REPORT

JOBS FOR A LIVABLE PLANET

Job Creation Potential of the Clean Energy Transition

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK
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ABOUT ESMAP

The Energy Sector Management Assistance Program (ESMAP) is a partnership between the World Bank and over 20 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. Through the World Bank, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7), which ensures access to affordable, reliable, sustainable, and modern energy for all. It helps shape World Bank strategies and programs to achieve the World Bank's Climate Change Action Plan targets. Learn more at: https://www.esmap.org.

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About this Report

This report presents the findings and conclusions of a program of analytical work undertaken to investigate the impacts of the global transition to clean energy on the quantity and quality of jobs in low- and middle-income countries. Under the program, entitled "Estimating the Job Creation Potential of the Clean Energy Transition," the World Bank's Energy Sector Management Assistance Program (ESMAP) undertook multiple streams of analysis:

- A review of the literature and commonly used methodologies of investigation (World Bank 2023a)
- Modeling of economywide job impacts of policies supporting the clean energy transition in selected countries in Sub-Saharan Africa (World Bank 2023b)
- Case studies of the effects on employment of selected World Bank clean energy projects (World Bank 2023d; World Bank 2023e; World Bank 2023f; World Bank 2023g; World Bank 2023h; World Bank 2023i; World Bank 2023l)
- Deep dives into the impact on jobs of closure of coal-fired power plants (World Bank 2023j); of productive uses of electricity associated with mini grids in Nigeria (World Bank 2023k); and of the Rusumo Falls Hydropower Project (World Bank 2023c).

In addition to this report, building on the above-mentioned streams of analysis, the program has produced a discussion paper to support project design, "Tracking Jobs in Projects Focused on Clean Energy and Productive Uses of Electricity" (World Bank 2023m). The note provides strategies for tracking and enhancing job creation that can be used in the World Bank Group's clean energy lending operations. It also documents the job creation benefits of the diverse set of projects examined in the case studies above.

The reports under this program together aim to support low- and middle-income countries in reaping greater socioeconomic benefits from the energy transition by supporting them in increasing the number and quality of local jobs generated while implementing clean energy projects.

The reports target multiple audiences, from policy makers to development practitioners and academics. They also aim to familiarize energy specialists with the effects of energy projects on jobs and give them tools that enable them to take account of—and, where possible, maximize—the socioeconomic benefits of the clean energy transition.

Reaping the benefits of the jobs created by clean energy interventions will depend on effective planning and preparation in the early stages of projects and sustained support during their implementation.

Abbreviations

CGE	computable general equilibrium
DPOs	Development Policy Operations
DRE	distributed renewable energy
EE	energy efficiency
EJETP	Eskom Just Energy Transition Project
EPM	Electricity Planning Model
ESMAP	Energy Sector Management Assistance Program
FTE	full-time equivalent
GDP	gross domestic product
GHG	greenhouse gases
IEA	International Energy Agency
IO	input-output
IRENA	International Renewable Energy Agency
LADP	Local Area Development Plan
MW	megawatt(s)
O&M	operation and maintenance
PIAAC	Programme for the International Assessment of Adult Competencies
PUE	productive use of electricity
PV	photovoltaics
RE	renewable energy
T&D	transmission and distribution
VRE	variable renewable energy

All currency is in United States dollars (US$, USD), unless otherwise indicated.

Glossary

Direct jobs	Jobs associated with the design, development, management, construction/installation, and maintenance of projects and project facilities.
Employment factors	A jobs-per-megawatt employment calculation.
Full-time equivalent	The number of hours considered full-time work. For example, if a company considers 40 hours full time, then two employees working 20 hours per week would equal 1.0 full-time equivalent (FTE).
Indirect jobs	Jobs associated with the manufacturing of equipment and materials used for a facility, the supply chain that provides the raw materials and services needed for the manufacturing process, and the finance and banking sectors that provide services for the construction and operation of a facility.
Induced jobs	Jobs created due to the spending of earnings by persons directly and indirectly employed by a project. Induced jobs can also stem from increased spending using consumer savings achieved thanks to energy efficiency, the cost competitiveness of renewables or jobs stemming from productive uses of electricity from newly acquired energy access.
Local development	A multidimensional concept of change bringing together economic, social, cultural, and environmental dimensions. Local development may be seen as a method that helps improve quality of life, supporting or accelerating the empowerment of people, developing or preserving local assets, strengthening cohesion, and defining and delivering grassroots development projects.
On-the-job training	A training approach by which trainees acquire the skills and competencies needed for a job in an actual workplace environment.
Quasi-natural experiment	Quasi-natural experiments refer to serendipitous situations in which economic agents are randomly assigned to treatment or control groups, approximating the randomized design of a well-controlled experiment and allowing causal inference.
Piece rate contract	A piece rate contract refers to payment per unit of work rather than per unit of time.

Randomized control trials	The randomized control trial is a trial in which subjects are randomly assigned to one of two groups: one (the experimental group) receiving the intervention that is being tested, and the other (the comparison group or control) receiving an alternative (conventional) treatment.
Skills development	The acquisition of practical competencies, know-how, and attitudes necessary to perform a trade or occupation in the labor market.
Social license	In this report, a social license is the acceptance granted to a company, organization, or industry by a community. The concept encompasses a company's or industry's standard business practices and operating procedures.
Socioeconomic benefits	Tangible social and economic improvements to inequality, poverty, and marginalization, measured through employment, income, resource access, and power and control. This report focuses on three categories of socioeconomic benefits: domestic value creation, local development, and gender equality and social inclusion.
Technical and vocational education and training	A form of education designed to develop practical skills, understanding, and knowledge relating to specific occupations, often in the trades (for example, electrical works, plumbing, etc.).

Key Findings

The global transition to clean energy must accelerate if global warming is to be limited to 1.5°C to avoid devastating climate change. The transition will result in disruptive changes to energy production and consumption with the growth of sustainable energy technologies, such as renewable energy and energy efficiency, at the same time as traditional fossil-fuel industries will progressively phase-out. These changes will also result in new demands on energy infrastructure, such as the expansion of power grids and energy storage.

The massive investment in sustainable energy and the infrastructure upgrades required for the transition to clean energy will provide a significant impetus to GDP growth and job creation. Jobs will be created in the energy sector and in the related sectors of the economy. At the same time, jobs dependent on fossil fuels will decrease over time. The success of this transition will depend crucially on how the impacts on the labor force, i.e., the 'jobs transition', is managed, and particularly whether it is seen to be 'just' to those who are negatively impacted.

Key questions for policy makers therefore relate to facilitating job creation, managing the job losses that will ensue, and ensuring that those who lose their livelihoods and way of life due to the energy transition are made whole. In the communities that are entirely dependent on fossil fuels production, the impacts of the energy transition can be existential, so thoughtful and inclusive planning will be needed for an economically and socially acceptable transition.

What kinds of jobs will the transition to clean power create? What skills will workers need in these new jobs? How can governments take advantage of sustainable energy projects to support local employment and therefore increase socio-economic benefits of these projects?

International energy think tanks, academia, the International Labour Organization as well as the World Bank have shown that the energy transition will create significant net additional employment in the energy and associated sectors and a boost to economic growth and overall jobs in the economy through the new energy investment. Whether the jobs created are local or created abroad will determine the extent to which they benefit the local economy.

Jobs are created directly by power sector projects at all stages—design, construction, commissioning, operation and maintenance, and decommissioning. About one third of these jobs require highly skilled professionals with training in engineering, finance, project management, law, etc., while the balance require a semi-skilled or unskilled workforce of technicians, construction workers and diverse support roles, often recruited locally. World Bank project experience shows that sustainable energy jobs are attractive, with competitive remuneration and good employment conditions. For semiskilled and unskilled positions on-the-job training is often provided due to the lack of skills needed. To maximize domestic job creation, governments, in collaboration with private sector, should set up appropriate technical and vocational education programs, preferably in the areas designated for future clean energy development. To increase female participation, governments should adopt a gender agenda with specific targets and mandates and follow through on its goals in individual projects.

Indirect jobs or jobs created upstream of project investments, particularly those requiring highly specialized skills, special materials, or specific technologies, are often located in a few countries overseas. To maximize the potential for local employment generation in the supply chains of clean energy technologies, governments should identify which parts of the value chains are already produced locally – cement, aluminum mounting structures or cabling would be typical examples – and which parts of the value chains could be developed over time in a cost-competitive manner – heat pumps, efficient building insulation materials, energy efficient windows are examples of the equipment whose local production, reflecting the specificities of the local building stock, could be worthwhile to pursue. In countries with abundant metal or mineral deposits, development of mining related to materials needed for clean energy equipment is a clear avenue to pursue.

Jobs associated with the increase in economic activity due to energy sector investments, so-called 'induced' jobs, represent most of the jobs created by the energy transition. They are not restricted to the energy sector and could ultimately be longer lasting than jobs associated directly with project construction or operations and maintenance. A regulatory and policy framework that facilitates creation and expansion of businesses; assists labor mobility, and supports re-skilling is an important enabler of induced job creation. Complementary actions such as awareness raising, access to credit and availability of new technologies enabling productive use of power can help to ensure an increase in enterprise productivity related to the improved power supply.

As fossil fuels and the related industries are phasing out, can the labor released in this process be employed in sustainable energy sectors? How can the 'jobs transitions' be as smooth as possible?

Governments need to plan to replace fossil fuels by assessing options for investment in clean energy and developing strategies for adoption. The loss of fossil fuel jobs will not translate one-for-one into new clean technology jobs, complicating the labor transition. Deciding on repurposing options for existing fossil fuel infrastructure and facilities should take into consideration the implications of different options for generating local benefits, including employment.

World Bank analysis has shown that the tasks involved, and skills required, for clean energy jobs are quite different from those required in fossil-fueled power plants; indeed, jobs in the latter are closer to those in construction and manufacturing. The most promising repurposing options may therefore not be in the energy sector and when decisions are made it is important to take into account the skill sets and job transition preferences of current employees.

The transition process for the labor force should include a determination of which workers would retire, which could be re-skilled and the jobs they could be re-deployed to. Governments will need to design the corresponding educational and training programs to foster skills needed for development of clean energy technologies or other industries identified for re-deployment of labor, consistent with the country's strategic and policy objectives and to international standards. They will need to create labor transition paths that are credible from a skills point of view and lifestyle point of view, and they will need to conduct active labor market outreach to enhance awareness of career opportunities in clean energy. Coordination and collaboration between different ministries will be crucial in this respect, while the feedback from the private sector remains crucial to deliver governmental programs corresponding to the demands of the new labor markets.

Executive Summary

The global transition to clean energy must accelerate if global warming is to be limited to 1.5°C and the effects of climate change mitigated. For the energy sector, the transition involves replacing fossil fuels with clean sources of energy and electrifying traditionally unelectrified areas (such as transport, heating, and industrial processes) while working toward universal access to clean energy services.

Disruptive changes in production and consumption in the economy will result from phasing out traditional fossil-fuel industries and promoting sustainable energy technologies. Policy makers will need to understand, plan for, and address the positive and negative impacts of such transitions. Maximizing the national, sub-national, and local socioeconomic co-benefits of these transitions—particularly their job creation potential—will be increasingly important to help overcome resistance from traditional interest groups, particularly, organized labor, that are concerned about being left behind. More positively, harnessing the potential of the energy transition for job creation can foster buy-in to the move away from fossil fuels and increase local development impacts of decarbonization. The move can be facilitated by proactive investment in the education and skills needed for clean energy, once the potential for employment creation is understood. Political discourse often provides a simplistic view of reskilling workers from "brown" to "green" jobs, but the ground reality is much more complex. This is why systematic, data driven analysis of employment aspects of the energy transition is so important.

To bring evidence to bear on this issue, the World Bank's Energy Sector Management Assistance Program (ESMAP) implemented a program of analytical work from 2020 to 2023. Entitled "Estimating the Job Creation Potential of the Clean Energy Transition," it assessed the job creation potential of the clean energy transition in low- and middle-income countries.

The program started with a review of the academic and policy literature to identify what is known and to guide the analysis going forward. In view of the limited applicability of the literature to the energy transition for developing economies and data constraints that preclude an *ex post* analysis, a computable general equilibrium model was developed to simulate, *ex ante*, the economywide employment impacts of clean energy interventions characterizing the energy transition in a sample of strategically important Sub-Saharan African countries. Focusing on Sub-Saharan Africa permits studying the impact of new power production better than studying other regions, since new power production in Africa typically comes into the system as additional power, while in developed countries clean power often simply displaces existing fossil fuel–based power.

While modeling can indicate likely high-level outcomes, it sheds little light on the mechanisms by which clean energy projects create jobs, which is important for policy design. Modeling also abstracts from spatial, temporal, and skills frictions that arise in real labor markets. Therefore, to complement the modeling and understand how clean energy interventions create jobs in developing countries and also characterize the jobs created, detailed case studies of selected World Bank–supported clean energy projects were carried out, supplemented by deep dives into jobs created by productive use of electricity in mini grids and insights on the labor transition options for workers of coal-fired power plants.

The findings, conclusions, and recommendations of this program of analytical work are presented in this report.

Summary of Findings

The report finds that the academic and policy literature on employment impacts of the energy transition has significant limitations. In the absence of data, *ex post* methods, which permit an evaluation of causality and could provide estimates of the actual employment impacts of projects, have scarcely been used. Instead, the literature is dominated by *ex ante* modeling of potential employment impacts, with coverage of developing countries particularly limited across models. Both *ex ante* and *ex post* models lack coverage of new jobs induced by greater availability and use of electricity.

Four clean energy scenarios were analyzed using the computable general equilibrium model. The analysis found that in the context of Sub-Saharan Africa the most effective scenarios for boosting economic growth and employment are improvements in electricity grid reliability and rollout of energy efficiency programs, both reflective of the low quality and limited availability of power in these countries. Increased deployment of renewables and regional electricity trade (which expands the market for renewable source power) also have a positive impact on gross domestic product and employment overall, although of lesser magnitude per dollar spent. All four clean energy interventions result in more productive and better-paid jobs; in combination, as in real-life reform programs, synergies would produce even greater impacts.

Overall, the modeling and literature review both indicate that jobs associated with the increase in economic activity due to energy sector investments, so-called induced jobs, likely represent a majority of the jobs created by the energy transition. Induced jobs are not restricted to the energy sector and could ultimately last longer than jobs associated directly with project construction or operations and maintenance (O&M).

The case studies show that the overall employment benefits of the energy transition are not always obvious at the project level—sustainable energy projects tend to generate a large number of temporary, high-quality jobs during construction (a period of a few months to a few years), but fewer O&M jobs, which typically last several decades. Table ES.1 summarizes the findings of the case studies on direct and indirect jobs attributable to the projects reviewed.

In addition to jobs directly associated with the project, sustainable energy projects also create indirect jobs in supply chains for the materials and equipment required to deploy renewable energy, energy efficiency, and other clean energy interventions. Since the supply chains of major sustainable energy technologies are currently concentrated in a

TABLE ES.1

Total Job Creation Assessed in the Case Studies (Full-Time Equivalents)

PROJECT	DIRECT			INDIRECT	TOTAL
	DESIGN, MANAGEMENT, CONSTRUCTION	OPERATION AND MAINTENANCE	TOTAL DIRECT		
Rampur Hydropower Project (India)	18,131	15,084	33,215	18,530	51,745
Malawi Energy Sector Support Project	32,191	51,953	84,144	168,341	252,485
Kosovo Energy Efficiency and Renewable Energy Project	326	n.a.	326	122	448
Nigeria Electrification Project	40	151	191	206	397
Sindh Solar Energy Project (Pakistan)	817	1,137	1,954	1,368	3,322
Second Rural Electrification Project (Peru)	57	59	116	154	270
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	3,854 (construction and O&M) and 4,021 (LADP activities)	n.a.	3,854 (construction and O&M) and 4,021 (LADP activities)	n.a.	7,875

Note: LADP = Local Area Development Plan; O&M = operation and maintenance; n.a. = not available.

handful of middle- and high-income countries, in the short term, developing countries are likely to host only a limited portion of this supply chain, leading to greater reliance on imports to support the energy transition.

In large-scale projects requiring land acquisition and resettlement of inhabitants, an additional job creation channel relates to activities focused on resettlement and restoration of livelihoods. While the funding required for such activities is typically a small percentage of the project cost, it can have a major job impact, in certain cases creating more local employment than the project itself. Many of these jobs last only through the construction phase, but service jobs often provide long-term employment for the local population. Further, resettlement and restoration of livelihood activities often provide not only men but also women with new employment possibilities (for example, in schools, health centers, newly established shops), as well as lead to a reduction in drudgery or an increase in the time saved due to the availability of new services.

Overall, the case studies suggest that sustainable energy jobs are attractive. Salaries, wages, and working conditions are crafted to attract and retain workers. Companies offer competitive remuneration packages combining higher-than-average wages with on-the-job training even for semiskilled and unskilled positions. Table ES.2 summarizes the findings of the case studies on the quality of jobs attributable to the projects studied.

Two-thirds of the jobs directly created by clean energy infrastructure projects require semiskilled or unskilled labor. The case studies did not find significant risks of specific skill

TABLE ES.2

Salaries, Wages, and Working Conditions in the Projects Studied

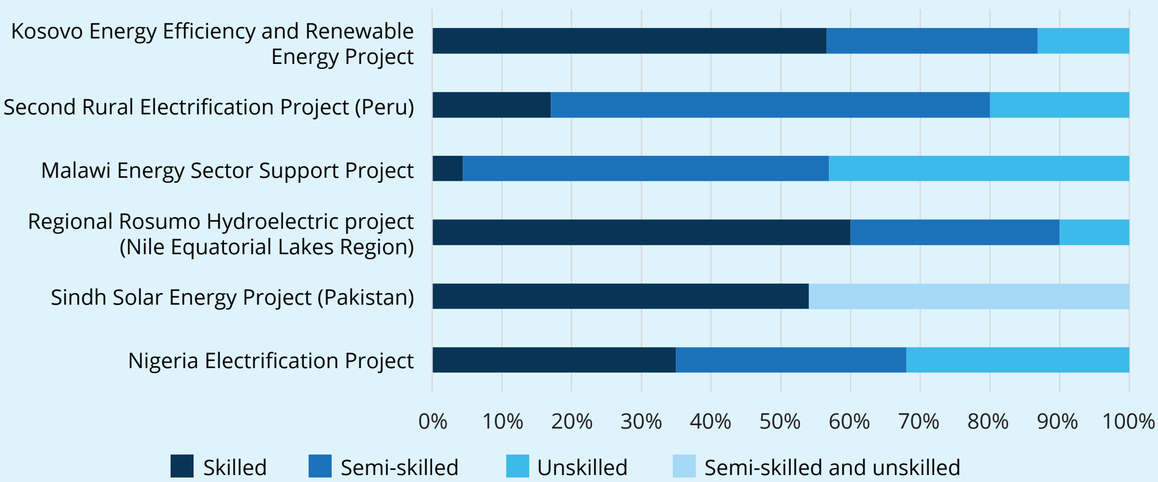
JOB-RELATED POLICY	TYPICAL CHARACTERISTICS OF JOB-RELATED POLICIES IN PROJECTS STUDIED
Is the job market regulated (minimum wages, social schemes)?	Minimum wages typically required by law and paid based on skill level. In certain cases annual and sick leave mandated by law.
Informal versus formal work	Skilled workers had formal contracts in all projects. Semiskilled and unskilled workers had in certain projects formal and in others informal contracts.
Are wages higher than market average?	Comparable to market wages or higher in response to labor shortages.
Staff retention policy	Skilled workers were hired on long-term contracts. Selected semiskilled workers were retained based on job performance.

shortages in the projects studied. Semiskilled and unskilled employees are easily sourced from the projects' vicinity as the needed skills can be acquired on the job. This dynamic can drive engagement with local communities and increase their acceptance of these projects. From the implementation perspective, local anchoring of projects helps to limit employee turnover, but it means that semiskilled and unskilled workers are not offered long-term employment or absorbed into a mobile cadre of workers in the construction companies developing clean energy projects. Figure ES.1 summarizes the findings of the case studies on skills requirements in the direct jobs attributable to the projects studied.

Electrification—and the resulting improvement in electricity supply and service quality—has significant potential to create jobs involving productive uses of electricity. The new productive uses may stem from a switch to electricity from traditional fuels or changes in

FIGURE ES.1

Shares of Skilled, Semiskilled, and Unskilled Direct Jobs in the Studied Projects



Note: The shares of skilled, semiskilled, and unskilled workers were not available for the Rampur Hydropower Project (India).

electricity costs for users; both enable households and enterprises to be more productive, often by adopting more efficient technologies. However, such projects require complementary activities and outreach to maximize the uptake of power, including, among other measures, (i) disseminating information on the options for productive use available to those with access to electricity, and (ii) making electrical appliances available and accessible through appropriate financing and credit options. As a consequence, and also since the changes in local habits and practices brought about by electrification take time to play out, productive uses take time to materialize.

At the same time, mechanization of production may actually destroy manual jobs if the market is not able to absorb increases in production. While accessible and reliable electricity increases labor productivity, whether this results in increased employment depends heavily on the potential for expanding production (for example, to meet unmet demand). Where power supply is the binding constraint on enterprise expansion, its improvement is *likely* to increase hiring.

The energy transition also implies the decline of fossil fuel–based energy production, in particular coal-fired power generation. Detailed research on the tasks performed and the skills needed in conventional (“brown”) industries and new, clean energy (“green”) industries shows that jobs in coal-fired power plants have little in common with clean energy jobs: in fact, they have far more in common with jobs outside the energy sector, such as in construction and manufacturing. Jobs in sectors other than clean energy may therefore be better alternatives for coal plant workers than clean energy jobs since they would not imply a change in lifestyle, even though they may necessitate some reskilling.

Transitions out of the energy sector can be complicated by information barriers as well as by socio-cultural and lifestyle factors. Remuneration may be an additional hurdle to overcome since jobs in coal-fired power plants can pay much more than clean energy jobs and, in many countries, also pay more than similar jobs in other sectors.

Contribution of this Report

The report adds to the academic and policy literature on job creation associated with energy transitions, particularly with regard to the macroeconomic impacts of key energy transition policy scenarios and their implications for electricity sector and economywide employment. Also important, drawing from World Bank–supported projects, the report adds perspectives from developing countries and emerging market economies to the global knowledge base on job creation in the energy transition.

By shedding light on the mechanisms that lead to the creation of jobs, especially induced jobs, the report helps fill the gap between high-level modeling of the job impact of the energy transition and ground reality. Its granular characterization of jobs created directly and indirectly by a range of sustainable energy interventions complements the global assessments conducted by international energy think tanks. The report provides noteworthy insights on the labor transition, particularly the potential for new green jobs to absorb labor released as brown jobs recede. On all these counts, it can inform the design of strategies for incorporating job creation in investment projects in developing countries.

Summary of Messages for Policy Makers and Development Practitioners

- Transitions from fossil fuels to clean energy are likely to boost the total number of jobs not only in the energy sector but also more broadly in the overall economy.
- The majority of job creation due to the energy transition is through induced jobs—clean energy investments will increase output, labor productivity, and employment in the economy.
- Transitions from brown to green energy jobs are neither automatic nor easy—often sectors other than energy would be a better fit for workers formerly employed in fossil fuel extraction and use.
- Investment in local development around resettlement is an important lever in long-term and stable employment. Impacts are positive, particularly for women, who often cannot benefit from jobs on the energy project itself but can be employed in new services developed as part of local development.
- Jobs associated with the energy transition include “indirect” jobs—those jobs in supply chains for RE and EE equipment and related materials. These jobs are currently concentrated in a few countries, so many developing countries cannot easily benefit.
- At the clean energy project level, a reality check on the jobs created indicates:
  - most jobs require unskilled or semiskilled (technical, vocational training) labor that can be sourced locally and trained on-the-job—it is a myth that most clean energy jobs require tertiary degrees;
  - most jobs are temporary, particularly those in construction; however, O&M jobs, although fewer by comparison, are good-quality, longer-lasting jobs;
  - while it is tempting to promote solely local hiring, the urge needs to be balanced against the benefits of developing a mobile cadre of experienced workers able to implement projects in different locations and therefore fill longer-tenured and better-paid jobs;
- Addressing job losses in incumbent high-emission industries, such as coal extraction and use, is critical for energy transition processes:
  - focusing purely on technological options for energy transition but failing to consider a “job transition” for workers will hinder progress toward the adoption of clean energy;
  - a sustainable job transition from brown jobs takes account of skills required for existing and potential replacement (new) jobs, worker preferences, demand in the replacement sectors, and multiple behavioral and social barriers to change;
  - the potential magnitude of job losses through the closure of coal-fired power plants is much smaller than the jobs at risk in coal extraction; however, transition can be hard in places where whole communities depend on this single industry.

Recommendations

This report makes three sets of recommendations to enhance the positive impact on jobs of the energy transition in developing countries by: (i) improving understanding of the mechanisms for job creation in the energy transition, (ii) incorporating specific actions into policies, project design, and implementation modalities, and (iii) developing a suite of education and training programs for a clean energy labor force.

The first set of recommendations is directed at academia, think tanks, International Financial Institutions (IFIs), Multilateral Development Banks (MDBs), and similar organizations. It pertains to building a knowledge base by collecting data and empirically identifying causality. This knowledge base would feed into the design of policies, projects, and education and training programs, summarized in the following two set of recommendations, which are directed at policy makers.

Data and Knowledge Creation

- Support systematic efforts to collect administrative and survey data on skills and jobs related to clean energy.
- Implement a pilot program of surveys to quantify and characterize jobs directly created by projects of different types across different geographic regions and country characteristics. Use pre and post project construction surveys to track and assess jobs through the project's life by requiring such reporting in project implementation contracts.
- Create a database of canonical employment factors applicable to different groups of developing countries through surveys in multiple geographic areas.
- Initiate a program to improve understanding of the causal chain for job creation associated with the local and regional economic development catalyzed by energy sector investments. This requires understanding the causal links between interventions and job outcomes, typically articulated in a 'theory of change' (TOC). The program should include a series of 'randomized control trials' (RCTs), which are the gold standard of impact evaluation, or quasi-experimental methods (if RCTs are not feasible) focused on the labor market to bring empirical evidence to bear on these causal links and identify the complementary factors necessary for job creation.

Policy Recommendations and Recommendations for Program/Project Design and Implementation

- Governments in developing countries, particularly in Sub-Saharan Africa, should prioritize investments in improving the reliability of power systems and energy efficiency since they are likely to be the most effective interventions for boosting both economic growth and employment.

- Policy makers should push forward with increased deployment of renewables and enhance openness to regional electricity trade since these policies have positive impacts on GDP and employment.
- Governments should also focus on support that facilitates labor market mobility and training of new and existing workers.
- At the project design stage, teams should:
  - Develop theories of change (TOC) to conceptualize channels of job creation;
  - Use the TOC to trace implications of enhanced access to power and availability of more reliable power for enterprises. On this basis, implementing agencies should design M&E to track jobs impacts;
  - Establish mechanisms to track creation of direct and indirect jobs, e.g., through periodic surveys;
  - Implement active labor market policies to enhance job creation in communities:
    - use information campaigns/advertisements to increase local and regional awareness of employment opportunities in projects coming up;
    - balance hiring locally (unskilled labor) with creating opportunities and providing training for semiskilled workers to be hired for longer-duration contracts in work that is more specialized and more mobile;
    - design technical and vocational education and training programs in line with expected needs in the market.
- For electrification projects, support productive use of power through awareness raising, training, and complementary interventions.
- Use the funding made available for resettlement and livelihood-restoration activities in communities impacted by infrastructure projects to train and employ local workers, ensuring that disadvantaged groups are included.
- In communities heavily reliant on coal, which often lack acceptable job alternatives, follow a deliberate process when re-purposing coal-fired power plants:
  - Identify use/development options for region/site based on local circumstances;
  - Analyze potential for jobs and the nature of those jobs based on market surveys;
  - Assess skills in existing labor force and their preferences, and determine the numbers needing to be absorbed;
  - Agree on a repurposing option that takes into account the availability of labor as well as the possibility of employing it.
- In places where governments have concerns about switching from a dependence on fossil fuels to a dependence on imported technologies, or are keen to pursue clean energy industrialization, industry-level analyses are needed to identify the segments of specific supply chains in which a given country would be competitive. Many developing countries have the potential to invest in particular segments of clean energy supply chains, but careful country and industry analysis is needed prior to implementing such strategies.
- Include learning opportunities in first mover/early projects and incorporate lessons from these projects into the design and rollout of larger programs so that subsequent projects can benefit.
- Ensure that all data collected is gender disaggregated and that accountability is fixed, incentives are provided (including through appropriate support to enhance inclusion of

women), and specific actions taken to improve gender balance in employment generated through clean energy projects.

- Understand that large-scale “one-size-fits-all” programs rarely work—detailed socioeconomic research and consultation are needed at the local community level no matter which energy transition–related intervention is being deployed.

Establishing Education and Training Options for Successful Clean Energy Skills Development

- Governments should clearly communicate career opportunities in clean energy to raise awareness of clean energy job prospects and to inform job-seekers about required qualifications. Collaboration between different ministries is crucial in this respect.
- When designing education and training programs, governments should work with industry and aim to meet clean energy industry needs consistent with the country’s strategic and policy objectives (e.g., focus on skills for solar PV plants if a government’s renewables plan focuses on solar deployment). To keep the training programs up-to-date in line with rapid technological development may require sustained financing flows from the government.
- To ensure quality education and training, governments should recognize international standards, develop national standards or collaborate with the private sector to establish accreditation schemes specific to clean energy jobs.
- To facilitate the supply of qualified workers in places where clean energy deployment is planned, governments should align program locations with clean energy project sites.
- To establish best-practice education and training programs, governments can look to neighboring countries with established programs in clean energy to harness lessons learned or join forces with them.

ONE
WHY ASSESS THE EMPLOYMENT IMPACTS OF THE CLEAN ENERGY TRANSITION?

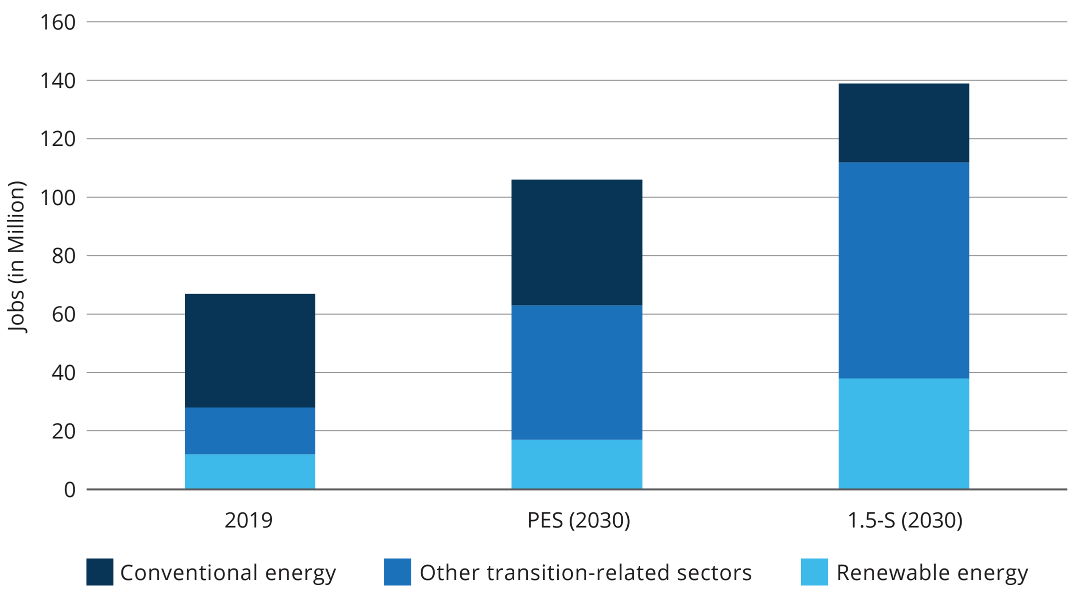
The global transition to clean energy must accelerate if global warming is to be limited to 1.5°C and the effects of climate change mitigated (IRENA 2022a; IEA 2021). For the power sector, the transition involves replacing fossil fuels with clean sources of power and electrifying traditionally unelectrified services (such as transport, heating, and industrial processes) while working toward universal access to clean energy services for all. The phaseout of traditional fossil fuel industries, along with the rise of sustainable energy technologies, will transform patterns of energy production and consumption.

These energy transitions are not merely technological processes or sets of financial transactions; people's work is at the heart of all such transitions. Jobs in declining energy industries—and the consequences for those who hold those jobs—are the key to unlocking the transition. Jobs in the new energy industries—and ensuring they are created in all regions and countries—are equally critical.

The changes in patterns of energy production and consumption do not imply a simple 1:1 shift between fossil fuels and renewable energy jobs. According to IRENA (2022a) the number of energy-related jobs globally is poised to increase significantly no matter which scenario for energy sector development is considered (figure 1.1). A climate-friendly future implies more jobs, however: the number of people working in the global energy sector by 2030 is expected to rise to 139 million under the 1.5°C Scenario, 31 percent more than the 106 million under the less ambitious Planned Energy Scenario. Job losses in conventional energy (i.e., fossil

FIGURE 1.1

Global Energy Sector Jobs Under a Range of Scenarios, 2019 and 2030



Source: IRENA 2022a.

Note: Planned Energy Scenario is based on governments' energy plans, targets, and policies as of 2020. 1.5°C Scenario aims to limit global average temperature increase by the end of the present century to 1.5°C, relative to pre-industrial levels.

fuels and nuclear), expected under the 1.5°C Scenario, would be more than offset by gains in renewables and other energy transition–related technologies (i.e., energy efficiency, power grids and flexibility, hydrogen). By 2030, the total number of renewable energy jobs should more than triple, from 11.5 million in 2019 to 38.2 million, while other energy transition–related sectors are expected to rise to 74.2 million, in the 1.5°C Scenario (IRENA, 2022a). Governments have a crucial role to play in establishing enabling frameworks for firms and workers in making their respective transitions. This role includes planning, providing information, and implementing policies, such as social protection measures, financial support or training options that smoothen transitional frictions.

The idea of estimating employment impacts first emerged in the energy sector when concerns were raised about the economic efficiency of feed-in tariffs and other schemes to support renewable energy. Research on jobs was triggered by the need to incorporate employment creation in economic assessments while comparing the costs of decarbonization pathways over the 2020–30 horizon, which initially concerned mainly Europe and the United States. That research focused on direct and indirect job creation. The focus has now moved to striking a balance between job destruction in traditional energy industries and job creation in sustainable energy industries.

While the United States and Europe are at the forefront of assessing job impacts, uncertainties remain about the fairness of energy transitions in individual countries, particularly low- and middle-income countries. When faced with the need to rapidly transition to sustainable energy, policy makers will naturally be concerned about the economic and employment impacts of the radical shifts involved, as well as about energy security and independence.

As laid out in recent work by the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA),[1] it is commonly acknowledged that many aspects of the transition to zero carbon power have significant potential to create local employment (IRENA 2020 (IEA 2020). While the direct and indirect jobs impact of energy transitions has been estimated at the global level, quantifying the overall jobs impact at the local level is challenging. The transition to clean energy will rely on increased and sustained investments in a portfolio of technologies (IRENA 2022a; IEA 2023a), including renewable energy; grid strengthening to absorb variable renewable power; decentralized generation, including for energy access; digitization of the energy sector; and widespread adoption of energy-efficient appliances and energy efficiency in buildings, industry, and transport. The good news is that all of these can create local employment.

In addition to jobs created within the energy sector, the provision of expanded and improved energy services, pursued through Sustainable Development Goal 7 ("Ensure access to affordable, reliable, sustainable, and modern energy for all") is expected to boost economic activity and induce job creation in the broader economy. Stimulus packages addressing the energy transition are likely to have multiplier effects on economic output and jobs, especially where the quality and quantity of power supply have been binding constraints, as when expansion of access to energy results in increased use of energy for productive purposes. At the same time, the retirement of coal-fired power plants, the closure of coal mines, the replacement of internal combustion engine–propelled vehicles with electric vehicles, and other changes, all carry a potential for job destruction, which must be accounted for and managed appropriately as integral to the global decarbonization agenda.

Economic agents and political constituencies need to understand the disruptive technological and process changes underlying the clean energy transition. Raising awareness about the job creation potential of the transition can have several beneficial effects. Greater awareness can help overcome resistance from traditional energy interest groups, particularly labor, that are concerned about being left behind. It can also reduce inertia to change by encouraging investment in the education and skills needed to work in the clean energy sector. And it can foster buy-in to efforts to move away from fossil fuels.

High-level analysis and modeling based on data from low- and middle-income countries suggest that their energy transitions will result in net job creation at the global level (IRENA 2022b). But quantifying the job impacts of the transition to zero-carbon power at the local level is challenging. More evidence and understanding of the precise mechanisms that lead to job creation, especially of induced jobs in developing countries, are needed, however. This report helps fill that gap.

This report complements the global analyses conducted by international energy think tanks. It adds value to the global conversation by bringing perspectives from developing countries and emerging market economies, based on ground-level data collected from World Bank projects. Its characterization of direct jobs created through a range of sustainable energy interventions adds important granularity missing from global assessments; its elucidation of the microeconomic determinants of job creation, including for induced jobs, serves the same function.

The report adds to the academic and policy literature on job creation associated with energy transitions, particularly on the macroeconomic impacts of key energy transition policy scenarios and their implications for electricity sector and economywide employment. It also provides insights on the labor transition, particularly the potential for new green jobs to absorb labor released as brown jobs decline and fade away.

The report is organized as follows. Chapter 2 reviews the literature and data on employment related to clean energy investments and introduces key definitions and concepts. Chapter 3 presents the results of economywide modeling of policy changes supporting the clean energy transition in selected countries in Sub-Saharan Africa. Chapter 4 presents findings on direct and indirect job creation from selected World Bank projects in support of clean energy transitions. Chapter 5 studies job transitions in several coal regions. Chapter 6 focuses on the induced job effects of clean energy projects. Chapter 7 summarizes the report's key insights.

Endnote

1. IEA (2020) analyzes the jobs potential of various energy investments with the aim of identifying those that could support a green recovery from the pandemic. Also, IRENA (2020) assesses the regional employment impacts of the energy transition using an integrated global macroeconometric model.

TWO
EMPLOYMENT IMPACTS OF THE ENERGY TRANSITION: WHAT DO WE KNOW?

HIGHLIGHTS

- The academic and policy literature is dominated by *ex ante* modeling that assesses the impact of the energy transition on direct, indirect, and induced job creation, generally at the sector, policy, or economy levels.
- Establishing causality requires *ex post* analyses. *Ex post* methods have not been widely used, because of lack of data, which are often costly or difficult to collect.
- Global work by international organizations tends to be insufficiently empirical, does not examine causality, and does not include adequate representation of developing countries. Deeper analyses are needed to understand the mechanisms by which energy projects create jobs.
- The literature addressing developing countries is limited. The little research that has been conducted focuses on induced jobs—particularly jobs created by electrification and the productive use of electricity.
- The theory of change underlying the creation of jobs (particularly induced jobs) by clean energy interventions is not fully developed and needs empirical backing.

2.1. Definitions

Energy transitions around the world will create millions of jobs. They will also cause job losses, which will be concentrated in specific sectors and locations. To make transitions socially sustainable over time, they must be just and inclusive, addressing the needs of workers who are adversely affected.

The Just Transition for All concept, as defined by the World Bank (World Bank 2018), builds on the International Trade Union Confederation's concept of a just transition, defined as one that "brings together workers, communities, employers, and government in social dialogue to drive the concrete plans, policies, and investments needed for a fast and fair transformation. It focuses on jobs, livelihoods, and ensuring that no one is left behind as we race to reduce emissions, protect the climate, and advance social and economic justice." The concept complements this definition by envisioning reforms of labor and social policy and institutions to ease the disruption faced by people affected by the transition to clean energy and to support them in their post-transition jobs and lives (World Bank 2018).

The standard definition for job creation attributable to investment projects typically divides them into direct, indirect, and induced jobs (Sustainable Energy Jobs Platform 2022). The distinction between direct, indirect, and induced jobs can vary based on the nature of the issue being evaluated and the level of analysis—a point the literature has largely overlooked. For example, global assessments may consider manufacturing jobs as direct, whereas project-based assessments may consider them indirect. Local area development plans included in the financing envelope of an infrastructure project could be considered direct rather than induced if they are financed by municipalities through a tax on the project. Productive activities funded as part of access projects could be direct rather than induced jobs. It is therefore important to specify up front the scope of a project when assessing its job impact.

Direct jobs include all jobs directly related to the installation, operation, and maintenance of energy projects. For off-grid solar projects, for example, the distribution, marketing, and sale of solar equipment create direct jobs.

Deployment of clean energy also creates jobs *indirectly* in sectors that supply inputs to the energy sector. For example, additional employment can be expected in the steel industry, which produces components for wind turbines, and in the semiconductor industry, which furnishes materials with which to build solar cells, as well as in these industries' upstream sectors (such as mining). The size of indirect employment will depend on the volume of inputs from upstream sectors that is required by new renewable energy projects and the employment factors in these sectors[1] (the number of employees required per unit of output). When accounting for indirect jobs, it is important to realize that many of these jobs can be located abroad, since production of materials, metals, and certain clean energy equipment (e.g., solar PV panels) is concentrated in a few countries.

Consumption spending by people performing direct or indirect jobs results in further economic growth, creating *induced* jobs. Induced jobs can also stem from increased spending using consumer savings achieved thanks to energy efficiency or the cost competitiveness of renewables. These jobs may be found in all sectors of an economy. They are especially important in the context of large-scale governmental stimulus or investment programs. Increases in medium-skill jobs are likely to have strong induced effects, especially in low-income countries, where households have a high marginal propensity to consume and most spending is local. Strong induced effects are likely to benefit local communities.

Some induced jobs are "replication" jobs—jobs created by increased demand for a particular type of project or installation spurred by an initial project. For example, a rooftop solar installation in a public building can lead to a sudden increase in demand for other rooftop solar installations. Jobs created in these new projects could be accounted for as jobs induced by the original project (as viewed from the perspective of the original project).

Energy access projects that deliver sufficient capacity to sustain productive activities and provide affordable and reliable power connections have the potential to generate significant employment through *productive uses of electricity* (a subset of induced jobs). Power for All (2022) estimates that in 2021, productive use jobs attributed to distributed renewable energy (DRE) for electricity access outnumbered DRE-related direct and indirect (formal) jobs by a factor of more than four.

Electrification can give rise to productive use jobs through four mechanisms (Power for All 2019):

- *Increased farm and nonfarm productivity*. In rural areas, electricity can increase agricultural productivity and output—for example, by providing access to electrified water pumps and irrigation systems. Non-agriculture-based firms may also experience efficiency gains by substituting fossil energy sources with electricity and investing in new machinery, lighting, refrigeration, and information technology. Although some of these investments may replace labor, they are likely to boost firm growth, increase incomes, and create more direct and indirect employment across sectors.
- *Business creation.* Access to electricity allows new industries and services that use electricity as an input to operate.
- *Labor supply*. An electric connection saves households substantial time in performing domestic labor, allowing women (who perform most domestic labor in developing countries) to increase their participation in the labor market.
- *Education*. In the long run, electrification—particularly better lighting in schools and at home—is likely to improve educational outcomes, increasing the possibility of obtaining a better job.

2.2. Global Analyses

Global energy organizations and think tanks have estimated the number of clean energy jobs that energy transitions could create globally. According to the International Energy Agency (IEA 2023b), the number of jobs in "new sectors" driving the energy transition rivaled the number of jobs in conventional energy as early as 2019 and the trend continued in 2022 (figure 2.1). Those new sectors are renewable energy (RE) and energy efficiency (EE), modern grids capable of accommodating variable renewable energy, and the rapidly growing electric vehicle sector.

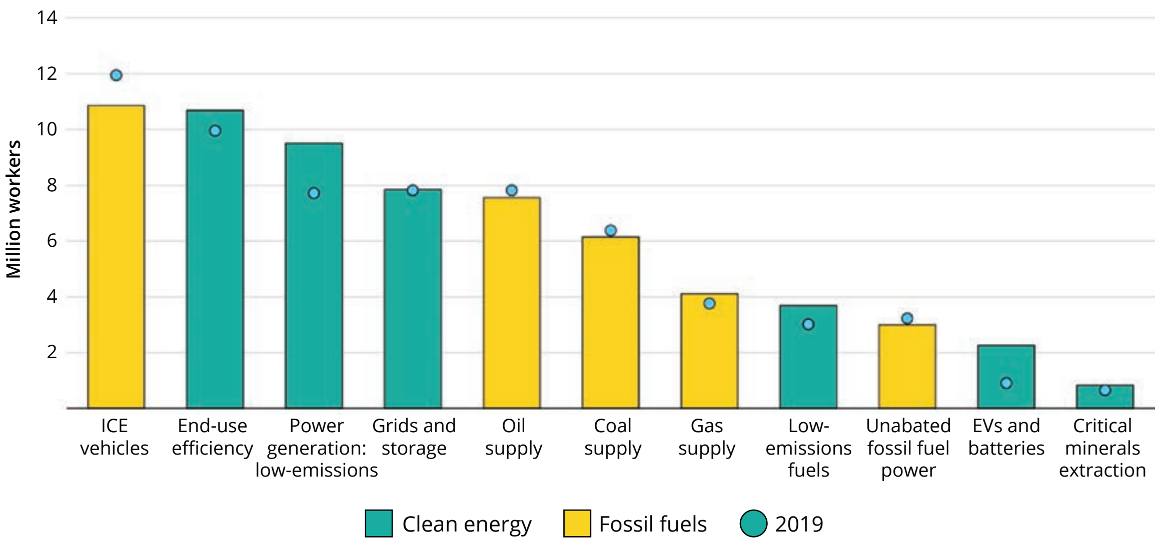
IEA estimates that 10.9 million people were employed in improving energy efficiency in buildings and industry in 2019. Nearly half of those jobs worldwide were in construction. China accounted for nearly one-third of global EE-related employment. IEA estimates that 6.9 million people worked in renewable energy power generation in 2019, 60 percent of them in manufacturing and construction and 40 percent in operation and maintenance (O&M). China generated the most solar and wind jobs because of its many installations and its global dominance in manufacturing solar and wind equipment.

The International Renewable Energy Agency (IRENA 2022b) reports that global RE employment grew to 12.7 million in 2021 (figure 2.2).

Job estimates by IRENA include the entire production chain for each renewable technology, from manufacturing, installation, and O&M to employment in upstream sectors. IRENA

FIGURE 2.1

Global Employment in Selected Energy Subsectors, 2022

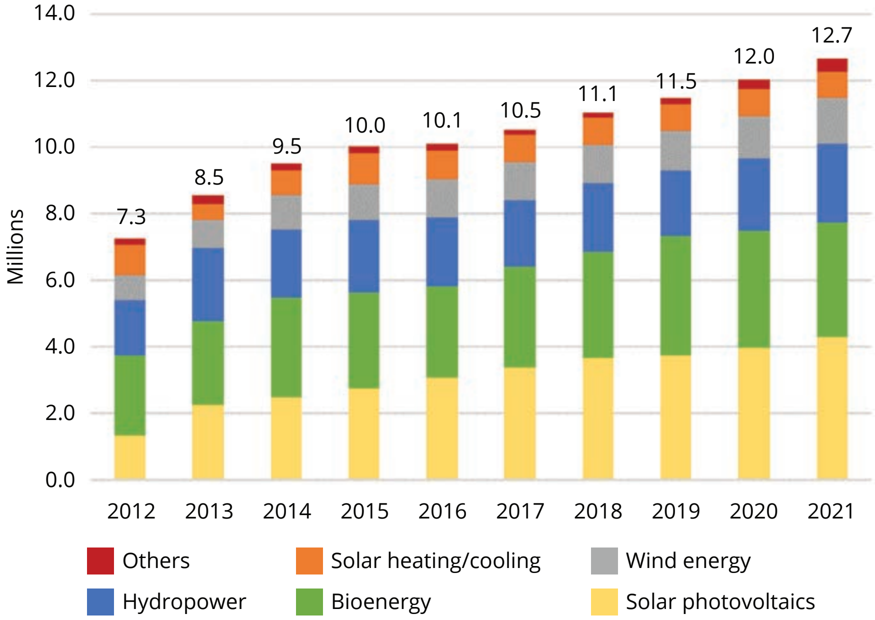


Source: IEA 2023b.

Note: ICE = internal combustion engine.

FIGURE 2.2

Global Renewable Energy Employment, by Technology, 2012–21



Source: Based on data from IRENA (2022b).

highlights that RE jobs are concentrated in a few countries, most of them developed or emerging market economies. China is the global leader. It is followed by the European Union, Brazil, India, and the United States. These five economies account for nearly three-quarters of global RE employment. Renewables have also seen rapid growth in other parts of Asia. The region accounted for 64 percent of global RE jobs in 2020.

Most global clean energy employment figures include manufacturing of clean energy equipment, construction, and O&M, aggregating the largest direct and indirect job categories. Detailed reports on the composition of value chains—such as those put out by IEA (2022b) and IRENA (2017a, 2017b) on employment impacts along the solar PV and onshore wind value chains—include additional categories, such as planning and decommissioning, but they represent only a small fraction of total jobs.

IEA's employment estimates are based on its comprehensive data on global investments and on energy production and demand. Its assessments draw on national labor statistics, data from corporate filings, company interviews, international organizations, and the academic literature. They do not include induced jobs. IRENA's data draw on a range of studies and reports by government agencies and industry associations, and some report direct jobs only, while others report both direct and indirect. IRENA's numbers for hydropower are a result of modelling and include direct jobs only.

2.3. Key Considerations in Assessing Job Impacts

Not all job types materialize in a given country. The majority of direct jobs are clustered in the installation and O&M portion of the value chain; indirect jobs generally emerge in a few equipment-manufacturing countries. Depending on the capabilities of the local labor force, foreign nationals may perform a share of jobs across all the above categories, thus not contributing to local job creation.

A key consideration when assessing the job creation potential of an investment is where the jobs are located. Asian countries, particularly China, are the world's largest manufacturers of clean energy equipment; African countries do not have significant local production capacity and are unlikely to develop notable competitive manufacturing sectors in the short or medium term. Over these time spans, employment gains will therefore primarily favor exporters of clean technology components.

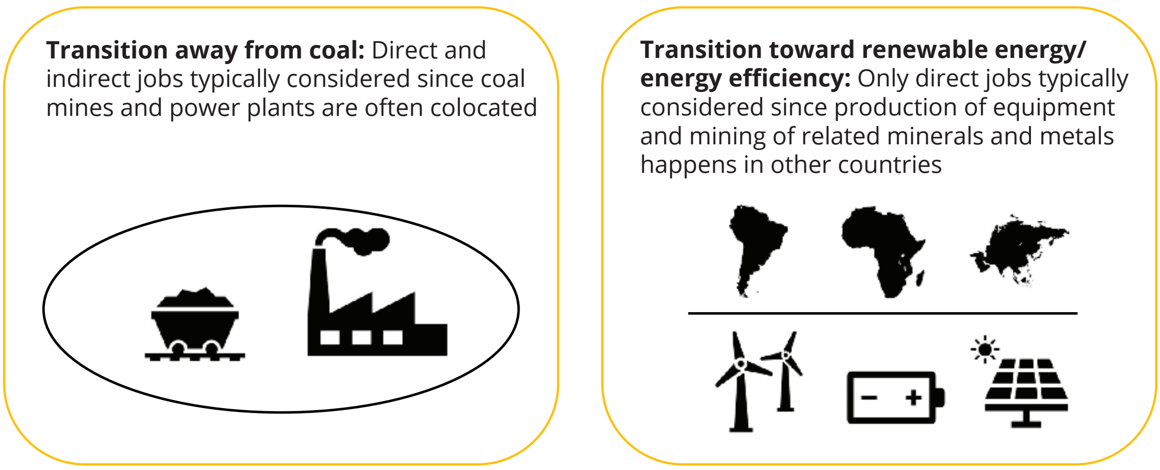
The co-location of jobs in the value chain can affect perceptions of employment when comparing fossil fuels and clean energy—particularly for country-level analyses. The literature often overlooks a number of the indirect jobs that contribute to total renewable energy (RE) or energy efficiency (EE) employment, such as jobs needed to produce the equipment or in mining for minerals and metals needed to produce that equipment. Steel, aluminum, polysilicon, and lithium for example, are used in the production of wind turbines, PV panels, batteries, and energy efficiency equipment used to build and install clean energy projects. The disparity in treatment of clean energy and fossil energy indirect jobs is due in part to the fact that upstream activities take place far from where the power is generated, while coal power plants are often co-located with mining operations. As a result, mining jobs (indirect jobs for coal-based power) show up prominently in coal power employment numbers (figure 2.3). The absence of co-location often causes underestimation of the potential number of jobs that clean energy could create if parts of value chains were localized in a competitive manner.

The role of global supply chains in spurring job creation worldwide is of interest to researchers and policy makers in the context of just transitions, as jobs from emission-intensive industries are phased out, creating a need for workers to be absorbed by other parts of the economy. RE and EE technologies tend to be more labor intensive than their fossil fuel counterparts, but clean energy investments still create relatively few direct jobs (World Bank 2023a; World Bank 2023n). Because of the concentration of the manufacturing supply chain in a few countries, most developing economies are expected to capture few upstream (indirect) jobs (IEA 2023a).

The global energy transition will not lead to a 1:1 transition from old (brown) to new (green) jobs, because direct jobs in clean energy are not as evenly distributed across countries as those in conventional generation. Installation (and often maintenance) jobs require workers to be highly mobile in order to support many smaller installations. As the skill requirements of fossil fuel and clean energy jobs differ widely, as explained in chapter 5, it may be more feasible for displaced fossil fuel workers to transfer to jobs in nonenergy sectors of the economy requiring similar skills rather than taking up sustainable energy jobs.

FIGURE 2.3

Varying Scopes of Employment Impact Assessments for Coal and Renewable Energy/Energy Efficiency Installations



Source: Authors' compilation.

2.4. Review of the Literature and Methodologies Used

Several methodologies are available for evaluating the possible impact of energy transition policies on jobs at the country level (World Bank 2023a). The five basic approaches are (1) bottom-up engineering models, (2) input-output (IO) tables, (3) computable general equilibrium (CGE) models, (4) macroeconometric models, and (5) econometric assessments. The first four provide *ex ante* evaluations of the potential impact of projected investments; the fifth provides *ex post* assessments of completed projects. It should be noted that jobs modeling is a rapidly evolving field with new models and methods constantly being developed. The technical complexity, data requirements, ease of implementation, and scope of results of the five approaches differ (table 2.1).[2]

The literature so far, particularly on emerging and developing economies, has largely focused on *ex ante* assessments, which are not validated by empirical observation and often assume labor markets without any frictions[3] (World Bank 2023a) so they end up estimating potential labor demand. While studies using *ex ante* methods have analyzed a wide range of policy interventions and projects in developing countries to estimate direct, indirect, and induced job creation mechanisms, *ex post* methods, necessary to establish causality, have had a narrower focus on induced jobs.

The literature shows that the impact of the energy transition on induced jobs can be significant. This impact is variable as induced jobs result from the increase in economic activity spurred by energy investments and therefore depend on the characteristics of the economy. In fact, the primary impact of the sustainable energy transition on employment in many countries might be through induced jobs, including productive uses of energy. For example, Power for All (2022) estimated that in 2021, productive use jobs attributed to distributed renewable energy (DRE) outnumbered DRE-related direct and indirect (formal) jobs by more than four times. Concrete evidence of the creation of induced jobs and the mechanisms behind their creation can therefore provide valuable insights into the employment impact of the sustainable energy transition.

Evaluating the impact of the transition on induced jobs requires collecting specific microdata, which should be included in the design stage of clean energy projects or programs. For some projects, *ex post* evaluation may remain possible after project completion even if it was not envisioned at inception (World Bank 2023a).

Over the past decade, the economics literature has used both observational and experimental methods to study the creation of induced jobs associated with improved access to electricity and with its productive uses in South Asia, Latin America, and Sub-Saharan Africa. This work focused on electrification because it is easier to tease out causal impacts of new access than of incremental additions to the power supply. The literature shows that clean electrification has the potential to create many jobs in developing countries, provided the newly available power can be put to productive use, which often requires specific support measures (World Bank 2023a, 2023m).

TABLE 2.1

Comparison of Methodologies Used to Assess Employment Impact of the Green Transition

METHOD	DATA REQUIREMENTS	TECHNICAL COMPLEXITY	STATIC VERSUS DYNAMIC	TYPE OF JOB CREATION ASSESSED	IMPLEMENTATION IN A DEVELOPING ECONOMY
Bottom-up engineering	Moderate. Engineering assessments rely on technology assumptions that are similar across the world and widely available.	Low	Static or dynamic	Direct (in certain cases also indirect)	Suitable for developing countries. The technology assumptions on which bottom-up models rely are often not country dependent, making them useful in data-poor environments. If the number of assumptions is limited, this approach can yield results from simple investment figures.
Input-output (IO) tables	High. Obtaining results on renewable technologies requires identifying the corresponding sectors in the IO table, which requires a high level of sectoral disaggregation.	Moderate	Static	Direct and indirect (in certain cases also induced)	Difficult. IO tables are collected by national statistical offices in a process that is long and difficult; even high-income countries collect these data only every 5–10 years. Global multi-regional IO databases are available based on modelled data (e.g., GLORIA, GTAP, WIOD).
Computable general equilibrium (CGE) models	Very high. CGE models expand the data requirements of IO models to include a complete parametrization of elasticities of substitution between various factors of production, imported and domestic goods, and intermediate consumptions.	High	Dynamic	Direct, indirect, induced	Very difficult. This methodology is the most demanding of the four in terms of data and complexity. CGE models are hard to justify for small discrete projects, as their general equilibrium effects are probably negligible.
Macroeconometric models	High. Typically have IO tables at the core. Single-country models can be based on country data and data from international institutions. Global models require consistent IO data sets.	Moderate	Dynamic	Direct, indirect, induced	Difficult. Useful to analyze whole of economy effects from price-based policies (results present net effects). Allow to see the trajectory and path dependence along different investment paths.
Econometric models	High. Econometric assessments require the identification and collection of high-quality microdata before the investment is carried out.	Variable	Static	Direct	Difficult. Econometric modeling is the only methodology allowing *ex post* assessments, making it highly desirable. However, microdata requirements make implementation of econometric assessments difficult, particularly when causal links need to be identified. Data collection should be integrated from the start because few contexts lend themselves to quasi-experimental assessment after the fact.

Source: Adapted from World Bank (2023a).

The papers surveyed in a literature review (World Bank 2023a) that complements the present report focus primarily on labor supply and business creation as potential job creation mechanisms. Electricity access is believed to boost productivity in performing domestic tasks, freeing up time for income-generating activities, especially for women. Household electrification can also spur microentrepreneurial activity, especially for services that require electricity supply and can be performed from home (for example, cooking, sewing, ironing, phone charging, and informal retail). The results of these studies range from no measurable impacts to large impacts of electrification on labor supply, business creation, and overall employment, suggesting that effects are likely context dependent and that electrification alone is not sufficient to drive economic development in the absence of other favorable factors. Research on the heterogeneity of treatment effects will help determine where and when investments in electrification reap larger and more widely shared benefits.

The literature review reveals a focus on the household-related consequences of electrification and the lack of evidence of its impacts on small- and medium-size business creation and development. Future assessments of RE investments could benefit from data collection targeting the private sector (World Bank 2023a).

Jobs attributable to the productive uses of electricity are difficult to estimate using *ex ante* methods, which are more adapted to estimating direct and indirect jobs. Direct measurement via household and firm surveys is possible, but it would be costly given the need to achieve a large-enough sample size. Overcoming these obstacles requires quasi-experimental *ex post* assessment methodologies.[4]

In short, evaluating the impact of the energy transition on induced jobs requires microdata. Lack of data is the main reason behind the paucity of employment impact assessments. The problem is acute in developing economies, where official statistics may not be collected at the required level of detail and/or spatial granularity.

Plans for collecting such data are best included in the design stage of clean energy projects or programs. Embedding data collection initiatives in publicly funded projects would facilitate *ex post* evaluations of employment impacts. For some projects, however, *ex post* evaluation may be possible only after project completion even when not envisioned at inception (World Bank 2023a). Such initiatives could range from simple surveys conducted before and after an intervention to panel studies to randomized controlled trials. At a minimum, assessing the impact of a clean energy investment program requires estimating the status at project inception, to provide a reference point.

Endnotes

1. An additional complication in accounting of jobs stems from the fact that, depending on country's accounting systems, clean energy jobs can be accounted under different sectors, such as construction, manufacturing, etc.
2. Macroeconometric models have recently gained attention, because they are grounded in empirical analysis and data and allow for market imperfections, path dependence and

rigidities. For instance, IRENA has used macroeconometric models of renewable energy employment as part of their work on clean energy development globally and for a string of developing country studies (IRENA 2022a; IRENA 2022d). The World Bank has also strengthened its expertise in non-neoclassical, non-equilibrium model development, to provide further insights into the labor market effects of clean energy and climate policies. Notably, the World Bank has adopted and further developed the MINDSET model, a price endogenous multi-region IO model, which has been extended to a macroeconometric model. This model has increasingly been incorporated into Country Climate Diagnostic Reports, such as for the Philippines and Pakistan. The model has also been utilized to assess the job impacts of the EU's carbon border tax adjustment mechanism in Bosnia and Herzegovina and provides projections of clean energy job impacts under Paris aligned scenarios for ongoing World Bank analyses.

3. In real labor markets, spatial, temporal, and skills frictions arise. Taking them into account in policy making is crucial for the match of potential labor demand with labor supply.
4. Quasi-natural experiments refer to serendipitous situations in which economic agents are randomly assigned to treatment or control groups, approximating the randomized design of a well-controlled experiment and allowing causal inference. These methodologies allow researchers to estimate the causal effect of electricity access on the level of employment and economic activity across multiple levels of aggregation, from households to regions. Although these observational studies are typically less costly to implement than randomized controlled trials, they need large quantities of data, because they require simultaneous measurement of electrification status and economic outcomes.

THREE
ECONOMYWIDE EMPLOYMENT IMPACTS OF CLEAN ENERGY INVESTMENTS IN DEVELOPING ECONOMIES

HIGHLIGHTS

- All four policy scenarios examined for this report yield positive economywide job impacts in Sub-Saharan Africa countries studied.
- The greatest potential impact on gross domestic product and employment results from improvements in the reliability of electricity grids, followed by demand-side energy efficiency programs because availability of power is often a binding constraint in these economies.
- Increases in the use of renewables and regional electricity trade also have positive impacts on the economy.
- The policy scenarios examined yield “better” jobs since workers receive higher wages that reflect higher labor productivity.

This chapter presents the results of an *ex ante* analysis using a computable general equilibrium (CGE) model to determine economic impacts of different scenarios, such as GDP growth and job creation. The advantage of CGE analysis is that it can capture economy-wide job creation, including the induced jobs created when economic activity increases through energy investments and employment resulting from the boost to demand and growth provided by consumption (spending) of people employed in direct or indirect jobs. Focus on Sub-Saharan Africa allows us to study the impact of new power production better than in other regions, since new power production in Africa typically comes as additional power in the system, while in developed countries clean power often simply displaces existing fossil-based power.

For this report, the ENVISAGE CGE model was used to assess the potential labor market impacts of different elements of a clean energy transition in nine Sub-Saharan African countries (Côte d’Ivoire, Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Senegal, Tanzania, and South Africa).

The model used data inputs from the Global Trade Analysis Project (GTAP)-Power database, which distinguishes electricity generation by source. It was linked to the Electricity Planning Model (EPM) of the World Bank’s Energy Sector Management Assistance Program, which provides a detailed breakdown of electricity generation by source; projections on how the share of generation from each source changes over time under different scenarios; and the investment costs associated with each scenario.[1] This information was used to create a bottom-up linkage between EPM outputs, which provide detailed technical specifications for electricity production, and the CGE framework, which allows simulation of the macroeconomic effects of different energy policies. Linking CGE with EPM ensures that the mix of generation sources reflects technical constraints in the power system—namely, the resources available in the country and the size, dispatchability, variability, and flexibility of the mix of sources that can cover power demand.

The CGE model was used to simulate the economywide impact of four policy scenarios in the context of Sub-Saharan Africa:

- Scenario 1: Increased power generation from renewable energy (RE) sources
- Scenario 2: Deeper regional integration through electricity trade
- Scenario 3: Increased reliability of power systems
- Scenario 4: Investments in energy efficiency (EE)

The analysis shows that real gross domestic product (GDP) increases under all four scenarios, thanks to greater demand for skilled and unskilled labor and a rise in real wages with respect to the baseline (or business-as-usual scenario). Jobs are both more productive and better paid.

3.1. Setup of the CGE Model Used and Scenarios Studied

Neither renewable nor fossil fuel electricity generation is very labor intensive. For that reason, increasing power generation is not expected to directly boost labor demand substantially. Cheaper, more reliable electricity, however, helps the economy grow, which in turn boosts both labor demand and wages.

In all the countries analyzed except South Africa, unemployment rates are low and labor force participation of both men and women is high relative to international standards, albeit with widespread informality.[2] The ability to increase the labor supply in these countries is therefore limited. The CGE model takes baseline labor supply over time as exogenous by assuming that labor participation rates, informality rates, and unemployment levels remain constant and that labor supply changes only as a result of changes in the size of the working-age population. When policy shocks are simulated, labor supply levels are unchanged with respect to their baseline level, and the estimated changes in labor demand translate into wage changes that clear the labor market. New jobs are generated in energy sectors that expand; new and better-paid jobs are created in economic sectors in which labor productivity increases, thanks to cheaper or more reliable electricity supply. Although changing energy policies and associated shifts in labor demand create and destroy jobs in different sectors, the tight labor supply constraint means that relatively few new jobs can be created in the economy.

A baseline simulation is used to assess the impact of each scenario. In the baseline simulation, the rate of growth of real GDP of every country is based on the long-term growth projections of the Organisation for Economic Co-operation and Development. Labor supply growth is projected using growth of the working-age population, taken from United Nations' population projections. Labor supply is then fixed at these baseline values, and changes in wages ensure that the labor market clears. Workers can move between sectors, but the overall level of employment does not change for any given year. Real incomes change as wages adjust to match the total demand and supply of workers.[3] An increase in labor demand as a result of a shock or policy that increases overall economic activity raises wages; contractions in overall economic activity reduce wages.[4]

Workers are divided into two groups, skilled and unskilled, each with a different wage rate, reflecting the balance between demand and supply for that kind of labor.

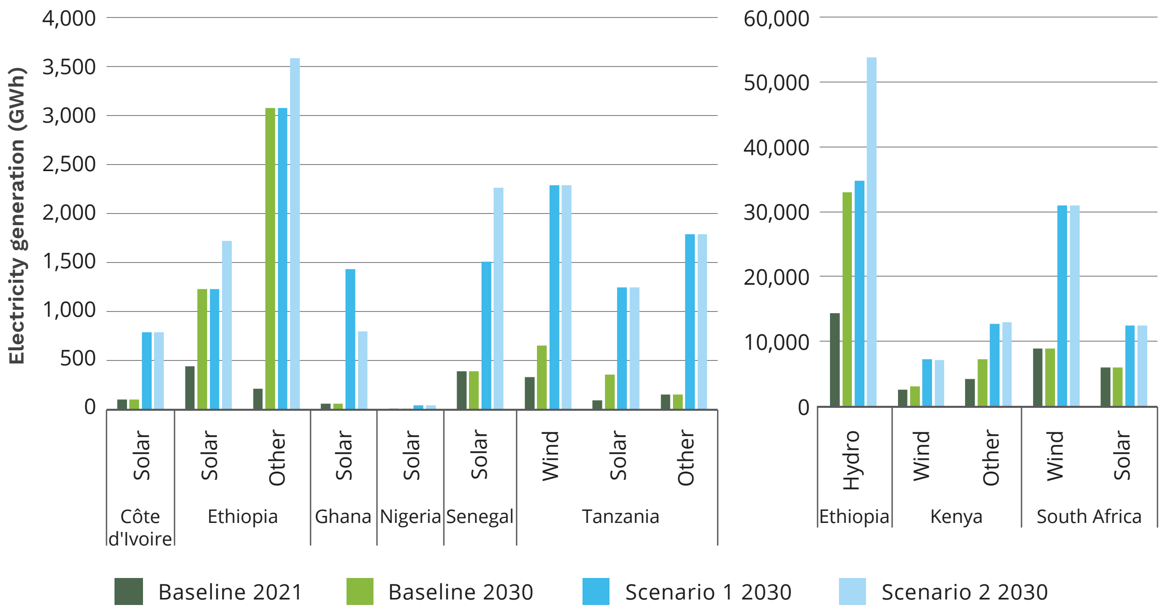
Data on the electricity generation mix and the growth of electricity supply come directly from the EPM. For the baseline scenario, the EPM assumes that trade levels remain at their level in 2020 (the initial base year) through 2030 and that countries build only already committed transmission lines and renewable plants. (A plant is considered committed when a final investment decision has been made.) Plants that are candidates for generation expansion over the period are restricted to thermal generators to be brought online to meet demand growth beyond the levels met by committed renewable sources and transmission investments.[5]

Scenario 1: Increase in Renewable Electricity Generation

The expansion of generation from renewable sources varies by country, reflecting each country's renewable energy resource endowments and their competitiveness with fossil fuels (figure 3.1). Increases in renewable generation increase total electricity generation in most countries. Over and above the initial increase, additional renewable generation results from the general equilibrium effect of lower prices of renewable power sources, which reduce the average electricity price faced by firms and households. Lower electricity prices allow firms to produce more at the same cost, which increases their demand for electricity.

FIGURE 3.1

Electricity Generation in the Baseline and Scenarios 1 and 2, by Country, 2021 and 2030



Source: World Bank 2023b.

Note: The figure is provided in two panels because of the significant differences in scale. GWh = gigawatt-hour.

Real GDP increases in all countries along with the increase in renewable power generation. The deployment of more productive and lower-cost renewable generation sources lowers the final price of electricity by about 5 percent for most countries. The availability of more electricity that is cheaper increases electricity demand, spurring overall economic activity. The size of the GDP change in a country depends on the magnitude of the initial increase in renewable generation, how total electricity supply (including electricity trade) is affected, and the average electricity intensity of the country.

The increase in economic activity increases the demand for labor. As the total number of workers does not change, real wages rise. Wages increase for both unskilled and skilled workers in all countries except Mozambique and Nigeria.

Changes in electricity generation affect economic sectors differently. Lower energy prices lead to greater expansion of production in energy-intensive sectors than in non-energy-intensive sectors. These changes in sectoral production affect the sectoral demand for labor. Sectors and activities that are expanding attract more workers, but these effects are negligible, with only around 0.05 percent of workers moving across sectors.

Scenario 2: Increase in Regional Electricity Trade

As in Scenario 1, renewable generation expands if it is the least-cost option, and regional trade increases thanks to construction of additional cross-boundary power lines. More interconnections lead to increased electricity trade, affecting the build-out of power plants and stimulating the construction of renewable generators in countries such as Ethiopia and Senegal, which are particularly well endowed with renewable resources and can use them to generate power at very low cost. In these cases, electricity exports can contribute to the least-cost generation plans of neighboring countries. Ghana is the only country in which renewable generation in Scenario 2 is lower than in Scenario 1 (because Ghana can import low-cost solar power from its neighbors with better solar resource endowments and therefore lower costs of solar power).

Real GDP increases in all countries except Nigeria. Ethiopia and Kenya display the largest GDP change thanks to greater electricity generation and net electricity exports in both countries.

Real wages are positively correlated with increases in real GDP, as the expansion of the economy increases labor demand. In Ethiopia and Kenya, wages in 2030 increase by around 1.5 percent over the baseline. This increase is almost twice the wage increase these countries experience in Scenario 1. Wages also increase in the other countries, providing a strong indication of positive employment impacts from an increase in electricity trade.

Scenario 3: Increase in the Reliability of Power Supply

Scenario 3 models increases in electricity stability (reductions in outages, intermittency, and voltage fluctuations) resulting from improvements in the grid brought about by investments in transmission and distribution (T&D). T&D investment rises to the level that allows each country's grid to eliminate outages by 2030. The power generation mix and trade levels are fixed at baseline levels. Improved stability and reliability of electricity are expected to increase firm productivity by reducing production shutdowns, uncertainty, and the costs incurred for expensive backup sources of power, such as private diesel generators. Data on output losses attributable to outages were obtained from World Bank Enterprise Surveys[6] and used to calibrate increased manufacturing productivity associated with a fully functional grid that provides stable electricity supply.

Better-quality electricity supply also yields second-round (general equilibrium) effects. Greater manufacturing output increases GDP and aggregate demand, which raises electricity demand across the board, increasing total generation. The power generation mix and electricity trade remain unchanged from the baseline values, as all generation sources increase proportionally.

This scenario yields significant GDP gains. Relative to the baseline, real GDP increases on average by around 1.5 percent in 2030 in Scenario 3. In Senegal, GDP, total electricity generation, and wages increase by substantially less than in the other countries because outages are less frequent at baseline.

As economic activity expands, the demand for labor grows. Wages rise by about 2 percent above the baseline. Skilled labor benefits more than unskilled labor because of the expansion of the manufacturing sector, which employs skilled workers more intensively than other sectors.

Scenario 4: Improvements in Demand-Side Energy Efficiency

This scenario focuses on improved efficiency in residential lighting as a result of the switch to lamps using light-emitting diodes (LED). It relies on data on LED penetration in Tanzania. The same EE gains were applied to the other countries. As in Scenario 3, the baseline electricity generation mix and trade levels do not change.

Due to the use of LED bulbs, households obtain the same consumption utility from lighting (as before switching) by purchasing less electricity. As a result, they gain discretionary income to spend on other goods and services.[7] The electricity saved in lighting also leaves more electricity available for other users, including manufacturing firms.

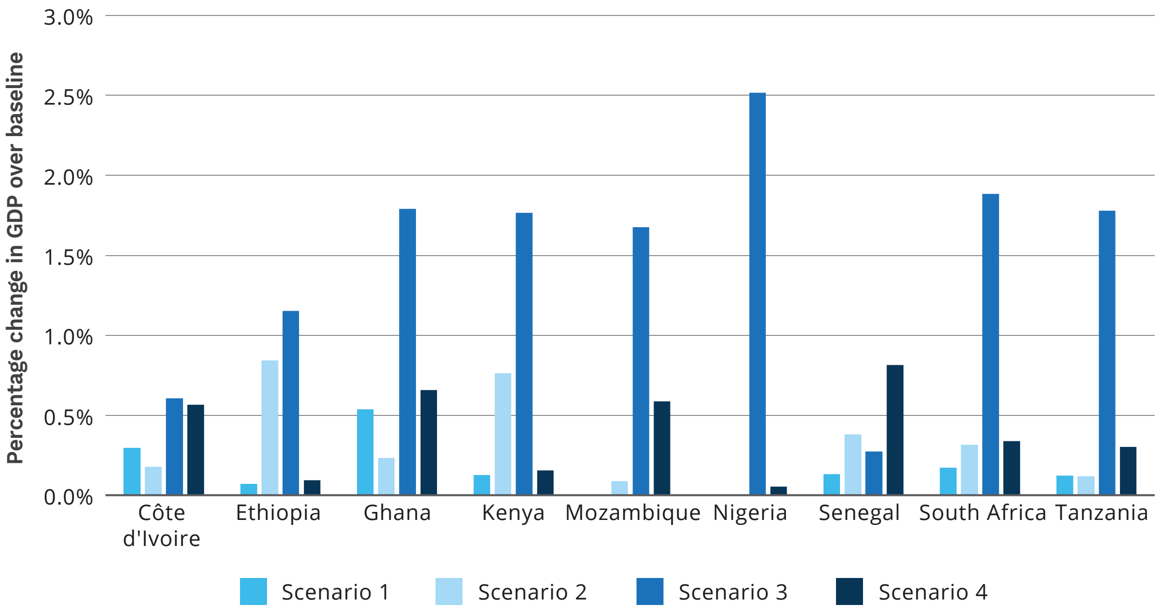
In this scenario, all countries experience gains in real GDP and electricity generation. As economic activity expands, the demand for labor increases. Wages rise as a result, but the increase is modest given the small size of the investment needed to improve energy efficiency.

3.2. Impacts of Different Scenarios on Real GDP, Labor Demand, and Wages

All four policy scenarios have positive effects on real GDP. Higher GDP translates into higher demand for labor and higher real wages for both unskilled and skilled workers. The magnitude of the macroeconomic impacts differs across scenarios (figure 3.2).

FIGURE 3.2

Changes in Real GDP in 2030 in the Four Scenarios, by Country



Source: World Bank 2023b.

Note: GDP = gross domestic product.

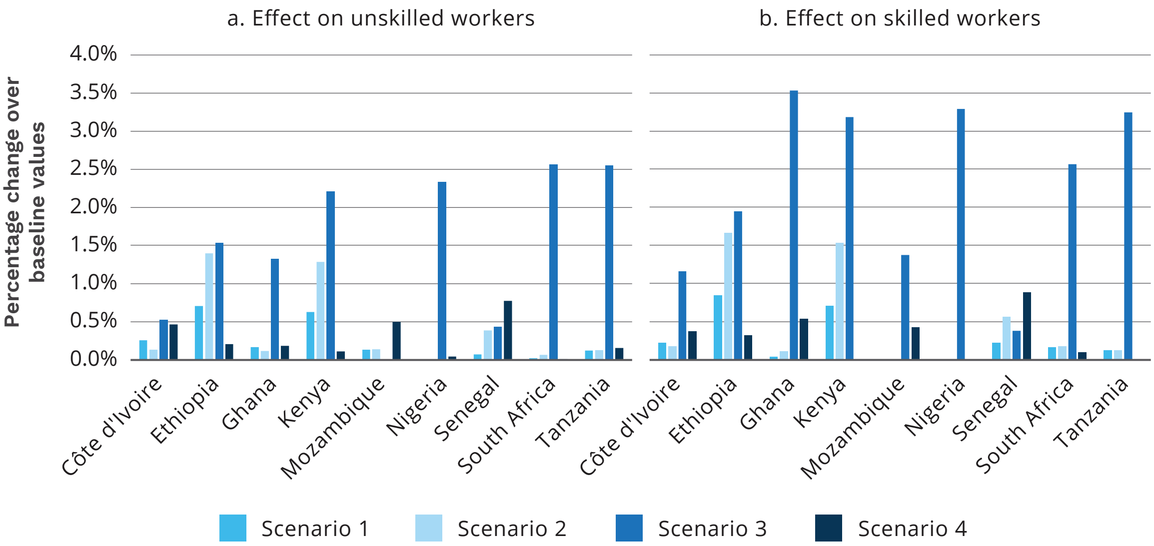
In Scenarios 1 and 2, the GDP impacts are associated directly with the increase in total electricity generation and associated general equilibrium effects after the introduction of policy changes. The positive impacts are generally smaller than those of the other two scenarios. The improved reliability of the power supply (Scenario 3) and greater demand-side energy efficiency (Scenario 4) boost production in the economy and stimulate aggregate demand, producing additional increases in power generation. This combination generates the largest GDP gains for most countries (In Scenario 4, household savings from energy efficiency permit further expansion of consumption, adding to the increase in aggregate demand).

Increasing power reliability through additional investments in T&D (Scenario 3) has the greatest impact on GDP, particularly for Nigeria. Increased energy efficiency (Scenario 4) has the greatest GDP impact in Senegal. More regional electricity trade (Scenario 2) has relatively large effects in Ethiopia and Kenya. Increasing renewable electricity generation (Scenario 1) has relatively low impacts on GDP compared with the other scenarios, although the effect is substantial for Ghana. These findings reflect the different mechanisms each scenario triggers under differing country-specific conditions.

Figure 3.3 shows the impacts on real wages, which are similar to the effects on GDP. All scenarios generate positive real wage effects, with the largest impacts associated with greater power reliability. The low unemployment and high labor force participation rates in the sample countries mean that there is limited capacity to increase the size of the labor force by creating new net jobs. Instead, the policy scenarios improve the quality, productivity,

FIGURE 3.3

Changes in Real Wages of Unskilled and Skilled Workers, by Scenario and Country, 2030



Source: World Bank 2023b.

and remuneration of existing jobs, with the wages of both skilled and unskilled workers rising under all scenarios.

The additional electricity sector investment in each scenario provides an idea of the returns on investment. Scenario 4 has the lowest investment cost, but that of Scenario 3 is also low. Scenarios 1 and 2 involve large investments in RE plants.

Scenario 3 has the highest returns, followed by Scenario 4. GDP increases in Scenarios 1 and 2 are generally lower than in the others, while the initial investment required is much larger. Scenarios 3 and 4 can be considered low-hanging fruit, with relatively large economic gains associated with modest additional investment.

The CGE model estimates how labor is reallocated to economic activities after a policy shock is introduced. Economywide employment is kept constant at baseline levels; sectoral employment levels can change, as labor moves from contracting sectors and economic activities to expanding ones. Employment in the electricity sector itself changes under each scenario.

Table 3.1 presents the estimated number of new jobs in electricity generation under each scenario, reporting direct jobs in electricity generation and related T&D. It does not capture labor in upstream activities.

The number of new direct jobs is proportional to the change in electricity generation and the number of workers expected to be employed in the electricity sector in 2030. In most scenarios, changes in employment levels in electricity generation activities are very small: New workers moving into the electricity sector represent less than 0.05 percent of total employment in each

TABLE 3.1

Estimated Change in Electricity Generation and Number of Direct New Jobs Created in the Electricity Sector, by Scenario and Country, 2030

COUNTRY	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	PERCENTAGE CHANGE IN GENERATION	NUMBER OF DIRECT JOBS CREATED	PERCENTAGE CHANGE IN GENERATION	NUMBER OF DIRECT JOBS CREATED	PERCENTAGE CHANGE IN GENERATION	NUMBER OF DIRECT JOBS CREATED	PERCENTAGE CHANGE IN GENERATION	NUMBER OF DIRECT JOBS CREATED
Côte d'Ivoire	3.9%	2,935	3.9%	2,935	1.1%	809	0.9%	679
Ethiopia	4.3%	10,557	55.0%	134,618	3.3%	8,194	3.3%	7,954
Ghana	4.6%	5,726	2.5%	3,056	2.8%	3,463	7.8%	9,563
Kenya	42.2%	167,347	45.3%	179,883	1.3%	5,166	4.5%	18,049
Mozambique	0.0%	0	0.0%	0	1.6%	1,547	0.6%	603
Nigeria	0.1%	408	0.1%	408	1.9%	11,671	7.5%	45,948
Senegal	9.5%	1,315	16.0%	2,201	0.6%	87	1.1%	146
South Africa	9.0%	24,848	9.0%	24,848	0.2%	503	3.5%	9,763
Tanzania	13.8%	10,512	13.8%	10,512	1.8%	1,396	0.8%	633

Source: World Bank 2023b.

country. Ethiopia and Kenya in Scenario 2 and Kenya in Scenario 1 experience large changes in employment associated with large hydroelectric and geothermal projects. The capital intensity of RE projects is high, but the construction jobs associated with that investment (for example, building of solar farms or hydropower plants) are counted as construction activities, not as electricity activities.

3.3. Estimates of Economywide Job Creation

As the CGE model assumes that the number of workers in the economy is fixed, an increase in the demand for labor traceable to the increase in productivity associated with the rise in GDP results only in higher wages, not more jobs. In order to assess the implications for job creation, the concept of the "employment equivalent to changes in real GDP" is used to provide an indirect measure of the jobs likely to be created. Box 3.1 presents these results, which show a net increase in jobs in all scenarios.

BOX 3.1

EMPLOYMENT EQUIVALENT TO CHANGES IN REAL GDP

One of the main assumptions in the CGE simulations is that labor supply is held fixed at the baseline value. This is reasonable because the average rate of labor participation in Sub-Saharan Africa is above 85 percent for both women and men, and unemployment is less than 5 percent. Thus, it is assumed that most people able to work are likely doing so, even if they are underemployed.

The model shows that due to increased availability/quality of power, the productivity of labor and output (GDP) rises, along with the demand for labor. Since labor supply—the number of workers in the economy—is fixed in the model, greater demand for labor means wages must rise for the labor market to clear. The wage that clears the labor market equals the new (higher) marginal product of labor. Thus, the new equilibrium is characterized by an increase in GDP, higher productivity of labor, and an increase in wages.

(*continues*)

BOX 3.1 (*Continued*)

To assess the effect on job creation, one option is to estimate how many more workers (with the same productivity as in the baseline) would be required to achieve the new real GDP levels in the different scenarios. This concept—the "employment equivalent to real GDP changes"—provides an indirect measure of jobs created.

Table B3.1.1 shows the GDP-equivalent employment results for each scenario. Using this implicit employment measure, net jobs increase in all scenarios. Scenario 3 (reduction in outages) has the largest implicit job creation potential for all countries except Senegal, and Nigeria has the largest job increase in this scenario. In Senegal, Scenario 4 (increase in the efficiency of electricity consumption) has the largest job impact.

TABLE B3.1.1

Employment Equivalent to Change in Real GDP, by Scenario and Country

COUNTRY	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	PERCENT CHANGE IN NUMBER OF NEW WORKERS	NUMBER OF NEW WORKERS	PERCENT CHANGE IN NUMBER OF NEW WORKERS	NUMBER OF NEW WORKERS	PERCENT CHANGE IN NUMBER OF NEW WORKERS	NUMBER OF NEW WORKERS	PERCENT CHANGE IN NUMBER OF NEW WORKERS	NUMBER OF NEW WORKERS
Côte d'Ivoire	0.26%	24,087	0.18%	16,482	0.60%	55,420	0.57%	51,935
Ethiopia	0.21%	134,791	0.84%	533,442	1.15%	727,511	0.10%	60,072
Ghana	0.47%	72,476	0.23%	35,904	1.79%	274,077	0.66%	100,635
Kenya	0.43%	125,162	0.76%	220,432	1.77%	511,806	0.16%	44,977
Mozambique	0.11%	17,378	0.09%	14,298	1.68%	271,420	0.59%	95,104
Nigeria	0.00%	1,288	0.00%	299	2.51%	1,772,058	0.05%	38,390
Senegal	0.13%	6,631	0.38%	19,400	0.27%	13,917	0.82%	41,399
South Africa	0.29%	48,118	0.32%	52,634	1.88%	314,296	0.34%	56,580
Tanzania	0.12%	44,158	0.12%	43,942	1.78%	656,875	0.30%	111,290

Source: World Bank 2023b.

3.4. Summary of Economywide Modeling Results

The results of the CGE analysis for the 9 Sub-Saharan Africa countries are promising: All four policy scenarios have positive effects on real GDP compared with the baseline, increasing the demand for labor and raising real wages for both unskilled and skilled workers. As GDP is higher with the same number of workers, labor productivity (output per worker) is higher. Jobs are thus both more productive and better paid.

The magnitude of the macroeconomic impacts differs across scenarios. For all countries analyzed (except Senegal), improving power reliability through additional investments in T&D (Scenario 3) has the largest effect on GDP. It is strongest in Nigeria. Although the other scenarios have lower impacts on GDP, they are substantial in some countries. Increased regional electricity trade (Scenario 2) generates relatively large economic gains in Ethiopia and Kenya, for example, and increased renewable energy generation (Scenario 1) has a significant impact on GDP in Ghana and Kenya. In Senegal, increased energy efficiency (Scenario 4) has the largest impact on GDP of the four scenarios.

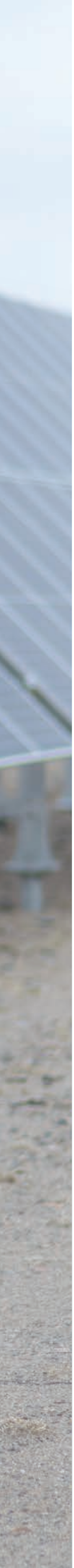
Wage gains are correlated with GDP effects. Scenario 3 has the greatest potential to generate better jobs in the countries studied, for both unskilled and skilled workers; it also has the greatest potential to generate economywide output gains. Scenario 4, which involves relatively low investment, yields moderate economic gains. It is important to highlight that these results were obtained for countries in Sub-Saharan Africa, where power supply is much less reliable than in more developed regions and where energy efficiency liberates power for alternative uses given that quantity and quality of power is often a binding constraint in these economies. Results of similar scenarios in other regions could be different.

Endnotes

1. The EPM is a power system planning tool developed by ESMAP's Power System Planning Group in 2015. The model optimizes the expansion of generation and transmission in the long term as well as the underlying dispatch of generation and flows on transmission lines for existing and new transmission assets. The model has been implemented in more than 80 developing countries to inform investment decisions and policy analyses.
2. It is important to note that CGE analysis abstracts from realities on the ground in developing countries: low unemployment rates in Sub-Saharan Africa are traceable to inadequate social protections that trap individuals in informal and insecure jobs, with irregular hours, underemployment, and unproductive activities. Barriers to formal employment are multifaceted and depend on various factors, including labor market policies, governance, and the rule of law.
3. The fixed labor supply implies that both unemployment and labor participation rates are fixed in the long term based on their initial values. Therefore, the economy is not assumed to be operating at full employment.

4. The model also assumes that workers can move freely between sectors without any short-term adjustment costs—a medium- to long-term perspective on labor market adjustments. It does not explicitly account for adjustment costs to workers, which are implicitly assumed to be compensated by higher wages in the new job.
5. The CGE model requires that any expansion in electricity generation be matched by a proportional increase in transmission and distribution activity in order to ensure that the increased electricity supply can reach final consumers.
6. www.enterprisesurveys.org.
7. This simulation accounts only for the benefits that accrue to households using more LED lamps; it does not account for other gains (such as EE gains in street lighting and the energy savings of firms using LED lamps), which could be substantial.

FOUR
DIRECT AND INDIRECT JOB CREATION: FINDINGS FROM SEVEN CASE STUDIES



HIGHLIGHTS

- Sustainable energy infrastructure projects generate many temporary but high-quality direct jobs during construction. Although they create fewer direct operation and maintenance jobs, these jobs last for decades.
- Two-thirds of the direct jobs created by sustainable energy projects require semiskilled and unskilled workers. Energy efficiency projects may mobilize a larger share of skilled workers than other sustainable energy projects.
- The projects studied sought to attract and retain temporary workers through more attractive remuneration packages than those offered in the local market.
- In large-scale projects requiring land acquisition and resettlement of inhabitants, an additional channel for job creation involves resettlement, restoration of livelihoods, and local area development activities. The number of these jobs is similar to the number of construction-related jobs, while employing many more women.
- Electrification projects require complementary technical assistance and outreach so people accessing electricity for the first time can maximize their uptake and realize the potential for productive uses of power.

This chapter presents the results of seven case studies of World Bank–supported projects carried out in low- and middle-income economies. They examine renewable energy (RE)–based new generation, both centralized and decentralized, in India, Nigeria, Pakistan, and the Rusumo Falls Region of the Nile Equatorial Lakes Region that spans Burundi, Rwanda, and Tanzania; grid infrastructure investment supporting increased energy access through new and upgraded lines in Malawi and Peru; and renovation of buildings to improve energy efficiency (EE) in Kosovo (World Bank 2023c, 2023d, 2023e, 2023f, 2023g, 2023h, 2023i).

Multiple criteria were used to select the projects. They had to:

- support energy transition (renewable energy, energy efficiency, or energy access);
- be relatively representative of the World Bank's present portfolio regarding clean energy deployment (including projects under preparation);
- be completed or nearly completed so that jobs in the construction phase could be traced; and
- offer some geographic spread.

These criteria meant that projects that are expected to be integral to the World Bank portfolio, but are not yet at an advanced implementation stage could not be covered. For example, e-mobility, wind, and green hydrogen projects could not be covered. To address these gaps, job creation information is supplied in boxes 4.1 and 4.2, a green hydrogen project in Mauritania and offshore wind projects, respectively.

BOX 4.1

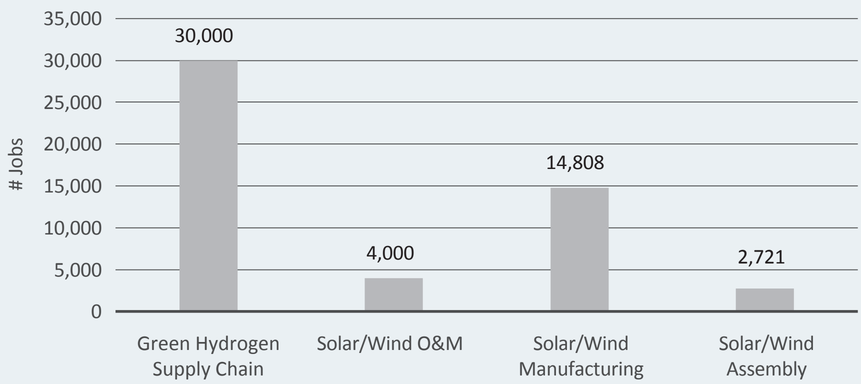
EXPECTED JOB CREATION IN MAURITANIA FOR A GREEN HYDROGEN PROJECT

The Aman Project in Mauritania, expected to begin operation in 2037, illustrates the potential for job creation in the emerging green hydrogen industry. The project will generate an estimated 1.7 million tons of green hydrogen per year, powered by 18 GW of wind capacity and 12 GW of solar and creating a range of direct, indirect, and induced jobs. The construction phase could create as many as 15,000 direct jobs, while O&M should generate 4,000 long-term jobs lasting the lifetime of the project.

Indirect jobs will be created by the demand for inputs during construction and operation, such as jobs in equipment manufacturing and those associated with renewable power inputs (figure B.4.1.1). The number of indirect jobs is expected to far outweigh the number of direct jobs but how many of these jobs will be domestic will be strongly influenced by the ability of the country to capture parts of the green

FIGURE B.4.1.1

Projected Indirect Jobs Created by the Aman Project in Mauritania



Source: Gielen and others 2023.

Note: Supply-chain jobs include those that result from the manufacturing of components needed to produce green hydrogen, such as electrolyzers, compressors, and pipes. For this calculation, they include jobs generated by the manufacture of higher-value goods produced with green hydrogen, such as green ammonia. These jobs have been modeled separately from the indirect jobs resulting from the renewable power inputs, such as jobs in solar/wind manufacturing, assembly, and O&M.

(*continues*)

BOX 4.1 (*Continued*)

hydrogen value chain: the ability to manufacture components domestically would create a more favorable indirect job scenario. Mauritania is also currently exploring the potential to utilize green hydrogen locally to create higher value-added products, such as direct reduced iron and hot briquetted iron. Alongside improved revenues, this would create an additional opportunity to boost domestic employment creation.

As a result of spending by those directly and indirectly employed, a wide array of induced jobs will also be created, such as those in food, healthcare, and education. However, induced jobs remain challenging to quantify and were beyond the scope of the job modelling for the Aman project.

Sources: CWP 2022; Gielen and others 2023.

BOX 4.2

EXPECTED JOB CREATION IN OFFSHORE WIND INDUSTRY AND LEVERAGING EXPERIENCE FROM OFFSHORE OIL AND GAS JOBS

Offshore wind projects combine the scale of large hydropower projects and the complexity of offshore hydrocarbon extraction, making them entirely different from onshore wind or solar. The specialized supply chain, large port and grid infrastructure requirements, and long-term O&M offer opportunities for countries to create local jobs and significant economic benefits throughout a project's lifecycle.

In an emerging market, around 43,000 full-time equivalent (FTE) years of employment are required to develop, construct, operate, and decommission a typical 1 GW offshore wind project over a 35-year period. Half these jobs occur during the 6 years of the manufacturing and construction phases. In comparison, the +25-year operational life of a project supports fewer long-term, skilled, local jobs—typically 60–80 FTEs per year—within the local O&M port and associated suppliers.

(*continues*)

BOX 4.2 (*Continued*)

When considering the development of a new multi-GW offshore wind market, however, the number of potential jobs could be far higher. For example, the United States is estimated to require up to 58,000 FTE per year by 2030 to deliver 30 GW of offshore wind. More jobs and economic benefits could be generated if one factors in export opportunities: Denmark, which operates less than 3 GW of offshore wind, has a strong supply chain that exports globally. For every MW of offshore wind deployed in European waters, 9.1 FTE Danish jobs are supported.

The export opportunity is an important consideration as the offshore wind supply chain is truly global, with components regularly transported worldwide. New manufacturing facilities are expensive and need large order volumes—often GWs per year—to justify investment. So suppliers need to consider opportunities outside the domestic market. Localized manufacturing is possible in emerging markets, especially for large components like blades, towers, foundations, and substations. In addition to eyeing export opportunities, investors will look for clear, long-term domestic opportunity in the local supply chain and new manufacturing facilities.

Ports are essential infrastructure for the construction and operation of offshore wind projects. The size of components prevents transport by land, so they are manufactured near ports to ease shipping costs. For this reason, ports often become industrial clusters. The introduction of this new industry can help ports attract investment, upskill and internationalize local suppliers, and lead to more diversified and resilient port economies. For some ports, such as Hull in the United Kingdom, the high value of offshore wind has helped to revitalize coastal communities affected by declines in, for example, shipbuilding, commercial fisheries, and tourism. The Danish port of Esbjerg has become a major offshore wind manufacturing, assembly, and logistics hub, attracting various international suppliers now clustered around the port. This new industrial opportunity has provided the port and local community with new income, helping the city to transition from offshore oil and gas on which the port used to be heavily reliant.

More broadly, offshore wind can provide a natural “just transition” from offshore oil and gas industries. The workforce required for the two industries have many similarities and workers can be readily trained in the skills required to move from

(*continues*)

BOX 4.2 (*Continued*)

one to the other. The jobs roles supported by offshore wind are not limited, however, to just offshore construction or manufacturing; offshore wind is a broad, multidisciplinary industry that directly supports well over 100 different roles, plus numerous roles related to indirect and induced activities.

For example, Ørsted, the largest offshore wind developer globally, currently employs around 1,365 people in the UK and Ireland. Of those, 10 to 15 percent are estimated to have come either directly from the oil and gas sector, or via this sector at some point in their previous career history, from jobs focusing on geoscience, commercial and business development, procurement, legal, environment, health and safety, HR, and other support functions. The main obstacles to people transferring from oil and gas are disparities in pay and benefits as the oil and gas sector typically pays more than the renewables sector for equivalent roles. Another obstacle is geographical location, as renewable energy projects tend to be in coastal or remote locations, and not necessarily where oil and gas has been traditionally concentrated, e.g., London and Aberdeen.

Source: NREL 2022, Star of the South 2023, Wind Denmark 2020, Wind Europe 2021, World Bank 2021, communication with Ørsted.

Additional in-depth case studies in this chapter complement the above analyses and enrich the findings. These studies take different angles of approach:

- a synthetic case study of coal plant closure and repurposing is based on the literature covering multiple countries to gain insights into possible job transitions for coal workers (the results are presented in chapter 5);
- examination of a series of World Bank development policy loans that supported policy actions to improve power sector performance, including energy subsidy reform as a crucial underpinning of the energy transition (the results are presented in chapter 6);
- a deep dive into the rollout of mini grids in Nigeria to understand the potential impacts of increased access to electricity on productive use of electricity and related employment (the results are presented in chapter 6).

These studies were designed to complement analysis of direct (and indirect) jobs by looking at job destruction and possible job transitions among workers in a declining energy industry. In doing so, it is hoped to gain deeper insights on possible mechanisms for induced jobs creation through policy actions or productive uses of electricity.

4.1. Summary Descriptions of the Case Studies

The case studies underscore the dominance of construction in direct job creation in projects involving large infrastructure works (for example, hydropower, transmission, and distribution)—and a substantial share of the World Bank funds in all of the studied cases was devoted to construction (including rehabilitation).[1] These jobs are short-lived, lasting only through the construction phase. The projects' main contribution to long-term job creation is from O&M. These jobs last for the duration of the projects' operational life (20–50 years). The number of O&M jobs—in full-time equivalent terms—exceeded the number of construction jobs in the projects in Nigeria, Pakistan, and Peru.

"Local area development jobs" are often created by large projects requiring the resettlement of local populations. These jobs arise from projects requiring construction or rehabilitation of roads and water infrastructure, the resettling of habitations, and the building of new health facilities and schools, among other uses. The case studies show that the number of local area development jobs is sizable. For the Rusumo Falls project, it is comparable to the number of construction jobs for the hydropower plant.

World Bank–supported projects often draw workers from less remunerative or otherwise less attractive employment; they may have been underemployed or even unemployed. In either case, employment by the project improved their livelihoods.

The Energy Sector Support Project in Malawi (approved in 2012, closed in 2018) was designed to increase the reliability and quality of power supply in the country's major load centers. The project included the construction and rehabilitation of 33 and 11 kilovolt lines and upgrades to five substations. These efforts complemented the 2013–18 Millennium Challenge Corporation's Malawi Compact, which funded significant investment in transmission and distribution lines and the refurbishment of a hydropower station. The construction and rehabilitation component of the project received $41.9 million of the total World Bank investment package. The direct jobs created included jobs in design, construction, and O&M of the distribution network. Indirect jobs were created to produce inputs for construction, such as cables, circuit breakers, and voltage transformers—these necessary materials and equipment were procured internationally, implying that all indirect jobs described in the case study were foreign jobs. Induced jobs grew out of improved household access to electricity—more productive uses of power—and from the improved reliability of power supply for enterprises, which allowed them to expand.

The Kosovo Energy Efficiency and Renewable Energy Project (approved in 2014, expected to close in December 2023) was designed to reduce fossil fuel use in public buildings through investments in energy efficiency and renewable energy and to enhance the broader policy and regulatory environments for both. The project financed EE retrofits and RE installations for 140 buildings owned by the central government, which received $22 million of the total World Bank investment package. Direct jobs resulted from the design and construction of EE building retrofits; installation of solar-powered and energy-efficient appliances; and training and audits. Indirect jobs were created through demand for inputs, including building materials and appliances. Induced jobs have not been quantified, although it is believed that the project may have led to the replication of jobs from increased demand for similar EE investments in Kosovo.

The Nigeria Electrification Project (approved in 2018, expected to close in 2023) was designed to increase access to electricity services for households, educational institutions, and micro, small, and medium-size enterprises. The project has built 850 mini grids with solar generation, battery storage, and diesel backup, which together received $180 million of the total World Bank investment package for the project. Direct jobs have been created in the design, construction, and O&M of the mini grids. Indirect jobs grew out of the demand for equipment and building materials needed for the mini grid systems. Induced jobs may yet emerge as electricity access expands the potential for productive activities and new small businesses open.

The Pakistan Sindh Solar Energy Project (approved in 2018, expected to close in 2023) has the objective of increasing solar power generation and access to electricity. The project has included the installation of 20 megawatts (MW) of rooftop-solar-generating capacity on and around hospitals in the province, which received $25 million of the total World Bank investment package for this project. Direct employment arose out of construction and O&M activities. Indirect jobs emerged from the demand for project inputs, including solar equipment and building materials. Induced replication jobs may result from increased demand for similar investments in the future.

The Peru Second Rural Electrification Project (approved in 2011, closed in 2017) was designed to improve rural access to electricity, particularly in localities far from the grid with dispersed populations. The project electrified 42,500 households, small businesses, and community facilities through grid expansion or the installation of individual solar photovoltaic systems, as well as technical assistance for rural electrification to promote productive uses of electricity. These two components together received $36 million of the total World Bank investment package for the project. Direct jobs were those needed for design, management, construction, and O&M. This category covers jobs created by the electricity distribution companies as well as those created in nongovernmental organizations to build capacity for productive uses of electricity. Indirect jobs resulted from demand for inputs in construction and O&M, including equipment and building materials. The case study also assessed the degree to which induced employment associated with productive uses of electricity at the end of the intervention was sustained during the five years after the project ended.

The Rampur Hydropower Project in India (approved in 2007, closed in 2014) had among its goals making India's Northern Electricity Grid more reliable through the addition of renewable energy. The project financed the 412 MW Rampur run-of-river hydroelectric scheme, which received $350 million of the total World Bank investment package. Direct jobs grew out of the design, construction, and O&M of the project as well as through resettlement, rehabilitation, and community development activities carried out in project-affected communities. Indirect jobs were generated by demand for inputs needed to build and operate the hydropower plant. Induced jobs are believed to have been created locally to meet the consumption and other needs of project employees. The reported improvement in reliability of the Indian Northern Electricity Grid is believed to have boosted economic activity broadly, increasing employment in India.

The Regional Rusumo Falls Hydroelectric Project (approved in 2013, expected to close in 2024) is intended to increase the supply of electricity to the national grids of Burundi, Rwanda, and Tanzania. The project has included the construction of 80 MW in hydropower generation capacity and the installation of 378 kilometers of transmission lines across the beneficiary countries, which together accounted for $340 million of the total World Bank investment package for the project. Direct jobs were created in construction, O&M, and activities carried out as part of the Local Area Development Plan, a cornerstone of the project's environmental and social activities. Indirect and induced jobs, and productive uses of electricity were not assessed in this case study.

4.2. Quantification of Direct and Indirect Employment Impacts

The case studies addressed both the number and quality of the jobs created. The analysis that follows examines the durability of the new positions, the transferability of employees to other potential employers, the attractiveness of the remuneration packages offered, and the gender balance of the workforce across the projects.

The number of direct jobs created in each case was estimated from interviews and complementary project documentation. The estimated number of indirect jobs created was approximated by using employment factors (the ratio of direct to indirect jobs taken from the literature assessing similar projects), given that efforts to estimate upstream supply chains for all the materials would be too complex and were deemed not feasible. The total number of direct and indirect jobs created is provided in table 4.1.

Figure 4.1 shows the ratios of direct to indirect jobs in the projects under study. For new (distributed) generation in Nigeria and grid extension in Malawi and Peru, the share of indirect jobs created is potentially larger than the share of direct jobs. In the Rusumo Falls project, the number of jobs generated by resettlement activities under the Local Area Development Plan is estimated to be comparable to the number of direct jobs. These activities promote benefit sharing through community-based development to diversify livelihoods and strengthen communities' organizational capacities. In Kosovo, the share of direct jobs was higher than in the other projects. As noted earlier, they included the design and construction of energy-efficient building retrofits, the installation and maintenance of solar-powered and energy-efficient appliances, and training in and audits of EE services.

TABLE 4.1

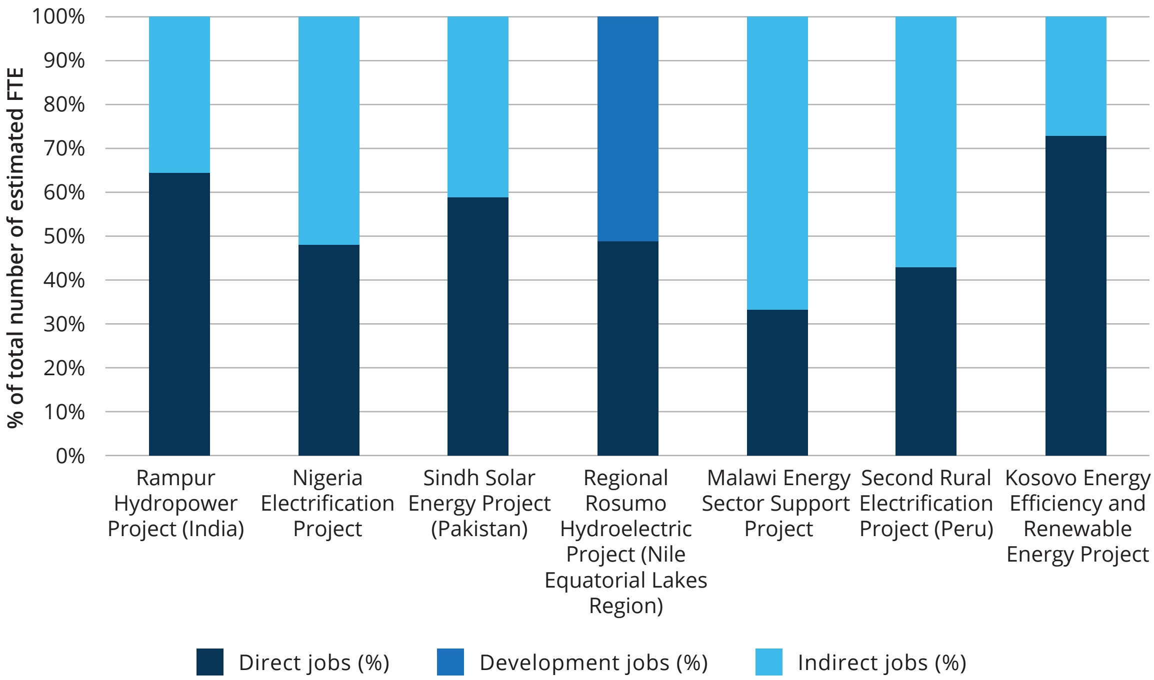
Total Job Creation Assessed in the Case Studies (Full-Time Equivalents)

PROJECT	DIRECT			INDIRECT	TOTAL
	DESIGN, MANAGEMENT, CONSTRUCTION	OPERATION AND MAINTENANCE	TOTAL DIRECT		
Rampur Hydropower Project (India)	18,131	15,084	33,215	18,530	51,745
Malawi Energy Sector Support Project	32,191	51,953	84,144	168,341	252,485
Kosovo Energy Efficiency and Renewable Energy Project	326	n.a.	326	122	448
Nigeria Electrification Project	40	151	191	206	397
Sindh Solar Energy Project (Pakistan)	817	1,137	1,954	1,368	3,322
Second Rural Electrification Project (Peru)	57	59	116	154	270
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	3,854 (construction and O&M) and 4,021 (LADP activities)	n.a.	3,854 (construction and O&M) and 4,021 (LADP activities)	n.a.	7,875

Note: LADP = Local Area Development Plan; O&M = operation and maintenance; n.a. = not available.

FIGURE 4.1

Share of Direct and Indirect Jobs in Case Study Projects



Note: FTE = full-time equivalent.

The case studies reveal the methodological challenges of conducting an *ex post* evaluation of employment impacts of clean energy projects in situations where such an assessment was not part of the project design. For most of the case studies, assessments even of direct jobs were difficult, as contractors and subcontractors were not always responsive nor had they maintained records of disaggregated employment data.[2] In India, for example, data were collected more than five years after the project's closing date, making it difficult for many respondents to provide precise job estimates. Many companies seemed unable or unwilling to share employment records. In addition, numerous levels of subcontracting made it difficult to get a full picture of large, relatively complex projects.

Table 4.2 indicates the job categories considered direct, indirect, and induced. Direct jobs can exceed the academic definition to include job categories that would otherwise fall under the induced or productive use categories—for example, jobs created by resettlement, rehabilitation, and community development (India); EE auditors (Kosovo); mini grid sales personnel (Nigeria); productive use jobs in nongovernmental organizations involved in project implementation (Peru); and jobs stemming from corporate social responsibility activities (such as those created through the Local Area Development Plan for the Rusumo Falls case study).

The table also provides specifications of indirect jobs in each case study. Suppliers of equipment and inputs are typically established entities that already employ staff; projects therefore rarely create new jobs. Using full-time equivalents captures the employment impacts of assigning labor to a specific time-bound task.

It proved difficult to identify similar projects and supply chains from the literature for the purpose of extracting representative ratios for estimating indirect jobs. Assessments of supply chains of sustainable energy technologies in developing countries are scarce. In addition, countries' industrial capacity and endowments of primary materials differ, affecting the mix of local versus foreign contributions. The ratios extracted from the literature were therefore adjusted to reflect the share of domestic content, given that for some projects a fraction of domestic inputs was available.

A broader and more systematic evaluation of direct and indirect employment impacts of sustainable energy investments would increase confidence in employment ratios. Surveys in additional geographic areas for particular industries would be of particular help. Data should be disaggregated by segment of the value chain, citizenship (domestic versus international), gender, ethnicity, age, and disability (World Bank 2022a).

Figure 4.2 summarizes the findings of the case studies on skills requirements in the direct jobs attributable to the projects studied. Based on the case studies, skilled and semiskilled workers represent most of the workforce for new power-generation projects (Nigeria, Pakistan, Rusumo Falls). For the Rusumo Falls Hydropower Project, only partial information was available, which biased the data toward skilled jobs. Semiskilled workers represent the largest job category for infrastructure upgrades supporting increased energy access through new and upgraded lines (Malawi, Peru). The Kosovo Energy Efficiency and Renewable Energy Project created a higher percentage of skilled jobs. The project aimed to deploy EE strategies and technologies tailored to each building characteristic. This demanded skilled jobs in management, architecture, and engineering, which required university-level training and relevant work experience.

TABLE 4.2

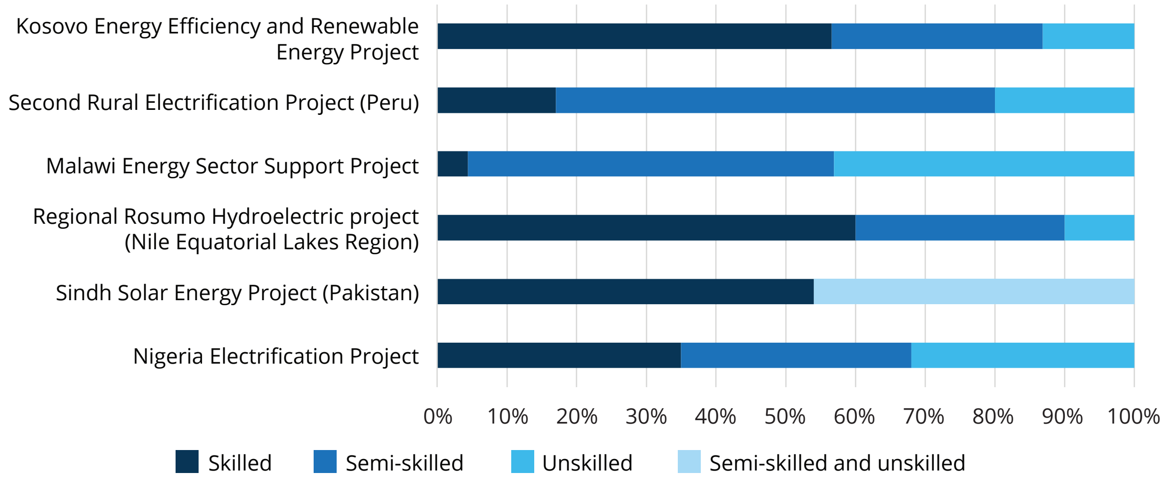
Definitions of Direct, Indirect, and Induced Jobs in Case Studies

PROJECT	TYPE OF JOBS		
	DIRECT	INDIRECT	INDUCED
Rampur Hydropower Project (India)	Design; management; construction; O&M; and resettlement, rehabilitation, and community development	Employees of construction and manufacturers of materials	Productive use jobs created by improvements in the quality of electricity for power consumers and their employees
Malawi Energy Sector Support Project	Design, management, construction, and O&M	Employees of firms producing wiring, substation equipment, and related industries	Productive use jobs created by improvements in the availability and quality of electricity for power consumers and their employees
Kosovo Energy Efficiency and Renewable Energy Project	Design, management, construction, O&M, sales, training, and audits of energy efficiency services	Employees of companies manufacturing key inputs (building materials, insulation, windows, doors, and lighting)	Replication jobs by increased demand for energy efficiency
Nigeria Electrification Project	Design, construction, management, sales, and O&M of mini grids	Employees of companies manufacturing solar power inputs (wiring, solar panels, batteries, inverters, and mounting structures)	Productive use jobs created among mini grid customers and their employees
Sindh Solar Energy Project (Pakistan)	Design, construction, management, and O&M	Employees of companies manufacturing solar power inputs (solar PV panels and inverters, wiring, cables, and aluminum and iron structures)	Replication jobs created by increased demand for rooftop solar projects
Second Rural Electrification Project (Peru)	Design, construction, management, O&M, and jobs created by electricity distribution companies and nongovernmental organizations employing workers to carry out project-related activities	Employees of firms producing wiring, construction materials, and related industries and material manufacturers	Productive use jobs created among users of grid electricity and their employees
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	Civil works, supply and installation of mechanical and electrical equipment, O&M, and social and environmental activities under the Local Area Development Plan	n.a.	n.a.

Note: O&M = operation and maintenance; n.a. = not available; PV = photovoltaics.

FIGURE 4.2

Shares of Skilled, Semiskilled, and Unskilled Direct Jobs in the Studied Projects



Note: The shares of skilled, semiskilled, and unskilled workers were not available for the Rampur Hydropower Project (India).

Analysis conducted for "Renewable Energy Jobs and Sector Skills Mapping in Pakistan" (World Bank 2022b) estimates that 75 percent of employment created by non-hydropower renewable energy between 2021 and 2030 will consist of jobs for semiskilled and unskilled workers. That assessment is consistent with the findings of this report.

4.3. Skills Requirements, Local Hiring Mandates, and Transferability of Skills

The requirements for a skilled position (possession of a degree plus experience) are similar across the case studies. The requirements for a semiskilled position can include either a degree or experience. These requirements vary across projects and locations (table 4.3). For skilled positions, employers did not require a qualification or degree specific to clean energy. Rather, employees were expected to have degrees from broader disciplines, such as engineering. This was likely due to a lack of such credentials in the labor market. Experience in the field was thus critical for such roles to gain the skills specific to energy efficiency and RE industries. For example, in the Nigeria Electrification Project, developers said they struggled to find skilled labor for mini grid projects in the northern regions of the country. Consequently, they either resorted to transferring employees from other sites or posted job openings that had lower qualifications and relied on on-the-job training to upskill these employees.

TABLE 4.3

Skills and Enabling Frameworks for Localization of Skilled Jobs Directly Created by the Energy Transition, by Project

PROJECT	SKILLED AND SEMISKILLED JOBS AS SHARES OF TOTAL JOBS (PERCENT)	APPLICABLE LOCALIZATION POLICY	HIRING CONDITIONS (LOCAL, IMPORTED, INTERNATIONAL, REGIONAL, URBAN CENTERS)
Rampur Hydropower Project (India)	n.a.	Seventy percent of employees were to be hired locally in Himachal Pradesh	Hired domestically
Malawi Energy Sector Support Project	Skilled: 4.4 percent Semiskilled: 52.5 percent Professional jobs required a diploma/degree (for example, in civil, mechanical, or electrical engineering for engineering positions) or certification from an accredited training institute. In certain cases, they also required registration with relevant professional associations. Skilled jobs (such as operators and technicians) required a technical license and some years of experience handling heavy-duty machinery.	No formal policy	Mix of domestic and international hires
Kosovo Energy Efficiency and Renewable Energy Project	Skilled: 56 percent Semiskilled: 30 percent Skilled jobs in management, architecture, and engineering required university-level training and relevant work experience. These workers were also given on-the-job training in conducting energy audits.	Initially the design/supervision company hired international experts for senior staff roles pursuant to project's terms of reference. Workers from Kosovo were later recruited for these roles owing to COVID-19.	Hired domestically (with the exception of international experts hired initially for senior staff roles)
Nigeria Electrification Project	Skilled: 35 percent Semiskilled: 33 percent The skilled category included management, engineering, and technical design.	No formal policy	Hired domestically (with the exception of two workers hired internationally by one developer)[a]
Sindh Solar Energy Project (Pakistan)	Skilled: 54 percent[b]	No formal policy	Hired domestically Reside in urban centers
Second Rural Electrification Project (Peru)	Skilled: 17 percent Semiskilled: 63 percent Requirements included experience in the electricity sector, marketing, supply-chain management, and related areas. Prior sector experience included skills in project development focusing on productive uses of electricity and operations management, budget development, and commercialization of electric energy in rural areas.	No formal policy	Hired domestically (typically from Lima or other large cities)
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	Skilled: 50–70 percent Semiskilled: 20–40 percent Skill levels 3 and 4 (high): managers, professionals, technicians, and associate professionals. Skill level 2 (medium): clerical support workers; service and sales workers; skilled agricultural, forestry, and fishery workers; craft and related trades workers; plant and machine operators; assemblers. For local stakeholders (about 18 percent of the workforce), the shares of highly skilled and medium-skilled professionals were high (at 50–70 percent and 20–40 percent, respectively). The share of unskilled employees was lower (10–15 percent). For international contractors, numbers for semiskilled staff were not disclosed.	n.a.	Mostly local, higher share of expatriates with the owner's engineer, which represents approximately 5 percent of the workforce Hires from Rwanda, Tanzania, and Burundi

Note: n.a. = not available.

[a] The firms reported that skilled labor was difficult to find for projects in northern Nigeria. So they transferred permanent employees from other project sites. In addition, job postings for projects in northern Nigeria tended to have lower qualifications. Finding unskilled workers posed no challenges.
[b] Semiskilled workers were reported for this project with unskilled category (i.e., in the table that follows).

Employers reported in the case studies that they competed for skilled workers on the larger job market through traditional channels. Competition with other industries posed a challenge in some instances. For example, in the Sindh Solar Energy Project in Pakistan, solar contractors reported that they often preferred to hire young graduates directly from university programs because their salary expectations were lower. Accordingly, many reported providing on-the-job training to these employees, for example, on health, safety, and environment standards or in the use of specialized engineering software.

Specific clean energy skills were also not a prerequisite for semiskilled and unskilled workers in the projects studied. Again, this was likely because such specific skills were not available within the local labor pool. In several cases, employers resorted to on-the-job training to upskill such workers. This approach is counterintuitive, as project delays and constraints would call for a rapid onboarding of workers; however, it allowed the companies to train workers to their own standards and with their preferred equipment and technologies. For local communities, it had the advantage of permitting local recruitment for less-skilled positions.

For instance, in the Rampur Hydro Project in India, a program was established to provide technical education to local youth. Selected students were provided with scholarships and monthly stipends to undergo vocational training at industrial training institutes. This was enhanced with an apprenticeship scheme, where technically qualified youth from project-affected areas were then given the opportunity to work for one year on the Rampur Hydro project and gain relevant skills and experience. About 30 people were trained per year, with 195 trainees in total, and approximately 55 percent obtained employment with contractors afterwards. This strategy helped address a skills gap and bolster local support for the project.

The creation of direct local jobs is a major point of interest for communities affected by a project, as well as for governments supporting the energy transition; it is recognized as a significant factor enhancing acceptance of projects by affected populations. From the case studies it is clear that the decision to hire locally was driven not only by localization policies but also by the need to engage local communities in projects, mitigate turnover, and secure a sometimes large number of workers on site for the duration of a project.

Even in the absence of explicit localization policies, most semiskilled and unskilled workers in the projects studied were recruited locally, on temporary or piece-rate contracts, as indicated in tables 4.3 and 4.4. Not surprisingly, skilled positions were filled by workers mobilized from larger geographic areas (typically urban areas) than those used for unskilled jobs.

In the sample of projects addressed by the case studies, only two reported explicit localization policies:

- In India, the State of Himachal Pradesh set a threshold of 70 percent of employees to be hired from within the state.
- In Pakistan, skilled workers required a degree from an institution registered with the Pakistan Engineering Council or accredited by the provincial Technical Education and Vocational Training Authority.

TABLE 4.4

Skills and Enabling Frameworks for Localization of Unskilled Jobs Directly Created by the Energy Transition, by Project

	JOB TYPE/CATEGORIES[a]	UNSKILLED JOBS AS SHARE OF TOTAL JOBS	APPLICABLE LOCALIZATION POLICY	HIRING CONDITIONS (LOCAL, IMPORTED, INTERNATIONAL, REGIONAL, URBAN CENTERS)
Rampur Hydropower Project (India)	Unskilled (no formal education requirements)	Not available as respondents did not provide specific estimates	Seventy percent of employees to be hired locally in Himachal Pradesh	Local workers (from the vicinity of the project site) preferred; relatively more labor-intensive jobs held by migrant workers (domestic migrants from other states of India as well as unskilled laborers from Nepal)
Malawi Energy Sector Support Project	Unskilled (no technical training or certification requirements)	43.1 percent	No formal localization policy	Hired domestically
Kosovo Energy Efficiency and Renewable Energy Project	Unskilled (no formal education requirements; relevant work experience preferred)	13 percent	No formal localization policy; priority given to those living in proximity to project sites	Hired locally (close to project sites)
Nigeria Electrification Project	Unskilled (no formal education requirements; technical certificate advantageous)[b]	32 percent	No formal localization policy; workforce drafted from project host communities	Hired locally (from project host communities)
Sindh Solar Energy Project (Pakistan)	Unskilled (no formal education requirements; experience preferred)	Semiskilled and unskilled: 46 percent	Preference for hiring workers living near project sites as locals were reportedly better accustomed to the weather and spoke the local language	Hired locally (from Sindh Province) when possible; hired from neighboring regions in case of shortage
Second Rural Electrification Project (Peru)	n.a.	20 percent		
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	Skill level 1 (low): Elementary occupations	10–15 percent (data available for estimated 18 percent of the workforce of the project)	n.a.	n.a.

Note: n.a. = not available.

[a] Construction workers, drivers, storekeepers, workers, assistants, security guards, and site cleaners.
[b] Including local sales agents.

Job localization policies have benefits and drawbacks. On the one hand, they increase the share of project-generated wealth captured by the local economy; on the other, they can set barriers to deployment and generate delays due to staff shortages when specific qualifications are required but not available in time, in sufficient quantity, or at competitive cost. Job localization policies can also be a barrier to the movement of workers to nonlocal assignments, thereby limiting their employment options.

Laws that require companies to hire from within a defined area are common across Indian states. As a result, firms cannot easily move their workforces to other projects. The case study of the Rampur hydropower project in India notes that local people from around project sites objected to outside competition. After the project's closure, employees who were not offered continued employment were formally laid off and given a settlement package. This agreement was negotiated by the Center of Indian Trade Unions.[3]

For new power generation projects, skilled workers were often sourced internally within companies or from larger cities in the country (India), or recruited regionally (Nigeria, Pakistan). Skilled profiles were said to be transferable from one project to another (India, Nigeria). Unskilled (and semiskilled) workers were recruited from local communities in India, Nigeria, and Pakistan. Because the project in Rusumo Falls crossed borders, unskilled workers were recruited on a larger geographic scale, though primarily within the national boundaries of the participating countries, with a minor share of expatriates.

For grid infrastructure upgrades supporting increased energy access through new and upgraded lines (Malawi, Peru), both skilled and unskilled workers were hired domestically. Similarly, workers renovating buildings to improve energy efficiency (Kosovo) were hired domestically, with priority given to those living near the construction site. In the project's first phase, international experts were hired for senior staff roles by the design/supervision company as required by the terms of reference. In the second phase, the company hired senior experts from Kosovo owing to limitations stemming from COVID-19, without any demonstrable adverse effects on project implementation.

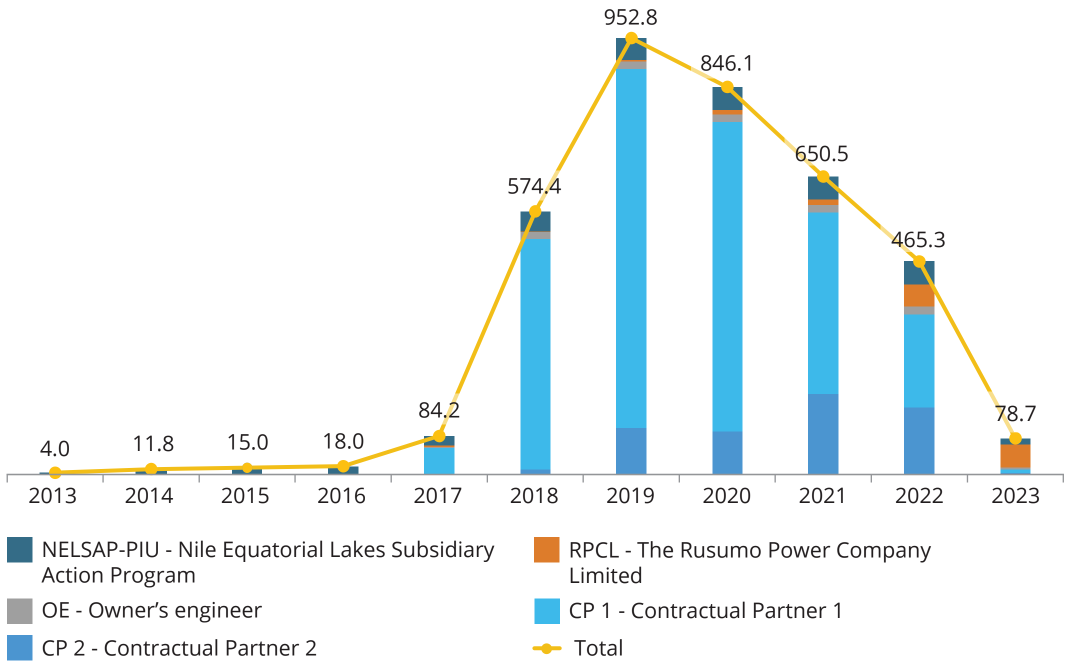
Infrastructure projects generate many temporary jobs during construction, but relatively few positions remain in the longer term for operation and maintenance, an effect exacerbated by the digitalization of technologies. Thus, just because a project generates a large number of jobs does not mean these jobs will endure over time.

The hiring patterns of the Rusumo Falls Hydropower Project (figure 4.3) are typical of a construction project. After a first phase of dimensioning and specifications (2013–17), the project hired many workers (2017–22), followed by a low-intensity O&M phase (World Bank 2023c).

A solution to the intermittency of employment is to ensure that skills are transferable across projects within a company, or within a geographic entity (regionally, nationally). It then becomes possible to reassign workers to other projects with similar needs, provided a stable pipeline of projects. But the case studies show that skills transfer is not equitable across worker categories; job insecurity is prevalent among the least-skilled employees. Skilled workers tend to enjoy formal, long-term contracts whether they are permanent employees or independent contractors. Unskilled workers, by contrast, tend to be hired under short-term, piece-rate contracts (tables 4.5 and 4.6).

FIGURE 4.3

Total Direct Employees (Full-Time Equivalent) Per Organization Involved in the Rusumo Project



Source: World Bank 2023c.

TABLE 4.5

Transferability of the Workforce, Direct Skilled Jobs

	CONTRACT TYPE	TRANSFERABILITY
Rampur Hydropower Project (India)	Long-term contract (including permanent employees)	Typically, permanent employees of the builder/contractor with skills that were transferable from one project to another
Malawi Energy Sector Support Project	n.a.	n.a.
Kosovo Energy Efficiency and Renewable Energy Project	Long-term contract	Workers would be transferrable due to experience gained, which would be applicable to new investments in energy efficiency projects.
Nigeria Electrification Project	Permanent employees	Transferred from other project sites to the northern regions. Formal employees are transferable.
Sindh Solar Energy Project (Pakistan)	Formal contracts, duration n.a.	Worker's skills are transferable from one project to another, as evidenced by large share of jobs sustained by existing workers (i.e., employees already working with contractors before the project)
Second Rural Electrification Project (Peru)	Most workers hired as independent contractors (with project period explicitly stipulated) with the exception of workers at electricity distribution company in Moquegua and Tacna and the NGO in Ayacucho, which offered "dependent" (long-term) contracts	Skills associated with project transferable from one project to another, as evidenced by use of existing skilled employees by distribution companies for project-specific tasks
Regional Rusumo Hydroelectric project (Nile Equatorial Lakes Region)	n.a.	The expatriates will return to their home countries, the locals will have to look for new employment opportunities. However, the skills that were acquired such as welding techniques, will increase their chances to find a good job. The technical skills will be easily transferable to other construction sites, not necessarily hydro.

TABLE 4.6

Transferability of the Workforce, Direct Unskilled Jobs

	CONTRACT TYPE	TRANSFERABILITY
Rampur Hydropower Project (India)	"Piece rate" contracts	Local recruitment requirements (whereby a certain share of workers must be recruited from the state in which the project is located) can be a barrier to transferability of unskilled workers.[a]
Malawi Energy Sector Support Project	n.a.	n.a.
Kosovo Energy Efficiency and Renewable Energy Project	Short term	Increase in experience related to energy efficiency (e.g., using thermodynamic valves and heat pumps, working on large-scale retrofit projects) gained by unskilled workers made them better qualified for potential work in related projects (such as those financed by the Millennium Challenge Corporation)
Nigeria Electrification Project	Short term	Skills and experience gained through on-the-job training and from working on project-related tasks (such as installing mini grid components) transferable to other related assignments
Sindh Solar Energy Project (Pakistan)	Short term daily-wage labor	Skills and experience gained through on-the-job training and from working on project-related tasks (such as installing mini grid components) transferable to other related assignments Cultural and language barriers across provinces limit transferability potential
Second Rural Electrification Project (Peru)	"Piece rate" contracts	n.a.
Regional Rusumo Hydroelectric project (Nile Equatorial Lakes Region)	n.a.	n.a.

[a] Given that many states have laws that require companies to hire a minimum share of employees (sometimes as high as 70 percent) from within the state, the firms were not able to move their entire workforce from one project to another. Many unskilled workers, such as security guards, cleaners, janitors, and low-skilled construction workers, had difficulty finding employment after the project ended. All of these workers were contractual employees whose employment was linked to project construction that terminated with the project. Unlike others who received training or education, these workers were not especially well prepared for further opportunities. Many reportedly returned to farming or were "sitting idle in their villages," suggesting that employment opportunities in the local area were limited.

Skilled workers can typically be reassigned to other projects elsewhere, assuming they are mobile and available to move across the country. Typically, skilled workers' contracts in the clean energy industry would require a level of flexibility in their work locations.

By contrast, most unskilled workers (the majority of them recruited locally) would typically not be reassigned to other sustainable energy projects, in part because companies do not want to bear the costs of their relocation, which tend to be higher than the costs of training new workers. Despite the experience gained, therefore, their future employability relies on the availability of projects nearby.

In summary, questions of job durability and workforce transferability have a social impact and should be carefully considered when designing long-term action plans supporting the energy transition. Thus, the capacity of authorities to organize project pipelines (for example, as a series of auctions over time and per region), as well as organizing skills development to support project deployment, is important for facilitating the transition of workers between projects and sites. Potential approaches to skills development are summarized in box 4.3.

BOX 4.3

PREPARING SKILLED LABOR FOR THE CLEAN ENERGY TRANSITION

Ensuring the availability of skilled labor for the clean energy sector is vital not only for successful and rapid deployment but also for maximizing the socioeconomic value that clean energy investment brings to the economy. Professions needed for successful clean energy deployment are varied and they are summarized for renewable energy in figure B.4.3.1.

Given the boom in clean energy deployment globally, even high-income countries with mature technical education sectors are experiencing skills shortages in specific clean energy sectors. The shortage can be even more acute in developing nations with few higher-education graduates and an often insufficient or outdated skills-development infrastructure. Absence of focus on gender equality in employment further exacerbates the shortage since the labor force participation of half the population is effectively ignored.

Successful job creation in the clean energy sector hinges not only on the private sector, but also on government initiatives that provide relevant education and training, attract new graduates, and enable labor to move into clean energy-related jobs. To tackle skills gaps comprehensively, countries need to develop a strategy encompassing education, training, and reskilling programs. Multiple pathways for skills delivery—including technical and vocational education and training (TVET), apprenticeships, and higher education—should be considered and prioritized based on each country's unique circumstances.

Country level assessments of skills and professions needed for a successful energy transition have been conducted, for example, for Pakistan (World Bank 2022b) and Tunisia (World Bank 2023p).

Potential solutions to boost awareness of career opportunities in clean energy, enhance education and training quality, and expand access to skill development include:

Communicating career opportunities: Information campaigns and targeted outreach programs can raise awareness of clean energy job prospects and required qualifications. Internship and mentorship programs, including those focusing on women and disadvantaged groups, facilitate entry into clean energy careers. Collaboration between energy ministries and labor and skills development ministries can promote career awareness in clean energy fields, including prospects for reskilling workers from declining fossil fuel industries.

(*continues*)

BOX 4.3 (*Continued*)

FIGURE B.4.3.1

Professions Needed in a Typical Value Chain for a Renewable Energy Project

RE value chain	Critical public sector jobs	Critical private sector jobs
Renewable energy legislation and planning	• Policy makers • Energy sector planners • Energy modelers • Energy regulation experts • Environmental, social, and gender experts • Legal experts	• Energy modelers • Environmental, social, and gender experts • Policy experts • Legal experts
Enabling infrastructure investments	• Public procurement experts • Power system technical experts • Environmental, social, and gender experts • Public finance experts	• Power system technical experts • Investment and finance experts • Environmental, social, and gender experts • Legal experts
Feasibility, financing, and project tendering	• Renewable energy technical experts • Public procurement experts • Legal experts • Public finances experts • Environmental, social, and gender experts • M&E experts	• Financial advisors • Transaction advisors • Renewable energy technical experts • Environmental, social, and gender experts • Legal experts • M&E experts
Project design and procurement of inputs	• Renewable energy technical experts • Legal and taxation experts • Environment, social, and gender experts	• Renewable energy technical experts • Logistics experts • Environmental, social, and gender experts
Construction, transport, assembly, and commissioning	• Renewable energy technical experts • M&E experts • Environmental, social, and gender experts • Health and safety experts • Compliance experts	• Renewable energy technical experts • Environmental, social, and gender experts • Construction workers • Electricians, Mechanics • Quality control and M&E experts • Community engagement experts
Operation and maintenance	• Renewable energy technical experts • M&E experts • Environmental, social, and gender experts • Health and safety experts • Compliance experts	• Renewable energy technical experts • Environmental, social, and gender experts • Operators, Technicians, Electricians • Health and safety experts • M&E experts • Security
Decommissioning and recycling	• Renewable energy technical experts • Regulatory experts • Environmental, social, and gender experts • Health and safety experts • Compliance experts	• Technical experts • Civil engineers • Environmental, social, and gender experts • Health and safety experts • Laborers

(*continues*)

BOX 4.3 (*Continued*)

Designing education to meet clean energy industry needs: Developing national standards specific to clean energy job profiles ensures that workers possess the necessary competencies. Recognizing international standards or collaborating with the private sector to establish accreditation schemes can also enhance skills development.

Expanding access to education and training: Higher education and TVET institutes require support to upgrade programs and facilities and maintain them in line with rapid technological development. This may involve financial aid, staff development initiatives, and technical assistance. Geographic diversity in program locations should be considered, aligning with clean energy project sites. Encouraging participation by women and disadvantaged groups, providing scholarships, and exploring mobile and online training options can also improve access.

Regional collaboration: Governments can look to neighboring countries with established programs in clean energy for regional collaboration to meet their skills development needs. Governments of small countries or countries with small clean energy markets may consider joining forces when creating education and upskilling programs.

Addressing skills shortages in the clean energy sector is essential for its growth and success. Governments must take proactive measures to develop a skilled workforce that aligns with the industry's demands.

Source: World Bank 2022a , World Bank 2022b, and World Bank 2023p.

4.4. Attractiveness of Sustainable Energy Jobs

The quality of jobs (remuneration and working conditions) should be sufficiently attractive to retain workers throughout project implementation and beyond to secure expertise during the O&M phase.

In countries with regulated working environments (minimum wages, social security schemes), such as Kosovo and Peru, wage levels and conditions in the projects under study complied with the legislation and were at parity with the job market for similar skills.

In less-regulated markets, the case studies' results differ for skill levels. Skilled personnel are scarcer than unskilled personnel and tend to be transferred from other locations or hired from within a wider geographic area (i.e., from the same country, or neighboring countries). They are also the most reemployable and, for the projects under study, were hired primarily through long-term or permanent contracts. After their tasks are completed, such personnel may be reassigned to other projects elsewhere (as stipulated in their contracts). Skilled workers tend to receive benefits over and above their salaries, such as sick leave, earned leave, severance compensation, provident funds, maternity leave, and bonuses (India); transportation allowances, paid leave, housing, communication allowances, health insurance, and pension benefits (Nigeria); and health insurance and transportation allowances (Pakistan) (table 4.7).

Compensation is limited for semiskilled or unskilled personnel, who are typically hired on a short-term or piece-rate basis and often lack the benefits extended to skilled employees. The reliance on temporary contracts for semiskilled and unskilled personnel appears to coincide with their limited transferability.

Contract flexibility, however, cuts both ways since it requires the project contractors to compete with other occupations or industries for workers—an important consideration since low-skilled and unskilled employees can represent up to two-thirds of the total project workforce. For semiskilled and unskilled positions where on-the-job training was provided, high turnover could create additional onboarding costs and delays in implementation. The projects therefore sought to attract and retain temporary workers through more attractive compensation packages than the local market offered. These packages combined higher-than-average wages and additional benefits (table 4.7).

TABLE 4.7

Salaries, Wages, and Working Conditions in the Projects Under Study

	IS THE JOB MARKET REGULATED (MINIMUM WAGES, SOCIAL SCHEMES)?	INFORMAL VERSUS FORMAL WORK	ARE WAGES HIGHER THAN MARKET AVERAGE?
Rampur Hydropower Project (India)	Yes. Minimum wages were paid based on skill level.	Skilled: Formal contract workers Semiskilled/unskilled: Blended (formal contract or piece-rate)	Yes. A negotiated minimum wage increase (project allowance), hydro and tunnelling allowance, and paid overtime resulted in wages higher than the national average for unskilled laborers engaged in public works.
Malawi Energy Sector Support Project	n.a.	Countrywide, informal employment is larger than the formal private and public sectors combined.	n.a.
Kosovo Energy Efficiency and Renewable Energy Project	Yes. Benefits are required by law (including annual leave and sick leave).	Formal	Wages increased in response to labor shortages, resulting in parity with similar jobs in different sectors of the economy.
Nigeria Electrification Project	Yes. A statutory minimum wage applies.	Skilled: Formal Semiskilled: Blended (formal and informal) Unskilled: Informal	Some mini grid developers reported paying more than the average market wage for both formal and informal workers.

TABLE 4.7

Salaries, Wages, and Working Conditions in the Projects Under Study (*Continued*)

	IS THE JOB MARKET REGULATED (MINIMUM WAGES, SOCIAL SCHEMES)?	INFORMAL VERSUS FORMAL WORK	ARE WAGES HIGHER THAN MARKET AVERAGE?
Sindh Solar Energy Project (Pakistan)	n.a.	Skilled: Formal Semiskilled: Blended (formal and informal) Unskilled: Informal	n.a.
Second Rural Electrification Project (Peru)	Yes. Benefits are required by law.	Formal	Comparable to market wage
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	n.a.	Not reviewed for the project, but informal employment accounts for 90.8 percent of total employment in Tanzania, 98.3 percent in Burundi, and 80.1 percent in Rwanda (based on International Labour Organization data).	n.a.
	ADDITIONAL BENEFITS BEYOND WAGES	**CONSIDERATIONS FOR HARDSHIP**	**STAFF RETENTION POLICY**
Rampur Hydropower Project (India)	Skilled workers: Sick leave, earned leave, severance compensation, provident fund, maternity leave, gratuity, and bonuses. Semiskilled and unskilled workers: Paid overtime, uniform expenses, and access to project facilities	None	Skilled workers were hired in “permanent” roles; selected semiskilled workers were retained based on job performance.
Malawi Energy Sector Support Project	n.a.	n.a.	n.a.
Kosovo Energy Efficiency and Renewable Energy Project	Semiskilled and unskilled workers: One meal per day, transportation	Additional health and safety measures (such as treatment protocols pertaining to hazardous materials, including asbestos and fluorescent lamps)	Highly skilled workers (such as architects and engineers) were offered long-term contracts.
Nigeria Electrification Project	Skilled/formal workers: Transportation allowance, paid leave, housing, communication allowance, health insurance, and pension benefits Unskilled/informal workers: Food, “flexible work hours”	Additional safety measures, including provision of personal protective equipment, and safety standards for working environment	Formal employees (for example, engineers, compliance and accounts officers) were in permanent jobs; selected semiskilled workers were kept on in operation and maintenance roles after completion of construction.
Sindh Solar Energy Project (Pakistan)	Skilled/formal: Health insurance and transportation allowances Unskilled/informal: Limited insurance benefits (for example, emergency/accident insurance) reported by some companies Food and accommodation provided to all field employees	Flexible and adjustable working hours (for example, night shifts) to account for hazardous working conditions (for example, hot daytime temperatures)	One contractor reported that workers who had received on-the-job training to install inverters were retained after the project was completed.
Second Rural Electrification Project (Peru)	Equipment requirements (for example, vehicle, meals) met when in field.	None	None
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	n.a.	n.a.	None

Note: n.a. = not available.

4.5. Gender Balance

In the projects under study, no specific measures were undertaken to address gender imbalance. The findings presented in this chapter can therefore be seen as a baseline that could be improved through targeted requirements.

Although these assessments pertain to each project and the regulatory frameworks of the project countries, some general lessons can be drawn from the project sample. For all projects studied, women represented only a minor share of direct employment. Women comprised no more than 15 percent of workers in the Nigeria Electrification Project; women were 14 percent of the workforce in the Rusumo Hydroelectric Project—figures well below those for women working in the RE sector (32 percent) globally (IRENA 2022c).

The case studies show no clear trend in the types of jobs held by women across the projects studied. However, the projects show significant potential for women's employment to rise in different occupational niches (table 4.8). Of women in direct jobs, the majority were employed in unskilled positions in Malawi, semiskilled jobs in Nigeria, and in specific skilled positions in Kosovo. Women also account for about a quarter of all direct jobs in the local development schemes supported by the Rusumo Falls project.

TABLE 4.8

Gender Aspects of Jobs Created by the Projects Under Study

PROJECT	SPECIFIC MEASURES TO ENCOURAGE GENDER BALANCE	SHARE OF WOMEN IN DIRECT JOBS	GENDER RATIOS FOR INDIRECT JOBS	SHARE OF WOMEN		
				IN SKILLED DIRECT JOBS	IN SEMI-SKILLED DIRECT JOBS	IN DIRECT UNSKILLED JOBS
Rampur Hydropower Project (India)	No formal measures promoted women's employment; certain unskilled jobs (for example, cleaning, sweeping, housekeeping, gardening) were informally reserved for women, with priority given to women from project-affected areas.	Women primarily recruited for unskilled positions were locally hired. Working hours accommodated responsibilities at home. Some women's activities were carried out through resettlement and community development measures related to land-acquisition (World Bank 2015).	Women were found in some skilled administrative positions and nursing.	n.a.	n.a.	n.a.
Malawi Energy Sector Support Project	No formal gender-balance policy was in effect.	7 percent	n.a.	7 percent	0	15 percent
Kosovo Energy Efficiency and Renewable Energy Project	No formal gender balance policy was in effect.	9 percent	n.a.	16.7 percent	0 percent	0 percent

TABLE 4.8

Gender Aspects of Jobs Created by the Projects Under Study (*Continued*)

PROJECT	SPECIFIC MEASURES TO ENCOURAGE GENDER BALANCE	SHARE OF WOMEN IN DIRECT JOBS	GENDER RATIOS FOR INDIRECT JOBS	SHARE OF WOMEN		
				IN SKILLED DIRECT JOBS	IN SEMI-SKILLED DIRECT JOBS	IN DIRECT UNSKILLED JOBS
Nigeria Electrification Project	No formal gender balance policy was in effect. One developer reported encouraging female employment as long as it did not disrupt the religious and social order of project host communities.	15 percent	n.a.	6 percent	30 percent	7 percent
Sindh Solar Energy Project (Pakistan)	No formal gender balance policy was in effect.	<1 percent	n.a.	< 1 percent	0	0
Second Rural Electrification Project (Peru)	No formal gender balance policy was in effect.	6 percent	n.a.	0	10 percent	0
Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region)	None	Construction related: 14 percent Activities related to Local Area Development Plan: 23 percent		n.a.	n.a.	n.a.

Note: n.a. = not available.

Very few women work in semiskilled positions. Unlike unskilled positions for women, such as cooking and cleaning, these are technical jobs. Ideas about appropriate gender roles, concerns about safety and security (IRENA 2019), and logistical factors (for example, the need to pay for separate accommodation) limit the number of women hired into these positions. In general, developers reported that they encouraged the hiring of women as long as the practice did not disrupt the religious and social order of the host communities. That said, no developer reported any special policies or practices to promote the hiring of women or to enable their integration on site.

There is increasing evidence on the barriers and constraints women face in the energy sector; opportunities to address gender gaps, drawing from recent work, are summarized in box 4.4. Addressing the gender gap requires improving the awareness of gender imbalances by private companies and generating commitments and developing strategies to tackle them. Toolkits and capacity-building programs are available to support the momentum necessary to increase women's employment and secure genuine support for gender equality (ESMAP 2022b, 2022c).

BOX 4.4

GETTING TO GENDER EQUALITY IN THE ENERGY SECTOR

Based on World Bank research and on-the-ground experience from diverse projects, the recommendations on policy and programmatic actions that can be taken to enhance women's participation and empowerment in clean energy interventions are:

- **Start with education and implement actions to remove constraints on the numbers of women who pursue STEM degrees:** The underrepresentation of women in STEM programs is seen as a significant barrier to achieving equality in the energy sector. This lack of women with STEM degrees makes it challenging for utilities and companies to recruit more women. To address this issue, it is important to create an environment, in both the education system and the labor market, that welcomes and normalizes women studying STEM subjects. To increase the number of qualified women entering the sector, efforts should be made to encourage women and girls to study STEM subjects, by ensuring their access to information, raising awareness of their potential in the sector, creating inclusive teaching environments, and hiring female STEM teachers.
- **Identify gender gaps in the workplace and enact policies to close them**: To address gender inequality in the energy sector, the first step is for stakeholders such as governments, academia, utilities, companies, and civil society to acknowledge its existence. The second step involves research to understand the extent and nature of the inequality. The third step is to undertake gender mainstreaming and gender-specific actions, which involve systematically assessing and integrating gender considerations into corporate decisions and processes. This includes assessing how an organization's operations impact women and men differently and implementing inclusive workplace policies. By doing so, it is possible to significantly improve women's employment opportunities and experiences in the sector.

(*continues*)

BOX 4.4 (*Continued*)

- **Raise awareness to promote clean energy sectors (e.g., hydropower, utility scale solar, rooftop solar, energy efficiency, etc.) as appealing career options for women:** These sectors have a significant opportunity in the 2020s to drive the energy transition and change the traditional, male-dominated image of the energy sector. By showcasing stories of women working in clean energy and encouraging them to share their experiences, enthusiasm, and pride, the energy sector can become a leader in gender equality. Various actors, including the industry itself, can play a role in promoting the energy sector as an attractive career option for women.
- **Provide mentoring for women, as well as role models, networking, and leadership opportunities:** Mentoring is an effective way to promote professional development for women in the energy sector. With mentoring, women build skills, expand networks, find role models, and achieve career success. Sector decision-makers should ensure that women are leading the change toward gender equality and diversity. Professional women already working in the sector can identify gaps, design solutions, and educate others (both men and women) about the importance of equity and equality. Energy companies, utilities, and STEM programs can benefit from the potential within their workforce by creating opportunities for women to guide the change and inspire more women to join the sector.
- **Include more men in the gender-inequality discussion and encourage them to be proactive in reducing gender gaps**: Men must act as allies and be part of the solution to achieve gender equality. Their recognition of gender biases, efforts to address them, and leadership in promoting equality can have a significant impact. As mentioned, it is crucial for the industry and stakeholders to acknowledge the existence of gender gaps, gather data, implement concrete measures, evaluate their effectiveness, and share evidence of successful strategies.

In addition, it will be important to consider context and address the cultural barriers women might face.

Source: World Bank 2023o.

4.6. Clean Energy Jobs: A Profile Based on Case Studies

The case studies examined World Bank–supported projects in seven countries that ranged across technologies and designs. They included generation (India, Nigeria, Pakistan, and Rusumo Falls); grid infrastructure investment to widen energy access through new and upgraded lines (Malawi, Peru); and rehabilitation of buildings to improve energy efficiency (Kosovo). Such studies, based on individual project data, are rare. Despite the small number of projects, the cases capture the typologies of the most common energy infrastructure projects supported by the World Bank and may therefore be considered representative of different types of sustainable energy interventions.

The case studies reveal insufficiencies in the accounting methodologies for sustainable energy jobs, such as rigid definitions of direct jobs that do not accurately capture their diversity, and inconsistent definitions of direct and indirect jobs.

Consistent with the literature, the case studies reveal that two-thirds of the jobs in energy infrastructure projects are semiskilled and unskilled. EE projects involve a larger share of skilled jobs (half of all jobs) than other types of projects.

Semiskilled and unskilled workers could acquire skills on the job for the purpose of a project, and most of these positions were filled locally. None of the case studies reported acute skills gaps.

The decision to hire locally was driven not only by policy but also by the need to engage local communities and foster their acceptance of project interventions. From the implementation perspective, local anchoring mitigates risk by limiting turnover and keeping a share (sometimes a large share) of workers on site for the duration of the project.

Semiskilled and unskilled positions are hired on a short-term, project, or piece-rate basis. The reliance on temporary contracts for semiskilled and unskilled personnel appears to reflect their low rate of transferability to other projects. That said, the projects studied sought to attract and retain temporary workers through more attractive remuneration packages than those offered in the local market.

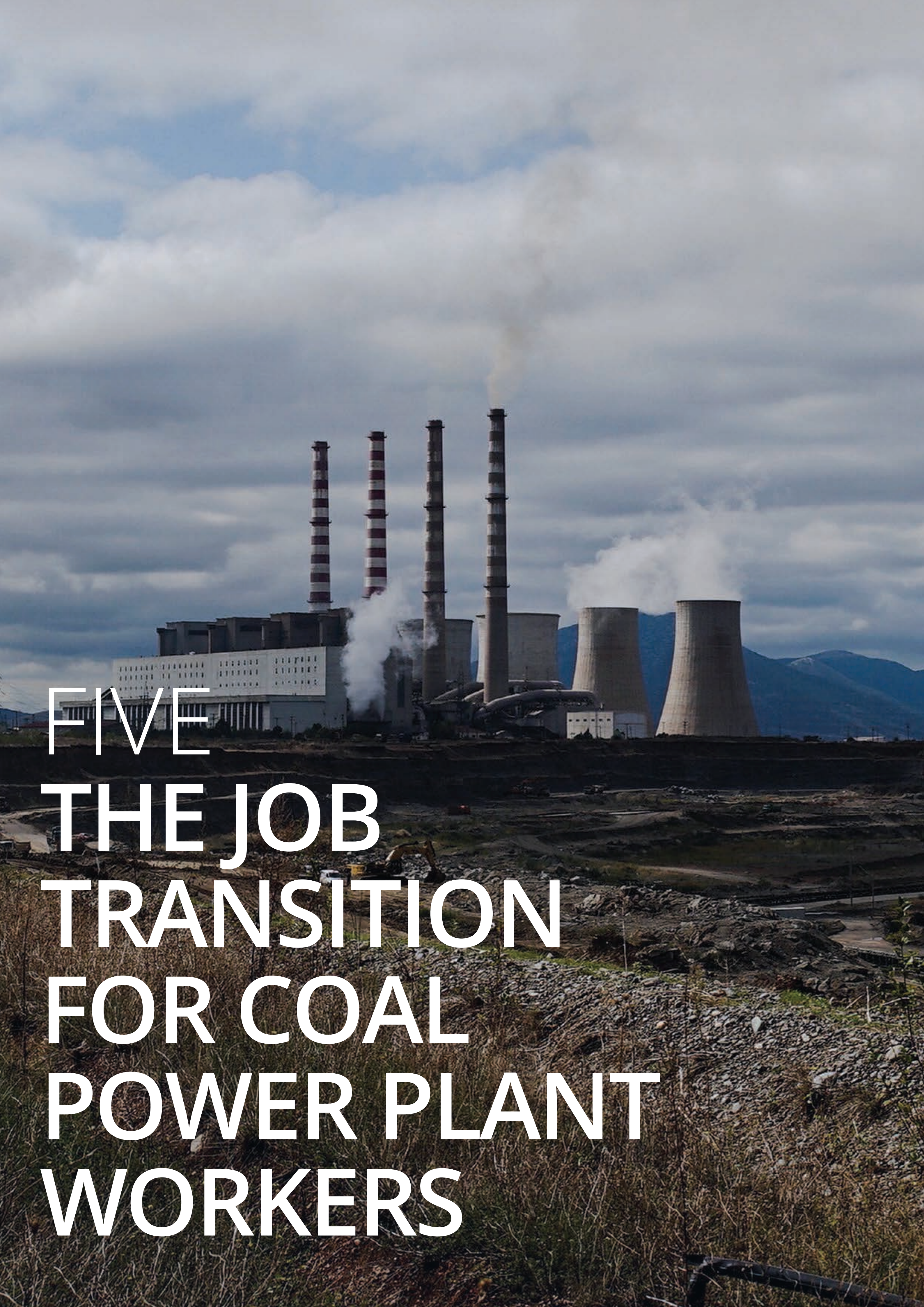
While unskilled workers tend to be recruited locally, skilled personnel are scarcer and tend to be transferred in from other locations where the contractor is working or hired from farther away. These workers tend to be hired on long-term contracts, as contractors are evidently intent on employing them on other projects. Skilled workers tend to receive the most employment benefits.

In the projects under study, the gender balance starts from a low baseline. The challenges to hiring more women, highlighted by the case studies, are consistent with the literature (IRENA 2019) that shows women barely represented in semiskilled positions owing to perceived gender roles and concerns about safety and security. Improving the gender balance will require dedicated efforts.

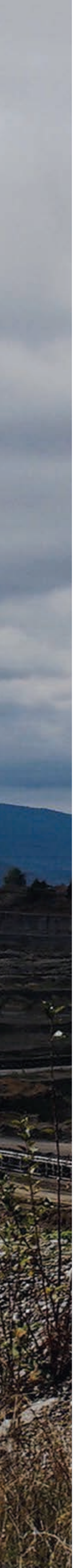
Overall, the case studies show the appeal of sustainable energy jobs, as salaries, wages, and working conditions are crafted to attract and retain workers. Companies offer competitive remuneration packages that combine higher-than-average wages with benefits. This is especially true for semiskilled and unskilled positions that offer on-the-job training. Because infrastructure projects briefly mobilize a large, local, temporary workforce, the boost to local economies promises to be similarly brief. It could collapse when the construction phase of the project ends. These features of sustainable energy jobs remain a topic for future research.

Endnotes

1. The share of total project costs dedicated to construction is an indicative assessment estimated by dividing the total World Bank funds allocated for components that appear to be focused on construction by total World Bank funds for the project, including funds for components of the projects not covered by the case study. The shares were as follows: Malawi Energy Sector Support Project, 69 percent; Kosovo Energy Efficiency and Renewable Energy Project, 88 percent; Nigeria Electrification Project, 64 percent; Sindh Solar Energy Project (Pakistan), 95 percent; Second Rural Electrification Project (Peru), 97 percent; Rampur Hydropower Project (India), 99 percent; Regional Rusumo Hydroelectric Project (Nile Equatorial Lakes Region), 83 percent.
2. Specifying the coverage of an assessment is rarely straightforward. From a value-chain perspective, direct jobs center on the installation, operation, and maintenance of clean energy projects. From a project perspective, direct jobs encompass activities financed by the project—direct personnel costs (World Bank 2023a).
3. Many unskilled workers, such as security guards, cleaners, janitors, and low-skilled construction workers, had difficulty finding employment after the project ended. All of these workers were contractual employees with employment linked to project construction, which terminated after the project ended. Unlike others who received training or education, these workers were not especially well prepared for further opportunities. Many reportedly returned to farming or were "sitting idle in their villages," suggesting that local employment opportunities were limited.



FIVE
THE JOB TRANSITION FOR COAL POWER PLANT WORKERS



HIGHLIGHTS

- A just transition away from coal-fired power requires support for power plant workers, including assistance with finding viable alternative jobs and access to targeted reskilling programs. A transition that does not find alternative jobs for displaced workers will not be socially and politically acceptable.
- The package of transition support will depend on the repurposing options for the power plant site, workers' skills and job preferences, and demand for alternative occupations.
- In coal regions where coal is the only sizable industry, acceptable job alternatives do not exist and will need to be created. Business development activities in the region and programs to foster entrepreneurship may be necessary. Transitions may be easier in regions that are not reliant on a single industry.
- For many workers, the job transition will require a change in sector of employment, since jobs in coal power plants are more similar to jobs in construction or manufacturing than those in clean energy. Transitions to similar jobs may also require a change in lifestyle, which can reduce acceptance of change.
- In certain countries, jobs in coal-fired power plants pay much more than similar jobs in other sectors or jobs in clean energy; for millions of workers, the transition will therefore bring pay cuts.

Coal plant retirements are beginning to spread beyond Europe and the United States. South Africa and India, for example, have initiated long-term programs to retire their oldest coal-fired plants. Such programs are expected to have immediate socioeconomic effects on affected communities and positive long-term environmental and economic effects. The speed of such plant closures is expected to vary across the globe, but retirements will occur: To achieve global net-zero emissions by 2050, global coal-fired capacity will need to fall by 82 percent from present-day levels.

This chapter examines the transition from carbon-based energy sector jobs ("brown jobs") to "jobs of the future" ("green jobs"), which support the transition to clean energy. It argues that policy makers must develop realistic options that are just to workers in declining energy industries and affected communities and support the development of a qualified workforce for clean energy and related industries. To do so, they must consider many factors touched on in the chapter. Those factors include changes in local and national economic output, trade, and employment; energy security; the distributional effects of changes in jobs available, and the overall effects on local and disadvantaged populations. Other factors relate to the preferences and experience of individual workers. The chapter draws heavily on the experiences from Poland, where the World Bank over the years collected a lot of original data, but the chapter also cites data and analysis from other coal-dependent countries.

Borrowing the taxonomy used elsewhere in this report, the closure of coal mines and coal power plants affects direct, indirect, and induced jobs. Employment generated directly by a coal-fired power plant is characterized as direct employment. Indirect jobs are those in upstream industries that supply and support the activities of a coal-fired power plant, such as the mining of coal and its transport to the power plant or the provision of equipment. Jobs generated in response to the spending by people holding direct and indirect jobs, such as catering or other services to power plant workers, are induced jobs.

It is estimated that around 8.4 million people work worldwide in coal-related jobs. This comprises 6.3 million workers in mining, processing, and transportation, and 2.1 million in power generation, including both formal and informal workers (IEA 2022a). The number of workers affected by closure of an individual power plant is not high (hundreds, to a few thousand for very large plants).

In theory, governments could offer to pay workers a handsome incentive to retire early. However, this strategy would have a disproportionately negative impact at the community level, particularly in mono-industrial communities, since the main source of community income would disappear, resulting in an overall decline in economic activity. The fact remains that the coal industry is important in many municipalities because their ability to finance public services depends on taxes and levies paid by the coal-mining industry. A replacement for these revenue streams will need to be identified if basic public services are to continue to be provided.

5.1. Repurposing Coal Power Plants

Mitigating the impacts of coal power plant closures requires strategies for repurposing the site. After environmental remediation, the land surrounding coal power plants can often be used for energy or nonenergy purposes. Some of the physical power plant assets can continue to contribute to the power system.

The workforce of a closed power plant is also an asset; depending on demographics, training, and individual preferences, specific conversion strategies need to be developed. These will depend in part on the repurposing strategy for the affected land and physical assets and in part on the local economy, including the local job market.

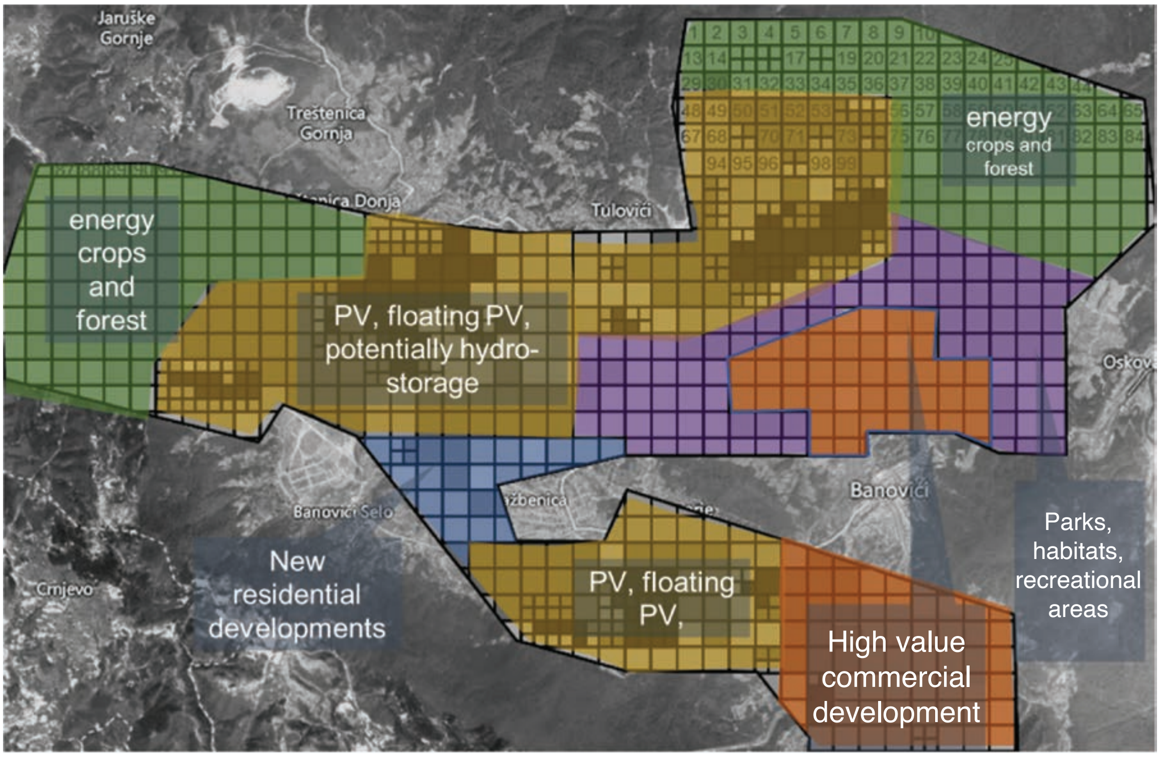
Based on the experience with coal transitions in Europe, the United States, and more recently China, the World Bank has developed a framework for the transition out of coal (Stanley and others 2018) that is applicable to both coal-fired power plants and coal mines. The framework consists of pillars focused on Institutional Governance, People and Communities, and Environmental Reclamation and Re-purposing Land and Assets. It provides guidance on actions to be taken in different phases of the transition out of coal in order to achieve a just transition. Also developed by the World Bank, the Land Utilization and Repurposing Assessment (LURA) tool helps policy makers to assess the potential for repurposing the land after mine/plant closure for (a) energy production and storage/industrial production/waste processing; (b) agricultural/horticultural/forestry uses; (c) recreation/tourism; and (d) office/research/technology parks (World Bank 2022a) (figure 5.1).

Coal-fired power plants can be repurposed to generate RE; store energy (in batteries, thermal storage, or pumped storage hydropower); or provide ancillary services (through battery storage or a synchronous condenser). The selected option depends on various factors, including the availability of land; the quality of RE resources; the requirement of the wider system for energy, storage, and/or ancillary services; the relative economic value of the repurposed project; and social and environmental considerations (ESMAP 2021).

Land has been repurposed for energy purposes in Australia, Canada, India, the United Kingdom, and the United States. In Holyoke, Massachusetts, the Mount Tom coal-fired power plant was repurposed as a solar facility with storage, after several repurposing scenarios were developed, taking into account technical options for the site, job creation potential, and revenue to be generated through municipal taxes (Massachusetts Clean Energy Center 2015, Huntley et al. 2022).

FIGURE 5.1

An Example of Suggested Repurposing of Mining Lands



Source: World Bank 2023j.

Note: Suggestions made using the World Bank's Land Utilization and Repurposing Assessment (LURA) tool. PV = photovoltaics.

The decision to close a plant and repurpose it is based on a techno-economic analysis of potential uses of the site; possibilities for adapting or reusing the physical plant; labor preferences and mobility; and the costs and availability of financing. Specific aspects to consider are location and site characteristics, including accessibility; alternative uses for existing infrastructure and assets; regulations and permissions that constrain use (for example, licenses for power production and environmental permits and constraints); and the transferability of labor in terms of skills and willingness of workers to switch occupations.

5.2. The Workforce in Coal-Fired Power Plants

As coal-fired power plants close, companies need to deal fairly with their former workers by proposing viable solutions to reemploy them. The solutions envisaged typically consider different categories of workers and their age profiles.

Data are available for certain countries in the Organisation for Economic Co-operation and Development (OECD), where the sector's workforce is dominated by highly experienced older workers who have often spent their entire careers at the same company. Many of these workers will retire if the plant closes. Younger workers will need to learn new skills to find new jobs. If repurposing is to be undertaken by the original owner, employees can be reskilled in-house.

Data on the age composition of coal-fired power plant workers in developing countries are widely not available, but these workers are believed to be younger than in high-income countries. When large coal conglomerates close a plant, they often redeploy younger workers to their remaining plants and facilities as older workers retire. Redeployment is expected to be a viable strategy for many developing countries in the years to come, though willingness to relocate will certainly play a role in many situations.

Workers operating coal-fired power plants are skilled. In Greece and Poland, for example, a significant percentage have five-year university degrees in engineering or business. Many technical professions in power plants require postsecondary but not university education; even workers that provide basic maintenance have secondary education in these countries. In both countries, coal-fired power plant workers are more educated than miners on average. The above-average education of these workers increases their potential to find new jobs once a plant closes.

Policies for supporting the job transitions of displaced coal-fired power plant workers need to be tailored to local circumstances (World Bank 2023j). Options depend on workers' age, education, skills, gender, current position, current salary, the availability of jobs, and their preferences, such as willingness to change sector of employment or work farther from home.

5.3. Possible Job Transition Pathways

When formulating policies and strategies for job transitions of coal-related workers, professional preferences, individual attitudes, skills, and experience, as well as certain social elements, are often overlooked, despite their importance in ensuring that future job opportunities will be acceptable to the workers.

Job transitions can take two paths: transitioning to a similar job in a different sector or transitioning to a different job within the same sector (from a brown job to a green job in the energy sector, for example). Ideally, workers could transition within the energy sector (for example, reskilling a belt maintenance technician to be able to install PV panels), but such paths are not always realistic. This is because many new and emerging jobs are more complex than jobs in the brown energy sector, and the level of education they require (including digital skills) may prevent workers from transitioning smoothly to greener jobs. In addition, green jobs are not always located where the brown jobs were and may pay less, on average, than the (unionized) brown jobs from which workers were displaced. Finally, it is necessary to ensure that there is an immediate and longer-term demand for the output produced by the new jobs—that a market exists for the green energy sector to which workers are transitioning.

Green jobs tend to require higher skills than brown jobs (World Bank 2023n). Figure 5.2 shows the distribution of three types of skills—numeracy, literacy, and problem solving from the Programme for the International Assessment of Adult Competencies (PIAAC) survey—required to perform brown and green jobs in Poland. It shows that green jobs require higher proficiency for all skill types than brown jobs.

A detailed look at the distributions shows that the differences between green and brown jobs are particularly great for workers with lower education levels. For numeracy, the difference between workers in brown and green jobs is 20 percentage points among lower-skilled workers and 15 percentage points among higher-skilled workers.

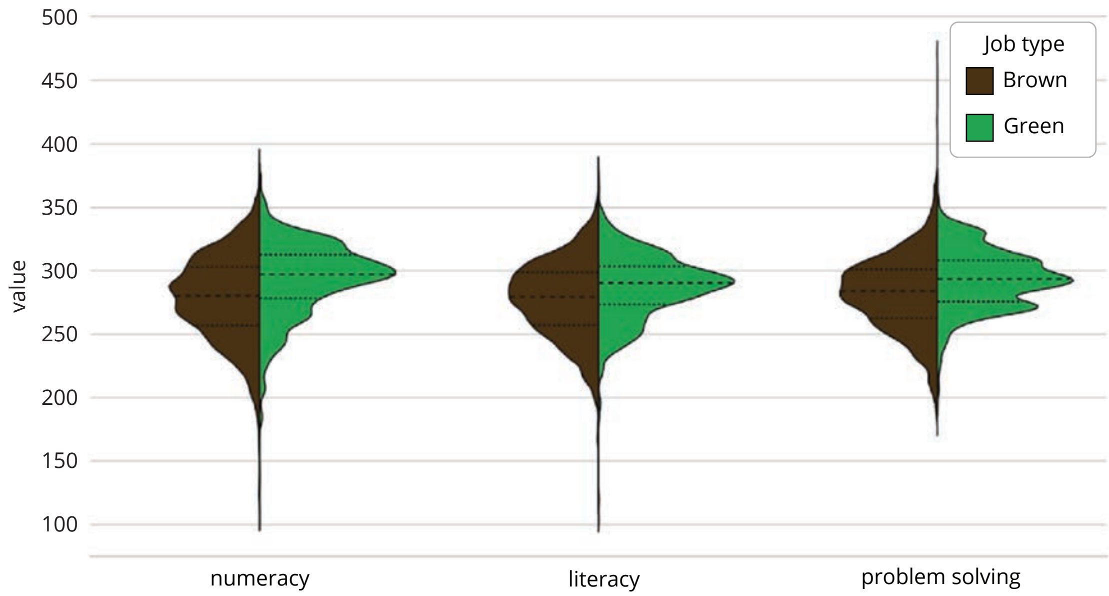
Education levels also differ: People in brown jobs have 11.8 years of schooling on average, compared with 13.4 years for people in green jobs. Both groups are similar in age; however, women constitute a larger share of the green jobs workforce than of the brown workforce (World Bank 2023n).

To study possible job transition pathways for coal-fired power plants' workers, the job-matching algorithm developed in Christiaensen and others (2022a) and big data techniques were used. The most viable transition pathways were selected by identifying positions requiring skills most similar to those required in the original job. In addition to task similarity, the analysis considered two other constraints: demand for the new position, and wage differential. The objective was to reduce the amount of reskilling. The algorithm also provides coarse information about a job's "greenness."

Figure 5.3 depicts the results of the analysis for a mechatronics engineer, a typical engineering job at a coal-fired power plant. It shows that professions most similar to mechatronics engineer entail fewer green tasks and lower pay. Only one of the three most similar positions,

FIGURE 5.2

Distribution Density Plots of Numeracy, Literacy, and Problem-Solving Skills Required in Green and Brown Jobs in Poland

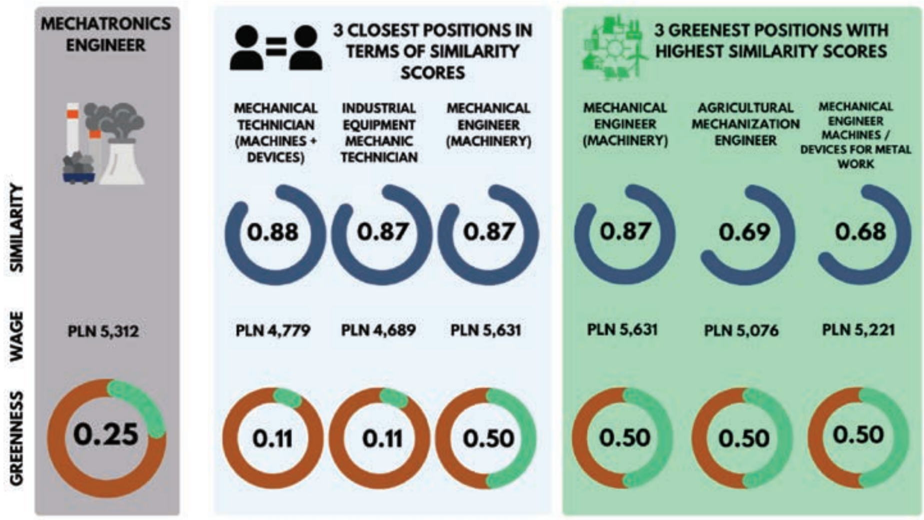


Source: World Bank 2023n.

Note: The density plots in the figure are presented in a vertical way as mirror density charts, as opposed to the traditional horizontal plots, to allow for easy comparison of densities of the 3 presented attributes of brown and green jobs distributions. Dashed lines represent medians of each distribution.

FIGURE 5.3

Analysis of Potential Job Transitions for a Displaced Mechatronics Engineer in Poland



Source: World Bank 2023j.

Note: The three closest position in terms of greenness in the figure were produced by ranking the transitions from the initial to the final position by their greenness and retaining only the greenest transitions in the top three positions based on similarity score.

mechanical engineer (machinery), is both greener and pays more. The transition to positions in RE or EE is not highly viable, however, because these fields employ few mechanical engineers. The three greenest positions with the highest similarity scores entail an exit from the energy sector and a transition to other industries (for example, agricultural mechanization engineer, mechanical engineer for metal work devices), but the income level remains about the same.

Similar analysis was conducted for the position of production master at a coal-fired power plant. The job transitions requiring the least amount of reskilling (production master in the textile, electronics, or wood sectors) entailed a change of sector and pay cuts. The transitions to the greenest jobs with the highest similarity scores also involved a change of sector (construction) but resulted in a significant pay increase in most cases. For a truck mechanic at a coal-fired power plant, all of the job transitions requiring the least amount of reskilling were the greenest, but they entailed various degrees of salary reduction.

This analysis reveals that the following factors impede transitions from coal-fired power plant positions to clean energy jobs in Poland:

- Jobs in coal-fired power plants are not similar to clean energy jobs.
- Jobs in coal-fired power plants are more similar to jobs outside the energy sector. Information barriers as well as a sense of belonging to the power sector complicate such transitions.
- Jobs in coal-fired power plants often pay much more than similar jobs in other sectors (including clean energy jobs), implying that most transitions will result in substantial pay cuts, although it is possible that job markets where demand for workers in clean energy is higher than it is in Poland could pay more.
- Many transitions imply a change in lifestyle that requires a shift from going to the same place (the power plant) every day to going to different sites that may be farther from the worker's home. Workers are reluctant to change their lifestyles, especially by commuting longer distances or relocating.

The transitions requiring the least amount of reskilling are often toward other sectors of activity. Such transitions may be challenging, because (a) these sectors may not be located near the power plant; (b) power plant workers may not be familiar with other sectors; (c) some workers will be unwilling to move out of the sector they identified with over their entire career; and (d) the salaries paid in other sectors are often lower (box 5.1).

Some companies have trained displaced workers to work in the RE sector. In Poland, that approach has been only minimally successful (box 5.2).

Communities heavily reliant on coal often lack acceptable job alternatives; these must be created from the ground up. Given the varied preferences of workers and of community members,[1] multiple sectors, not just power generation, must be considered when looking for alternative jobs. In addition to clean energy, those sectors might include manufacturing (including the manufacture of clean energy equipment, such as heat pumps or building insulation material, and the manufacture of other goods for which there is local demand); agriculture (including agrivoltaics, the development of land area for both solar PV and agriculture); and a general support to entrepreneurship across different sectors. All interventions should be accompanied by targeted reskilling programs (in collaboration with

BOX 5.1

REGIONAL DIFFERENCES IN WORK PREFERENCES ACROSS POLAND

Coal-related workers favor stability and continuity, although the magnitude of these preferences varies across regions. All coal-related workers (mine and power plant employees) and residents of nearby municipalities want to continue living in their municipality and to hold similar positions and to work in similar sectors as they currently do. They also value job security. However, workers across Eastern Wielkopolska, Lower Silesia, and Silesia show vast differences regarding the amount of money they will forgo to work near their homes and in their preferred sector of activity or for open-ended contracts.

Living close to a thriving economic center (the Katowice industrial region in Silesia or near the German border of Lower Silesia) increases a worker's willingness to commute or relocate. In Eastern Wielkopolska, an additional hour of commute is worth PLN 5,342 per month (more than the average monthly salary in the Konin subregion) (1 PLN was worth approximately 0.25 USD in 2022). Affected residents in Lower Silesia value an additional hour of commute at PLN 749 per month; mine workers there value an additional hour of commute at PLN 1,148 per month.

Local labor market characteristics affect workers' willingness to accept positions less aligned with their skill sets. Workers in Silesia and Eastern Wielkopolska have a stronger preference for transitioning to jobs aligned with their skills and education (and are willing to forgo about PLN 1,200 per month to do so). Affected workers in Lower Silesia—where traditional sectors of activity, including manufacturing, account for a smaller share of employment—are willing to forgo PLN 556 to secure a job aligned with their education and skills.

Source: Christiaensen and others 2022a, 2022b, 2022c.

BOX 5.2

THE DIFFICULTIES OF RETRAINING POLISH COAL WORKERS TO WORK ON RENEWABLE ENERGY PROJECTS

ZE PAK Capital Group is a private company and one of Poland's largest lignite companies. Unlike in other regions of Poland, ZE PAK's vertically integrated structure means that most coal-related activities in Eastern Wielkopolska take place within the ZE PAK Capital Group. ZE PAK began laying off workers in 2020. To facilitate the transition to RE opportunities, the company sponsored two three-day courses that trained participants to become PV panel fitters. Over 300 workers who were about to be dismissed were offered the training, and 50 of them registered. They all completed the course. Of the 50 graduates, 21 were shortlisted for a position. Of those workers, 14 eventually accepted a job offer, 5 as PV system electricians, 6 as PV installers, and 3 as construction engineers.

Although the training was high quality, few displaced workers transitioned to become PV installers. The lack of appeal of the installer job partly reflected the long daily commute (up to 120 kilometers) to reach the installations. The newly trained employees were considered too old to work as installers at a PV farm. And the PV sector does not offer too many long-term job opportunities: Installers are in high demand when infrastructure has to be built for a solar farm, but demand disappears later, as maintenance requirements are limited.

Source: Honorati 2022.

local technical and vocational education and training institutes, for example). Entrepreneurship should be promoted through incubation and business development services. The transition also offers an opportunity to boost the participation of women in the workforce, which tends to be low in brown jobs. Their participation can be encouraged through provision of childcare services, for example.

But few jobs are likely to score high on the three key dimensions of being local, meeting the job seeker's preferences, and matching the job seeker's skills. Evaluating transition reskilling options requires local studies that map out these dimensions and analyze the trade-offs among them. Box 5.3 illustrates the implementation of a framework to ensure the just closure of power plants.

BOX 5.3

WORKING TOWARD A JUST TRANSITION FOR WORKERS LAID OFF FROM SOUTH AFRICA'S KOMATI COAL-FIRED POWER PLANT

The World Bank, through the Eskom Just Energy Transition Project (EJETP), is supporting efforts by Eskom, the South African power utility, to decommission and repurpose the 1 gigawatt Komati coal-fired power plant while mitigating the socioeconomic impacts of its closure on workers and communities. The EJETP will serve as a demonstration project for South Africa and other countries that are phasing out coal-fired power plants.

The Komati power plant is located in the heavily coal-dependent Mpumalanga Province. Given Eskom's mandate and the site's suitability for power generation, it was decided to repurpose the site for renewable power generation. In recognition of the significant economic and social impacts of the closure on the local community, the project includes a sizable component aimed at reducing the negative socioeconomic impacts of the plant's closure and creating income generation opportunities for Eskom workers and the nearby communities during and after the transition process. This project component emphasizes job creation; reskilling; and support to local manufacturing and local green-tech micro, small, and medium-size enterprises, consistent with Eskom's Just Energy Transition Strategy and the Mpumalanga Green Economy Development Plan.

The project provides transition support and creates opportunities for permanent workers, suppliers, and contract workers who depend on the Komati-based plant. It also supports the development of nearby communities and the diversification of the local economy. It has put in place mechanisms to enable stakeholders to share their input and to exchange views.

(*continues*)

BOX 5.3 (*Continued*)

Eskom's transition strategy includes transferring affected workers to other Eskom-owned power stations; reskilling workers for the planned repurposing of Komati as an RE-based generation center; and supporting the diversification of economic activities in the region to generate varied employment opportunities for the communities affected by the plant's closure. The project will support local enterprise development, especially the development of local suppliers and contractors to participate in the procurement value chain for EJETP's decommissioning and repurposing components. These efforts are expected to contribute to the longer-term sustainability of the local economy.

The project is also supporting diversification into manufacturing and agricultural activities to prepare the region for future rounds of plant closures—closures that will not necessarily result in repurposing for energy generation. Preparing the ground for activities and jobs outside the energy sector is therefore a priority.

Source: World Bank 2022c.

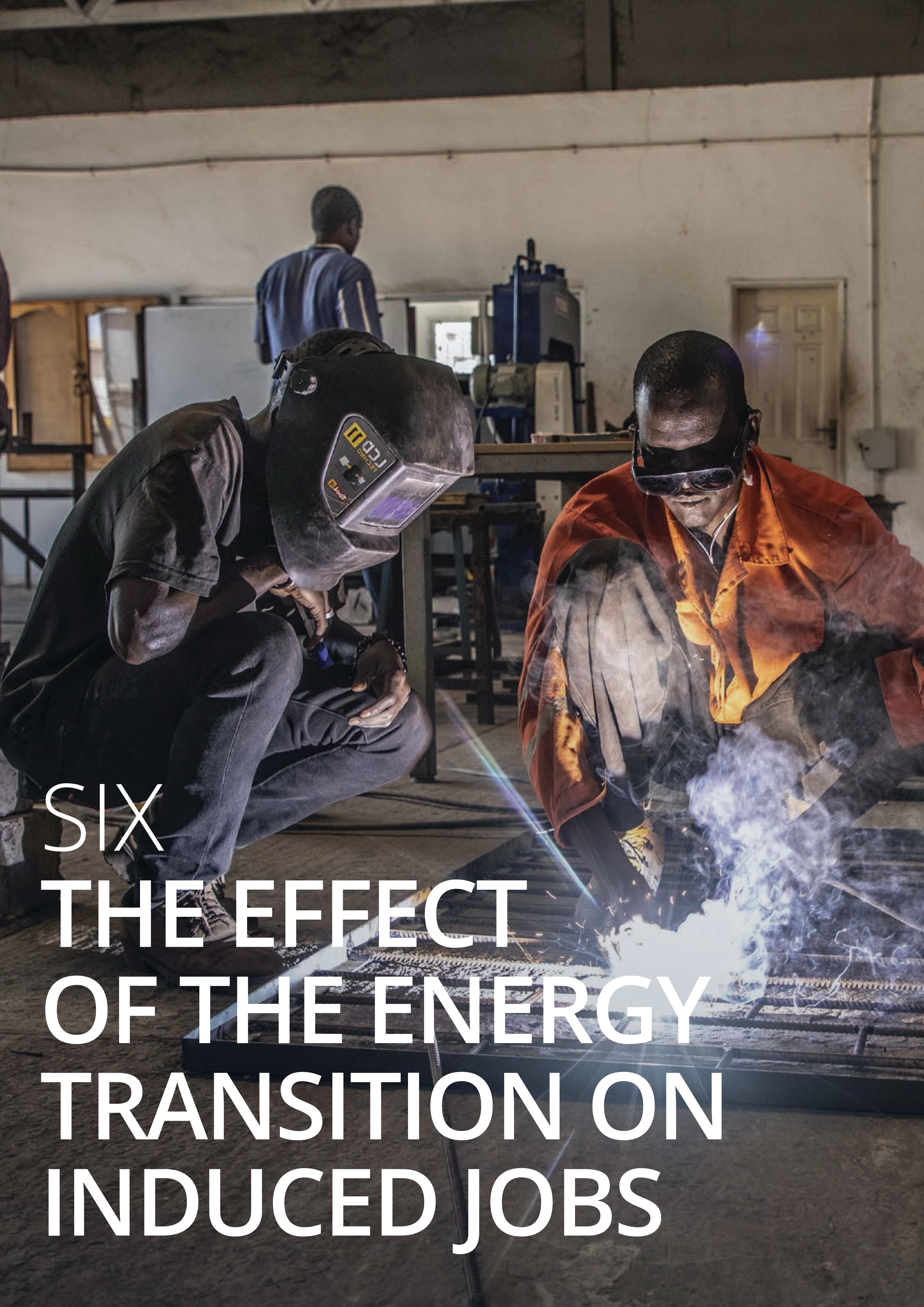
5.4. The Bottom Line on Transitioning from Brown to Green: Not a Simple Matter

The job transitions of coal-fired power plant workers must be tailored to the circumstances not just of individual countries but also of each local community (2023j). Options for workers depend not only on their age, education, skills, gender, current occupation, and current salary, but also the local availability of acceptable alternative employment, which can differ widely from one community to another, and personal preferences, such as willingness to change their sector of employment, the distance they must travel to work, or their place of residence. Difficulties in finding acceptable job transitions are exacerbated by the fact that coal-related jobs typically pay higher salaries than locally available job alternatives.

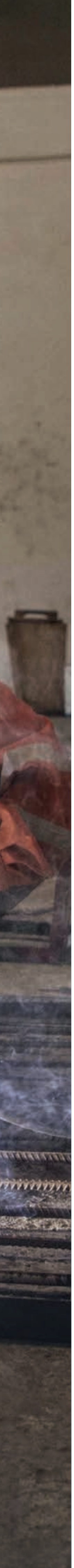
When designing reskilling programs and programs to promote local job creation, policy makers must recognize that jobs in coal-fired power plants have little in common with clean energy jobs: in fact, they have more in common with certain jobs outside the energy sector. Transitions out of the energy sector can be complicated by information barriers, as well as by a sense of pride in having worked in the coal sector. Many transitions to similar jobs imply a lifestyle change, shifting from a routine of going to the same place every day to going to different sites, whether for general construction jobs or for installing RE or EE equipment. Workers may find this change difficult to accept. Setting up local manufacturing facilities and staffing them may be better alternatives to clean energy jobs since they do not bring such stark changes, even though this may necessitate reskilling. Remuneration may be an additional hurdle. Jobs in coal-fired power plants can pay significantly more than clean energy jobs and pay more than similar jobs in other sectors in general. This implies that any transition may involve a pay cut for workers.

Endnote

1. The involvement of community members is twofold. First, the workers' family members are oftentimes affected by the preferences and lifestyles of their worker. Second, community members may have preferences for new industries that do not pose environmental challenges (such as water or air pollution, or high noise levels) of are bringing additional social benefits (some industries may be willing to invest in free commuting services, local health centers, etc.).



SIX
THE EFFECT OF THE ENERGY TRANSITION ON INDUCED JOBS



HIGHLIGHTS

- Most of the jobs created by the energy transition are likely to be induced jobs. These jobs could be longer-lasting than direct jobs.
- Electrification has significant unrealized potential to create induced jobs through productive uses of electricity.
- Where power supply is the binding constraint on the expansion of enterprises, improved power availability and quality is likely to increase hiring. More work is needed to identify the conditions under which it does.
- Improved electricity availability and quality increases labor productivity; whether greater productivity boosts employment depends on demand for the output produced and on the potential for expanding production. Mechanizing production could eliminate some manual jobs.
- Quantifying the magnitude of induced jobs requires investment in data collection and tracking.

Induced employment for the purposes of this report comprises those jobs created by the economic activity around energy sector investments. Jobs that meet consumer demand for goods and services are induced jobs because they take in money workers spend because of their direct and indirect employment in the energy sector. Induced jobs also include employment through productive use of electricity arising from improved electricity supply, service quality, and price.

These employment impacts are difficult to estimate using *ex ante* methods, however. They need to be evaluated using *ex post* methods that can establish causality, ideally through randomized controlled trials (RCTs). In the absence of RCTs, the effect of improved electricity quality and access on job creation can be assessed using quasi-experimental observational methods.

The quantification of induced jobs requires substantial microdata. Although this employment category is possibly larger than the combined categories of direct and indirect jobs created, there is limited ground-based evidence on such impacts. This chapter presents findings from case studies of rural electrification in Nigeria; case studies on India, Malawi, and Peru; and findings from a review of energy subsidy and other policy reforms in Rwanda to highlight the channels through which induced jobs emerge.

6.1. Assessment of Productive Uses of Electricity from Mini Grids in Nigeria

To complement the case study on the Nigeria Electrification Project (covered in chapter 4), the World Bank commissioned a deep-dive study on the potential impacts of increased access to electricity through mini grids on key outcomes (productive use, employment, and earnings) using a cross-sectional design.[1]

A field survey sought to isolate statistically significant differences between communities with and without mini grids in order to understand the productive use of power at sites with mini grids. Data were obtained from about 1,200 households across 60 sites in 6 Nigerian states, about half of which had mini grids (World Bank 2023k).

Mini grid–based electrification brought quick improvements in basic comforts (lighting, air circulation, refrigeration, entertainment). Mini grid–connected households purchased and used electrical appliances much more than nonconnected households. The main uses were domestic: the use of lightbulbs, TVs, electric fans, and refrigerators more than doubled. Impacts were also noteworthy for businesses, for the same types of appliances. Refrigerator use by businesses almost tripled, suggesting that the potential for productive uses might improve labor market outcomes over time. Additional labor-market impacts may yet emerge after households have had time to leverage access to mini grid–based, reliable electricity services. But estimating these would require rigorous impact evaluations.

The results suggest that in the immediate period after deployment, mini grids appear to deliver electricity service with far fewer outages than the regular grid. Mini grids also appear to reduce household drudgery (particularly for the male members) and to increase the use of other electrical appliances like TVs, electric fans, lightbulbs, radios, and refrigerators.

Commercial use of major electric appliances for productive purposes was in little evidence, such as grinding mills, irrigation equipment, welding, and other machinery. This is perhaps in part due to a lack of awareness of the potential benefits of productive use appliances, a lack of availability of such appliances, and/or a lack of financing to address what are often high upfront costs to acquire these appliances. The time elapsed between the survey being conducted and the introduction of mini grids may also have been too short to observe any changes in employment, income, or enterprise-level activities. These results suggest that promoters of solar mini grids may want to do more to encourage the use of productive appliances in communities with mini grids.

6.2. Induced Employment in India, Malawi, and Peru

The case studies in chapter 4 tried to estimate induced employment impacts for single projects. These impacts could not be quantified because of lack of data. A sample of induced activities and benefits was identified through interviews in India, Malawi, and

Peru, where the projects increased the availability of affordable and reliable electricity, supporting the emergence of sustainable businesses.

The Rampur Hydropower Project in India built a new hydroelectric plant to improve the reliability of India's northern electricity grid. Power from the plant now supplies several states in northern India, and interviews conducted near the project captured information about induced jobs.

The induced jobs were created through new grocery stores, markets, restaurants, and small eateries all catering to the workers employed on the project. Some of these businesses were started by people who had earlier been worked on the project. Nearby community demand for basic project inputs (such as spare parts and construction materials) is reported to have had similar impacts on business creation in the area. Although the project is not believed to have raised net induced job creation in the region (Vaidya and Singh 2015), it did shift jobs out of agricultural labor into the services sector and wage labor linked to businesses. In sum, the more reliable northern electricity grid is expected to bring broad economic activity and induced employment, although lack of data means these impacts could not be assessed (World Bank 2023d).

The Energy Sector Support Project in Malawi was designed to improve grid quality and increase access through the construction of new substations, the extension of distribution and transmission networks, and the construction and rehabilitation of distribution and transmission lines. The assessment of induced jobs encompasses the project's impacts through improved electricity access for households and improved electricity quality for companies. For households, productive-use jobs are created through improvements in electricity access and the mechanization of activities, which could reduce household drudgery and free up productive time. That electricity access did actually reduce hours of household chores for women was not established (World Bank 2023f).

It is estimated that a 1 percent reduction in outages would result in a 0.19 percent increase in employment for enterprises. The 32–40 percent outage reduction achieved by the project could therefore bring several thousand workers in the labor force employed in formal enterprises. This number is highly uncertain, however.

Induced jobs associated with Peru's Second Rural Electrification Project were estimated from interviews with nine small businesses connected to the grid through the project. Most beneficiaries acknowledged that electrification had transformed their businesses, but employment changes were mixed. In some cases, electrification associated with the use of new technologies displaced labor, because productivity increased with mechanization. The introduction of machines to milk dairy operations and machinery to harvest and sort olives replaced work that had been done manually, for example. In other cases, after initial labor displacement, businesses expanded their operations and employment increased. An Amazonian coffee producer, for example, employed two to three workers who produced coffee for local consumption. Under the project, the producer received three-phase electrical power, which allowed the processing plants to operate and select higher-quality coffee beans more efficiently. Access to more reliable electricity helped the producer export its coffee. To meet this new demand, it hired additional workers to perform export-related roles (World Bank 2023i).

Lower production costs could lead to more hiring (as found in avocado and coffee production). Alternatively, it could lead to a reduced demand for labor (as found in olive production and one of the milk producers). One milk producer and a guinea pig farm saw no change in employment following electrification. These varied outcomes appear to reflect firm characteristics, the nature of the technological change implemented, and other factors. They point to the need for comprehensive empirical assessments of employment outcomes to assess final impacts.

Some case studies mention another category of induced jobs, so-called replication jobs, implying that the projects contributed to the emergence of a new sustainable energy value chains, creating capacities valuable for implementing future projects. In Kosovo, an increase in building retrofits (and a demand for trained workers) was reported in various municipalities, while in Pakistan, further rooftop solar projects could be supported by donors. The actual impacts are not yet documented (World Bank 2023e, 2023h).

6.3. Economywide Induced Jobs in Rwanda

The Rwanda case study sought to capture the results of the policy reform program supported by three Development Policy Operations (DPOs), implemented between 2017 and 2020. The development objective of these operations was to enable a fiscally sustainable expansion of electricity services. The DPOs stewarded the fiscal support required by the electricity sector and improved the operational efficiency, affordability, and accountability of electricity service.

The case study examined the link between economywide employment and DPO-supported reforms. The reform program was expected to have an effect on national employment trends by improving electricity services. These gains would in turn reduce fiscal transfers to the power sector and boost potentially productive public investments in other domains. The direct provision of additional budgetary resources to the Government of Rwanda would enable more productive investments. A direct causal link between these reforms and (induced) job creation was not directly traceable, however, most likely because induced jobs stem from such a broad set of factors.

The policy reforms were expected to deliver two types of impacts.

First, reduced subsidies to the electricity sector were expected to increase the fiscal resources available for capital and social investments in other sectors. Capital investments create public infrastructure related employment in the short to medium term. Social sector investments increase the productivity of the labor force, resulting in an increase in the longer-term employment potential of the population.

Second, increased access to affordable and reliable electricity was expected to expand the quantity and range of goods and services that households and enterprises could produce, raising labor productivity. Both outcomes could help create new enterprises and expand existing ones, resulting in higher wages and employment.

The DPO series supported more cost-reflective tariffs and better revenue-collection methods. Together, these were expected to improve the balance sheet of the Rwanda Energy Corporation and reduce its recourse to government subsidies. Over the period under study, tariffs fell for the lowest-consumption tier (the poorest customers) by 8 percent and increased significantly for the largest nonindustrial consumers (92 percent for residential and public buildings) and small industries (36 percent). Tariffs plummeted for medium-size and large companies (by 8 percent and 16 percent, respectively). Government subsidies to the Rwanda Energy Corporation declined (from RF 21.5 billion in the 2017–18 budget to RF 16 billion in the 2020–21 budget).

During this period, the government also addressed other priorities, such as a fuel shortage and the high price of fuel, which required additional fiscal support. It is therefore difficult to assess whether lower subsidies to the electricity sector led to additional investments in other sectors of the economy (World Bank 2023l).

Electricity access rose approximately 13 percentage points (to nearly 47 percent of the population) over the period, with disparities remaining between urban and rural areas despite this rapid growth. Most rural Rwandans still lacked electricity access at the end of the DPO series. The series did improve the quality of electricity services: the number of outages fell by 60 percent, while there was 40 percent drop in duration (World Bank 2023l). Nevertheless, the impact of improved electricity access on jobs is not clear.

Some 600,000 jobs were created in the period studied, but they cannot be attributed to improvements in the availability and quality of power supply that occurred during this period. Most employment growth was in the agriculture sector (where employment rose 75 percent), possibly as a result of the combination of improved productivity and favorable weather conditions in 2020. Energy-intensive sectors, such as manufacturing, expanded by 10 percent in value and in employment. In the manufacturing sector, economic output per job increased from RF 328 million to RF 388 million per job. Employment doubled in the accommodation and food service, administrative, and support subsectors, and job creation in these subsectors accounted for 18 percent of all jobs created. These subsectors still represented, however, just 5 percent of total employment in 2020.

The case study reveals several caveats about the impact of electricity sector reforms on employment generation:

- Attributing induced job creation to power sector reforms is difficult because other factors can be at play.
- The redirection of subsidies to capital and social investments to other sectors could not be traced because the government budget structure changed as part of the reform.
- Households' ability to produce an expanded range of goods and services could not be demonstrated. Even when it occurs, it may not lead to the creation or expansion of new or existing enterprises if there is limited demand for those goods and services.
- More reliable power is not likely to affect employment if the reliability of electricity services is not the main or binding constraint to expansion.

6.4. To Understand Induced Jobs: More Rigorous Evaluation Over Longer Periods

This chapter illustrates the complex mechanisms underpinning induced job creation, which itself emerges from a mix of factors that go beyond specific project interventions. The literature review summarized in chapter 2 strongly recommends conducting *ex post* impact evaluations using RCTs to ascertain the impacts of clean electricity investments on local employment. This in turn will enable estimating direct, indirect, induced, and productive-use jobs.

The deep-dive study on the potential impacts of increased access to electricity through mini grids in Nigeria (and reviewed in this chapter) showed that the productive uses of electricity expected from new mini grids had not materialized, at least by the time of the survey, probably because the short time between the survey and the introduction of mini grids. In comparing communities with and without mini grids, some differences were observed in key labor market outcomes (employment, income, and business earnings). Men spent less time on nonmarket activities as time devoted to household chores decreased. But this time saving did not translate automatically or immediately into the creation of small businesses. This outcome emphasizes the need to repeat data collection over a longer time horizon to generate sufficient information to understand clean electrification's medium- and long-term structural effects on employment. Complementary services promoting productive uses (for example, information campaigns to increase awareness about the ways electricity can be used, provision of financing to make electric appliances more accessible, development of quality control and standards applicable to appliances used for productive uses, and business development initiatives to foster the creation and growth of electricity-using enterprises) can help address this concern (World Bank 2023m).

The methods described above were used as part of the Second Rural Electrification Project in Peru, which hired local nongovernmental organizations to raise awareness among targeted local businesses and help them build skills to use electricity to support commercial activities. These organizations also partly supported businesses in accessing complementary services, including access to financing to purchase items required to implement productive uses of electricity.

Yet greater productive use may not always translate into more jobs. Findings from Peru suggested that the rural electrification project created new enterprises and new jobs but also eliminated enterprises, with the net effect unclear. This was primarily because new technologies displaced labor. For example, the introduction of mechanical milking and machinery to harvest and sort olives replaced manual work, leading both types of enterprises to reduce employment. In some cases, employment losses were sustained. In other cases, after the initial labor displacement, businesses expanded their operations and the job types changed. Such ripple effects of productive uses on local employment blur causality.

Case studies in India, Malawi, and Peru did not use rigorous RCT methods but relied on a small sample of interviews. They did not lead to conclusive findings on the magnitude of induced jobs created by projects, although there was some evidence of additional on-site activity. The Peru case highlighted nuances in the creation of induced employment in small and medium enterprises. The case illustrates well the complexities faced when empirically estimating induced employment and points to the need to conduct empirical assessments of employment outcomes using representative samples.

The Rwanda case study faced the specific challenge of assessing the causal link between improved electricity supply and jobs using country-level data. The cases of India, Malawi, and Rwanda show the difficulty of tracing induced jobs and underline the need to isolate the employment impacts of improved power quality or greater access to electricity from unrelated factors.

Induced jobs are an active area for further investigation. It is important to have a robust understanding of the theory of change underlying the creation of induced jobs when estimating job creation due to specific investments. The cases underline the need to rigorously evaluate impacts, e.g., using RCTs to establish causality between clean energy investments and jobs. Embedding such evaluations in the design of selected projects will be critical to enhancing understanding of job creation and clean energy investments (World Bank 2023m).

Endnote

1. This study can also be used to create a baseline for the World Bank to rigorously assess impacts of the Nigeria Electrification Project (NEP) in the future, using a pre- and post-comparison group design.

SEVEN
CONCLUSIONS AND RECOMMENDATIONS

This report has presented the findings and conclusions of a program of analytical work, "Estimating the Job Creation Potential of the Clean Energy Transition," undertaken to investigate the impacts of the global transition to clean energy on the quantity and quality of jobs in low- and middle-income countries. Under the program, the World Bank's Energy Sector Management Assistance Program (ESMAP) undertook multiple streams of analysis with the overall aim of supporting low- and middle-income countries in understanding and harnessing the potential of the clean energy transition to generate local jobs.

The report adds to the academic and policy literature on job creation associated with energy transitions, particularly the macroeconomic impacts of key energy transition policy scenarios and their implications for electricity sector and economywide employment. It is important to note that in drawing on World Bank–supported projects, the report adds perspectives from developing countries and emerging market economies to the global knowledge base on job creation in the energy transition.

The report's granular characterization of jobs created directly and indirectly by a range of sustainable energy interventions complements the global assessments conducted by international energy think tanks. It provides specific insights on the labor transition, particularly with regard to the potential for new green jobs to absorb labor released as brown jobs disappear. On all these counts, it can inform the design of strategies for incorporating job creation in investment projects in developing countries.

Key Messages

- Transitions from fossil fuels to clean energy are likely to have positive impacts on the total number of jobs in the energy sector as well as more broadly on job creation economywide.
- The majority of job creation due to the energy transition occurs through induced jobs—clean energy investments will increase output, labor productivity, and employment in the economy.
- Transitions from brown to green energy jobs are neither automatic nor easy—often sectors such as manufacturing or construction could be a better fit for workers formerly employed in fossil fuel extraction and use. This is because many clean energy jobs require digital skills and need much higher willingness to travel to many different installation sites.
- Investment in resettlement, restoration of livelihoods, and local area development activities to mitigate impacts of large-scale projects is an important lever of long-term and stable employment in local communities. Impacts are positive for everyone since many of such projects decrease drudgery, particularly for women, who often cannot benefit from jobs in the energy project itself but can be employed in local schools, hospitals, or shops constructed as part of local area development activities.
- Jobs associated with the energy transition include "indirect" jobs, jobs in supply chains for the materials and equipment required to deploy renewable energy, energy efficiency, and other clean energy interventions (e.g., manufacturing of solar panels, heat pumps, or EE equipment, among others). These jobs are currently concentrated in a few countries, and

governments may want to explore which parts of supply chains they could develop locally in competitive ways, to increase local job creation related to energy transition.

- At the clean energy project level, a reality check on the jobs created reveals that:
  - most jobs require unskilled or semiskilled (technical, vocational training) labor that can be sourced locally and trained on-the-job; it is a myth that most clean energy jobs require tertiary degrees, a myth that misdirects governments' efforts to target primarily university-level clean energy education, while many more technical and vocational education and training programs are needed;
  - most jobs are temporary, particularly construction jobs in clean energy projects; however, O&M jobs, although scarce by way of comparison, are good-quality, longer-term positions that can typically be sourced locally if some training is provided;
  - while it is tempting to favor local hiring, this urge needs to be balanced against the alternative possibility of developing a cadre of experienced, mobile workers who implement projects in different locations. Such workers must be willing, of course, to adopt a relatively nomadic career, but the jobs last longer and are more secure and better paid;
- It is critical to address job losses in incumbent high-emission industries, such as coal extraction and use, since they could impede energy transition processes:
  - focusing purely on technological options for energy transition but failing to consider a "job transition" for workers will hinder progress toward adoption of clean energy and can even mean a complete halt to the transition in certain communities;
  - a sustainable transition from brown jobs takes account of skills required for existing and potential replacement (new) jobs, worker preferences, demand in the replacement sectors, and multiple behavioral and social barriers to change;
  - the potential size of job losses through closure of coal-fired power plants is much lower than the size of employment at risk in coal extraction; however, in places where whole communities are dependent on this single industry the transition can be extremely difficult given that coal not only pays for the salaries of workers directly working in the coal industry but it typically supports local businesses and also the social and cultural life of the community.

Recommendations

This report makes three sets of recommendations to enhance the positive impact on jobs of the energy transition in developing countries by: (i) improving understanding of the mechanisms for job creation in the energy transition, (ii) incorporating specific actions into policies, project design and implementation modalities, and (iii) developing a suite of education and training programs for the clean energy labor force.

The first set of recommendations is directed at academia, think tanks, IFIs, MDBs, etc. It pertains to building a knowledge base by collecting data and empirically identifying causality in ways that would feed into the design of policies, projects, and education and training programs, summarized in the following two sets of recommendations, directed at policy makers.

Data and Knowledge Creation

- Support systematic efforts to collect administrative and survey data on skills and jobs related to clean energy (e.g., support national statistics offices in labor surveys, enterprise surveys and collection of data on education and training enrolments and graduates.
- Implement a pilot program of surveys to quantify and characterize jobs created directly by different types of projects across various geographic regions and country characteristics. Use pre- and post-project construction surveys to track and assess jobs through the project's life by collecting information on numbers, skills requirements, compensation, etc., with a defined periodicity and with all data gender disaggregated as a reporting requirement built into project implementation contracts.
- Create a database of canonical employment factors applicable to different groups of developing countries. This could be achieved through a systematic quantification of jobs created in the supply chains for specific sustainable technologies or industries through surveys in multiple geographic areas.
- Initiate a program to improve understanding of the causal chain for job creation associated with the local and regional economic development catalyzed by energy sector investments. This requires understanding the causal links between interventions and job outcomes, typically articulated in a theory of change (TOC). Academic institutions together with international development agencies could be tasked with running a series of randomized control trials (RCTs), which are the gold standard of impact evaluation, or quasi-experimental methods (e.g., difference-in-differences, regression discontinuity design, propensity score matching) focused on the labor market to bring empirical evidence to bear on these causal links and identify the complementary factors necessary for job creation. To capture structural, longer-term impacts on the local economy, for example, clean electrification's medium- and long-term employment impacts (such as freeing up hours for nondomestic work, creating and developing new businesses, and educational attainments over an extended time frame), the trials should be implemented over a few years with data collected two, three, or even four years after the initial investment.

POLICY RECOMMENDATIONS AND RECOMMENDATIONS FOR PROGRAM/PROJECT DESIGN AND IMPLEMENTATION

- Governments in developing countries, particularly in Sub-Saharan Africa, should prioritize investments in improving the reliability of power systems and energy efficiency since they make more power available for final consumption and are therefore likely to be the most effective interventions for boosting both economic growth and employment, resulting in more productive and better-paid jobs.
- Policy makers should push forward with increased deployment of renewables and more openness to regional electricity trade (which expands the market for renewable-source power) since these policies have positive impacts on GDP and employment, particularly when implemented in concert, creating synergies between interventions.

- Governments should also focus on support that facilitates labor market mobility and training of new and existing workers through programs developed with input of the private sector that typically implements clean energy projects.
- At the project design stage, teams should:
  - Develop theories of change (TOC) to conceptualize channels of job creation (see box 7.1 and figure 7.1 for details);
  - Use the TOC to trace implications of enhanced access to power and availability of more reliable power for households, enterprises, MSMEs, and large-scale enterprises. On this basis, implementing agencies should provide complementary inputs and design M&E to track jobs impacts (for details on how to achieve this, see World Bank 2023m);
  - Establish mechanisms to track creation of direct and indirect jobs, e.g., through periodic surveys;
  - Implement active labor market policies to enhance job creation in communities:
    - use information campaigns/advertisements to increase local and regional awareness of employment opportunities in projects coming up;
    - balance local hiring (unskilled labor) with creating opportunities and providing training for semiskilled workers for longer-duration contracts in work that is more specialized and mobile;
    - design technical and vocational education and training programs in line with job requirements of government clean energy deployment programs in collaboration with implementing agencies and contractors.

BOX 7.1

WHAT IS THE TOC OF A CLEAN ENERGY PROJECT?

In any project, the articulation of a theory of a change (TOC) is essential to devise measures to track jobs (direct, indirect, and induced). A TOC comprehensively illustrates how a set of interventions/activities may lead to the change that a program or project is trying to achieve within a particular context. Designing a TOC assists in ensuring that a project is grounded in evidence, as charting the steps in a causal pathway allows project designers to assess whether the path is valid. Additionally, a TOC helps inform the design of effective performance monitoring and evaluation systems to further identify suitable indictors that can measure the success of interventions along the causal pathway. Also, a TOC identifies the long-term outcomes (and impacts) that are to be achieved through related outputs and outcomes.

(*continues*)

BOX 7.1 (*Continued*)

Figure 7.1 provides an example of an overarching TOC for a clean energy development project with job creation as an explicit objective. It highlights four major project activities: (i) infrastructure investments; (ii) capacity building; (iii) use of incentives; and (iv) local community development. Depending on the job creation objective and project intervention, the TOC can be broken down by specific sets of activities-outputs-outcomes.

Specifically, the TOC illustrates how these activities can create direct and indirect jobs associated with a project, as well as induced jobs at various stages of the project cycle. Jobs are created at both output and outcome stages depending on the causal pathway designed. Most induced jobs are created at the outcome level because, for induced jobs to materialize, projects often need to be at an operational and/or implementation phase. For example, productive uses of electricity can arise only once electricity is available, after which jobs are created; or once community development projects are developed, local businesses can provide services that, in turn, increase induced jobs.

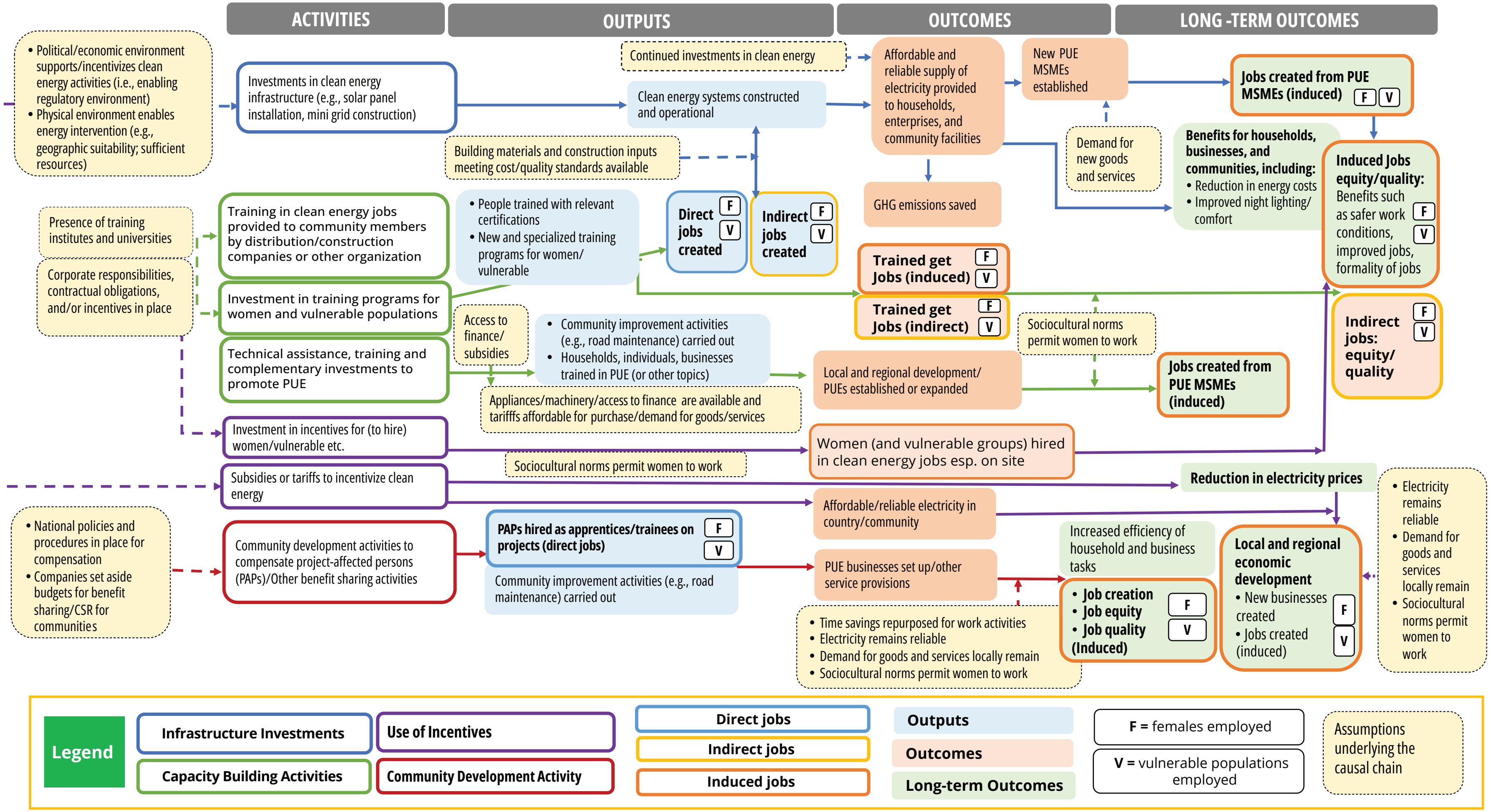
Each outcome statement in the TOC should be measured with one indicator, or a set of indicators, that comprise the results framework. Two key indicators are job equity and job quality. To assess job equity the data collected should be disaggregated per gender and vulnerability status, while other variables of interest can be age, geographic locations, urban/rural split, etc. For job quality, the key data points to follow are wages, safe work conditions/standards, and job formality status.

The TOC should highlight key assumptions along the causal pathway that must hold for project outputs to translate into immediate and long-term outcomes. For example, in the absence of sociocultural norms that favor the participation of women in the labor force, project-level investments in training women are unlikely to improve employment outcomes. If these assumptions do not hold, projects need to carry out complementary activities that help ease these constraints. This may mean going beyond the typical focus on only electricity and including activities that support the design of a project.

Source: World Bank 2023m.

FIGURE 7.1

Overarching Theory of Change for Clean Energy Interventions



Source: World Bank 2023m.

Note: The TOC is not intended to be replicated in its entirety as the causal pathways will be country- and context-dependent. Relevant indicators can be selected to fit any particular project.

- For electrification projects, support productive use of power through awareness raising, training, and complementary interventions (e.g., provision of credit), using private sector implementors including NGOs, as needed.
- Use the funding made available for resettlement and livelihood restoration activities in communities impacted by infrastructure projects to train and employ local workers, ensuring that women, minorities, and less-advantaged groups are included in the hiring pool.
- In communities heavily reliant on coal, which often lack acceptable job alternatives, follow a deliberate process when repurposing coal-fired power plants:
  - Identify use/development options for region/site (based on terrain/land-use possibilities, location/proximity to markets, existence of transport or other infrastructure, etc.);
  - Analyze potential for jobs and the nature of these jobs based on market surveys (i.e., carry out an assessment of demand for potential products/uses of the site);
  - Assess skills in existing labor force and their preferences, and determine the numbers needing to be absorbed;
  - Agree on a repurposing option that accounts for the availability of labor as well as the possibility of employing it, among other considerations.
- In places where governments have concerns about switching from a dependence on fossil fuels to a dependence on imported technologies, or are keen to pursue clean energy industrialization, industry-level analyses are needed to identify the segments of specific supply chains that a given country would be competitive in. Many developing countries have the potential to invest in particular segments of clean energy supply chains but careful country and industry analysis is needed for such strategies to be successful.
- Include learning opportunities in first mover/early projects and incorporate lessons from these projects into the design and rollout of larger programs so that subsequent projects can benefit.
- To address gender gaps, improve the awareness of all players involved and design concrete action plans. Developers typically do not proactively enable women's integration on site. This can impede the participation of women in semiskilled positions in large-scale projects because of ideas about appropriate gender roles, concerns about safety and security, and logistical factors such as need for separate accommodation. Therefore, it is important that financiers mandate that all data collected is gender disaggregated and that accountability is fixed, and incentives are in place for actions to be taken to improve gender balance in the employment generated through clean energy projects.
- Understand that large-scale "one-size-fits-all" programs rarely work—detailed socioeconomic research and consultation is needed at the local community level no matter which energy transition–related intervention is being deployed, whether it is a coal transition project, or support to productive uses of electricity, or local area development related to resettlement of people as part of a large-scale RE project. Every community has different wants, needs, potential and actual sources of income, locational constraints, etc., all of which must be taken into account in the TOC and, following that, in the design of interventions for job creation of a given project.

Development of Education and Training Options for Successful Clean Energy Skills Development

- Governments should clearly communicate career opportunities in clean energy. Information campaigns and targeted programs (such as internship and mentorship programs) can raise awareness of clean energy job prospects and inform job-seekers about required qualifications. Collaboration between ministries of energy, labor, and education is crucial for development of successful information campaigns.
- When designing education programs, governments should aim to meet clean energy industry needs in their country's circumstances (e.g., focus on skills for solar PV plants, if government's renewables plan focuses on solar deployment). This process requires input from industry players present or willing to invest in the country. Higher education and TVET institutes require support to upgrade existing programs and facilities and keep them in line with rapid technological development. This may involve financial aid, staff development, and technical assistance.
- To ensure quality education and training, governments should recognize international standards, develop national standards or collaborate with the private sector to establish accreditation schemes specific to clean energy job profiles ensures that workers possess the necessary competencies.
- To facilitate supply of qualified workers in places where clean energy deployment is planned, governments need to pay attention to expanding access to education and training. Geographic diversity in program locations should be considered, aligning with clean energy project sites. Encouraging participation by women and disadvantaged groups, providing scholarships, and exploring mobile and online training options can also enhance access.
- To establish best-practice education and training programs, governments can look to neighboring countries with established programs in clean energy to harness lessons learned. Governments of small countries or countries with small clean energy markets may consider joining forces when creating education and upskilling programs.

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