SOLUTIONSplus
Summer School

Module 5: Introduction to Electric Micromobility

November 16th, 2020

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Agenda

- Introduction
- Market Overview
- Technical Solutions

Introduction
Questions to be Answered within This Webinar

- **Which types of vehicles will this webinar focus on?**
- **What are relevant requirements from a user and technical perspective?**
- **What are general market characteristics and which requirements do they imply?**
- **Which requirements result from existing vehicles and mobility services?**

Classification of Focus Vehicle Types
Vehicle Categories According to UNECE Reg. No 168/2013

Relevant vehicle classes

Category	Pedelec	E-Scooter	L1e	L2e	L3e	L4e	L5e	L6e	L7e	M1 (Smart)
Category name	Pedal electric cycle	EKF (electric small vehicle)	Light two-wheel powered vehicle	Three-wheel moped	Two-wheel motorcycle	L3e + side-car	Powered tricycle	Light quadricycle	Heavy quadricycle	Motor vehicles
Length					Depending on sub-category up to 4,000 mm					2,500 mm
Width					Depending on sub-category up to 2,000 mm					1,510 mm
Height					Depending on sub-category up to 2,500 mm					1,520 mm
Number of wheels			2	3	2	2 + side car	3	4	4	4
Maximum design vehicle speed	≤ 25 km/h (with electric motor support)	≤ 20 km/h	L1e-A ≤ 25 km/h others ≤ 45 km/h	≤ 45 km/h	No speed limit	No speed limit	No speed limit	≤ 45 km/h	L7e-B1&L7e-C ≤ 90 km/h	135 km/h
Maximum continuous power	≤ 250 W	≤ 500 W or ≤ 1,400 W if balancing requires 60 %	L1e-A ≤ 1 kW others ≤ 4 kW	≤ 4 kW	No power limit	No power limit	No power limit	L6e-A ≤ 4 kW, L6e-B ≤ 6 kW	L7e-A, L7e-B2, L7e-C ≤ 15 kW	30 kW - 55 kW
Mass in running order			Tech. permis. mass decl. by manufacturer	≤ 270 kg	Technically permissible mass declared by the manufacturer		≤ 1,000 kg	≤ 425 kg	≤ 450 / 600 kg dep. on category	720 kg - 805 kg
Seats				≤ 2		≤ 4 motorcycle + side car (≤ 2)	≤ 5	≤ 2	≤ 4	2









Sources: Table: EU-LIVE „ FEASIBILITY STUDY ON A RADICALLY NEW L6E VEHICLE CONCEPT; Pictures: wikipedia.com

Introduction
Examples for typical Micro Mobiles on Asian and African Market

Source: enelx.com

Cargo tuk-tuks in India

Source: Khmer Times

Autoriksha Service in Cambodia

Source: Khmer Times

Motorcycle tuk-tuk in Cambodia

Source: Alibaba.com

Chinese autoriksha

Source: Indian Autosblog

Light motorcycle Bajaj BS6 CT100

Source: chetak.com

Electric scooter Chetak

Classification of Focus Vehicle Types
Example: Electric Vehicles in India

Vehicle Classes

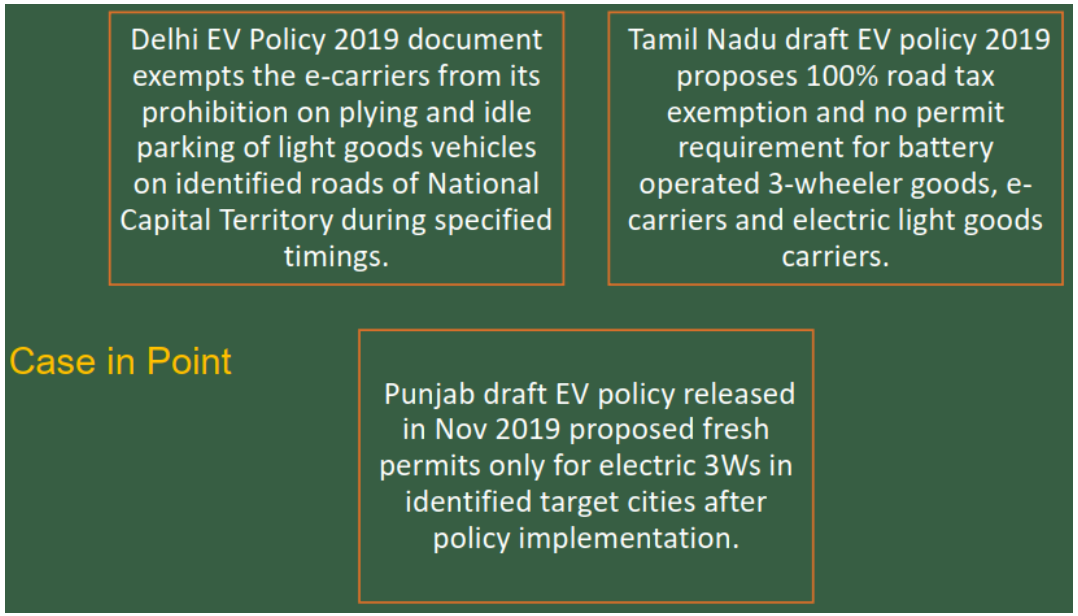
Category	L3	L5N
Category name	E-carts	three-wheeled motor vehicle
Area of application	India	India
Width		
Height		
Number of wheels		3
Maximum design vehicle speed	≤ 25 kph	> 25 kph
Maximum continuous power	≤ 2 kW	≤ 500 W or ≤ 1400 W if balancing requires 60 % thereof
Mass in running order	310 kg + driver	1500 kg incl. driver, excl. weight of batteries
Seats		

- Similar classification system as in Europe
- Vehicle classes derivated from classes of ICE-powered vehicles

Source: Evreporter.com

Incentives for electric vehicles in India

- Indian central governments FAME II policy scheme incentives purchase of electric vehicles with Li-Ion battery depending on vehicle characteristics, aiming to close the price gap to ICE-powered alternatives
- Further incentives provided by Indian state governments:

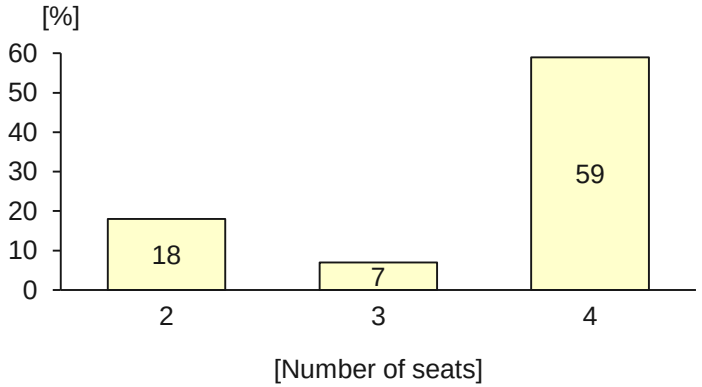


Source: Evreporter.com

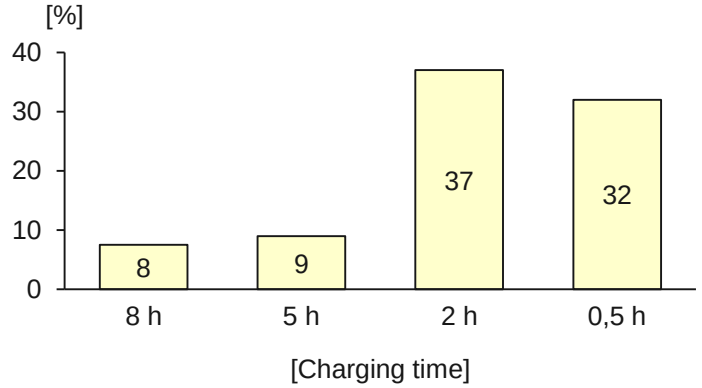
Introduction
User Requirements on Micro Mobiles

An online survey on user needs for the EU-funded epsilon project revealed the following (selected) results:

If you would buy an electric micro mobile, what would be your favourite number of seats?

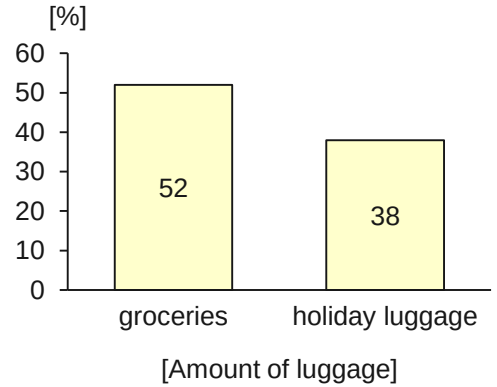


What would be an acceptable charging time for 150 km of range?

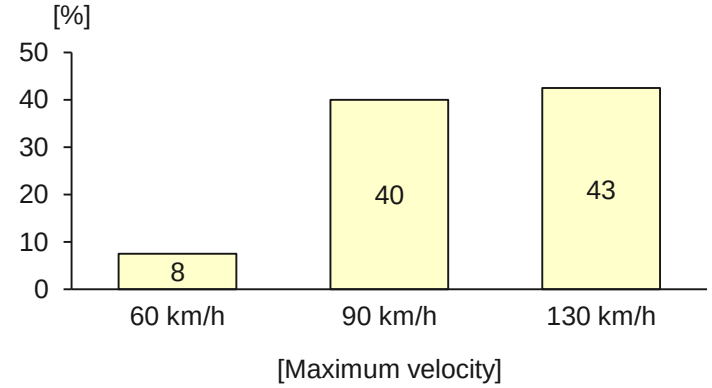


Source: epsilon-project.eu

Which amount of luggage must fit into the luggage compartment?



Which minimum v_{max} should be possible?



Sources: FREGONESE, R.: epsilon Deliverable D1.1 Summary report on scenario and market analysis epsilon project consortium, Turin/Italien, 2014

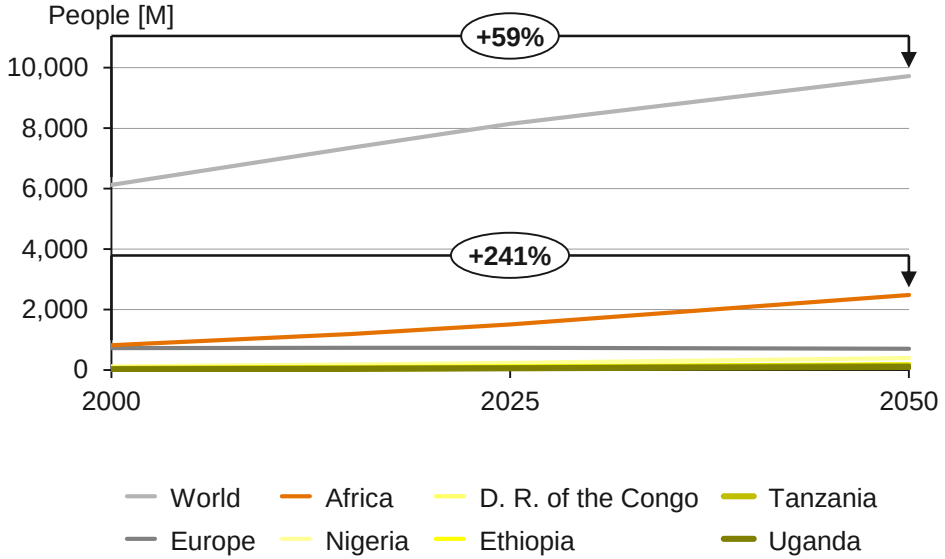
Agenda

- Introduction
- Market Overview
- Technical Solutions

Market Overview: Africa
Population

Population

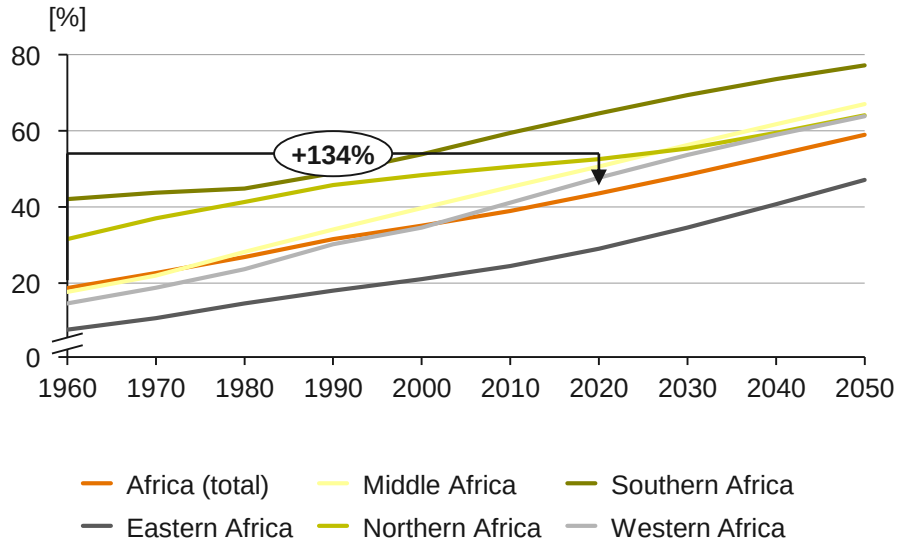
- Total population:



- Africa‘s population will grow four times faster than the World‘s population until 2050
- Five out of nine countries with highest absolute population growth are African

Urbanisation

- Level of urbanisation:



- Urbanisation increased over the last decades and is still growing, which implies smaller travel distances but higher traffic density
- Nearly 60 % of African population is expected to live in urban areas in 2050, nearly 80 % in Northern Africa

Sources: Bundeszentrale für politische Bildung / United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2015 & 2018 Revision, Online Edition; OECD;

Market Overview: Africa
Vehicle Market & Mobility Behaviour

Vehicle Market

- Small (but growing) domestic motor vehicle industry, nearly all vehicles are imported
  - Low rates of car ownership: 2-28 cars/1,000 people in major markets Ethiopia, Kenya and Nigeria (2015)
  - Passenger cars: often used vehicles (80-90 % of fleet) from USA, Europe and Japan, subject to high import duties
  - Approx. 1.55 M new vehicle sales (PC & CV) in Africa in 2015
- Transport is relatively expensive in Africa, car ownership is not affordable for wide parts of the population:

Average costs per commute

Source: Medium.com

- Alternative: Light two/three wheelers, mainly imported from Asia (China, Japan, India)
- CAGR of 12% is expected for African two-wheeler market until 2025
- For the uprising classes, two- or three wheelers are often the first owned motorised vehicle

Mobility Behaviour

- Mobility behaviour depends on income:
  - Still a high number of trips is made by walking
  - Motorcycle taxis and informal transportation services are very popular in cities, as officially provided public transport is inadequate
- For motorized transport, road transport is dominant (80 % of goods, 90 % of passengers)

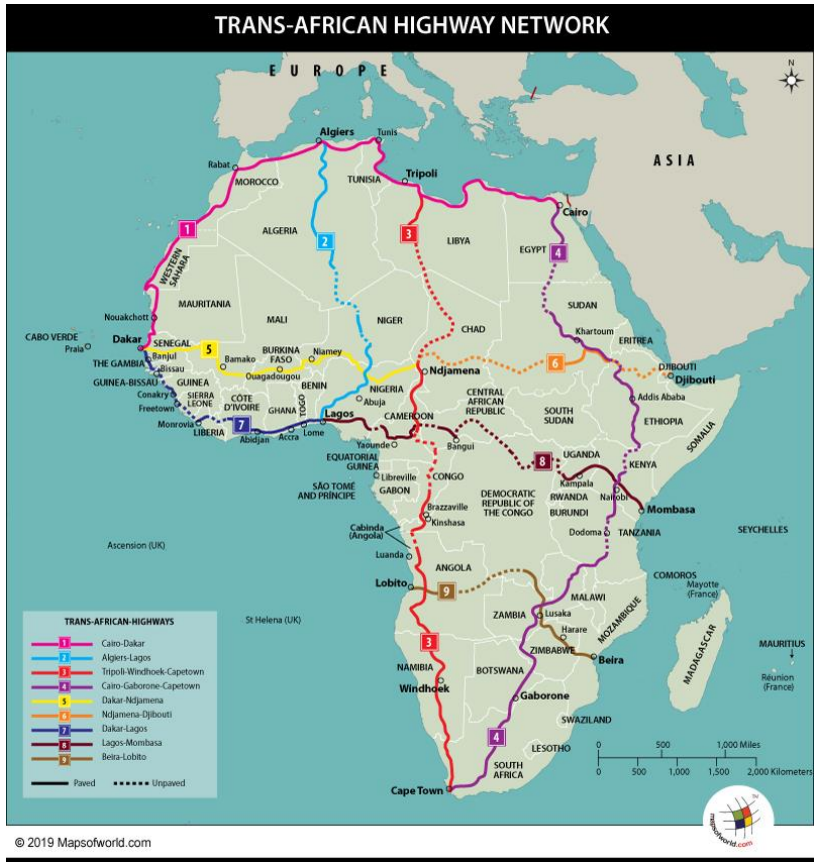
Source: Umaizi.com

- Due to growing smartphone adoption, innovative services are on the rise: already more than 50 e-ridesharing services in 21 African countries

Sources: Reportlinker.com; Medium.com; Deloitte

Market Overview: Africa
Infrastructure

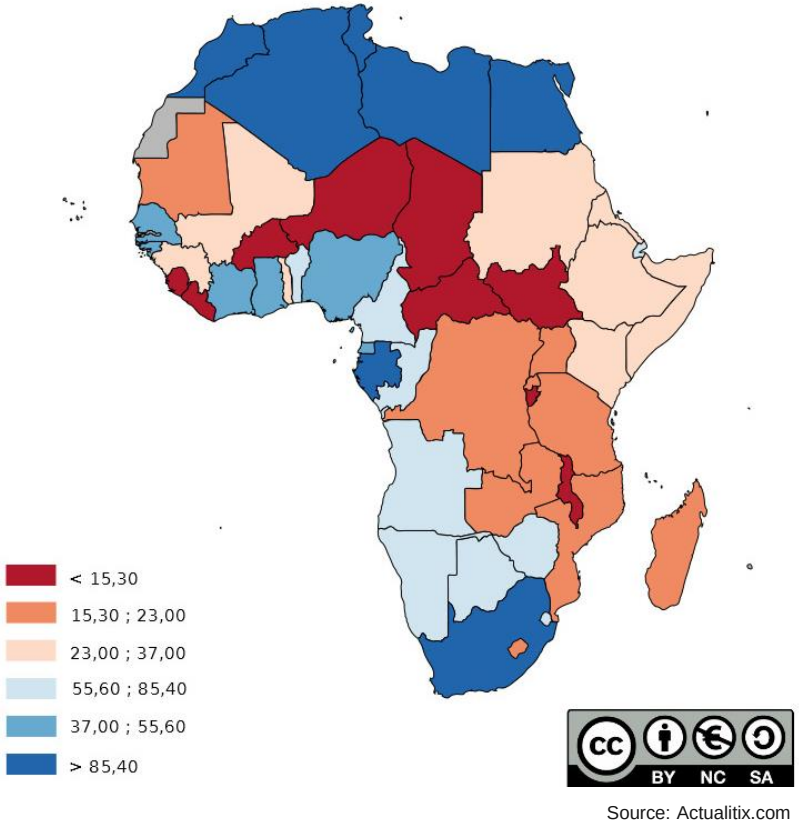
Road Traffic Infrastructure



Source: mapsofworld,com

- High share of unpaved road, especially in suburban and rural area

Access to Electricity (% of Population)

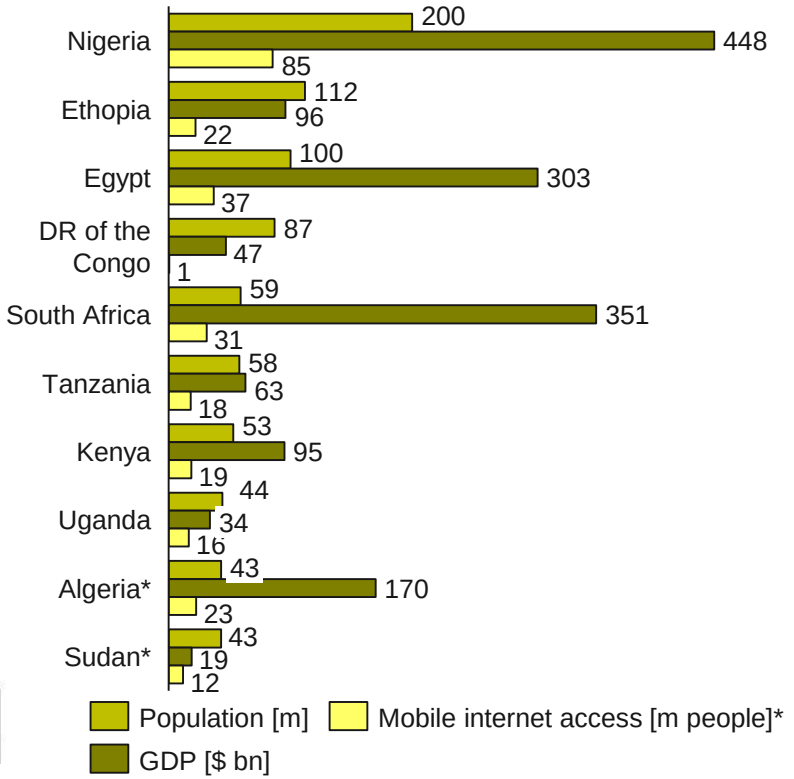


Source: Actualitix.com

- No comprehensive electricity supply in most African states

Mobile Internet Access

Top ten African states by population:



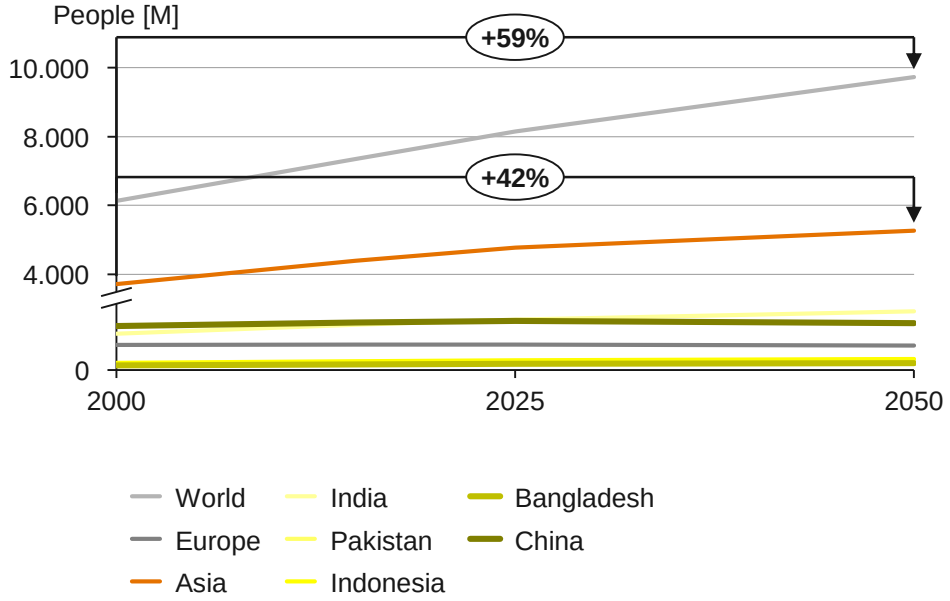
- Mobile internet access depends on GDP and reaches about 50 % in best case

*estimated values for Algeria and Sudan
Sources: Statista, Worldbank

Market Overview: Asia
Population

Population

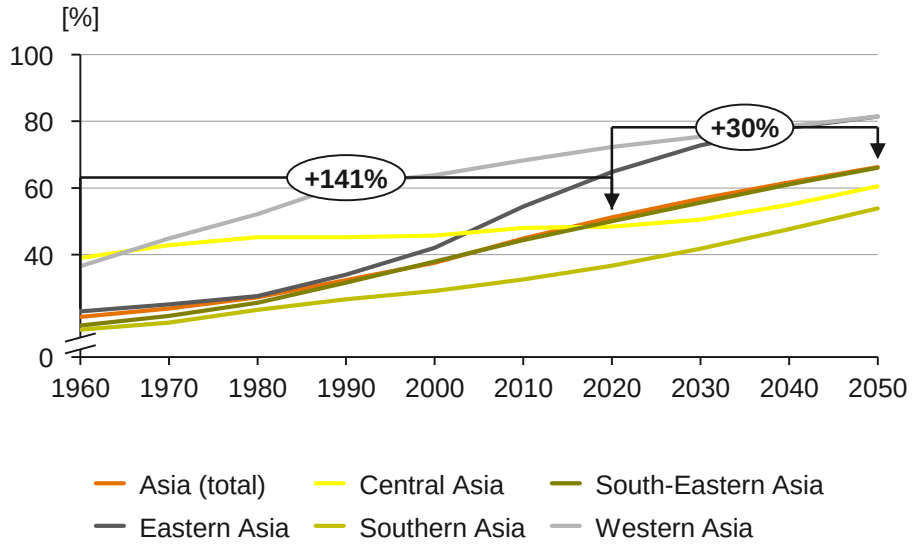
- Total population:



- Asia will stay the continent with the biggest population with nearly 5 B people in 2025
- The populations of countries as India, Pakistan, Bangladesh or Indonesia are expected to keep continuously growing until 2050

Urbanisation

- Level of urbanisation:



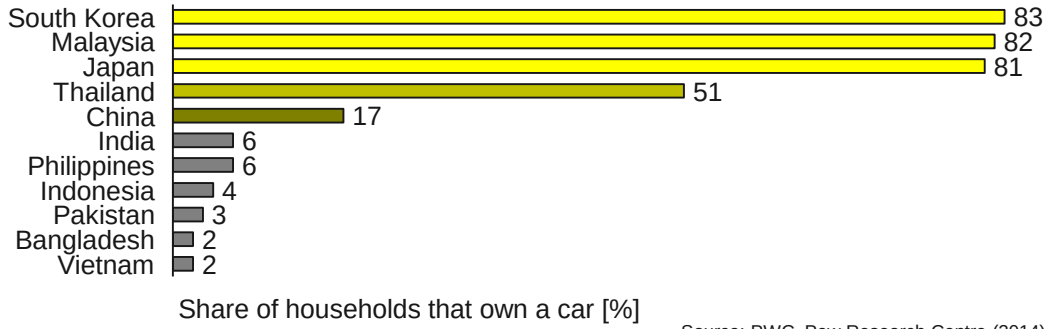
- Urbanisation increased over the last decades and is still growing, especially in South-Eastern Asia
- Nearly two thirds of Asian population is expected to live in urban areas in 2050, over 80 % in Eastern and Western Asia

Sources: Bundeszentrale für politische Bildung / United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2015 & 2018 Revision, Online Edition; OECD;

Market Overview: Asia
Vehicle Market & Mobility Behaviour

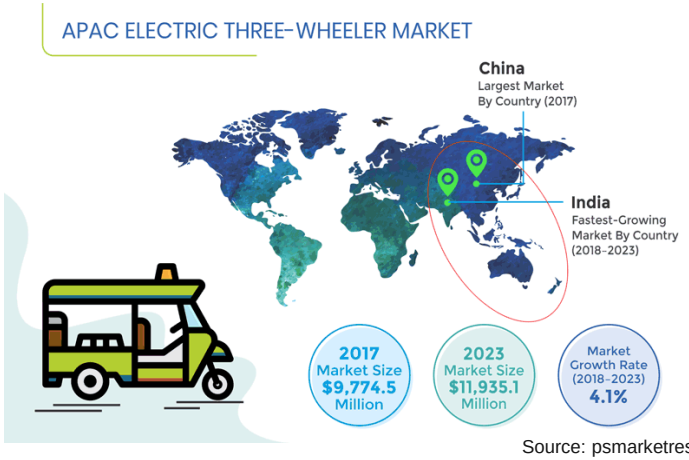
Vehicle Market

- Car ownership varies extremely between different countries:



Source: PWC, Pew Research Centre (2014)

- APAC market for electric three-wheelers is expected to grow up to $12 B by 2023:



Source: psmarketresearch.com (2018)

- Top 5 motorcycle markets by revenue are Asian, lead by India and China

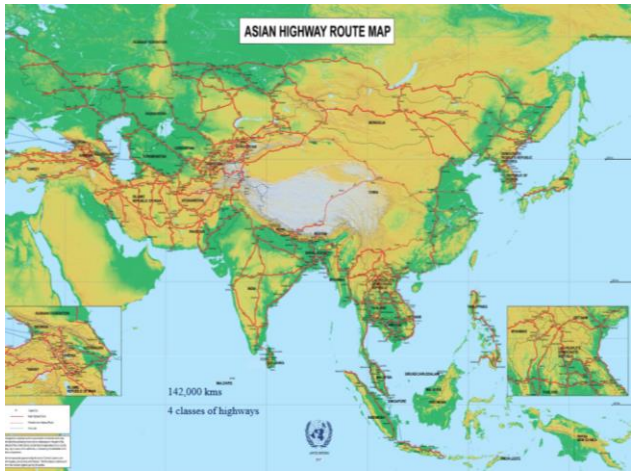
Mobility Behaviour

- Especially Southeast Asian megacities suffer from congestion
  - Daily congestion in Jakarta causes estimated costs of $6.5 B per year
  - Jakarta, Ho Chi Minh City and Hanoi opened or are building up rail transport services for commuters aiming to reduce road traffic
- Asia has a fast growing digital start up scene with players as GoJek (picture) or Grab offering alternatives to public mass transport and individual vehicle usage
- Their approach is different from companies in other parts of the world: instead of a transport-only app they are aiming to provide a “superapp” with a multi-service ecosystem

Sources: PWC, psmarketresearch.com. AsiaTechDaily, Delloite, Statista, Forbes, ADEK BERRY/AFP via Getty Images

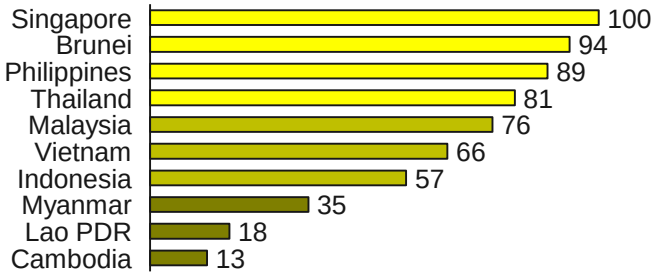
Market Overview: Asia
Infrastructure

Road Traffic Infrastructure



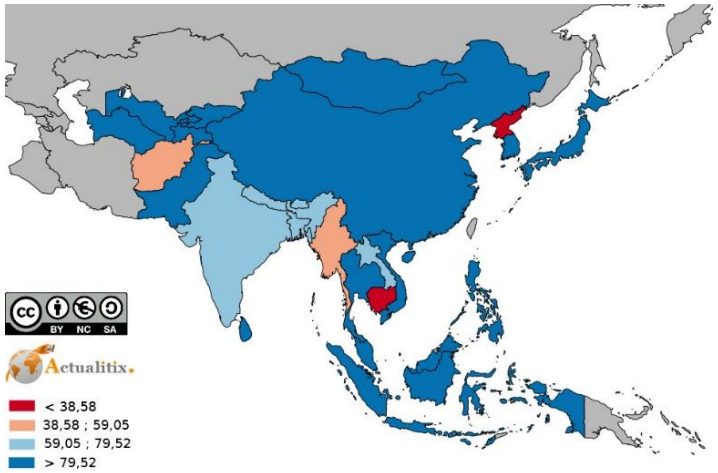
Source: United Nations ESCAP

- Paved Roads in South East Asia [%]:



- No comprehensive highway network
- Still wide areas with high shares of unpaved roads

Access to Electricity (% of Population)

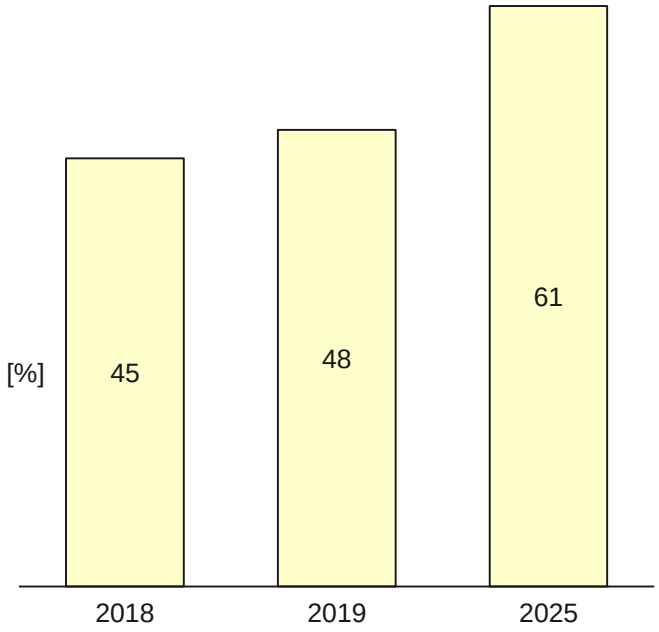


Source: Actualitix.com

- While China and Southeast Asia show good availability of electricity there are still states including India without comprehensive supply

Mobile Internet Access

- Percentage of population using mobile internet:



- More than one third of population is not expected to have mobile internet access in 2025

Sources: United Nations, ASEAN Statistical Yearbook 2016/2017

Market Overview Asia & Africa: Summary
Key Challenges and Main Requirements

Challenges:

Source: Luc Gnago/Reuters

Infrastructure: No comprehensive electricity supply and paved road network

Source: AFP

Low incomes, high mobility demand: In Lagos, commuters spend on average 40 percent of their income on transportation

Source: stock.adobe.com

Green house gases: Motorised transport is the fastest growing source of CO2 emissions in Africa

Source: Bay Ismoyo/AFP/Getty Images

Air and noise pollution: High emissions from ICE powered vehicles

Congestion: As a result of growing urbanisation, South Africans lose 90 hours/year sitting in traffic

Source: naijaloaded.com

Safety: 19 % of global traffic deaths occur in Africa; Motorcycle taxis banned from Lagos due to safety concerns

Requirements:

- **Compatibility with various charging and battery swap systems**
- **Robust chassis layout**
- **Affordable prices and low TCO**
- **Low maintenance requirements**
- **CO2 neutral production (components, vehicles, energy)**
- **Recycling strategy**
- **Competitive usability to enable shift to electric vehicles**
- **Suitability for shared mobility services**
- **Compact vehicle dimensions**
- **Safe body structure and reliable components**
- **Mandatory personal safety equipment**

Agenda

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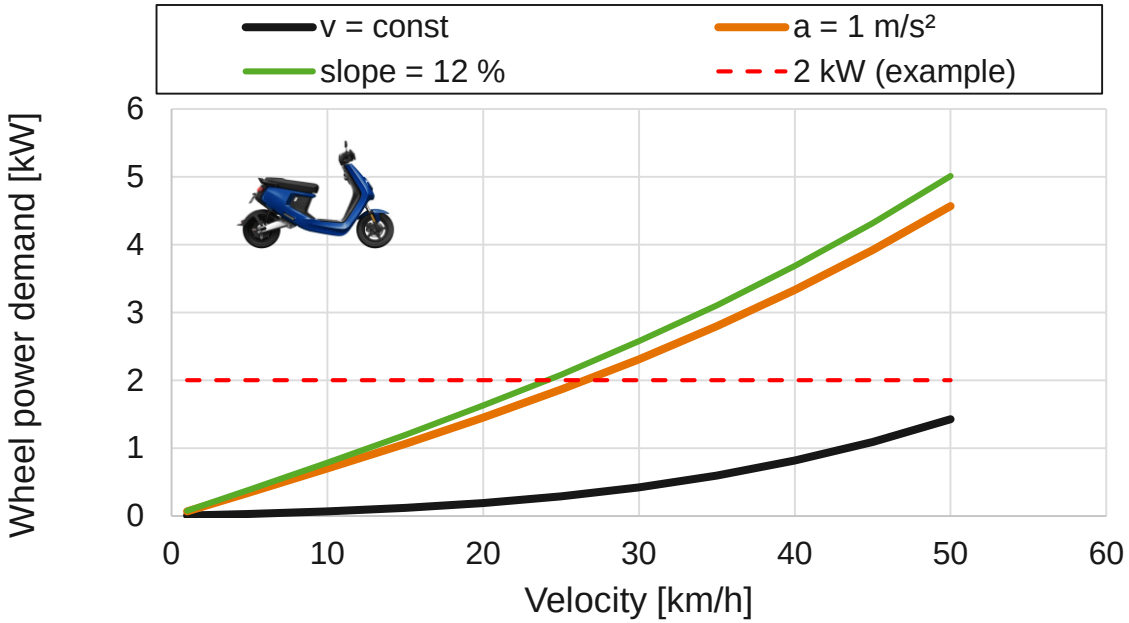
Technical Solutions
Power Demand of Micro Mobiles

Power Demands of Electric Two-Wheelers

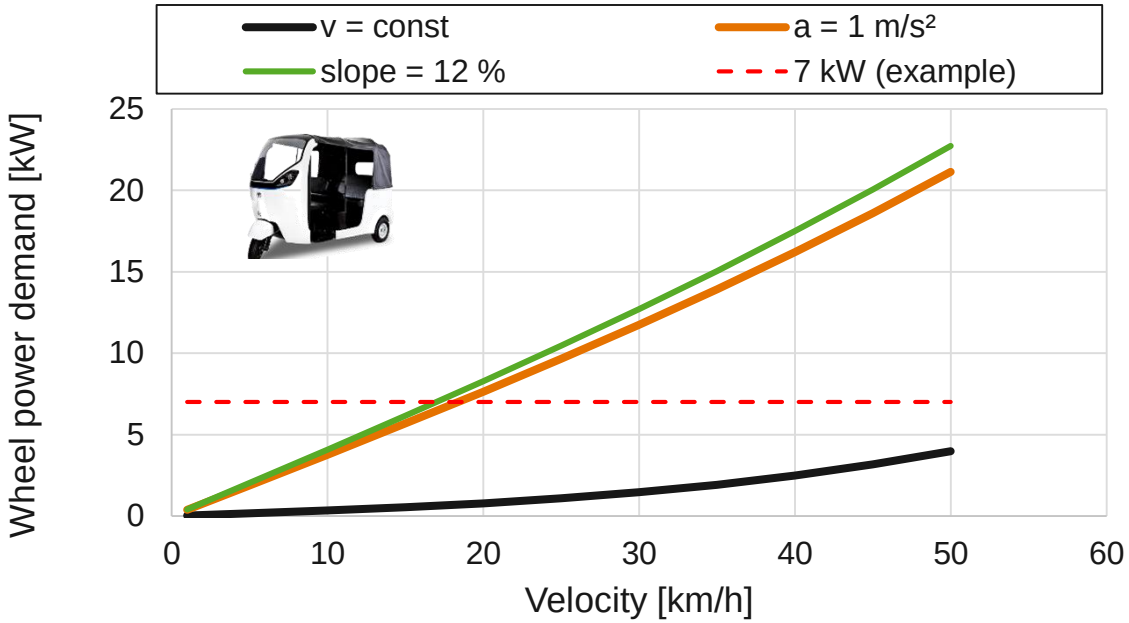
For an exemplary electric two-wheeler, the following power demands result:



- A constant speed of ~ 50 km/h requires around 1.5 kW power at the wheel
- Due to additional friction within the drivetrain, electric motor power for electric two-wheelers with v_{max} ~ 50 km/h is typically around 1-2 kW (depends on vehicle mass)

Power Demands of Electric Three-Wheelers

For an exemplary electric three-wheeler, the following power demands result:



- A constant speed of ~ 50 km/h requires around 5 kW power at the wheel
- Due to additional friction within the drivetrain, electric motor power for electric three-wheelers with v_{max} ~ 50 km/h is typically around 5-7 kW (depends on vehicle mass)

Technical Solutions
Benchmarking: Technical Vehicle Specifications

Three-wheeler market is lead by Indian and Chinese players for both electric and ICE powered vehicles.

	Electric powered					ICE powered	
	Niu NQi	**Terra Motors Y4A**	**SpeeGo CR**	**Omega Seiki Singha Max**	**GMW Taskman SmartAuto**	**Bajaj RE**	**Piaggio Ape Classic**
Production	China	India	India	India	India	India	Italy / India
Use Case	Passenger transport	Passenger transport	Cargo transport	Cargo transport	Cargo transport	Passenger transport	Cargo transport
Power	1.8 kW (2.4 max)	1 kW	1.62 kW	6 kW	4.5 kW	7.6 kW (ICE)	6.2 kW (ICE)
V_{max}	45 km/h	25 km/h	25 km/h	60 km/h	55 km/h	n.a.	45 km/h
Electric range	50-70 km	n.a.	90 km	100 km	110 km		
Charging time	7 h	8-12 h	8-10 h	3 h	3 h		
Battery type	Li-Ion, 29 Ah	n.a.	n.a.	Li-Ion, 10 khW	Li-Ion, 7 kWh	8 l fuel tank	10.5 l fuel tank
Seats / Load capacity	2	5 seats	1 seat + 310 kg load capacity	1 seat + 460 kg load capacity	1 seat + 500 kg load capacity	4 seats (load capacity 310 kg)	1 seat + 750 kg load capacity
							

Sources: EVreporter.com, bajajauto.com, piaggiocommercialvehicles.com, speegovehicles.com, terramotors.in, pcqs-china.com; Pictures: EVreporter.com, bajajauto.com, piaggiocommercialvehicles.com, speegovehicles.com, terramotors.in, pcqs-china.com, niu.com

Technical Solutions
Vehicle Innovations on Asian and African Market

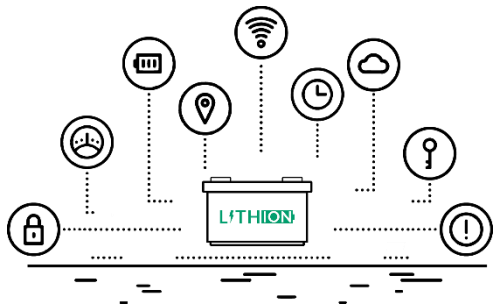
Battery-as-a-Service

- Example: MAXe (Nigeria)
- Development of an electric motorcycle with detachable battery and built up of battery swap stations

Source: max.ng

Source: max.ng

- Example: Lithion (India)
- India's largest Battery-as-a-service provider
- Provides batteries at its swapping stations for electric motorcycles and three-wheelers



Source: lithionpower.com

Maintenance-free Electric Scooter

- Example: Chetak electric scooter (India)
- Chetak promises maintenance-free and self optimising powertrain
- OEM provides guarantee on battery for up to 50,000 km
- Complete vehicle is IP67-rated (water resistant)
- Scooter comes with reverse gear

Source: chetak.com

Connected Electric Motorcycle

- Example: Ather 450 (India)
- Scooter comes with 7" touchscreen dashboard and Android OS
- Connected via mobile smartphone app
- OTA software updates

Source: bikewale.com

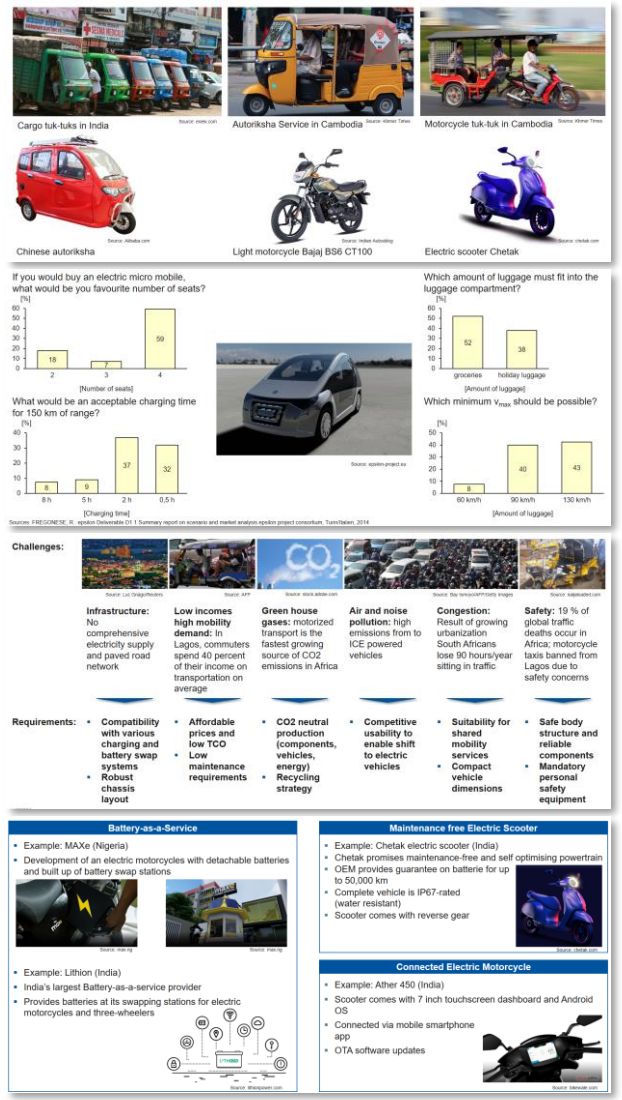
Summary
Questions to be Answered within This Webinar

- **Which types of vehicles will this webinar focus on?**
  - Focus lays on electric powered light two- and three-wheelers as motorcycles and autorikshas

- **What are relevant requirements from a user and technical perspective?**
  - Transport of up to four people with small luggage
  - Daily charging time should be below two hours
  - v_{max} should be sufficient for interurban usage (up to 60 km/h)

- **What are general market characteristics and which requirements do they imply?**
  - Safe, durable and affordable construction with low CO_2 footprint
  - Compatibility with local charging infrastructure
  - Suitability for commercial shared mobility usage

- **Which requirements result from existing vehicles and mobility services?**
  - Required power and max. speed depends on area of application (urban vs. interurban)
  - Electric mobility and digitization offer new possibilities for innovative business models



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