women for Sustainable Energy – Fostering Women's Talent for Transformational Change" presents a wide array of strategies that stakeholders employ already now to overcome unconscious bias and promote the participation of women in sustainable energy.

Findings

According to available statistics, at best one third of the labor force SE are women. When it comes to STEM professions, or leadership level functions the numbers are worse. Disaggregated data of good quality is in little supply which compounds the problem. This situation shortchanges women and deprives the energy transition of a critically needed talent-pool.

The study links this under-representation of women to severe obstacles – mostly connected to unconscious bias and traditional gender-stereotypes. It demonstrates that women are less likely than men to get hired for entry level employment. If hired, women are left behind from the moment they are hired, in terms of performance reviews and promotions.

Women experience greater difficulties when it comes to reconciling family and job responsibilities. These and other inequalities are reflected in the gender wage gap. The research also revealed a differential between women in men in terms of how aware they are of the prevailing gender inequalities. The study also demonstrates how companies, national economies, society at large and the world economy benefit from the involvement of women on an equal footing with men.

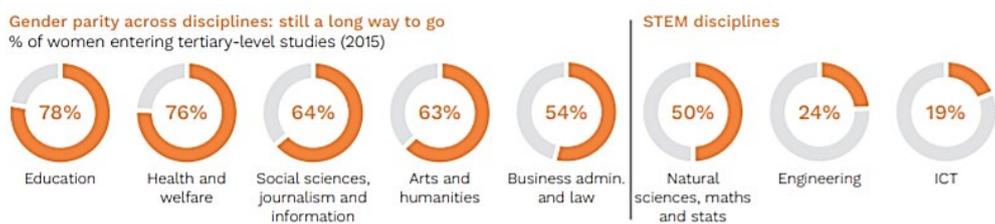


Figure 1: Women remained underrepresented in STEM disciplines.

Source: Education at a Glance 2017, OECD Indicators



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GWNET, 2019. Women for Sustainable Energy: Strategies to Foster Women's Talent for Transformational Change.

Co-Benefits Knowledge Commons is a factsheet series published by:



Technical implementation:





Methodology

The Global Women's Network for the Energy Transition commissioned a study to answer the question: "What can we do to promote women's employment in sustainable energy?" in 2019. The study assesses evidence from existing literature and uses data from semi-structured interviews of a random sample of 34 women and men from within the renewable energy sector.

Most of the information used in the study is derived from developed and emerging countries. The study draws on sector experiences and other economic sector standard practices to show how the highlighted hurdles can be successfully overcome. The report outlines workplace inclusion methods and shows specific examples that are already taking place in the energy sector and other industries. The study concludes with recommendations for individuals, (corporates, companies and educational institutes), government and international organizations, on appropriate strategies and measures for the SE sector.



Gains from gender inclusion

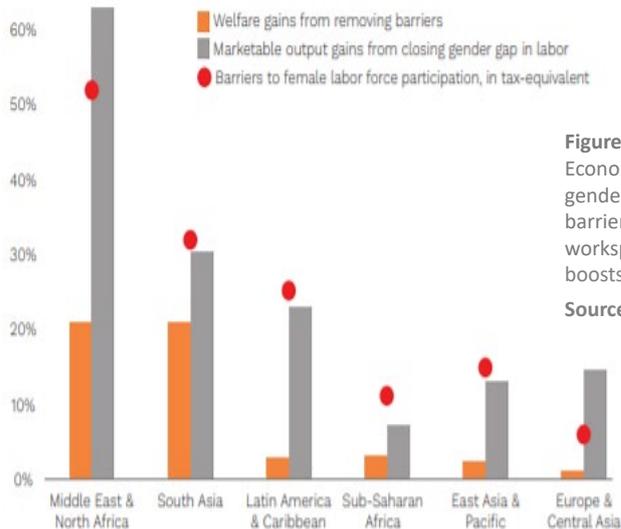


Figure 2 :
Economic gains from gender inclusion – reducing barriers to women in the workspace significantly boosts welfare and growth.
Source: IMF, 2018.

Recommendations

Recommendations are divided into two sections: (1) What can be done to support women engaged in sustainable energy and (2) What can be done to make the sustainable energy sector more inclusive?

Recommendations on (1) include: considering top level actions such as revisiting and upgrading gender policy implementation; enhancing networking among and visibility of women by hosting conference events specifically targeting women. Capacity development is highlighted (training for public speaking, mentorship programs). In addition, focusing on flexible and family-friendly work schemes and support, implementing a good parental policy including flexible working & family support are also presented as key ways on improving the participation of women in SE.

Recommendations on (2) include: to project the SE sector as offering a much wider range of career opportunities than the "old" energy sector with technology overcoming traditional obstacles linked to sheer physical strength. In addition, promoting the values of the energy transition and the importance of diversity for mobilizing.



GREEN JOBS IN TUNISIA

MEASURING METHODS AND MODEL RESULTS

GWS for the International Labour Organization

- **Country:** Tunisia
- **Co-Benefit:** Employment (Jobs)
- **Method:** Input-Output (IO) analysis
- **Assessment by:** GWS, Germany
- **Published by:** ILO
- **Year:** 2018 (updated yearly)

Pathways to a green economy

Green employment is an important indicator of the successful transition to a green economy. **Analysis of the status of green and decent employment, and of the potential for future creation of green and decent jobs is therefore a necessary first step on the pathway to a green economy.** Against this background, the International Labour Organization (ILO) is supporting a series of studies in an attempt to develop a method for the measurement of green and decent employment (the ILO Green Jobs Initiative).

This report contributes to the series in two ways: a) methodologically, by proposing rules for constructing a tool to measure direct and indirect jobs resulting from the green transition; and b) by presenting a quantitative analysis based on a case study of Tunisia. The quantitative analysis includes an ex-post evaluation and a simulation model for different future scenarios for green jobs. Tunisia has undergone tremendous social and economic changes since the revolution of 14 January 2011. **The targets of the transition to a green economy overlap with some of the most pressing economic, environmental and social needs and challenges the country is facing.**

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GWS, 2018. Green Jobs in Tunisia. Measuring Methods and Model Results.

Infographic

	2005	2006	2007	2008	2009	2010
Agriculture	32.09	34.00	33.44	33.09	34.30	34.00
Other industries	1.59	1.60	1.71	1.60	1.50	2.18
Chemical industry	3.33	3.35	3.49	3.88	3.60	3.82
Machinery and electronics	0.68	0.69	0.71	0.80	0.74	0.79
Mining	3.02	3.10	3.37	5.21	4.16	4.60
Electricity and gas	0.40	0.41	0.40	0.32	1.20	1.3
Water and waste	28.13	28.87	26.00	23.15	27.44	26.29
Public administration	27.18	27.67	28.64	29.04	29.92	30.35
Other services	4.17	4.25	4.35	4.81	5.00	5.28
Other sectors	1.42	1.39	1.56	1.58	1.50	1.31
Total	102.01	105.331	103.67	103.48	109.355	109.92

Figure 1:
Ex-post analysis:
Green jobs in
Tunisia
2005 – 2010,
in thousands

Source:
ILO, 2018

Indicators assessed

- Additional employment in jobs per sector and year
- Additional employment in direct and indirect jobs
- Share of green jobs in overall jobs by 2030

Co-Benefits Knowledge Commons
is a factsheet series published by:



Technical implementation:





Methodology

An Input-Output (IO) analysis has been applied to open consider direct jobs, but also to calculate indirect jobs by tracking deeper employment impacts in the economy. For the analysis of future developments under different scenarios, IO tables are used to forecast future demand with the help of projections of GDP and population growth. Differing uptakes of green products are also allowed for in the demand equations. The result is a macro-driven, IO-based model “e3.tn” which serves to estimate employment impacts from greening under different assumptions.

It comprises Tunisian IO tables extended to capture the effects of increased energy efficiency and additional investment in renewable energy systems.

Infographic

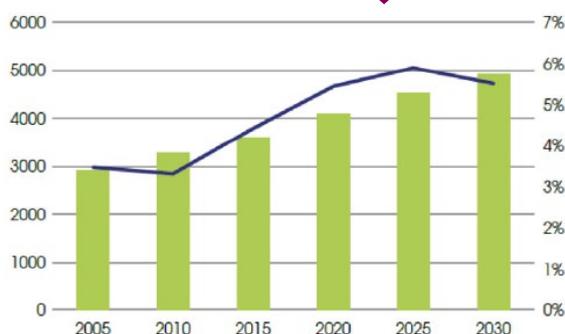


Figure 2: Employment and the share of green jobs in Tunisia by 2030

Source: ILO, 2018

Key findings

The results of the study are quite encouraging. In 2010, there were almost 110,000 green jobs. This figure declined in 2011 due to the recession that followed the revolution but, according to the latest estimates, has slowly increased again to around 120,000. Assuming massive investment, 8,000 additional people will find work in the waste sector; developments in green energy and energy efficiency can create up to 30,000 additional jobs; and organic agriculture may provide 40,000 additional job opportunities. **Taking indirect effects into consideration, a green strategy should yield 272,000 green jobs in Tunisia by 2030.**

Conclusion

- **Green sectors lower environmental pressures and create better and healthier living conditions.** The costs of an additional job in most green (sub-)sectors are not much higher than in their conventional counterparts. Renewable energy currently involves additional costs, but past developments have shown how rapidly costs can come down.
- **The simulation model and approach proposed here should be regarded as explorative.** To simulate complete strategies with monetary incentives, the approach would need to be complemented by a system covering national accounts and budgets, as well as demand equations estimated from time series ...

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PRIORITIZATION AND ASSESSMENT OF VALUE CHAINS WITHIN THE RENEWABLE ENERGY SECTOR IN LEBANON

GWS and tta for CEDRO-UNDP

- **Country:** Lebanon
- **Co-Benefit:** Employment (Jobs)
- **Method:** Input-Output (IO) analysis
- **Assessment by:** GWS & tta
- **Published by:** International Labour Organization
- **Year:** 2019

Assessing renewable energy value chains

The Lebanese Electricity Sector is highly dependent of imported fossil fuels. Fuel expenses for power generation and thermal use account for a very significant portion of the national GDP. With electricity tariffs heavily subsidized, these expenses substantially contribute to the country's national debt through the financial deficit of the state-owned power utility Electricité Du Liban (EDL). Furthermore, the country suffers a serious shortage of power supply that requires EDL to conduct load shedding, causing daily black outs of up to 16 hours per day.

Renewable energy (RE) can contribute to a potential solution to overcome some of these challenges. RE is expected to provide employment opportunities for people at all qualification levels. Experiences from other countries in the region and elsewhere has shown that this is possible under a stringent regulatory framework, ambitious plans and support for building the respective capacities.

This study compares RE sub-sectors and identifies three key RE value chains that have relatively larger potential for growth and job creation with a limited need for investment. Once key REs have been identified, a full-fledged value chain analysis has been carried to estimate the number of direct and indirect jobs in manufacturing, construction, installation, operation and maintenance of these renewable energies that can be created from 2010 until 2021.

Methodology

To calculate direct jobs, OECD employment factors for different value chain phases were used to calculate the number of jobs created per MW of installed capacity. The value chain phases considered were manufacturing, construction and installation as well as operation and maintenance.

Indirect jobs have been estimated by using Input-Output-Tables including RE-specific input vectors. Those vectors illustrate how additional RE capacities translate into demand in other sectors and thus into additional employment. Jobs have been calculated in full-time jobs equivalents.

Indicators assessed

- Direct and indirect jobs from biogas, PV and wind from 2011 to 2021 in full-time equivalents
- Jobs per capacity installed expressed in megawatt for electricity generating technologies (MW)

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COBENEFITS



IRENA
Coalition
FOR ACTION

Technical implementation:

IASS
POTSDAM

UfU

Infographic

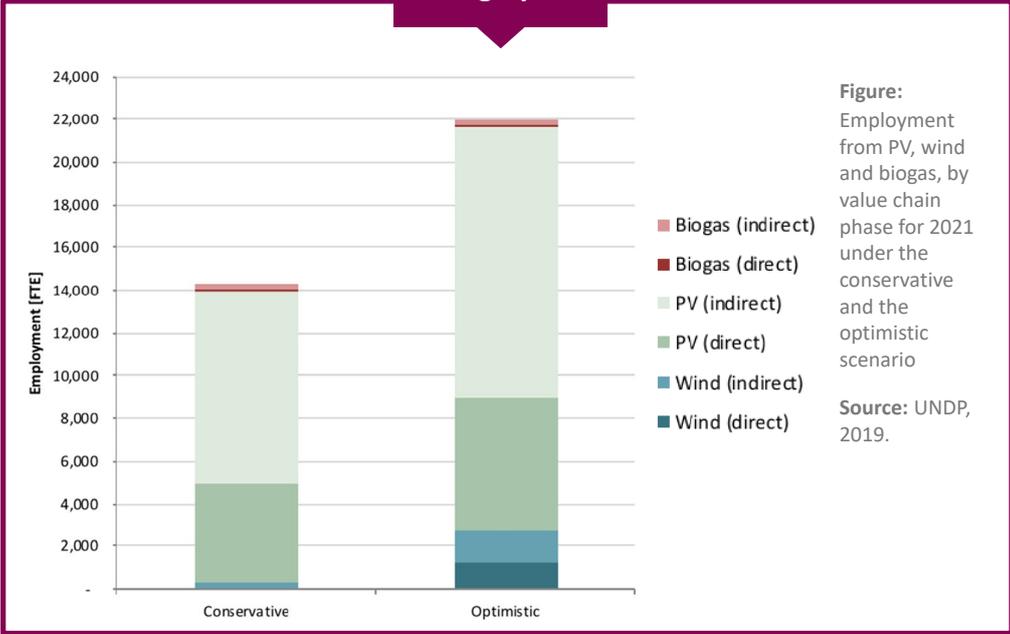


Figure: Employment from PV, wind and biogas, by value chain phase for 2021 under the conservative and the optimistic scenario
Source: UNDP, 2019.

References

Vallvé, X., Lehr, U., Petrick, K., Sallent, R., Chaar, R. & Hoballah, F., 2019. Prioritization and assessment of value chains within the renewable energy sector in Lebanon. CEDRO-UNDP, Beirut.

Key findings

The results from the value chain assessment model indicate that **more than 20,000 jobs** could result from the deployment of the selected **renewable energy technologies** by 2021 under the optimistic scenario. The bulk of this number is found in the PV sector, from distributed as well as from large PV installation.

For the year 2021, a total of 21,976 jobs are created under the optimistic scenario and compares to the 14,323 jobs under the conservative scenario. Wind energy would represent a total of 2,753 people from these jobs under the optimistic scenario, roughly half of them in direct jobs.

Conclusion

The Lebanese industry can become more involved in the growth of RE and jobs. Especially the supply side with new possibilities for the production of RE parts and components is still too little developed.

The following recommendations to support the deployment of RE and related job creation in Lebanon have been made:

- Establish a central RE knowledge hub that provides general RE but also technology specific support and services
- Promote R&D and companies working on hybrid systems
- Implement a quality assurance framework for PV
- Provide education and training, especially for PV installers and wind service engineers

FUTURE SKILLS AND JOB CREATION THROUGH RENEWABLE ENERGY IN VIETNAM

ASSESSING THE CO-BENEFITS OF DECARBONISING THE POWER SECTOR

ILSSA

- **Country:** Vietnam
- **Co-Benefit:** Employment (Jobs)
- **Method:** Input-Output (IO) analysis
- **Assessment by:** ILSSA, GreenID, IET
- **Published by:** IASS
- **Year:** 2019

Assessing the potential of EE and RE

The Vietnamese Green Growth Strategy (VGGG) and Nationally Determined Contributions (NDC) to the implementation of the Paris Agreement, amongst other national economic planning documents, suggest and establish the need for a transition in the country’s energy sector to a low-carbon pathway.

Changing the structure of the power generation mix is therefore a key factor for a broad energy transition. Understanding the employment impacts of this shift to low-carbon power generation (especially with the use of renewable energy sources) is an imperative to mobilising efforts for a just energy transition.

This study therefore assesses the gross employment impacts of various power generation scenarios based on differing contributions of renewable energy. It also provides a comprehensive case study analysis of the skills required to drive this transition in the power sector.



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COBENEFITS, 2019. Future skills and job creation through renewable energy in Vietnam.

Infographic

Replacing coal power plants in Vietnam with solar or wind will more than double the number of jobs per average MW capacity.



*Results are based on Vietnam-specific assessments.

Figure:

Replacing coal power plants with solar or wind will more than double the number of jobs per average MW capacity. Replacing coal with gas alone will lead to job losses.

Over a 15-year period, solar and wind will create 3.5 jobs and 2.8 jobs per average installed MW capacity, whereas coal creates only 1.4 jobs. Across all scenarios, around 80% of the jobs created in the power sector by the year 2030 are in construction and installation.

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Technical implementation:





Methodology

The assessment combines interviews with key RE stakeholders with a quantitative analysis to estimate gross employment impacts of increased RE deployment arising from specific scenarios.

- Four scenarios are analyzed for the future development of the power sector in Vietnam, including a BAU-scenario (PDP7 rev.), as well as scenarios that include higher shares of renewables in the future power generation mix.
- The quantitative analysis relies on a Vietnam-adapted Input-Output (I-O) model.
- The employment impacts are assessed for the period 2018 to 2030.

Indicators assessed

- Direct, indirect and induced jobs
- By MW installed
- By construction and O&M phase
- Employment skills offer and demand

Key findings

- For each direct job created in the power sector in Vietnam, two additional jobs (indirect & induced) are created in the country irrespective of the scenario assessed. More than 60% of jobs created through changes in the power sector are positive-increase employment opportunities in the broader Vietnamese economy.
- In the ambitious renewable energy scenario by GreenID, solar and wind power contribute over 20% of the jobs created in the power sector by 2030
- A shift to the ambitious RE scenario will increase gross employment in the RE sector to approximately 434,000 job-years, a 38% increase from the PDP7 (rev.) scenario
- By the year 2030, the demand for higher-skilled workers in the power sector is expected to grow by 31% for jobs during the construction and installation phase, and 25% for jobs in operation and maintenance.

Conclusion and recommendations

With the decision by the Vietnamese Government to increase the share of renewables from 6% to 10.7% in the current power sector plan (PDP 7 rev.), the government paved the way to create 315,000 job-years through the power sector by the year 2030.

For wind and solar, around 25% of jobs created are for high-skilled workers. Therefore, the training capacities at universities and technical schools need to be reconciled with this development in order to meet the expected demand in the country.



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RENEWABLE ENERGY JOBS IN AUSTRALIA

SOLAR, WIND, HYDRO AND BATTERIES JOBS

Institute for Sustainable Futures, UTS for the Clean Energy Council

- **Country:** Australia
- **Co-Benefit:** Employment (Jobs)
- **Method:** Employment factors, surveys
- **Assessment by:** Institute for Sustainable Futures, UTS
- **Published by:** University of Technology Sydney
- **Year:** 2020



Why measure renewable jobs?

Jobs in renewable energy (RE) have emerged as a key issue for the energy transition. Skill and labour shortages have been a recurrent problem as 'boom-bust' cycles have been repeated. This has led to offshore recruitment, reducing local benefits. There is currently limited information on the number and type of jobs RE will create, and whether these will be located in regions currently relying on coal-based employment. The Clean Energy Council commissioned the Institute for Sustainable Futures, University of Technology Sydney, to undertake the **first large-scale survey of employment in renewable energy in Australia**. The objectives of the project were to:

- **Estimate total renewable energy jobs** from 2020 – 2035;
- **Profile the renewable energy workforce** by occupation and location;
- **Support workforce planning** through employment projections and information on recruitment issues and skill shortages;
- **Assist transition planning for regional areas** by comparing the volume and location of RE and coal mining and generation jobs.

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Briggs, C., Rutovitz, J., Dominish, E., Nagrath, K. 2020. Renewable Energy Jobs in Australia – Stage 1. Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney

Infographic

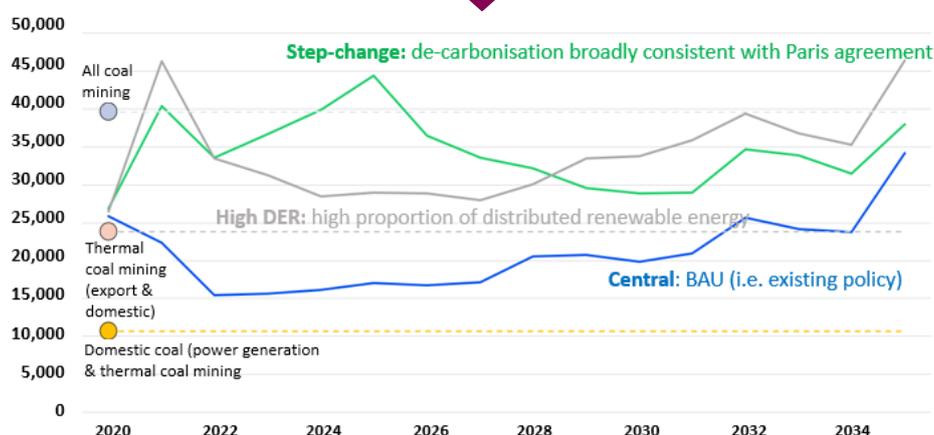


Figure 1: Australian renewable electricity jobs are the highest in the Step Change scenario, averaging 34,000 between 2020 and 2035 (electricity scenarios are from the Australian Energy Market Operator 2020 Integrated System Plan and the Western Australian Whole of System Plan). Source: Institute for Sustainable Futures, 2020

Indicators assessed

- Gross employment by year until 2035 for three electricity scenarios
- Detailed occupational breakdowns for wind, solar, hydro, and batteries
- Employment projections by technology, broken down into project phase
- Detailed occupational projections by technology
- Skill shortages and recruitment difficulties

Co-Benefits Knowledge Commons is a factsheet series published by:



Technical implementation:





Methodology

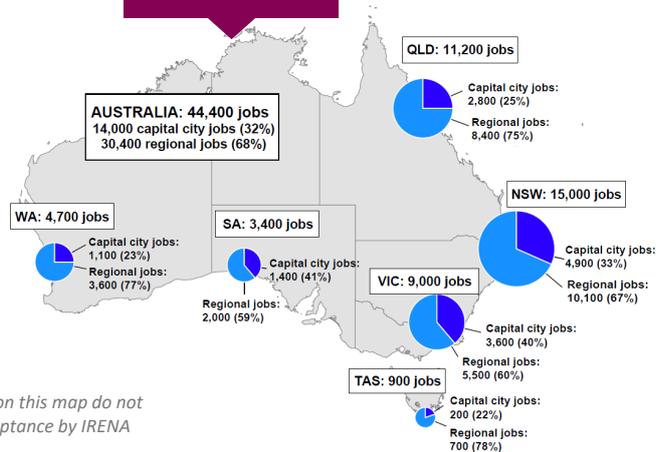
The study used an employment factor (EF) method (full-time equivalent jobs/megawatt). The five key steps were:

- **Detailed industry surveys** to derive EFs for wind, solar, batteries, and hydro.
- **Calculate EFs** from survey data.
- **Collate scenarios for renewable energy capacities**, based on the Australian Energy Market Operator 2020 Integrated System Plan and Whole of System Plan for Western Australia.
- **Calculate employment projections** for each technology and region based on the capacity projections and the employment factors using an excel model.
- **Calculate the occupational composition** using survey data and the gross job numbers from projections and identify skill shortages from the surveys.

Infographic

Figure 2: Nearly two thirds of renewable electricity jobs in Australia could be created in regional areas.

Source: Institute for Sustainable Futures, 2020



Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA

Key findings

- In the AEMO growth scenarios, RE jobs peak around 45,000, with an average of 34,000 jobs to 2035. Boom-bust trajectories are common.
- RE currently creates more jobs than domestic coal power and is expected to reach numbers comparable to all coal employment, including coal mining for export.
- RE creates jobs across diverse occupations, led by trades, technicians or laborers. Around 20% of RE workers are electricians or electrical trade assistants.
- RE skill shortages are significant. Major recruitment difficulties included electrical and grid engineers, construction managers, and electricians.

Conclusion

- Renewable energy (RE) will be a major source of jobs in the next decade.
- Job growth is strongest in rooftop solar and wind.
- Most jobs are currently in construction, but over time the proportion of on-going operations and maintenance jobs increases, to more than 50% by 2035
- RE can contribute to alternative employment as the transition out of coal accelerates - but this should be an element of comprehensive industry diversification efforts in affected regions.
- There are significant opportunities to improve employment outcomes through better coordination and investment, in particular training for key occupations.

References

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Government of Western Australia Energy Transformation Taskforce, 2020. Whole of System Plan.

Rutovitz, J., Briggs, C., Dominish, E., Nagrath, K. 2020. Renewable Energy Employment in Australia: Methodology. Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney

SOCIOECONOMIC IMPACTS OF THE ENERGY TRANSITION

THE CASE OF JAPAN
International Renewable Energy Agency

- Country: Japan
- Co-Benefit: GDP, Jobs and welfare
- Method: Macroeconometric, E3ME
- Assessment by: IRENA
- Published by: IRENA
- Year: 2021

Socioeconomic trends in Japan

One of the world’s most economically and industrially advanced nations, Japan, faces future challenges because of its ageing population, shrinking workforce and shrinking space for innovation, diminishing energy security threatened by natural disasters as well geopolitical shocks. Japan is also the world’s fifth largest CO₂ emitter from fuel combustion, exacerbating air pollution and causing adverse health impacts.

To address many of these concerns, Japan unveiled “Japan’s Green Growth Strategy Through Achieving Carbon Neutrality in 2050,” in December 2020. The strategy goes beyond energy planning and encompasses wider industrial and technological strategies, aiming to bring numerous structural shifts in the economy. The GHG emission reduction ambition for 2030 has been further strengthened in 2021.

Understanding the implications of such a strategy is the first step towards informed policy making, not only in terms of achieving economic growth but also environmental sustainability, resource efficiency, and social equity. The International Renewable Energy Agency (IRENA) is supporting a series of studies on socioeconomic implications on the national economy and support countries in a holistic approach to policy design to maximise the benefits. **The countries and regions analysed are Indonesia, ASEAN, Egypt, South Africa. The method is applicable to most IRENA member states.**



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Organization: IRENA

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Methodology

The socioeconomic analysis assesses the impacts of two roadmaps: The Transforming Energy Scenario (TES) and Planned Energy Scenario (PES). **The roadmaps are developed by IRENA’s REmap model that explores renewable energy potential using a bottom-up methodology. It is carried out in close collaboration with country experts.** For Japan, TES shows new ambition and PES outlines previous less ambitious plans. The technology pathways and investment needs are key outputs of the model.

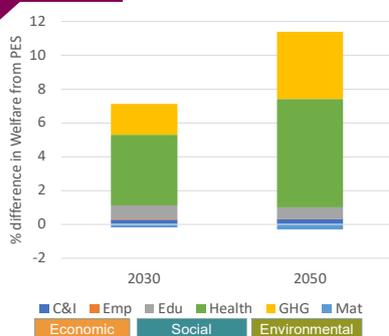
The socio-economic analysis of TES and PES scenarios is carried out with a macro-econometric model (E3ME model) that links the energy system and world’s economies within a single and consistent quantitative framework. It analyses the impact of the energy transition on variables such as GDP, employment and welfare to inform energy system planning, economic policy making, and other measures undertaken to ensure a just and inclusive energy transition at the global, regional and national level.

Welfare gains

Figure 1: Welfare benefits of the energy transition



Source: IRENA, 2021



Co-Benefits Knowledge Commons is a factsheet series published by:



Technical implementation:



Indicators assessed

- Gross domestic product
- Economy wide employment effects
- Energy sector jobs
- Reduction in GHG emission
- Health and education benefits

Key findings

The results of the study show multiple benefits from pursuing their net-zero ambition. Under the TES, the country’s economy is estimated to perform better: GDP is on average 2.14% higher during the 2020-2050 period bringing in a cumulative additional gain of USD 4.8 trillion in the economy.

Employment in Japan’s energy sector increases. TES will provide 41% more jobs (0.62 million) than the PES in 2030 and by 2050, the TES will have 21% more energy sector jobs (0.3 million) than the PES.

TES sees a significant increase in renewable energy jobs over PES (by 70% in 2030 and by 82% in 2050), reaching 0.79 million jobs by 2050 from the current 0.33 million jobs.

Human welfare in Japan, as measured by IRENA’s welfare index, improves by 6.9% in 2030 and 11.1% in 2050. This result is dominated by the reduction in negative health effects from local air pollution and reduction in cumulative CO2 emissions.

Renewable energy jobs



Figure 2: Renewable energy jobs in Japan, in TES and PES, 2017, 2030 and 2050

Source: IRENA, 2021

Holistic policy set

- **A set of structural and just transition policies are required to manage potential shifts in the economy introduced by the energy transition.** Japan’s unique demographic challenge can be addressed by integrating labor market interventions with energy transition policies. Current concerns, such as higher R&D funds dedicated to conventional technologies, difficulty in accessing grid or market data also would require energy sector-specific as well as cross-sectoral policy solutions.
- **Green sectors lower environmental pressures and create better and healthier living conditions.** The energy transition is vital to meet climate goals as well as to reduce the potential impacts of pollution and natural disaster shocks.



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RENEWABLE ENERGY AND JOBS

ANNUAL REVIEW

IRENA

- **Country:** Global and countries
- **Co-Benefit:** Jobs
- **Method:** Desk search, Employment factors
- **Assessment by:** IRENA
- **Published by:** IRENA
- **Year:** Since 2013, most recent 2021

Renewable Energy and Jobs

IRENA monitors jobs from renewable energy since 2013. The series started out with a stand-alone report establishing the relevant definitions and concepts, such as **direct jobs, indirect jobs, induced jobs, short term and long-term employment**, and examining **policy implications**. The subsequent annual reports expanded on scope, country coverage, level of detail, and also began to examine the **quality of jobs** and **just transition aspects**. Gender aspects were increasingly included, drawing from IRENA's work on gender in the RE industry and in selected technology fields.

The current report covers solar PV, liquid biofuels, wind, and hydropower in-depth. Less information is available for other technologies such as solid biomass and biogas, solar heating and cooling, concentrated solar power (CSP), geothermal energy and ground-based heat pumps, waste-to-energy, and ocean or wave energy. The report also offers observations on off-grid and mini-grid developments, and peeks at other energy transition technologies (battery storage and green hydrogen). One strength of the series is its flexibility, while maintaining the annually updated core information.

Methodology

The series is based on a hybrid methodology. A thorough **desk search** and **literature review**, as well as **data provided by IRENA's member state focal points** provide the bottom-up base. To fill gaps, and take the analysis one step further, an **employment factor analysis** is added. Employment factors from the literature are combined with IRENA's statistics on renewable energy installation, both new and existing capacities. Regional adjustments with regards to labor productivity, own database assessments on trade and local manufacturing round off the picture.

The final assessment combines results and insights from all of IRENA's works: survey-based work on gender and literature-based assessment of employment along the value chain, which are found in the *Leveraging Local Capacity* series and own calculations.

IRENA annual reviews and reports

Annual reviews of employment in renewables



Analyses of local capacities



Assessing gender equity in renewable energy



Measuring the socio-economic impact of renewables



Figure 1: IRENA's knowledge base on renewable energy employment and the socio-economics of the energy transition

Source:
IRENA



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Link

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(and previous editions, 2014 to 2020)

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Technical implementation:



Indicators assessed

- Jobs by renewable energy technology, by region, and by selected countries

Key findings

The **Annual Review - Renewable Energy and Jobs 2021** finds that renewables fared better than conventional energy during the COVID-19 pandemic. Employment in renewable energy worldwide is **estimated at 12 million in 2020, compared with 11.5 million in 2019**.

With 4 million workers, the solar PV industry has a third of the total renewable energy workforce. Sales of off-grid solar equipment suffered due to COVID-19. **Biofuels jobs worldwide fell slightly to 2.4 million**, due to COVID-19-driven reductions in demand, lower prices for conventional transport fuels, and some adverse policy changes. **Wind power supports 1.25 million jobs**. The offshore wind segment is gaining prominence, as multiple countries build or expand their domestic industrial base.

The integration of **local content** and local employment, in particular in wind energy, remains a challenge and requires further efforts on contracting arrangements, technical development and cooperation, and local capacity development. **Decent jobs** (good wages, safe workplaces, and rights at work) are a must for a just transition. Outcomes depend on enforcing internationally recognised labour standards, national legislation, and collective bargaining arrangements in individual industries.

Women account for one third of the global renewables workforce, but their participation varies widely among countries and industries. The pandemic has had a mostly negative impact on gender equity. Along with gender equity, providing adequate opportunities for youth and inclusion of minorities and marginalised groups are key for ensuring a diverse workforce that reflects the mix of people in society at large.



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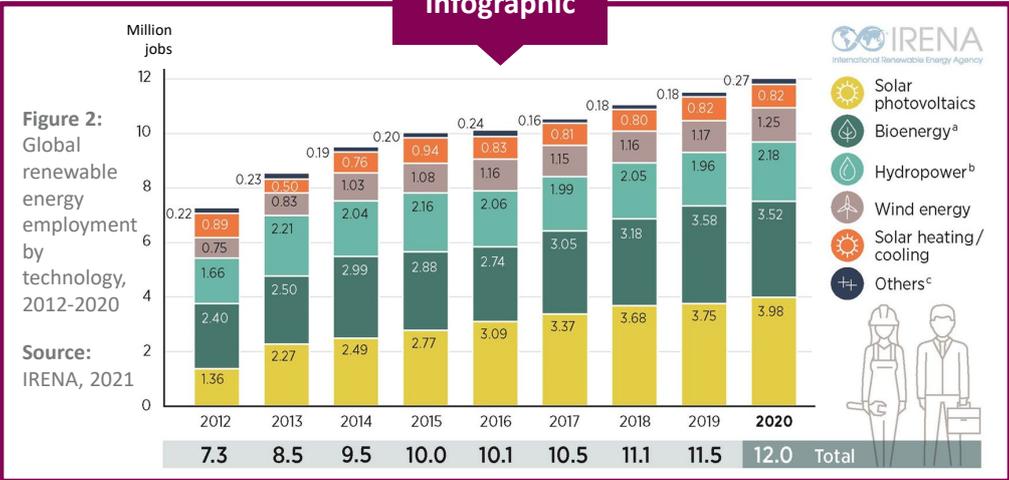
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Infographic



Outlook on skills and holistic policy set

- **The energy transition cannot be successful without a skilled, workforce which enables local deployment and operation of renewables.** The report gives an outlook on policies needed to skill, re-skill and train.
- **A set of structural and just transition policies are required to manage potential shifts in the economy introduced by the energy transition.** IRENA addresses the respective holistic framework in many publications.



JOB CREATION THROUGH RENEWABLE ENERGY IN TURKEY

ASSESSING THE CO-BENEFITS OF DECARBONISING THE POWER SECTOR

Istanbul Policy Center

- **Country:** Turkey
- **Co-Benefit:** Employment (Jobs)
- **Method:** Value chain-based analysis
- **Assessment by:** Istanbul Policy Center
- **Published by:** IASS
- **Year:** 2019

Power consumption in Turkey

With electricity consumption doubling in the past twelve years and projections of a continuing growth, Turkey will probably see the fastest medium- to long-term growth in energy demand among International Energy Agency (IEA) member countries.

Turkey's geography and climatic conditions are particularly advantageous for renewable energy generation, thus giving positive preconditions to cover this surplus by renewable energies such as solar, wind and geothermal. The current public policy framework in Turkey includes not only strategies to increase the share of renewable energy resources in the energy mix but also aims to develop a local manufacturing industry and to enable technology transfer.

This study examines the co-benefits to job development and future-required skills of increased deployment of renewable energy in Turkey. It also provides initial insights on the estimated occupations distribution, thus predicting the changes and employment opportunities available to Turkey in its solar and wind sectors.

Jobs added by Renewables

Increased renewable energy capacity can significantly boost employment in Turkey.

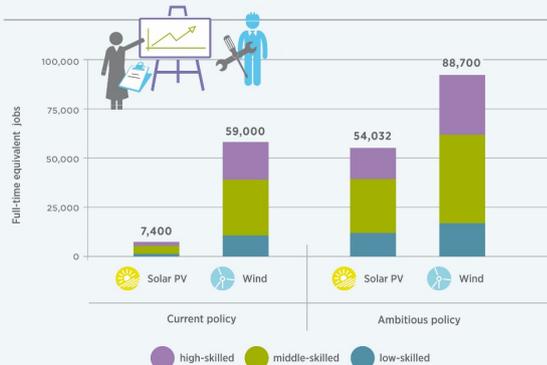


Figure:

A more ambitious deployment of renewable energies in the power sector in Turkey has the potential to add in the next ten years more than 75,700 full-time equivalent jobs related to solar PV and wind energy to the jobs projected to be created if current policies are followed.

Indicators assessed

- New full time equivalent (FTE) jobs between 2020 and 2028 in solar and wind power generation sector (high-, middle- and low-skilled)
- Added FTE jobs per sector and occupation type from 2020 to 2028 under alternative scenarios (high-, middle- and low-skilled)

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Coalition
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Technical implementation:

IASS
POTSDAM

UfU



Value chains of Renewables

- Value chains for the solar and wind energy sectors in Turkey have been defined by using licence and pre-licence information from the Energy Market Regulatory Authority and a unique administrative micro dataset, Entrepreneur Information System (EIS).
- Coefficients for the current ratio of employment per megawatt (MW) in the solar and wind sectors have been calculated.
- Based on this, projections of employment increases and skills-requirements were estimated according to four scenarios for increased renewable energy (RE) capacity.

Renewables and new Jobs

- With the decision to increase the solar energy capacity by 60% and more than double the wind power capacity, the Turkish government paved the way to create over 7,400 jobs along the solar and over 59,000 jobs along the wind value chain in the next ten years.
- **Turkey can significantly boost employment by increasing the share of renewables:** If a more ambitious transformation of the power sector is followed, up to 61,400 jobs in the solar and 147,700 jobs in the wind sector can be created in the country from 2018 to 2028.
- The fossil-fuel sector has currently a trade deficit which will escalate, thus deteriorating employment and value creation, regardless a shift in power generation towards renewable energy sources.

Skills for the energy transition

- Jobs in the renewable power generation are concentrated in the electricity production and trade related sectors, while the bulk of job-creation in the wind and solar sectors lies within the middle-skilled labor group.
- The highest increase of employment in the solar sector is for sales and services workers (21.1%), in the wind sector the highest increase is for plant operators and assemblers (18.4%).
- For each job directly created among wind energy producers, 1.75 additional jobs are created indirectly in upstream segments of the value chain in the country.

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A ROADMAP FOR THE POWER SUPPLY SECTOR IN ARGENTINA

IMPLICATIONS OF AMBITIOUS CLIMATE ACTION FOR POLICY AND INVESTMENT

New Climate Institute: Ambition to Action

- **Country:** Argentina
- **Co-Benefit:** Employment (Jobs)
- **Method:** EIM-ES tool
- **Assessment by:** New Climate Institute
- **Published by:** New Climate Institute
- **Year:** 2019

Job implications of energy transition

For Argentina’s climate policies, the energy sector – including supply and demand sectors such as transport and buildings – is highly relevant, responsible for 53% of national emissions.

The Argentinian government developed an action plan for the energy sector, including mitigation measures that will be implemented along four axes: 1) energy efficiency, 2) renewable energy, 3) fuels, and 4) large scale generation. One of the main goals is an increased share of non-conventional renewable energy sources in the power sector, namely from 8% in 2018 to 20% by 2025 (unconditionally) and to 25% by 2030 (conditionally). This transition will come along with new investments and developments from which some societal groups gain more and others are potentially disadvantaged. An analysis of the likely magnitude and distribution of future impacts can help policy makers to prepare the skills and capacities required to support the transition, to ensure that those losing are appropriately compensated and to best facilitate a just transition that works for all.

NewClimate Institute assessed – among other aspects – **the domestic employment opportunities resulting from electricity generation across all technologies to provide a comparative assessment of potential impacts under different future scenario pathways for the power sector development in Argentina.**

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Technical implementation:



Infographic

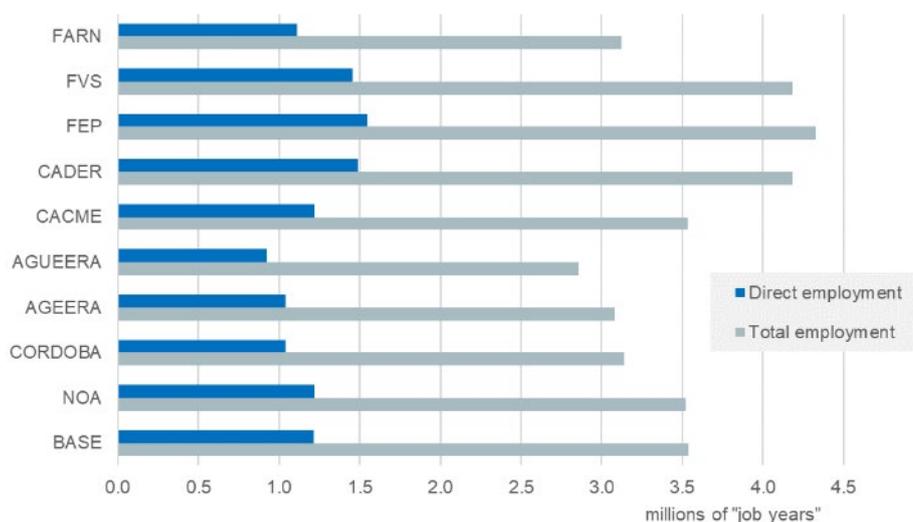


Figure: Direct and total (direct, indirect and induced) employment impacts for different electricity supply scenarios developed by stakeholders to the Plataforma Escenarios Energéticos 2040, estimated using NewClimate’s EIM-ES



Methodology

NewClimate used the EIM-ES tool to estimate employment impacts in the electricity supply sector and its associated value chains in Argentina until 2040. The calculation is based on ten scenarios developed by stakeholders from the Plataforma Escenarios Energéticos 2040, covering all major technologies.

In collaboration with the Plataforma, the EIM-ES tool was aligned to all relevant scenario information including both inputs and outputs of their scenario modelling in LEAP. The Plataforma stakeholders also provided critical input to inform estimates of the local content share of the range of component parts that make up each technology.

Indicators assessed

- Direct employment impacts expressed as full time jobs lasting one year in duration (job years), for each year over the period 2017 to 2040
- Total employment including indirect and induced impacts expressed as full time jobs lasting one year in duration, or (job years), over the period 2017 to 2040
- Employment impacts broken down by year, economic sector and electricity supply technology

Conclusions and recommendations

According to our analysis, employment impacts for fossil fuel-based generation, such as natural gas-fired power plants, are relatively similar to employment impacts for renewable options, such as wind and solar PV, when compared per unit of investment or unit of electricity generation.

Critically, however, as a signatory to the Paris Agreement, Argentina – like all other countries – will need to fully decarbonise the electricity supply sector in the medium term. Creating new jobs today in natural gas-based electricity generation means that at some point these workers will need to re-train and possibly relocate. Supporting re-training and relocation of the labour force can be extremely costly for the government both in terms of offering support to workers and, in some cases, welfare payments, as well as in terms of reduced tax revenues.

In contrast, creating new jobs today in RE generation technologies presents much less of a risk because the skills and experience of these workers are needed in increasing abundance over the coming decades.



**NEW
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A GREEN AND JUST INVESTMENT PROGRAM FOR PENNSYLVANIA

IMPACTS OF THE REIMAGINE APPALACHIA & CLEAN ENERGY TRANSITION PROGRAMS FOR PENNSYLVANIA

PERI

- Country: USA (Pennsylvania)
- Co-Benefit: Employment (Jobs)
- Method: Input-Output (IO) analysis
- Assessment by: PERI
- Published by: PERI
- Year: 2021

Investing in green jobs in Pennsylvania

Written at the height of the covid-19 induced economic slump, the report proposes a recovery program for Pennsylvania that can exert an effective counterforce against the state's ongoing recession in the short run while also building a durable foundation for an **economically viable and ecologically sustainable longer-term recovery**. It shows that a robust climate stabilization project for Pennsylvania will also serve as a major engine of economic recovery and expanding opportunities throughout the state. The report develops a clean energy investment project through which Pennsylvania can achieve climate stabilization goals in alignment with those set out by the Intergovernmental Panel on Climate Change (IPCC) in 2018, that is, to reduce CO₂ emissions by 45 percent as of 2030 and to achieve net zero emissions by 2050. The goals can be accomplished in Pennsylvania through **large-scale investments to dramatically raise energy efficiency standards** in the state and to equally dramatically **expand the supply of clean renewable energy supplies**, primarily including solar, wind, low-emissions bioenergy, geothermal and small-scale hydro power. We also show how this climate stabilization program for Pennsylvania can serve as a major **new engine of job creation and economic well-being throughout the state**, both in the short- and longer run.

Methodology

The report proceeds in four steps: first, the CO₂ emissions goals are translated into investment needs into clean energy technologies and contraction trajectories of fossil-fuel related industries. Second, these investments are translated into local direct, indirect and induced jobs in various clean energy industries, bearing in mind that part of the supply chain and activity will spill over into other states and countries. We also calculate jobs from investment programs into manufacturing, infrastructure, land restoration and agriculture. Third, these jobs are contrasted with the jobs lost in fossil-fuel related sectors and a just transition program for these workers and communities are discussed and costed. Lastly, we examine and propose ways to finance these investments in the Pennsylvania state context.

Indicators assessed

- Investment needs for reducing Pennsylvania's CO₂ emissions by 45% in 2030 and achieve net zero emissions by 2050
- Direct, indirect, induced jobs created from clean tech investments
- Fossil fuel jobs lost from phaseout
- Transition programs for financing of cost of investment and fossil fuel worker compensation



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Technical implementation:





Key findings

As an average over 2021–2030, a **clean energy investment program scaled at about \$23 billion per year will generate about 162,000 jobs per year in Pennsylvania** for a wide range of educational backgrounds (see infographic). An additional investment program over the same time into **manufacturing, infrastructure, land restoration and agriculture at \$8.2 billion per year** or 1 percent of Pennsylvania’s 2019 GDP, would generate an additional roughly **81,000 jobs per year** in the state. Meantime, about 1,800 workers per year will be displaced in fossil-fuel related industries between 2021 – 2030 while another roughly 1,000 will voluntarily retire each year. Pennsylvania can finance these investments with a combination of state-level borrowing and federal programs set up or proposed in the context of the covid-19 crisis and/or response to climate change.

Infographic

	Energy Efficiency Investments				Clean Renewable Energy Investments				
	1. Building retrofits (10,120 workers)	2. Industrial efficiency (2,880 workers)	3. Grid upgrades (2,610 workers)	4. Mass transit (12,006 workers)	5. Solar (17,640 workers)	6. Wind (5,780 workers)	7. Low-emissions bioenergy (8,250 workers)	8. Geo-thermal (6,300 workers)	9. Small-scale hydro (7,686 workers)
Share with high school degree or less	59.9%	21.1%	63.5%	55.3%	46.1%	52.3%	60.4%	49.6%	56.6%
Share with some college or Associate degree	23.3%	19.1%	26.8%	26.9%	20.4%	21.8%	22.8%	21.4%	23.1%
Share with Bachelor's degree or higher	16.8%	59.8%	9.7%	17.7%	33.5%	25.9%	16.8%	28.9%	20.3%
Racial and gender composition of workforce									
Pct. non-white	14.8%	16.5%	10.2%	32.5%	15.8%	15.0%	14.6%	15.4%	14.1%
Pct. female	8.8%	32.6%	6.2%	32.0%	22.0%	16.5%	11.6%	18.3%	10.2%

Figure:
Educational Credentials and Race/Gender Composition of Workers in Pennsylvania Clean Energy Industries: Direct Jobs Only.
Source: Pollin et al. 2021

Conclusion

- The combination of investments in clean energy, manufacturing/infrastructure, and land restoration/agriculture will create **about 243,000 jobs in Pennsylvania** —equal to roughly 4 percent of Pennsylvania’s current work- force— while providing the foundation for a long-term sustainable growth path for the state.
- The loss in fossil-fuel related jobs, 1,800 a year, is far smaller and it is critical that all of these workers receive pension guarantees, health care coverage, re-employment guarantees, wage insurance, and retraining support, as needed, with additional support measures for especially hard-hit communities.
- The financing calculations show that such a program is not only desirable but also feasible in Pennsylvania.

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AUSTERITY VS. GREEN GROWTH FOR PUERTO RICO

LARGE-SCALE INVESTMENTS IN ENERGY EFFICIENCY AND RENEWABLES CREATING NEW JOBS

PERI

- **Country:** Puerto Rico
- **Co-Benefit:** Employment (Jobs)
- **Method:** Input-Output (IO) analysis
- **Assessment by:** PERI
- **Published by:** Challenge
- **Year:** 2017

Investments in energy efficiency and renewables

Puerto Rico is in a severe economic and social crisis with an overwhelming public debt. The prevailing approach to solving this problem is an austerity agenda. However, these austerity policies will exacerbate the crisis, as austerity will lead to the reduction of incomes, private spending, and to corporate divestment, as well as a shrinking tax base to service the debt.

The study proposes a "green growth" program for Puerto Rico as an alternative to austerity policies which is based on large-scale annual investments in energy efficiency and clean renewable energy. **A co-benefit of these investments, in addition to climate policy goals, is the sustainable creation of new employment opportunities.**

Key findings

- The green growth program enables the successive replacement of fossil fuel imports with low-cost, domestically produced clean energy. The objective is to complete substitution by 2050. This reduces dependence on fossil fuel imports while creating an important source of **new jobs and opportunities for new business ventures, including small-scale community-owned and cooperative enterprises.**
- A major source of job creation will be the investments themselves. The annual investments in clean energy will generate about **23,500 jobs** within the existing production processes.
- The second major source of employment will be the substitution of energy imports, as the economy's spending on energy imports steadily declines and these funds can be invested differently. Reducing energy imports to zero between 2020 and 2050 would result in a reduction of imports by **\$174 million per year.**

Indicators assessed

- Job creation per \$1 million investment in renewable energy and energy efficiency
- Job creation per \$1 million of new spending in the aggregate economy



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Austerity Versus Green
Growth for Puerto Rico,
Challenge 60(6), 543-574.

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Technical implementation:





Methodology

- We used input-output tables for Puerto Rico to derive employment/output ratios for investments in clean renewable energy and energy efficiency.
- For both the investments in renewable energies and energy efficiency, the numbers presented in the infographic are weighted averages of employment/output ratios for specific groups of activities in Puerto Rico's input/output tables.

Infographic

Employment Creation through Clean Energy Investments

Renewable Investments, 2020	
Job creation per \$ 1 million in investments	10.4 jobs
Job creation through \$ 2.1 billion in investments	21,800 jobs (= 10.4 x 2,100)
Energy Efficiency Investments, 2020	
Job creation per \$ 1 million in investments	12.5 jobs
Job creation through \$ 133 million in investments	1,700 jobs (12.5 x 133)
Total Job Creation through Clean Energy Investments, 2020	23,500 jobs
Total Job Creation, 2050, with 1% average annual labor productivity growth	17,500 jobs

Figure:
Based on specific investment profiles, the table shows employment levels generated by investments averaging \$2.1 billion annually in renewable energy and \$133 million annually in energy efficiency.
Source: Page-Hoongrajok et al (2017)

Conclusion

- Large-scale annual investments in energy efficiency and clean renewable energy are crucial elements of a green growth program for Puerto Rico.
- Fossil fuels will be replaced through renewable energy sources reducing energy dependencies and aligning with climate policy objectives.
- The study identifies two important sources of job creation: large-scale investments in clean energy and energy import substitution. Considering the total net job creation, we reach a number of **about 50,000 jobs in 2035** and **between about 60,000 and 80,000 jobs as of 2050**.
- Substantial debt relief will be necessary to advance the green growth program on a large scale.

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Austerity Versus Green Growth for Puerto Rico, Challenge 60(6), 543-574.



JOB CREATION FROM CLEAN INVESTMENT

STATE-LEVEL EMPLOYMENT IMPACTS OF PROPOSED NATIONAL THRIVE AGENDA

PERI

- Country: USA
- Co-Benefit: Employment (Jobs)
- Method: Input-Output (IO) analysis
- Assessment by: PERI
- Published by: PERI
- Year: 2021

New Jobs through THRIVE Agenda

The report presents estimates of the job creation that would result in selected U.S. states if the U.S. Congress passed **economic recovery legislation that implements a national THRIVE investment agenda**, as described in a September 2020 Congressional resolution. The Congressional resolution's commitment is to "Transform, Heal and Renew by Investing in a Vibrant Economy"—i.e. "THRIVE"—through investments to rebuild the U.S. economy. At the date of writing (March 2021), the THRIVE Agenda had been endorsed by more than 100 members of Congress and hundreds of major union, racial justice, and climate organizations. The aims of the THRIVE Agenda are similar to those proposed in the Build Back Better program advanced by President Biden during his 2020 presidential campaign.

The THRIVE Agenda consists of four major investment areas: **clean renewable energy and energy efficiency; infrastructure; agriculture and land restoration; care economy, public health and the postal system**. The THRIVE Agenda is designed as a 10-year investment national program, with an average annual budget of \$954 billion, or about 4% of US GDP over 2021-2030.

Methodology

The state level job creation estimates result from the state receiving its share of the overall THRIVE budget based on its share of the U.S. population. **After defining 36 activities that fall under each of the four investment areas, e.g. building retrofits, dam repairs or farmland restoration, we calculate direct, indirect and induced jobs per million dollar invested for each activity**. Indirect jobs are created in the supply chain, and induced effects from spending by the new employees on local purchases. These results are then **scaled by the state and activity specific budgets** to calculate the total employment effects. The calculations utilize the set of input-output tables compiled for all US states by IMPLAN.

Indicators assessed

- 36 industries in four low-carbon transition relevant sectors
- Direct, indirect and induced job creation for each industry per million \$ investment
- Job creation scaled by industry-level budgets at state-level informed by US THRIVE agenda



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R. Pollin, J. Wicks-Lim, S.
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Proposed National THRIVE
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Technical implementation:





Key findings

Results vary with the state investigated. We illustrate state-level findings with the example of Arizona. Its annual budget allocations between 2021 – 2030 amount to: \$8.1 billion for clean renewable energy and energy efficiency; \$7.4 billion for infrastructure; \$4.2 billion for agriculture and land restoration; and \$1.9 billion for the care economy, public health and postal service. This level of investment spending in Arizona will generate an average of **about 205,000 jobs a year within the state**. This is equal to 5.6 percent of Arizona’s labor force as of February 2020. The infographic shows how these aggregate job figures break down for the case of clean tech investments.

Infographic

	1) Total Jobs/ \$1 Million	Annual Job Creation		Job-Years Created, All Years		
		Annual Budget	Job Creation per Year	# of Years	Total Budget	Total Job Years
Energy efficiency						
Building retrofits	9.1	\$1.3 billion	11,800	10	\$13.0 billion	118,000
Industrial efficiency	4.7	\$141.9 million	700	10	\$1.4 billion	7,000
High-efficiency autos	0.3	\$1.3 billion	400	10	\$13.0 billion	4,000
Renewable energy						
Wind energy	3.4	\$2.4 billion	8,200	10	\$24.0 billion	82,000
Solar energy	4.4	\$2.4 billion	10,600	10	\$24.0 billion	106,000
Geothermal energy	9.7	\$540.6 million	5,200	10	\$5.4 billion	52,000
Total		\$8.1 billion	36,900	10	\$81.0 billion	369,000

Figure:
Energy Efficiency and Clean Renewable Energy Investments in Arizona: *Total Jobs Created with Budgetary Figures*

Source: PERI, 2021a

Conclusion

Staying with the example of Arizona, this level of job creation would have a major impact on Arizona's economy. All else equal, the new jobs created would result in the **state’s unemployment rate falling to 2.3 percent** from its average level of 7.8 percent between July – December 2020. Such a reduction in the unemployment rate would represent a major expansion in job opportunities. Indeed, implementing the THRIVE Agenda in Arizona would likely encourage a large number of people to enter Arizona’s labor force, or to reenter after having dropped out previously. Overall, **the rise in the state’s employment opportunities will provide a foundation for a broader improvement in living conditions** for the people of Arizona, all in addition to the benefits through implementing the THRIVE investment program.

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ENERGIZING MEXICO'S DEVELOPMENT WITH CLEAN SOURCES

CRUNCHING NUMBERS – QUANTIFYING THE SUSTAINABLE DEVELOPMENT OF CO-BENEFITS OF MEXICO'S CLIMATE COMMITMENTS

SD Strategies and GIZ Mexico

- Country: Mexico
- Co-Benefit: Employment (Jobs)
- Method: Employment factor approach (EFA)
- Assessment by: SD Strategies
- Published by: SD Strategies and GIZ
- Year: 2020

Linking agendas

In Mexico, electricity and heat generation is the second largest source of greenhouse gas emissions after the transport sector and constitutes 18.3% of the country's total carbon dioxide equivalent (CO₂-e) emissions (SEMARNAT & INECC, 2018). This makes it a key area for action in the NDCs. Besides climate change mitigation, accomplishment of Mexico's actions to reduce GHG emissions can materialise multiple co-benefits, which underline a resilient low-carbon future, while also accelerating development.

In 2018, the Mexican Government, together with the Office of the Presidency, SEMARNAT, INECC and GIZ Mexico, commissioned a **study on the co-benefits of implementation of Mexico's Nationally Determined Contributions (NDCs) for the achievement of the SDGs**. Power generation has been identified as one climate action whose co-co-benefits shall be assessed.

To calculate co-benefits of different clean electricity targets, four scenarios have been considered: A business-as-usual scenario based on Mexican BAU projections for the NDC from 2015, a PRODESEN scenario from the Ministry of Energy, a scenario oriented on Mexico's current NDCs and an ambitious SD+ (REP 100) scenario.

From the three types of co-benefits of clean power generation calculated in the Crunching numbers-study, outcomes regarding job creation & are shown at this page.



Contact

SD Strategies

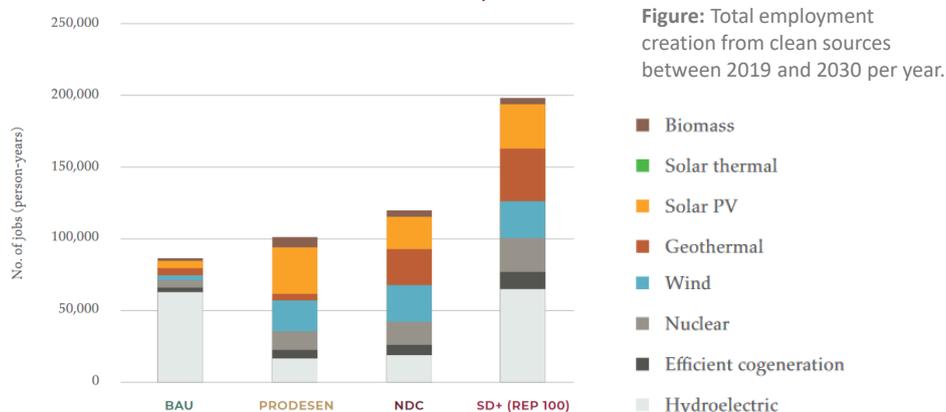
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Link

SD Strategies/GIZ Mexico.
Crunching Numbers.
Quantifying the Sustainable Development Co-Benefits of Mexico's Climate Commitments.

New jobs for Mexico



Indicators assessed

- N° of jobs from clean sources per year between 2019 and 2030, in person-years
- N° of jobs from clean sources per year

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Technical implementation:





Calculating employment benefits

The calculation of the job creation potential of increased deployment of clean energy sources in Mexico is based on the employment factor approach (EFA). Employment factors are technology-specific factors to estimate job impacts if multiplied with the respective installed capacity.

In the quantification, only direct employment (manufacturing, installation, operation and maintenance) associated with electricity generation is considered. The potential jobs are related to the plant lifetime for comparability within the value chain. They are then accounted with the capacity factor to make them comparable between the different technologies.

Key findings

- Under all explored scenarios, the number of jobs compared to the BAU scenario increase; with a gain of 16% in the PRODESEN scenario, 38% in the NDC scenario and 129% in the SD+ (REP 100) scenario.
- The biggest share of new employment in Mexico is expected to be in operation and maintenance. The methodology employed for this calculation asserts that the jobs created in operation, maintenance and construction of power plants will be filled by local workforce. There is, however, the possibility that international companies employ foreign staff for parts of their projects, particularly in manufacturing of the generation technologies.

Conclusion

- Electricity generation from clean sources can contribute to the achievement of SDG 8 Decent Work and Economic Growth
- Effective government programs and initiatives promoting innovation and growth in the clean energy sector can directly support the SDG 8 target 8.3, promoting “development oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises...”



References

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This joint factsheet edition by the IRENA Sustainable Energy Jobs Working Group and COBENEFITS connects policymakers in local and national government agencies with expert organisations and contact persons to quantify employment co-benefits, assess policy options and unlock potentials for people and communities.

COBENEFITS works with national authorities and expert organisations in countries across the globe to quantify and unlock the social and economic co-benefits of early climate action with renewable energy. The project facilitates capacity building and cross-country learning among policymakers, expert organisations, CSOs and the private sector.

The IRENA Sustainable Energy Jobs Working Group addresses knowledge gaps in sustainable energy jobs and provides analysis showcasing the energy transition's ability to increase overall employment and benefit local economies.

Co-Benefits Knowledge Commons

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