Republic of Rwanda

Ministry of Public Service and Labour

e-Mobility Skills Snapshot

SKILLS RWANDA

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Acronyms

AI	—	Artificial Intelligence
BEV	—	Battery Electric Vehicle
CAGR	—	Compound Annual Growth Rate
EV	—	Electric Vehicle
HEV	—	Hybrid Electric Vehicle
ICE	—	Internal Combustion Engine
MINEDUC	—	Ministry of Education
MININFRA	—	Ministry of Infrastructure
PHEV	—	Plug–In Hybrid Electric Vehicle
RTB	—	Rwanda TVET Board
TVET	—	Technical and Vocational Education and Training


ClipperCreek Pedestal
PMD-10 ProMountDuo

Executive Summary

Rwanda is experiencing growth in its transport sector, as it can have numerous positive impacts on trade, business, employment and the daily lives of its citizens. However, this growth also comes with environmental challenges such as air pollution, greenhouse gas emissions, and noise pollution.

It is therefore the Government of Rwanda's ambition to provide safe and environmentally sound transport options. These goals, particularly through electric mobility are envisaged to be achieved through the following ways:

1. **Promoting Electric Vehicles** (EVs) which involves the adoption of electric cars and motorcycles, with the aim to significantly reduce air pollution and greenhouse gas emissions. This could include incentives such as tax breaks or subsidies for EV buyers, as well as expanding the charging infrastructure across the country as well as special tariff for electricity for EV charging facilities.
2. **Investing in Public Transportation** by developing an efficient and eco-friendly public transportation system, such as electric buses, is aimed to reduce the number of private vehicles on the road, thereby decreasing pollution and congestion.
3. **Regulations and Standards** through implementation of strict emissions standards for vehicles are aimed to help limit the environmental impact of the transport sector. Additionally, enforcing noise pollution regulations can make urban areas more pleasant for residents.
4. **Green Innovation** which encourages research and innovation in green transportation technologies, such as electric vehicles, hydrogen fuel cells, and alternative fuels.
5. **Public Awareness** by promoting awareness among citizens about the benefits of electric mobility and the environmental impact of their transportation choices, is aimed to encourage more people to opt for electric vehicles.
6. **Urban Planning** in the form of developing urban planning strategies that prioritize pedestrian and cyclist-friendly infrastructure, reducing the need for short car trips and promoting healthier, more sustainable modes of transportation.
7. **Transportation Electrification Policy** by creating a comprehensive policy framework for transportation electrification, outlining goals, incentives, and guidelines for transitioning to electric mobility.

By pursuing these strategies, Rwanda can make significant progress towards providing safe and environmentally friendly transportation options for its citizens while simultaneously contributing to green growth and reducing dependency on fossil fuels in the transport sector.

This skills snapshot is designed to cater to a diverse audience, including skills providers, skill seekers (demand), and policymakers. It aims to offer a concise overview of the evolving sub-sector of e–Mobility in Rwanda, based on existing activities. However, it's important to emphasize that this snapshot is a compilation of information from various sources and should be viewed as an initial overview. A more comprehensive research study into the required skills is imperative. Additionally, we encourage active engagement and commitment from various partners to advance the recommendations outlined herein. This collaborative effort is essential to strengthen the acquisition of talent and skills necessary to support and sustain the growth of the e–Mobility sector.

The e–Mobility Sector — An Overview

The shift to e–Mobility is expected to be a sustainable solution to reduce carbon emissions and dependency on fossil fuels in the transport sector. Globally, the adoption of electric vehicles (EVs) has witnessed rapid growth, with Battery Electric Vehicles (BEV) growing at a CAGR of 65% and Plug-In Hybrid Electric Vehicles at 85%. While China and Europe are leading the transition, Rwanda has identified e–Mobility as a key driver to combat its increasing carbon emissions, especially in the transport sector, which contributes to 13% of the country's emissions. The government and private sector are collaborating to introduce incentives for the growth of e–Mobility, including lower electricity tariffs, tax exemptions, and rent-free land for charging stations. The Ministry of Infrastructure in Rwanda (MININFRA) developed a Strategic Paper on Electric Mobility Adaptation in Rwanda, which highlights the country's efforts to transition to EVs to address environmental concerns and reduce dependency on fossil fuels in the transport sector. Rwanda currently heavily relies on internal combustion engine (ICE) vehicles, leading to air pollution, greenhouse gas emissions, and over–dependence on oil imports. There are various types of EVs, including Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), and Plug-in Hybrid Electric Vehicles (PHEVs).

The e–Mobility ecosystem comprises various stakeholders operating within a complex and interconnected framework. Illustrated in Figure 1, the e–Mobility ecosystem consists of four essential interactive sectors: Electric Vehicles, infrastructure, customers, and regulations and subsidies. Each of these segments plays a vital role in shaping the overall system, and they each bring their unique set of opportunities and challenges. A shared requirement among all these segments is the imperative for capacity development to effectively fulfill their respective roles.

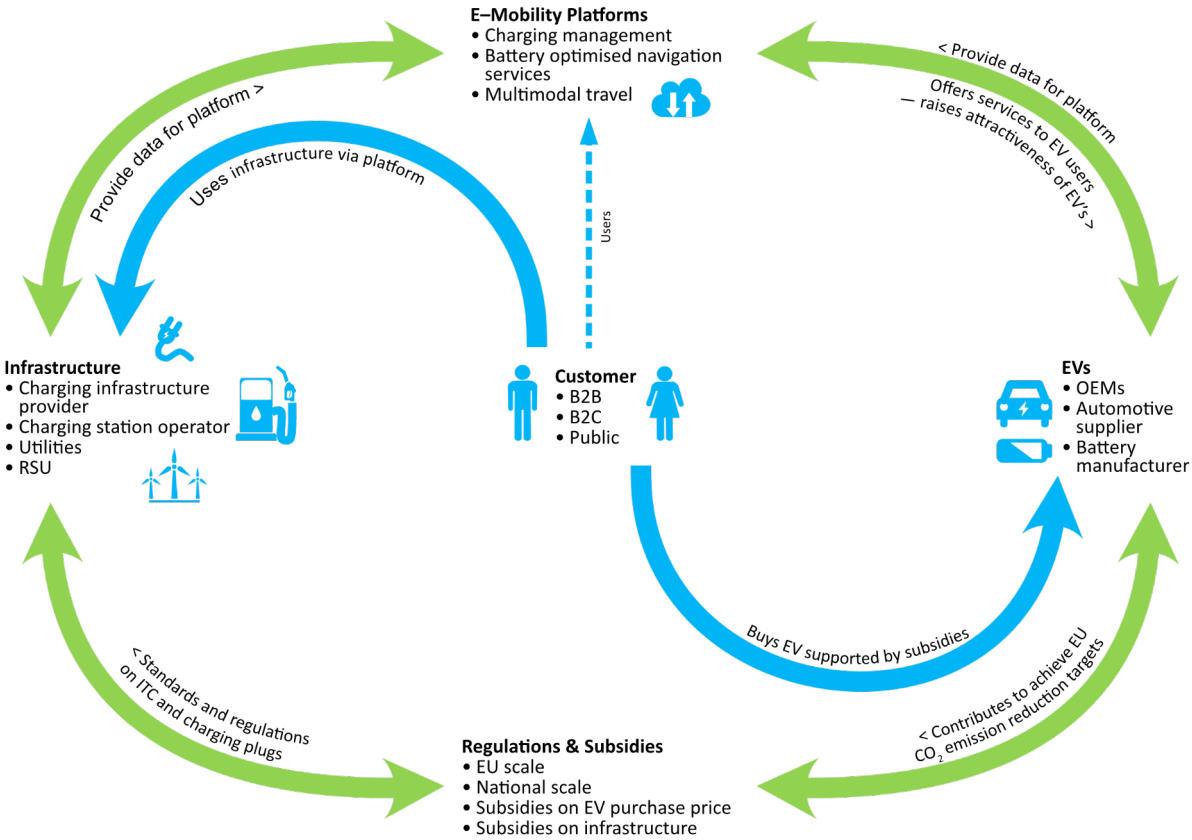

Figure 1: The e-Mobility Ecosystem (Ziegelmayer, Daniel & Gotschol, Catrin & Schulz, Wolfgang & Geis, Isabella. (2016). eCo-FEV D502.3 Potential Business Model. 10.13140/RG.2.1.3266.2648.)

In addition, there are key elements throughout e–Mobility ecosystem which include ensuring the resilience of supply chains and securing essential raw materials, promoting environmentally friendly power generation, establishing readily available charging infrastructure, integrating electric vehicles with smart grid technologies, developing digital platforms and mobile applications for efficient EV charging optimization, and identifying and educating the future workforce in order to ensure sustainability of the sector. The transition to e–Mobility is expected to have profound implications for the future of skills and jobs in the automotive industry. As electric vehicles (EVs) gain popularity and traditional automotive technologies evolve, there will be a shift in the demand for specific skills and job roles. Jobs related to traditional internal combustion engine (ICE) power–train assembly may decline, while positions in battery manufacturing, electric drive–train assembly, and electronics integration are likely to see growth (Byiringiro, 2020). This shift in manufacturing processes will necessitate the retraining and upskilling of the workforce to adapt to the changing demands of the industry (ILO, 2021).

The widespread adoption of electric vehicles will create a demand for specialized technicians with expertise in electric vehicle repair, maintenance, and diagnostics. This shift will require traditional automotive mechanics to undergo additional training and re-skilling to work on EVs effectively (ILO, 2021). Additionally, with EVs relying heavily on software and data-driven technologies for various functions, such as battery management and regenerative braking, there will be an increased demand for software engineers and data analysts in the automotive industry (IEA, 2021).

The rise of e–Mobility will also lead to the emergence of new job opportunities in the field of charging infrastructure. Jobs related to the installation, maintenance, and management of EV charging stations will be in demand, creating employment opportunities for electricians, construction workers, and technicians (Byiringiro, 2020). Furthermore, as the automotive industry focuses on research and development to improve battery technology, power electronics, and vehicle design, there will be an increased demand for engineers with specialized knowledge in these areas (IEA, 2021). To address the skills gap and ensure a smooth transition, collaboration between governments, educational institutions, and industry players will be essential in providing training and reskilling programs for workers in the automotive sector (World Economic Forum, 2018).

Current e–Mobility Landscape

The realm of electric mobility represents an emerging sector that offers a foundation for conducting a qualitative evaluation of prospective employment opportunities within this domain. As the sector continues to expand, there will be an escalating demand for new experts proficient in servicing and maintaining electric vehicles. Additionally, a workforce will be necessary to uphold the essential charging infrastructure. The extent of these potential income–generating opportunities hinges on the comprehensive systems that are established.

The electric mobility sector holds the potential for generating additional employment opportunities, primarily due to the comparatively lower environmental impact of the transportation services offered, in contrast to conventional vehicles presently in use. It's worth noting that vehicle assembly is already a well–established practice in Rwanda, and the direct outcome of the shift in drive–train technology on job creation within this sector remains challenging to predict. This sector hinges on robust support for the advancement of electric mobility. While the business-as-usual scenario introduces some electric vehicles, a substantial scaling-up necessitates governmental backing. Economic analysis suggests possibilities to reduce the initial

capital cost through lowered VAT and import duties specifically for electric mobility components. Furthermore, ensuring an appealing electricity tariff for electric mobility charging can stimulate growth.

Limitations on Skills Related Data for the e–Mobility Sector

- The sector is an emerging sector resulting in limited literature and data on both the skills supply and skills demand side.
- Limited research on e–Mobility related skills development.
- Existing surveys and reports do not include e–Mobility data e.g., Labour Force Survey, Education Statistical Yearbook etc.
- Limited infrastructure for practical/Industrial training.

Skills Overview in the e–Mobility Sector

In certain domains, particularly the technical sphere, concerted efforts are underway to cultivate these skills. These initiatives are taking shape through partnerships between educational institutions, private sector collaborators, and development partners, facilitating the development and dissemination of essential competencies to drive the e–Mobility sector forward.

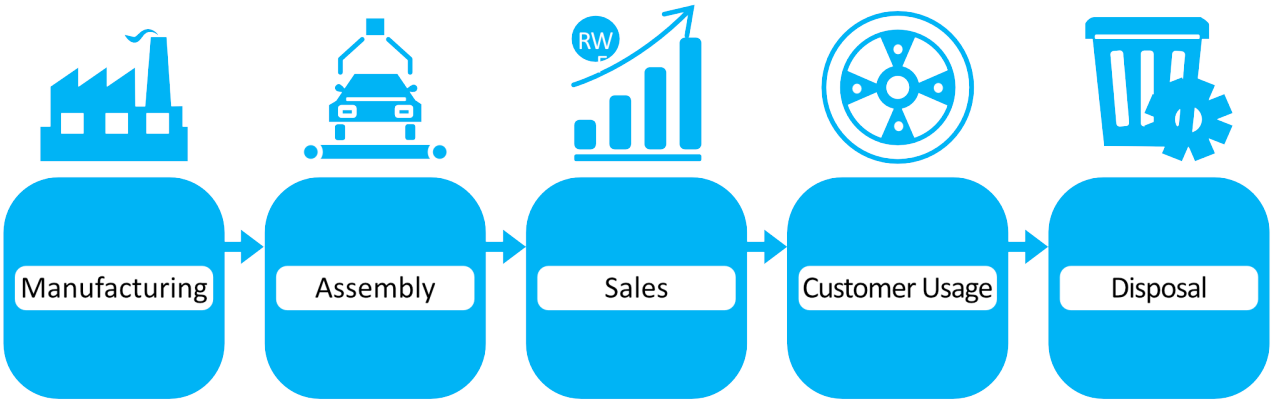

Figure 2: Skills required against the value chain (Author)

When examining the e–Mobility value chain (Figure 2), a diverse array of skills are required across each facet of this intricate network. These include certain skills such as:

- **Skilled Technicians**: These individuals possess the expertise to assemble and maintain electric vehicles, spanning from electric cars to e–bikes and e–scooters.
- **Battery Specialists**: Experts in battery design, manufacturing, and management, with a specific emphasis on lithium-ion battery technology, which is prevalent in electric vehicles.
- **Charging Infrastructure Professionals**: These individuals bring their knowledge to bear in the installation, maintenance, and management of EV charging stations.

- **Electric Power–train Engineers**: Their proficiency lies in the design and optimization of electric power–trains to suit various types of electric vehicles.
- **Renewable Energy Integrators**: Specialists in integrating renewable energy sources such as solar and wind into e–Mobility infrastructure to curtail carbon emissions.
- **Policy and Regulatory Experts**: Professionals well-acquainted with the intricate regulatory frameworks and policies specific to e–Mobility, including incentives designed to promote EV adoption.
- **Software Developers and Data Analysts**: These individuals are instrumental in crafting software solutions for EVs, charging stations, battery swapping software and platforms for e–scooters and e–Mobility platforms. Moreover, they have the capability to extract valuable insights from e–Mobility data.
- **Cyber–security Specialists**: Experts proficient in safeguarding electric vehicle systems and charging infrastructure against potential cyber threats.
- **Supply Chain Managers**: These professionals excel in managing the intricate supply chain for EV components, including batteries, ensuring a seamless flow of materials.
- **E-Waste Management Specialists**: Individuals responsible for the responsible handling, recycling, and disposal of electronic waste, including batteries and other e–Mobility components.
- **Trainers and Educators**: Those capable of developing and delivering programs that elevate the skills of the workforce and raise awareness about the significance of e–Mobility.
- **Environmental Impact Assessors**: Experts with the ability to assess the environmental repercussions of e–Mobility projects and instigate sustainable practices.

The identification of skills gaps would be linked to an in–depth assessment of the current state of e–Mobility within Rwanda and the corresponding capacity of its workforce to meet the demands of this growing industry.

To identify these skills gaps, we scrutinized the existing landscape of e–Mobility technologies, market trends, and industry requirements within the Rwandan context. Simultaneously, a perceptive evaluation of the country's workforce capabilities, encompassing both technical competencies and soft skills, was undertaken.

The skills gap in e–Mobility in Rwanda, a relatively new entrant to the e–Mobility sector, involved considerations of various stages within the e–Mobility value chain, bench–marking, and engaging stakeholders who are already involved in the e–Mobility sector. The existing skills gaps highlight the complexity and diversity of expertise required for the successful development and implementation of e–Mobility in a new market like Rwanda. These categories provide a clearer overview of the different skills gaps within the e–Mobility sector, making it easier to identify specific areas that require skill development and workforce investment.

The following are the identified skills gaps in the e–Mobility sector:

1. Manufacturing and Production

- **Battery Technology Engineers**: Specialized engineers for developing advanced battery technologies.
- **EV Manufacturing Technicians**: Workers trained in electric vehicle assembly and maintenance.

2. Operations and Maintenance

- **EV Roadside Assistance Technicians**: Offering specialized assistance for electric vehicle breakdowns and emergencies.

3. **Charging Infrastructure**

- **Charging Station Technicians**: Skilled technicians for installation and maintenance of charging infrastructure.

4. **Electric Vehicle Technology**

- **Electric Power–train Engineers**: Experts in designing and optimizing electric vehicle power–trains.
- **Software Developers for EVs**: Developing software for electric vehicle control systems and applications.

5. **Battery and Energy**

- **Battery Recycling Specialists**: Professionals to handle recycling and disposal of batteries.

6. **Maintenance and Repair**

- **EV Maintenance and Repair Technicians**: Skilled mechanics for electric vehicle repair and maintenance.

7. **Data and Analysis**

- **Environmental Impact Assessors**: Assessing the environmental impact of e–Mobility initiatives.

8. **Training and Education**

- **Technical Trainers for e–Mobility**: Training the workforce in e–Mobility technologies Grid Integration:
- **Grid Expansion Planners**: Planning grid expansion to accommodate increased electric vehicle charging demand.

9. **Business Strategy and Standards**

- **e–Mobility Business Consultants**: Advising businesses and organizations on e–Mobility strategies.
- **EV Financing and Leasing Experts**: Experts in financing and leasing options for electric vehicles.
- **EV Insurance Experts**: Developing insurance products tailored to electric vehicle ownership.
- **e–Mobility Standards and Certification Specialists**: Developing industry standards and certification processes.

These skills gaps represent a broad range of expertise needed to establish and develop a thriving e–Mobility sector in Rwanda. Addressing these gaps through education, training, and workforce development initiatives will be crucial for the successful growth of the e–Mobility industry in the region.

Emerging and Future Skills in the e–Mobility Sector

As the world continues to evolve and technology advances in the e–Mobility sector, new skills will become increasingly important to meet the demands of this rapidly growing industry. Here are skills that will likely be in high demand in the future, considering the various value chains within e–Mobility:

1. Research and Development

- **Advanced Battery Chemistry**: Expertise in developing next–generation battery technologies with improved energy density and safety.
- **Materials Science**: Proficiency in researching and creating advanced materials for lightweight and efficient EV components.
- **AI and Machine Learning for EVs**: Applying artificial intelligence and machine learning to optimize EV performance, battery management, and autonomous driving.

2. Manufacturing and Production

- **Automation and Robotics**: Expertise in designing and maintaining automated manufacturing processes for EVs.
- **Sustainable Manufacturing**: Knowledge of eco-friendly and sustainable production methods for EVs.

3. Infrastructure Development

- **Advanced Charging Technologies**: Specialized skills in high-speed and wireless charging technologies.
- **Smart Grid Integration**: Proficiency in integrating EV charging infrastructure with smart grid systems.

4. Software and Connectivity

- **Cyber–security for Connected Vehicles**: Protecting EVs and their connected systems from cyber threats.
- **Over-the-Air (OTA) Updates**: Managing remote software updates for EVs.

5. Operations and Maintenance

- **Remote Diagnostics and Maintenance**: Skills in remotely monitoring and maintaining EVs.
- **AI-Based Predictive Maintenance**: Using AI to predict and prevent potential issues in EVs.
- **EV Fleet Management and Optimization**: Managing large fleets of electric vehicles efficiently.

6. Market Analysis and Strategy

- **Data Analytics for Market Insights**: Analyzing data to identify market trends and consumer preferences.
- **Business Model Innovation**: Developing new business models for mobility services and EV adoption.

7. Education and Training

- **e–Mobility Curriculum Development**: Designing educational programs and training modules for future e–Mobility professionals.
- **e–Mobility Instructors**: Skilled educators capable of teaching the latest e–Mobility technologies and practices.

These skills represent a forward–looking perspective on the e–Mobility sector's future needs, where technological advancements, environmental sustainability, and innovative business models will play crucial roles in shaping the industry. As the sector continues to evolve, individuals and organizations that possess these skills will be well-positioned to contribute to its growth and development.

Capacity Development Initiatives in the e–Mobility Sector

The development of capacity in the e–Mobility sector is currently driven by collaborations between the private sector and training institutions, responding to specific demands. These partnerships involve training programs and knowledge exchange facilitated by industry experts. Given that e–Mobility is a relatively new sector, knowledge gaps are inherent. These gaps can be effectively addressed through deliberate investments in skill enhancement, increased exposure, and community awareness campaigns highlighting the benefits of electric mobility.

Crucially, it is imperative that various stakeholders, encompassing both private enterprises and public entities, comprehend the profound value that e–Mobility brings to the table in terms of socioeconomic transformation. This understanding is pivotal for fostering a supportive environment for the growth and sustainability of the e–Mobility industry.

The Rwanda TVET Board (RTB) has spearheaded a series of impactful capacity development initiatives. These initiatives have been meticulously designed and executed to cater to the dynamic needs of the e–Mobility sector in Rwanda. Key initiatives include:

Short-Term Training Programs

- **E–Motorcycle Training**: These programs focus on equipping participants with comprehensive insights into electric motorcycles, covering essential aspects such as vehicle operation, safety measures, and efficient riding techniques.

- **E–Moto Maintenance and Repair**: Recognizing the importance of vehicle maintenance in ensuring the reliability and longevity of electric motorcycles, specialized training programs have been developed. These programs empower technicians and mechanics with the skills required for diagnosing, maintaining, and repairing e–motos. Two cohorts have successfully completed their training, and RTB will continue to provide similar programs to ensure they maintain a continuous supply of trained technicians to support the rapidly growing e–Mobility sector.

There are various e–Mobility related programs which are being delivered through Rwanda Polytechnic at the IPRC's in the Mechanical Engineering Department/Automobile program. The program range is outlined in the table below.

S/N	Module code and name	Level	Hours	Learning Outcomes
1	AUTEE601 — BASIC ELECTRICITY AND ELECTRONICS	Level 6 (Advanced Diploma)	50	• Describe electrical power system • Describe alternative current and polyphase circuits • Identify electronic materials and components • Describe number systems • Apply Boolean algebra and logic
2	ITLDS601 — ALGORITHM AND DATA STRUCTURE USING C	Level 6 (Advanced Diploma)	50	• Use Algorithm to solve problems • Apply C Programming • Apply Data Structures using C
3	AUTES601 — VEHICLE ELECTRICAL SYSTEM	Level 6 (Advanced Diploma)	120	• Identify vehicle electrical systems • Service main vehicle electrical systems • Service vehicle electrical system accessories
4	AUTEL601 — POWER–TRAIN ELECTRONIC SYSTEM MAINTENANCE	Level 6 (Advanced Diploma)	150	• Identify Power–train electronic system • Service electronic engine management • Service gearbox and clutch electronic control
5	ATMAS701 — MAINTAIN ANTI-THEFT SYSTEM	Level 7 (Advanced Diploma)	50	• Identify anti–theft systems • Diagnose anti–theft systems • Service anti–theft systems components • Install anti–theft systems components
6	TPM701 — MAINTAIN HYBRID AND ELECTRIC CAR	Level 7 (Advanced Diploma)	60	• Identify hybrid and electric car components • Service hybrid and electric car components • Install hybrid and electric car components
7	AUTHVAC701 — MAINTAIN HEATING, VENTILATION AND AIR CONDITIONING	Level 7 (Advanced Diploma)	50	• Identify heating and air–conditioning system components • Service heating and air–conditioning system components • Service auxiliary heating system components • Service automatic heating and air-conditioning system components
8	AUTVCP701 — VEHICLE COMPUTER PROGRAMMING	Level 7 (Advanced Diploma)	60	• Identify hardware components and software related to vehicle computers • Service vehicle computer components • Test vehicle computer (ECU) performance
9	AUTHE801 — HEAVY VEHICLE ELECTRICAL AND ELECTRONIC SYSTEM REPAIRING	Level 8 (Btech)	100	• Diagnose heavy vehicle electrical and electronic systems repair • Conduct heavy vehicle electrical and electronic systems repair • Perform post repair activities of heavy vehicle electrical and electronic systems.
10	AUTME01 — HEAVY MACHINES ELECTRICAL AND ELECTRONICS SYSTEM REPAIRING	Level 8 (Btech)	100	• Diagnose electrical and electronic systems • Conduct electrical and electronic system repair • Perform post repair activities on electrical and electronic system
11	AUTCS801 — CONTROL SYSTEM ENGINEERING PRINCIPLES	Level 8 (Btech)	100	• Describe Control Systems • Design Control systems • Analyze Control Systems

Furthermore, there is a TVET school located in Gacuriro, Kigali which is offering the e–Mobility program in the form of a short course in Electric Motorcycle Maintenance.

- **In–Company Instructors Training Program**: To ensure the consistent delivery of high-quality training within the e–Mobility industry, the RTB has established a dual short-course training program for in-company instructors. This initiative enhances the expertise of trainers, enabling them to pass on essential skills effectively. Through the program, in-company instructors undergo training tailored to address the specific gaps identified by their respective companies. The program will continually be conducted and aligned with the needs of the companies. Companies such as REM, SPIRO, VW and many others are conducting in-house training. This includes targeted technical training specific to electric vehicles. Training is tailored to the operations which allows the trainee to better understand the technology involved, such as the battery component, replacements, and wiring the connection. High voltage trainers are well as technical trainers are both required. Companies have emphasized the importance and benefits of the dual training approach so that it allows for the theoretical training to take place in schools while the company provides the workplace exposure.

- **Development of Occupational Profiles**: The RTB has taken a proactive role in defining and standardizing occupational profiles crucial to the e–Mobility sector's growth and operation. RTB held a workshop to engage stakeholders in a brainstorming session focused on refining occupation standards within the e–Mobility sector. The in-depth analysis and development of these occupations' standards in the e–Mobility are scheduled for the second quarter of the fiscal year 2023/2024. Role-players such as Swiss Corp, is working with RTB on a dual training program for electric motorcycles and electric vehicles. Curriculum on the repair and maintenance of an electric bike is also being developed. There are various Development Partners who are involved in interventions related to the e–Mobility sector. As this is a new sector, this information is dispersed and would require a focused effort to consolidate all interventions.

Recommendations

- **Recommendation 1**: Conduct a comprehensive research study that provides a thorough analysis of the skills requirements across the ecosystem, considering the diverse skills levels needed. This study should particularly focus on services related to EV assembly, charging infrastructure deployment, and the responsible management of batteries, including their reuse and disposal. This analysis will enable educational institutions (Universities, Polytechnics and TVET schools) to align their curriculum development with the current and future needs of the market, ensuring that students are prepared for the available job opportunities.

  Recommended lead institution: RDB & PSF

- **Recommendation 2**: Establish shared knowledge platforms with industry, government, and higher learning institutions to foster the growth of the e–Mobility sector. This collaboration should aim to nurture local talent to ensure that individuals have access to practical exposure within the e–Mobility ecosystem.

  Recommended lead institution: MININFRA & City of Kigali

- **Recommendation 3**: Expand the dual system training for learners to gain theoretical knowledge, practical skills and workplace exposure; to support the increasing demands of industry in the e–Mobility sector. To lead the dual training, it is important Train-the-Trainers; hence the capacity building of trainers is of utmost importance so that the training is relevant at schools and within the workplace.
  Recommended lead institution: MINEDUC with RP and RTB leading the training.

- **Recommendation 4**: Engage relevant institutions to gather, analyze and present e–Mobility related data which will inform policy formulation, advanced research endeavors and other related activities.
  Recommended lead institution: MINEDUC & NISR

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