CITY ROADMAP FOR ELECTRIC THREE-WHEELER
IN UDON THANI, THAILAND

This project has received funding from the European Union Horizon 2020 research and innovation Programme under grant agreement no. 875041

PROJECT PARTNERS

ABOUT

To present a roadmap to upscale electric three wheelers in Udon Thani

TITLE

City Roadmap For Electric Three-Wheeler in Udon Thani

CONTRIBUTORS

Mr Anupong Mokkaranurak, Director General, ETC
Mr Souliyo Vongdala, CEO, LOCA Co., Ltd.
Mr Pinyo Rukyart, Project Manager, ETC
Mr Borworn Kanpet, Project Officer, ETC

REVIEWER

Dr Shritu Shrestha, Senior Researcher, WI
Ms June Yeonju Jeong, Program Manager, UNEP
Mr Joachim Bergerhoff, Team Leader, SMMR

DISCLAIMER

The views expressed in this publication are the sole responsibility of the authors named and do not necessarily reflect the views of the European Commission.

LAYOUT

Yasin Imran Rony, WI

PICTURES

All the pictures are provided by the SOL+ partners

June, 2024

Purpose	To present a roadmap to upscale electric three wheelers in Udon Thani.
Coordination	Dr Shritu Shrestha, Senior Researcher, Wuppertal Institute Dr Pichai Uamturapojn, National Expert, SMMR
Contributors	Mr Anupong Mokkaranurak, Director General, ETC Mr Souliyo Vongdala, CEO, LOCA Co., Ltd. Mr Pinyo Rukyart, Project Manager, ETC Mr Borworn Kanpet, Project Officer, ETC
Reviewers	Dr Shritu Shrestha, Senior Researcher, Wuppertal Institute Ms June Yeonju Jeong, Program Manager, UNEP Mr Joachim Bergerhoff, Team Leader, SMMR

Executive Summary

Udon Thani City is the sixth largest city in Thailand and is a major commercial center in Northeast Region, serving as the gateway to Vientiane Capital City, Lao PDR. Despite its significance, the city still lacks a comprehensive public transport system and service. In the urban area, an informal paratransit system bridges the gap between conventional buses and private cars, meeting flexible transit demands. The iconic three-wheelers, known as "skylabs," range from 90 to 150 cc and evolved from the agriculture-based uses to various urban services, including ride-hailing.

With the support of SOLUTIONSplus project, the E-sarn Technological College (ETC) and LOCA Co., Ltd are collaborating to develop affordable and scalable electric three-wheeler services, aiming to boost local Light Electric Vehicle (LEV) adoption in Thailand. This partnership, coordinated by the Sustainable Design of Urban Mobility in Middle-sized Metropolitan Regions in ASEAN (SMMR) Project, addresses urban mobility challenges. ETC is working with the National Science and Technology Development Agency (NSTDA) to design and consult on prototypes, focusing on improving the maneuverability and safety of electric three-wheelers by redesigning the rear chassis, tilting actuator, and bracket mounting.

Additionally, ETC has collaborated with the Federation of Thai Industries (FTI) in Udon Thani Province to improve the urban mobility system and service in four phases: Inform, Inspire, Initiate, and Implement. This initiative involves the public and private sectors as well as young entrepreneurs, in raising awareness and brainstorming on electric three-wheeler systems and services. The ETC and LOCA have also designed an extension of the LOCA App and platform to integrate mobile technology with local drivers, aiming to co-create a better understanding of expanding the services as to new market.

The paper outlines the significance of the three wheelers in Udon Thani, their potential for scaling up, and the initial implementation plan for this transformative urban mobility initiative.

Table of Contents

List of Figures

List of Table

List of Abbreviations

E3W	Electric-three wheeler
ETC	E-sarn Technological College
EV	Electric vehicle
FTI	Federation of Thai Industries
LEV	Light electric vehicle
NSTDA	National Science and Technology Development Agency
SMMR	Sustainable Design of Urban Mobility in Middle-sized Metropolitan Regions in ASEAN

1. Background

1.1. Urban mobility context in Udon Thani City, Thailand

Udon Thani City, the sixth largest city in Thailand, is a major commercial center in Northeast Region and serves as the gateway to Vientiane Capital City, the capital city of Lao PDR. With a population exceeding 400,000, the city is a focal point for trade, tourism, and education. However, the city faces growing travel demands that lead to traffic congestion, particularly in the urban areas. Despite its importance, the city lacks a comprehensive public transport system, which hinders the development of new transport infrastructures and facilities and affects the quality of service, efficiency, and equity among operators, drivers and users. In the absence of a robust public transport system, an informal paratransit system that emerged to fill the gap of conventional buses and private cars, plays a significant role to meet the flexible transit demands. The iconic three-wheelers named “Skylab” are used to call the tuk-tuk have engine size ranging from 90 to 150 cc and were originally developed from the agricultural purposes. These vehicles have since evolved to serve various urban functions, such as ride hailing services. Currently, approximately 6,000 units of Skylab operate in Udon Thani. These Skylabs follow a traditional operational model where each is independently owned and operated by individual drivers or managed by small businesses that rent them to drivers. Drivers typically seek passengers through street hails or wait at designated stands, such as markets, bus stations, or other high-traffic areas. Payment for these Skylab services is usually made through direct cash transactions for each trip. Despite their significance, Skylabs face several challenges, including limited coverage, inconsistent service, high emissions, economic inefficiency, and safety concerns. Addressing these issues is crucial for improving urban mobility and enhancing the quality of life for Udon Thani’s residents and users.

In Thailand, the national policies aim at promoting electric vehicle (EV) adoption towards reducing greenhouse gas emissions from the transport sector. In line with these policies, Udon Thani has been expanding its EV infrastructure, including the installation of multiple electric vehicles charging stations to cater to the growing number of electric vehicles. Additionally, Udon Thani has implemented initiatives to promote sustainable urban transport solutions. The provincial government is working to address the challenges of insufficient public transport and high reliance on internal combustion engine (ICE) vehicles by encouraging the use of electric vehicles.

1.1. The electric three-wheeler demonstration project

With the SOLUTIONSplus project, the E-sarn Technological College (ETC) and LOCA Co.,Ltd are partnering to develop affordable and scalable electric three-wheeler services, specially targeting local levels of Light Electric Vehicles (LEV) adoption in Thailand. The ETC and LOCA are collaborating to address the urban mobility challenges, coordinated by the Sustainable Design of Urban Mobility in Middle-sized Metropolitan Regions in ASEAN (SMMR) Project. In terms of prototype design and consultation, the ETC has been collaborating with the National Science and Technology Development Agency (NSTDA) to develop electric three-wheeler with enhanced maneuverability. The specification of the vehicle includes dimensions of 1.48 x 3.38 x 1.93 meters (W x H x L), a ground clearance 0.13 meters, and a capacity of six passengers and one driver. It is powered by two Brushless DC wheel hub motors, each providing 5 kW, and 12 kWh 48V LFP battery, offering a cruising range of 70 km per charge. The rear chassis has been redesigned to improve is the tilting actuator and bracket mounting for safety.

Figure 1 Traditional Skylab to the electric three-wheeler

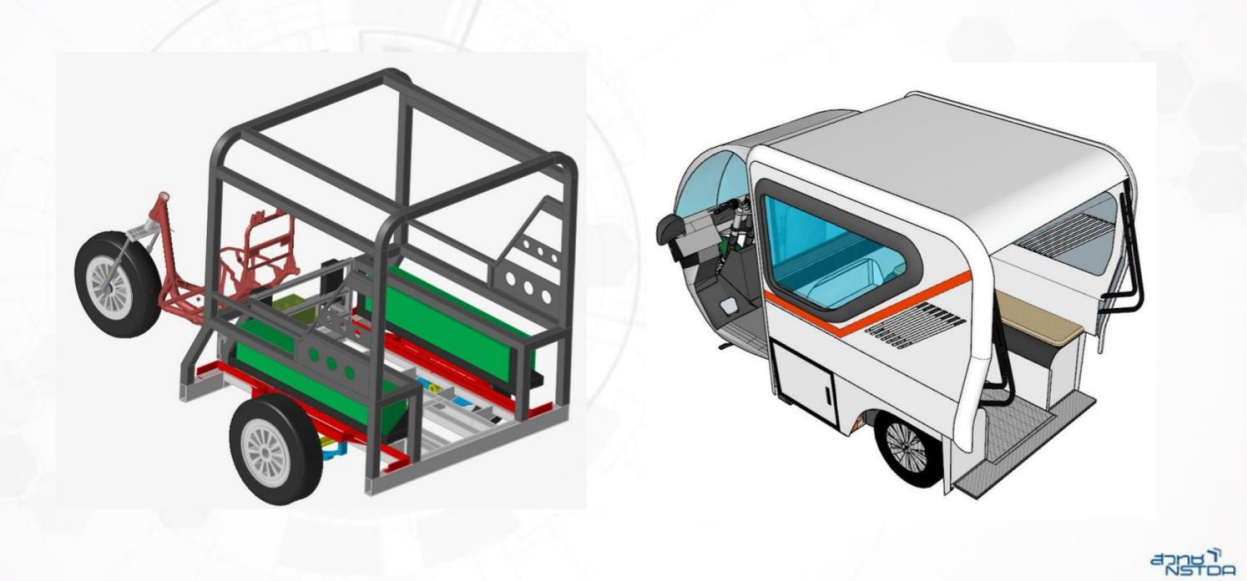

Figure 2 Detailed design of electric three-wheeler

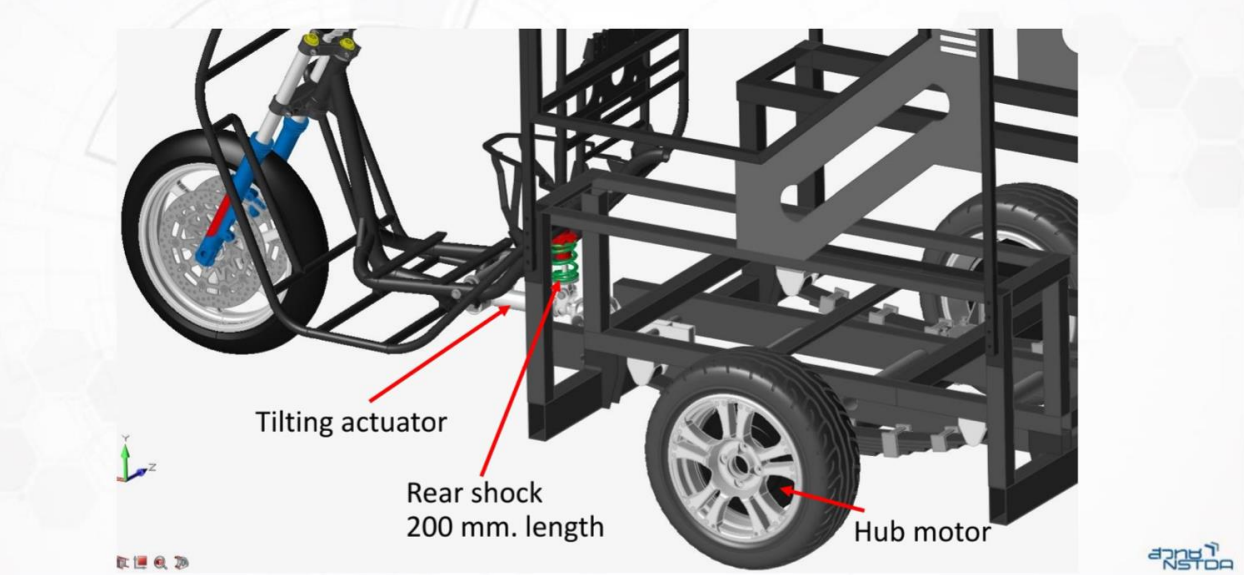

Figure 3 System Design of electric three-wheeler

Currently, 6,000 units of Skylab operate in Udon Thani, typically following a traditional model where each vehicle is independently owned and operated by individual drivers or owned by a small business that rents them out to drivers. Drivers either seek passengers through street hails or wait at designated stands, like markets, bus stations, or other high-traffic areas. Payment is generally made in cash for each trip.

1.2. Approach

The demonstration project consists of four phases: Inform, Inspire, Initiate, and Implement.

The Inform Phase involves conducting a baseline assessment of the current urban mobility landscape in Udon Thani City, identifying key stakeholders and users, as well as assessing potential strategic partners. The primary goal of this phase is to raise awareness among key stakeholders about the electric three-wheeler system and service.

The Inspire Phase focuses on engaging potential partners from both public and private agencies to foster collaboration and a shared vision. This Phase covers the development of the LOCA technologies on mobile application and platform to enable user interface and experience with electric three-wheeler system and service.

The Initiate Phase is to collaborate with strategic partners to develop the prototypes, as well as establish partnerships with local stakeholders towards initiating reliable sources for the electric three-wheeler system and service and co-creating benefits.

The Implement Phase marks the launch of the electric three-wheeler system and service. It includes collecting data on usage and impacts to refine the service and improve its effectiveness. Additionally, this Phase involves exploring options to scale the services with sustainable business models, ensuring continuity and long-term impact on urban mobility in Udon Thani City.

1.3. Operational environment and Market Readiness for deployment of e-three wheelers

The ETC has collaborated with the Federation of Thai Industries (FTI) in Udon Thani Province to enhance the urban mobility system through a phased approach: Inform, Inspire, Initiate, and Implement. This collaboration actively involves public and private sectors, as well as young entrepreneurs, to brainstorm and raise awareness about the electric three-wheeler system and its services.

One of the key challenges of the electric three-wheeler system and service is balancing and differentiating it from the traditional Skylab service. The project demonstrated value-added services to strengthen the public transportation system in Udon Thani City. Additionally, ETC and LOCA have partnered to extend and test the LOCA App and platform system, integrating mobile technology with local drivers. This collaborative effort aims to foster a deeper understanding and co-create opportunities for new services and market expansion.

The e3w service will operate on a fixed-route model, which is particularly beneficial for Udon Thani, a low-density city. During the pilot phase, there will be one fixed route with two vehicles operating at regular intervals. Scaling-up the operation is expected to have a significant impact, as more e3ws per route will increase frequency, addressing the gaps left by the current bus system. Multiple routes of this scale aim to achieve an efficient transportation system with lower operational costs.

To enhance the customer experience, the service will incorporate designated stops similar to bus stops. Each stop will be assigned a sign, QR code, and detailed service information. Passengers can scan the QR code to open a mobile web application that shows the real-time location of the vehicles on the route, allowing them to plan their journeys more efficiently.

Moreover, the initiative includes a pilot project where selected local drivers are equipped with electric three-wheelers and trained to use the LOCA App. This pilot aims to collect real-world data on vehicle performance, user satisfaction, and the overall feasibility of scaling up the service. Feedback from this pilot will inform the subsequent phases, ensuring that the final implementation is both practical and beneficial to the community.

By leveraging the expertise of ETC, FTI, and LOCA, this initiative not only aims to modernize urban mobility in Udon Thani but also serves as a model for other regions seeking sustainable transportation solutions. The collaboration shows the importance of innovation, community involvement, and the adoption of green technologies in shaping the future of urban transportation.

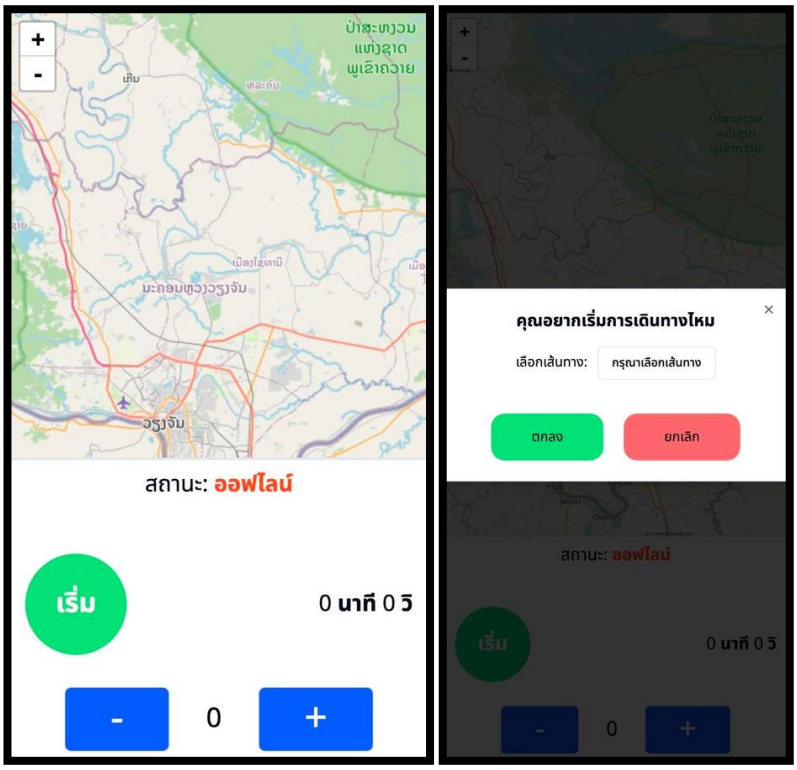

Figure 4 Driver Operation Screen Application on Device

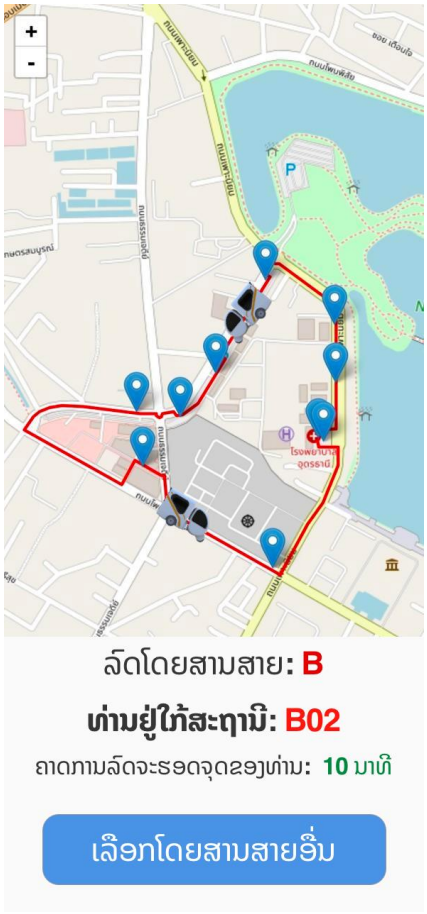

Figure 5 Passenger Mobile web, Application Screen after scan QR code

On 29 March 2024, the ETC and the Railway and Modern Transportation Research Group (RMT) introduced the electric three-wheeler at the NSTDA Annual Conference in order to enhance the capabilities of research and industrial collaboration.

Figure 6 Opening ceremony on the electric three-wheeler prototype development

Figure 7 President of NSTDA on the electric three-wheeler prototype

The ETC, FTI and LOCA plan to collaborate with strategic partners, local businesses, government agencies, and stakeholders to build partnerships and foster a sense of shared ownership of the electric three-wheeler project. The aim is to co-create mutual benefits, including its operating costs, increased accessibility, and positive environmental impacts. Furthermore, the ETC, FTI and LOCA have initiated pilot tests in collaboration with public agencies and private partners to collect real-time data. This data will provide accurate information for both drivers and users and help establish partnerships with suppliers and service providers. The goal is to ensure sustainable improvements to the electric three-wheeler services.

Figure 8 Battery and motor hub testing

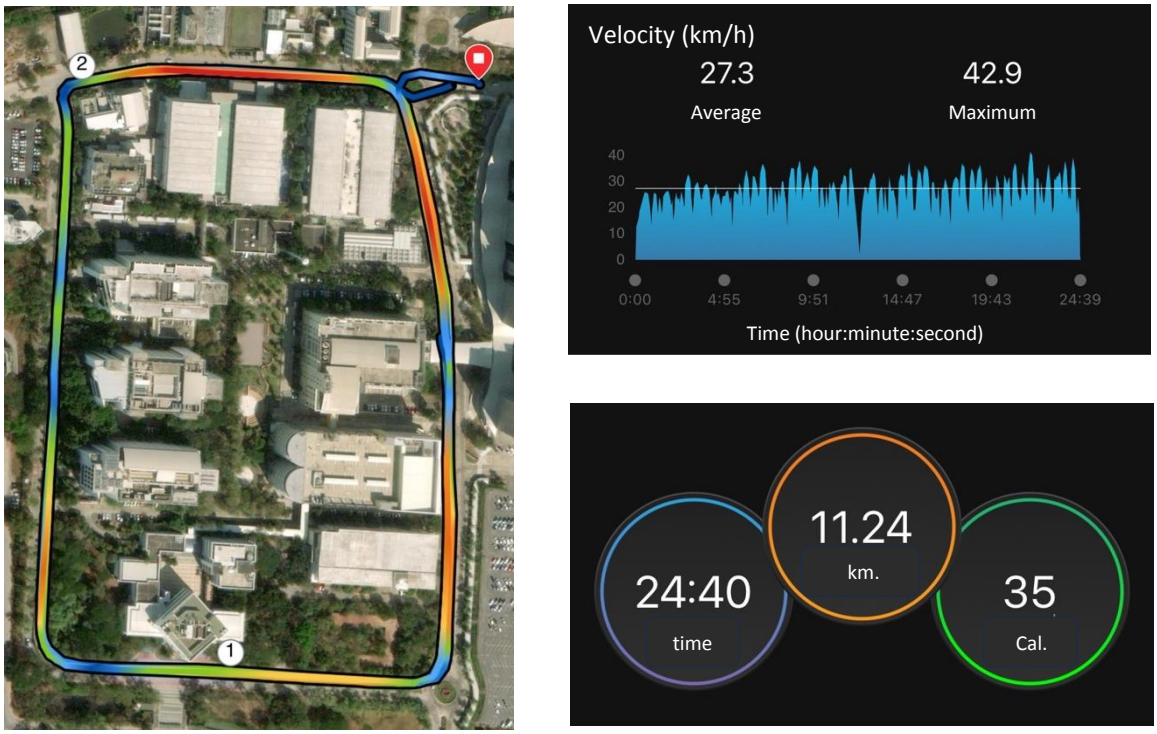

Figure 9 Operational test data collection at NSTDA

1.4. Financial and environmental impact of electric three wheelers

When comparing the gasoline-powered and electric three-wheeler, the economic and environmental advantages of the electric three-wheelers become evident.

Financial impact

The electric three-wheeler (E3W) is planned to operate on a fixed route, covering a distance of 5 kilometers per trip. Assuming an average of 20 trips per day, each carrying 5 passengers at a fare of $0.25 per passenger, both vehicle types generate a monthly revenue of $625. This fixed-route model ensures consistent and predictable operation, facilitating easier planning and management of both logistics and financial projections.

However, the operational costs differ significantly between the two types, as outlined below. The electric three-wheeler incurs much lower operational costs, bringing the total monthly expenses for the electric three-wheeler at only $113.04. This results in a substantially higher monthly profit of $511.96.

- Gasoline-Powered three-wheeler:
    - Fuel: $150
    - Fixed operational costs: $100
    - Maintenance labor: $50
    - *Total Monthly Expenses:* $300
    - *Monthly Profit:* $325 ($625 revenue minus $300 expenses)
- Electric three-wheeler:
    - Electricity: $43.04
    - Fixed operational costs: $40
    - Maintenance labor: $30
    - *Total Monthly Expenses*: $113.04
    - *Monthly Profit:* $511.96 ($625 revenue minus $113.04 expenses)

These figures illustrate that the electric three-wheeler demonstrates clear economic advantages, saving significantly on fuel and maintenance costs. The higher monthly profit of $511.96 compared to $325 for the gasoline-powered three-wheeler highlights its financial superiority.

Environmental impact

Beyond the financial benefits, the electric three-wheeler also offers considerable environmental advantages (Table 1). With CO2 emissions of just 12.8 g per passenger-kilometer compared to 23 g for the gasoline-powered counterpart, the electric three-wheeler contributes to a substantial reduction in greenhouse gas emissions. Based on

Thailand's grid factor [2] of 0.4 kg CO_2 per kWh, the electric three-wheeler can avoid 127.5 kg of CO_2 emissions over a one-month pilot.

This dual benefit of lower operational costs and reduced environmental impact makes the electric three-wheeler a compelling choice for sustainable urban transportation, providing a clear advantage for drivers who own and operate their vehicles.

Table 1 Operational data and comparison between gasoline Skylab and electric three-wheeler

#	Indicator	Dimension	Unit	Baseline ICV	EV vehicle
	Reference				
	Vehicle type				
	Vehicle model				
	Fuel			Gasoline/Diesel	Electricity
1	Type of vehicle			Skylab	E3W
2	number of seating capacity			6.0	6.0
3	Number of passengers per trip	Operational	no. / trips	5.0	5.0
4	Number of trips per day	Operational	No.	20.0	20.0
5	Distance traveled per trip	Operational	km	5.00	5.00
6	Vehicle operating time	Operational	minutes	600.0	600.0
7	Average Speed	Operational	km/h	40.0	40.0
8	Consumption / Battery level (vehicle)	Operational	kWh / %		
9	# incidents	Operational	#	0.0	0.0
10	Emissions per person travelled	Environmental	g CO2-eq / kg	23.0	12.8
11	Emissions per trip	Environmental	g CO2-eq / delivery	5750.0	3200.0
12	Energy consumption per km	Environmental	kWh / km		0.16
13	Energy consumption per trip	Environmental	kWh / trip		0.80
14	Monthly avoided emissions (CO2)	Environmental	kg. CO2 / month	0.00	127.5
15	Avoided emissions during the pilot (CO2)	Environmental	kg. CO2		127.5
16	Equivalence in trees	Environmental	# trees		
17	Purchase price per vehicle	Financial	$ USD	$ 3,000.00	$ 4,700.00
18	Expected useful life	Financial	years	$ 5.00	$ 5.00
19	Residual value	Financial	$ USD	$ 300.00	$ 940.00
20	Total operating costs	Financial	$ USD	$ 200.00	$ 73.04
21	Fixed operational costs	Financial	$ USD / month	$ 100.00	$ 40.00
22	Personnel costs	Financial	$ USD / month	$ -	$ -
23	Electricity/fuel cost	Financial	$ USD / month	$ 150.00	$ 43.04
24	Cost per delivery	Financial	$ USD / delivery	$ 2.50	$ 1.25

2. The Roadmap

2.1 Vision

The electric three-wheeler system and service has significant potential for scale-up and expansion within and beyond Udon Thani City. The Project can be replicated across the region as well as other cities facing similar challenges with inadequate public transport

services. The ETC, FTI and LOCA will focus on developing sustainable business models by co-creating with strategic partners in various potential markets. The project aims to build local partnerships and collaborations with government agencies, local business partners, and community organizations to ensure continuity and sustainability. The project involves exploring financial options and partnerships to strengthen the long-term impact of the electric three-wheeler system and service. To sustain operations in the long run, the project will cover the ongoing maintenance and operation costs, including charging stations and other necessary services. The focus is on providing sustainable, affordable, and environmental-friendly public transport options to cities across the region.

2.2 Objectives

The electric three-wheeler system and service aim to scaling operations sustainably, addressing both social and economic aspects. The project will provide ongoing support to ensure the efficient maintenance and operation of the electric three-wheeler system and service. To ensure smooth operation, the project has established clear agreements with partners regarding management and development.

2.3 Timeline

Phase	Demonstration	Scale-Up	Mainstream
Timeline	2023-2024	2024-2029	2030 onwards
Target/ Focus area	Successful pilots demonstrate feasibility in priority modes	Incentives and regulatory framework in place to stimulate demand	LEVs are the default choice due to better performance and lower costs
Finance responsible	Grants	Concessional loans	Commercial banks
Actions	Electric three-wheeler route service Mobile application platform and data analysis Capacity building with partners and stakeholders dialogue with public and private sector	Convert government fleet Public awareness campaigns Develop business models Develop technical standards	Strengthen battery recycling Local manufacturing Built up of renewable energy capacity Roll out of public charging

3. Implementation plan

3.1. Focus area 1: Urban Planning

The electric three-wheeler system and service will focus on community outreach, education, and stakeholder engagement to launch appropriate operation services. By

providing a reliable and accessible public transport option, the project aims to improve the quality of life for residents and support to reduce the environmental impact of transportation in Udon Thani City.

3.2. Focus Area 2: Regulatory measures

The project engages with government agencies, private organizations, and communities to build partnerships and secure collaboration aimed at co-creating shared ownership. The project is particularly involved in establishing the regulatory measures required to operate the system and service in Udon Thani City.

3.3. Focus Area 3: Economic and Financial measures

The electric three-wheeler system and service can lead to more localized and efficient public transport services, while also providing employment opportunities for local operators. The project can stimulate a positive impact on local economic growth with suppliers and service providers to facilitate a sustainable transition to electric public transport in Udon Thani City.

The deployment of 2,000 electric three-wheelers in the city would bring transformative changes. Each electric three-wheeler not only helps a driver save money but also contributes to a cleaner, greener environment. With every three-wheeler avoiding 127.5 kg of CO2 emissions each month, a fleet of 2,000 could prevent a staggering 255,000 kg of CO2 emissions monthly, equating to 3,060 metric tons annually. This would significantly improve our air quality and promote a healthier community.

Financially, the benefits for drivers are substantial. Each electric three-wheeler can save its owner about $187 per month in operating costs compared to a gasoline-powered three-wheeler. Over a year, this means savings of $2,244 per vehicle. Additionally, with a higher monthly profit of $511.96, a driver could earn approximately $6,144 annually from their electric three-wheeler.

Adopting a fleet of 2,000 electric three-wheelers would inject nearly $4.5 million into the pockets of local drivers every year while making a bold statement about the city's commitment to sustainability. This initiative not only supports individual livelihoods but also paves the way for a more sustainable urban transport system, positioning Udon Thani as a pioneer in green mobility.

3.4. Focus Area 4: Manufacturing & After-Service infrastructure

Ensuring the successful deployment and long-term sustainability of the electric three-wheeler (E3W) initiative is crucial. The manufacturing process is designed to produce high-quality, reliable electric three-wheelers that meet the demands of urban transportation.

By implementing cost-saving measures such as bulk procurement of materials and streamlined production techniques, manufacturing costs can be significantly reduced. This reduction will make E3Ws more affordable for drivers, encouraging widespread adoption. Given that each E3W saves about $187 per month in operating costs compared to gasoline-powered vehicles, these savings add up to $2,244 annually, enhancing the overall economic viability of the project.

Equally important is the development of a robust after-service infrastructure. As the project aims to scale up to 2,000 E3Ws, having a well-established network of service centers and charging stations is vital. This infrastructure will accommodate future growth. Ensuring that our chargers and service facilities are designed to handle the increasing volume of E3Ws will prevent bottlenecks and downtime, maintaining operational efficiency and driver satisfaction.

3.5. Focus area 5: Partnerships and public awareness

The project aims to raise awareness and build support among public agencies and private partners as well as local communities to secure collaborative engagements. The project involves outreach throughout public events to continuously inform the public about the benefits of the electric three-wheeler system and service.

4. Conclusion and next steps

With the roadmap for electrifying three-wheelers in Udon Thani established, the following steps are crucial for successful implementation and scaling across the city. This roadmap outlines a strategy to transition from traditional internal combustion engine three-wheelers to electric three-wheelers, addressing urban mobility challenges and promoting sustainability.

Implementing this roadmap requires continued stakeholder engagement. Maintaining collaboration with local government authorities, transport agencies, private sector entities, and community organizations will ensure alignment of interests and effective resource mobilization.

Securing funding is equally important. Obtaining financial resources from government subsidies where available, private investments, and international organizations will be essential for vehicle procurement, infrastructure development, and operational management.

Policy development plays a critical role in this transition. Formulating comprehensive policies and incentives will encourage adoption and make the transition financially viable

for operators and attractive to users. Infrastructure is another key aspect. Identifying strategic locations for charging stations and battery swapping facilities will ensure accessibility and convenience for riders and passengers alike.

Public awareness is crucial for success. Launching extensive campaigns will educate the population about the benefits of electric three-wheelers, including environmental advantages, cost savings, and improved urban mobility. To keep track of the initiative's success, progress monitoring is essential. Implementing a robust framework to track performance, collect data, and make adjustments based on feedback and observed outcomes will ensure continuous improvement.

Encouraging private sector participation is vital for scaling the project. Demonstrating the economic viability of electric three-wheelers will encourage partnerships and investment opportunities, accelerating adoption and scaling. Long-term sustainability must also be considered. Developing sustainable business models will ensure the financial and operational viability of the electric three-wheeler network. Exploring additional revenue opportunities and continuously improving service delivery based on user feedback will support this goal.

5. References

1) NSTDA Annual Conference 2024 https://www.nstda.or.th/home/news_post/sci-update-khamkoon-ev/
2) Thailand Carbon Dioxide Emission per Electricity Generation in 2023 https://www.ceicdata.com/en/thailand/carbon-dioxide-emissions-statistics/carbon-dioxide-emission-per-electricity-generation


solutions
plus