Sectoral Study

TVET for Sustainable Mobility

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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
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
Prof. Dr Oliver Lah (FAKT Consult)

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

Design / layout
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E-vehicle assembly by technician students at the Imperial Society of Innovative Engineers training centre in Aurangabad, supported by GIZ India and the Indian Automotive Skills Development Council. © GIZ India, Page 7; Training of trainers for electrical vehicles in Hyderabad, India. © GIZ IGVET II, Page 9 and 40; Training for e-motorcycle technichians in Kampala, Uganda (Developing Relevant and Innovative Vocational skills for e-mobility, DRIVe project). © GIZ/Fabian Jacobs, Page 45

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AHK	Deutsche Auslandshandelskammern (German Chambers of Commerce Abroad)
BILT	Bridging Innovation and Learning in TVET
BMZ	German Federal Ministry for Economic Cooperation and Development
BRT	Bus Rapid Transit
CO_2	Carbon dioxide
DC	Development cooperation
DRIVe	Developing Relevant and Innovative Vocational Skills for e-Mobility
E4D	Employment and Skills for Development in Africa
EU	European Union
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IEA	International Energy Agency
IHK	Deutsche Industrie- und Handelskammern (German Chambers of Commerce and Industry)
ITF	International Transport Forum
ITDP	Institute for Transportation & Development Policy
IPCC	Intergovernmental Panel on Climate Change
KeVET	Kenya Initiative for Vocational Education and Training
KTTC	Kenya Technical Trainers College
MaaS	Mobility-as-a-Service
MININFRA	Ministry of Infrastructure (Rwanda)
Mt	Megaton
NAMA	Nationally Appropriate Mitigation Action
NDCs	Nationally Determined Contributions
NMT	Non-motorised transport
OECD	Organisation for Economic Co-operation and Development
PREEEP	Promotion of Renewable Energy and Energy Efficiency (Uganda)
RPL	Recognition of Prior Learning
SDG	Sustainable Development Goal
SMART-SUT	Integrated Sustainable Urban Transport Systems for Smart Cities (India)
SME	Small and medium-sized enterprise
SSATP	Sub-Saharan Africa Transport Policy Program
TUMI	Transformative Urban Mobility Initiative
TVET	Technical and Vocational Education and Training
UBA	Umweltbundesamt (German Environment Agency)
UCDAVIS	University of California, Davis
UN-HABITAT	United Nations Human Settlements Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-UNEVOC	International Centre for Technical and Vocational Education and Training
UNIDO	United Nations Industrial Development Organization
WMW	Women Mobilize Women
WRI India	World Resources Institute India

Abstract

The global consequences of climate change and growing social injustice are increasingly underlining the urgency of the transition to a just and Green Economy (Just Transition) in order to conserve resources and reduce CO_2 emissions. Countries will need to put enormous effort into collaborating across borders. Transport is one of the world's largest and fastest growing sources of greenhouse gas emissions, accounting for almost a quarter of energy-related global CO_2 emissions. The mobility sector thus also plays a key role in achieving the goals of the Paris Climate Agreement, as well as the Sustainable Development Goals (SDGs) set out in the 2030 Agenda in the partner countries of German development cooperation (DC).

Training of trainers for electrical vehicles in Hyderabad, India. © GIZ IGVET II

To ensure a Just Transition to a sustainable mobility system and to create new value in partner countries, it is essential to have a skilled workforce. For this, initial and continuing Technical and Vocational Education and Training (TVET) of relevant professionals must be adapted at all skill levels.

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). The present study examines how partner countries of German DC can be supported in aligning Technical and Vocational Education and Training with a Just Transition in the mobility sector. Substantial changes in the content of TVET courses are analysed in order to develop action-oriented recommendations for the transition to sustainable mobility, especially for project planners and implementers in DC. The study focuses on electric micromobility and mobility services in urban passenger and freight transport, as this is where there is significant potential for development and demand in developing and emerging economies in Africa and Asia.

The study is based on an analysis of data and literature and on the outcomes of 20 interviews with government representatives, DC practitioners, as well as private sector and TVET stakeholders in the selected partner countries. Based on an analysis of technological developments in the mobility sector, the anticipated demand for skilled workers and examples of projects in four selected countries – India, Kenya, Nepal and Rwanda – the study develops recommendations for future project planning and implementation.

Future projects in the field of sustainable mobility need to pursue cross-sectoral and integrated approaches to project design more vigorously to promote better coordination between the development of sustainable mobility and employment-oriented TVET. In this context, it would be useful to integrate projects that share components or have personnel and organisational links. This would include the promotion of training partnerships between TVET institutions and e-mobility companies, especially with local start-ups, to strengthen local value creation and employment opportunities. It would also be advisable to develop interfaces with institutions of higher education to promote practice-oriented research, better subject-specific exchanges and improved coordination of training content between technical specialists and university graduates.

It is important to develop short-term training measures with the private sector to meet the current needs of a growing e-mobility sector. However, the author also recommends proceeding with a clear focus on the further development of relevant job profiles and curricula and their anchoring in national qualification frameworks. Designing the content of occupational profiles and curricula calls for an analysis of the skills needed along value and process chains in order to keep up with the requirements of a rapidly evolving sector. In view of the changing demand for skills, the TVET sector should give cross-sectoral skills greater consideration.

More upskilling courses on sustainable mobility are required. These include innovative lifelong learning opportunities, non-formal education that would include disadvantaged groups, as well as training accompanied by awareness-raising activities for women and girls to improve their employment opportunities in the sector.

1 Introduction

Climate change, biodiversity loss and rising social inequality threaten the stability of our economy, society and governance and our very existence. To conserve resources and reduce CO_2 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 best 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* 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 in poverty.

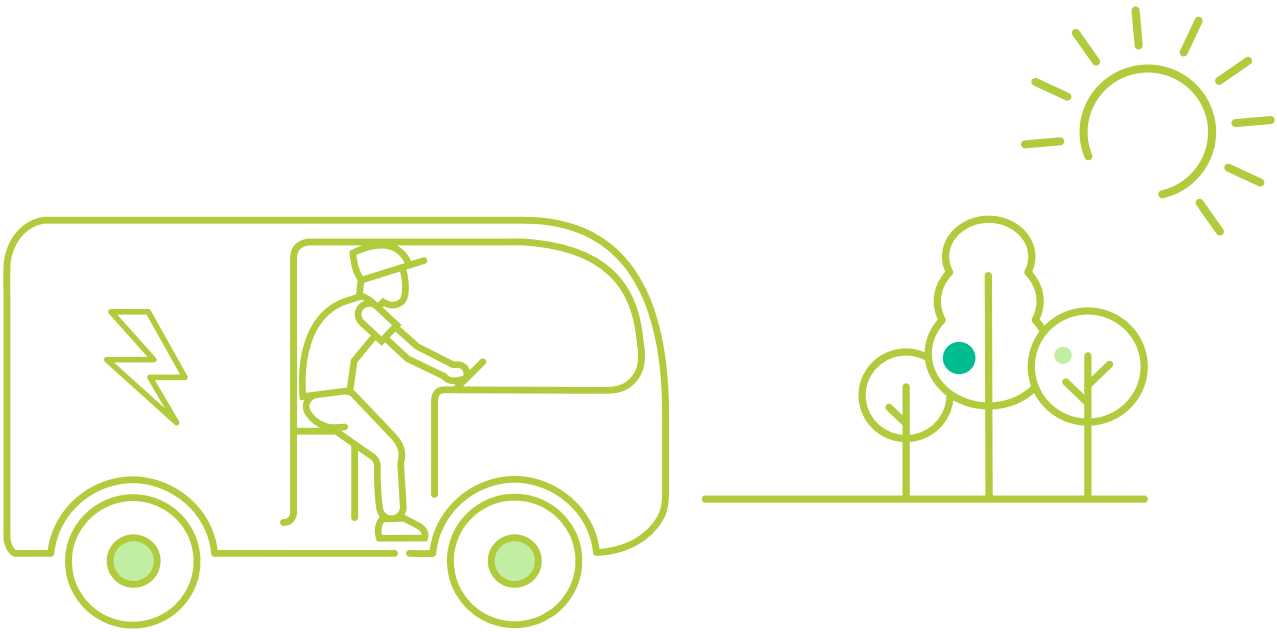
Policy-makers have the task of designing the foundation for a Just Transition early on. This work includes the legislative framework and labour market policy instruments, such as financial incentives for companies, along with accompanying social benefits. Technical and Vocational Education and Training (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 DC. The studies offer action-oriented recommendations on approaches how 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 technical and Vocational Education and Training 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 particular sectoral study highlights the role that TVET plays in a Just transition of the mobility sector in developing countries and emerging economies in Africa and Asia. It highlights core aspects of the mobility transition that offer significant potential in terms of sustainability, economic development and job opportunities. It also examines the substantial changes that will be required in terms of content for initial and continuing TVET. One key focal point here is electromobility (e-mobility), as it offers considerable potential in terms of both development and demand.

The study starts by outlining the relevance of the mobility sector in the context of sustainability, before highlighting technological developments from the perspective of partner countries in German DC. Conclusions regarding the need for skilled workers can be derived from this. Drawing on an analysis of the current training situation in four selected countries – India, Kenya, Nepal and Rwanda – best-practice projects are then presented. Recommendations for planning and implementing future sustainable transport measures (mobility projects) and TVET projects will be derived from these findings.

The study is based on an extensive analysis of data and literature and on the outcomes of 20 interviews with relevant government representatives and DC practitioners as well as private sector and TVET stakeholders in the selected partner countries.



2 The relevance of the sector in the context of sustainability

The mobility sector plays a key role in achieving the objectives laid down in the Paris Climate Agreement[1] as well as the Sustainable Development Goals (SDGs) set out in the 2030 Agenda[2]. It is also crucial to the Sustainable Urban Development Goals, which were summarized in the New Urban Agenda[3]. Mobility enables individuals to participate in socio-economic development. As an important element of the economy however, it plays a key role in a range of topics that are at the crux of sustainability, particularly climate change, air quality, safety, energy supply and the efficient use of energy resources.

The transport system spans different modes of air, sea and land transport and provides mobility services for freight and passenger transport. This study deals with land-based road transport for passengers and goods. Rail and maritime transport do not usually play a major role in the partner countries of German DC, and it is proving very difficult to make air transport sustainable. This study focuses on urban mobility, as the increase in motorised traffic is highest in urban areas. We examine e-mobility solutions in particular, as they are already being used in developing countries and emerging economies and can contribute to economic and employment growth.

The negative impacts that transport emissions have on the environment and human health are well known. Globally, transport is one of the largest and fastest growing sources of carbon emissions. At eight gigatonnes, transport accounts for almost one quarter of the world's energy-related carbon (CO_2) emissions (IEA, 2022). **Global carbon emissions from the mobility sector will almost double again by 2050 if we fail to take action** (ITF, 2019). Even in a scenario where we move away from modes of transport that use fossil fuels and towards significantly improved vehicle efficiency, the forecast is that global transport emissions in 2050 will not fall below 2015 levels (Lah, 2017). Achieving the goal of limiting global warming to well below 2°C compared to pre-industrial levels, as laid down in the Paris Climate Agreement, will therefore require a mammoth effort, in the mobility sector as well (IPCC, 2021).

Traffic is not only a major source of air pollution, it also takes up a lot of space, especially in congested urban areas. The marked increase in private transport plays a key role in this context. A growing middle class in many developing countries and emerging economies will lead to increasing motorisation. A change in direction will be particularly challenging to implement in the mobility sector due to the longevity of transport infrastructure and ingrained patterns of human behaviour. Current infrastructure and settlement

1 Paris Climate Agreement (BMZ)

2 Germany's Sustainable Development Strategy (for achieving SDGs) (The Federal Government)

3 New Urban Agenda (United Nations, 2017)

configurations are generating strong demand for transport in many urban areas (IPCC, 2014). At the same time, ongoing rapid urbanisation in the Global South poses a high risk of further entrenching inefficient and unsustainable transport patterns if the emission-intensive settlement patterns and transport systems developed in industrialised countries are replicated in developing countries and emerging economies (Seto et al., 2014).

On its own, however, transitioning to sustainable drive systems will not be enough to establish green, energy-efficient transport as a durable, long-term solution. Demand for transport and the number of vehicles are likely to continue rising, especially in developing countries and emerging economies (SOLUTIONSplus, 2021a). **A 'mobility transition' is therefore required, whereby people move away from private transport and gravitate more towards new usage models and shorter journeys**. Sustainable transport is characterised above all by the following three axes:

- **Avoid**: Avoid journeys altogether through 'smart' urban and transport planning (e.g. by developing mixed-use instead of separate commercial and residential districts, and by incorporating redensification[4] into zoning plans instead of new developments)
- **Shift**: Move away from motorised private transport towards non-motorised and local public transport (e.g. by expanding the bus system or building new bikeways). This will imply better integration of individual modes of transport
- **Improve**: Increase the energy efficiency of vehicles by supporting clean propulsion technologies and fuels (e.g. electricity, hydrogen, compressed natural gas, biofuels and other fuels)

The transition towards sustainable transport will therefore affect a number of closely interlinked industries, business sectors and value chains that will be needed to develop, introduce and operate sustainable mobility systems. There will of course be overlaps with other sectors, such as the renewable energies needed to charge electric vehicles. The transition also includes robust urban and transport planning, which will determine how often and how far people will need to travel by motorised transport (e.g. proximity to basic services, distance to work). Against this backdrop, it is important to adopt a systemic approach to e-mobility, by increasingly linking the traditional subsystems of vehicles, transport and energy, which up to now were viewed as separate entities. In order to develop an e-mobility system that is both future-proof and sustainable, it is vital to combine new vehicle technologies with innovative usage models and to connect private and public, individual and shared forms of mobility.

Sustainable transport offers us the opportunity to not only reduce carbon emissions in the mobility sector, but to also make the sector more accessible and equitable. Rather than happening of its own accord however, inclusive and comprehensive strategies will be called for. The mobility transition could therefore play an important role in achieving a number of the SDGs, in particular Good Health and Well-Being (SDG 3), Industry, Innovation and Infrastructure (SDG 9) and Sustainable Cities and Communities (SDG 11). At a secondary level, it will also help attain some of the SDGs, including Quality Education (SDG 4), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13) and Life on Land (SDG 15).

4 Redensification refers to an increase in urban density.

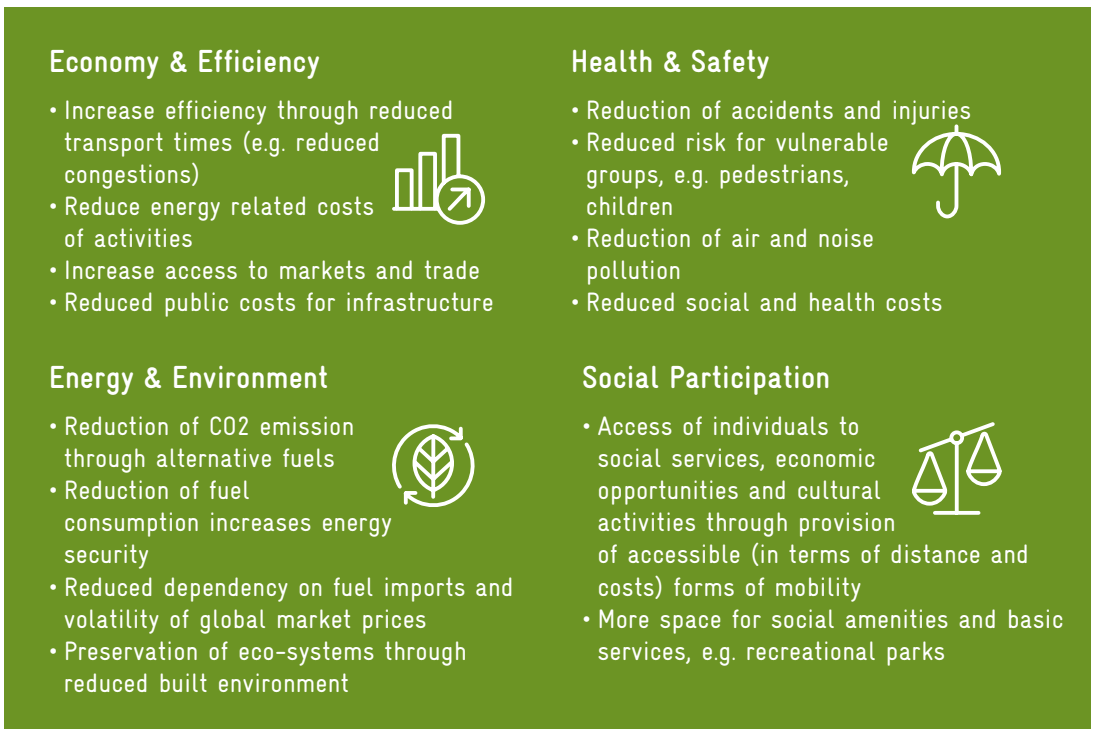
The positive effects of lower carbon emissions and less pollution on our climate and ecosystems are plain for all to see. Switching to public transport systems alone could increase energy efficiency by up to 30 per cent by 2040 (Lah, 2018). Less fuel consumption would reduce dependence on fossil fuels imports, which would – in developing countries and emerging economies in particular – protect against the volatility of global oil prices (in terms of economic stability and energy supply).

The mobility transition could also boost economic growth by, for example, reducing congestion and lowering the cost of transport. For example, between USD 50 and USD 100 trillion could be saved globally by 2050 through fuel savings, fewer vehicle purchases and a reduced need for infrastructure (UCDAVIS & ITDP, 2022). Markets for products and services would also become more accessible and would open up new job opportunities.

A sustainable transport system would have a positive impact on health and safety by, for example, reducing air pollution and the number of accidents, which often disproportionally affect disadvantaged or vulnerable groups such as children, the elderly or those on low income, as they rely on non-motorised transport (NMT).

Passenger transport plays a particularly important role in access to services, economic opportunities and social participation (Bibas et al., 2015; Angel & Blei, 2016). Lower costs and reduced travel times, in addition to improved connectivity in peripheral areas can increase access to social services, economic opportunities and cultural activities. By providing more accessible mobility services (in terms of distance and cost), a Just Transition would allow disadvantaged and vulnerable people in particular to be more mobile and would open up opportunities for social, economic and cultural participation.

Figure 1: Social and environmental potential of sustainable transport (author's own graphic)



The Green Transition could be used as an opportunity to make the mobility sector fairer and safer for women. Up to now, the sector has been heavily male-dominated worldwide. Globally, less than 20 per cent of employees in the sector are women; this figure is even lower in leadership positions (OECD, 2020). **It is therefore not surprising that transport planning and mobility services often do not take women's needs into account (e.g. when planning routes or schedules), although women depend on public transport to a greater degree than men** (OECD, 2020). A lack of safety and security in public transport, particularly at night or in certain areas, often makes women feel unsafe. In addition, an inadequate infrastructure, such as a lack of accessibility, appropriate toilets and safe waiting areas, means that it is difficult for women and girls to use mobility services. Gender-specific stereotypes may lead women and girls to avoid travelling alone or using public transport. As a result, many women cannot use mobility services as they do not meet their needs and put them at increased risk of assault. In India, 31 per cent of women surveyed said that having to commute to work prevented them from taking up employment (GIZ, 2023).

Awareness-raising and education can help identify women's needs and can promote safe and equitable participation in the mobility sector. Improved infrastructure, such as well-lit bus stops and gender-sensitive toilets, would help increase access.

In terms of economic development, the mobility transition also offers potential for creating new job opportunities in the locality. Shifting the focus away from (mostly imported) cars to shared and public mobility services increases demand for staff in the local public transport system, logistics and complementary services. This shift could generate significantly more local jobs in the mobility sector.

Transitioning to sustainable transport would also open up new business areas, creating potential for local economic development and job growth, both through electric vehicle manufacturing and increased need for sustainable mobility services. This calls for the development of innovative business models for new vehicle technologies and mobility strategies. To this end, it is vital that the private sector recognises new market developments early on and promptly develops business models that are tailored to local needs. The trend towards e-mobility also offers new economic opportunities for countries that do not yet have their own car manufacturing industry. This involves more than simply transitioning to new drive systems. Such systems must also be integrated into new transport and mobility services.

While it is extremely difficult to compete with well-established companies in the area of conventional drive systems and transport strategies, using electric vehicles in locally adapted mobility models offers the opportunity for economically viable start-ups at the local level (SOLUTIONSplus, 2020). Countries such as India and China channel the field of e-mobility to pursue industrial policy goals. Similar strategies could also be feasible for smaller countries in Asia, Africa and Latin America. An increasing number of developing countries already have their own research programmes and strategies (ILO, 2019), for example to develop low-tech micromobility solutions. There is also potential for small and medium-sized vehicles in particular to be built in countries that have not yet developed a car industry. **Policy-makers and industry in many countries around the world have not yet sufficiently exploited the economic potential of innovative mobility solutions** (IPCC, 2021).

3 Technological developments in the sector and their relevance in the context of development cooperation

On a global level, technological and usage-related changes are already being observed in the mobility sector. These trends are expected to lead to a shift towards green modes of passenger and freight transport, as well as an expansion of mass public transport (ILO, 2019). This refers not only to new propulsion technologies such as electric and plug-in hybrid vehicles or infrastructure systems such as bus rapid transit (BRT) systems[5], but also to new usage models such as Mobility-as-a-Service (MaaS)[6] and shared mobility[7]. In the medium to long term, developments such as automated driving or delivery drones will also shape the mobility sector. However, the availability of these technologies alone is not enough. Further research is needed on how the use of these technologies can be adapted to local contexts and made more widely available to drive more sustainable urban transport development (Saujot & Lefèvre, 2016; Creutzig, 2016). This also covers the question of initial and continuing TVET for skilled workers on the ground, to enable them to produce, operate and maintain the new technologies.

Technological developments to decarbonise transport are available and policy support measures are in place that can be implemented at local, national and international policy levels (see IPCC, 2021). However, a recent analysis by the International Energy Agency (IEA) shows that the pace of decarbonisation is not the same across different modes of transport, as the maturity of the technologies in particular, but also the political and regulatory capacities required to steer the transition within the subsectors, vary considerably (IEA, 2021). For example, there are currently fewer technological options available for long-distance transport, such as road, sea and air and governance of these sub-sectors is more fragmented than in the urban mobility sector.

The transition to sustainable transport will follow different pathways and the pace of progress will vary, depending on whether it takes place in industrialised, developing or emerging countries. The dissemination of sustainable transport technologies in the short to long term depends on the maturity of the respective technology, on existing technological capacities and on the political will of a country to decarbonise. This includes economic and political framework conditions such as regulatory and coordination capacities, subsidies, tax incentives and the availability of capital as well as

5 Bus Rapid Transit (BRT): Frequently scheduled rapid bus system with dedicated lanes

6 Mobility-as-a-Service (MaaS): Integration of different mobility services such as local public transport, car sharing, bike sharing, etc.

7 Shared mobility: The communal use of vehicles (such as rental bikes, e-scooters, kick scooters and cars)

research and development capacities. The problem can be addressed, for example, by managing demand for travel through urban planning and design, shifting to public transport and non-motorised transport (NMT), and reducing the carbon emissions from fuels and energy sources. However, the available mechanisms in this context differ from city to city and country to country (IPCC, 2014; Kok, Annema & van Wee, 2011).

The degree of maturity and complexity of new mobility technologies also influences whether they can be imported or developed and produced locally. Complex technologies require sophisticated technological and research capacity, skilled labour and high capital investment, which can be a challenge for many developing countries. Due to the high-tech nature of electric and plug-in hybrid vehicles, their development and production is therefore concentrated in a few industrialised countries and emerging economies. At the same time, the production of electric engines and basic electric vehicles, including electric rickshaws and electric bikes, will become increasingly important in developing countries and emerging economies.

Given that framework conditions vary in developing countries and emerging economies, the speed of market development and impact on jobs – and therefore the requirements for initial and continuing TVET – can be vastly different. In emerging economies, for example, markets for low-carbon technologies in the mobility sector are expected to grow significantly due to falling costs and increasingly ambitious environmental policy targets. For example, demand for electric and plug-in hybrid vehicles as well as for BRT systems and the integration of different modes of transport is expected to soar by 2030. Electric and plug-in hybrid vehicles will be slow to take off in developing countries and moderate growth is expected for BRT systems and the integration of different modes of transport (UNIDO, 2020). In this regard, the innovative adaptation and manufacturing of low-tech products and technologies in line with local conditions will open up new job opportunities in the partner countries, e.g. in the conversion of conventional motorbikes with locally produced electric engines (UBA, 2020) (see text box 1). In addition to highly skilled workers for technological development, the availability of skilled labour for production and maintenance is key. Technical skills profiles must be adapted to new technologies.

However, new mobility technologies and models will also create job opportunities in the launch of new technologies (for example, the development and construction of infrastructure) as well as in maintenance and operation. Skilled workers are needed in this context. Here too, the technological skills available will influence the pace of dissemination. As a general rule of thumb, the more complex a technology, the higher the level of skill required to install and operate it. Complexity usually decreases with technological maturity, as gradual developments simplify handling and maintenance (UNIDO, 2020).

Text box 1: Continuing training needs for the introduction of electric bike taxis and electric bus systems

Bike taxis are widely used in East Africa. Some start-ups are developing business models to establish the use of electric bikes among taxi drivers. One such company builds motorbikes for the local market from imported chassis and batteries that they produce themselves, for example. At a later date it is planned to expand production by manufacturing the chassis locally. Another start-up converts conventional motorbikes using their own batteries. The conversion itself is free, but the batteries must be leased. A battery exchange system from stations that are scattered across the city will give taxi drivers the range they need (Martin, 2020). The production of the motorbikes and 'franchise' models for battery exchange stations and for the taxi drivers themselves could generate employment. To achieve this, the operators need to undergo continuing education in battery maintenance and safety. Technicians are also needed to maintain the charging infrastructure. Mechanics need to be trained to repair the electric bikes safely and professionally at service stations and drivers also need instruction and safety training for the new vehicles.

The introduction of an urban electric bus system requires continuing education measures, for example for mechanics at bus operators. In addition to a basic understanding of the propulsion system and safety training, they need new skills to familiarise themselves with special tools and maintenance methods, to diagnose faults and to carry out the required repairs.

Measures to decarbonise urban mobility are well developed from a technical perspective and offer options that can be implemented in developing countries and emerging economies too (see list in Table 1).

Table 1: Relevant technologies and models for sustainable transport in developing countries and emerging economies

Area	Technologies and models
Vehicles	Electric two- and three-wheelers, electric buses, electric BRT systems, minibuses, taxis, conversion of electric (mini)buses, and logistics vehicles
Operation and maintenance of transport systems	Innovative charging solutions for high-performance bus systems, use of existing systems and networks for charging electric vehicles, seamless charging, smart charging, as well as charging services and related operations and business models
Integration of different modes of transport and mobility models	MaaS, network planning and management, pooling of vehicle fleets, urban logistics, rental systems and related integrative measures and business models

More recent digital technologies in the mobility sector can help change traditional perceptions of the sector and make it more attractive to women. Little will change, however, if we do not adopt a more comprehensive strategy. The percentage of women involved in the sector has remained at the same low level for 20 years now (WMW, n.d.). Scientific and technical subjects account for a significant share of TVET training in the mobility sector, but these subjects are perceived by society as unattractive for women. Strategies to enhance the inclusion of girls and women must therefore address traditional social stereotypes (OECD, 2020). Projects on their own cannot change these perceptions. It will require a broad multistakeholder partnership with a range of state and civil society actors. Specific aspects need to be taken into account in many developing countries and emerging economies, however. A key challenge in this context is the digital divide that affects women and girls in many countries. Limited access to digital technologies, insufficient infrastructure and a lack of technical skills can curtail their ability to benefit from new mobility solutions. The availability of internet connections, access to affordable smartphones and the provision of digital education are crucial factors in bridging this gap. Gender-specific usage patterns also play a role here. Traditional gender roles and social norms can make women and girls less likely to use or trust certain technologies and innovative mobility services. **It is important in this context to raise awareness and show how these technologies can improve their lives and mobility. Training and awareness-raising programmes can help build confidence, expand skills and overcome gender barriers**.

Despite these challenges, however, the sector also presents an array of opportunities. Digital inclusion for women and girls can be advanced through targeted digital education and training programmes. It is important to open up access to digital technologies and provide them with the skills they need to reap the benefits of new innovations in the mobility sector. Another opportunity lies in increasingly involving women in the development and design of new technologies, mobility solutions and business models. By increasing women's participation, better account can be taken of their needs and perspectives, which will lead to tailor-made solutions and to women and girls increasingly accepting and using the new technologies. Digital mobility platforms also provide an opportunity for women and girls by enabling them to identify their own mobility needs, share information and empower each other. These platforms can provide safe spaces where they can share their experiences, seek advice and find support.

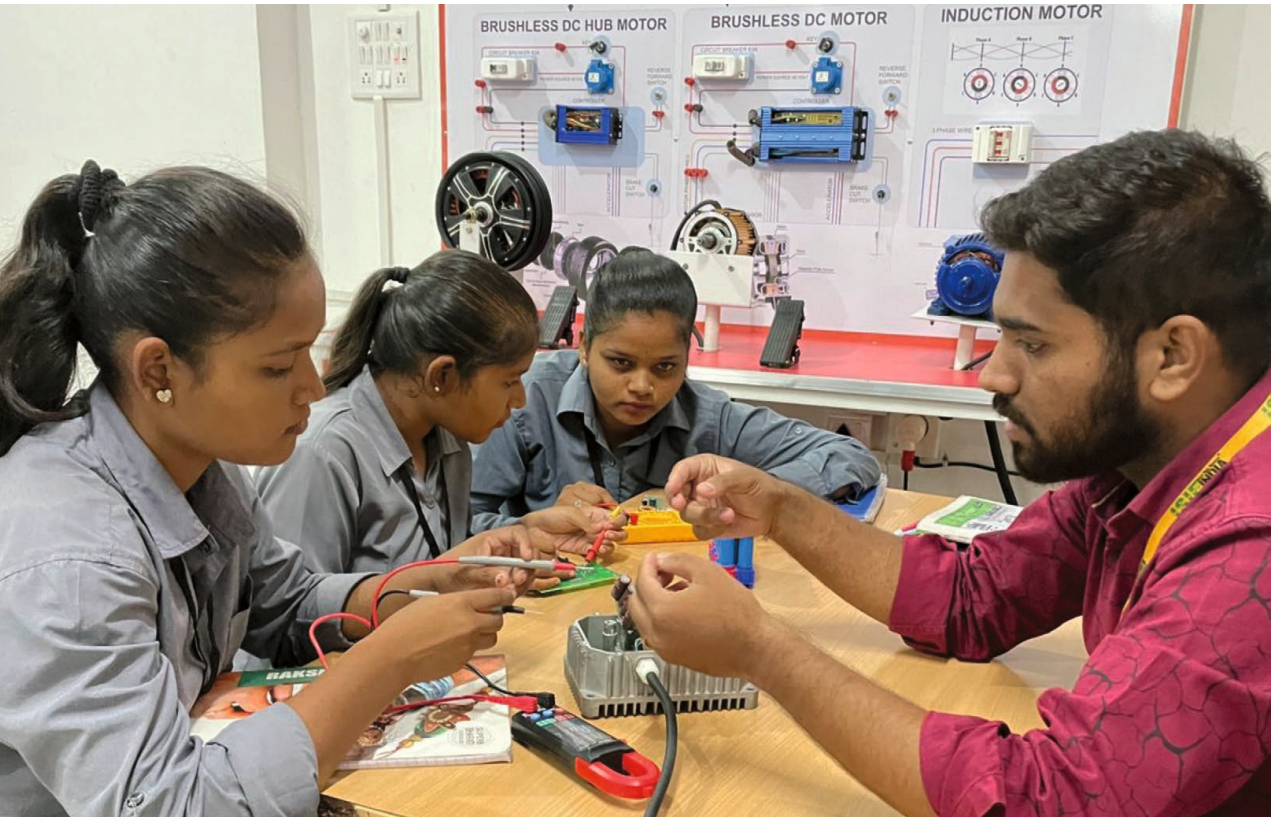
The following two sections identify the technological trends in sustainable transport that offer the greatest potential for implementation in developing countries and emerging economies due to environmental and social conditions and in terms of economic growth.

3.1 Development potentials in urban passenger and freight transport

Governments have different options for shaping the sustainability of mobility systems through infrastructure and service measures, policy decisions and private sector support measures. Key areas related to transport activity, the modal structure of transport, energy intensity, fuels and energy carriers can shift the demand for skilled labour from vehicle production to mobility services and urban planning (for examples see Table 2).

As part of sustainable transport planning, a package of complementary measures is needed to actively manage demand for transport and improve energy efficiency in transport. This includes improvements to local public transport as a reliable and affordable alternative to cars, as well as measures to increase the efficiency of the vehicle fleet. E-mobility can also play an important role in replacing conventionally powered trucks for urban logistics, especially in the last mile[8], to reduce emissions and ease congestion.

Municipalities have a key role to play in shaping the urban landscape and planning local transport infrastructure. Using integrated urban planning[9] and having the ability to regulate, finance and operate public transport services, a city can shape the modal structure[10] of its transport system to a significant degree. A mix of measures is crucial for successful sustainable urban mobility models (see Table 2), combining improvement of the vehicle fleet ('Improve'), reducing travel distances through integrated land use planning ('Avoid') and offering alternatives to the private motorised transport ('Shift'). While the national level is responsible for several measures that address energy management in the mobility sector (e.g. vehicle and fuel tax, fuel efficiency regulation), land use planning and the efficient linkage of different modes of transport are key areas for local government.



E-vehicle assembly by technician students at the Imperial Society of Innovative Engineers training centre in Aurangabad, supported by GIZ India and the Indian Automotive Skills Development Council, India. © GIZ India

8 The 'first and last-mile' connection describes the beginning or end of an individual trip made in a personal or urban context.

9 The term '**integrated urban development**' refers to the need to design planning processes holistically rather than sectorally. In the context of urban development for example, this means considering settlement structures, traffic, the environment and social concerns too, as part of the big picture. The aim is to enable sustainable development of urban neighbourhoods against the backdrop of rapidly changing framework conditions and the requirements of cities.

10 A modal structure refers to the use of different modes of transport such as cars, local public transport, NMT, etc.

Table 2: Overview of development potentials in urban passenger and freight transport (adapted from Lah, 2018)

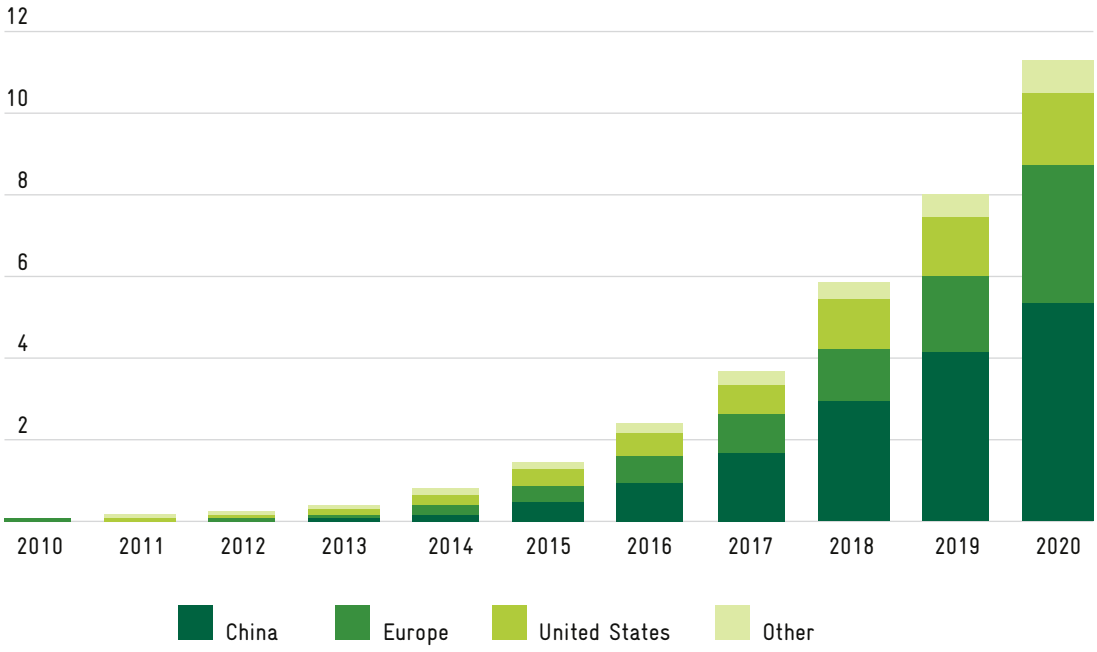
Strategy	Examples	CO_2 reduction potential	Synergies and risks for other policy areas		
			Industry/ Green Jobs	Society	Environment
Avoid traffic					
Road traffic charges	Road usage charges/ congestion charges/parking charges	Example of London (England): 25 per cent reduction in CO_2	IT systems technician	Social costs: Reduction: EUR 144 million/ year	Fees can be invested in public transport, for example
Shift away from private vehicles					
Local public transport	TransMilenio BRT system in Bogotá (Colombia)	Reduction of CO_2 emissions by 200,000 tonnes (in 3 years)	Bus driver; professional driver; transport service clerk Mechatronics technicians for vehicle maintenance	Access for all if ticket prices are positioned accordingly. 90 per cent less accidents on BRT corridors	Improvements in air quality
MaaS	Mobility services, e.g. first/last mile connectivity	Average CO_2 savings potential	Bus driver; professional driver; transport service clerk	Creating local value and jobs; women for women business models	Emission reduction, congestion avoidance
Urban logistics	E-cargo bikes in Quito (Ecuador)	Medium to high CO_2 savings potential	Efficiency gains, cost reduction; freight forwarding and logistics services clerk	Fewer health impacts, for example	Emission reduction, congestion avoidance
NMT	Pedestrian and bicycle traffic: bicycle-friendly city	Total reduction of greenhouse gas emissions not quantified	Urban planners; construction trades; bicycle mechanics	More physical activity, less health impacts and traffic accidents, better connections with transport networks and therefore easier access to social and commercial facilities	No air pollutants, less noise
Improvement of vehicle efficiency					
E-mobility	Conversion of conventional vehicles and new development of electric vehicles for last mile connectivity	Medium to very high CO_2 savings potential	Electronics technician; mechatronics technician; industrial electrician	Shifting value creation and job opportunities to locally producible mobility models; connecting peripheral urban districts.	CO_2 emission reduction potential depends on the electricity mix. Significant potential for sulphur dioxide and nitrogen emissions

The expansion of sustainable urban passenger and freight transport supports job creation. **From a jobs perspective, the intervention level 'Improve vehicle efficiency' is particularly relevant, as a number of business models and job opportunities may develop here**. This includes, for example, the production of electric two- and three-wheelers and their use in passenger transport and logistics. As regards the principle of 'Avoid traffic', regulatory and fiscal policy measures are relevant first and foremost. Government investment in local public transport and non-motorised transport in particular plays a role in the area of 'Shift away from private motorised transport'. In the area of 'Improve vehicle efficiency', however, a large number of private sector stakeholders can contribute to the transition. Electric micromobility is of key importance in this context, because it can help create substantial value at the local level through the local production and operation of vehicles.

3.2 Development potentials in transitioning the vehicle fleet

The uptake of electric vehicles is increasing due to targeted support programmes and the introduction of national regulations. This approach is being implemented by a growing number of cities and countries. The number of electric vehicles has grown rapidly over the past ten years. While there were around 17,000 electric cars on the roads worldwide in 2010, this figure had risen to around 10 million by 2020 (see figure 2). Around 2.3 million electric cars were sold in 2020 alone, but so far demand has been highest in the world's three major car markets – China, Europe and the USA.

Figure 2: Global electric car stock, in millions (IEA data, 2021)



Growth of the electric vehicle fleet in Africa and Asia will also impact on markets in developing countries through a growth in imports of used electric cars. In the four countries investigated in this study (India, Kenya, Nepal and Rwanda; see Section 5), we can see that demand for used electric vehicles follows the same trend as demand for conventional vehicles. However, the challenges of maintaining and repairing used vehicles are greater than for new vehicles. The skill requirements for repair and maintenance will also change substantially, albeit at a certain time lag. Stakeholders in e-mobility ecosystems therefore emphasise the importance of providing continuing education for workers to repair and maintain the vehicles as customer numbers increase.

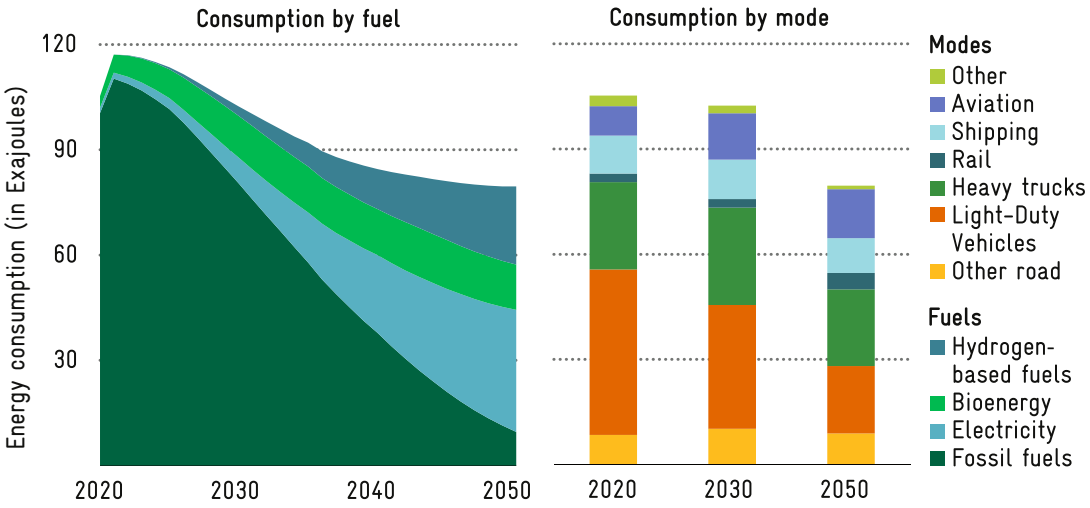
Micromobility vehicles, particularly scooters, motorbikes and rickshaws, are highly relevant for Asia and Africa, as they account for a substantial share of urban transport. It is assumed that two and three-wheelers currently account for 30 per cent of the motorised vehicle fleet worldwide. Over the past two decades, the average annual growth rate for two- and three-wheelers has been over 7 per cent. Numbers are expected to double every five years (GIZ, 2020a).

The area of electric micromobility (two- and three-wheelers) in particular is expanding rapidly, especially in Asian and African countries. The number of two-wheelers worldwide is expected to exceed that of cars by 2040 (GIZ, 2018). China accounts for by far the largest percentage in this context. 230 million of the approximately 260 million electric two-wheelers (motorbikes) are in China. Countries like India and Vietnam also have an ever-growing number of electrified two- and three-wheelers. **They are still much less popular in Africa, but here too numbers are on the rise (Black et al., 2018). It is estimated that electric two-wheelers will account for 45 per cent to 57 per cent of vehicles in sub Saharan Africa by 2040 (excluding South Africa)**. In some countries such as Rwanda and Kenya, between 60 and 75 per cent of all two-wheelers sold are expected to be electric by 2040.

Even if the cost of generating and distributing electricity remains moderate against the backdrop of increased demand for electric vehicles, there will be a significant impact on electricity generation, grids and charging systems. Industries involved in the manufacture of electric drive systems and components as well as battery production will benefit. Employment in the entire value chain for fuels and in the conventional automotive industry, by contrast, is expected to decline. Despite progress in biofuels and electricity, petroleum products accounted for more than 90 per cent of energy consumption in the mobility sector in 2020. In the International Energy Agency's net-zero scenario[11] (see figure 3), oil will account for less than 75 per cent of this consumption by 2030 and to just over 10 per cent by 2050. By the early 2040s, electricity will be the main energy source for mobility (IEA, 2021).

11 The goal of net-zero strategies is to remove as much carbon from the atmosphere as is produced. Net zero will therefore guarantee that the percentage of greenhouse gases in the atmosphere remains constant and does not increase any further.

Figure 3: Global final energy consumption in the mobility sector by fuel type and mode in a net-zero scenario (IEA, 2021)



The switch to e-mobility will therefore have an impact – albeit moderate - on the energy production sector. In the net-zero scenario, electrification of almost all road transport by 2050 would increase global electricity demand by around 27 per cent (Bloomberg, 2022). **Besides the positive effects resulting from growth in Green Sectors, countries that are major fossil fuel producers and have a traditionally robust automotive industry need to take appropriate measures to offset the negative economic and employment effects of such growth**. This applies equally to training and employment in the area of operating and maintaining existing systems, e.g. for people who often work in the informal passenger mobility sector in Africa and parts of Asia. These jobs may be jeopardised by expanding public transport or by imposing higher taxes on fossil fuels.

To help workers from declining industries transition to new jobs in growth industries, a comprehensive package of measures should be implemented for workers from carbon-intensive industries who lose their jobs. These include, for example, initial and continuing TVET measures, social protection, an active labour market policy and support for social partner dialogue (GIZ, 2022).

4 Demand for skilled workers and Green Skills

Against the backdrop of new technologies and fundamental changes in mobility models, the green mobility transition depends on the availability of a broad spectrum of low to highly skilled workers. Even if ambitious political strategies are in place, a country needs an adequate supply of professionals – from the fields of urban and spatial planning, engineering, political science, economics and technology and commerce – to plan, develop, operate and maintain new mobility systems in the long term.

The quality of infrastructure maintenance affects the rollout of new technologies. Faulty installation and maintenance can undermine confidence in green technology and slow down its growth. For example, e-mobility needs a reliable charging infrastructure and maintenance services, requiring maintenance technicians and mechanics with experience of electric vehicles and their repair. A lack of specialist knowledge among skilled workers not only makes new technologies less effective, it also increases costs and reduces acceptance among potential clients (Pavlova, 2019; UNIDO, 2020).

Equipping these workers with the required expertise calls for new core technical, vocational and social skills to be taught through the respective Technical and Vocational Education and Training (TVET) system. **In this way, TVET can proactively drive the mobility transition. Adapting basic and advanced education content early on will prevent a situation where the transition is hampered by skills gaps**. Anticipating relevant skills gaps at local level at an early stage and forging institutional links to develop the required skills on time play a key role in this context.

Teaching the skills required for a more sustainable mobility sector early on will also help develop local value chains, thereby creating job opportunities. In many countries, new business opportunities are emerging in the sustainable mobility sector. Local start-ups (in areas such as online ride service platforms, electric motorbike leasing models, electric bike production) often step into the breach. The short-term availability of skilled personnel is crucial for these companies to be able to expand. The development and operation of electric bike taxis for example, requires both highly qualified personnel for developing prototypes and production processes as well as skilled workers for assembly and operation.

Teaching the necessary skills early on can open up access to new markets, enhance competitiveness, support innovation and protect consumers and the environment. If relevant measures are not available, companies must develop in-house training measures to continue educating their employees. Experience in India indicates that it takes up to three months to train unskilled workers. Workers with the necessary skills can significantly increase productivity and reduce the cost of green mobility solutions. This is particularly beneficial for small companies that cannot afford in-house continuing TVET measures (WRI India, 2022).

Based on the trends described above, we will now take a closer look at the changing requirements for skilled labour (Section 4.1) as well as the core skills (Section 4.2) needed for the mobility sector in developing countries and emerging economies to make a successful green transition. The focus here is on the potential that e-mobility solutions offer as a key driver of transformation processes in developing and emerging countries.

4.1 Emerging need for skilled labour

Globally, the mobility sector provides direct employment to an estimated 60 million people, not including indirect jobs in the related value chains (ILO, 2020).

A wide variety of skilled workers is needed to ensure a Just Transition to a sustainable mobility sector. We need to make a general distinction between direct, indirect and induced employment effects. Developing public transport systems would, for example, create jobs in public transport and in expanding the supporting infrastructure (direct effects). At the planning and administrative level alone, rough estimates suggest that additional demand for workers in the urban mobility sector in developing countries will be at least a quarter of a million by 2050 (GIZ, 2020b). Jobs would also be created in areas related to services and products for the public mobility sector (indirect effects). Since local public transport is also cheaper for society as a whole than private transport, expansion of the former could boost consumption of other services and products outside of transport (induced effects).

It is also important to note that employment effects vary over time. Expanding public transport will generate short-term employment effects in the area of infrastructure planning and construction, for example, and long-term effects in their maintenance and operation. Employment effects in the production of electric vehicles depend on integration into global value chains and on the technological, economic and political conditions in the individual countries. While the e-mobility industry is more mature in larger Asian economies – such as India, where it is supported at the political level through regulations and funding programmes (WRI India, 2019) – it is still early days for electric vehicles in Africa (Black et al., 2018). However, a small but rapidly growing ecosystem of start-ups developing sustainable e-mobility solutions for two- and three-wheelers in particular, can nevertheless be found in countries such as Uganda, Kenya and Rwanda. In East Africa, for example, there are over 20 start-ups that focus on producing and converting electric two-wheelers (mainly for the taxi business), collectively raising over USD 25 million in investment in 2021 (UEMI, 2022).

Despite the many positive employment effects, there is a negative side too, however. Models developed in Nigeria, for example, show that investment in public transport will also lead to job losses in the oil refining sector and in petrol stations. The net employment effects[12] of expanding the Nigerian public mobility sector by 2035 are therefore estimated to be close to zero (UNDP, 2021). Low-skilled and marginalised groups will be particularly affected because they lack access to the education needed to adapt to the new requirements of a green mobility sector.

12 Net employment effects: new job opportunities created in growth industries less job losses in declining industries

Globally, ILO (2020) therefore estimates that even an ambitious expansion of public transport would only generate relatively few direct net employment effects across the different industries such as mobility, construction or energy production. This also applies to the electrification of vehicles. If the indirect jobs created by connected value chains are included however, the net employment effects of vehicle electrification are estimated at just under 18 million jobs, mainly in developing countries and emerging economies. New jobs are expected to be created in the development and production of electronic components and battery technologies on the one hand, as well as in infrastructure construction and energy generation on the other (ILO, 2020).

To ensure that the transition to a sustainable mobility sector is just, it is vital that vulnerable groups are not left behind. The quantitative employment effects must be recognised early on in order to not just develop initial and continuing TVET opportunities for growth sectors, but to also offer employees in declining sectors the opportunity to find new jobs through reskilling and upskilling (and other accompanying labour market measures). Taxi drivers could be retrained as bus drivers for new local public transport systems. Social resistance to the transition can be reduced in this way and the specialised knowledge of skilled workers used to accelerate progress (WRI India, 2022). In this context, it is important to dovetail with other labour market services as part of an integrated approach.

Women play an important role in shaping sustainable transport. Their integration into the mobility sector is crucial to equitably shaping and accelerating the transition towards sustainable transport systems. Currently, only about 22 per cent of workers in the sector are women (ITF, 2021). The increasing demand for skilled workers in the field of sustainable transport offers opportunities for women to play a key role in the sector's future. By actively involving women in the planning, construction and operation of environmentally friendly transport systems, they can make a key contribution to generating direct, indirect and induced employment effects. Targeted measures such as training programmes and quota systems can encourage women to play an active role in the transport industry and enable equity in the workplace.

The need for flexible working hours in the transport industry poses challenges for women with family responsibilities, yet the sector also offers opportunities for women and girls. Promoting equality and eliminating prejudice and discrimination facilitates equal job opportunities. Mentoring programmes and the visibility of successful women in the transport industry can encourage girls to develop their interests and skills in this field. Providing flexible work models and creating family-friendly work conditions would help women pursue a career in the mobility sector without having to neglect their family commitments.

At the same time, women can help counteract negative effects on the labour market and support marginalised groups by using their expertise and perspectives to develop education and training programmes.

At the national level however, it is difficult to make reliable quantitative forecasts of employment effects for the mobility sector. In developing countries and emerging economies, forecasts are complicated by the fact that there is often a lack of general data on the structure and volume of local level transport, which are required to create employment forecasts. This is especially true for data on women's mobility. Non-gender-disaggregated

data or the fact that data are collected from a male perspective is viewed as a major challenge for the design of a more equitable mobility sector (WMW, n.d.). A number of international cooperation projects and multistakeholder initiatives such as SOLUTIONSplus and TUMI are currently working on creating a database that will provide better information on the current job situation and future potential.

In general, the availability of labour market data is considered problematic for many partner countries. Many of these countries do not routinely conduct labour market and needs assessments. For 2020, for example, only 20 per cent of African TVET stakeholders surveyed stated that their country routinely collects labour market information (BILT, 2022; UNESCO-UNEVOC, 2020). The high percentage of informal jobs in many DC partner countries also poses challenges for obtaining reliable employment forecasts. It can be assumed that a high percentage of those working in the mobility sector do not have formal qualifications, e.g. as drivers or road-side mechanics (ILO, 2019). As traditional approaches to collecting labour market data are insufficient in this context, there is a lack of reliable data on informal employment in most partner countries (BILT, 2022).

An important recommendation for future projects would therefore be to conduct routine local labour market and needs analyses for skilled workers. These analyses need to include declining employment effects and provide data on the situation of women in the mobility sector. The specific local effects on employment illustrate that not enough highly aggregated labour market data are available to allow education provision for skilled workers to be tailored to local labour market conditions and to facilitate an integrated approach to job creation. Indeed, capacities need to be strengthened at grassroots level to pave the way for local detailed labour market projections that include declining industries and support a Just Transition.

4.2 Skills required in the green mobility sector

The transition from conventional modes of transport to more sustainable systems will influence the skills required along entire process and value chains. New technologies, increasingly cross-sectoral work and the growing digitalisation of the mobility sector will change the tasks to be carried out and therefore the skills required of workers too. This concerns technical, occupational and social skills and their impact will vary, depending on the type of employment and the level of qualification.

In general, it is assumed that the mobility transition will require the adaptation of existing occupational profiles to new technologies and models rather than the creation of entirely new profiles (ILO, 2019). In the TVET models that are now well established, occupations are linked to a specific set of competences that skilled workers are expected to have to be able to deal with typical occupation related tasks and problems. These competences are broken down into technical and social skills that learners must demonstrate in order to obtain a vocational qualification (Wilbers, 2022). Any changes in the skills expected of workers in the course of the transition can be adapted in this way within the framework of an occupational profile. New occupational profiles may need to be developed if there are significant changes to the required skill sets (ILO, 2019).

It is also assumed that the use of new technologies will require technical skills to be adjusted at the vocational and academic level within different occupational profiles. The expansion of public transport and the electrification of vehicles for micromobility, logistics and local public transport will bring changes in occupational profiles along entire value and process chains, which will have a range of different impacts on typical work processes and tasks. There will also be changes across qualification levels. For example, an analysis of the skills required for introducing public electric bus systems in Indian cities found that the higher and middle management levels in bus operating companies need to have additional skills for planning, procurement and operations management. At the same time, technicians and mechanics also require continuing training in maintenance and repair of electric buses.

To provide comprehensive support for the introduction of new sustainable transport systems, it is not enough to simply adapt individual occupational profiles. Instead, systematic promotion should be consistently oriented towards the corresponding value and process chains that are needed for developing, introducing and operating the specific systems. Table 3 lists examples of occupations in individual areas of the value chains.

Table 3: Examples of occupations needed to expand sustainable transport along the value chain (WRI India, 2019)

Value chain	Examples of key occupations for expanding sustainable transport
Research and development	Chemists and material scientists
Design and development	Chemical, electronics, electrical, mechanical, material engineers; technicians and drafters, software developers and industrial designers
Manufacturing	Electrical and electronic equipment assemblers, engine and machine assemblers, machinists, production managers, tool operators and final product assemblers
Vehicle maintenance	Automotive service technicians and mechanics
Fleet services	Operators, dispatch, planners, drivers, technicians, accountants
Sales and support	Retail persons, customer support representative and auto dealers
Energy suppliers and retailers	Staff at battery swapping and charging centres
Infrastructure developers	Urban and regional planners, electrical power line installers and repairers, electricians

The technological changes in the mobility sector are a major challenge for the TVET sector, as conventional transport technologies and mobility models still very much predominate. In existing curricula, modules on combustion engines cannot simply be replaced by content on electric engines and batteries. Job opportunities in dedicated e-mobility sectors are still only available on a very small scale, and servicing and maintaining conventional vehicles will continue to be part of the job description for automotive mechatronics

technicians, for example, in the years to come. The TVET sector therefore faces the specific challenge of teaching skills required for conventional drives as well as additional content for developing, servicing and maintaining electric vehicles over the next 10 to 15 years. Skilled workers such as mechanics need to master conventional drive systems in order to find employment. At the same time, they also need skills related to electric systems in order to meet emerging needs and be able to do what they can to initiate change.

For TVET systems, it will be vital to identify training needs early on and to adapt education provision accordingly. Skills gaps must be closed by gradually adding relevant Green Skills to occupational profiles and curricula. Broader occupational profiles may be useful in skills-based systems. This requires the training content and skill requirements of the private sector to be continuously and routinely reviewed by TVET (BILT, 2022). To this end, institutional capacity for developing partnerships with the private sector should be strengthened. This may also require government support to build bridges between TVET providers and the private sector. In countries with a strong informal sector in particular, measures may therefore be needed to convince relevant stakeholders of the value of cooperation (BILT, 2022).

The following section briefly highlights some particularly relevant skill requirements that will become more important as the mobility transition progresses. We will start by highlighting significant changes in technical and occupational skills profiles, before outlining key cross-cutting competences.

Core technical and occupational skills

Generally speaking, the technical and occupational skills required for e-mobility encompass a very broad and diverse range of knowledge, subjects and themes. From a knowledge structure point of view, there are various disciplines associated with e-mobility. Given the systemic understanding of e-mobility, which increasingly links the previously separate conventional sub-systems of vehicles, transport and energy, most of these disciplines are related to the natural and technical sciences.

Table 4 outlines the main technical knowledge areas that are related to e-mobility and are central to its development, promotion and rollout. As the knowledge areas change, the skills in relevant occupational profiles will also have to adapt to the different qualification levels. For example, both engineers and mechanics have to work with battery systems, but the need for change in the relevant skills profiles will differ.

Table 4: Key technical knowledge areas for e-mobility

Knowledge areas	Examples of key technologies and models
Electronics	• Equipment and systems (e.g. battery chargers, power converters) • Operating technology • Automation technology • Information and systems technology
Electrochemistry	• Battery charging • Battery diagnosis and maintenance • Battery repair and overhaul • Battery recycling
Fluid mechanics and thermodynamics	• Air conditioning systems for electric vehicles • Battery thermal management • Thermal management in the vehicle
Electromagnetism	• Electric engines • Electromagnetic compatibility
Electricity	• Electricity for cars • High voltage batteries in electric vehicles • Intrinsic safety of the vehicle • Charging infrastructure for electric vehicles • Energy technology
Mechanics	• Automotive mechatronics • Process management • Production mechanics • Machines and propulsion technology • Electromechanics of electric vehicles
Calculation and programming	• Systems and IT • Networking of systems • Communication of electric vehicle charging infrastructure
Private sector	• Mobility-as-a-Service (MaaS) • Vehicle sales and aftersales • Production management • Business models for passenger and freight transport

The skills profile required for manufacturing electric vehicles is a combination of traditional and new skills and knowledge. The management, design and marketing skills used in the conventional car manufacturing industry are transferable to electric vehicles. However, the production of batteries, the need for lighter materials and changing production processes (which are likely to become more automated, not least for safety reasons) require new technology-related skills.

Skill requirements will change the most for highly skilled workers. Due to the high degree of complexity, e-mobility requires many highly qualified specialists such as chemical, electrical, industrial and mechanical engineers as well as computer analysts. A wide range of high-skilled occupations are also required by the public agencies responsible for traffic management. In West Africa, for example, we can see that positions in municipalities and traffic management are usually always filled by university graduates (SSATP, 2021).

Practice-oriented higher education and research play a key role due to the leverage effect of such occupations for sustainable transport models. **The development of relevant higher-education programmes is therefore of vital importance. Here, interfaces with TVET must be created for training content to be efficiently coordinated across the qualifications level, for the practical orientation of higher education to be reinforced and for permeability between the education systems to be supported**, also with a view to making TVET more attractive (Frommberger, 2016) (see Section 6).

At the intermediate qualifications level, skill requirements are not expected to change dramatically. Changes will affect a larger share of workers involved in the production and servicing of vehicles or the maintenance and operation of infrastructure. These skilled workers will need to use new or adapted technologies and familiarise themselves with new work processes. For example, they will need to know how to retrofit and convert fuel systems, and electric vehicle mechanics will need sound technical diagnostic skills. **As a result, TVET systems will need to develop offerings for the continuing education and training of existing skilled workers and prepare future workers for the new requirements by adapting existing occupational profiles and curricula. To this end, the systems will – together with the private sector, civil society and research institutions – need to tailor these profiles and curricula by broadening technical and occupational skills**. In modularised systems, it will also be possible to combine relevant new skills into individual modules, insert them in existing framework curricula and offer them as certified continuing education courses (Frommberger, 2016).

In the low-skills sector, it is assumed that any changes will focus on basic adaptation of work processes for which non-formal continuing education will suffice, for example driving electric vehicles instead of conventional vehicles (GIZ, 2020b). **TVET institutions can support the development and delivery of short-term continuing education and offer safety and driver training for electric bike taxi drivers, for example**. As this qualification level often has a high proportion of disadvantaged groups in (informal) employment that normally only have limited access to education provision, this is an opportunity for TVET to help provide more secure and better jobs for these groups and to facilitate a more Just Transition.

In this context, the transition to a sustainable mobility sector will clearly require new skills at all qualification levels. **Due to the varying degrees of change required and the differing capacities of the educational institutions involved, comprehensive support for the sector will require different approaches to address skilled workers in low-, medium- and high-skilled occupations**.

Cross-sectoral skills

The adoption of a systemic approach and the broad range of e-mobility themes that need to be addressed will require the integration of different subjects as well as training in interdisciplinary learning and work methods. In future, a more comprehensive understanding of the overall system will be required, spanning industry sector boundaries. Employees in

relevant sectors are increasingly required to acquire cross-sectoral technological expertise in their day-to-day work. **Adopting a holistic approach and integrating technology-related subjects would therefore be an important change at TVET and in higher-education institutions, in order to support interdisciplinary learning and enhance learners' skills in related areas that lie outside their own field of specialisation**.

The TVET system can respond to this by developing broader occupational profiles that enable future skilled workers to cover different areas of responsibility. Lesson units could address interdisciplinary tasks and problems in joint working groups in order to strengthen dialogue and cooperation between the different specialist areas. Strengthening of cross-cutting skills among the learners is crucial, however. Interdisciplinary cooperation and communication must be supported, and workers given the skills to independently acquire new knowledge, enabling them to quickly familiarise themselves with new areas of expertise. Due to increasing interdisciplinarity and ever shorter technological innovation cycles, continuing education for trainees, teachers and staff is key (lifelong learning). **The strengthening of self-learning skills should therefore be promoted as well as the conceptualisation of innovative interdisciplinary training programmes that enable individualised continuing education, using digital learning platforms, for example**.

The increasing importance of cross-cutting expertise such as interdisciplinarity, continuing education and social and communication skills must be reflected in the content of the TVET training provided. At the same time, the cross-cutting expertise must be incorporated into the design of lesson units. Continuing education measures that enable trainers to design appropriate lessons are important in many partner countries.

Text box 2: Growing need for cross-cutting skills

In general, the need for cross-cutting skills such as critical and innovative thinking and social skills is also set to increase. These include:

- Analytical skills to evaluate and organise information and data
- Adaptation and transfer skills to learn new technologies, for example
- Coordination skills and the ability to work in a team to enable interdisciplinary, cross sectoral work in e-mobility
- Communication, marketing and advisory skills to win over customers for new mobility models and products
- Entrepreneurial and innovation skills to develop strategies and discover new market opportunities

5 Country profiles and selected project examples

This section uses specific examples to illustrate the extent to which there is a need for change in developing countries and emerging economies with regard to skilled workers and the competences outlined above. We also analyse a selection of international cooperation projects in the countries in question and present the lessons learned. As the main focus of German DC activities is in Asia and Africa, we have chosen to examine India and Nepal as well as Kenya and Rwanda in greater depth. These choices reflect both large and small economies in the two regions, with India and Kenya being regional leaders in locally produced electric vehicles and Nepal and Rwanda both least-developed countries with significant potential and high aspirations in this area. All four countries are home to a number of emerging e-mobility companies for locally produced vehicles, especially in the areas of local public transport and micromobility, and for logistics applications. Training needs and education provision in the area of e-mobility were examined based on interviews with representatives of DC projects, companies, research and training institutions[13] and on an analysis of studies and documents.

The recruitment of skilled workers presents a major challenge in all four countries. This applies to all areas of sustainable transport, but especially to the growth of the e-mobility sector. The companies interviewed mentioned that it is difficult and expensive to find, recruit and retain skilled e-mobility workers, particularly for the technical development and implementation of new mobility models, but also for mobility services.

The shortage of skilled workers is particularly noticeable at higher and intermediate qualification levels. In addition to engineers, (electrical) mechanical engineers are urgently needed above all to develop the field of e-mobility in existing companies or to establish start-ups. Currently, most training institutions do not focus on teaching specific skills in core areas of e-mobility. Skills in quality assurance, technical design review, the internet of things[14] and data and system integration are particularly lacking. The lack of engineers means that many start-ups, especially in Kenya and Rwanda, are still being set up by entrepreneurs from Europe, the USA or Nigeria, for example, rather than by local entrepreneurs.

A number of e-mobility companies have also had to outsource R&D activities such as prototype development and vehicle design to external contractors, due to a lack of skilled labour. Many companies also mentioned that parts of development and/or production have to be outsourced to mostly foreign companies due to a shortage of skilled workers. The companies would prefer to do this in-house. This applies to the actual vehicle components and to different software products, e.g. for monitoring and managing engines and

13 For example with green mobility start-ups in Kenya or the Wuppertal Institute

14 The internet of things is the term used to describe the network of physical objects that are equipped with sensors, software and other technologies to exchange data by networking with other equipment and systems via the internet.

batteries, automating payments or localising the vehicles. A special focus of the training must therefore be on software development.

Operational roles such as bus drivers or lorry drivers in passenger or freight transport are also affected by changes, but much less. Bus drivers, for example, need to learn how to operate electric buses and interpret new error and warning messages. Some of the companies interviewed have even developed non-formal, short-term, on-the-job training to provide their staff with the necessary training.

5.1 Kenya

Building an efficient public transport system, ensuring a sustainable energy supply and investing in sustainable urban planning are key to Kenya's commitment to reducing its greenhouse gas emissions by 30 per cent by 2030 (Government of Kenya, 2016).

Kenya's dominant mode of transport is its road network, which accounts for 93 per cent of freight and passenger traffic. Kenya Vision 2030 envisages supporting mass transit systems to facilitate the mobility of a large proportion of people who use non-motorised modes of transport. **Shifting road freight to rail, water and non-motorised transport** (NMT) could save up to 4.1 megatonnes of CO_2 annually by 2030 (Kenya's National Climate Change Action Plan). The government is currently working on a comprehensive package of measures to foster local production and facilitate the import of electric vehicles.

The capital city of Nairobi is considered the hub of Kenya's economic growth, with more than 4.4 million people now living there. Over the years, the capital has invested heavily in car-centric development – with large sums spent on expanding the road network, even though only 12 per cent of Nairobi's population uses private vehicles, with the rest relying on NMT and the public transport system. With increasing motorisation, Nairobi has seen an increase in pollution, congestion and health problems such as high obesity rates due to lack of exercise. In 2017, guidelines on NMT were therefore adopted to better integrate different modes of transport (buses, minicabs, cycling and walking, etc.) (UNEP, 2017).

Even though Kenya already has a dynamic range of e-mobility start-ups, there is still a distinct lack of suitable training courses in the field of green mobility. **The interviewees consider training courses with a strong practical orientation and a high percentage of workplace-based learning as relevant**.

The Kenya Technical Trainers College (KTTC) offers a one-year dual course in equipment and systems for electronics technicians. It provides two weeks practical training in the company and one-week theoretical content in the school itself. The course was developed by KTTC in cooperation with the German Chambers of Commerce Abroad (AHKs) and the German Chambers of Commerce and Industry (IHKs). With financial support from BMZ, the Giessen-Friedberg Chamber of Commerce and Industry and the Chamber of Skilled Crafts Frankfurt-Rhein-Main established the Kenya Initiative for Vocational Education and Training (KeVET) together with Kenyan partners, including KTTC. The aim is to **align TVET more closely with the needs of the economy.** The initiative covers several occupational profiles, including automotive mechatronics, that are relevant to the e-mobility

industry. To this end, **curricula were developed together with local representatives of professional associations, companies and TVET institutions.** Measures that combine the dual elements of practical and theoretical content have been piloted and trainers have received further training. Curricula are then to be certified by local authorities.

Text box 3: Dual TVET in Kenya

As part of the Kenyan-German TVET Initiative, GIZ supports the TVET reform in Kenya. Three centres of excellence have been established that are jointly funded by the two countries. The project aims to strengthen the technical capacities of the Nairobi, Kiambu and Thika training institutes as centres of excellence. GIZ is working with seven national education institutions to expand the centres of excellence and pilot a dual (cooperative) TVET model in which 50 per cent of the curriculum is completed at the school and the other 50 per cent in partner companies. One area of cooperation includes developing curricula and occupational standards for automotive mechatronics technicians and drafting learning guidelines for in-company training in cooperation with industrial partners in Kenya. This process is still at an early stage. In this context, it will be important to link the mobility projects of various DC stakeholders with further development of the curricula. In addition to traditional companies such as Kenya Vehicle Manufacturers, start-ups from the e-mobility sector will also be included in dual training provision.

The *boda boda* bike taxi sector in Kenya currently employs around 1.6 million people (SOLUTIONSplus, 2021b). Many of the taxi drivers rent their motorbike, but some also own the vehicle. According to the Kenya Association of Manufacturers, each *boda boda* contributes either directly or indirectly to the income of at least eight people. In addition to the families, this also includes workers in maintenance, repair and (energy) supply. The e-commerce sector benefits substantially from an increase in two- and three-wheeler transport, as **almost all deliveries in urban areas are made by bicycle, boda boda, or rickshaw.** The market for developing and using two- and three-wheelers is undergoing radical change, with local and national authorities recognising the potential of last-mile mobility and active support being provided for developing local vehicle and service models. As we can see in text box 3, this shift will **require a range of skilled workers at all qualification levels.**

Projects funded by the Nationally Appropriate Mitigation Action Facility (NAMA) in Kenya support the local market for electric bike taxis (Small Vehicles E-Mobility) and the introduction of electric buses (Mass Rapid Transport System for Nairobi). A number of capacity development measures for stakeholders from the administration and academic community are also envisaged in these projects. No TVET components are planned at present. NAMA Facility projects in Rwanda, Kenya and Nepal are engaging in dialogue with the SOLUTIONSplus project to systematically survey training needs and develop proposals for TVET measures.

5.2 Rwanda

Rwanda's Nationally Determined Contributions (NDCs) identify the **mobility sector as key to achieving climate protection targets.** The aim is therefore to build an efficient transport system. Measures include the promotion of public transport, expansion of transport infrastructure and the setting of emission standards and regulations for vehicles. The country plans to **introduce a subsidy to encourage the use of clean vehicles.** A Green Transport Fund is also to be piloted in order to support the introduction of innovative transport technologies, among other things. Kigali plans to **limit the use of private transport and to support public transport to a greater degree.**

The mobility sector accounts for about 52 per cent of carbon emissions in the capital Kigali. The volume of traffic in Rwanda is steadily rising with the number of vehicles expected to have risen by 16.5 per cent by 2030, and light commercial vehicles by 20 per cent. The minibus system is the main form of public transport. The city's goal is to switch from minibuses and private cars to buses and offer only public transport in the long term.

Due to favourable framework conditions and the government's ambitious goals at national and local level, there is already a very active start-up scene in the field of e-mobility and mobility services. International and local private investors in Kigali are supporting the expansion of e-mobility. In response to high fuel costs and pollution, for example, Kigali is promoting e-mobility by testing electric bikes. **Rwanda's energy mix currently consists of 55 per cent renewable energies,** with plans to expand this even further (MININFRA, 2022). The aim is to offer bike taxi drivers in particular an inexpensive and environmentally friendly means of transport. This initiative is driven by private investors such as the electric vehicle company Ampersand. The German car manufacturer Volkswagen has also built an assembly plant in Rwanda. Volkswagen in Rwanda is also training mechanics to set up a local production facility. **Although only conventional vehicles are being manufactured so far, plans are in place to produce electric cars.** In cooperation with GIZ and other partners, electric commercial vehicles for the agricultural sector in Rwanda are also being developed. Rwanda is an investor-friendly environment and has a plethora of stakeholders that develop e-mobility solutions. However, they repeatedly face the challenge of a lack of sufficiently skilled workers.

Text box 4: Gender inclusion in e-mobility projects

Support for gender equality has become increasingly important in development cooperation projects in recent years. With support from GIZ, for example SOLUTIONplus and the company Ampersand are working to raise awareness of gender-specific aspects in e-mobility as part of the electric bike taxi project. One example of these efforts is the pilot project to promote women motorcyclists in Kigali, which is supported by SOLUTIONplus and implemented by Ampersand. The project in Kigali aims to improve women's participation in e-mobility, both as drivers and as users. The German Government has funded a new project in order to further strengthen the integration and awareness of gender aspects in e-mobility projects. The project Mobility as a Driver

for Change – Towards a Gender Transformative and Just Transition to Electric Mobility is implemented by the United Nations Environment Programme (UNEP). The aim of this project is to take into account the gender dimension in e-mobility projects and to support equal opportunities for women and men.

The lack of local capacities for operating and servicing electric vehicles is a major concern for all surveyed. Qualified technicians are also needed as automotive design drafters. Given that the rapidly developing local e-mobility system is offset against an overall vehicle fleet that is only changing very slowly, skilled labour requirements in the areas of manufacturing and maintenance are perceived very differently indeed. **While new skills are urgently needed for the development and manufacturing of electric vehicles, the requirements for service and maintenance staff are changing at a much slower pace.** In view of the increasing need for skilled workers who are available at short notice, the University of Rwanda is working on **short-term programmes for the technical planning and development of electric vehicles.** The content is to be incorporated into ongoing engineering courses. Short courses to teach public transport drivers how to operate the new vehicles will also be offered. One transport company stressed the need for training plans for electric vehicle mechanics (SOLUTIONSplus, 2022).

Relevant training programmes at local TVET institutions and polytechnics[15] are aligned with the national qualifications framework and curricula. In addition to specific skills related to electric vehicles and components however, **there needs to be an even greater focus on teaching skills for electric vehicle maintenance, charging systems and system integration.** Current training provision at polytechnic colleges includes courses on mechanical production and vehicle electrics, short courses on engine mechanics, assembly and welding, and diploma programmes in automotive, production and manufacturing engineering. **A significantly larger number of graduates still works in the field of repairing and maintaining conventional vehicles** (mostly imported used cars). There are as yet no courses that have been designed specifically for training in the production and maintenance of vehicles for electric micromobility, especially electric bikes and buses, are lacking so far. **Even though there is a proactive start-up scene in the fields of e-mobility and mobility services, there is still a lack of demand to initiate the required curricula changes.**

5.3 Nepal

Economic growth, social change and rapid urbanisation in Nepal have increased the ownership and use of vehicles, especially in urban areas. **Road transport dominates the mobility infrastructure** (cars, buses, motorbikes and NMT to a marginal degree).

The Nepalese Government has adopted a number of guidelines to support electric vehicles. The goals outlined here include increasing the percentage of electric vehicles, supporting

15 Polytechnics are tertiary-level educational institutions that offer advanced diplomas, undergraduate and postgraduate programmes and usually focus on technical, scientific and engineering subjects. They are comparable with technical colleges (*technische Fachhochschulen*) in Germany.

the conversion of vehicles with conventional drives to electric vehicle, and establishing a **subsidy programme to promote electric and non-motorised vehicles.** The Nepalese Government has been charging a fee of Nepali rupee (NPR) 0.5 for each litre of fossil fuel since 2007, using it to invest in air pollution control programmes. Since 2016, the government has also repeatedly facilitated the import of electric vehicles through tax cuts. However, incentives such as tax cuts and tax exemptions are not enough to sufficiently promote e-mobility in Nepal. **Suitable financing models are required to create incentives for entrepreneurs and users** (Shahi, 2017).

The capital Kathmandu is working on pilot measures to help create an e-mobility ecosystem by providing different electric vehicles to improve public transport, as well as appropriate charging solutions and related services (SOLUTIONSplus). To this end, support will be provided for integrating several innovative solutions such as new and converted electric three-wheelers (for public transport) along with electric scooters, bikes and minibuses. The electric buses (minibuses) and electric three-wheelers are to be used on the existing routes and serve the connections to the main local public transport lines.

Text box 5: Need for skilled labour in Nepal to maintain electric buses

The NAMA Support project, which is coordinated by the GIZ country office, is an ideal anchor for cooperation arrangements for potential TVET projects in Nepal. The creation of Green Jobs needs to be aligned with ongoing training programmes in the local manufacturing, maintenance and use of electric minibuses. Within the framework of the project, a number of continuing education measures are also planned at the technical level, but courses have not yet been specified. The objective of the NAMA project is for 85 per cent of all new minibuses purchased in Nepal to be electric by 2030. Whether this will help generate added value and jobs at the local level depends on the development of local capacities, especially with regard to automotive mechatronics.

Although Nepal is aware of the growing and changing electric vehicle market, the country not only lacks a robust strategy but also the skilled labour to implement it. **Currently, only continuing education measures for developing skills for handling batteries, engines and other elements of electric vehicles are available, taken both by mechanics with a traditional training and by those wishing to change career. Specific modules for undergraduate TVET programmes in the field of e-mobility are still lacking**.

Text box 6: Cooperation arrangements with international mobility companies in Nepal

Together with TATA Motors India, the company TATA Sipradi recently opened an electric vehicle learning centre in Kathmandu. Through this centre, Sipradi aims to further develop the electric vehicle ecosystem in Nepal by training workers and technicians for the industry. TATA Motors is working on a dual certificate programme to train mechanics in cooperation with educational institutions. The local provider EV Guru works with the Indian company DIY Guru. It offers online training modules that cover key technical aspects, such as the basics of electric and electronic systems for electric vehicles, as well as battery and engine integration.

Projects that focus on sustainable transport in Nepal are concentrated mainly in urban areas and include improving infrastructure, supporting public transport and NMT and creating an enabling environment for electric vehicles. So far, relatively few projects focus specifically on basic and advanced training in technical occupations with a view to promoting local e-mobility. The challenges for developing an electric vehicle industry in Nepal are significant, as neighbouring China and India have a multitude of suppliers with technically advanced and commercially very competitive products on the market. From the point of view of vocational training, it is therefore **not yet foreseeable whether the serial production of electric vehicles will be feasible or whether the demand for skilled labour will be limited primarily to servicing and maintaining imported vehicles.**

5.4 India

India's rapid urbanisation goes hand-in-hand with annual growth in sales of two-wheelers and passenger cars of over 10 per cent. The share of private vehicles is projected to increase from 24 per cent in 2007 to 46 per cent by 2030 as a result. At the same time, it is estimated that the share of public transport and NMT will decrease from 46 per cent at present to 26 per cent in a 'business as usual' scenario (Dubash et al., 2013). **As the highest source of carbon emissions after energy, mobility plays a crucial role in whether India achieves its mitigation targets.** The National Urban Transport Policy (2014) marked a paradigm shift, based on its focus of 'moving people, rather than vehicles' and the requirement to introduce an 'Avoid (cars)-Shift (to sustainable modes of transport)-Improve (infrastructure)' framework to guide mobility planning in urban areas.

This was accompanied by **significant investment in public transport projects. The Indian e-mobility sector has experienced steady growth, especially since plans were announced to only sell electric vehicles by 2030.** In parallel, the **expansion of renewable energies** has been strongly promoted and is to be increased further. Renewables accounted for 40 per cent of energy sources in 2020 and this figure is expected to exceed 50 per cent by 2030. **The central government has therefore prepared several action plans, including subsidies for the sale of electric vehicles and the prioritisation of developing charging infrastructure.** These efforts have moderately improved the spread of electric

vehicles across the country. Electric vehicles comprised just 1.3 per cent of all cars sold in 2016, rising to almost 5 per cent in 2022. It is estimated that 450,000 electric two-wheelers are currently on Indian roads, while the number of electric rickshaws is over 500,000 (TERI & YES Bank, 2018). This market segment will continue to grow as a number of vehicle manufacturers are offering affordable models that facilitate a cost-efficient switch to green vehicles. **India has emerged as a leader in the electric three-wheeler market not just regionally, but globally too.**

Training of trainers for electrical vehicles in Hyderabad, India. © GIZ IGVET II

The electric three-wheeler sector is a key driver of India's demand for skilled labour in the electric vehicle industry. Technicians across qualification levels are especially in demand. Around 11,000 electric rickshaws are sold every month in India and USD 1.1 billion in added local value had been generated in this segment by the end of 2021, reflecting growth of around 158 per cent since 2020. Expansion in the electric vehicle sector also means that there will be a **future need for vehicle maintenance and repair.** The main training programmes relevant to sustainable transport are offered by polytechnics and industrial training institutes. India also has a **large contingent of workers with no recognised qualifications who do technical jobs on an informal basis.** Of particular relevance here are drivers, for whom a number of projects (such as Ride with Pride) offer courses in driving and charging electric rickshaws.

Text box 7: Short-term continuing education measures for using electric vehicles

Several projects in India provide short-term continuing education measures to support policy-makers, operational staff and drivers and expand the use of electric vehicles.

The Decarbonising Transport in Emerging Economies project in India, which is led by the International Transport Forum at the OECD, is working at national and local level to improve the technical capacity of decision-makers to plan and implement low-carbon mobility based on an e-mobility approach. In this context, the project identifies growth sectors and determines the needs of the private sector.

The BMZ-funded SMART-SUT project, which is implemented by GIZ, supports local decision makers in reducing emissions from conventional urban transport and quantifying the benefits of going green. The focus here is on opportunities for continuing education, e.g. for operational staff in transport companies. The project also provides continuing education measures for drivers on eco-friendly driving techniques to reduce carbon emissions generated by public transport.

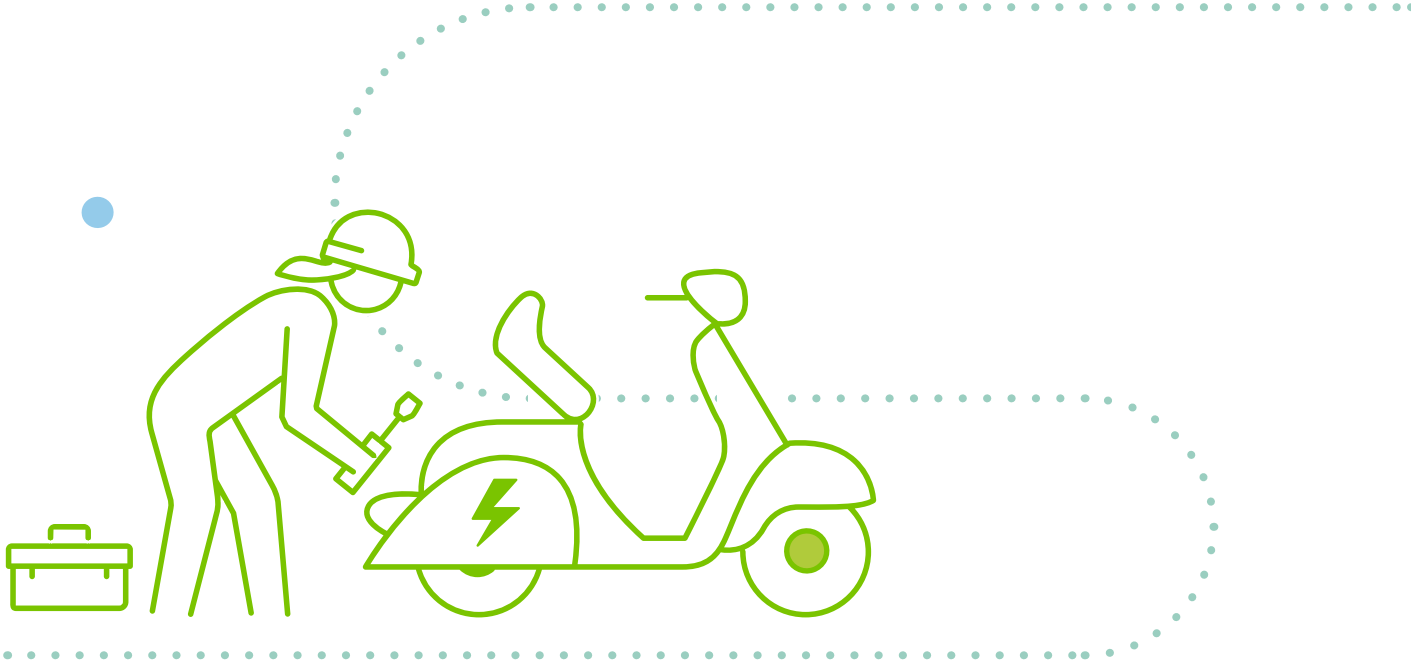
UN-Habitat and the Wuppertal Institute supported the Kochi Municipal Corporation in implementing an electric rickshaw pilot project as part of the Urban Pathways project funded by the International Climate Initiative. Together with the city's rickshaw drivers' association, drivers were made aware of e-mobility and the associated economic benefits. Savings include lower maintenance costs. The emphasis here is on training drivers. On-the-job training measures suffice here and do not require direct support from TVET projects.

GIZ is currently launching a programme for transport operators in India as part of the TUMI e-Bus Mission to train planners in operating fleets of electric buses. The planned training programmes are brief, in-service measures. The programme has so far not been embedded in initial training courses.

A growing number of TVET institutions, polytechnics and universities offer continuing education specifically in the area of e-mobility. Initial TVET programmes are still difficult to find. So far, **conventional training courses have been supplemented with short modules. Many courses are offered in cooperation with training centres, institutions of higher education and partners in different industry sectors.** In addition to academic programmes, the Centre of Excellence for E-Mobility, for example, offers a range of short-term training courses on technology development, battery concepts and charging infrastructure. Autobot Engineers India is a private company specialising in technical consultancy services for the electric vehicle market. It offers internships in the electric vehicle industry in Bengaluru that include the development of a working electric vehicle prototype. It also offers a range of fee-based short-term courses that culminate in medium and high-level qualifications, for example in the retrofitting, servicing, maintenance and repair of electric vehicles. Learning content has so far not been mainstreamed into formal TVET programmes, however.

Country profiles – the gender perspective

Through targeted support, women and girls can be empowered and improve their opportunities for equitably participating in the mobility sector and the labour market. This is evident in the sample country profiles presented here. Educational programmes and campaigns have been introduced in some countries (such as India) to raise awareness of the needs of women and girls in the area of mobility services. Measures have also been taken to improve infrastructure by creating barrier-free and safe facilities. Furthermore, measures to empower women have been introduced in the mobility sector to encourage them to play an active role and facilitate equal employment. Examples such as the gender-responsive projects in Rwanda, Nepal and India show that despite the challenges that may exist, there are opportunities for promoting the participation of women and girls in mobility services and the mobility sector in general, and that progress has been made. By adopting an inclusive and holistic approach, barriers can be broken down at the national and local level and equal opportunities can be created for women and girls in mobility and transport.



6 Recommendations for designing sustainable transport projects

German DC has supported partner countries in implementing sustainable transport projects for many years now. A variety of projects has supported a number of different areas such as the introduction of local public transport systems through policy and process advice (such as Improving transport, mobility and logistics in Namibia). Global and regional projects support dialogue, networking and knowledge transfer (such as TUMI). This theme is also addressed in sustainable urban development projects and programmes (such as Connective Cities). Individual measures support the development of rail transport (such as Making freight traffic in India more climate-friendly).

Text box 8: Global projects in the field of sustainable transport

The BMZ-funded global TUMI project, which is implemented by GIZ, offers capacity development services that incorporate the teaching of technical skills. Many measures are aimed at transport and urban planners and political decision-makers. Online and face-to-face courses are also offered for technical staff in local public transport companies, start-ups and small and medium-sized enterprise (SMEs), covering topics such as logistics, last mile connectivity, electric buses and charging systems. In the provision of continuing education at the regional level in particular, TUMI cooperates with the EU-funded SOLUTIONSplus project.

SOLUTIONSplus cooperates with industry partners, local public transport providers and local start ups and develops a range of continuing education measures (individual seminars, one to two week courses and online seminars that run for between two and ten weeks) on technical and strategic issues such as the integration of electric engines and batteries, type approval and charging concepts. One focus of the project is the development of business models by women for women, such as electric moto taxi services in Kigali and minibus services in Kathmandu.

The Global Programme on Training and Job Creation, which is part of BMZ's Special Initiative on Decent Work for a Just Transition, supports economic sectors in Africa that help create jobs. In the area of mobility, it focuses on electric micromobility and assisting companies that develop, manufacture and operate vehicles in this field. To this end, continuing education measures are to be offered for technical staff, especially for automotive mechatronics

technicians. The programme is conducting surveys to identify employment potential and training needs in Ghana, Kenya, Morocco and Rwanda.

Traditionally, job creation and vocational training programmes implemented under German DC have focused on expanding TVET systems. The training of mechanics, mechatronics engineers and technicians for conventional vehicles plays an important role at the lower and higher end of TVET qualifications (e.g. technician level). However, no information on projects that systematically pursue the development of Green TVET interventions for the mobility sector could be found when conducting the surveys within the framework of this study.

This is an opportunity for German DC. **The potential of the sector can only be achieved if enough suitably qualified, skilled workers are available. Labour market-oriented initial and continuing TVET measures are required that enable people to carry out work in a skilled manner, taking into account health and safety provisions ('decent work').**

At a general level, it must be noted that the area of sustainable transport as a whole is still in its infancy, relatively speaking. Often, quality standards, government regulations and industry standards for the technologies and their use are still not in place and educationally relevant frameworks such as specific framework curricula and qualifications standards are lacking.

In many partner countries, we have also seen that the private sector does not yet have a large market share in the sustainable mobility sector. The e-mobility industry is still in its early days in most partner countries. Market opportunities in e-mobility are mainly embraced by start-ups. However, these companies often lack the resources required to provide their skilled workforce with the initial and continuing TVET they require to scale up implementation. Sector-wide initiatives often prove difficult because the industry is still in its infancy and lacks the organisational structure and coordination required to this end.

The following sections outline recommendations for better integrating the specific needs of skilled workers in the sustainable mobility sector when designing future projects.

6.1 Integrated project design

The mobility sector has traditionally been heavily regulated by local authorities. Cooperation with municipalities is therefore crucial, as it is here that important urban and transport plans are drafted and operational decisions made. A number of global and bilateral projects provide policy and process advice to support local and national governments in developing strategies for sustainable transport systems. **Many projects already have experience in developing short (non-formal) continuing education courses for managerial and operational occupations in the sustainable mobility sector**. So far, however, the systematic integration of TVET training and mobility projects has been largely lacking.

TVET projects can use this experience to help expand and scale up the measures developed (for more broad-based implementation after the pilot phase, for example).

At the same time, the focus should go beyond credit-funded public infrastructure projects. E-mobility has so far been a niche market in most partner countries and offers a number of new business opportunities for small local companies as well that can contribute to the development of local value chains. Active support for local enterprises must start

Training for e-motorcycle technichians in Kampala, Uganda (Developing Relevant and Innovative Vocational skills for e-mobility, DRIVe project). © GIZ/Fabian Jacobs

with advice on technical and business management issues as well as with the basic and advanced training of staff.

Cross-sectoral, integrated approaches allow for activities that support sustainable transport and jobs oriented TVET to be better coordinated. This will harmonise the availability of skilled labour and demand on the labour market in a more efficient manner. The aim is to address both short-term capacity development needs and long-term needs in TVET and higher education institutions.

In order to support sustainable transport, it therefore makes sense to promote linkages between future projects that advise partner countries on sustainable mobility strategies and TVET (and employment promotion) measures to a greater degree. Mobility projects could, for example, include components for developing the required occupational profiles and curricula.

As integrated project design is not always feasible at a practical level, existing individual projects could be better coordinated instead. Interlinkages could be fostered between independent projects by encouraging networking between staff and organisational structures, for example working groups to jointly support mechanisms to encourage dialogue between administrations, educational institutions and the private sector.

6.2 Cooperation with the private sector

The e-mobility sector is in its infancy in most German DC partner countries. A strong focus on dynamic technological developments and local implementation opportunities offered by the private sector will also leverage greater potential for basic and advanced TVET. Partnerships with companies, municipalities, formal local public transport providers and informal mobility service providers are important both in terms of implementing sustainable transport solutions and ensuring that education provision is needs oriented.

Information on current and future needs is essential to effectively tailor TVET provision with labour market needs and proactive labour market policy instruments. **DC projects should therefore support coordination capacities between the labour market and TVET institutions and with the private sector in order to strengthen skills forecasting and labour market research in the mobility sector** (see Section 4.1).

When identifying training needs, the needs of small emerging start-ups in e-mobility and mobility services should be included in addition to the needs of well-established transport companies, vehicle producers, importers and mobility providers. Although these start-ups play an important role in promoting sustainable transport solutions in many partner countries, they are often only able to offer basic and advanced training to a limited extent. **Strengthening these small enterprises is particularly relevant as they often create local value and job opportunities that can also provide opportunities for disadvantaged groups** (WRI India, 2022).

TVET projects should consider the option of cooperating with local start-ups and international companies to identify training needs and to design training programmes in response to existing market needs. The private sector frequently uses non-formal continuing

education programmes as a first line of response for upskilling its own workforce. TVET projects can support the development of continuing education measures, for example by developing curricula or by training trainers (see text box 9).

At the institutional level, capacities of TVET institutions can be strengthened to establish mechanisms for fostering dialogue with the private sector. The aim is to routinely familiarise both teachers and learners with the practical application of emerging technologies that are evolving rapidly. The development of practice-oriented continuing education provision for TVET teachers in the companies can also be strengthened in cooperation with TVET institutions.

It is often possible for projects to build on existing mobility project partnerships. In some partner countries, for example, projects support the development of local e-mobility solutions together with local companies, the academic community and the political arena. By testing practical solutions, it can be demonstrated here that the introduction of sustainable transport solutions is also feasible and profitable in a local context. *'Living labs'*[16] can provide a role model in this context, bringing together stakeholders from education and research, public administration and the private sector to jointly research and test e-mobility solutions, for example, in real-life conditions. TVET projects can use living labs as a platform for identifying training needs and, together with local companies, developing continuing education modules for scaling-up pilot measures (for maintenance of charging stations, for example). In Nepal, for example, the BMZ-funded TUMI project has developed a viable e-mobility model together with a local public transport provider and other stakeholders. In order to have the labour required to pilot the electric bus system, the project developed an eight-day training course to upskill mechanics to maintain electric buses (see text box 10). The GIZ sector programme Sustainable Mobility 2.0, TUMI, the SOLUTIONSplus project and the e-mobility platform of the Global Environment Facility support living labs with a view to jointly designing e-mobility solutions. This could provide a starting point for future projects.

In terms of gender, it is important to note that the sustainable transport industry and TVET programmes offer opportunities for reducing inequalities and supporting the participation of women and other disadvantaged groups. In the field of sustainable transport, measures can be taken above all to support the creation of jobs for women in technical and managerial roles. This includes raising awareness of gender issues among companies and educational institutions and developing programmes and measures to support women in the sector.

In the area of TVET, targeted programmes can be developed to enable women and girls to access technical occupations in the mobility sector and to support them during their training. This can be achieved through targeted awareness-raising campaigns, mentoring programmes and financial support. Cooperation with women's organisations and gender equality officers in companies and educational institutions can also help to promote equal opportunities in the mobility sector.

16 Living labs: Living labs bring together partners from public administration and the private sector, civil society and research to jointly develop solutions (for rolling out electric buses, for example) and test them under realistic conditions. The different partners involved draft collaborative approaches (for promoting sustainable transport) and trial them on the ground.

Overall, it is important that gender aspects are taken into account when planning and implementing projects in the field of sustainable transport and TVET. This includes supporting equality and diversity within project teams and partner organisations. By adopting a gender-transformative approach, projects in the field of sustainable transport and TVET can help reduce inequalities and strengthen women's participation in socio-economic development.

6.3 Forging linkages with institutions of higher education

Promoting sustainable transport requires more than merely modifying individual occupational profiles. These profiles need to be adapted to new skill requirements along the different value chains in order to be able to develop, operate and maintain sustainable transport solutions. Higher education institutions play an important role here. Professionals with higher-education qualifications are key to development, planning and management, among other things. The practical orientation of higher education programmes is important to ensure that any mobility solutions developed can be implemented locally. **When designing projects, it therefore makes sense to develop interfaces with higher education institutions. The aim should be to strengthen practice-oriented research, facilitate better subject-specific dialogue and improve the coordination and harmonisation of training content between professionals with technical and higher education qualifications**.

Practical orientation can also be supported by ensuring greater permeability between TVET and higher education institutions (Frommberger, 2016). Qualification frameworks lay down overarching criteria that link different sub-areas of education (such as general education, TVET and higher education) with each other. Skills and qualifications are assigned to a specific level, making educational pathways and qualifications comparable. This makes it easier for higher education institutions to recognise and credit vocational qualifications and achievements. Opening up further education pathways for groups with professional and vocational qualifications can also make TVET more attractive as a whole. **When developing short-term Technical and Vocational Education and Training measures, TVET projects should therefore ensure that programmes can be transferred to national systems**. Completing the programme can then offer new higher education pathways for participants and increase their earning potential.

At the governance level, projects can also support coordination between higher education and TVET institutions, in order to better align curriculum development. Most partner countries have so far focused on occupations in the fields of transport infrastructure and conventional drives. Sustainable transport requires an expansion of the higher education portfolio, particularly in the areas of vehicle technologies, traffic management, integration of different modes of transport and efficient logistics systems. Portfolios should be expanded by introducing appropriate TVET programmes, e.g. for clerks in the fields of transport services and logistics.

7 Recommendations for designing TVET measures

German DC has a long tradition of supporting TVET cooperation projects in partner countries at different levels. A **multi-level approach should be adopted when implementing Technical and Vocational Education and Training measures in the field of sustainable transport, based on the following principles: Development/adaptation of occupational profiles and curricula (governance level), implementation of measures in partnerships between TVET centres and the private sector, and practice oriented/ module-based design of training units (institutional and implementation level)**.

The following overview summarises the key measures for designing TVET in the field of sustainable transport. Some aspects have already been listed in previous sections. This section provides key recommendations at each level.

Governance level:

- Support for labour market and training needs analyses in the mobility sector: Early identification of the skills needed at the local level;
- Development of nationally recognised training, examination and certification standards with involvement of the mobility industry for relevant occupational profiles;
- Strengthening of coordination between TVET and higher education institutions, for example to synchronise the revamping of curricula, promote permeability, conduct joint research projects and improve the status of TVET;
- Support for the development of industry associations and involvement of social partners in designing TVET programmes;
- Designing of capacity development measures and mechanisms for fostering dialogue with the public administration in order to promote sustainable transport.

Institutional/implementation level:

- Support for the modernisation of workshops in the area of e-mobility; e.g. by determining the equipment required to train and further educate electric vehicle mechanics;
- Support for TVET institutions in developing digital content and using digital technologies in mobility-related programmes, and in ensuring that the necessary equipment is available and maintained;
- Support for the integration of cross-sectoral Green Skills into the teaching and learning material across occupational profiles (e.g. by setting up working groups with teachers to revise individual training units);

- Development of non-formal training measures, especially for the informal sector, to promote the safe use of technologies (e.g. safety training for taxi drivers on the use of electric bikes);
- Support for the development of cooperation projects with research institutions, public administration and the private sector (e.g. living labs);
- Support for cooperation mechanisms (such as working groups) between teachers and the private sector, including innovative start-ups, e.g. to identify typical tasks and work processes.

7.1 Further development of occupational profiles and curricula

At governance level, active support for the development of green occupational profiles and curricula for sustainable transport is to be recommended. Projects could pursue two strategies when developing occupational profiles. A mix of short-term and longer-term measures is recommended in order to strike a balance between the immediate needs of a growing number of start-ups and small and medium-sized enterprise (SMEs) and changes in the mobility sector that will occur over a longer period.

In the mobility sector, short-term training measures for skilled workers in companies have been the most common approach so far. Systematic changes in basic and advanced training have been lacking for the most part. In order to accelerate the transition in partner countries, TVET projects should adopt a 'forward-thinking' approach when supporting training for skilled workers.

Development of continuing education measures with the private sector

In India, but also in countries such as Kenya, Nepal or Rwanda, there is a growing group of SMEs in cities that are already actively researching, developing and piloting local mobility solutions. Additional skills for manufacturing, operation and maintenance are required however, to scale up inclusive and broad-based solutions. This is often where the need for skills is most acute.

Experience shows that TVET projects can use this level as an initial point of intervention. **In cooperation with companies, they can support the development of (non-formal) training programmes to meet the urgent needs of industry**. To this end, companies firstly need support for analysing what skills they need. Appropriate short-term training programmes can then be developed and implemented that are geared to in-house staff and to other potential skilled workers (e.g. in the sense of franchises). When developing programmes, attention should be paid to subsequent institutional mainstreaming in order to ensure comparability and permeability. The following text box illustrates the process,

using an example from Uganda. Cooperation with local start-ups and SMEs appears promising. Their focus is often the local market and they are therefore good at providing practical skills that are important for introducing appropriate technologies and models that are tailored to the local context.

Text box 9: Uganda – Further development of occupational profiles along the value chain

In terms of job creation, the *boda boda* bike taxi industry is one of the most promising sectors in urban areas of Uganda. Electrification of the fleet offers strong potential for growth, but is being hampered, among other things, by a lack of skilled workers to operate and maintain the new technologies on the one hand and to manage and scale up business processes on the other. Together with the private sector partner *Bodawerk*, the GIZ projects Promotion of Renewable Energy and Energy Efficiency (PREEEP) and Promoting Employment in Africa Through Public Private Cooperation (E4D) have launched the project Developing Relevant and Innovative Vocational Skills for e-Mobility (DRIVe). It aims to improve the employability of skilled workers in the e-mobility sector in Uganda through basic and advanced TVET measures. The project is geared towards electric vehicle operators, managers and technicians who play a crucial role in the areas of assembly, maintenance and diagnosis in the e-mobility sector.

Bodawerk is a Ugandan company that leases batteries and electric bikes to end users. As the project's implementing partner, *Bodawerk* – with the support of the DRIVe project – develops and implements the training measures, focusing on the technical and organisational skills required in this sector. Three relevant groups of skilled workers in different occupations along the electric bike value chain were identified:

1. Professionals in management positions in e-mobility companies: They often still lack in depth technological knowledge, management skills and practical experience. Their training focuses on basic technological skills, digitalisation as well as cross-cutting skills such as self-management and effective collaboration.
2. Further training for the technicians focuses on technology fundamentals, assembly and conversion as well as the fault analysis, repair and maintenance of electric bikes.
3. Electric motorcyclists: Advanced training measures focus on the basic operation and maintenance of electric bikes and on road safety. Financial literacy is a core element as drivers often use private loans to buy their vehicles.

The project aims to develop training programmes with teaching and learning materials to help close the skills gap in the e-mobility sector. The training measures and curricula are therefore implemented, reviewed and adapted in

an iterative process. The result – field-tested curricula for three occupational groups – will be made available to relevant private sector stakeholders and TVET institutions. The three curricula are to be accredited by national educational institutions.

Institutional mainstreaming of occupational profiles and curricula

Projects should support the institutional mainstreaming of relevant skills in occupational profiles and curricula that are important for sustainable transport. National institutions can be supported in developing training, examination and certification standards with the involvement of the mobility industry.

To develop the required occupational profiles and curricula, the Green Skills needed within an occupation need to be defined for specific areas and tasks. They should be tailored towards the actual tasks and problems encountered in everyday working life. To this end, the learning-field approach breaks down the range of tasks into action areas that pool certain requirements of the occupation (such as communications with the customer or vehicle maintenance). Based on these areas, learning fields that incorporate key skill requirements are then developed within the national framework curricula (Wilbers, 2022). New competences that skilled workers are expected to have to handle new technology or approach their work in a more environmentally friendly manner can then be integrated here.

The following points should be considered when developing occupational profiles and curricula:

Analysis of skill requirements along value and process chains

DC projects should first support an analysis of new or changing tasks within an occupation, taking into account the associated requirements and skills. The skills required are identified in close cooperation with the private sector, the academic community and civil society. In this context, occupational and task-related skills are assigned to (future) occupational action areas. Taking into account the level of qualification, an empirical basis can then be created to determine the need for existing occupations to be tailored to actual needs.

The selection of occupations in the field of sustainable transport should be consistently geared towards the value and process chains of related industries and need to include specific local labour market analyses. Appropriate measures need to be developed and, if necessary, higher education institutions, companies and civil society need to be involved to cater for all qualification levels (see text box 10).

Text box 10: Detailed needs analyses along the process chain for the introduction of electric buses in India

The SMART-SUT project – funded by BMZ – has been implemented by GIZ since 2017 to improve the planning and implementation of a sustainable mobility system in selected Indian cities.

To support the cities in introducing a public electric bus system, it conducted a detailed needs analysis with five municipal bus operators responsible for running and maintaining the public transport systems. Among bus operating companies, a range of occupations was identified along the process chains (purchasing, fleet management, marketing, maintenance, etc.) with varying levels of qualification (from mechanic to top management).

Task-specific occupational profiles were developed for the roles of top management, senior management, middle management, drivers, technicians and warehouse staff. These roles cover aspects related to the planning, procurement, management and implementation of electric buses. Surveys querying staff on their current skills in the field of electric buses were conducted in all departments (transport, civil engineering, electrical engineering, mechanical engineering, IT and procurement). In order to obtain a comprehensive overview of the skill requirements, it was important to involve a wide range of stakeholders on the supply side (such as manufacturers of electric buses, batteries and chargers, and industry organisations and experts) to identify the skills and qualifications that would be required of staff in the future.

Based on the qualifications identified, skills profiles were then prepared for the different roles and qualification levels along the process chain (from purchasing to recycling). They provided the basis for developing curricula consisting of several sub-modules. The modules were developed so that they can be taught either as a short version that provides an overview of the topic – primarily for managerial roles – or as an in-depth version that is about twice as long, to strengthen the skills required for implementation.

Content design of occupational profiles and curricula

Tailoring needs vary, depending on the occupational profile and the qualification level. A detailed adaptation of the corresponding occupational profiles must be based on the needs analyses. Relevant learning content for the following areas will probably need to be added to occupational profiles and curricula.

Table 5: Key technology and action areas for sustainable transport

Field	Modules
(Further) technical development of vehicles, operations and maintenance	Development of technological components of an electric vehicle, system integration
Usage models	Models for using electric vehicles in core areas of the mobility transition, in particular local public transport and logistics companies
Value-added services	Services that make e-mobility more attractive or influence its functionality
(Further) development of business models	Business models for the manufacturing, assembly and import of electric vehicles (skills in the areas of business administration, marketing and sales)
Energy and charging infrastructure	Coordination with stakeholders in the energy sector and development of infrastructure
Policy integration and planning	Cooperation between mobility providers, pricing and service integration
Regulation and standardisation	Development and expansion of the regulatory framework and national standards for vehicles, components and charging infrastructure

Technical and occupational skills continue to play a fundamental role. **However, cross-cutting skills will become increasingly relevant as the transition to a Green Economy and a sustainable mobility sector progresses. TVET must focus on these skills to a greater degree**.

In this context, the focus should be on the following skills:

- **Cross-sectoral understanding**: Skills profiles should be more systemic and cross-sectoral in order to address the complexity of sustainable transport and the increasing need for an interdisciplinary, holistic understanding of systems. TVET projects can help update and further develop occupational profiles in the fields of vehicle technology, traffic management and logistics in order to nurture a stronger interdisciplinary and cross-sectoral understanding of systems across sectors, industries and technologies (e.g. interaction between urban development, system integration, mobility and digitalisation).
- **Integration of digital skills in education**: Increasing digitalisation in the mobility sector (e.g. automated sharing and data analysis, digital business models) requires a solid understanding of digital processes and digital skills across all mobility-related occupations. In addition to digital skills in specific technical areas, however, cross-cutting digital skills must not be overlooked. Online customer communications, confident handling of digital contracting, methodological skills for information procurement and continuing education opportunities are becoming increasingly important. These areas can play a particularly important role in facilitating access to training provision that is not yet available locally.

- **Incorporating entrepreneurial and business skills**: Many areas of sustainable transport are new business areas that are often also occupied by local start-ups. Strengthening entrepreneurial skills in TVET courses will help generate added value at the local level. Measures here should focus on specific local needs and business models in the mobility sector. They could, for example, include innovation management, management of cooperation projects or digital sales opportunities.

Ideally, these skills should be taught as part of the specific core subject and not as parallel stand-alone content. It is important, therefore, to not just expand curricula by including isolated components, but to integrate relevant cross-cutting skills across all learning fields and incorporate these skills into the educational concept.

Due to the increasing interdisciplinarity and the size of the companies, skilled workers, especially in small e-mobility companies, often have to fill several roles and therefore require a broad range of expertise. The lines between once very separate areas – such as technical development and customer sales – have become more blurred, and these areas must be increasingly interlinked. As well as core technical skills, knowledge in areas such as business administration and digital processes is required, so staff can take on additional responsibilities.

In the medium term, skilled workers will need an increasingly broad range of skills to find jobs in Green Sectors. **To address this trend, TVET projects could assist in developing broader occupational profiles that enable graduates to take on a wider range of tasks and tap into new income streams**. Cross sectoral knowledge can be supported through greater permeability between subject areas (e.g. through a credit system) as well as through cooperation projects that are mainstreamed into the curriculum.

Text box 11: Mainstreaming Education for Sustainable Development into the TVET system

In line with the guiding principles of Education for Sustainable Development, development cooperation projects should support the inclusion of **key green cross-cutting issues** across educational sectors, school types and subjects related to initial and continuing TVET. The aim is to raise awareness of sustainable development and empower young people to act in an environmentally friendly, climate-action-oriented and resource efficient manner in their working and living environment. **Cross-cutting Green Skills** (such as environmental awareness and climate action and sustainable work practices) do not relate exclusively to a specific occupation or task, but are relevant in a variety of work environments. They can therefore have a general educational benefit and should be integrated into the curricula of all forms of basic and advanced education and training. Education for Sustainable Development should ideally be taught as part of a specific core subject and not as parallel standalone content. Learners will then be able to understand how their occupation or area of expertise not only helps in addressing sustainability challenges, but can also help find solutions in ways that are relevant to them.

7.2 Development of innovative skills development and teacher training

Due to the increasing need for continuing education (lifelong learning) and for the inclusive design of TVET measures in terms of a Just Transition, at institutional and implementation level it is advisable to develop innovative formats for continuous professional development, to provide non-formal education and to strengthen teacher capacities for curriculum development.

Development of lifelong learning offers

Given the increasing pace of technological innovation and the growing need for cross-sectoral knowledge, the importance of continuing TVET is set to grow. **To this end, the self-learning skills of learners should be strengthened in all educational programmes to upskill them in independently identifying, analysing and applying relevant information and knowledge**. It is vital to incorporate these skills into educational concepts and not just transfer them in terms of content. Teacher capacities for organising lessons accordingly must also be strengthened.

Opportunities for lifelong learning also need to be continuously expanded which requires the development of innovative training measures that can provide all learners with flexible, individualised pathways for upskilling the workforce. In this context, TVET projects can also broaden their focus beyond in-company and extra-company continuing TVET formats and supporting the development of innovative measures such as freely accessible digital learning platforms.

Development of non-formal trainings

TVET cooperation projects should support the introduction of non-formal training in cases where a high percentage of the workforce is employed in the informal sector. In the mobility sector, this often includes taxi drivers and roadside mechanics. Core components of training content could be offered outside of formal training programmes to facilitate participation by the informal sector.

Non-formal training is particularly suitable for workers in the informal economy, as content, educational concepts and learning conditions (time, place) can be flexibly adapted to suit the needs of target groups. Driving and safety training for the drivers of electric bike taxis is relevant because electric drives have different requirements. Safer and more efficient driving techniques can also cut costs and boost income. Specialised health and safety training for roadside mechanics can also play an important role here.

Activities should aim to step up the process of linking formal and non-formal learning opportunities, making access to basic and advanced training more inclusive and equitable. The introduction of a system for the Recognition of Prior Learning (RPL) is closely linked to these efforts. RPL measures may include certification by examination/certification boards of skills that were previously acquired through informal or non-formal channels

and can promote the economic and social integration of target groups that have been marginalised in the past.

Measures for a more gender-just mobility transition

TVET measures for women for occupations in the mobility sector that are usually male dominated should include additional accompanying activities in the following areas:

- Creation of an inclusive learning environment: Educational institutions should aim to provide a safe and supportive learning environment for all students and trainees. This includes the provision of gender-responsive teaching materials, the consideration of cultural and social differences, and the involvement of teachers who are able to respond to the needs of different groups of students.
- Awareness raising and targeted recruitment: Targeted information and awareness-raising campaigns are needed to attract women, girls and marginalised groups to TVET courses in the field of sustainable transport. These campaigns should dismantle prejudices and stereotypes that could discourage these groups from participating and highlight the benefits of a career in this field. Measures should include information and awareness-raising activities with family members, where necessary.
- Development of information campaigns and learning content on gender discrimination and sexual harassment to create a safe and gender-transformative working environment. In this context, it is important to sensitise line managers and HR staff in companies to the needs of these target groups and the challenges they face. Training and workshops can help raise awareness of the benefits of diversity and inclusion and develop strategies to create equal opportunities in the work environment.
- Strengthening the social skills of women to respond to unpleasant situations, for example with clients, including harassment or even assault (e.g. through role plays)
- Specially tailored training measures for start-ups and self-employment in the mobility sector to support role models
- Provision of financial support and flexible learning opportunities: Scholarships, grants and other forms of financial support should be provided to improve accessibility. Flexible learning options, such as part-time or distance learning options, should also be considered to enable students to balance their education with other commitments, such as family or work.
- Use of digital technologies and eLearning: The integration of digital technologies and e-learning can help facilitate access for women, girls and marginalised groups and offer them flexible options for upskilling, irrespective of their location.

Widespread prejudice in the mobility sector calls for a more comprehensive approach to create more and better job opportunities for women. Measures could include:

- Promotion of mentoring and role models: Women and girls in TVET can benefit from mentors and role models who offer them orientation and support. Support for training women as role-model trainers and teachers is another option.

- The establishment of networks and platforms to support the sharing of knowledge and lessons learned can help strengthen cohesion within the target group and open up job opportunities.
- Creation of incentive systems for companies and educational institutions: Incentive systems can be developed to motivate companies and educational institutions to become more involved in the integration of women, girls and marginalised groups in sustainable transport. This could include financial support, awards or public recognition of best practices.
- Support for 'By women, for women' business models to make the mobility sector safer.

Teacher training for designing lessons

Framework curricula define action areas with specific learning fields and core competences for each occupational profile. Learning fields are broken down into smaller units known as learning situations that shape each field. Rather than incorporating part of the framework curriculum, they are developed by the teachers within the school environment and are designed to simulate typical tasks and processes in companies (Wilbers, 2022). The key to designing vocational curricula for Green TVET is therefore for teachers to create learning units with educational content that imparts task-related, problem-oriented practical skills and embodies the fundamental principles of sustainable mobility.

In this context, it is important to remember that teachers are agents of the green transition – they act as role models for learners. They need to exemplify sustainability in their everyday professional life at the TVET institutions in which they work, in order to inspire learners. It is therefore vital that both school based and in-company **teachers be made particularly aware of resource conservation and climate action, and how to behave accordingly**. At the implementation level, TVET projects can **support teachers through educational and methodological training on skills-oriented lesson design**. The aim here should be for teachers to be able to differentiate the content of learning objectives in framework curricula, define appropriate skill requirements and develop educational concepts for practice-oriented teaching.

Text box 12: SOLUTIONSplus Nepal: Living labs for e-mobility solutions

The Nepalese Government is keen to expand the country's e-mobility fleet to meet its climate targets. Public transport and three-wheelers show particular potential in this regard. Definitive technological solutions for the transition are still lacking, however, as are viable business models for operating electric buses and regulatory measures for governance.

SOLUTIONSplus (which is funded by the EU) has therefore launched the Living Lab project, in cooperation with the municipality, the University of Kathmandu and a Danish university, as well as two local private companies from the mobility sector and two international companies from the e-mobility sector. The aim is to research and test potential technologies for converting conventional vehicles and adapting them to the local context, developing a viable business model and advising on national regulations and framework conditions. By testing e-mobility solutions in Kathmandu, the project also aims to raise awareness among stakeholders and demonstrate the feasibility of such solutions.

Local capacities for manufacturing, operating and maintaining electric vehicles in Nepal are limited at present. Electric vehicles have yet to be mainstreamed in university curricula, and there are no providers of continuing technical training in this field. Feasibility studies and needs assessments were conducted during the first phase, with all stakeholders expressing concern about shortfalls in local capacities to operate and maintain electric vehicles. In particular, a need for further training programmes for mechanics was identified, along with practice-oriented training for trainers.

The Nepalese start-up *Sajha Yatayat* (which intends to import electric buses) has developed a seven-day training course on repairing and maintaining electric buses in response. The measure was developed together with the Chinese company that exports the buses and SOLUTIONSplus. 23 participants received continuing training in the following areas:

- Basic introduction to electric vehicles
- Special tools and maintenance methods
- Safety practices and text-to-speech features
- Maintenance and general troubleshooting
- Understanding the components/maintenance work on the underside of a bus
- Practical elements of maintaining and servicing electric buses

8 Conclusion

Both TVET and sectoral measures need to be adapted and further developed if we are to actively shape the Just Transition and make transport more sustainable. The introduction of sustainable transport solutions has substantial economic potential in Asia and Africa and can promote sustainable economic development if there is a clear focus on supporting local businesses.

The automotive market is undergoing rapid change. The growth of battery and plug-in hybrid vehicles (in markets such as China, Europe and North America) will increase demands on skilled workers in traditional import markets for used vehicles, especially in Africa and parts of Asia. The employment implications of the sector's transition to electric vehicles depend to a large degree on the competitiveness of local products and services. The mobility models outlined in this paper (for electric micromobility in particular) offer significant economic potential at the local level. The automotive industry, as well as small and medium-sized enterprise (SMEs) in partner countries, are investing substantially in innovative technologies and creating new product portfolios that are needed for smart, safe and sustainable transport. The need to train, retrain and upskill the workforce is now more important than ever.

While there is a strong focus on the development of new vehicle and business models in the area of e-mobility and *MaaS* in the four countries examined in this study, the entire mobility ecosystem will also have to change, especially as regards vehicle repair and maintenance as well as further mobility services for passenger and freight transport. The vehicle repair and maintenance sector in the value chain offers employment opportunities for young people. The availability of skilled staff is an important prerequisite for enabling a Just Transition to a sustainable transport system and to support the creation of added value in partner countries. TVET institutions, which are still very much focused on conventional drives and vehicle usage models, must expand their portfolio so that they succeed in equipping graduates with the skills required on the current and future market. Partnerships between TVET institutions and e-mobility companies can make training more practice-oriented and can work more closely with established companies and with start-ups to identify the training content needed.

The qualifications required to transition to sustainable transport are changing substantially, as is the supply and demand structure on the labour market. The acute shortage of skilled workers in sustainable transport growth sectors cannot be met solely with traditional TVET concepts. In order to become fit for the future and address current and future needs in a meaningful way, deficits in the current supply of initial and continuing TVET need to be addressed by linking targeted short-term training programmes, adapting existing offers and developing new initial and continuing TVET concepts. The economic opportunities and climate imperatives of the transition to sustainable transport require measures to be closely coordinated with stakeholders in economic cooperation, climate protection and vocational training. This will ensure that climate policy measures do not

fail due to a lack of skilled workers and will enable future skilled workers to leverage the sector's economic potential. A special focus should be placed on locally adapted e-mobility solutions and mobility services. There is great potential here for local value creation and linkage with environmental, climate and social policy goals.

The reallocation or replacement of jobs by emerging industries in the mobility sector is only a matter of time (GIZ, 2022). The TVET systems in India, Kenya, Nepal and Rwanda that are presented in this study are changing slowly and continue to focus on conventional drive systems, vehicles and usage models. A growing range of short-term measures, within the framework of projects and other temporary initiatives for example, form the basis for developing modules that can be integrated into existing training programmes. In order to take into account the dynamic trends in demand for skilled labour, there needs to be a clear focus not just on refining curricula, but beyond that, on complementary continuing TVET in the context of e-mobility.

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10 Annex

Description of selected occupational profiles

Automotive mechatronics technician

Automotive mechatronics technicians work on the maintenance, repair and servicing of vehicles. They also carry out inspections, necessary service work and retrofitting of vehicle systems. This applies in particular to automotive mechatronics technicians who specialise in systems and high-voltage technology and work for manufacturers of hybrid and electric cars, for example. During their training, they learn to test and repair high-voltage systems, for example. Their training focuses on a number of areas, including passenger car, commercial vehicle, motorbike, system and high-voltage and bodywork technology. Automotive mechatronics technicians who specialise in system and high-voltage technology are particularly relevant for the use of electric vehicles, as they are responsible for maintaining and repairing electric motors, testing various components and repairing electronic systems. As electric vehicles account for a very small market share in Africa and most of Asia, demand for skilled workers specialising solely in electric vehicles is currently still very low. Demand will continue to increase however, once skills in handling conventional and electric drives become necessary over the coming years. In the area of micromobility, knowledge of low-voltage technology (up to 48 volts) is needed, which simplifies the requirements somewhat, particularly with regard to safety, as there is less potential for risk.

Electronics technicians for automation technology

Increasing automation is needed for scaling up automotive manufacturing systems in partner countries. Electronics technicians for automation technology work on constructing these complex automation systems. It is their job to assemble, install and configure individual components. To do this, they programme and test the systems, thereby ensuring that the manufacturing facilities operate smoothly. Their area of responsibility also includes the installation of electronic assemblies in CNC machines, setting up machines and drive systems, and taking care of control and feedback mechanisms of the corresponding machines. Electronics technicians for automation technology routinely monitor and maintain these systems to ensure that no errors occur. In the event of a malfunction or fault, they diagnose, locate and rectify it immediately. If required, they also programme, configure and test automation and IT systems. Electronics technicians for automation technology analyse the function of automation systems and their interrelationships, and modify and expand them. They also install electrical drive and program automation systems, install components, equipment, sensor and operating systems, use programmes for measurement data acquisition, transmission and processing and for production, machine and process control. This occupational profile is very relevant in India in particular, which has a strong automotive industry. Increasing automation is also evident in Kenya. The development of similar occupational profiles in Nepal and Rwanda is an important component for developing a competitive industry, on a regional level at least.

Electronics technicians for equipment and systems

Electronics technicians for equipment and systems are required for developing a supplier industry and for integrating the different components of the system, particularly engines and batteries. They inspect and test the engine and drive controls and assemble the electronic components. They also manufacture different components and microcomponents and programme the associated systems. The occupational profile is characterised by comprehensive competence in electronics systems. They understand the individual hardware and software components of an automotive system in detail, both in terms of their technical structure and their systemic functionality with the associated sensors and actuators. Electronics technicians for equipment and systems manufacture components and build equipment and systems. They commission and maintain systems and equipment. In the action area of 'vehicle technology', electronics technicians for equipment and systems will in future build electric engine controls, drive controls and inverters, for example. Electronics technicians for equipment and systems are responsible for designing circuits and producing prototypes and for integrating electronic assemblies and components. They install and configure software programmes, analyse and test technical functions and check and repair equipment and systems. They mainly work in production halls, workshops and test laboratories. Some countries in Asia, such as India, the Philippines and Vietnam, already have training programmes in this area. Kenya, Nepal and Rwanda offer no such programmes to date.

Electronics technicians for equipment and systems (battery charging equipment)

Electronics technicians in this field build equipment and systems and manufacture the relevant components. Their main task is to plan and control production processes for equipment and they also commission and maintain systems and equipment. In the area of 'infrastructure-stations', electronics technicians for devices and systems inspect, build and test equipment such as battery chargers and charging management systems for a wide range of electric vehicles – from electric cars to pedelecs. They design circuits and produce prototypes, integrate electronic assemblies and components, install and configure software programmes, analyse and test technical functions and repair systems and equipment.

Electronics technicians for machines and drive technology

Core components for electric vehicles produced in partner countries are currently imported from China and Europe. Electronics technicians for machines and drive technology are needed for the local production of electric motors. They specialise in electric engines and the systems required for controlling and regulating them and are familiar with the different types of engines, their winding data and performance. They set up production plants, manufacture different windings, insulate windings in electrical machines, dismantle and assemble electrical machines, test and repair, and commission and maintain them. In the area of 'automotive technology', these technicians build and maintain a wide variety of designs for engines for drive systems. They work in metal engineering and mechanical engineering and construction, engine development and for workshops with electrical equipment and systems.

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
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