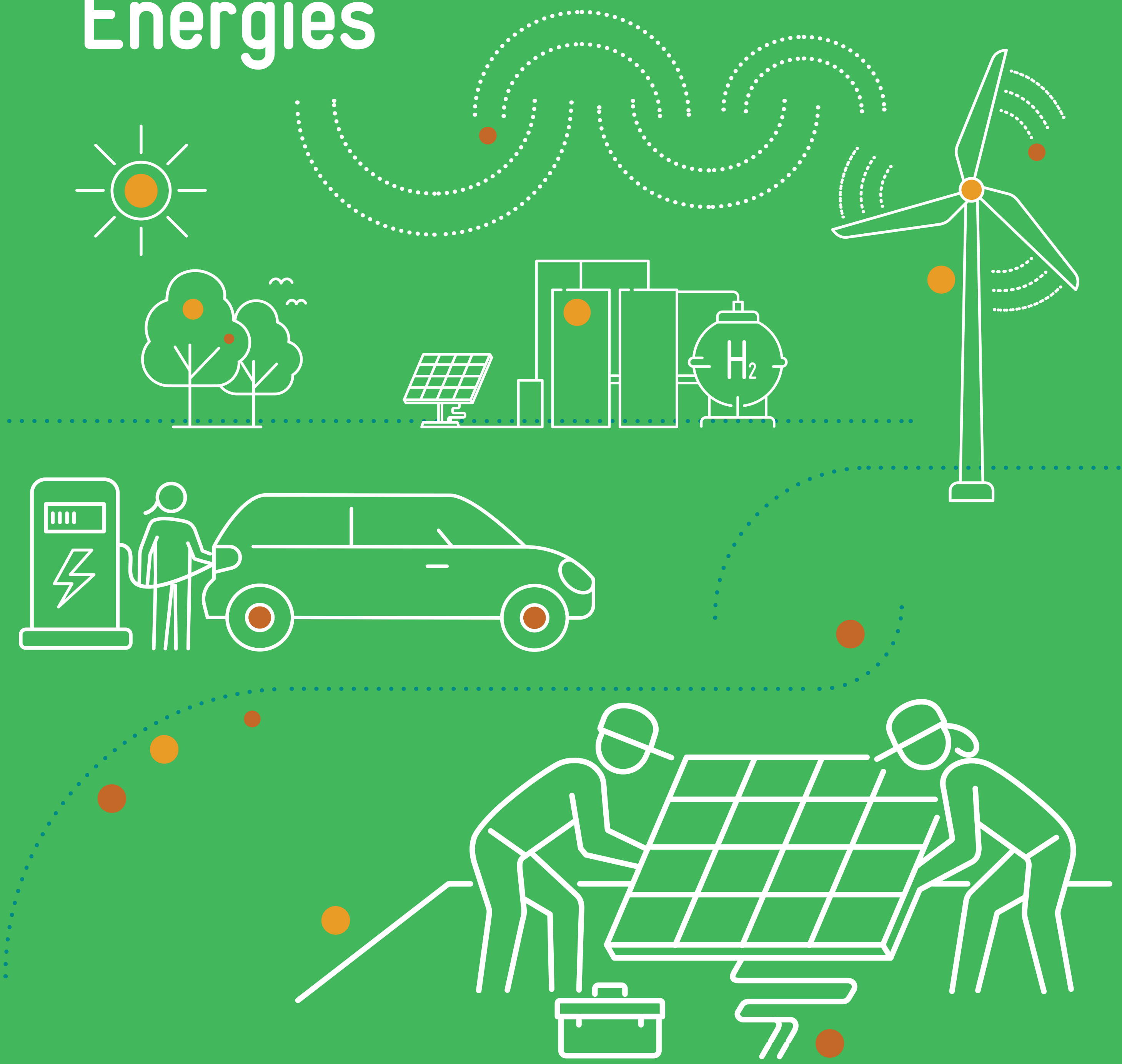
Sectoral Study

TVET for Renewable Energies



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Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany

T +49 228 44 60-0
F +49 228 44 60-17 66
I www.giz.de

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Sector Project Technical and Vocational Education and Training (TVET)
svbb@giz.de

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Discussion Paper: Skills for a Just Transition to a green future
Sectoral Study: TVET for Renewable Energies
Sectoral Study: TVET for Sustainable Construction
Sectoral Study: TVET for Sustainable Mobility
Vision Paper: What TVET can and must do in a Just Transition to a Green Economy

Authors
Waldemar Bauer (FAKT Consult)
with the collaboration of: Niklas Hayek (FAKT Consult)

Responsible / Editor
Amelie Daas, Annika Hornberger, Anja Speicher, Svenja Müller, Ute Jaskolski-Thiart

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List of abbreviations

ADA	Austrian Development Agency
ASEAN	Association of Southeast Asian Nations
AU	African Union
BDEW	Bundesverband der Energie- und Wasserwirtschaft (German Association of Energy and Water Industries)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development)
CEDEFOP	European Centre for the Development of Vocational Training
CNI	Confederação Nacional da Indústria (Brazilian National Confederation of Industry)
CSP	Concentrated solar power
DACUM	Developing a Curriculum
ESCO	Multilingual classification of European Skills, Competences, Qualifications and Occupations
ESD	Education for sustainable development
EU	European Union
EUEI	European Union Energy Initiative
FC	Financial cooperation
G7	Group of Seven: informal group of the most important western industrialised nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GW	Gigawatt
IEA	International Energy Agency
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
ISCO	International Standard Classification of Occupations
JETP	Just Energy Transition Partnership
KfW	KfW Development Bank
kWh	Kilowatt hour
kWp	Kilowatt peak
LNOB	Leave no one behind
MINT	mathematics, computer science, natural science and technology (used in German as more or less equivalent to STEM)
MME	Ministério de Minas e Energia (Ministry of Mines and Energy, Brazil)
MNRE	Ministry of New and Renewable Energy (India)
MT	Millions of tons

MW	Megawatt
MWh	Megawatt hour
MWp	Megawatt peak
NISE	National Institute of Solar Energy (India)
NOS	National Occupational Standards
NQF	National Qualifications Framework (NQF)
O*NET	Occupational Information Network (USA)
OACPS	Organisation of African, Caribbean and Pacific States
OECD	Organisation for Economic Co-operation and Development
PIDA	Programme for Infrastructure Development in Africa
PtX	Power-to-X
PV	Photovoltaics
REN21	Renewable Energy Policy Network for the 21st Century
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SCGJ	Skill Council for Green Jobs (India)
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All (an international organisation that works in partnership with the UN)
SENAI	Serviço Nacional de Aprendizagem Industrial (National Service for Industrial Training, Brazil)
SHS	Solar home system
SSC	Sector Skills Council (India)
SSDP	Suryamitra Skill Development Programme (India)
STEM	Science, technology, engineering and mathematics
TC	Technical cooperation
TEI	Team Europe Initiatives
TVET	Technical and vocational education and training
TWh	Terrawatt hour
UBA	Umweltbundesamt (German Environment Agency)
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-UNEVOC	UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training
WE4A	Women Entrepreneurship for Africa

0 Abstract

Worldwide, the energy sector is one of the main sources of CO_2 emissions. The consequences of climate change and growing social injustice are making increasingly clear that there is an urgent need to limit climate change, promote sustainable growth, and improve access to clean, modern energy for all. This will require a global energy transition that will phase out electricity generation associated with CO_2 emissions and move towards a carbon-neutral energy supply.

In African and Asian states, rapid economic and population growth has pushed up demand for energy in recent years. Rolling out the use of renewable energies is thus key to achieving many of the Sustainable Development Goals set out in the 2030 Agenda in the partner countries of German development cooperation. **Renewable energies are vital for climate change mitigation. In developing countries, they are also pivotal in providing access to modern energy for sustainable economic development, and thus reducing poverty. However, a just energy transition can only succeed if enough skilled workers are available**. Labour-market-oriented initial and continuing technical and vocational education and training (TVET) are needed to ensure work on energy technology systems is conducted professionally.

This is one of five studies exploring *Skills for a Just Transition to a green future*, published by the Sector Project TVET of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). It explores **how German development cooperation can help partner countries align TVET with the imperatives of a just energy transition**. Substantial changes, such as technological developments in the energy sector, are examined for their relevance to the content of initial and continuing TVET. This is then distilled into **recommendations for action that address those responsible for planning and implementing development projects**. The study is based on an analysis of data and literature and on interviews with representatives of government institutions and development projects in selected partner countries, India, Brazil, Vietnam, Nigeria, Uganda and South Africa.

Wind farm in the Atacama Desert, Chile.
© GIZ/Thomas Imo

The greatest potential is offered by wind and solar energy, with geothermal energy and modern biomass contributing to some extent. Existing cooperation arrangements to produce green hydrogen could also be valuable for some partner countries. In rural regions not yet connected to the national power grid, small photovoltaic systems and mini-grids must be rolled out, along with clean cooking technologies. Grid-connected photovoltaic (PV) systems and wind turbines are increasingly being installed in many countries. The electricity generated from renewables must be safely and flexibly fed into power grids and distributed. Smart technologies should thus help these partner countries expand their electricity grids and achieve greater flexibility.

Future projects should always be planned under the broader guiding principle of a just energy transition rather than targeting only the energy sector. When planning future projects, the author recommends that **technology activities always be linked with measures to promote employment and TVET**. In this way, skilled workers can be trained at an early stage. Their professional work can promote innovation, ensure quality, minimise risks and thus help develop the sector. Two conceptual approaches can be pursued: **(1) cross-sectoral, integrated project designs** that directly link TVET components to technology promotion measures; **(2) connected project designs** with organisational or work units acting jointly, thus enabling projects that would normally be separate to share staff and content.

In order to promote the involvement of and cooperation with the private sector, the study suggests organising **sectoral committees for green employment**. These institutions should identify the demand for skilled labour and qualifications, and be involved in the development of occupational profiles, professional standards, curricula and the regulation of examinations and certifications.

The study proposes three measures for the design of TVET. **Green occupational profiles and curricula should be developed for existing and new regulated occupations.** In ongoing vocational training projects, the **existing conventional occupations in construction, electrical, metal and supply engineering should be reviewed and adapted accordingly**. In future projects, **relevant occupations for renewable energies should be identified and developed from the outset on the basis of needs analyses**. It is also recommended that future projects to support **green TVET centres should take a holistic approach**. When they are designed, the buildings themselves and the technical energy systems should be planned to factor in use for pedagogical and didactic purposes.

The author emphasises the importance of teaching and learning processes in the acquisition of practical vocational skills and in generating awareness of the need to act sustainably. He recommends the use of **action-oriented learning concepts**. **Teachers should be prepared and trained** to design action-oriented learning environments.

1 Introduction

Climate change, biodiversity loss and rising social inequality threaten the stability of our economy, society and governance and to our very existence. To conserve resources and reduce CO2 emissions, we urgently need to transform our economic model into a Green Economy. This endeavour will take tremendous efforts that transcend all national borders. The transition to a Green Economy will do more than simply benefit the climate; it will also create many new jobs in Green Sectors and in industry as a whole. For instance, it is estimated that 25 million new jobs in renewables will be created by the year 2030.

German development cooperation (DC) is committed to a Just Transition to a Green Economy that takes account of the needs of everyone involved. But how can we shape this Just Transition? This exact question is currently at the heart of development debates. After all, not everyone will be a winner under this transition. Industrial sectors that harm the climate will no longer be needed. Many people will lose their jobs and have to find a new job in a different line of work. These people must not be left behind (in keeping with the 'leave no one behind' (LNOB) principle). In fact, everyone must be given the opportunity to take part in and benefit from the transition, especially those who did not have this opportunity in the past or who will lose their job as part of the transition. Therefore, decent jobs must quickly be created in the new Green Sectors to provide new income opportunities for as many people as possible and avoid leaving people behind.

Policy-makers have the task of designing the foundation for a Just Transition early on. This work includes the legislative framework and labour market policy instruments, such as financial incentives for companies, along with accompanying social benefits. Technical vocational education and training (TVET) plays a vital role here because it will be the vehicle through which new skilled workers will be trained to perform green jobs. TVET ensures that people remain employable in the Green Economy and can actively advance the transition with their skills.

Therefore, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Sector Project TVET is publishing five studies on Skills for a Just Transition to a green future on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). The first study developed theses and recommendations for the design of DC interventions related to Green Skills. They include supporting partner countries in aligning TVET with a Just Transition (GIZ, 2022). The three practical studies, addressing the renewable energy, green construction, and sustainable mobility sectors, are primarily geared towards project planners and implementers in development cooperation. The studies offer action-oriented recommendations on ways that Green TVET can support the Just Transition to a Green Economy in partner countries. The policy vision paper focuses on the development of the future economy and illustrates how TVET in partner countries must be adapted to meet new training needs. In doing so, it draws on the combined findings of the three sectoral studies.

This study, one of the three sectoral studies, addresses the renewable energy sector. It analyses technological developments and employment in the renewable energy sector in developing countries and emerging economies in Africa and Asia. The demand for green occupations and skills is identified in this context. The study then goes on to explore strategies, measures and experiences in TVET projects in the renewable energy sector. Based on the outcome of these analyses, recommendations are set out for TVET experts involved in the planning and implementation of future projects (at both political level and implementation level) regarding Green TVET in the renewable energy sector as part of development cooperation. These recommendations for action are translated into more detail in the form of exemplary measures for green vocational training projects. The study thus contributes to the further development of Green TVET projects with cross-sectoral links (in line with the BMZ 2030 reform process; BMZ, 2022a).

In the 2030 Agenda, the international community adopted 17 Sustainable Development Goals (SDGs) for socially, economically and environmentally sustainable development. These goals form the basis for cooperation between countries. SDG 7 is to ensure access to affordable, reliable, sustainable and modern energy for all – an important agreement for the energy sector. In conjunction with the Paris Agreement on climate change, this SDG can support the transition to low-emission and resource-efficient economies and lifestyles.

The need to limit climate change, foster sustainable growth and improve access to clean, modern energy for all people is driving the global energy transition, which aims to phase out all forms of power generation that entail CO2 emissions, and to move to a carbon-neutral energy supply. **Renewable energies do much to mitigate climate change and promote sustainable social and economic development.** Furthermore, improving access to affordable and sustainable energy in developing countries and emerging economies is key to reducing poverty and thus a central goal of development cooperation. The 2030 Agenda explicitly calls for a focus on the weakest and most vulnerable members of society and demands that no one is left behind (LNOB) (**BMZ**, 2022b; **BMZ**, 2022c).

Renewable energy sources and technology can be used in many different contexts and cover a wide spectrum in terms of output. They are used to generate electricity, and provide energy for heating and cooling, such as heating water or buildings and providing process heat in industry. Furthermore, fuels can be produced for the mobility sector. Replacing fossil fuels with renewables in different areas such as buildings, industry and transport helps decarbonise energy consumption in these sectors. This study mainly looks at generating electricity from renewables and the related occupations and employment. Other applications are considered in the other two sectoral studies.

2 The relevance of the renewable energy sector in the context of sustainability

International agreements such as the Paris Agreement, the 2030 Agenda with its Sustainable Development Goals, political agreements (e.g. the European Green Deal and the package of political Team Europe Initiatives (TEI)) as well as other national policies around the world have ushered in the green transition in many countries. In the 2015 Paris Agreement, almost all countries in the world committed to limit the global temperature increase to well below two degrees Celsius, preferably to 1.5 degrees Celsius, and to adapt to the consequences of climate change (BMZ, 2022d).

Since the Rio+20 Conference in 2012, if not before, the vision of a Green Economy has become generally accepted, in conjunction with sustainable development (OECD, 2011; UBA, 2013). The United Nations Environment Programme (UNEP) defines the Green Economy as 'one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.' The German Federal Ministry for the Environment and the German Environment Agency see the Green Economy as an innovation-oriented national economy that is in harmony with nature and the environment. In this economy, harmful emissions and pollutants are avoided in all ecosystems and the use of non-renewable resources is reduced, especially by making more efficient use of energy and raw materials. Non-renewable resources are replaced by sustainable renewable resources in order to achieve an energy supply based exclusively on renewable energies in the long term (BMU, 2012; UBA, 2013). This illustrates the key role played by the green energy transition in the move towards a low-carbon and low-emission economy.

In the international discourse, this broad guiding concept is termed Just Transition. The International Labour Organization (ILO) believes that a 'Just Transition means greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind.' (ILO, 2022) A **Just Transition is thus a socially acceptable shift to a sustainable economy and to coping with anthropogenic climate change, which can only be managed with a global energy transition.** This is where the guiding concept of the just energy transition comes in. The energy supply of the future must be fair and climate-neutral for all people (BMZ, 2022e).

The 2030 Agenda's SDG 7 states that by 2030 all people are to have access to affordable, reliable and modern energy and that the percentage of the global energy mix accounted for by renewable energy is to be significantly increased. The targets make specific mention of developing countries and least developed countries. In these countries, infrastructure is to be expanded and technologies modernised in order to provide clean energy for all. To achieve this goal and attain the 1.5 degree target, renewable energy will have to be rolled out much faster and used to a much greater extent across all applications in industry, commerce, trade, households, agriculture and transport. Like the African Union (AU) in its Agenda 2063: The Africa We Want, many countries and regional associations have translated this goal into regional and national strategies and taken the first steps towards a green energy transition.

The situation in terms of access to energy and security of energy supply varies enormously in different African and Asian states. Africa's share of global energy consumption is around 6% while it is responsible for only 3% of global electricity consumption. Africa is the continent with the lowest level of electrification. Sub-Saharan Africa in particular suffers from severe energy poverty. In these countries, around 600 million people have no access to electricity (IEA, 2022a). The energy supply is often unreliable, there are supply bottlenecks and energy costs are high. It is estimated that two-thirds of the electricity grids in sub-Saharan Africa (excluding South Africa) are inefficient (PwC, 2021). The North African countries and South Africa are exceptions, with a substantially higher degree of electrification and total energy consumption. Population growth and rising living standards mean that energy demand in Africa is expected to double by 2040. Energy poverty and inefficient electricity supply impact adversely on economic and social development in sub-Saharan Africa. They hinder productivity and limit educational opportunities and health care. Many households and schools have no electricity supply. Here, the interconnectedness of different development goals becomes apparent, such as between SDG 7 and SDG 4 (ensure inclusive and equitable quality education). In sub-Saharan Africa, almost 70% of primary schools do not have access to electricity (UN, 2021). This makes electrification and improving access to energy priority development goals in many African countries. Sustainable development, energy and climate policy, education and poverty reduction are thus directly interlinked (BMZ, 2022c; GIZ, 2022a).

Commissioning of solar mini grids in Northern Uganda. © GIZ Uganda/Energy and Climate Cluster

In recent years, rapid economic and population growth, along with increasing urbanisation in member states of the Association of Southeast Asian Nations (ASEAN) have significantly pushed up demand for energy in a region already badly affected by climate change. Energy consumption has increased by more than 80% in the last 20 years and is expected to increase by another 60% by 2040, representing 12% of the global increase in energy consumption. Currently, ASEAN member states generate most of their energy from fossil fuels, which account for about 80% of the region's energy supply (ACACE, 2020). In their Plan of Action for Energy Cooperation (APAEC), ASEAN member states set out the aspirational target of increasing to 23% the share of renewable energies in the ASEAN energy mix and raising the share in electricity production to 35% by 2025 (ACE, n.d.). The individual countries are taking very different paths towards this goal, with different technological focuses.

Text box 1: Renewable energy expansion potential in Africa and Asia

Africa's climate and geography gives it enormous potential for harnessing renewable energies. If the continent makes greater use of biomass, geothermal energy, solar energy, hydropower and wind energy, it can play a stronger role in the global energy economy (KfW, GIZ & IRENA, 2020). The International Renewable Energy Agency (IRENA) estimates that Africa could meet almost a quarter of its energy needs and almost half of its electricity needs from local renewable energy sources by 2030, provided that plants with an installed capacity of 310 gigawatt (GW) are put in place. This would require investments of 70 billion US dollars every year until 2030 (IRENA, 2021).

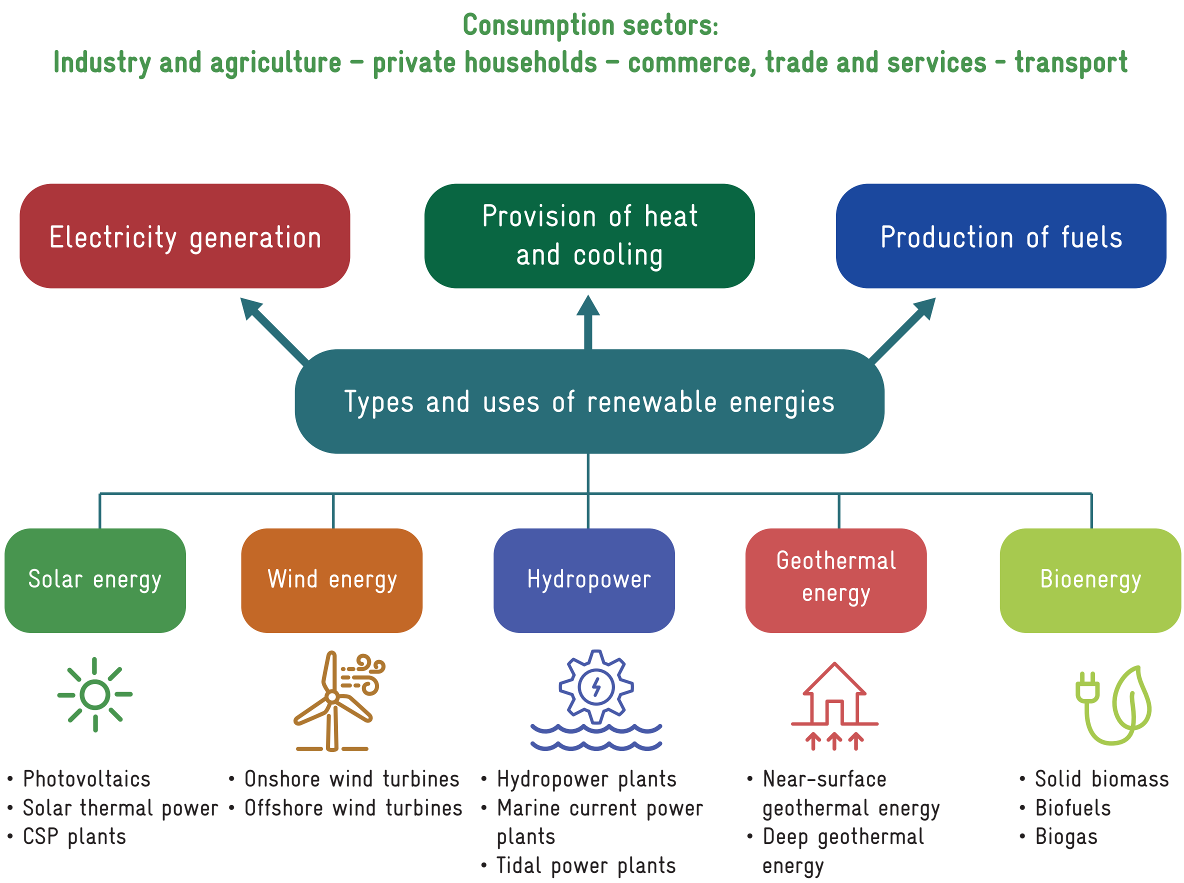
India is currently overtaking China and has become the most populous country. For further economic development, not only sufficient jobs for young people must be created, but the energy supply must also be expanded. The International Energy Agency (IEA) forecasts that electricity demand in India will increase by 50% by 2030 (IEA, 2021a). India is already the third largest consumer of electricity (and the third largest emitter of greenhouse gases) in the world. India has passed several laws and regulations on sustainability and renewable energy. The power generation capacity from non-fossil energy sources is to be expanded to cover 40% of the country's energy mix by 2030 and the capacity is to be increased to 500 GW (MNRE, 2022). Some 400 renewable energy projects with an investment volume of almost 200 billion US dollars are currently being implemented across the country (GTAI, 2021). Moves to drive the development of renewable energy in India are pursuing several different technologies, including rooftop and ground-mounted photovoltaic (PV) systems, floating PV systems, wind farms and wind-solar hybrid parks (GIZ, GTAI & AHK, 2021). In addition, old coal-fired power plants are being retrofitted and new coal- and gas-fired power plants are being built (over 100 projects, volume approx. 100 billion US dollars). The power grid is being modernised and expanded (GTAI, 2021).

3 Technological developments in the renewable energy sector and their relevance in the context of DC

Use of renewable energies

Renewable energies include solar energy (e.g. photovoltaics and solar thermal energy), wind energy (onshore and offshore wind turbines), hydropower (hydroelectric power plants), biomass (e.g. biogas, biofuels, wood and other solid fuels) and geothermal energy. Renewable energies have many uses and are used to generate electricity, supply heating and cooling, in transport, industry, agriculture and many other areas.

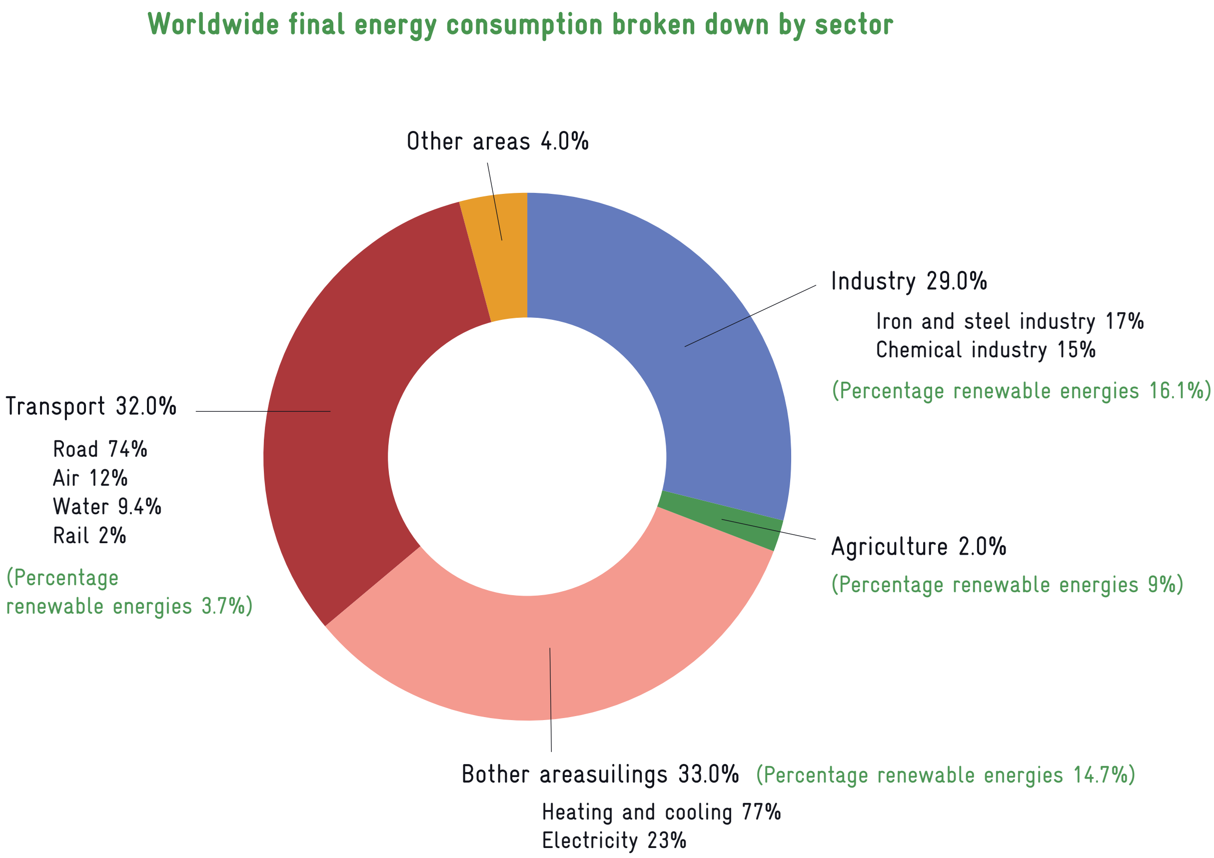
Figure 1: Renewable energies and applications



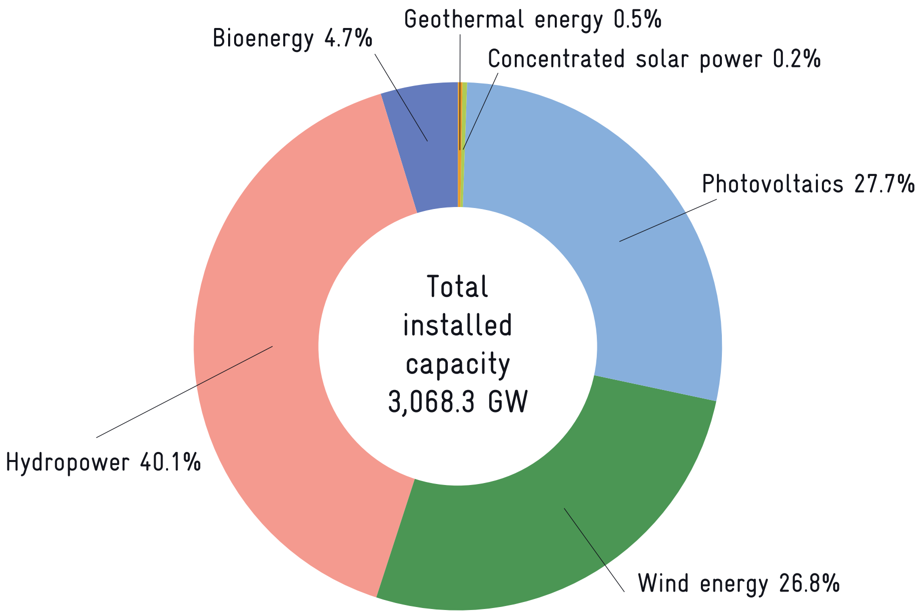
The energy-consuming sectors used e.g. in energy balances, are industry, private households, trade, commerce and services, and transport. International statistics show the buildings sector (households, etc.) separately. In 2019, global final energy consumption (cf. figure 2) was broken down by sector as follows (REN21, 2022): buildings 33% (77% heating and cooling), industry 29%, agriculture 2% and transport 32% (of which 74% was accounted for by road transport).

Worldwide, most electricity (63% of the total) is generated in fossil-fuel-fired thermal power plants. Renewable energies account for some 28% of the global electricity mix (REN21, 2022). **Renewable energies in fact accounted for only 12.6% of final energy consumption in 2020.** Hydropower has the highest share of electricity generation from renewable energies, at about 40%. This is followed by PV solar energy with almost 28% and wind energy with just under 27% (IRENA, 2022a). **To meet the 1.5 degree target, the share of renewables would have to be increased to at least 65% by 2030,** which would require an additional capacity of 8,000 GW. The total capacity of PV plants would have to be increased to 5,200 GW, of wind turbines to 3,000 GW and of hydropower plants to 1,500 GW (IRENA, 2022b).

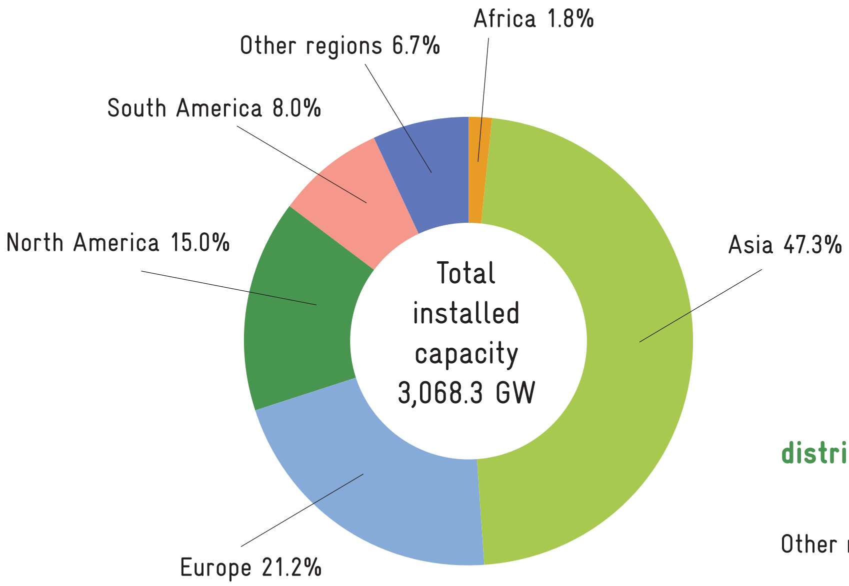
Figure 2: Global final energy consumption by sector (2019) and renewable electricity generation by energy type and region (2021) (based on IRENA, 2022a and REN21, 2022)



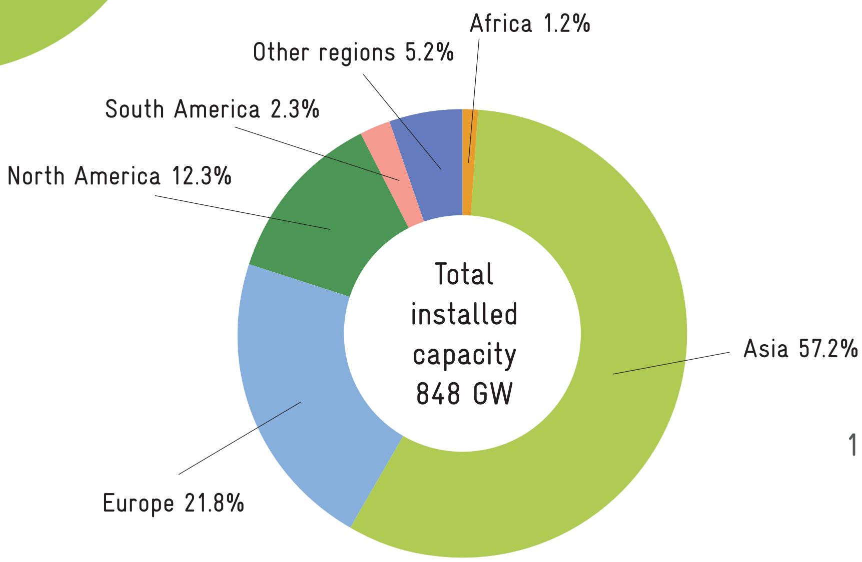
Electricity generated from renewable energies – broken down by type of energy and technology



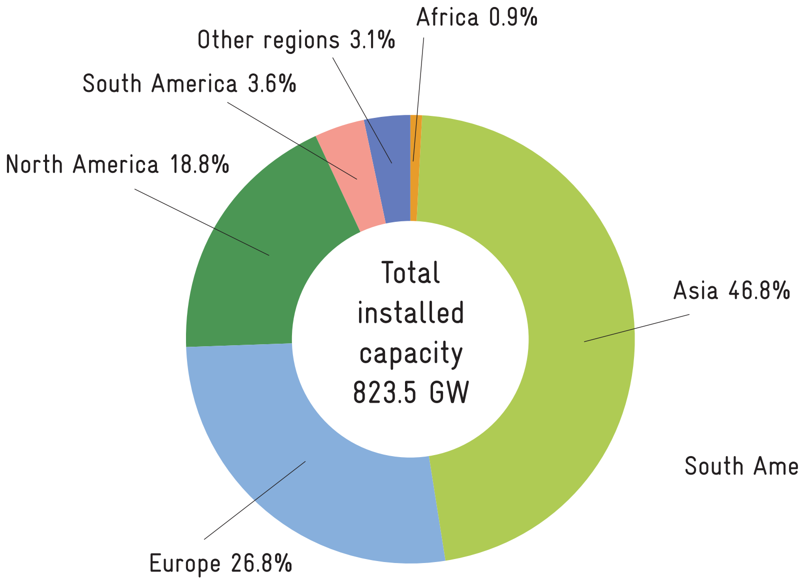
Electricity generated from renewable energies – Breakdown of installed capacity by region



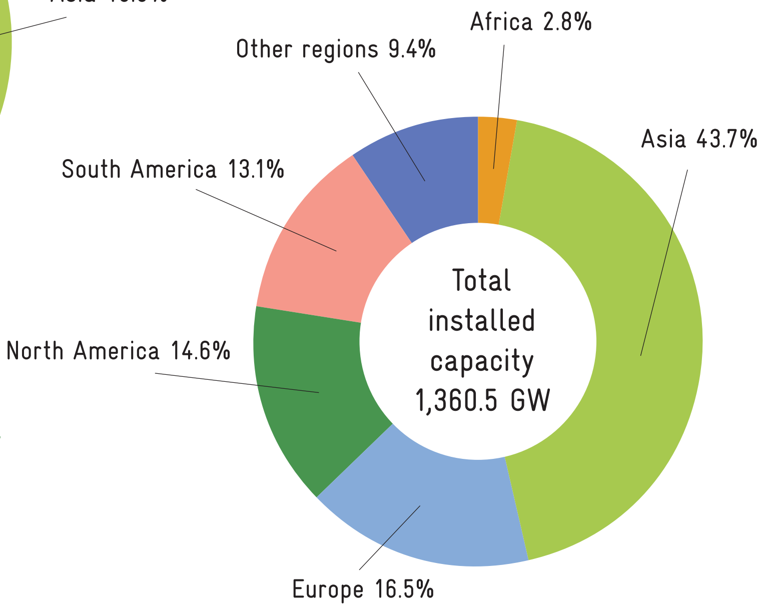
Photovoltaics: distribution of installed capacity



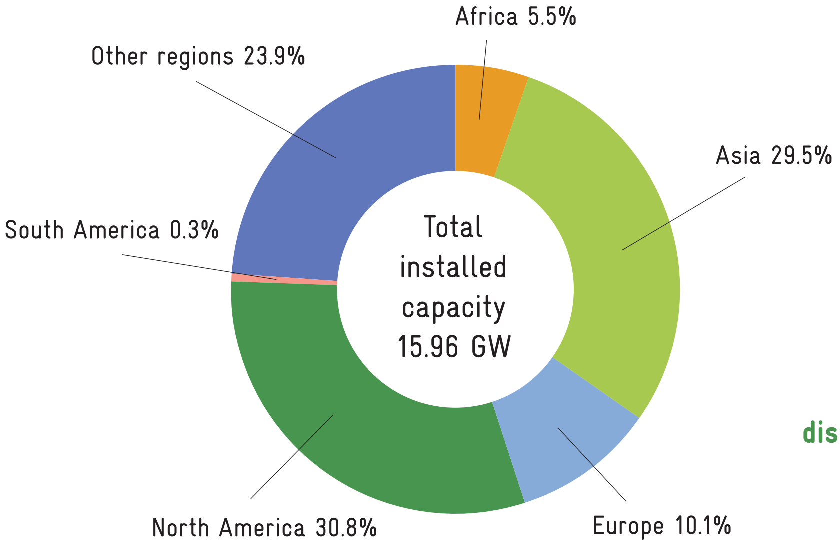
Wind energy: distribution of installed capacity



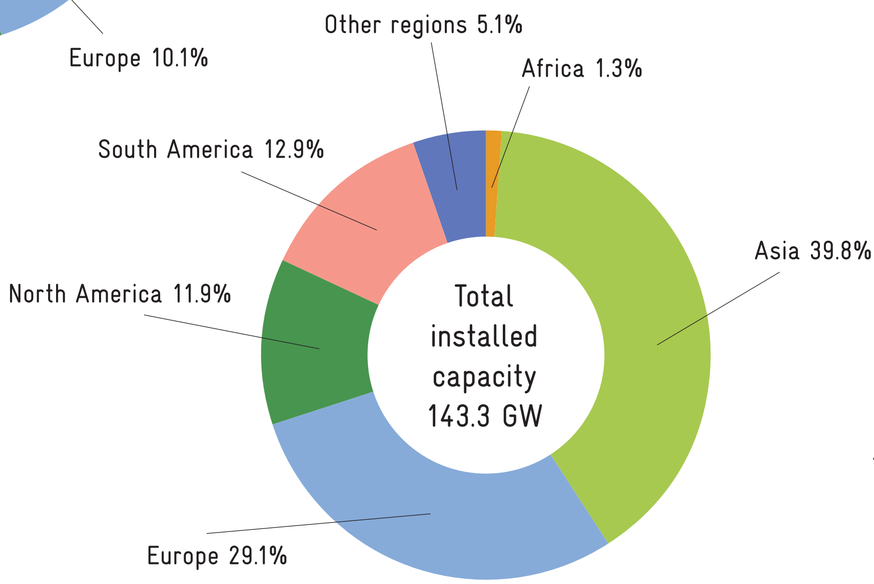
Hydropower: distribution of installed capacity



Geothermal energy: distribution of installed capacity



Bioenergy: distribution of installed capacity



Solar energy

Photovoltaic (PV) systems and solar thermal systems use solar radiation to generate power. PV systems use solar cells (combined to form modules) to convert the sun's energy into electrical energy. Solar thermal systems convert the sun's energy into thermal energy. They are used to generate heat (e.g. for hot water or space heating), steam and cooling.

Solar thermal power plants use solar energy to generate electricity. They collect and concentrate sunlight (concentrated solar power, CSP), to heat a transfer medium (e.g. thermal oil or steam). The steam is converted into mechanical energy in a turbine which powers a generator to produce electricity. CSP plants worldwide have a total installed capacity of 6.4GW, of which 1.1 GW are installed in Africa (South Africa and Morocco approx. 0.5 GW each) and 0.92 GW in Asia (India 0.34 GW). **Solar thermal power plants are found less frequently in developing countries due to high investment costs.**

PV systems for electricity generation can broadly be divided into two types: off-grid and on-grid (or grid-connected) systems. Stand-alone systems are available for very many applications involving a wide range of output. One important application is low-cost pico PV kits (small solar systems with a maximum output of 10 W), which are used to power small devices (e.g. lighting or mobile phone chargers). Another technology for households in regions not served by the national grid, especially in sub-Saharan Africa, are solar home systems (SHS). Solar home systems are small, stand-alone photovoltaic systems that provide a basic power supply, e.g. for simple huts.

Decentralised, off-grid PV systems supply electricity to a larger number of consumers (e.g. small villages) via stand-alone grids (mini-grids). A solar mini-grid is usually an integrated system that includes energy generation, storage, conversion and distribution. **This technology is important in many green energy development projects, including the Green People's Energy for Africa initiative, to provide electricity to households, small businesses and other facilities in rural areas** (GIZ, 2022a; GIZ, 2022b). Hybrid systems are frequently installed, that also incorporate energy systems such as diesel generators.

Grid-connected systems are integrated into the public electricity grid. These can be divided into residential rooftop PV systems (approx. 1-50 kWp), commercial or industrial rooftop PV systems (> 40 kWp) and ground-mounted PV systems (> 1 MWp). In some countries in Africa and Asia, more grid-connected systems are now being introduced.

In 2021 the global installed capacity of PV systems was around 848 GW (cf. figure 2, Photovoltaics). About half of the capacity (486 GW) is in Asia (China 307 GW, India 49.3 GW) (IRENA, 2022a). Vietnam's progress in adding capacity should also be mentioned. It increased its renewable energy capacity from 18.7 GW in 2018 to 42.7 GW in 2021. The expansion was financed through projects implemented by international organisations and encouraged by high feed-in tariffs for an interim period (GIZ, 2020). Vietnam has also launched the Rooftop Solar Promotion Programme with the aim of installing 100,000 rooftop solar systems (or 1,000 MWp) (GIZ, 2021a).

In 2021, PV plants in Africa had an installed capacity of 10.3 GW, equivalent to 1.2 % of the globally installed PV capacity. South Africa and Egypt have the greatest installed capacity at 5.7 GW and 1.7 GW respectively. Solar installations are spread across the entire African continent, from the savannahs of sub-Saharan Africa to the densely populated West African states and the Sahara Desert (KfW, GIZ & IRENA, 2020). With an installed capacity of 1.5 GW, Egypt's Benban solar park is the largest PV plant in Africa. Morocco is home to the Ouarzazate and Midelt solar complexes, which consist of three CSP power plants and one PV plant with a total capacity of 580 MW. Two more CSP/PV hybrid power plants are to provide a capacity of 800 MW (IRENA, 2021).[1]

Wind energy

Wind turbines for electricity generation are very common, operating in over 100 countries. The turbines can be located on land (onshore) or in the sea (offshore). These plants account for about 6% of electricity generation worldwide. In 2021, the total capacity was around 823 GW (cf. figure 2, Wind energy), of which some 385 GW was installed in Asia (China 329 GW, India 40 GW, Vietnam 4.1 GW) and 7.3 GW in Africa (South Africa 3 GW, Egypt 1.6 GW, Morocco 1.4 GW). The total capacity of all onshore plants is 769 GW, while a small share of around 54 GW is installed offshore (IRENA, 2022a). In 2021, almost 94 GW of capacity was added worldwide, of which around 20 GW was offshore (GWEC, 2022).

Hydropower

Hydroelectric power generation has a long history and is used in many countries. **Worldwide, most electricity generated from renewable energies comes from hydropower**. It accounts for 40% of electricity generated from renewables and 16% of all electricity generated (IEA, 2022b; REN21, 2022). In 2021, the total capacity was 1,360 GW (conventional and renewable, see figure 2, hydropower), of which 594 GW are installed in Asia (India 51.6 GW, Vietnam 73.5 GW) and 37.7 GW in Africa (Ethiopia 4.1 GW, Angola 3.7 GW, South Africa 3.5 GW) (IRENA, 2022b).

Africa has a vast potential for generating electricity from hydropower, with less than 10% of that potential tapped so far. Most hydropower plants (about 40%) are located in Central Africa, followed by East Africa with about 28%. The theoretical total electricity that could be generated by hydropower plants is put at just under 1,500 terawatt hours (TWh) per year (KfW, GIZ & IRENA, 2020).

1 Some large solar projects are planned in some African countries, such as Algeria (4 GW by 2024), Zimbabwe (4 GW), South Africa (3 GW) and Ethiopia (3 GW). Nigeria launched the Solar Power Naija project in 2020 as part of its national development plan. The project aims to expand energy access for 25 million people by installing five million new household connections in rural areas in the form of solar home systems (SHS) and stand-alone PV systems (IRENA, 2021).

Geothermal energy

Geothermal plants use the geothermal energy stored in the accessible part of the Earth's crust. The geothermal heat can be used directly or to generate electricity. This can be realised technologically through near-surface geothermal energy (up to 400 m depth) and deep geothermal energy. Here, either the heat of the thermal water present underground or the heat from the deep rock is used.

In 2021 the total capacity of geothermal plants was 16 GW (see figure 2, Geothermal energy), of which Asia has a share of 4.7 GW (Indonesia 2.3 GW and Philippines 1.9 GW). In Africa, geothermal plants are found only in Kenya (0.86 GW) and Ethiopia (7 MW). In the Great Rift Valley, which runs through East Africa from Mozambique to Djibouti, a total potential of about 15 GW is available, which has not yet been harnessed (KfW, GIZ & IRENA, 2020).

Bioenergy

Biomass can be used to produce solid, liquid and gaseous fuels. Typical examples of solid bioenergy are wood fuels (e.g. wood chips, wood pellets). Liquid bioenergy sources are biofuels such as biodiesel or bioethanol. Biomass has multiple uses in many different areas (in the form of solid fuels for heating, biofuels for vehicles, and biogas for electricity generation).

The use of solid biomass can be divided into traditional and modern use. In traditional use, wood, charcoal, agricultural and forestry residues and manure are used for cooking and heating (BMWi, 2020). Globally, the traditional use of biomass still accounted for a larger percentage of final energy consumption (6.5%) in 2019 than modern biomass use (5.1%) (REN21, 2022). The International Energy Agency (IEA) estimates that **around 2.7 billion people use traditional biomass such as charcoal and firewood for cooking and heating**. In most African countries, around 90% of households use biomass to meet their daily energy needs, because biomass tends to be the only available energy source. **Cooking on traditional fireplaces or with inefficient cookers leads to extreme smoke pollution with harmful effects on human health and the environment. Another negative aspect is the irreversible deforestation** (KfW, GIZ & IRENA, 2020; REN21, 2022). The second largest contiguous tropical forest in the world lies in Central Africa. The forests of the Congo Basin account for around 25% of the CO_2 storage capacity of tropical forests worldwide and are therefore the second most important green lung of our planet. However, due to the loss and degradation of forests, caused primarily by the land and fuelwood requirements of the growing population, is this CO_2 storage capacity declining, (GIZ, 2020a). Alongside ensuring the supply of electricity, an important goal of development cooperation in rural regions is thus to provide clean cooking technologies.

In 2021, the global bioenergy capacity for electricity generation was around 143 GW (cf. figure 2, Bioenergy). Asia has an installed capacity of 57 GW (India 10.6 GW), while the figure for Africa is 1.8 GW (Ethiopia 0.34 GW, South Africa 0.27 GW) (IRENA, 2022a). **The scale of electricity generation from biomass in Africa is still low, but Central Africa in particular offers considerable potential**.

Green hydrogen

Global demand for hydrogen was around 87 million tonnes (MT) in 2020 and the World Bank expects demand to rise to 500-680 MT by 2050 (IEA, 2019). Currently, more than 95% of hydrogen production relies on the use of fossil fuels. Green hydrogen, produced by electrolysis with renewable energy, still accounts for only a tiny percentage of the total (IEA, 2021b). **Given the falling costs of solar and wind energy plants, the use of electrolysers at locations with suitable conditions for renewable energies could become a cost-effective option for producing hydrogen**.

Green hydrogen and sector coupling (see below) are also deemed to have the potential to foster sustainable development and socially and environmentally sound ecological economic transformation in developing countries. The creation of a hydrogen market in partner countries opens up opportunities for local value creation, job creation, and education and training. In development cooperation, advisory services, cooperation and export earnings offer great opportunities for partner countries in this context. Provided that green hydrogen is used appropriately on the ground, it can contribute to energy security, decarbonisation and the achievement of climate goals in partner countries, while at the same time promoting the expansion of renewable energies. The development of a local hydrogen market with corresponding value creation can thus make an important contribution to achieving the Sustainable Development Goals and a Just Transition (BMBF, 2022). This potential is already being taken up in several partner countries of German development cooperation. India, for example, has set mandatory quotas for the use of green hydrogen in refineries (10% as of 2023/24, increasing to 25% in the following five years) and for fertiliser production (5% as of 2023/24, increasing to 20% in the following five years). In the near future, green hydrogen is also to be used in the steel industry in India (IEA, 2021b). Brazil is currently planning the world's largest production facility for green hydrogen. As of the end of 2023, it is to produce 10,000 tonnes of hydrogen per year using renewable energies (Araujo, 2022).

System integration

The electricity increasingly generated by solar and wind power plants as well as other decentralised energy plants must be integrated into the electricity grids in a stable and reliable manner. The feed-in is subject to weather-related and local fluctuations. The high and variable percentage of electricity generation from renewable energies requires enormous flexibility on the parts of power plants and energy grids. Grid integration requires smart grids that can flexibly manage the generation, transport, distribution, consumption and storage of electricity. **Expanded and reinforced electricity grids and a high-performance telecommunications infrastructure (broadband) are needed, that can ensure the optimal exchange of energy and data and compensate for fluctuations in electricity generation.**

The integration of renewable energy systems thus increases the complexity of the energy system. Instead of a few centralised power plants, many decentralised, mostly weather-dependent plants are powered by renewable energies, while consumption sectors are becoming more interconnected. Consequently, systems must be networked, processes securely automated to a greater degree, and communication and coordination between different actors and plants improved. This transformation of the energy system will only be possible with digital technologies such as communication technologies, internet technologies, artificial intelligence and smart metering. The energy sector faces the challenge of managing large data streams from feed-in and grid operation in order to guarantee efficient, automated and secure processes. This is making the analysis of large volumes of data (big data), and the security of data and IT systems increasingly important, as well as the smart market, in which boundaries between sectors are blurring (BDEW, 2016; GSGwS, 2023). Digitalisation thus encompasses the networking of systems, IT innovations, handling big data and internet-based platforms in the energy sector.

Digitalisation will modify the processes and requirements in place in many companies and work areas along the value chain. The current activities of employees in the energy sector and other relevant sectors will undergo profound changes, which will open up new potentials, but also entail challenges. Not only will new tasks arise, but some activities will be taken over by digital technologies and artificial intelligence. Digital skills are therefore a necessary component of professional profiles and education and training in the energy sector.[2] The digitalisation and smart networking of systems are important for a successful green energy transition, which can only be achieved if an appropriately trained and highly motivated workforce is available. TVET in the renewable energy sector thus has a crucial role to play in ensuring that the required skilled workers are available.

In addition to technical measures to integrate renewable energy systems, the expansion and restructuring of energy networks also requires an enabling political and regulatory framework. Both fields of action are a challenge for many developing countries and must be taken into account when planning development projects.

Grid expansion and adaptation calls for both technical measures and an appropriate regulatory framework. In many countries this will require a fundamental expansion and restructuring of the energy supply system. Ensuring a reliable, environmentally sound and economically efficient power supply is one of the major challenges of the energy transition.

Sector coupling

The energy system of the future will involve flexibly linking industry, and the electricity, heat and transport sectors. Various sector coupling technologies can be used for this, such as power-to-X (PtX) technologies, cogeneration[3], fuel cells and electric vehicles. Power-to-X refers to the conversion of surplus electricity generated from renewable energies into another energy carrier such as heat, climate-neutral fuels, raw materials and fuel gases (cf. figure 4). The technologies are power-to-heat, power-to-gas (e.g. power-to-hydrogen), power-to-liquid (liquid fuels) and power-to-fuel (synthetic fuel, e.g. for mobility sector). Other types are power-to-chemicals and power-to-mobility.

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2 In a study, BDEW gives two examples of new requirements: Technicians in network control centres now need more software and programming skills, and service staff need skills in augmented reality and the use of drones and robots for the maintenance of energy and industrial plants (BDEW, 2016).

3 Cogeneration is the simultaneous conversion of energy into mechanical or electrical energy and usable heat within a thermodynamic process. The heat produced parallel to electricity generation is used for heating and hot water or for production processes. The use of combined heat and power (CHP) reduces energy consumption and the resulting carbon dioxide emissions (UBA, 2022)

The overarching goal of coupling the individual energy- and consumption sectors is to ensure that energy can be supplied and used on a climate-neutral basis. For this, however, energy supplies must be secure and cost-effective.

With sector coupling, green electricity can be converted into PtX downstream products that are used or stored in other application areas and replace fossil fuels. Energy can be stored in various forms, such that energy storage outside the power sector can be used to compensate for fluctuations in power generation from renewable energies. Through the smart coupling of sectors with the help of PtX technologies, energy and resources can be used more efficiently and greenhouse gas emissions significantly reduced. Smart sector coupling with digital technologies is a key technology for future energy systems and for the green energy transition, because **without PtX technologies, it will be practically impossible to achieve a greater decarbonisation of the heating and transport sectors as well as industry** (e.g. the energy-intensive steel and chemical industries)**.**

So far, however, there is no example in the world that fully couples the electricity, heat, transport and industry sectors with renewable energies (REN21, 2022). In individual countries, sectors such as electricity and heat are more strongly coupled[4]. There tends to be little coupling of the electricity and transport sectors, which is an obstacle for the green mobility transition. Currently, there is a focus on PtX technologies, which convert green electricity into green hydrogen (or synthetic natural gas). Green hydrogen is versatile; it can be used directly instead of fossil fuels to supply heat or generate electricity, or converted again into climate-neutral fuel gases or fuels.

The increasingly smart networking of sectors and digitalisation are changing work and professions. Professionals will have to deal with new digital and conventional technologies in energy technology and work across traditional trades boundaries. Thus, new tasks and requirements will arise that have hardly been explored so far. **For development cooperation in the field of renewable energies, sector coupling will be an important field of action in the future with great employment potential.** TVET in development cooperation can help shape this field of action in a forward-looking way.

Solar panels installed at the Kilaguni Serena Safari Lodge, Kenia © GIZ / James Ochweri

4 A classic example is combined heat and power (or use of waste heat) because it uses more energy that would otherwise be lost.

Figure 3: Sector coupling and power-to-X technologies (adapted from Heinrich Böll Foundation, 2019)

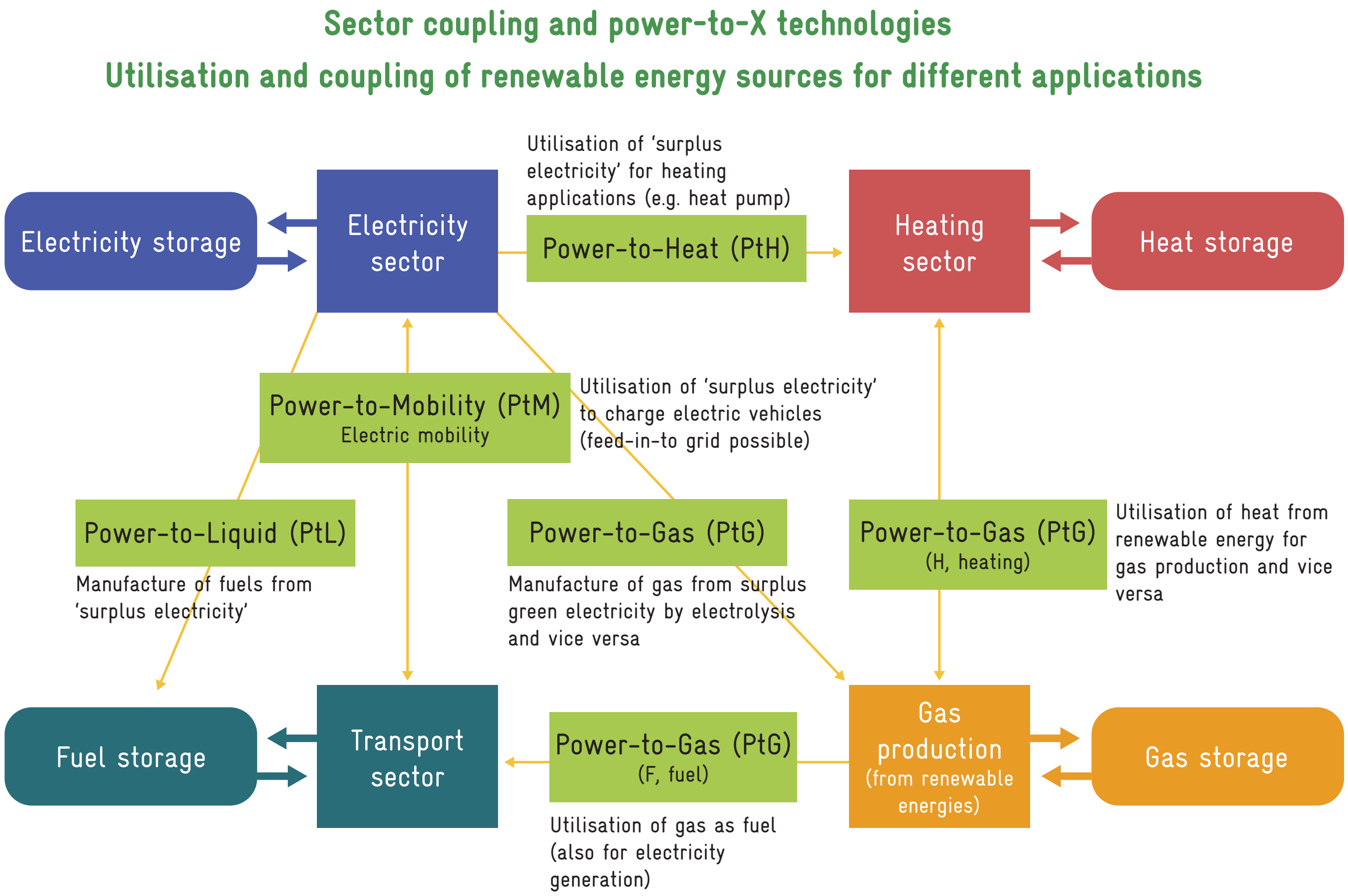


Diagram: Bartz & Stockmar (M), CC BY 4.0, adapted by author

Relevance of renewable energies for development cooperation

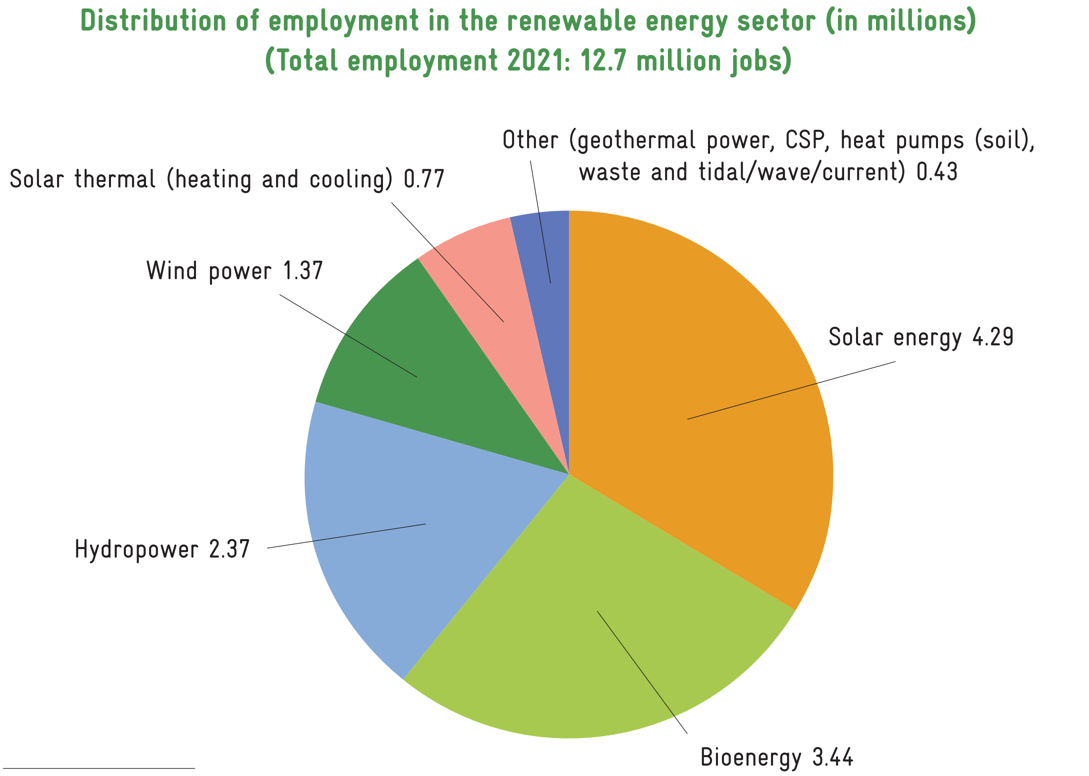
In summary, it can be said that the expansion of renewable energies is a priority goal of German development cooperation. For developing countries in particular, renewable energies are key to obtaining access to modern energy and hence reducing poverty. They thus make a significant contribution to social and economic development. The greatest potential is in wind and solar energy. But geothermal energy (e.g. in Africa) and the use of modern biomass are also relevant. To promote the use of renewable energies, technical measures are needed along with enabling political and legal frameworks. Rural regions that have not yet been electrified still need more small-scale PV systems and mini-grids as well as clean cooking technologies. Grid-connected PV systems and wind turbines are increasingly being installed in many countries. For this, it will be important to provide support to expand and convert electricity grids so that they are sufficiently flexible and stable to integrate renewable energies.

4 Demand for skilled workers and Green Skills in the renewable energy sector

Employment in the renewable energy sector[5]

In 2017, almost 58 million people were employed in the energy sector (conventional and renewable energy, energy efficiency and grid infrastructure) worldwide (IRENA, 2020). In 2021 the International Renewable Energy Agency (IRENA) put the number of worldwide jobs in the renewable energy sector at 12.7 million, of which 4.29 million were in photovoltaics, 2.37 million in hydropower, 1.37 million in wind power, 3.44 million in bioenergy, of which 340,000 in biogas, 770,000 in solar heating and cooling, and 196,000 in geothermal energy (IRENA, 2022d). Almost two-thirds of all jobs are in Asia, mainly in China (42%). The European Union (EU) and Brazil each account for 10% of the workforce; the United States and India each account for 7%.

Figure 4: Employment in the renewable energy sector (based on IRENA, 2022d)



5 In the energy industry, economic structures and activities for the extraction and provision of energy are categorised. This section looks not only at employment and occupations in the energy sector in the strictest sense, but also at occupations in branches along the entire value chain from the extraction of energy to the production and operation of energy plants (cf. figure 5). This includes, for example, employees in companies that manufacture renewable energy components, systems and plants and those that install and maintain energy plants as well as delivering other energy services.

In the photovoltaic sector, 79% of global jobs are in Asia. Ten countries together account for 87% of the jobs. Besides China (63% of worldwide employment), there are high employment figures in India (217,000), Bangladesh (110,000) and Vietnam (32,000) (IRENA, 2022d).

These figures also include the manufacturers of PV solar modules and PV components in the solar industry. China is the world market leader in the solar industry. In Southeast Asia, PV modules are produced in Thailand, Vietnam and Malaysia, mostly by foreign companies. Otherwise, few companies produce PV components in the countries on the continents we are looking at here. In Burkina Faso, one company has been producing PV modules since 2020 (30 MW factory in Ouagadougou). The country has more than doubled the capacity of grid-connected PV systems since 2019 (IRENA, 2021). Solar equipment is also produced in South Africa. The *Solar Power Naija* project in Nigeria aims to increase the percentage of solar components produced and assembled locally, creating 250,000 new jobs in the process (UN, 2021).

In 2021, the wind energy sector (onshore and offshore) provided jobs for 1.4 million people (IRENA, 2022d). Most wind energy jobs are concentrated in a relatively small number of countries. Asia accounts for around 57% of global jobs (China 48%), Europe 25%, the Americas 16% and Africa and Oceania together around 2%. In some countries, many wind turbines were installed in 2021, which led to an increase in employment. Vietnam is one example. Wind energy projects are expected to install a capacity of about 4 GW in Vietnam, which could create about 21,000 jobs (GWO & GWEC, 2021).

IRENA puts the number of jobs in hydropower at around 2.37 million. In this sector too, most jobs are in China (37%). In Asia, India accounts for 17.6% and Vietnam for 5.2% of worldwide jobs. In some countries in Africa, there are major hydropower construction projects that will increase both capacity and employment (IRENA & AfDB, 2022). For example, in 2021 Ethiopia was in the top ten in terms of job numbers in this sector (1.7% of worldwide jobs) (IRENA, 2022b).

Employment potential

In a positive energy transition scenario (in which the 1.5 degree target is attained), and with sufficient investments, IRENA estimates that employment in the energy sector could increase to 139 million by 2030, with 38 million of these jobs in the renewable energy sector (IRENA, 2022d). By 2050 it forecasts that 43 million people will be employed in the renewable energy sector: 20 million in solar power, 13.7 million in bioenergy, 5.5 million in wind power and 3.7 million in hydropower (IRENA, 2021).

African states are estimated to have very positive employment potential in the renewable energy sector. By 2030, the expansion of PV, wind, hydropower and biomass plants in Africa could generate some 4.8 million short-term jobs and 370,000 medium- to long-term jobs (PwC, 2021). In India, the installation of 238 GW of solar and 101 GW of wind power plants to reach the target of 500 GW installed capacity free of fossil fuels by 2030, is forecast to have the potential to create about 3.4 million jobs (short and long term) (Tyagi et al., 2022).

IRENA estimates that investments in electrolysers and other green hydrogen infrastructure could create around 2 million jobs worldwide between 2030 and 2050 (**IRENA**, 2022d). The EU's *Hydrogen Roadmap Europe* assumes the creation of one million direct new jobs across the entire hydrogen sector by 2030 (not only green hydrogen). Of these, about 500,000 jobs would be in the manufacture of hydrogen production and distribution equipment and the development of end-use infrastructure. The jobs in these areas require mainly highly skilled workers, technical skills and knowledge. Other jobs are attributed to the value chains for fuel cells, specialised components and end-use applications, such as the production of fuel cell-powered vehicles or retrofitting of industrial heating equipment (**Fuel Cells and Hydrogen 2 Joint Undertaking**, 2019). The estimates are derived from employment factors based on capacity increases or investment volumes. According to BIBB (2023), existing vocational training occupations (*Ausbildungsberufe*) in Germany largely cover necessary qualification requirements for skilled workers. According to Krichewsky-Wegener, Abel and Bovenschulte (**iit**, 2020), there is still a lack of 'scientifically sound forecasts and detailed studies on the actual employment potential and skills requirements for the development of a hydrogen-based economy'. For developing countries, estimates of the employment potential offered by green hydrogen are only available at project level. For example, the construction and operation of the *Prieska Power Reserve* production facility in South Africa (planned production capacity 12,900 tonnes of green hydrogen per year) is expected to create 22,000 jobs in the region (**Mere**, 2022).

Employment situation of girls and women

Girls and women still face many legal barriers and social prejudices worldwide. Gender inequality is found on labour markets[6] around the globe, especially in terms of skills, access to employment, job opportunities and remuneration (**GIZ**, 2021c). This is also true in the renewable energy sector.

To ensure that they actively participate in the labour market and pave the way for a Just Transition, women need to be trained in green occupational fields. In practice, the main challenges are the difficulties they face accessing TVET and hence their lack of TVET qualifications, and the limited access women have to jobs in the renewable energy sector. (**BMWK**, 2023) Women tend to find it difficult to access professions that have traditionally been male-dominated, whereas the reverse is less true. They also face the problems of reconciling family and professional commitments and gender-based disparities in terms of qualifications and working conditions. In all development projects, the concerns of women and girls must be taken into account appropriately through the gender-differentiated planning and implementation of German bilateral development cooperation. **In line with the BMZ's feminist development policy, the anchoring of gender-transformative and intersectional approaches and the participation of local actors and target groups should be strengthened throughout the project cycle** (**BMZ**, 2023).

6 The ILO's Women at Work Report provides the most up-to-date data on the position of women on the labour market. It examines the factors behind the trends and explores the driving (political) forces behind the changes (ILO, 2016).

Girls and women are currently underrepresented in energy-related professions worldwide. Analyses and data from the IEA and IRENA indicate an acute need for action in the energy sector to achieve equal participation and pay (IRENA, 2022e). Currently, the percentage of global energy-sector jobs held by women is below the 46% of jobs they hold in the economy as a whole. **While the figure is slightly higher in the renewable energy sector (32%) than in the conventional oil and gas industry (22%), even here there is a huge untapped potential**. Moreover, less than 5% of top positions and fewer than 14% of senior positions in the energy sector are held by women (IEA, 2021c). **The persistent gender inequalities in the energy sector are often due to prejudices embedded in society**. For example, physically demanding jobs and technical professions are often seen as male-dominated and thus unusual and unsuitable for women (IRC, 2022). The IRENA survey also shows that cultural and social norms, the lack of gender-sensitive programmes and policies, and insufficient knowledge and training opportunities are further barriers that prevent women finding work in the renewable energy sector.

In order to make better use of women's potential in the renewable energy sector, BMZ is committed to overcoming gender bias and social norms in TVET and on the labour market, as well as to ensuring that girls and women can, in fact, participate in technical training courses (BMZ, 2023). **Developing women's networks and platforms in male-dominated sectors, and drawing up political strategies and action plans with a view to eliminating structural barriers that prevent women accessing green jobs** (VET Toolbox, 2023) are also extremely important. High-profile female role models play a major role. This can include cooperating with companies that already employ women in the renewable energy sector and spotlighting them as role models. **As change agents, women can help drive a just green transition. Their own professional activities in the renewable energy sector make them role models**. In order to promote gender-transformative approaches, BMZ promotes educational work, e.g. awareness and dialogue activities that target different levels and involve families, the local community, the private sector and institutional actors (e.g. vocational schools).[7]

Occupations and qualification levels in the renewable energy sector

The renewable energy sector employs people in numerous professions at all skill levels. IRENA's analysis of human resource needs for the solar and wind industries (IRENA, 2021) shows that over 60% of the workforce requires a minimum formal education. The need for qualified people with STEM degrees is estimated to be lower at around 30%. About 5% of the workforce is made up of highly qualified non-STEM professionals (e.g. lawyers, logistics experts, marketing specialists or experts in regulation and standardisation). Administrative staff account for only 1% of the total workforce (IRENA, 2021).

In its scenario, the International Labour Organization (ILO) assumes that **the green energy transition can create 25 million jobs by 2030** (ILO, 2019). A large number of the jobs will be in construction (6.5 million), the manufacture of electrical machinery and equipment (2.5 million) and the mining of copper ores (1.2 million). Employment figures in hydropower and photovoltaics are put at around 0.8 million each. In terms of

7 Examples of the promotion of women can be found in this study on pp. 29-30.

occupational sectors (in line with ISCO), demand is greatest in the main group of construction occupations (buildings) and related occupations (excluding electricians) with about 4 million jobs, followed by the group of unskilled workers in mining, construction, manufacturing and transport with about 3 million, the group of metalworkers, mechanics and related occupations with about 1.1 million, and the group of electricians and electronic technicians with about 1 million jobs.

In the field of green hydrogen and for its production relevant PtX technologies, most jobs require a higher education level, primarily in technical fields, mainly because the sector is still at an early stage of development. In developing countries, there are often not enough training opportunities for engineers and technicians. Employers also criticise the quality and practical relevance of the training that is available. In South Africa, for example, there is a shortage of electrical and chemical engineers as well as process technicians, who are particularly relevant for the development of a hydrogen sector (Krichewsky-Wegener, Abel & Bovenschulte, 2020).

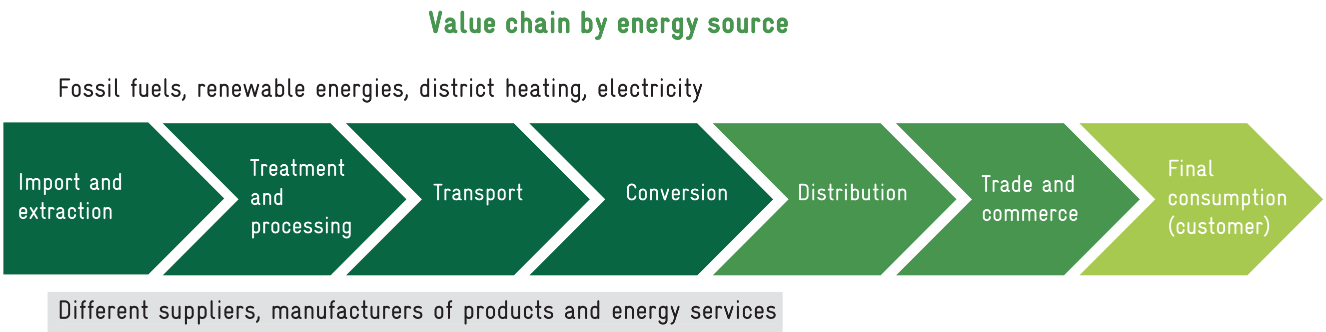
The ILO predicts that almost 7 million jobs will be lost, mainly in oil production and refining, coal mining and coal-fired power generation. About 5 million of the workers who lose their jobs will be able to find a new job in the same occupation in a different industry. This is particularly relevant for countries undergoing structural change, such as phasing out the use of coal, and should be taken into account in labour market measures. **In the spirit of a Just Transition, people must therefore be given support, in the form of access to skills and qualifications as well as complementary labour market services and welfare benefits, so that they can benefit from the new income opportunities that are emerging** (see also GIZ, 2022).

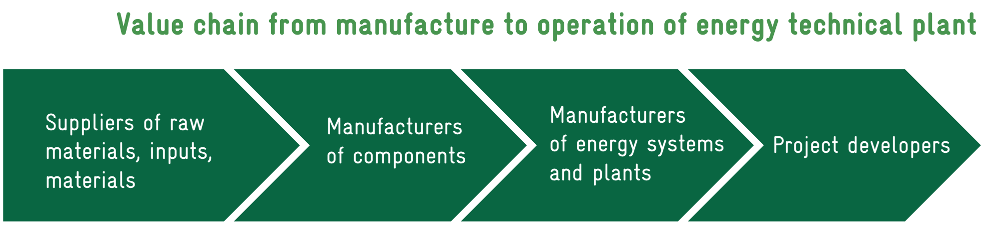
Many studies predict that the energy transition will impact employment positively, with more jobs created than lost. The manufacture of products and the provision of services for low-emission applications that make efficient use of resources as part of the energy transition are changing the work to be performed and the qualifications required. The green transformation of the increasingly digitalised economy will create new occupations, existing occupations will change and some occupations will see their importance dwindle until they disappear altogether (Graf & Reuter, 2017). **This can simultaneously create both unemployment and a shortage of skilled workers** (Brehm, 2021). Overall, however, most international organisations believe there is a risk that the shortage of skilled workers could be an obstacle to the energy transition and the transition to a Green Economy.

The requirements and developments in relation to green occupations vary for different skill levels. The ILO sees the most important changes at medium and high skill levels. New occupations tend to emerge at higher skill levels, while less skilled professionals usually only need to hone their environmental awareness and adapt to changing tasks. Some studies thus state that for the transition to the green economy, no new occupations are needed at the middle and lower skill levels, but existing occupational profiles and skill standards should simply be enhanced. It is more important to **enhance existing vocational skills to meet the needs of the green economy than to create distinct green occupations** (Brehm, 2021; CEDEFOP, 2019; Helmrich et al., 2016).

To analyse employment areas and changes in qualification requirements, we must look at the consideration of the main fields of work in the energy sector. To this end we can use the value chain, which follows an energy carrier (all types including coal, natural gas, oil, renewable energy) from extraction to delivery to the end user (Böhmer et al., 2015). It comprises the following steps: extraction and procurement of primary energy sources, production or conversion of primary energy into secondary or useful energy (e.g. in power plants), and distribution and transport to the consumer (using grids, pipelines or pipes for instance). In the case of energy suppliers, there is also trading, sales and customer management. Energy supply companies are responsible for the construction, operation and maintenance of energy and supply technology plants and systems. In liberalised systems, grid operation and energy supply are separated. Employment in the entire energy sector, in the generation, distribution and use of renewable and conventional energies, thus encompasses a wide range of occupations and activities in technical, economic and other fields (Brehm, 2021).

Figure 5: Value chains in the energy industry (based on **Böhmer et al.**, 2015 and **Brehm**, 2021).





Another look at value chains follows the processes of manufacturing energy technology systems and plants through to project development for the construction and installation of these plants. In this value chain, manufacturing industry and many economic sectors are relevant. Suppliers provide raw materials, inputs and other materials for manufacturing companies. Companies in mechanical engineering, metal construction, the electrical industry, the solar industry and other sectors produce components for energy technology systems and plants. In addition, there are technical trades that assemble, install, commission, maintain and repair such systems and components, or offer other energy services. In the manufacturing sector, a range of different company structures, business and work processes, products and services are found. This also applies to the manufacture of technical systems for renewable energies. Large amounts of energy and resources are often needed to manufacture products for environmentally friendly applications (e.g. PV modules, rotor blades, generators, turbines, storage). These production processes can then have adverse environmental impacts (GIZ, 2013). Production and work processes are therefore not necessarily green in themselves, but can contribute to the green energy transition. This is true of numerous traditional occupations in construction, electrical, metal and supply engineering. Furthermore, in the context of resource- and energy-efficient production standards, energy management (ISO 50001) and energy audits are relevant for companies and should be given greater consideration in international cooperation.

It can be deduced from this that in the field of renewable energies, it is not only occupations and work tasks that differ in the energy industry, in the extraction of raw materials, in manufacturing, installation and in services. The 'green percentage' also varies. There are then different types of green occupations, which affects their categorisation. Numerous international studies indicate that there is no generally accepted understanding of green jobs and occupations.

In some classification systems, such as the Occupational Information Network database (O*NET) in the USA, a distinction is made between three types of green occupations:

1.) New green occupations, which involve a whole series of new tasks.

2.) Green occupations, i.e. established occupations that have been further developed to take environmental factors into account, and incorporate supplementary green tasks.

3.) Occupations that do not have green components and are unchanged, but nevertheless support the Green Economy. The European Skills, Competences, Qualifications and Occupations (ESCO) classification takes account of green competences. ESCO lists 381 skills, 185 knowledge concepts and 5 transversal skills that are significant for a green labour market. Green Skills include conducting energy audits and training staff in recycling.

Development of professions and training standards

Career development in the context of a Just Transition takes the following approaches[8]:

- Further development of existing occupations to integrate and add supplementary new tasks and Green Skills. One example is incorporating qualifications for handling decentralised energy systems, such as PV systems, in conventional occupational profiles for electricians or electric engineers. Further training in the new fields (skills, knowledge, technologies, tools, equipment, etc.) can be offered to fully trained skilled workers.
- Developing new green occupations for a range of new tasks. In some countries, typical examples are solar installer, wind turbine technician or energy consultant. There can also be hybrid occupations which create new occupational profiles by linking existing occupations, e.g. mechatronics engineer.
- A third strategy primarily concerns countries that are going through phases of structural change, such as phasing out fossil fuel extraction or ending the operation

8 Higher (in some cases tertiary) TVET (technician, technologist) right up to university education is also required (cf. Section 5).

of thermal power plants that run on fossil fuels. In line with the Just Transition philosophy, comprehensive retraining and further training measures are required for affected employee groups to prepare them for new jobs in the energy sector or in other industries.

- Another pragmatic approach often used in cooperation projects is the adaptation of international training standards and curricula in the partner country. The German regulated occupations of electronics technician for energy and building services engineering and plant mechanic for sanitation, heating and air-conditioning technology, are typical for this approach. They have been introduced in Vietnam, for instance, by the GIZ Vocational Training Reform project.

Overall, it can be stated that for the **development of green occupations and Green Skills, various measures** are **needed at all skill levels**. These cover the entire education and qualification spectrum and range from on-the-job training, to retraining for employment, initial vocational training programmes for the recruitment of future renewable energy specialists, vocational training for new technologies and tasks for skilled workers, to higher vocational education for planning, project and management responsibilities in the renewable energy sector. Business start-up activities and entrepreneurship training are also required for new technologies.

Green Skills and competences

The discussion of Green Skills and competences is anything but consensual. It is dominated by concepts of general Green Skills that are designed to apply to all people, educational modalities and professions, dominate. The EU's reference framework for sustainability competence (GreenComp) (Bianchi et al, 2022), for example, consists of four competence areas with twelve generic competences (e.g. systems thinking and critical thinking). In country studies on green jobs, the ILO has identified eleven core green competences including environmental awareness, willingness to learn about sustainable development, adaptability and transferability, that are needed to learn and apply the new technologies and procedures required for green jobs (ILO, 2011).

On the one hand, models like these can be used as a universal framework to integrate transversal green competences in all TVET (and in any education), thus making the idea of greening occupations part of the curriculum. The aim is to raise awareness for sustainable development and to enable young people to live and work in an environmentally friendly, climate-friendly and resource-conserving way. On the other hand, before specific occupational profiles and curricula can be developed, the green competences required, for instance to manufacture and use green technologies, must be detailed for each domain and task. This means that in cooperation projects new or changed tasks and hence the **requirements and competences in the renewable energy sector should first be investigated, taking into account the qualification level**. This data can then be used to identify **the need for new occupations or the further development of existing occupations, and to develop occupational profiles and curricula.**

5 Exemplary project approaches and lessons learned

Green occupations and Green Skills are topics that have been addressed in German TVET cooperation and employment promotion since the mid-1990s (GIZ, 2013). Renewable energies are now the focus of a large number of TVET projects in international cooperation. Measures commonly undertaken include the development and modernisation of occupational profiles, curricula, teaching and learning materials, - and media, training specialists and managers in the fields of energy efficiency and renewable energies, the promotion of Green TVET centres, the delivery of advisory services to TVET authorities and the establishment of cooperation mechanisms between private companies and vocational training institutions.

Some examples of projects and initiatives identified through literature reviews and interviews with experts are set out below. Examples include Sector Skills Councils for the development of green occupational standards in India, the development of occupational profiles in Brazil's hydrogen sector, green vocational training centres in Vietnam, the development of renewable energy training in Nigeria, non-formal training in green education centres and certification in Uganda, an Austrian solar thermal energy project in Southern Africa, the BMZ's Green People's Energy initiative and women's initiatives in Africa.

Vocational Training Institute teachers measure solar voltage during Solar PV Training at the Daniel Comboni Vocational Institute in Gulu District, Uganda. © GIZ Uganda/Energy and Climate Cluster

India: Sector Skills Council for Green Jobs

In India, there are 38 Sector Skills Councils (SSCs) for different economic sectors. The SSCs are autonomous bodies that are registered as companies or societies. They play a crucial role in matching the requirements of industry and the range of training on offer. They are tasked with identifying the skills needed and developing skill and competence standards in the sectors. They are also responsible for standardising accreditation, examination and certification procedures in line with the National Skills Qualifications Framework. In 2015, a dedicated Skill Council for Green Jobs (SCGJ) was established. The SCGJ develops national occupational standards in the fields of renewable energy, sustainable mobility, sustainable construction, water and waste management, among others (SCGJ, n.d.).

The SCGJ has developed two Greening National Occupation Standards: Optimise resource utilisation at workplace and Adopt sustainable practices at workplace. The two National Occupation Standards (NOS) include competencies on energy and material conservation, resource audit and waste management, which are integrated in occupational standards in several sectors such as agriculture, manufacturing and construction. India now has 44 nationally recognised qualifications in solar energy, wind energy, bioenergy, clean cooking stoves, small hydropower and waste and wastewater management. Since 2015, some 100,000 workers have been trained in the renewable energy sector (mainly solar). Of these, 78,000 were certified under a national programme (Suryamitra) (Fiinovation, 2020).

The National Institute of Solar Energy (NISE) is an autonomous institute of the Ministry of New and Renewable Energy (MNRE). Under the MNRE's skills development initiative, NISE is responsible for the implementation of the Suryamitra Skills Development Programme (SSDP). It offers courses (approx. 600 hours) in the installation, operation and maintenance of solar systems. Within the framework of the GIZ Indo-German Programme for Vocational Education and Training (IGVET), for example, a standard was produced for the installation of PV systems.

This example from India illustrates the importance of sectoral committees. Created at an early stage, the SCGJ is an organisation that has identified demand for green occupations in various sectors and introduced nationally accepted standards for qualifications and certification. **This leads to the recommendation that in TVET projects in the renewable energy sector, sectoral institutions should be established with the involvement of the private sector. They can support the organisation of the sector, provide impetus for economic and technological development, identify skilled labour needs in the sector and guide the development of national occupational, examination and certification standards.**

Brazil: Occupational profiles and competences for green hydrogen

Practical training at Casa Solar in Brasilia, Brazil. © GIZ/Christoph Büdke

In the BMZ-funded project H2Brasil GIZ is cooperating with the Brazilian National Service for Industrial Training (*Serviço Nacional de Aprendizagem Industrial*, SENAI). SENAI is a private vocational training institution with public interest, which reports to the Brazilian National Confederation of Industry (*Confederação Nacional da Indústria,* CNI) or, in the individual federal states, to the regional employers' associations. SENAI operates professional vocational training, skills and technology centres in the individual federal states and offers a variety of courses and programmes at all skill levels. SENAI has established sectoral technical committees (*Comitê Técnico Setorial*) in which representatives from industry, politics and the science and research community work in close consultation to identify and describe occupational profiles and competences in the sectors, in order to develop educational offers on this basis. For the green hydrogen sector, five new qualifications and occupational profiles were identified and validated at an early stage of development in the still young sector. These are three new vocational qualification courses, one specialist course at intermediate technician level and one course at postgraduate level. The course for engineers covering the planning, design and operation of electrolysers is currently being developed. **The innovative aspect of SENAI's approach is the institutionalisation of sector committees, which effectively take account of needs and employment potential in the industry, while also generating a broader awareness of green hydrogen and PtX in Brazil at an early stage.** In addition to the consultation process, GIZ supports curriculum development, in-service training for TVET staff, and exchanges and partnerships with German universities (GIZ, 2022d). Furthermore, with support from the Brazilian Ministry of Mines and Energy (*Ministério de Minas e Energia,* MME) and GIZ, SENAI is preparing the establishment of the first national centre of excellence for green hydrogen in Brazil, as well as five other regional training centres in Ceará, Paraná, Bahia, São Paulo and Santa Catarina. GIZ is providing technical support and funding for the training of multipliers and the establishment of training workshops (GIZ, 2022d).

Vietnam: Green competence centres

Vietnam is pursuing ambitious goals in the transition to a Green Economy and the expansion of renewable energies. To this end, supportive policy frameworks have been put in place and a green growth strategy has been adopted. Germany is promoting numerous activities in the field of renewable energies and TVET. The objectives of GIZ's advisory activities are, for example, to improve the legal framework for renewable energies and promote technology transfer.

As part of the reform strategy for the TVET sector, KfW Development Bank is supporting the establishment of competence centres in which high-quality, labour market-oriented, demand-driven education and training for a green and sustainable economy is to be offered. The competence centres for green TVET are to be regional innovation centres with substantial spillover effects, and are to demonstrate what is possible (KfW, 2022).

In one project, the campus of the Vocational College of Machinery and Irrigation (VCMI) in Dong Nai is to be expanded to include new buildings and the technical equipment will be supplemented with renewable energies. In the construction and procurement of the machinery, special consideration is to be given to energy-efficient and resource-saving criteria (KfW, 2022). The complementary technical cooperation (TC) component, in the form of the GIZ (Programme Reform of TVET in Vietnam II) supports the project by developing education and training programmes for a green economy. The aim is to integrate content on strengthening environmental responsibility and energy- and resource-efficient action into existing training courses and to strengthen cooperation with the private sector (GIZ, 2022e). The two German training occupations of electronics technician for energy and building technology and plant mechanic for sanitary, heating and air conditioning technology have been introduced for the renewable energy sector.

The holistic approach to Green TVET in Vietnam is remarkable. Guidelines for Green TVET address several fields of action that should be taken into consideration when Green TVET centres are designed. Specifically, these are green school campuses, green curricula, green teaching methods and media, a green community, green workplaces and a green institutional culture. School managers must thus address a very wide spectrum of factors at Green TVET centres (Nguyen et al., 2018).[9] **Future projects to support green vocational training centres should take this holistic approach. When providing financial support for vocational training centres it would also be desirable if a clean, modern energy supply were planned holistically, in addition to construction and extension work on buildings, and supplying technical equipment. The centres should be self-sufficient with a decentralised energy supply generated from renewables. This can be used for demonstration purposes for third parties and for training and further education.**

9 The approach is based on the concept of Dr Shyamal Majumdar (then UNESCO-UNEVOC), who devised five dimensions (green campus, green technology, green community, green research, green culture) for the sustainable design of greening TVET institutions (Majumdar, 2011).

Nigeria: Training courses for PV installation, hydropower plants and energy audits

In 2013, the European Union and BMZ jointly launched the *Nigerian Energy Support Programme* (NESP) to expand the use of renewable energy, increase energy efficiency and improve access to sustainable energy, especially for disadvantaged target groups. In the first phase (2013 to 2018), solar-powered mini-grids were established and energy-efficient pilot projects implemented in public buildings and in industrial enterprises. In addition, new laws and regulations for renewable energy and energy efficiency (e.g. mini-grid ordinance, energy efficiency code for buildings and energy efficiency label for household appliances) were introduced (GIZ, 2021b). The follow-up programme NESP II supports Nigeria in integrating renewable energies into the grid and expanding rural electrification. NESP II follows a multi-level approach, combining energy policy, economic and technical advisory services for a wide range of actors.

At that time, Nigeria had no structured training in the field of renewable energies, but only stand-alone courses that taught few relevant practical skills and were not officially recognised. As a result, seven renewable energy and energy efficiency qualifications were devised in 2016 for different target groups and qualification levels. These were a course in planning mini-grids (solar PV and small hydropower plants) for engineers; a PV installation training course for electricians with low or informal qualifications to enable them to install, troubleshoot and maintain small PV systems; PV installation training for electricians with formal qualifications to supervise PV installation work; a course in planning and operating rural hydropower plants for engineers; energy management training; energy audit training; and a course in energy efficient building design for architects and engineers. These training courses are offered by a network of twelve educational institutions.

Based on demand surveys and market analyses, competence standards for clean energy and course modules were drawn up in consultation with industry and experts, taking into account the National Curriculum Framework. Uniform standards are also to be developed for examinations and certification.

Comparable examples can be seen in other projects. **It can be deduced from this that short-term upgrading measures for skilled workers should firstly be planned as a cross-cutting issue in the promotion of renewable energies. The next step can be to draw up education and training standards and systematically mainstream these in (vocational) education systems to ensure comparability and quality of the qualifications issued**. Early upgrading and standardisation are particularly relevant for these technologies, as there is a risk that unprofessional work, such as the faulty installation of PV systems, will cause damage. This is not only a risk for people and buildings, but also hinders the acceptance and introduction of new technologies.

Uganda: Green College, non-formal education and life skills

Welthungerhilfe supports the Green College project in the Rwenzori region of Uganda. Disadvantaged young people can complete non-formal, practice-oriented training, lasting between 45 and 180 days, in six green occupations at twelve training centres for sustainable professions.

Training allows young women and men to acquire knowledge and skills in organic farming methods, solar technology, repairing mobile phones or building and marketing energy-saving stoves. Additional courses offer knowledge in the areas of business start-ups and entrepreneurial independence. With this approach, Welthungerhilfe pursues two goals. Firstly, young people receive a chance to train, giving them better chances of finding a job or setting up their own business as an 'ecopreneur' (an entrepreneur in a sustainable profession). Secondly, a new awareness is created for sustainable, environmentally conscious and resource-conserving action (Welthungerhilfe, 2022a).

In Welthungerhilfe's education projects, the teaching of life skills is particularly relevant.[10] The often neglected and disadvantaged target groups need the skills and abilities to cope with the challenges and problems of everyday life. As part of the project work, a manual for educational activities to support the acquisition of life skills in Uganda was prepared. The measures cover personal development, community and leadership, healthy living, integration and belonging, improving employability, nature conservation and climate action. Priority target groups are youth in the informal and non-formal sectors, out-of-school youth, school dropouts and underemployed or unemployed youth (Welthungerhilfe, 2022b). **From this example, we can derive the recommendation that the teaching of life skills should generally be taken into account in educational measures, especially in rural areas.**

In Uganda, the importance of the informal sector is emphasised in TVET policy. To this end, the Business, Technical, Vocational Education and Training Act and the BTVET Strategic Plan regulate ways of recognising informally acquired skills and non-formal education. This regulation enables individuals who have acquired skills in an informal setting to take examinations to have their skills officially confirmed. The examinations are based on occupation-specific standards of the formal education sector and the National Qualification Framework. Certification takes the form of the Worker's PAS (Worker's Practically Acquired Skills), a document that certifies the skills and competencies of an individual for a specific occupation.[11] In the Welthungerhilfe project, examinations of beneficiaries of non-formal education measures were also held according to these regulations, and the Worker's PAS issued.

10 The VET Toolbox also offers a life skills tool (GIZ & E4D/ SOGA, 2019).

11 This positive example of certification of informally acquired skills in Uganda is described in the GIZ Toolkit 'Learning and Working in the In-formal Economy' (GIZ, 2019b).

This example shows that the recognition of non-formally and informally acquired competences is possible and is particularly important for countries and regions where many people acquire professional skills informally and are rarely able to provide evidence of their competences. Regulations and frameworks such as examination and certification standards and a qualification framework are necessary for the recognition of certificates. In Uganda, these regulations enable the recognition of informally acquired vocational skills, facilitate the transition from the informal to the formal education sector and thus improve the employment situation.

South Africa: Promotion of solar thermal plants

The *Austrian Development Agency* (ADA) supports the Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN), which is coordinated by an Austrian research institute (AEE INTEC) and is considered a successful example of Austrian development cooperation. The initiative works with universities, research institutions, vocational schools, the local solar industry and energy ministries in a total of six African states (South Africa, Namibia, Botswana, Lesotho, Mozambique and Zimbabwe) to promote solar thermal energy more strongly in the region. Solar thermal demonstration plants were set up and knowledge transfer initiated in southern Africa. Local heating systems were built for a university in Johannesburg and a large-scale solar process heating system installed in a factory (ADA, 2019).

This example indicates that **there is market potential for solar thermal energy in some African and Asian countries. In this sector, support can be given to companies and jobs created, while new regulated occupations such as the installer for solar thermal systems can be introduced. The market potential of solar thermal energy in international cooperation in the field of renewable energies should be examined more closely and, where appropriate, supported more strongly**. So far, the focus has been on renewable energies for electricity generation.

Africa: Green People's Energy Initiative

BMZ's Green People's Energy for Africa initiative promotes a better, decentralised, citizen-responsive energy supply in countries of sub-Saharan Africa and thus makes an important contribution to improving access to energy in Africa (SDG 7). The involvement of citizens, municipalities, public associations, cooperatives and small and medium-sized enterprises promotes community development. Citizens become co-owners of their own energy systems. They take responsibility for the climate and environmentally friendly planning, installation and operation of energy supply systems and shape the green energy transition in rural Africa (GIZ, 2022b).

In selected projects, facilities like schools, health centres and other public facilities are supplied with energy. Women have founded energy cooperatives (e.g. Uganda and Ethiopia). In some projects, training in solar technology was offered to young women entrepreneurs (e.g. Togo). In other projects, solar cooling systems (e.g. for agricultural products and medicines) and solar pumps are used and biogas plants are built (e.g. Ethiopia).

The BMZ's Green People's Energy initiative for Africa is an example of an **objective-oriented strategy for scaling up renewable energy in combination with community participation, business support and support for rural schools serving often neglected target groups**. It is also a good example of linking different development goals such as SDG 4 (improve quality of education through electrification), SDG 7 (access to clean energy for disadvantaged sections of the population) and SDG 10 (reduced inequalities). **Complementary to large national programmes to promote renewable energies, initiatives of this sort should be rolled out and more attention paid to establishing decentralised solar plants and mini-grids, especially in neglected regions. The expansion of energy systems should be supported with TVET measures such as advanced training.**

Africa: Promotion of women in renewable energies[12]

Women Entrepreneurship for Africa (WE4A) is a programme co-financed by the European Union, the Organisation of African, Caribbean and Pacific States (OACPS) and BMZ. In line with the BMZ's feminist development policy, the WE4A programme strengthens the entrepreneurial capacities of African women entrepreneurs, facilitates access to financial services, enables the integration of women entrepreneurs into local and regional value chains, and helps to eliminate existing gender gaps on labour markets. Under this programme, individual businesses have started up in the fields of solar energy, clean cooking technology and recycling.

IRENA and the Centre for Renewable Energy and Energy Efficiency of the Southern African Development Community (SACREEE) have been running a programme to promote entrepreneurship in renewable energy in the region since 2017, in which women are a specific target group. Along the same lines as the WE4A programme, entrepreneurial skills are honed and entrepreneurs are given access to investment. The programme offers some positive examples in the area of household solar appliances, mini-grids, solar water pumps and clean cooking technology.

In addition to the initiatives and programmes funded by international donors and organisations[13], there are also private initiatives, such as Solar Sister, a women-led green energy initiative. In rural Africa, Solar Sister recruits, trains and supports women to become Solar Sister entrepreneurs. Through training and ongoing mentoring, the women entrepreneurs acquire important skills such as financial management and technical product knowledge. Women start sustainable businesses selling, for example, solar lamps, mobile phone chargers and fuel-efficient cooking stoves. Solar Sister has built a network of more than 4,500 women entrepreneurs who generate an income while

12 See also Section 4, Employment situation of girls and women.

13 The International Finance Corporation (IFC) of the World Bank Group has launched the Energy2Equal initiative with the support of Canada. Here, measures are also being implemented to improve women's access to jobs and leadership positions, as well as to promote business start-ups in the renewable energy sector.

providing more than 1.5 million people in Nigeria, Tanzania and Uganda with access to clean energy (Solar Sister, 2022).

The Solar Sister model illustrates that measures like this not only improve household income and women's financial independence. They also have a positive impact on health, education, women's status and self-confidence. Families who switch to clean cooking stoves significantly reduce time spent collecting wood, money spent on solid fuels, and smoke output. Children have reliable, bright lighting to study by at night.

The author recommends networking the various initiatives and programmes in Africa to harness synergies and step up the promotion of women in the field of renewable energy, especially in rural parts of Africa. The individual projects and initiatives are implementing similar measures, like entrepreneurship courses and training in solar energy. Uniform supra-regional training standards and certifications for Africa could be developed here.

In addition, the author suggests **launching a global #reSkills4Girls initiative (analogous to G20 initiative #eSkills4Girls) for renewable energy skills development for girls and young women**. This could be done under the Women and Youth at the Forefront programme of the UN Sustainable Energy for All (SEforAll).

A farm in Ghana using solar energy for irrigation – supported by GIZ's Green People's Energy Project. © GIZ

6 Recommendations for project design

The stronger expansion of TVET, especially for sunrise industries in the field of renewable energies, was already mentioned in the ten objectives for education of the BMZ Education Strategy 2010-2013 (BMZ, 2012a). This objective is still relevant for the renewable energy sector. Renewable energies make a significant contribution to climate change mitigation, which is a priority of the BMZ 2030 reform strategy. Just Transition is also one of BMZ's current political priorities. TVET has a key role to play in a Just Transition, as it provides training in the sectors that will be essential in future.

German development cooperation has been helping developing countries and emerging economies promote and expand the use of renewable energies for many years. Advisory services in partner countries target, for example, the creation of legal and regulatory frameworks, the drafting of technical standards, the design and implementation of support mechanisms, the planning of investment projects and training. As renewable energies account for an increasing percentage of electricity generated, it becomes more challenging to ensure grid stability and reliability of electricity supply. Therefore, projects are increasingly addressing the system integration of variable renewable energies. In many countries, partner institutions (e.g. energy utilities, grid operators, regulators) are advised on system planning, electricity market design, grid regulation, grid management and the flexibilisation of the energy supply (GIZ, 2020).

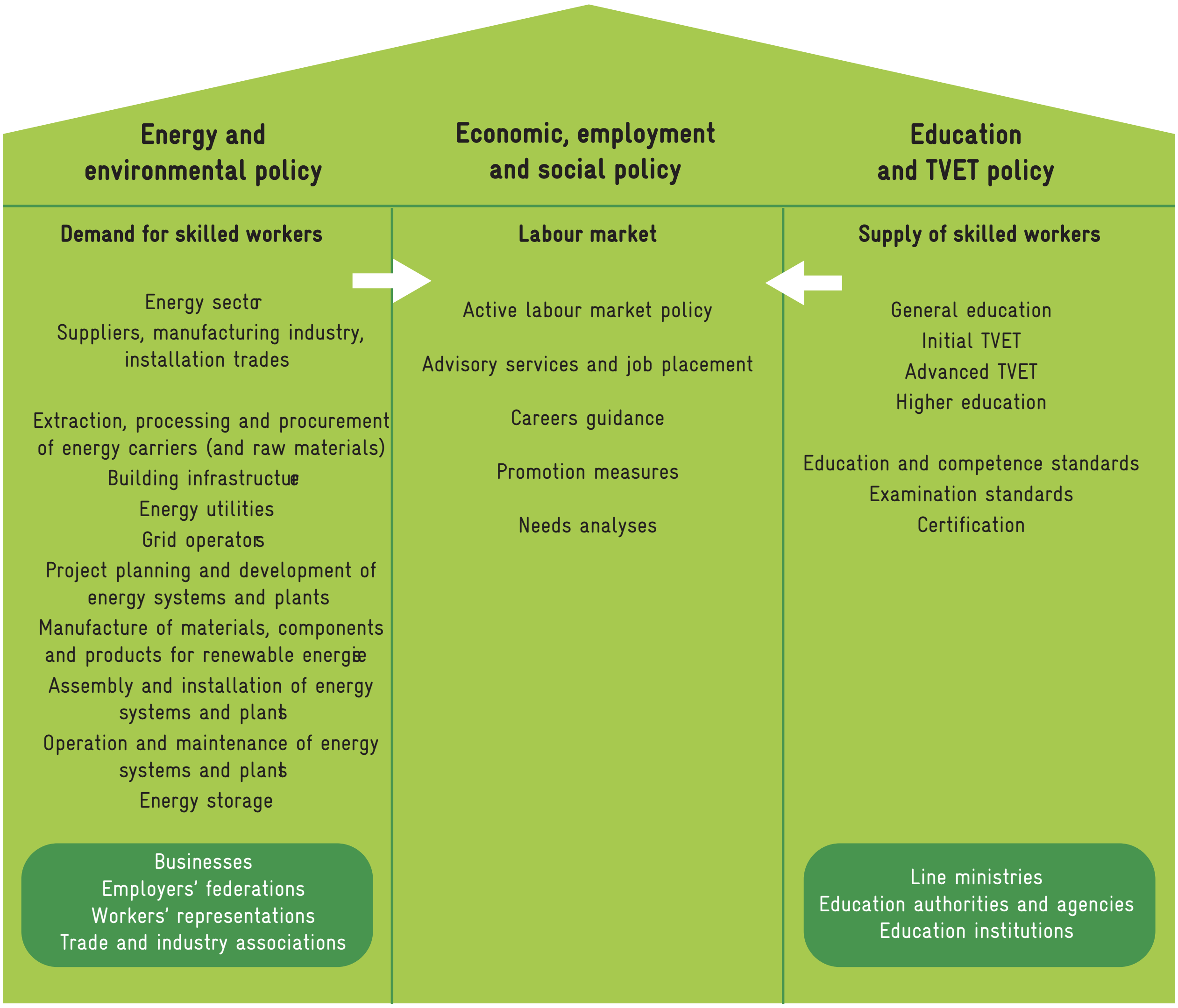
Renewable energies are a central pillar of the just, green energy transition, which can only succeed if enough qualified skilled workers are available. This requires labour market-oriented education and training measures that enable people to carry out work on energy technology systems in a professional manner, complying with measures to ensure occupational health and safety. In this respect, the energy transition offers great potential for generating employment, provided parallel TVET measures are in place to support it.

With regard to the guiding principle of education for sustainable development (ESD) and its integration into TVET, many projects and measures have now been implemented at national and international levels. Older studies note that the concepts and implementation measures are often not linked (GIZ, 2013). Thus, as far back as the UN Decade of Education for Sustainable Development (2005-2014) it was recommended that coherent policy-making should be pursued with integrated and systemic approaches to ESD. Education and training systems should be reshaped through coherent national and local policies and integrated approaches, and ESD should be centrally anchored as a guiding principle. Policies should be developed and implemented through inter-sectoral and inter-ministerial approaches involving business and industry, civil society, local communities and the science and research community. **Sustainable development is a cross-cutting issue that is important in all educational sectors, school types and school subjects**. This statement is still relevant for the implementation of the 2030 Agenda.

The demand for coherent and integrated approaches can be transferred to the promotion of renewable energies technology, employment and TVET, which should be considered in one context. **In this respect, a holistic policy framework is necessary that includes coordinated measures in different political and social areas**. To develop strategies and concepts to address problems of this complexity requires greater awareness at all levels as well as intersectoral and interministerial cooperation.

In development cooperation, an integrated approach to employment promotion is usually pursued, which is coordinated with TVET projects and labour market activities. The interrelationships for the energy sector, taking suppliers and manufacturers into account, are shown in the following figure:

Figure 6: Relationship between the energy sector, the labour market and the education system (based on **Heidebrecht & Hase**, 2017)



6.1 Guiding concept for a just energy transition

Mitigating climate change requires a global green energy transition and the increased use of renewable energies. Yet sections of the populations of many partner countries of development cooperation still do not have adequate access to energy. This is particularly true of rural areas and marginalised communities (IRENA, 2021). The expansion of renewable energies therefore offers the opportunity for more people in developing countries to gain access to energy (BMZ, 2022c; GIZ, 2022a). We must, however, recognise the fact that in the context of the just energy transition there will not only be winners, but also losers. The ILO predicts, for example, that almost 7 million jobs will be lost in oil production and refining, coal mining and coal-based power generation (ILO, 2019). This is particularly relevant for countries undergoing structural transformation processes such as phasing out the use of coal, where mine and power plant closures have already resulted in job losses with the concomitant loss of income. In terms of Just Transition, social and economic risks must therefore be identified jointly and with foresight. Decent income-generating and employment opportunities in alternative sectors must be created rapidly so that as many people as possible have new prospects for the future. Firstly, policy-makers must lay important foundations for a Just Transition by putting in place legal and regulatory frameworks, economic incentives and complementary labour market services and social benefits. Secondly, TVET must take on the central task of providing those affected with access to skills and qualification acquisition, such as further training or retraining measures, so that they too can benefit from the newly emerging income opportunities.

Germany is rightly committed to the globally necessary energy transition in bilateral cooperation and in cooperation with international organisations (BMZ, 2022c; GIZ, 2022f). The G7 recently created the Just Energy Transition Partnership (JETP) model for international cooperation in the energy and climate sector (G7, 2022). JETPs are intended to promote ambitious climate and energy policies based on the Paris climate goals. Together with other committed countries, the G7 partnerships intend to significantly advance the global energy transition and massively expand the use of renewable energies (BMZ, 2022e). **In the future, German development cooperation, together with the G7 countries, should promote green employment and Green TVET more strongly in the context of a Just Transition, and specifically a just energy transition**.

In future, cooperation with partner countries in the renewable energy sector should be aligned with this guiding concept. **In future projects in the field of renewable energies, objectives and measures should be formulated in a correspondingly ambitious manner and implemented consistently. Appropriate wording of objectives should be taken into account in the project design and indicators should be determined.** In partner countries, national and regional energy policies must be refined in line with this guiding concept. This will call for persuasive communication processes and for raising awareness at political level and within society of the need for a just and green energy transition. However, policy initiatives and new programmes in the renewable energy sector should take into account existing energy transition strategies and ongoing measures of the countries, and be tailored to the national and local circumstances in the energy sector. Project appraisals must clarify the readiness, capacities and needs of partner countries regarding the expansion of renewable energies. In the past, ambitious reforms in the energy sector have failed because the benefits and reliability of renewable energies were questioned (IRENA, 2021). In addition, due to limited financial resources and politically divergent interests, the use of renewable energies cannot be expanded everywhere, immediately and comprehensively. **Priorities need to be set for partner country support. Planning projects in the renewable energy sector thus requires a realistic assessment of relevance, impact and sustainability. To this end, the most relevant policy areas and institutions should be involved in project planning.**

6.2 Integrated and linked programme approaches in the renewable energy and TVET sectors

Strategies for the expansion of renewable energies in international cooperation should not focus exclusively on the promotion of renewable energies per se, but should take into account green employment promotion and green TVET training as of the design and planning phases, in order to provide a structural framework for the coordinated and concerted design of an enabling environment for TVET training, the labour market (in the energy sector and related industries) and the energy industry.

Technical and financial cooperation programmes and projects in the renewable energy sector usually focus on financing and technological measures such as technology transfer, the promotion and expansion of power generation facilities or the expansion of energy grids. Some projects have pursued a cross-sectoral approach by incorporating a TVET training component in energy programmes (e.g. Brazil). In other energy projects, individual TVET measures such as advanced training courses were also factored into planning. In yet others, the need to develop TVET training measures, such as advanced training for skilled workers, became apparent in the course of project implementation. Experience gained with programmes pursuing integrated approaches points to them achieving better results with respect to the recruitment of skilled workers, labour market placement, participation of the business community and the image of new technologies.

The author of this study recommends two strategies for project design. (1) Cross-sectoral, integrated and sector-linked approaches allow for better coordination between renewable energy development and employment-oriented TVET. **Therefore, in future larger-scale projects in the renewable energy sector, a TVET component should be planned if at all possible, with the design of training measures taking into account the requirements of the education systems in place.** The organisational capacity of companies in the energy sector should be supported, in particular. This could involve strengthening and advising sector and trade associations. In cooperation with TVET institutions, these associations can help design TVET (cf. Section 6.4).

Smaller projects should at least develop further training for different green technologies (such as wind energy and solar plants) **and qualification levels** (e.g. planning and project management, installation and commissioning, maintenance and service, energy consulting) **and devise relevant certification concepts**. There are some good examples of this (e.g. Nigeria; see Section 5). Care should be taken to ensure that courses and certificates of this sort can be incorporated into national qualification systems.

(2) A second approach is the planning and implementation of linked project concepts: Since it will not always be possible in practice to implement integrated approaches[14], **independent programmes in the two sectors of renewable energy and TVET (as well as employment promotion) can be linked in the project design in terms of organisation and personnel**. This means establishing joint working groups or working areas that coordinate cooperation, goals and measures in parallel projects. Communication between project staff from separate projects is, in fact, common practice, but it often emerges by chance and depends on the interests and commitment of individual persons. We thus propose the institutionalisation of communication and working structures, which should be factored in when energy projects are planned. The project design could provide for joint work packages, such as the development of coordinated sector strategies taking into account the sectoral labour market and employment promotion (e.g. involving ministries of education, labour and energy), or for analyses and studies to be conducted to explore employment and requirements in the sector.[15]

6.3 Employment promotion and labour market policy

International studies point to the employment opportunities that can be generated by developing the use of renewable energies, while also warning of the risk that shortages of skilled workers could jeopardise the green energy transition. It thus comes as no surprise that the global discussion calls for more training and degree courses in STEM subjects in general and in renewable energies in particular.

In addition to TVET, employment promotion and labour market policy measures are needed to attract skilled workers to the renewable energy sector. This requires coherent strategies to dovetail technological measures in the renewable energy sector with employment and labour market policy measures.

Active labour market services are long-standing fields of action in economic and employment promotion programmes in partner countries (GIZ, 2019a). However, typical challenges exist in many partner countries (Specht et al., 2018). Active labour market policy instruments are often rudimentary and are not always consistently linked to TVET services. Many partner countries have no labour market information systems, and where they do exist they are not sufficiently developed, meaning that labour market intermediation is not particularly effective. Labour market and TVET research is not established in many countries, so that data and information on sectors, skilled labour needs, skills developments and requirements, especially in new sectors, are often not available.[16]

14 This means that sector promotion and TVET must be integrated.

15 The following example will illustrate this approach. Assuming that a new project in renewable energy is planned, the project concept, design and appraisal mission should explore the possibility of linking the new project to an ongoing TVET project in the country in question. Relevant actors must be identified and staff in the ongoing projects contacted in order to explore possible avenues of cooperation.

16 A study by UNESCO-UNEVOC (2020) shows that progress is being made regarding skills forecasts. Most countries surveyed report that they regularly conduct skills forecasts or plan to do so in the future. However, specific forecasts for green occupations and Green Skills are rare, especially in developing countries.

These aspects, given here as examples, are an obstacle especially for emerging and rapidly developing sectors such as renewable energies. There is a lack of basic information and data for planning labour market- and demand-oriented TVET. Against this background, the author of this study recommends that **future employment promotion and TVET programmes help partner countries introduce systems to recognise at an early stage and forecast skills requirements and employment in the field of renewable energies**.

No one measure can achieve an impact on employment. A variety of different coordinated instruments and measures are needed. There are numerous well established concepts for this (GIZ, 2016). Due to limited state funding and implementation capacities, active labour market policy measures should be implemented as a priority in the partner countries in light of the guiding principles of Just Transition and the green energy transition. The impacts of the measures should be continuously monitored and evaluated.

Text box 2: Supportive labour market measures for a just energy transition

An important labour market policy field of action can be seen in countries experiencing structural transformation towards a green economy, as is the case when coal is phased out and a conversion to renewable energy systems undertaken. Here, affected workers need labour market measures to help them transition from the conventional energy industry to the renewable energy sector. These include, for example, appropriate placement services, measures to facilitate labour mobility, social protection programmes for affected workers and regions, and green transformation funds to retrain workers. **For the groups of employees who leave or lose their old jobs, re- and upskilling measures are needed to prepare them for new tasks in the energy sector (or in other sectors).**

6.4 Involvement of the business community through sectoral committees

One principle of German TVET cooperation is to foster intensive dialogue between the state, the private sector and civil society, and to involve the private sector to a greater degree in TVET (BMZ, 2012b). The quality of TVET and the acceptance of qualifications obtained are better when the private sector, employers and employees are involved in the management, design and control of TVET.

This principle should also be followed in the renewable energy sector. However, many countries face the challenge that this sector is still hardly organised or very much in its infancy. **In many developing countries, very few companies work with renewable energy systems and plants, and there is a lack of industry or business associations. The structures of the private sector in partner countries should thus be taken into**

account in project planning and provision made to help companies establish their own sector or trade organisations.

Sector, occupational, professional and interest associations in the private sector are important for economic development, dissemination of new technologies, building confidence in new technologies and promoting employment. They can also make an important contribution to the management and quality assurance of TVET and thus help shape the development of labour market-oriented training provision.

There are different forms of interaction (and mediation) between the state and the market and the involvement of associations and organisations in the steering and shaping of TVET (Frommberger, 2015).[17] One construct originating in the UK and widespread in many English-speaking countries are Sector Skills Councils (or comparable institutions), which essentially are charged with identifying skills needs in the sector, developing quality and qualification standards, and improving educational provision in the sector. The way agencies of this sort are organised and funded varies widely around the globe (governmental, semi-governmental or autonomous organisations, statutory tasks, advisory tasks, etc.). In many countries, these tasks are the responsibility of national TVET authorities or regulatory bodies. Private-sector actors are often involved in an advisory capacity and in development work.

The following recommendations can be derived for future projects: **Strategies should be devised to foster private-sector organisations in the renewable energy sector. Future renewable energy projects should include a concept to establish agencies, associations or similar organisations[18] that are enabled to conduct surveys to identify skilled labour needs and develop TVET, examination and certification standards**. The strategy selected will depend on the conditions on the ground and objectives of the partner country, which should be explored in more detail during the project appraisal.

As described above, India has had a Sector Skills Council for green jobs since 2015. Its responsibilities include identifying needs and developing standards in the renewable energy sector. The comprehensive approach is remarkable, since this institution is responsible for green employment and occupations in several areas including renewable energies (solar, wind, hydropower, energy storage, clean cooking technology), waste management (including e-waste), sustainable construction, sustainable transport, water management and the circular economy. The author recommends **following this approach when designing sectoral organisations or setting up dedicated units in existing TVET agencies.**

17 There are very different names for such institutions with similar functions, such as TVET Authority, TVET Agency, Training Authority, Skills Standard Authority, Education and Training Board, Sectoral Training Board, National VET Council, etc. In this context, the term National Training Authority is also used for mostly state authorities.

18 The VET Toolbox provides a guide to setting up Sector Skills Councils (Enabel & British Council, 2020). The ILO has also published a guide (West, n.d.)

6.5 Green guiding principles for TVET programmes and projects

All future TVET programmes and projects should be aligned with green guiding principles. The 2013 strategy paper TVET for a Green Economy (GIZ, 2013) and the first study in this series (*Skills for a Just Transition to a Green Future*) (GIZ, 2022) noted that TVET is increasingly being integrated into national sustainability strategies and programmes, but that TVET policy as well as environmental and climate policy are often not coordinated. The 17 Sustainable Development Goals of the 2030 Agenda now provide a more complex framework that sets out extremely comprehensive goals and principles for environmentally, socially and economically sustainable development. This argument must then be seen in a broader context with regard to the coordination of the various fields of policy and action.

TVET programmes should support national sustainability and green growth strategies in the context of renewable energy development in partner countries with the help of a tailored Green TVET strategy. **A holistic green approach should be developed for the entire TVET system, including TVET institutions, buildings, infrastructure and equipment, courses and curricula, competences, teaching and learning processes, media, stakeholders, learning culture, management and administration**.

Three fields of action are particularly relevant for TVET in development co-operation. Firstly, the **fundamental strengthening of environmental education** in all TVET courses. Second, the **intensification of initial and continuing TVET** in sectors and industries that contribute to environmental protection and achieving climate neutrality as well as promoting a just green energy transition. Thirdly, the **further development of existing vocational competences** as well as re- and upskilling, taking into account the needs of a resilient, green, digital economy.

Wind energy in Vietnam. © GIZ Vietnam/Energy Support Program (ESP)

7 Recommendations for TVET interventions in the renewable energy sector

In promoting TVET, German development cooperation has long pursued a multi-level approach (BMZ, 2012b; GIZ, 2014). At the policy level, partner countries receive assistance to help them devise reform strategies and introduce legal regulations such as training laws. It is almost always important to draw up or refine training standards, occupational profiles, curricula and examination standards. As a rule, there are links with the labour market and employment promotion. For example, demand and employment analyses are carried out or labour market information systems developed. Cooperation and intensive dialogue between the government, the private sector and civil society are especially relevant for German cooperation in the TVET sector.

At institutional level, support is provided to establish and modernise TVET and competence centres. The institutions receive capacity building services, further training for specialists and managers, and assistance with steering and management tasks. To introduce cooperative learning models or dual training concepts, cooperation is fostered between TVET schools, training centres and private companies.

At implementation level, Germany supports pre- and in-service training for teaching and administrative staff. Workshops, laboratories and classrooms are expanded, modernised and equipment provided. Curricula, teaching and examination materials are developed on the basis of occupational profiles and training standards.

Taking into account the multi-level approach, the author recommends **TVET for renewable energies measures in the fields of occupational standards and curricula (macro level), TVET centres (meso level) and the didactic design of TVET (micro level)**. The following overview summarises the most important measures for the design of Green TVET in the renewable energy sector:

Figure 7: Overview of important TVET measure

Macro level **Policy and system level**	• Further develop the legal regulations governing TVET and integration of the guiding principles of Green TVET • Establish and support sectoral quality committees or organisational units in TVET agencies for renewable energies (or green occupations) • Identify needs and conduct labour market studies in the renewable energy sector • Develop training, examination and certification standards for renewable energies with the participation of the private sector • Develop standardised learning units and competences relating to sustainability, environmental protection, and the digital world of work and integrate these in all TVET courses

Meso level Institutional level	• Design Green TVET centres with holistic approaches (infrastructure, buildings, outdoor areas, curricula, learning materials, management and learning culture). • Modernise equipment and workshops for renewable energies as well as sustainable building and supply technology • Test cooperative training concepts with the support of renewable energy sectoral committees or other industry associations • Help TVET institutions use digital media in the field of renewable energies
Micro level Implementation level	• Provide in-service training for school managers on the design of green TVET centres • Support TVET staff in the development of competence-oriented learning environments in the field of renewable energies • Establish working groups comprising teachers of courses such as solar technology or wind energy, which should then develop instruction jointly • Develop teaching and learning materials and manuals for the relevant regulated occupations

7.1 Green TVET standards and curricula

The transition to a Green Economy opens up new employment opportunities, especially in the green energy and green production sectors. In principle, the quality and quantity of training and degree courses in the field of renewable energies should be stepped up.

The author of this study proposes the following measures:

- In current TVET projects, examine conventional regulated technical occupations (such as electrician and mechanic) with regard to tasks and technologies in the field of renewable energies and add appropriate elements to the curricula (e.g. planning, installation and maintenance of PV systems).
- Future TVET projects involving system reforms should have as their focus the development of green occupations and Green Skills as well as employment promotion in green fields of work. The project objectives and indicators should be aligned with this.
- Future TVET projects in the field of renewable energies should plan for the identification and development of occupational profiles for work in the renewable energy sector, with the participation of the private sector, at the outset of project conception. In addition to needs analyses, specific studies are needed to identify areas of responsibility and competences required in the renewable energy sector. Based on this data, it can be decided whether new regulated occupations should be developed or existing ones updated. This can also provide information for the development of occupational profiles and curricula.[19]

19 There are a number of tools for labour market studies, identification of skill needs or skills forecasting. For example, ILO has published guidelines on forecasting skills needs for green jobs (Gregg et al., 2015). Welthungerhilfe (2021) has produced a practical facilitation guide for green jobs analysis. To develop occupational profiles and curricula further information is needed, e.g. on duties, objects, means and competences. Here, some instruments are also available such as Developing A Curriculum (DACUM) and expert workshops (GIZ, 2022; Norton, 1985). In a project within the framework of the German-Israeli Programme for Cooperation in Vocational Education and Training, the duties of a specialist in solar technology were identified through expert workshops. On this basis modules were developed and action-oriented learning units designed (Bauer et al., 2015).

Future renewable energy projects should, at an early stage, offer skilled specialists training courses at different qualification levels covering responsibilities and technical systems in the field of sustainable energy supply (including green hydrogen), system integration (including smart grids), sector coupling and energy storage. The credits obtained can be transferred to the formal system (examination and certification). There are good examples of this in many projects, which should be systematically evaluated. Furthermore, measures for business start-up and management should be offered.

- For countries undergoing structural transformation and with new industries (such as green hydrogen), incentives and opportunities should be put in place for re- and upskilling of skilled workers. In this way, the rapidly growing demand for labour can be met and alternative employment opportunities created for skilled workers from the conventional energy sector in the spirit of the Just Transition.
- In current and future TVET projects, sustainability, energy efficiency, resource efficiency and environmental protection in professional and everyday life should be integrated into all occupational profiles and curricula.

The measures to be implemented must be selected based on the situation and conditions in the specific partner country and the actual project objectives. Some projects pursue a two-pronged strategy: advising on the design of initial TVET while also developing fast-impact continuing TVET services. In both cases the energy sector and relevant industries should be involved, and stronger links established to practical working life. **When developing initial TVET programmes and continuing TVET courses, care should be taken to ensure that occupational profiles and certification standards can be integrated into the country's existing TVET system** and that permeability is guaranteed.

Short-term solutions such as **developing non-formal continuing TVET measures can be useful for the energy sector because they can be adapted rapidly and flexibly to the needs of companies and target groups**. Experience in projects indicates that non-formal measures are helpful, especially for the informal economy (Heidebrecht & Hase, 2017). Some projects have produced concepts for having non-formal training officially recognised. This can involve the relevant bodies holding examinations and certifying the results. In this context, procedures and instruments can also be developed for obtaining credits for informally acquired competences (as in Uganda).

Another point to bear in mind is the integration of cross-cutting green competences that are not exclusive to any one occupation or task, but are relevant in a variety of working environments or have a general educational character. Sustainability, environmental protection, energy efficiency and resource efficiency should be included in all curricula across TVET at all levels (qualification, initial and continuing TVET and higher vocational education) and in all sectors as well as in pre-vocational and in-service programmes (greening of occupations).

The anchoring of contents and competences on sustainability in occupational profiles and curricula is necessary, but not in itself enough to firmly integrate these topics in practical TVET. Experience indicates that there is often a gap between aspiration and reality (GIZ, 2013), which makes supporting measures necessary. Firstly, **TVET institutions should be further developed according to green guiding principles**. If a green learning culture is to be firmly established, school development measures will be needed, along with in-service training for teachers and school managers. Secondly, **instruction development measures are necessary, in which new didactic and methodological concepts are produced along with teaching and learning materials to integrate green content into educational programmes**.

In the meantime, many programmes and projects have developed and tested new regulated occupations and training courses for renewable energies, especially in solar and wind energy. Typical training courses are installers for PV systems, service technicians for wind turbines and energy consultants. In some projects, German regulated occupations were transferred and adapted (e.g. Vietnam). **The author suggests conducting a curriculum evaluation project. These project-specific training standards, curricula and examination concepts should be evaluated and the experiences of implementation in practical training should be assessed. This could provide important findings for the development of occupational profiles and curricula for future TVET projects in the renewable energy sector.**

7.2 Green TVET institutions (institutional level)

Green TVET needs Green TVET institutions. In TVET cooperation, this concept is not consistently implemented at present, although promising concepts for the development of Green TVET institutions are now available (e.g. UNESCO-UNEVOC, 2017)[20], which take a holistic approach to green institutions (infrastructure, buildings, outdoor areas, curricula, stakeholders, management, learning and culture). Financial cooperation currently fails to take this holistic approach in the promotion of TVET and competence centres, for example. For future projects, holistic design concepts are needed so that sustainability becomes an institutional, pedagogical and cultural quality feature of TVET centres.

When planning new buildings, and converting or renovating TVET centres, a wider spectrum of factors should be taken into account, including physical, technical, aesthetic, functional and pedagogical criteria (Staudt, 2022). TVET centres with their buildings, premises, equipment and outdoor areas, as well as the learning and working environments, must be considered in their entirety from an organisational stance and from a (vocational) pedagogical point of view, because the design of buildings, rooms and spaces has an impact on learning processes.

In the context of renewable energies and sustainable buildings, one sustainability feature of a green TVET institution is clear: the decentralised clean energy supply. The building and the rooms should be built and extended in compliance with the most rigorous environmental, energy and building biology standards (Staudt, 2022). Resource- and en-

20 Many concepts and guidelines for the design of Green TVET institutions are now available, e.g. from the EU and ILO (2011), the ILO (2015) and UNESCO-UNEVOC (2017). In the project presented, Welthungerhilfe uses the Green College concept developed by the SkillGreen Global Organisation (2018) in India. The GIZ TVET Academy offers re- and upskilling on green TVET institutions.

ergy-efficient design means that clean, renewable energies should be used throughout.[21] This not only has added value for the TVET institution itself, but also generates positive impetus for the region. TVET institutions can help spread sustainability principles and values in the field of renewable energies and sustainable construction. They can act as role models for decentralised, clean energy supply locally, while delivering capacity development services for the Green Economy.

What is unique to TVET institutions is that they combine learning environments and working environments relevant to everyday working life. They have workshops, laboratories and other didactically designed specialised facilities in which typical occupational activities can be simulated, carried out and reflected upon, thus linking learning with occupational practice. This gives Green TVET institutions their particular vocational and pedagogical credentials. The TVET centre with its buildings, rooms, equipment and outdoor areas can be used as a place of learning in which renewable energy systems and plants are used themselves to further learning. Buildings become a learning topic in their own right and enable sustainable learning experiences on the basis of actual objects, rendering visible the principles of supplying buildings in a sustainable and energy-efficient manner and allowing learners to acquire new skills.

In electrical and supply engineering training, for example, energy, building and supply engineering equipment and systems can be used for analysis, installation, measurement and optimisation, for learning and work assignments, and for project work. Learners can, for example, work on tasks for planning and installing energy supply systems and on the energy-efficient design of buildings at the TVET centre.

Subject and learning spaces must be built in such a way that action-oriented, independent, cooperative and research-based learning is made possible and theory is linked with practice, e.g. through integrated subject rooms. Learners must have the opportunity to help shape the use of rooms, which requires flexible and multifunctional rooms. Digitalisation also opens up new opportunities, making it possible to create virtual learning environments, which is particularly useful in energy, building and supply engineering.[22]

In the past, pedagogical and didactic concepts for the use of energy systems and technical equipment, and the concomitant additional requirements, have rarely been taken into account in the funding of these for educational institutions. Against this background, the study recommends taking a holistic approach to designing funding projects for TVET and competence centres. When planning projects, buildings, rooms, equipment and outdoor areas as well as the extended criteria listed above should be taken into account. In addition, the design of Green TVET centres should incorporate the aspects listed above (buildings, outdoor areas, curricula, learning culture and management).

21 However, financial constraints mean that it is not always possible to promote multiple systems and installations for a decentralised renewable energy supply.

22 Digital technologies and competences play an important role for all occupations nowadays and should be integrated in all TVET. In the field of renewable energies, skilled workers have to deal with a variety of digital technologies. Many occupations require knowledge of relevant software and programming, applications for planning and dimensioning energy technology systems, maintenance and servicing devices and software (e.g. remote monitoring, drones), robot systems, grid technologies and data security. Digital technologies are both tools and learning media and should therefore always be part of TVET in the field of renewable energies. For TVET cooperation, this raises the question of availability of and access to such media. This aspect should be taken into account in the planning and implementation of projects (especially in the development of green vocational training facilities and technical equipment).

Several suggestions emerge for technical cooperation. **First, processes should be initiated to develop Green TVET centres and green learning cultures**. The principles of sustainable development must be firmly anchored in the TVET centres themselves. **Secondly, in projects that have already been funded, TVET centres should be reviewed and further developed in terms of space and building design for TVET and (learning) organisation**. **Thirdly, didactic training concepts should be produced for the systematic use of TVET centres**, especially in the areas of renewable energies and sustainable buildings. This might require additional measures and support such as upskilling for management and training staff.

7.3 Didactic and methodological recommendation (micro level)

Competence orientation is now accepted worldwide as a guiding principle for the design of vocational curricula and learning processes. It is therefore hardly surprising that there are many models and concepts for competency-based learning at international level. The author suggests that the German concept of learning fields and learning situations in TVET schools should be used as a guide in designing TVET. The aim is not to adopt concepts and transfer curricula, but to implement the underlying didactic concepts and principles. Essential didactic principles include action and task orientation. Teaching and training in TVET are linked to tasks and problems learners can expect to encounter in their subsequent working life. These are processed didactically and methodologically by teachers for specific learning units. Complex learning units thus relate to vocationally relevant situations and actions that learners master independently.

This concept has implications for the planning of learning units over the entire course of training. As a rule, a training course consists of several curricular elements such as modules. These elements (in Germany these are termed learning fields) must be broken down by the responsible teachers into coherent, meaningful learning units (in Germany these are termed learning situations) and coordinated in terms of content and time. This results in a process of curriculum specification on site with joint lesson development and educational programme management. The planning of complex learning units thus requires joint development work by teachers who are responsible for a regulated occupation. Tasks and problems must be identified and didactically processed for learning units, competences must be specified and learning units must be sequenced. Furthermore, it is important to establish connections between the learning units and to prepare supplementary information, materials and media.

Against this background, the study recommends that activity- and competency-based learning concepts be used in TVET for the renewable energy sector. In this context, lesson development, i.e. the joint didactic planning of learning units by working groups consisting of teachers and trainers, should also be institutionalised.

This learning concept has potential to take account of the principle of learning in work processes. In the work on courses, teachers and representatives of companies can set up communication and organisational structures (such as working groups) in order to identify, for example, typical duties within the company, work processes or customer orders, to develop projects and learning tasks typical of the occupation, and to open up access to companies. Teachers and learners are given opportunities for company analyses, discussions with skilled workers and project work.

Following on from the above example of installing energy supply systems, learners can work on the following learning tasks, projects or customer orders (WEQUA & TU Dresden, 2010):

- Advising clients on energy use concepts (e.g. role play or simulated customer order)
- Determining energetic and structural parameters, e.g. for PV or solar thermal systems
- Using software to design and dimension PV and solar thermal systems
- Preparing estimates for energy systems
- Planning work and organising a plant project
- Performing maintenance work
- Optimising existing energy supply systems (e.g. residential or commercial buildings)
- Communicating with regional energy suppliers (role play or real).

In TVET cooperation, action-oriented learning concepts have been tested for many years. In some TVET projects, relevant didactic concepts have been developed for learning and working with PV, solar thermal and wind energy systems. The author of this study suggests **collecting and evaluating these examples in specialist groups. The findings can be used to produce subject-specific didactic manuals that set out didactic and methodological competency-based learning concepts as well as examples of learning and work tasks, customer orders and projects to be used in TVET in the field of renewable energies.** The didactic concept should include instructions for lesson development and training course management with the necessary steps involved in the process of developing competency-based learning units.

To this end, new guidelines could be produced on the didactic design of TVET and competency-based learning for the VET Toolbox. The Toolbox offers assistance, instruments and methods for many relevant topics. Instruments and tools must also be developed for the core didactic task of practical TVET practice at micro level (teaching and learning processes). The implications of the sometimes controversial international discussion on competence orientation could thus be illustrated in didactic terms.

8 Conclusion

Improving access to affordable, reliable and sustainable energy for all is a particularly relevant goal (SDG 7) of the 2030 Agenda. Renewable energies contribute to climate change mitigation, while also being essential factors in economic and social development and poverty reduction. Developing countries should thus be given support to help them expand the use of renewable energies. New projects in this sector should always be designed in line with the principles of a just energy transition and should help partner countries achieve a just green energy transition.

However, future projects should not be planned in isolation in the energy sector, but should take into account the interrelationships listed above. For the planning of future projects in the renewable energy sector, the author recommends linking technology promotion with employment promotion and TVET measures. In this way, qualified specialists can be recruited at an early stage who, thanks to their professional working methods, promote innovation, ensure quality, minimise risks and thus contribute to sector development (also in the field of green hydrogen). Two conceptual approaches can be adopted. (1) With cross-sectoral, integrated project designs, TVET components can be directly linked to technology promotion measures. Approaches of this sort are already being practised, as illustrated by the examples in the renewable energy sector and with green hydrogen in Brazil. In this new technology field, which is particularly relevant today, new qualifications have already been developed at various levels with the involvement of the private sector. (2) Connected project designs with organisational or working units acting jointly enable projects that would normally be separate to share staff and content.

TVET projects should always be aligned with green guiding principles at all levels and in all areas of action. With regard to the involvement of and cooperation with the private sector, the study suggests organising sectoral committees for green employment. Depending on the governance structure of TVET in the partner country, such agencies, advisory boards and expert groups can be organised and financed in different ways (state, private, autonomous). In any case, such institutions should assume responsibility for identifying skilled labour needs, qualifications and requirements for green employment and green occupations, and should be involved in the development of occupational profiles, occupational standards, curricula and the regulation of examinations and certifications. We recommend combining several fields, such as renewable energy, the circular economy, water and waste management (example India) as well as green hydrogen.

The study proposes three measures for the design of TVET. Green occupational profiles and curricula should be developed for existing and new regulated occupations in the renewable energy sector. In ongoing TVET projects, the existing conventional occupations in construction, electrical, metal and supply engineering should be reviewed and adapted accordingly. In future projects, relevant occupations for renewable energies should be identified and developed from the outset on the basis of needs analyses. Many projects already have experience with new regulated occupations that can be drawn on.

We also recommend initiating the further development of TVET centres as part of TVET projects, and suggest that green TVET centres should in future be planned holistically. This includes sustainable, energy-efficient and resource-efficient buildings, rooms and outdoor areas, green curricula, green learning and activities, as well as green administration and management concepts. Another holistic consideration in the context of renewable energies is the pedagogical and didactic design and use of building and supply technology, which should be taken into account when designing TVET centres.

Finally, the author discusses what he considers the most important level of action: teaching and learning processes. Ultimately, Green TVET is about acquiring practical vocational skills and creating awareness of the need to act sustainably and conserve resources and energy in working and everyday life. Basically, action-oriented learning concepts should be used in which learners work independently and cooperatively on tasks and problems typical for their occupation, while acquiring the ability to shape sustainability. Teachers and trainers must be trained to design competency-based and action-oriented learning environments.

Ninh Thuan Vocational College trainees perform measurements on PV panels during a practical training session.
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Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de

On behalf of

Federal Ministry
for Economic Cooperation
and Development