issued without formal editing

ENGLISH ONLY

UNITED NATIONS
CENTRE FOR REGIONAL DEVELOPMENT

In collaboration with

Ministry of Environment and Renewable Energy (MERE), Government of Sri Lanka
Ministry of Transport (MOT), Government of Sri Lanka
Ministry of the Environment, Government of Japan, and
Clean Air Asia (CAA)

EIGHTH REGIONAL ENVIRONMENTALLY SUSTAINABLE TRANSPORT (EST) FORUM IN ASIA,
19-21 NOVEMBER, 2014, COLOMBO, SRI LANKA

e-Mobility as the Next Generation Solutions for Clean Air and Sustainable Transport in Asia

(Background Paper for Plenary Session 2 of the Programme)

Final Draft, 23 December 2014
incorporate with input from the Eighth Regional EST Forum in Asia

----

This background paper has been prepared by Mr. Frank Wolter, for the Eighth Regional EST Forum in Asia. The views expressed herein are those of the author only and do not necessarily reflect the views of the United Nations.

8th Intergovernmental Regional Environmentally Sustainable Tranport Forum in Asia
19 to 21 November 2014
Bandaranaike Memorial International Conference Hall | Colombo, Sri Lanka

Background Information and Discussion Paper

Next Generation Solutions for Clean Air and Sustainable Transport in Asia: Electric Mobility

Final Draft

Author: Dr. Frank Wolter, InnoZ, Berlin, Germany

Prepared for
United Nations Centre for Regional Development (UNCRD)
Nagoya, Japan

Abstract

Electric mobility enjoys growing public interest. There are widespread expectations that electric mobility technologies can offer new options for addressing some of the growing transport challenges, especially in Asia and its rapidly growing cities. In fact, some Asian cities are already quite advanced in terms of facilitating pilot projects, and may well establish themselves as world leaders in this new field. However, experiences, models, policies and lessons learned are not easily transferable from one city to another. Asian developing countries and their metropolitan cities will each need to assess and explore for themselves in which application electric mobility may be commercially viable, economically beneficial and environmentally sustainable.

This paper provides an introductory overview and selected background information to explore under which preconditions a scaling up of electric mobility can help to address the growing urban transport challenges faced by Asian cities. Options for public and private investments in electric mobility are discussed, taking into account national policy environments and various consumer expectations. The paper also presents a brief analysis of national policies and measures aimed to promote electric mobility, and it concludes with ten general recommendations for consideration by policy makers.

Acknowledgements

The author acknowledges with thanks the support and guidance provided by UNCRD for the preparation of this paper. The author also acknowledges with thanks the technical contributions of Christian Scherf, InnoZ, and Ralph Wahnschafft, Independent Senior Advisor on Sustainable Development Policies, Berlin. Fu Jia assisted in the collection and review of information materials from China.

Version 031 (23 Dec 2014)

E-mobility – Various urban transport applications

ADB Project – electric tricycle taxi
in Manila, the Phillipines

DHL GoGreen Ford Delivery Van
New York, USA

BYD E-6 Electric Taxi, Shenzhen
People's Republic of China

Electric bicycle
(for food delivery) in

Small E-Bus, Rome, Italy
People's Republic of China

Postal Delivery Vehicle
Electric bicycles and scooters
for sale in People's Republic of China

Mini / BMW (electric drive)

Table of Contents

1 (Un)sustainable Transport: Addressing one of Asia's greatest post-2015 sustainability challenges and the potential role of electric mobility

1.1 Trends, issues and challenges in urban transport in Asia

(a) Rapid urbanization and growing demand for transport

The world population continues to grow, and the global urbanization trend is widely projected to continue for the foreseeable future. In 2011, world population reached 7 billion, with an estimated 4.25 billion living in Asia. The two most populated countries are the People's Republic of China (1.35 billion) and India (1.26 billion), but other Asian countries also have a large population, including Indonesia (241 million), Pakistan (180 million), Bangladesh (153 million), and Japan (128 million)[1]. Forecasts predict that 60 per cent of the world's population will live in cities by 2030, and that number may further increase to 67 per cent by 2050.

Urbanization leads to rapid growth in urban demand for transport for both, passengers and goods. Most cities rely on external supply of goods and services. City dwellers also need and want to be increasingly mobile. Urban growth is often associated with a growing spatial segregation of urban functions such as residential, industrial, commercial, and recreation and education zones, causing ever growing needs for transport of people and goods between them. Urban sprawl is also prevalent in Asia. Today, some 64 per cent of all travel and transport occurs within and between cities and urban areas, and this amount is widely expected to grow and even triple by 2050. The distance that needs to be traveled can be overcome by various means of transport, including walking, biking, or public transport, but individual private use of motor vehicles is the increasingly preferred mode of transport for all who can afford.

Since 2010, the total number of registered cars worldwide exceeds 1 billion. According to the World Automobile Association OICA, some 60 million additional vehicles are expected to be added each year. The OECD International Transport Forum expects the global number of cars worldwide to reach 2.5 billion by 2015. Historically, North America and Europe have the highest density of cars per 1000 inhabitants [USA 786 cars/1,000 inhabitants in 2011; Germany 588 cars/1,000 inhabitants in 2011]. Car ownership in Asian developing countries is much lower [People's Republic of China 69 cars/1,000 inhabitants, and Pakistan 20 cars/1,000 inhabitants][2], but is growing at a very rapid rate. In Beijing in the year of 2010 (before the car restriction policy), about 1,900 cars were registered on average every day[3]. New car registrations are also very high in many other cities. The density of automobiles to people will more than triple in India, more than quadruple in Indonesia, and is expected to grow tenfold in China, and the associated challenges will grow accordingly.

---

1 Source: United Nations Department of Economic and Social Affairs, Statistics Division (2012): Population and Vital Statistics Report, Statistical Papers Series A Vol. LXVI.

2 Source: http://data.worldbank.org/indicator/IS.VEH.NVEH.P3 (last accessed 9 October 2014).

3 Source: http://europe.chinadaily.com.cn/china/2010-12/31/content_11782500.htm (last accessed 9 October 2014).

(b) Limited transport infrastructure and growing land use for transport

Most Asian cities implement ambitious plans and programmes for urban road and other transport infrastructure expansion but can nevertheless hardly cope with the rapid growth in transport demand. Slow traffic flows; congestion and traffic jams are posing great problems, in particular for commuters. Urban traffic congestion also means productivity lost, extra motor fuels burnt and wasted, and additional air pollution. Most Asian cities, including Bangkok, Bangalore, Bejing, Ho Chi Minh City, Jakarta, Manila, and other cities, suffer from serious problems of traffic congestion. Some estimates suggest that Asia's developing economies experience economic losses equivalent of 2 or 3 per cent of their gross domestic product due to congestion.

Furthermore, high transport demand leads to heavy use of existing transport infrastructures and accelerated depreciation if necessary repairs and maintenance are not carried out on schedule. Expansion of urban transport infrastructure also requires additional urban space, which may then no longer be available for other uses. The rapid growth in private motor vehicle use also requires additional spaces for parking. Expanded transport infrastructure in suburban areas can have negative impacts on the local quality of life in residential areas, affect biological habitat and biodiversity, and can have impacts on local surface or ground water reservoirs and their management. Due to lack of space, some roads and other transport infrastructure have been built in areas that are prone to flooding.

Expansion of transport infrastructure is often also associated with other conflicts and competition between different modes of transport and their users. In addition to additional road space, pedestrian sidewalks, bikeways, taxi stands and bus lanes are also needed. It has been observed that in many cities motor vehicles users and their demands in terms of additional road space and parking space are given relatively greater attention (and resources) than the needs of other users. However, investments in fly-overs, under-passes, additional lanes and entirely new roads have not always been able to alleviate the traffic congestion problems, more especially if cities have fallen behind in upgrading and expanding their urban public transport infrastructure and services.

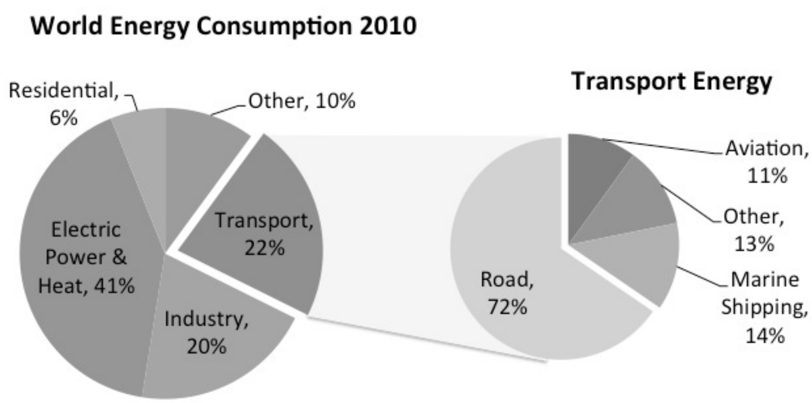
(c) High energy use and growing CO_2 emission from transport

The transport sector relies almost exclusively on petroleum for its energy needs. Motorized transport is responsible for about one quarter of global primary energy consumption, with private motor vehicle use accounting for a large part of it. Most motor vehicles operate on an internal combustion engine running on fossil fuels (mostly gasoline or diesel) and many developing countries do not produce their own oil or hydrocarbon products. Many less and least developed countries depend entirely on imported fuels for their transport sectors.

High and inefficient use of motor fuels is also causing environmental concerns. Whereas emissions of CO_2 of other economic sectors have tended to stagnate, or have even been falling, emissions of the transport sector have continued to increase unabated. Transport accounts for some 20 per cent of global CO_2 emissions, and road transport accounts for some 75 per cent of transport CO_2 emissions. At the global level, road transport accounts for some 43 per cent of global oil consumption.

Many trend analysts suggest that in a "business as usual scenario" world energy consumption and CO_2 emissions may increase by up to 50 per cent by 2030. Most of the additional energy use and emissions will come from transportation and from the projected growth of global motor vehicle fleets.

Figure 1: Anthropogenic CO_2 emissions (by economic sector)



Source: International Energy Agency (2012).

(d) Increased urban air pollution from transportation

In many cities of developing countries, and in particular in Asian cities, high levels of particulates, NOx and other air pollutants from motor vehicles can cause serious health risks for city dwellers. Government agencies monitoring air quality in Chinese cities frequently report very high level of particulates, also recommending residents to remain indoors. At times, maximum levels of particulates - as recommended by the World Health Organization (WHO) - have been exceeded by 20 to 30 times.[4] According to WHO estimates[5] some 3.7 million people died in 2012 as a result of air pollution, suffering from stroke, heart attack, chronic bronchitis, lung cancer and other illnesses. Eighty-eight per cent of these deaths occurred in low and middle income developing countries, mostly in East and Southeast Asia.[6]

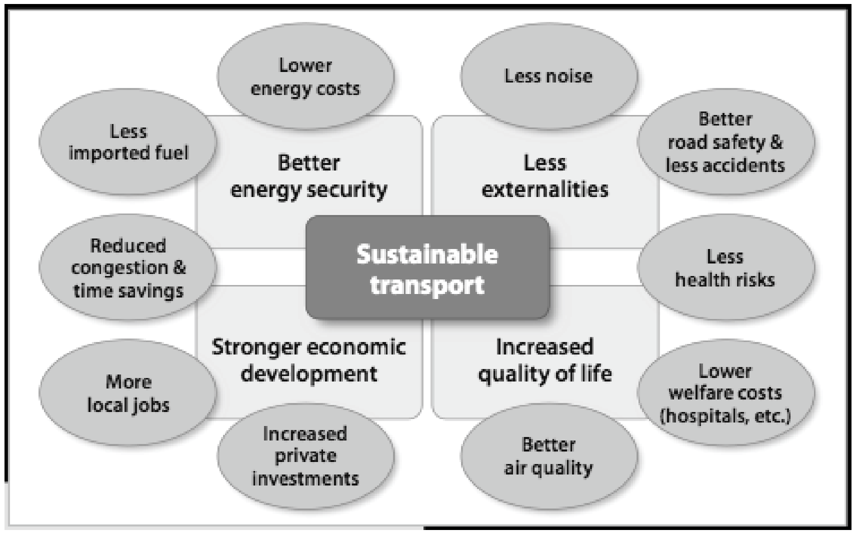
1.2 Managing the urban transport challenges in Asia

Addressing the urban development and the urban transport challenges is increasing urgent, in particular in Asia's large cities. It is evident that the underlying issues and the resulting problems are technically and politically complex and financially costly, and that there is therefore no single measure that can resolve the "congestion nightmare" in urban transport. Evidently a package of

4 The WHO suggested maximum is 25 microgram per cubic meter of air.
5 See: http://www.who.int/entity/mediacentre/factsheets/fs313/en/index.html (last accessed 7 October 2014).
6 Source: http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/ (last accessed 7 October 2014).

coordinated investments and public transport policy measures will be needed. Any combination of appropriate measures can only be determined at the national and the relevant municipal local level.

Figure 2: Multi-criteria qualitative definition of Sustainable Transport



Source: Susanne Böhler-Baedeker, Hanna Hüging: Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities, Module 5h: Urban Transport and Energy Efficiency, p.19

Over the past two decades, most Asian developing countries and their cities have experienced and have benefitted from comparatively rapid economic growth. There has been significant technological progress and most Asian countries and their economies have successfully established themselves in the increasingly competitive world market. The main challenge is to find local solutions that enable higher levels of mobility and economic prosperity, without the undesirable resource depletion and negative environmental impacts. Figure 2 describes multiple dimensions of efforts needed to make urban transport more sustainable.

Urban density, available infrastructure and the sustainability of urban transport vary greatly between Asian cities. Hong Kong Special Administrative Region of China and Singapore have implemented local transport projects and solutions that can provide international benchmarks and best practice examples for other countries. In other cities, such as Hanoi, Ho Chi Minh City or Ulaan Baatar, much still needs to be done to prevent congestion in local transport to get worse.

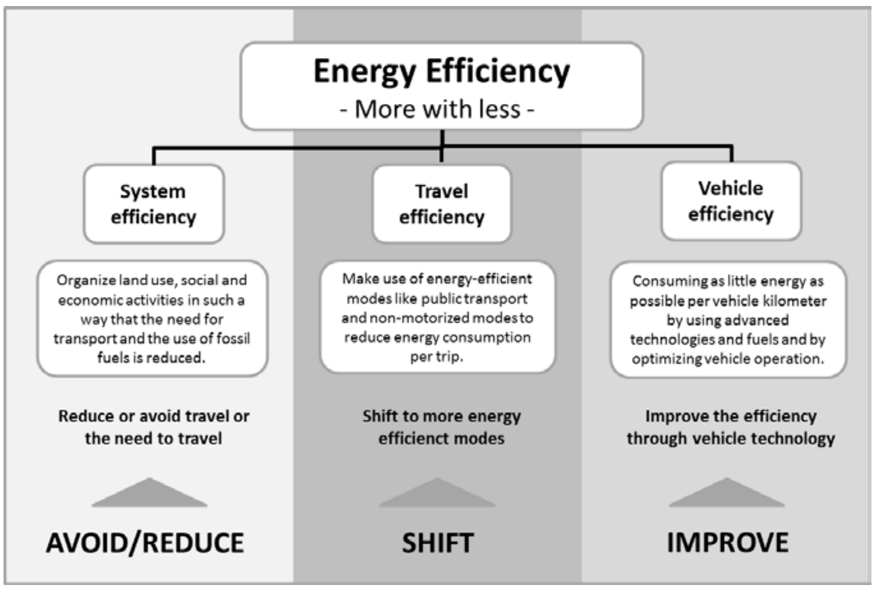
During recent years the Asian Development Bank (ADB) has announced plans to review its lending strategy and its transport project portfolio with a view to ensure all aspects of sustainable development are duly taken into account. The historic banking approach of financing mostly road infrastructure is more and more being replaced by investment projects in public transport which aim to increase access to better (public) transport also for low income social groups in an affordable and environmentally benign manner.[7]

[7] See: http://www.adb.org/sectors/transport/key-priorities (last accessed 21 October 2014).

(a) The "Avoid–Shift–Improve" approach to enhance sustainability in urban transport

The "Avoid-Shift-Improve" paradigm describes a simplified and widely accepted approach to cost-effective management of energy efficient policies. It should continue to guide urban planners and transport policy makers also in future.

Figure 3: The "Avoid-shift-improve" paradigm for cost-effective management of transport policies



Source: Susanne Böhler-Baedeker, Hanna Hüging: Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities, Module 5h: Urban Transport and Energy Efficiency, p.8.

Reducing transport demand begins with spatial planning that anticipates and seeks to minimize future mobility and transport needs by integrating the various urban functions of living, working, studying, shopping, recreation and culture, in "(sub)urban centers of short distances" which are well interconnected by public transport.

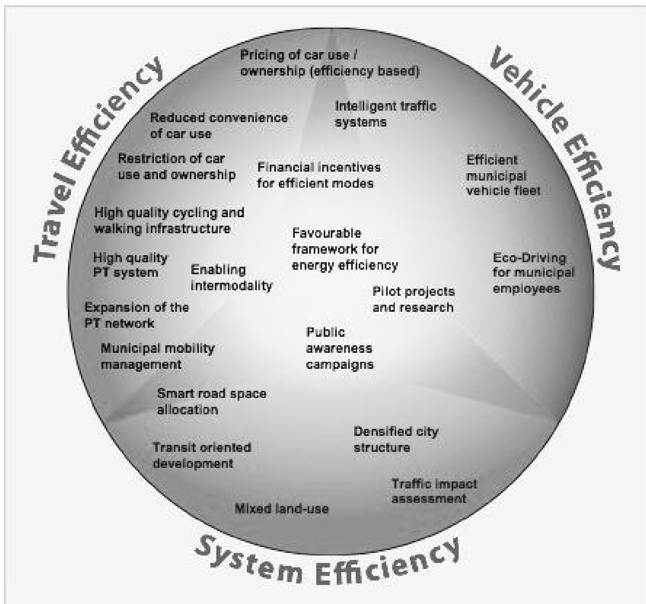
It is increasingly recognized that cities need to meet the needs or all social, population and age groups, which may require and rely on different forms of transport. In addition to roads, optimal local transport infrastructure systems need to provide for rapid, affordable and high-quality public transport, as well as separate pedestrian walkways and bicycle lanes. Car- and bike-sharing systems and their parking and service stations as well as taxi stands also need to be well integrated, so that the need to use private individual motorized transport is reduced, and transport demand can easily be shifted from private cars to more energy-efficient modes of public transport.

However, promotion of modal shifts requires longer-term vision and transport planning, including good interconnections between the various urban transport modes, as well as corresponding infrastructure investments, regulatory measures, incentives and consumer information.

Even with all of the fore mentioned measures taken, there remains a considerable demand for individual motorized mobility in the form of travel by automobile. However, in this field, too, various options are available to make individual motorized travel safer, more convenient, more energy efficient and more environmentally benign through the introduction of new technologies, including electric mobility.

Figure 4 shows that a considerable variety of policy options and other regulatory measure are available for cities and local authorities which seek to improve energy use and operational efficiency in the transport sector.

Figure 4: Energy-and transport efficiency navigator for cities and local authorities



Source: Susanne Böhler-Baedeker, Hanna Hüging: Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities, Module 5h: Urban Transport and Energy Efficiency, p. 23.

Motor vehicle manufacturers are constantly improving the safety, comfort and efficiency of vehicles. In many countries there are often still various options for further improving the environmental performance of combustion engines, e.g. by improved catalytic converters, direct fuel injection, optimizing of transmission, or engine downsizing. At the same time, there are also technical limits to fuel efficiency improvements, and other alternatives, such as electric propulsion may be considered. In comparison with internal combustion engines, electric propulsion is highly energy efficient as the convention of energy to heat is not necessary. Energy conversion efficiency of conventional gasoline engines can be estimated at approx. 37 per cent, and at approx. 43 per cent for diesel engines. By comparison, electric propulsion can reach up to 90 per cent efficiency. Thus, electric mobility can make its own contribution to improving sustainability of urban transport, if seen within the wider framework of "avoid-shift-improve" approaches.

(b) Electric mobility: Options and possible contributions to addressing the transport challenges in Asia

Electric mobility refers to various types of vehicles propelled by different types of electric drives as explained here below.

Combustion engines and electric motors are different concepts of vehicle propulsion that can be combined in one and the same car, which is then referred to as a Hybrid Electric Vehicle (HEV). HEVs are characterized by significantly lower fuel consumption and lower emissions per kilometer travelled. There are various technical variants among HEVs. "Micro-hybrid vehicles" have an engine start-stop-function, which shuts off the combustion engine whenever it may not be needed, but keeps all other vehicle aggregates running, and re-starts the engine, when it is again needed. "Mild hybrid vehicles" also have torque support for faster acceleration and a recovery of brake energy (e.g. Toyota Prius). "Full hybrid vehicles" have a more powerful electric motor and battery, and can also cover shorter or longer distances in electric mode. Hybrid vehicles can save up to 25 per cent of fuel, when compared with conventional gasoline cars.

Some HEVs are engineered to rely mostly on their electric drive and the battery, but still have a combustion engine for occasional long-distance driving (e.g. BMW i3 plus, GM Volt/Opel Ampera). This report reflects only on HEVs which can be recharged externally, and which can cover shorter or longer distances by electricity. Such vehicles are known as Plug-in-Hybrid vehicles (PHEVs).

Battery electric vehicles (BEVs) are only equipped with an electric motor and a rechargeable battery. Various BEVs are commercially available, including vehicles for indoor use (e.g. e-fork lifts, e-transporters). Various international car manufacturers offer pure BEV versions of their passenger cars, buses or delivery vans. BEVs also include electric bicycles (also known as "Pedelecs"), electric scooters, e-rickshaw and other e-vehicles for passenger or goods transport.

The report only discusses PHEV and BEV electric mobility options. Another variant are so-called Fuel Cell Electric Vehicles (FCEV) which are also equipped with an electric motor powered by an on-board fuel cell and a battery. This technology has been demonstrated, but it has as yet to be successfully commercialized. It is, therefore, excluded from the discussion in this paper.

1.3 Emerging markets for electric mobility in Asia: Trends and development perspectives

Electric mobility is still a start-up infant industry but it is widely expected to gradually gain greater market share in the future.[8] The United States, Japan, the People's Republic of China and France are the countries with the relatively highest numbers of recorded EV sales and registrations. Some 40,000 PHEVs and some 15,000 BEVs were sold and registered in the United States in 2012. In

---

8 See: http://www.iea.org/publications/globalevoutlook_2013.pdf (last accessed 14 October 2014).

Japan, distributors sold some 6,000 PHEVs and approx. 16,000 BEVs in the same year. In the People's Republic of China, 11,000 BEVs and HEVs were sold during the same period. EVs are also on sale on commercial terms in France, Germany, the Netherlands and other countries of the European Union, in the Republic of Korea, in Australia, in India, in South Africa, and in a growing number of Asian and Latin American developing countries.

During the past 10 years, many countries have launched and implemented national programmes aimed at providing direct or indirect support to the electric mobility automotive industry. Some programmes have announced national sales targets; others have provided financial support for research and development. In parallel, national and local authorities have offered prospective EV owners a variety of privileges and benefits, which were meant to compensate EV buyers for their comparatively higher vehicle prices. Benefits have included rebates or direct grants as purchase price subsidies. Other benefits include free parking privileges in inner–city zones, access to exclusive bus-lanes, as well as tax or toll charge exemptions. Several of the publicly funded support programmes may be discontinued in the future, but they have certainly helped the EV industry to get established and to enter the competitive automobile market.

Since 2011, sales of PHEVs and BEVs have picked up, from an estimated number of 45,000 units in 2011, to well over 300,000 units in 2013. Some 31 per cent of all new EVs have been registered in Asia, mostly in Japan and the People's Republic of China, but also in India and other countries. It is expected that increased sales may also lead to greater economies of scale and eventual price reductions, including for the more expensive components, such as the lithium batteries. In parallel with increased EV sales there has been a significant increase and diversification in the service industry, including for battery (fast) charging outside the home or office, as well as for car-sharing schemes, new lifestyle products and services for tourists (e.g. local EV rentals in tourist destinations).

Supported by favorable local laws and regulations a new ecological transport system is on the rise in a growing number of locations. However, it also needs to be seen that most nascent EV markets are still fragile and in need of continued political and public funding support. EV producers and marketeers want to see better sales and faster returns; whereas candidate EV buyers and consumers expect significantly lower EV prices, preferential electricity tariffs, and an improved system and network of vehicle charging stations; and environmentalists want to be convinced that the promised environmental benefits in fact materialize.

Part 2: Trends, issues, challenges and opportunities for promoting e-mobility in Asia

2.1 Potential benefits of promoting e-mobility in Asia

The use of electric mobility in transportation can offer multiple benefits and it is therefore being considered or promoted by different countries for various reasons.

(a) Potential national economic benefits: Reduction of oil import dependency

Most developing countries are net hydrocarbon importers and oil import bills often consume a large share of foreign exchange earnings. However, some Asian developing countries are also major producers of hydro-electricity (e.g. Bhutan, Georgia, Armenia, Kyrgyzstan, Laos, Sri Lanka, Tajikistan). The use of domestically produced renewable energy for electric mobility enables some of these as well as other countries to promote low emission and low carbon transportation.

(b) Contribution of environmental protection: Lowering urban air and noise pollution

Electric vehicles have the distinct advantage of not generating any air polluting emissions, such as NOx or particulates, at the point of use. Greater use of electric vehicles can thus complement other measures and make potentially significant contributions to better in urban air quality (assuming that the vehicles are not powered by near-by inefficient coal fired power stations). Potential benefits for urban air quality and public health are particularly notable, if electric vehicles are used in vehicle fleets that make very frequent trips each day in urban areas, such as taxis, delivery vans, or public transport buses. In fact, in a growing number of cities, including cities in Asian developing countries, taxi, postal and public transport companies have already started to modernize and in part replace their fleets with electric vehicles. Some countries and cities have also introduced EV's into their service vehicle fleets (e.g., para-transit, police patrol vehicles, street cleaning vehicles, etc).

Electric drivetrains produce practically no noise. Electric vehicles are often preferred means of transport in areas where noise pollution is undesired, such as on educational campuses, in recreational zones and facilities, and along vacation resorts. In the People's Republic of China, for example, electric shuttle busses are regularly used by National Park Administrations to transport tourist visitors to and from and within parks.

(c) Social aspects: New mobility options in industrializing and developing countries

Electric motors of new generation electric vehicles have proven very robust and durable, requiring little if any maintenance. In some countries, electric vehicles have already been introduced also in remote locations, such as some rural areas or small islands, where conventional vehicle maintenance services are not available. Electric bicycles and scooters also offer a new mobility options. Electric bicycles and scooters can master slopes and travel longer distances with only limited physical efforts.Electric scooters offer new mobility options, including for women and for less affluent income groups, and in areas and situations where alternative public transport services are either non-existent, non-available, or of low quality or overcrowded. In some areas, new electric transport vehicles have become popular and have successfully been introduced to transport passengers or goods along inner city areas or clean air zones.

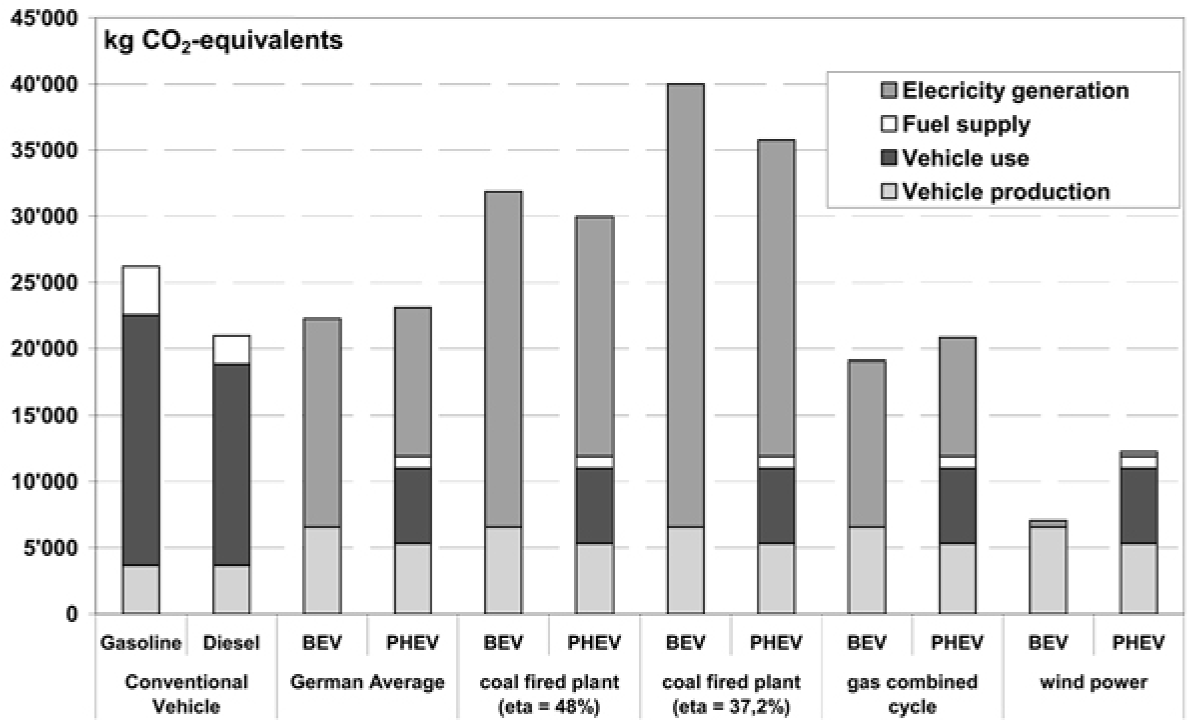
(d) Contribution of electric vehicles to CO_2 emission reduction goals

Electric mobility can offer environmental advantages in terms of reduced air pollution and lower CO_2 emissions. However, the more precise environmental benefits will need to be assessed carefully on a case-by-case basis.

If measured in terms of kg CO_2/km on a pure "tank-to-wheel" basis, electric vehicles will obviously always appear "greener" when compared with vehicles powered by conventional fuels. However, such an oversimplified comparison should be avoided, and a more comprehensive and differentiated analysis is needed for rational long-term policy decision-making.

In addition to "tank to wheel" emissions, "well-to-tank" emissions should also be considered in a comparative (CO_2) emission calculation[9]. This means that emissions caused in the process of gasoline or diesel production, as well as emissions caused in the process of electric power generation and transmission are also included in the comparison. In this scenario, the advantages of electric vehicles are less distinct.

Figure 5: Life cycle greenhouse gas emissions of a compact car with different drive trains (120,000 km ; 70% urban driving)



Source: Helms, H.; Pehnt, M.; Lambrecht, U.; Liebich, A.: Electric vehicle and plug-in hybrid energy efficiency and life cycle emissions, Proceedings of 18th International Symposium Transport and Air Pollution, Ifeu – Institut für Energie- und Umweltforschung, p. 113, Heidelberg (2010).

9 Emissions associated with oil extraction, oil transportation and refinery processes, as well as emission associated with electric power generation and transmission.

As shown in Figure 5, researchers at the Institute for Energy and Environment Research at Heidelberg Unversity, Germany, are even more comprehensive in their approach. In this case, the life cycle comparison of green house gas emission comparison of cars with different drive trains also includes emissions generated during the process of vehicle production. It has been observed that EV and battery production tends to generate emissions that can be higher than emissions in the manufacture of conventional gasoline or diesel vehicles. Figure 5 presents a recent model comparison based on conditions in Germany. The comparison concludes that based on a completed life cycle assessment battery powered vehicles and plug-in hybrid vehicles only emit lower CO_2 emissions if they are charged by electricity generated from renewable sources of energy, notably wind energy, or by efficient gas combined cycle power plants. Electric vehicles that are re-charged by electric power from low efficient coal fired power stations can even cause more CO_2 emissions that the conventional gasoline or diesel fueled passenger car.

2.2 Barriers and challenges to the promotion of electric mobility in Asia

(a) Challenges in meeting consumer preferences and expectations

In Asia, as well as in other countries, the further popularization of electric vehicles is faced with three main sets of challenges: the first remains the *relatively high first cost EV purchase price*, the second is the psychologically perceived barrier of a *limited driving range of EVs* (respectively a perceived long battery recharging time), and the third is the *lack of an adequate battery recharging infrastructure for EVs*.

EV operating costs and total costs of EV ownership (TCO) are typically lower than the costs associated with the operation and the depreciation of comparable conventional vehicles. However, high purchase costs still represent a major psychological obstacle; given that prospective buyers also face other uncertainties and potential risks, such as possible future electric price hikes.

In 2011, the United Stated Department of Environment (US DOE) and the Environement Protection Agency (US EPA), in cooperation with the Department of Transporation (US DOT) have amended the regulations on mandatory fuel economy labelling to include new generation vehicles, including PHEVs, BEVs, as well as Fuel Cell vehicles. The mandatory labels are providing potential car buyers / consumers with information which can facilitate a comparison of key fuel economy and environmental performace indicators ofr the alternative vehicles under consideration.

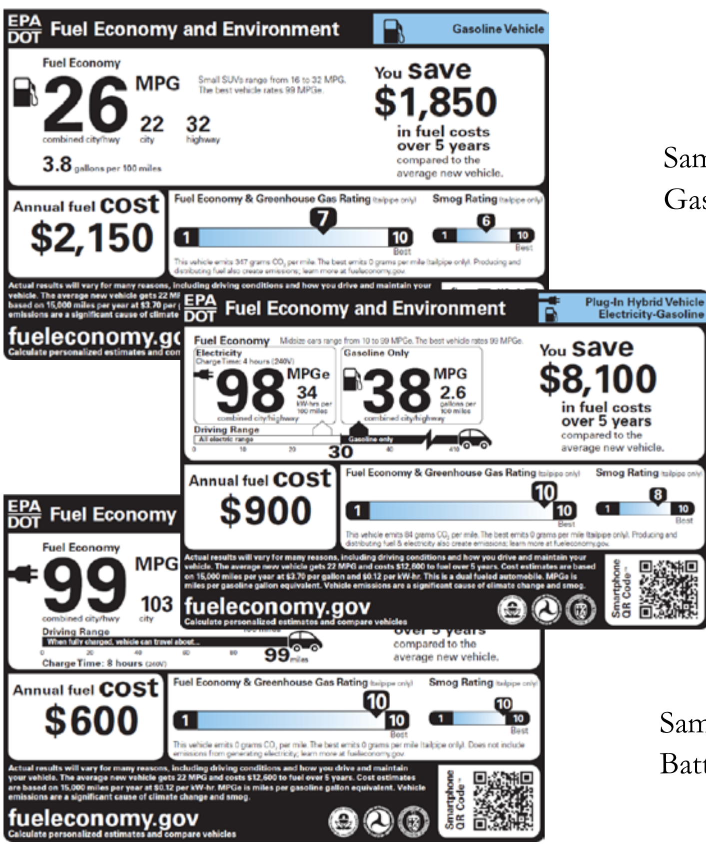
Figure 6 shows selected sample labels of a fuel efficient gasoline vehicle, a PHEV electricity and gasoline powered vehicle, and a pure electric BEV. The DOE/DOT comparison is based on the assumptions that vehicles are driven for 15,000 miles in a year, and they show the differences in fuel / operational costs, based on prevailing average gasoline and electricity prices. In the model example, a fuel efficient gasoline powered personal car (small SUV) can save the owner an estimated US$ 1,850 in fuel costs over a five-year operational period, if compared to the overall average of fuel efficiency of the vehicles fleet in the same vehicle category.

By comparison, a PHEV electricity and gasoline powered vehicle can save its owner up to US$ 8,100 in fuel costs over the same 5-year period. In other words, PHEV vehicles are more expensive to buy, but they can help save their owners an additional US$ 6,250, if driven for 15,000 miles/year for a 5 year period. A BEV vehicle could help its owner to even save fuel costs equivalent to US$ 7,750 over a five-year period.

The label comparison shows that investments in the higher cost electric vehicles makes more economic sense if owners will drive and use these vehicles a lot (e,g, 15,000 miles or 22,000 km per calendar year, or more). For private users who only make occasional short trips within urban areas, and who drive significantly less than the indicated distances, investments in electric vehicles may be environmentally desirable, but not be economically beneficial.

Other concerns that prospective EV buyers may have relate to vehicle re-sale values and to the durability of the vehicle battery. Modern EV batteries can be re-charged up to 2,000 times, and/or used for up to 8 years, before their performance begins to wear out. Vehicles and batteries can also be used for longer periods, except that battery recharging has to be done in more frequent intervals.

Figure 6: Fuel Economy and Environmental Performance: Comparison of Conventional Gasoline, PHEV and BEV vehicles



Sample label for fuel efficient Gasoline Vehicle

Sample label for PHEV Electricity and Gasoline Vehicle

Sample Label for Battery Electric Vehicle

Source: United States Environmental Protection Agency (2011): New Fuel Economy and Environmental Labels for a New Generation of Cars, online: http://www.epa.gov/otaq/carlabel/regulations.htm (last accessed 10 November 2014).

Electric vehicles and BEVs in particular, still face challenges in meeting consumer preferences and expectation. BEVs typically have only a limited range of up to 150-200 kms before they need to be recharged. In addition, experience has shown that depending on weather conditions, personal driving styles and other on-board uses of electricity (e.g. for air conditioning or heating) the driving range of the battery may be even more limited.

Most trips in urban areas are only of a short or limited distance. Commuters also only use their vehicles a few times per day, e.g. to travel between home and work in mornings and evenings, or between home and place of study in mornings and afternoons. Most consumers travel no more that 50 or 60 kms per day, and most travel much less. Thus, the driving range of BEVs fully covers the average daily travel or commuting distances. However, many potential EV buyers still feel that the limited driving range imposes an unacceptable or undesirable restriction.

It also needs to be noted that the times needed for battery recharge are considerably longer than the times needed for tank refills at petrol stations. BEVs, respectively their batteries, typically need to be recharged for several hours over night. Electric vehicles, which are in commercial use, can also be re-charged faster, but minimum charging times would still be no less than 30 minutes, and frequent rapid re-charging can have negative impacts on the lifetime of the battery. BEVs may well be a suitable option of urban transport for middle or upper income households which can own or lease their own private garages, also to be used as night-time slow re-charging station. Ownership of BEVs may not be affordable for low-income households or the urban poor. They may also not be practical due to difficulties in arranging battery recharging without a private parking lot.

Marketing of BEVs to private owners for private use will need to overcome the psychological barrier that candidate buyers may have vis-à-vis the driving range. Marketeers will also have to anticipate the challenges EV owners may face when in re-charging their car batteries. Both of the fore mentioned constraints do not apply to electric two-wheelers because their users never intend to travel long overland distances, and two-wheeler batteries are easily portable, and can conveniently be taken into the home at any time for re-charging.

Successful market penetration of EVs and their contribution to local sustainable transport solutions will greatly depend on a favorable policy environment and continued (in)direct support which can also come from regulatory restrictions imposed on the registration of conventional polluting vehicles. In various Chinese cities, for instance, the registration and use of conventional scooters and motorcycles with two- or four-stroke engines is prohibited since a few years. This measure alone has not only helped to curb local air pollution and to reduce the number of accidents in Chinese cities, it has also indirectly helped the domestic electric scooter industry to grow rapidly, and to establish itself a world leader in the manufacture of e-scooters that it is today. Electric mobility projects and programmes can also develop and flourish in other Asian countries and cities, if the necessary domestic sustainable transport policy back up is provided.

Figure 7: Public charging infrastructure

	Private charging in private areas	Public charging in private areas	Public charging in public areas	Fast charging
Charging duration*	5 – 8 hours	1 – 3 hours	1 – 3 hours	20 – 30 minutes
Electricity network	no or limited network expansion is required	strengthening of grid could be required	connection to grid required, typically below ground, near buildings	expansion of grid access required
Usage behavior	home charging typically between 7 pm – 7 am, workplace charging typically between 8 am – 6 pm	charging during the day, several charging cycles throughout a day	charging 24/7, several charging cycles throughout a day	charging similar to vehicle refueling, several charging cycles throughout a day
Challenge	-	dependency on private party	no business case, public investment needed, cities as indispensable partners	high initial investment, integration of utilities, business case

* based on a 25 kWh and begin of charging 20% SOC

(b) Expanding electric mobility: Resource constraints?

Several studies have been undertaken by national and international research institutes and commercial companies with a view to assess potential natural resource constraints if lithium battery production was to be scaled up significantly to meet the needs of a potential global increase in demand for electric vehicles and battery-powered IT products. Production of lithium batteries requires lithium carbonate, most of which is currently extracted from brines of desert salt lakes, e.g. in Latin America (Chile, Argentina, Bolivia), as well as in North America. Lithium-rich minerals are also mined in Australia for export to various battery producing countries. The People's Republic of China produces its own lithium batteries, in part based on own resources, and in part based on spodumene imports from Australia. At current and projected future levels of production, the presently known lithium reservese would be sufficient to supply world markets well into the next century.[10]

(c) Battery safety concerns

During recent years there have been occasional media reports on burning electric vehicles batteries which caught fire as a result of a traffic accident. In May 2012, the driver and a passenger on an BYD E6 electric taxi died in one such incident after their vehicle was hit by another car. In October 2013, the battery of a Tesla S Model electric vehicle caught fire after the vehicle and its bottom hit a big piece of metal. Incidents like those referred to in this section are rare exceptions. In general, the driving, the maintenance and the re-charging of batteries are not associated with any significant risks. However, additional crash tests and further e-vehicle design studies are recommended with a view further eliminate any remaining risks of electric shocks or battery fires.[11] A comprehensive listing of

10 See also http://www.australianminesatlas.gov.au/aimr/commodity/lithium.html (last accessed 28 October 2014).

11 TÜV SÜD successfully conducted the world's first dynamic crash test of lithium-ion batteries to determine how they perform in crash situations and to identify the ideal structural protocols required to ensure maximum safety. http://www.autofocusasia.com/knowledge_bank/articles/e-mobility.html (last accessed 27 October 2014).

national and international regulations and standards on electric vehice safety has been compiled and is periodically updated by the United Nations Economic Commission for Europe.[12]

(d) Waste management concerns: Future electric car battery disposal

The share of electric vehicles in the global market for transportation is widely expected to continue to grow. Demand for the necessary materials is thus also projected to continue to increase, raising concerns on the security of future material supply, future resource material costs, as well as battery waste management.

In the developing countries of Asia many of the more basic types of electric vehicles, notably two-wheelers, three-wheelers and so-called quadricycles, are mostly powered by conventional lead-acid batteries. Whereas most countries have legislated lead battery management and handling rules, the implementation and enforcement of these rules often still leaves much to be desired. In some, but not in all countries are lead acid battery manufacturers required to re-collect used batteries for recycling. However, collection systems for used batteries are also mostly inadequate. Thus, in many countries most scrap batteries end up with small-scale and backyard recyclers who can not afford expensive pollution controls. Most of them rely on coal to fuel crude furnaces, recoving lead at low quality and high environmental costs.[13]

In the future, most BEVs are likely to be equipped with lithium-ion batteries. Hence, management of battery disposal and battery recycling have become a crucial topic for the automotive industry.[14]

Like with other manufactured products, the performance and the durability of EV batteries varies. Studies of electric car batteries have shown that after some 10 years of service the capacity of EV batteries tends to decline by some 20, 30 or 40 per cent. Such used batteried may then need to be replaced if the EV driving performance it to be maintained. However, used EV batteries may still be used further for energy storage. They can have a feasible "second life" of up to 10 or even more years as storage devices in power plants. Such batteries can be used to balance fluctations of electricity generation from renewable sources.[15]

Some types of batteries are more conducive to recycling than others. While nickel sells for a high price, nickel-metal hydride batteries are valuable to and worth recycling. Lithium-nickel-manganese-cobalt batteries (found in the Nissan Leaf) also have a higher recycling value because nickel and cobalt are both expensive materials. The production of lithium is still rather inexpensive. Hence, the recycling of lithium batteries is not yet sufficiently lucrative, but that may change in the future. Some analysts believe that the share of recycled material may account for up to 40 per cent of lithium

---

12 United Nations Economic Commission for Europe (UNECE) (May 2013): List of relevant regulations for Electric Vehicle Safety (Document EVS-04-04-e).

13 For a case study on India, please see: Occupational Knowledge International (20 October 2010): Lead Battery Recycling in India.

14 Source: http://www.waste-management-world.com/articles/print/volume-12/issue-4/features/the-lithium-battery-recycling-challenge.html (last accessed 30 October 2014).

15 Nissan has formed a joint venture called 4R Energy with Sumitomo, a Japanese conglomerate, aimed at using the old batteries for storing energy from renewable energy sources like wind and solar and for backup power supplies in emergencies. See: http://www.nytimes.com/2011/08/31/business/energy-environment/fancy-batteries-in-electric-cars-pose-recycling-challenges.html?pagewanted=all&_r=2&; http://www.consumerreports.org/cro/news/2013/10/what-happens-to-electric-car-batteries-when-the-car-is-retired/index.htm (last accessed 30 October 2014).

production in the future. Some industry partnerships are already being established to develop better technologies and methods for battery recycling.

2.3 Competitive advantages in electric vehicle manufacture and battery production in Asia

Several developing countries in Asia have well-developed industrial manufacturing capacities, including for the manufacture of hi-tech machines, consumer goods and appliances. All of the larger developing countries of the region manufacture auto parts and/or host motor vehicle assembly lines. Several Asian countries, including Japan, People's Republic of China, Republic of Korea and India, have included the promotion of electric mobility as an integral part of their industrial modernization, diversification and domestic motor vehicle production strategies. It can be expected that future economies of scale will enable electric mobility producers from these countries to consolidate their leading positions in the respective world markets.

3. E-mobility Programmes and policies in Asia: Perspectives for scaling up model projects and good practices

Transport needs differ between countries, locations, and between urban and rural areas. Different types of electric vehicles can meet the different needs of different user groups.

Cities and other urban areas offer jobs in industries as well as in the various sevice sectors. Most of the more affluent households can be found in urban areas where most educational opportunities, public services and cultural facilities can be accessed relatively easily. Cities typically offer a better transport infrastructure and services than can be found in rural areas. Most trips undertaken in urban areas are of comparatively short distance. In most Asian cities, car ownership is on the rise, as the private car becomes more affordable. Car ownership also reflects social status. However, more and more cities, and even smaller towns are experiencing increasing difficulties in managing increasing congestions. Ubiquitous traffic congestion can have serious impacts on urban air quality and public health.

Most people living in rural areas depend on agriculture for their livelihoods. Accessibility and quality of goods and services is frequently less or inferior to urban areas. Most residents in rural areas live on lower level or disposable income, and in many developing countries residents in rural areas have remained poor. Residents of rural areas typically have to travel greater distances. The rural poor often need to carry their goods by themselves, or transport them by animals, animal drawn carriages, or bicycle. Depending on household or village income levels, motorcycles or small trucks are used for transport of people and goods. Travel density, frequency and emissions are typically low. Efforts to develop additional and affordable new transport and mobility options often face great challenges.

Figure 7 describes and distinguishes in a simplifying manner four typical market segments or clusters where transport needs and opportunities for introducing electric mobility vary.

Most potential applications for electric mobility are typically found in urban areas. Electric mobility is found to be more economically viable in urban settings and in applications in which vehicles need travel a lot, e.g. for frequent trips within the boundaries of given urban areas and their perimeter.

Figure 8: Differentiated transport needs and options for electric mobility

	Metropolitan area - High traffic density, air pollution, short transport distances	Rural municipality - Low traffic density, low air pollution, longer transport distances
... advanced infrastructure - High capacity power network, data network needed	Cities: Tokyo (Japan), Shanghai, Bejing (China), Singapore, Gumi (Korea) Examples: e-car sharing, e-car rental, inductive e-busses	Places: Goto Islands Nagasaki (Japan), ports / airports Examples: e-car rental, electric load carriers, e-busses
... basic infrastructure - Low load capacity of power network and no data network needed	Cities: Manila (Philippines), Delhi (India) Examples: e-jeepney /e-busses, e-tricyles, e-scooters, e-bikes	Places: countryside Examples: utility vehicles with battery change system, e-tricyles, e-load carriers, e-bikes

The section presented here below shows selected cases in which electric mobility has already made significant local contributions to sustainable local transport solutions.

(a) Urban electric delivery vans: Pilot projects in New York, Tokyo, Singapore and Hong Kong, Special Administrative Region of China

Global shipping, express mail and parcel delivery companies operate large vehicle fleets in almost any city around the world. Within urban areas consignments are collected and delivered by vans throughout the day. Urban delivery vans typically operate in a stop and go mode within a certain geographic district for between 60 to 140 kilometers daily on 8 hours shifts. In their effort to control operational and fuel costs most major companies, including DHL, FEDEX, UPS and others, have started pilot projects to use hybrid and BEV vans in their delivery fleets. DHL was among the first to successfully deploy some 80 Ford Transit Connect e-vans in New York City as a part of its GoGreen Programme. FEDEX has tested and is using Nissan e-NV200 electric vans in Tokyo, Japan, Singapore, Hong Kong Special Administrative Region of China, and other locations, and US built elecric vans in American destinations, including Washington, D.C. and California. UPS recent took delivery of more than 100 e-vans built by Electric Vehicles International. Local municipalities support several of the pilot programmes, in particular in locations where improvement of urban air quality is a major concern.[16]

All the initial tests and pilot projects have shown that e-vans are ideal for use as commercial delivery vehicles in urban areas. Municipalities and other cities, including Asian cities, where air quality is an

---

[16] Please refer to respective company websites for additional information: http://www.dpdhl.com/en/media_relations/press_releases/2013/five_years_gogreen.html; http://www.nissan-global.com/EN/NEWS/2013/_STORY/130712-01-e.html; http://news.van.fedex.com/nissan-and-fedex-express-expand-collaborative-testing-100-electric-compact-cargo-vehicle-us; http://www.evi-usa.com/ (last accessed 13 November 2014).

issue may consider to also encouraging their local service delivery providers to start deploying electric vehicles. In the People's Republic of China, the National Postal Service has already deployed some 62,000 electric tricycles and e-bicycles to make postal delivery services faster, more convenient for employees, and more environmentally benign.

(b) Pioneers in Shenzhen: The People Republic of China's first electric taxi fleets

Taxis are also vehicles which are driven a lot each day around cities. Thus, operational costs can be considerable, and so is the contribution of taxis to urban air pollution. In bigger cities, there are often 30,000 to 60,000 licensed taxi vehicles that operate full time each day. Licensing and regulation of the local taxi systems offers an important option for municipalities to control urban air quality.[17]

Shenzhen was one of the first cities to launch a fleet of electric taxis. The first batch of 30 BYD E-6 e-taxis started to serve the metropolitan area in 2010, and their number has since risen to some 800 today. The city government expects a further growth in the electric taxi sector and their number may be further increased to 2,200 vehicles, together with the installation of additional charging stations.

The taxis have a range of about 200 km per charge (or about 170 km with air conditioning) and travel for about 350 km to 500 km (or more) each day. Vehicle batteries need to be recharged twice daily. Re-charging typically takes an hour and half. At times, drivers take turns or change shifts during the re-charge wait periods.

E-taxis are significantly cheaper to operate than conventional taxis. Taxi fares are lower, too, as there is no fuel surcharge, and net incomes for drivers of e-taxis are better, too. At present, local electricity supply in Shenzhen is estimated to include a 30 per cent share of renewable sources of energy.

All electric taxis in Shenzhen are owned by Pengcheng Electric Taxi Company, a joint venture between the local Government owned Shenzhen Bus Group and BYD Automobile Co. The two companies hold a share of 55 per cent and 45 per cent respectively.[18]

Not all electric taxi projects have been a complete commercial success. Some recent reports from Japanese cities indicated difficulties with the durability of batteries, and consumer hesitation to use electric vehicles during the electricity shortage period after the Fukushima accident. However, several market analysts project increasing demand for low cost electric taxis in the future.[19] Key vendors of electric taxi vehicles are BYD Motor Corp., Chery Automobile Co. Ltd., Nissan Motor Co. Ltd., SAIC Motor Corp. Ltd., and Tesla Motors Inc. Other electric vehicle manufacturers include BMW AG, Fiat Group, General Motors Co., Honda Motor Co. Ltd., Mitsubishi Motor Corp., Toyota Motor Corp., and Volkswagen Group.

Cities which seek to enhance sustainable transport may consider supporting "greener" taxi fleets, including electric taxis, if a parallel "greening" of electric supplies is also contemplated.

---

17 For a general overview please see: http://www.taxi-library.org/regulation.htm and: http://www.taxi-library.org/rio.htm (last accessed 6 October 2014).

18 See: http://www.tdm-beijing.org/files/news/Factsheet_GoodPracticeChina_ElectricTaxi_20130409.pdf ; http://www.businesswire.com/news/home/20120224005686/en/World's-Largest-All-Electric-eBus-eTaxi-Fleets-Expanding#.VDMIlL7fZd0 (last accessed 6 October 2014).

19 E. g. http://www.technavio.com/report/global-electric-taxi-market-2014-2018 (last accessed 7 October 2014).

(c) (Re)Introducing electric buses for urban passenger transport: Shenzhen, People's Republic of China and Seoul, Republic of Korea

Like taxi, buses used for urban public transport also operate long hours every day. Buses typically drive along fixed routes and periodically return to their starting point and/or the bus depot.

The use of electricity for public buses has a long tradition. So-called "trolleybuses", which draw the electricity for their motors from overhead wires, were pioneered by Ernst Werner von Siemens in Berlin, Germany, in 1882, and came into commercial use for urban passenger transport in various cities at the beginning of last century. Trolleybuses were a popular and widely used form of urban public transport, in particular during the 1930s and 1940s, but later "lost out" to diesel buses, which were then cheaper and more flexible to operate. There are still some 300 towns and cities, mostly in (Eastern) Europe, which continue to operate trolleybus systems. During recent years, and against the background of growing environmental concerns, trolleybus systems are again appreciated, and some new systems are being built.

During recent years, some bus makers, notably BYD Motor Corp., headquartered in Shenzhen, People's Republic of China, have specialized in a new design and in the production of pure battery powered electric buses. Commercial sale and operation of such e-buses has started in 2011 and today, several hundred units are already operating in various Chinese cities, including Changsha, Xi'an and Shaoguan. BYD e-buses are also in operation in the Netherlands and several other European countries, as well as in Bogota, Colombia, and more projects in Latin America are also planned. Working in partnership with American bus manufacturers, BYD has also brought its technology and its products to the North American market.

Battery powered e-buses are built of lightweight materials with electric motors integrated into the wheels. Buses can drive some 200 to 240 km on a single charge. A full regular battery re-charge, which typically is conducted at night, takes 5 to 6 hours, but fast recharging can be done in one and half hours. According to information provided by manufacturers, batteries of e-buses can be re-charged up to 10,000 times before they begin to wear out. However, field tests undertaken in some countries indicate that not all batteries used in electric busses are this durable.[20] Depending on the price of electricity, available sources of electricity, and mode of operation, battery powered buses can also be a useful element in local sustainable transport promotion programmes.

As a part of a recent and still ongoing Seoul Electric Bus Project companies in the Republic of Korea have also developed advanced e-bus technology which is used in several pilot projects around the country. In addition, pilot projects have also been developed to test and demonstrate a wireless bus and battery re-charging system.[21]

---

[20] University of Ghent, Belgium (October 2014): Technical report on ev field tests (prepared for North Sea Region electric mobility network): http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/info-pool/E-MobilityNSR_WP5._R2.pdf (last accessed 13 November 2014).

[21] See also: http://esci-ksp.org/wp/wp-content/uploads/2012/05/Making-Clean-Future-Seoul-with-Eco-Friendly-Vehicles-Seoul-Electric-Bus-Project.pdf (last accessed 13 November 2014).

(d) Electric Three-wheelers and electric Jeepneys: Greening passenger transport in Metro Manila

There are approximately 3.5 million conventional combustion engine tricycles and motorcycles operating in the Philippines, contributing millions of tons of carbon dioxide emissions to the environment every year. These vehicles are typically used for formal and informal passenger transport. Because of their large number they are observed to have a significant impact on local air quality in Metro Manila, as well as in some other of the larger cities in the country.

In 2011, ADB, in partnership with the Philippine government and the Department of Energy, has launched a project initiative to transform the public transportation sector by introducing new types of electric tricycles (e-trikes). Using innovative technology and competitive financing, this project is aimed at a widespread adoption of electric tricycles and the development of a sustainable local e-trike manufacturing industry.

The ADB kicked off the project in April 2011, when it turned over 20 e-trikes to the city of Mandaluyong, where its headquarters is located. The e-trikes, powered by lithium-ion batteries, are three-wheeled vehicles that look similar to the "tuk-tuk," Thailand's popular auto rickshaw. At approximately US$ 5,000/unit, E-trikes cost significantly more than traditional tricycles (approx. US$ 3,000/unit), but daily operational (electricity) costs are also only a fraction for regular gas costs. Used for urban passenger transport, e-trikes typically operate at nearly all times of the day (except for battery re-charging times) and at every day of the month. The high mileage allows the owners and the operators to recover the initial investment rather quickly, and to realize a higher daily net income for the driver.

The e-tricycle projects aim to eventually bring some 100,000 units onto the roads of Metro Manila and other cities. Assisted by innovative financing, e-tricycle drivers may eventually own their own tricycle, and significantly improve their daily take home revenues. E-trikes are expected to help reduce local air pollution, create local jobs, and offer safer, more affordable and more environmentally benign local urban transport options.

There are also an estimated 370,000 vintage jeepney vehicles on the roads in the Phillipines serving as open-air shared-taxis or buses. Inspired by thee-tricycle initiative, several companies started to build electric jeepney prototypes, which may eventually also become attractive to owners, operators and passengers. The Electric Vehicle Association of the Philippines, its management and its members support the e-mobility initiatives. Apart from traditional tricycles, jeepneys are also a main source of urban air pollution. Their eventual replacement will also significantly alleviate the air pollution problem. Modern e-jeepneys will be assembled locally and can travel some 80 kilometers on a full five-hour charge.

Project initiatives such as the introduction of the e-trikes and the e-jeepneys offer e-mobility solutions that are adjusted to the local conditions that can offer multiple benefits for the various stakeholders concerned.

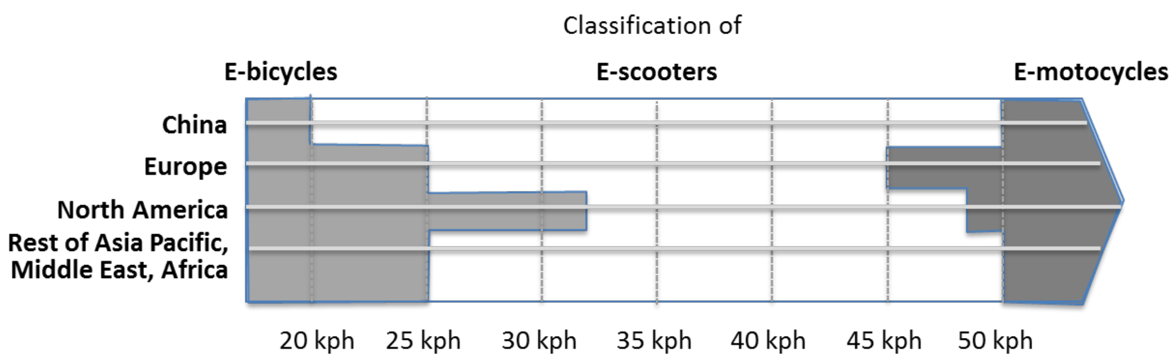
(e) Electric two-wheelers: efficient alternatives for mass transportation

Two-wheel vehicles, in particular bicycles, have been very popular and in wide spread use throughout Asia for a long time. With growing motorization, customers who could afford have switched over to motorcycles or motor scooters. However, the sudden wide spread use of two-wheelers with conventional two-stroke engines, fueled by gasoline-oil fuel mixes, have had detrimental effects on air- and noise pollution in many Asian cities.

The advent of electric two-wheelers has brought considerable relief to many of these cities. Like bicycles, motorcycles and scooters, electric bicycles and e-scooters are very popular as they are affordable, efficient and easy to use. They can navigate even through otherwise very congested traffic and they do not require large or costly parking spaces.

Electric two-wheelers can be categorized into electric bikes, electric scooters and electric motorcycles, depending on their structure (with pedals or without, with foot platform or without), vehicle weight and permitted top speed. The later differs between regions and countries.

Figure 9: Categorization of e-bicycles, e-scooters and e-motorcycles around the world



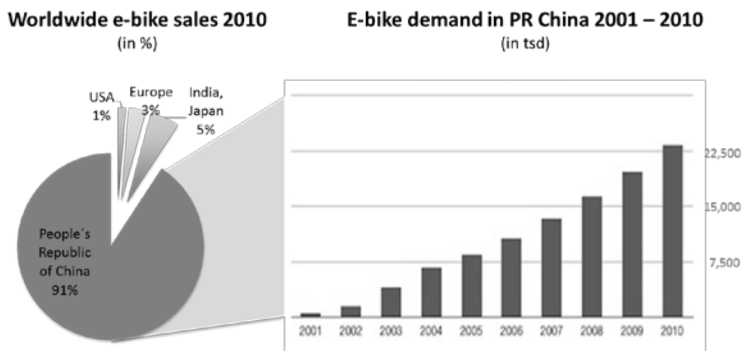
Source: http://en.wikipedia.org/wiki/Electric_bicycle (last accessed 21 October 2014).

Electric two-wheelers enjoy a booming popularity among Asian consumers as they offer higher speed and lesser air and noise pollution. E-bikes and e-scooter enable urban travel at greater ease and for a longer range.

Statistics of Navigant Research projects a steady sales growth of electric two-wheelers worldwide. More than 65 million units of electric two-wheelers are expected to be sold in Asia in 2018, with People's Republic of China accounting for the largest portion of these sales (60 million e two-wheelers)[22].

[22] See: http://www.navigantresearch.com/wp-content/uploads/2012/04/ETVAP-12-Executive-Summary.pdf (last accessed 13 October 2014).

Figure 10: Development of stock and distribution of electric two-wheeler fleets in Asia



Source: http://www.electric-bicycle-guide.com/chinese-electric-bike.html (last accessed 12 October 2014).

(f) Car sharing in Asia: New options for use of electric vehicles

Car sharing is a relatively new from of automotive mobility in which customers acquire access to a self-drive vehicle via a car sharing membership. Car sharing could also be described as a short-term car rental. Car sharing programmes offer their customers the benefit of individual mobility without the obligations that car ownership brings. Car sharing companies take care of all aspects of vehicle registration, insurance, maintenance, fuels and parking. Car sharing has rapidly become very popular in many European and American cities, in particular in locations where vehicle parking is costly.

Car sharing is still a novelty in Asian developing countries, but some e-vehicle service providers are catching up quickly. In 2012, the Chinese e-vehicle manufacturer Kandi launched a project entitled "Self-driving Electric Vehicle Rental for Public Transportation in Hangzhou". The objective of the project is to introduce the small e-vehicle"KD-5011"[23] to the public. The small BEV has a maximum range of up to 160 km and a maximum speed of 80 km/h. The vehicle is only produced and used for car sharing, and the rental tariff is equivalent to US$ 3/hour.[24]

A notable novelty of Kandi Car-sharing are the innovative car sharing stations which are smart mechanized high-rise vertical parking, vehicle recharge and storage buildings, also referred to as "Kandi Machines". The first four such buildings were completed in 2013.[25] Customers receive and return their cars in a small paking slot in front of the building. The automated parking system saves precious space. The system offers a combination of three advantages: (a) access to a low emission transport option, (b) efficient shared use of vehicles (several users can share a car), and (c) saved urban space through space saving parking/garage method.

In the start-up phase, the number of car-sharing stations is still limited. However, it is planned to build as many as 750 stations in Hangzhou alone. In future, customers will then also be able to return their cars at a different station after a one-way rental. Kandi is also planning to replicate the

---

23 See: http://en.kandivehicle.com/ProductDetail.aspx?kid=72 (last accessed 12 October 2014).

24 Source: http://green.autoblog.com/2013/12/27/kandi-ev-vending-machine-carsharing-china/(last accessed 13 October 2014).

25 See: http://www.forbes.com/sites/markrogowsky/2013/12/28/kandi-crush-an-electric-car-vending-machine-from-china-could-upend-the-auto-industry/ (last accessed 12 October 2014).

project in other Chinese cities, including Nanjing as well as Shanghai (5,000 vehicles planned). Kandi aims to increase its car sharing fleet to no less than 100,000 units in the foreseeable future.[26]

Car sharing programmes, such as Kandi, as well as others which offer e-car rentals can indirectly facilitate the dissemination of information on electric mobility by providing customers a direct personal hand-on experience in self-driving an electric vehicle.

3.2 National programmes and policies for e-mobility in Asia

(a) Bhutan

The Kingdom of Bhutan is a constitutional monarchy in the Himalayas with 700,000 inhabitants and close economic ties to India. In 2011, authorities had registered on average some 70 cars per 1,000 inhabitants (not including two-wheelers). Public transport services are limited, and mostly provided by buses. Apart from agriculture, forestry and tourism, Bhutan's economy relies to a large degree on hydropower. Exports of electric powers earn the country very important foreign exchange income. Power generation also contributes to Government revenues. Bhutan is one of the few countries that aim for "gross national happiness" and sustainable development, instead of "gross national income". Government programmes are determined and coordinated by the Gross National Happiness Commission, which also places great emphasis on environmental protection and cultural heritage conservation. Forests cover two thirds of the territory of Bhutan.

Bhutan has no oil deposits and all petroleum products are imported, placing a considerable drain on the country's foreign exchange reserves. The Government has recognized the option and the potential advantages of a transition to electric mobility. In early 2014 the Government of Bhutan and Mahindra & Mahindra of India have signed a Memorandum of Understanding on a strategic partnership to promote electric mobility. At the same time a pilot and demonstration project was initiated together with Renault-Nissan introducing the Nissan Leaf EV in Thimphu, Bhutan's capital. A National Electric Mobility Mission Plan (NEMMP) and various ambitious programmes are currently under consideration and implementation aimed at introducing a larger number of EVs to be used as taxis and as Government vehicles. In addition to the small "e2o" vehicle (previously known as "REVA NXR") Mahindra has also introduced the Mahindra "Verito" electric car to be used as a taxi. According to statements of H.E. The Prime Minister of Bhutan Tshering Tobgay, the Government will establish and implement a promotional programme which may include some incentives for buyers of electric vehicles, as well as investments in roads and in charging infrastructure.[27]

With a total of about 50,000 cars, Bhutan's vehicle fleet is comparatively small, and aiming for a high degree of electrification seems indeed achievable. Similarly, the country of Bhutan has only about 5,000 km of paved roads. Hence, investments needed in terms of charging stations also seem manageable. Given that Bhutan's electricity is produced entirely from renewable energy, the

---

[26] Source: http://earthtechling.com/2013/11/100000-electric-cars-target-of-chinese-car-sharing-project/ (last accessed 17 October 2014).

[27] See: http://www.thebhutanese.bt/mobility-through-electric-vehicles/ (last accessed 17 October 2014).

envisaged transition towards a high degree of electric mobility is simultaneously a transition toward a "greener" economy and sustainable development. However, domestic purchasing power in Bhutan is also still limited. Hence, the implementation of the NEMMP might take some more time than initially envisaged. However, if successful, the country of Bhutan may soon be the country with the highest density of electric vehicles, and potentially a model for transition to sustainable transport, based on electricity and renewable energy supply.

(b) People's Republic of China

The rapid growth in domestic consumption of motor fuels has made the People's Republic of China increasingly dependent on oil imports. The growing private motor vehicle use has also had negative impacts on local air quality, in particular in the metropolitan and other urban areas. It is estimated that up to 70 per cent of NOx emissions in urban areas originate from motor vehicles. Air pollution is a mayor problem in many Chinese cities. Various pollution control measures are already being implemented. The promotion of electric mobility is also seen as an option to simulaneously address the air pollution and energy security challenges.

The Government of the People's Republic of China has committed significant resources and public funding for the promotion of electric mobility. According to the current *„Development Plan for Energy Efficient Vehicles and Vehicles with Alternative Propulsion Technologies 2011-2020"* this sector is projected to receive public funding support of up to 115 billion RMB (equivalent to approx. 18 billion US$).[28]

The People's Republic of China's e-mobility promotion plan of 2009 originally focused on 13 cities for model projects, including Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changsha, Kunming und Nanchang. Twelve additional cities were added a year later, including Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou, Tangshan und Guangzhou. In February 2014, the total number of e-mobility model zones was increased further to a total of 40 locations. Most of the additional e-mobility promotion zones were located in the country's Northeastern regions.

As a part of the electric mobility promotion programme the Central Government offers buyers of EVs significant financial incentives. The private purchase of a BEV is subsidized by up to 60,000 RMB (approx. equivalent to US$ 10,000) and the private purchase of a PHEV is subsidized by up to 50,000 RMB (approx. equivalent to US$ 8,500).

As shown in Figure 11, in some cities, local authorities offer additional subsidies. Since September 2014 private purchases of BEVs or PHEVs are also exempted from sales taxes (currently at 10 per cent of purchase value).

28 Source Deutsche Bank, see: https://www.db.com/cr/en/docs/China_GreenCars_080712.pdf (last accessed 1 November 2014).

Figure 11: National and regional maximum PHEV and EV car purchase subsidies – 2012

	PHEV Car Maximum Subsidy	EV Car Maximum Subsidy
National	50,000	60,000
Additional Regional Subsidies		
Beijing	50,000	60,000
Changchun	40,000	40,000
Hangzhou	30,000	60,000
Hefei	20,000	20,000
Shanghai	20,000	40,000
Shenzhen	NA	60,000

Source: https://www.db.com/cr/en/docs/China_GreenCars_080712.pdf (last accessed 24 October 2014).

The e-mobility development plan pursues multiple objectives, including energy and resource security, improved environmental protection, as well as strategic industrial development objectives. The number of technical publications and the number of registered patents in the People's Republic of China has increased significantly during recent years. Various Government Ministries and Agencies collaborate on e-mobility, including the Ministry of Industry and Information Technology (MIIT) and the Ministry of Science and Technology (MOST).[29]

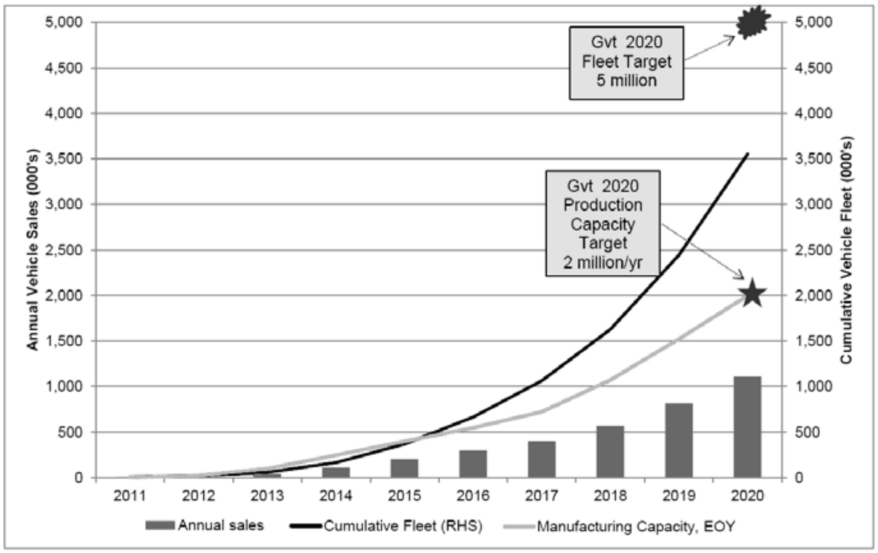
The Government of the People's Republic of China's target is to have some 0.5 million electric vehicles (not including two-wheelers) operating by the year 2015, and to raise this number to 5.0 million units by 2020. This target does not include two-wheelers. The plan foresees that electric vehicles will account for some 30 per cent of all registrations by 2025.

This production target appears to be quite ambitious, and not all analysts agree that it is achievable. However, e-mobility production capacities and actual output have grown considerably. During the first nine months of 2014, companies in the People's Republic of China sold as many as 38,163 new energy (electric) vehicles, nearly three times more than during the same period in the previous year.

Whereas the figures for production and sales are quite impressive, they nevertheless fall short of development plans. Therefore, some investment bank analysts have published more conservative growth projections. According to forecasts by Deutsche Bank, the EV production capacity in the People's Republic of China may increase to 2 million units per year by 2020.

[29] Tagscherer, Ulrike; Frietsch, Rainer: Analyse der technologischen Leistungsfähigkeit Chinas in der Elektromobilität, in: German Industry and Commerce Greater China (Eds): *econet china*. The German Chamber Network, p. 24. See: http://china.ahk.de/fileadmin/ahk_china/Dokumente/Environment/Econet_Monitor_Special_E-Mobility_September.pdf (last accessed 3 October 2014).

Figure 12: Government (Gvt) targets in the People's Republic of China and forecast of Deutsche Bank market analysts



Source: https://www.db.com/cr/en/docs/China_GreenCars_080712.pdf.

In spite of generous Government incentives, PHEVs and BEVs did not sell as fast or as many in the private passenger vehicle market, as may have been expected. Market analysts suggest three main obstacles. First, even after government incentives EV passenger cars are still relatively expensive if compared with regular gasoline vehicles. Second, in the opinion of many consumers EVs are not attractive cars due to their limited driving range, and possibly due to other image marketing problems. A third reason for the comparatively slow market uptake is the widespread lack of vehicle charging stations. Most residents of Chinese cities do not have their own reserved parking lot. Hence, lack of infrastructure for vehicle charging remains an important constraint and can hamper current or future sales.

Within the framework of the e-mobility development plan, the Government of the People's Republic of China also intends to have as many as 10 million charging stations built by 2020. The Government-owned energy company "State Grid" has already launched programmes to build more recharging stations. By the end of 2013, a total of 19,000 BEV charging stations were brought into operation.[30]

The production and use of electric vehicle in the People's Republic of China will continue to grow, but more likely at a slower pace than initially planned. Electric vehicles will continue to be more frequently found in municipal and other publicly-owned vehicle fleets, as well as in commercial taxi and delivery vehicle fleets, and in car sharing programmes. In China, as in other countries, electric vehicles are economically relatively more viable for those operators who need to drive a lot. Electric drives will also be found in passenger buses. In 2012 alone, Chinese companies produced a total of 2.7 million buses, including some 4,000 pure BEV buses.[31]

Whereas the production and sale of electric 4-wheel passenger vehicles grew slower than planned, electric bicycles, electric scooters, electric tricycles, electric motorbikes and "low speed four-wheel electric vehicles" are extremely popular. Bicycles, supported by electric motors make it easier to cover longer distances. With mass production, electric scooters also have become quite affordable. Scooters offer relatively new individual mobility options for many groups of society, both men and women, including the young, and the elderly. Electric tricycles and other "low speed electric vehicles" can be used for transporting passengers and goods, and thus have many commercial applications, including in suburban and rural areas where villages have been electrified.

The five main reasons that have been mentioned in discussions and in the literature to explain the popularity of electric two-wheelers are: (a) outright local bans of use of (air-polluting) two-stroke and/or four-stroke mopeds, motor-scooters and motorcycles in many Chinese cities; (b) non-available, overcrowed or other wise inadequate public transport services; (c) comparatively low purchase costs of electric two-wheelers (due to simple technology, and eocnomies of scale in production); (c) relative ease and low cost of operation (most electric two wheelers are categorized as „bicycles" and do not require a driving licence), (d) simple and inexpensive re-changing of two-wheeler batteries in the home or at the workplace.

Transport regulations distinguish between electric bikes and electric scooters. However, in the People's Republic of China most electric scooters are still categorized "electric bicycles". Whereas conventional motor scooters and motorcycles are prohibited in many Chinese cities, registration of e-scooters is allowed in most metropolitan and other urban areas. In most cases, operators of electric two wheelers also do not need driving licences.

Due to their popularity, the People's Republic of China has become the largest manufacturer, exporter and market for electric two-wheelers. Over the last decade, annual sales of electric two-wheelers have increased at double-digit rates. Whereas in the 1990s, there have only been a few thousand electric bikes on the People's Republic of China's roads, the total number of electric bikes and scooters in use in the Peoples' Republic of China is thought to have surpassed 120 million in

---

30 Source: Li Zoe: Chinese drivers hesitant to adopt electric cars, in: CNN, 24 April 2014, see: http://edition.cnn.com/2014/04/24/world/asia/china-electric-vehicles/ (last accessed 18 September 2014).

31 Ma JianYong: Research and Development of Electric Vehicle in China and Latest Trends on Diffusion, China Automotive Technology & Research Center (CATARC), See: www.cev-pc.or.jp/event/pdf_n/japanese/7-2.pdf (last accessed 2 October 2014).

2013.[32]

In a number of Chinese cities, electric bicycles and scooters are now also available via the public renting systems. The e-bike and e-scooter rentals are widely expected to further increase the popularity of these types of e-vehicles, also amplifying their positive environmental impacts.

The market for electric two-wheelers in China is widely expected to continue to grow fast. There is still unmet demand, and can be expected that some 5 million units of the existing stock may need to be replaced on annually.

Figure: 13 Classifications of Chinese Two-wheelers

Class	Types	Power (engine size)	Top speed (km/hr)	Fuel use (/100km)	Range (km)	Picture
Bicycle			10-15	n/a	n/a	
Electric two-wheeler	Electric bicycle	0.25-0.35 kW	20-30	1.2-1.5 kWh	30	
	Electric Scooter	0.3-0.5 kW	30-40	1.5 kWh	30-40	
Motor cycle	Gasoline Moped/ Scooter	3-5 kW (50-125 cc)	50-80	2-3 l	120-200	
	Gasoline Motorcycle	4-6 kW (100-125 cc)	60-80	2-3 l	120-200	

32 See: https://www.chinadialogue.net/article/show/single/en/6372-China-s-electric-bicycle-boom-will-the-fashion-last- (last accessed 21 December 2014).

Source: Jonathan Xavier Weinert (2007) : The rise of electric two-wheelers in China: Factors for their success and implications for the future, Dissertation at University of California, Davis, p 10-11.

The switch over from motor scooters and motorcycles to e-scooters and e-motorcycles offers indirect environmental benefits. Bywin, a Chinese manufacturer, estimates that if a gasoline motorcycle were replaced by an electric two wheeler, the reduced carbon emission in one year would equal the CO_2 absorption capacity of 12 trees.

The main environmental concern associated with electric two-wheelers is the historic dominant usage of lead-acid batteries and Pb pollution during battery production, recycling and disposal. During recent years, the Government of the People's Republic of China has also implemented stricter controls on informal production and recycling of lead-acid batteries.

Nickel metal hydride (NiMH) and lithium-ion (Li-ion) batteries have a higher energy density, lesser weight, better performance, longer liftime and higher cost, but have now also become more affordable and more widely used in electric two wheelers. The share of Lithium-ion batteries was quite low in the past, but it is now growing as these battery cells are becoming more affordable.

It can be expected that the Chinese market for electric two wheelers may gradually change in the nearer future. Manufacturers may gradually divert their attention away from relatively saturated urban e-mobility markets to low-income suburban and rural areas, where travel distances are further and higher-powered e-vehicles may be needed. Manufacturers can also be expected to focus more on quality and design, as competition among producers and distributors of two wheel e-vehicles is increasingly intense.

In China's rural areas small and inexpensive "low speed four-wheel electric vehicles' have also rapidly become very popular, essentially for similar reasons as electric two-wheelers become popular in the cities. In rural areas, public as well as private transport services are not always easily accessible. They are often inadequate in one way or the other, or comparatively expensive. Rural EV manufacturers, such as Shifeng Company in Shandong Provinve, and others, have recognized the mobility need of rural people and have specialized in the assembly of simple low cost and low speed electric vehicles which are often not considered "cars". These vehicles can, in many cases, be operated without a driving licence, taxes or insurance. Their popularity in the People's Republic of China demonstrates that simplified, standardized electic mobility products can come a long way in serving the needs of rural population.[33] Policy makers aiming to enhance sustainable urban and rural transport in developing countries of Asia may wish to study experiences with "low speed two-wheel, three-wheel and four-wheel electric mobility" in the People's Republic of China.

(c) India

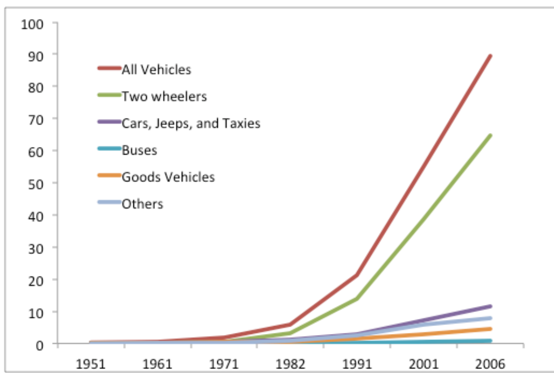
In terms of numbers of inhabitants India is the second largest country on earth. India's economy has also grown very rapidly during the last 20 years. India's transport infrastructure has also been expanded rapidly, but its expansion has not been able to keep pace with population growth and

[33] See: http://www.sdshifeng.com/en/product/Electric/ and: http://www.nytimes.com/2012/04/20/business/global/rural-chinese-flock-to-tiny-electric-cars.html?_r=1& and also: http://www.autoblog.com/2014/07/25/a-window-into-chinas-low-speed-electric-vehicle-revolution/ (last accessed 5 October 2014).

urbanization. Frequent traffic jams as well as crowded public transport are evident indicators of this development. India's automobile market is largely dominated by two-wheelers, scooters and motorbikes. Their number has been growing much faster than the registration of other motor vehicles.

India will soon be among the top 10 motor vehicle producing countries in the world. However, by international comparison India's motor vehicle density is still very low: 11 cars and 32 two-wheelers per 1,000 inhabitants. There are great industrial growth potentials on the one side, but limited purchasing power of the poorer segments of the population on the other. Petrol and petroleum product prices are relatively high in real terms in comparison with the average disposable incomes.

Figure 14: Trends in motor vehicle registrations in India 1950 – 2005 (in millions)



Source: JPS Associates (P) LTD. Consultants New Delhi Final Report: Study on Volume of Goods & Passenger Traffic on Indian Roads Road Transport, October 2011, Numbers taken from the Road Transport Year Book 2006-07.

In India, several companies have seen for some time opportunities for e-mobility development. There is a highly skilled workforce, ample manufacturing experiences and capacities, as well as transport engineering and software skills. The largest Indian car manufacturer *Tata Motors* and the smaller company *Reva* are already engaged in the manufacture of electric cars and tricycles since the 1990s. Other national e-mobility companies include *Electrotherm* (two-wheelers and parts)[34], *Ampere* and *Hero Electric* (two-wheelers) [35][36]. Other car manufacturers are not as yet engaged in electric vehicles.

Reva, which now belongs to *Mahindra & Mahindra,* specializes since 2001 in the manufacture of small electric passenger cars for both, the domestic market and for exports. Up to 2012, Reva sold some 3,200 small city cars, some of which were also exported to Europe. However, prospects for exports remain constrained because in some countries the import and registration of „micro-cars" is still not

---

34 See: http://www.electrotherm.com/electric-vehicle.aspx.
35 Source: http://www.ampvl.com/.
36 See: http://www.heroelectric.in/.

permitted due to lack of compliance with prevailing quality or safety standards. Whereas prospects for growing e-mobility sales in the domestic market are directly and indirectly encouraged by high petrol prices and certain financial incentives (including tax reductions and subsidies), they also remain constrained by high costs of batteries, and a very limited car charging infrastructure.

India places great emphasis on energy security. The rapidly growing domestic consumption of imported oil and petroleum products drains valuable foreign exchange reserves. Some see electric mobility as an option of curbing the growth in fuel imports.

Financial incentives for consumers to purchase electric vehicles vary between States and cities. The city of Dehli offers consumers a subsidy in the amount of 15 per cent of the purchase price as well as a vehicle tax deduction of 12.5 per cent. The central Government also offers nationwide incentives under the *Alternate Fuels for Surface Transportation Program (AFSTP)* of the Ministry of New and Renewable Sources of Energy. In 2011 and 2012, this programme provided small grants in the amount of 4,000 – 5,000 Indian Rupees (equivalent to 51-60 Euro) as cost contributions to subsidize the private purchase of some 130,000 electric two wheelers. The private purchase of three wheelers and cars was supported by larger grants amounting to 60,000 – 100,000 Indian Rupees (equivalent to 760-1,280 Euro per vehicle), but only some 1,000 buyers took advantage of this offer.

It has been widely acknowledged that the fore mentioned financial incentive programmes have not been sufficient to generate significant additional domestic demand for electric mobility. In 2011, the Government convened the *National Mission for Electric Mobility (NMEM)* to bring together relevant Ministers and senior officials as well as industry representatives and experts with a view to formulate a comprehensive national e-mobility promotion plan for the period up to 2020. Based a comprehensive consumer survey NMEMP projected increased domestic demand for electric vehicles, in particular two-wheelers (up to 5 million units). Demand for PHEVs was projected at 1.3 to 1.4 million units and BEVs at 200,000 to 400,000 units.

According to the empirical survey, consumers in India expressed their willingness in principle to pay a higher purchase price for a (hybrid) electric vehicle, but purchase prices should not exceed 10-20 per cent. Consumers expressed greater interest in PHEVs, rather than BEVs, which were widely seen as having various disadvantages (limited range, limited speed, inconvenient charging requirements, etc.). Continued and possibly more substantial incentives are widely seen as necessary if India's e-mobility market is to be expanded.

The NMEMP2020 presented differentiated concluding recommendations: With regard to electric two wheelers, the projected demand of 4.8 million units was considered strong enough. No additional public purchases were deemed necessary under the e-mobility promotion plan. The projected market demand for three wheel electric vehicles was considered to be modest, but no increases in the financial incentives were proposed. NMEMP2020 projected an aggregate demand of 20,000 to 30,000 vehicles in this category. With regard to PHEVs and BEVs, NMEMP2020 recommended additional public procurement programmes (e.g. of local governments) to further stimulate the industry, as well as continued subsidies for up to 200,000 vehicles for the period up to

2020. In addition, NMEMP2020 recommended the procurement of e-buses and e-vans for public transport under various pilot and local demonstration programmes, most of which to be carried out by local authorities.

Like in other countries, developers and promoters of e-mobility face the additional challenge of having to develop a publicly accessible battery-recharging infrastructure.[37] In 2012, some 1,000 EV battery-charging stations were already in operation in the country. The company Mahindra & Mahindra has been proactive and has also invested in charging stations in and around the city of Bangalore. However, in the longer term it is too costly for the company to maintain the public charging stations on its own, and the establishment of a public-private partnership could offer a mutually beneficial solution.[38] [39]

(d) Japan

Japan is one of the most highly industrialized economies, including in its transport sector. Average vehicle density is estimated at 453 motor vehicles per 1,000 inhabitants (not including trucks, and not including two wheelers).[40] Japan has only very limited indigenous natural resources. At the same time, the Government of Japan committed to greenhouse gas emission reduction targets under the UNFCCC Kyoto Protocol. Japan thus places great emphasis on enhancing efficiency of energy use and on diversifying energy sources. Since the nuclear reactor accident at Fukushima-Daiichi in 2011 the authorities in Japan also seek to expand the use of alternative sources of energy as a part of a more decentralized energy supply system.

Japan's battery and electric vehicle manufacturers are widely recognized for their technological leadership. In Japan, industry research and product development is often systematically supported by Government programmes. In the early 1990s, the Sony Company was the first to commercially market lithium-ion batteries for use in electric vehicles. In 1997, Toyota successfully introduced the first Prius model and its innovative hybrid technology. Japan's motor vehicle manufacturers were also among the first to develop, test and market BEVs and fuel cell vehicles. Today, almost all of the Japanese motor vehicle manufacturers offer e-vehicles as a part of their product range.

Japan has the second largest fleet of electric cars in the world, comprising of about 45,000 vehicles (including PHEVs). About 25 per cent of the entire global electric car population is registered and operating in Japan. Only in the United States the number of e-car is still larger (about 38 per cent of

37 See: Kumar, Praveen; Dash, Kalyan: Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market, in: Advance in Electronic and Electric Engineering, Volume 3, Number 4 (2013), pp. 471-476. Also online: http://www.ripublication.com/aeee/61_pp%20%20%20471-476.pdf (last accessed 6 November 2014).

38 See: http://www.dnaindia.com/bangalore/report-bangalore-to-get-quick-charging-stations-for-electric-cars-1963458 (last accessed 3 November 2014).

39 Source: http://forbesindia.com/article/auto-expo/electric-cars-hit-by-poor-infrastructure-and-government-inaction/37123/1 (last accessed 6 November 2014).

40 See: http://www.japan.ahk.de/fileadmin/ahk_japan/Publikationen/PDF/Trendbericht_Elektromobilitat_in_Japan_Februar_2014_Klein.pdf, p. 20 (last accessed 3 November 2014).

the global e-vehicle population).[41] According to the Government's e-mobility development targets, PHEVs and BEVs should account for some 15 to 20 per cent of the entire vehicle population by the year 2020. However, in Japan electricity prices are comparatively high and driving distances typically rather short. Hence, it is more difficult for electric vehicle projects to demonstrate their economic viability.

In many Japanese cities, parking spaces are limited, in particular in the inner city areas. According to some reports of 2013, only some 580 parking slots were available on average per 10,000 privately owned cars.[42] Hence, car sharing programmes, including e-mobility car sharing, have rapidly become rather popular. Japanese car sharing programmes currently operate about 8,800 vehicles which are shared by about 290,000 registered users. E-vehicles and e-vans have been successfully deployed as fleet vehicles by various Japanes companies.

In Japan, electric cars rentals are also frequently made available to tourist visitors in various domestic tourist destinations and scenic spots. The Goto Islands of Nagasaki Prefecture and the Hakone area can be regarded as representative examples for this type of e-mobility application.

In 2009, the Nagasaki Prefecture established the Nagasaki EV&ITS Consortium, a collaborative effort by industry, academia and government, to promote EVs and intelligent transportation systems (ITS) throughout the Nagasaki prefecture. The consortium introduced electric vehicles on the Goto Islands located near Nagasaki as a part of an effort to create a truly sustainable local island economy based on local renewable energy sources, and revenues from tourist visitors. Nagasaki Prefecture is also resolved to have the Goto Islands listed as a UNESCO World Heritage Site. A similar concept is being tested and implemented in the Hakone tourist area of Japan in the vicinity of the Fujijama Mountain as well as in other areas.

The Government of Japan and its New Energy Promotion Council are also promoting electric mobility as an integral component of innovative new smart cities, including for Yokohama, Toyota City, Keihanna and Kitakyushu.[43] In Yokohama, pilot projects are testing new technologies for rapid changing of electric vehicles used in car sharing programmes. The new systems interconnect rapid (re)charging stations with electricity storage facilities, the electricity grid and power generation from solar panels. The project seeks to optimize vehicle recharging, taking into account time-of-day variations in customer demand, weather data and time-of-day electricity tariffs. On Yume-shima Island, near Osaka, Sumitomo Corporation is operating one of the world's first power storage systems made entirely from re-used EV batteries. Japan's electric mobility industry is widely expected to continue its leadership in technology and innovations.

(e) Nepal

In Nepal, the use of electricity for transportation already has a considerable history, since the Government of China first supported a 13 kilometer long Trolley Bus system in 1975. During the

---

41 See: http://www.iea.org/publications/globalevoutlook_2013.pdf, p. 4 (last accessed 4 November 2014).
42 Source: http://www.japan.ahk.de/fileadmin/ahk_japan/Publikationen/PDF/Trendbericht_Elektromobilitat_in_Japan_Februar_2014_Klein.pdf, p. 21 (last accessed 7 November 2014).
43 See: http://jscp.nepc.or.jp/en/index.shtml (last accessed 6 November 2014).

1990, when the country experienced some fuel shortages due to trade embargos, small groups of engineers converted some old tricycle vehicles to run on batteries and thereby created the "Safa Tempo", a simple low-cost public transport vehicle which travel up to 60 kilometers per hour and carry up to 10 or 12 passengers. Today, many of the estimated 600 "Safa Tempo" vehicles that operate in the Kathmandu valley are chauffeured by women. Nepal's public transport e-tricycles are thought to be used my more than 120,000 passengers per day, and are seen as a significant alleviation of the Kathmandu's air pollution problem. Like in neighboring Bhutan, electric vehicles in Nepal in principle offer environmentally sustainable transport options, even if Safa Tempo operators face challenges such as rather frequent electric power cuts, increasing electricity costs, low purchasing power of customers, and limited, if any, public funding support. An expansion and improvement of the efficiency in Nepal's electricity generation from hydropower can make electric mobility an even more useful option for public transport.[44]

(f) **Republic of Korea**

Since the late 1960s, the economy of the Republic of Korea has rapidly expanded in a process of industrialization, modernization, increasing globalization and social transformation. The need for transport services has also multiplied. In 2011, average vehicle density in the Republic of Korea stood at 370 vehicles per 1,000 inhabitants (not including two-wheelers).[45]

All cities of the Republic of Korea have very well developed transport infrastructure and high-quality public transport systems and services. The subway system of the greater Seoul metropolitan area is one of the largest in the world, also carrying passengers in record numbers. There are ample inter-city highways, trains and bus links, interconnecting all Korean cities and making passenger travel convenient, fast and affordable. Many of the inter-city roads are toll ways.

Between 1990 and 2012 the number or registered cars has quadrupled. However, the rise in new car registrations and the growth in traffic volumes appear to have leveled off since.[46] Like in Japan, security of energy supply is a top priority concern for the energy and resource import dependent economy of the country. The country's policy makers and engineers are jointly working to continuously improve productivity and resource and energy efficiency. Since the Fukushima accident, the energy companies in Republic of Korea are also more vigorously exploring opportunities to develop indigenous sources of renewable energy.

The Republic of Korea and its automotive, electronics, information technology and chemical industries are world leaders in battery production technology, including lithium-ion batteries for use in electric vehicles. The Republic of Korea is a lead producer and exporter of PHEV and BEV batteries, but production or use of electric vehciles in the domestic market is still rather limited.

---

44 Informantion on "Safa Tempo" in Nepal can be obtained from the following websites: http://indiastreets.wordpress.com/2012/01/20/charina-cabrido-reports-on-safa-tempos-evs-in-nepal/; http://www.cen.org.np/uploaded/EV%20fact%20sheet.pdf; http://www.greentechlead.com/2014/06/20/nepal-ministry-to-announce-electric-vehicle-policy-14577 (last accessed 13 November 2014).

45 Status as of 2011, Source: http://data.worldbank.org/indicator/IS.VEH.NVEH.P3 (last accessed 23 October 2014).

46 See: http://internationaltransportforum.org/Pub/pdf/14IrtadReport.pdf, p. 305 (last accessed 23 October 2014).

One of the first commercially available electric vehicles is the Kia Soul which is also marketed internationally.[47] Thus far, most the other motor vehicle manufacturers seem to be still contemplating the pros and cons of electric mobility. Hence, there are only few companies that are "early adapters"and that anticipate a growing domestic e-mobility market. Government supported projects that aim to introduce e-mobility in taxi and public bus fleets will thus play a key role. In Seoul, the City Government has recently announced a trial and demonstration project with initially 10 pure electric taxis.[48]

(g) Singapore

In the city state of Singapore, population density is very high; 4.6 million inhabitants live on only 650 km^2. The high population density places great challenges for urban and transport planners. However, Singapore has successfully demonstrated a variety of innovative approaches to make urban transport management both, more efficient and more sustainable. Singapore's "best practices" in making public urban transport accessible, efficient, sustainable and affordable are widely recognized, not only in South-East Asia, but also in Europe and other regions. Some 60 per cent of Singapore's residents regularly use urban public transport systems. Since 2005, a part of the public bus system is powered by natural gas.

The Singapore authorities are implementing a tight system of controls to manage the size and the efficiency of the domestic fleet of private motor vehicles. The annual growth of motor vehicle registations is limited to a maximum of 3 per cent. Aspiring owners of private vehicles will first need to obtain by auction a private vehicle registatrion license. In general, such licences only become available if other old cars are decommissioned and their licenses returned. Vehicles that are older than 3 years are not allow to be imported into the country. Emission testing comparable to the Euro II norm is mandatory for all elder motor vehicles. Leaded gasoline is prohibited, and the maximum permissible SOx content in gasoline is 0.05 per cent. In addition, most of the newly built Express- and Motorways are toll roads. With this combination of measures the city of Singapore has one of the lowest levels of urban air pollution in the region.

Singapore also implements special measure to reduce noise pollution from vehicle traffic. Some roads are coated with a layer of special asphalt which reduces the noise from motor vehicles. Noise reduction measures are also implemented on light trains. Some metro cars are fitted with rubber covered wheels.

Singapore offers ideal conditions for the testing and the demonstration of electric vehicles. The city is limited in size, average distances travelled by car aournd the city are not very long, and the overall infrastructure is excellent. In 2011, the transport and energy authorities established the Interagency Electric Vehicle Taskforce (EVTF) which involved some 53 organizations from Singapore and

47 See company website for technical details: http://www.kia.com/eu/future/soul_ev/ (last accessed 23 October 2014).

48 See: http://english.chosun.com/site/data/html_dir/2014/09/01/2014090101238.html (last accessed 23 October 2014).

beyond. During a first demonstration and testing phase the performance of some 89 electric vehicles was tested. The test vehicles included Mitsubishi iMiEV, Daimler smart electric drive, Nissan Leaf and Renault Fluence Z.E, BMW, and other vehicles.[49] The phase 1 of the project has recently been successfully completed, and a follow-up demonstration and text phase has started.

Some mayor investments have also been undertaken in terms of building an EV charging infrastructure around the city. At the time of the preparation of this report more than 100 stations and charging points were already in operation. In terms of research ad development, Singapore's leadership was demonstrated in early 2014 when the „Singapore-MIT-Alliance for Research and Technology" presented a new fully automated vehicle to the public.[50] However, in spite of the successful demonstration and test projects, the interest of private consumers in purchasing an electric vehicle in Singapore has thus far remained very low, in particular due to high EV prices. Vehicle ownership in Singapore is comparatively expensive, also due to high import duties, which are equally applied to EVs.

(h) Sri Lanka

After a period of relative stagnation, Sri Lanka's island economy has resumed economic growth. Sri Lanka has some 20 million inhabitants. Statistics indicate an average motor vehicle density of some 76 motor vehicles per 1000 inhabitants (not including two-wheelers).

Like in neighboring India, motorcycles and other motorized two-wheelers are the prevailing form of private motorized transport. It is estimated that some 1.7 million motorcycles and some 700,000 motor tricycles are currently in operation in the country. An estimated 90 per cent of the population relies on public transport for their transport needs. The railways, as well as most bus systems, are operated by public companies.

Some 28 per cent of Sri Lanka's electricity supply comes from hydropower resources. Other power generation is based on imported fossil fuels. Sri Lanka's Government plans to develop its own oil and gas resources, also to make its transport sector less dependent on imported oil and hydrocarbon products.

The Government plans a significant expansion of the island's road network, which is planned to be expanded from 12,000 to 16,000 km in the nearer future. In addition, H.E. the President of Sri Lanka has announced plans for a „golden era of the public transportation", which would bring more and better public transport services to more areas of the country.

Electric mobility has only very recently been introduced to Sri Lanka, but there are already about 100 electric cars registered. Their number is expected to increase rapidly in the future. Nissan Leaf vehicles are commercially available. Construction of independent e-vehicle charging stations is, however, mostly still in the planning stage. Companies like E Lanka Automotive, as well as the software company Code Gen, and the Lanka Electric Vehicle Association (LEVA) have announced

---

[49] See: http://www.eco-business.com/news/singapore-concludes-electric-vehicle-test-bed-may-conduct-further-trials/ (last accessed 24 October 2014).

[50] See: http://www.eco-business.com/news/driver-electric-car-launched-in-singapore/ (last accessed 30 October 2014).

plans to pro-actively engage in the importation, domestic assembly and distribution of e-vehicles in Sri Lanka in the future. With support provided by the Global Environment Facility (GEF) of the United Nations, LEVA has introduced an electric minibus to Colombo for passenger transport and taxi services.

Amur Leopard, a Chinese company, supports and supplies a local assembly of electic scooters and motorcycles. Increased domestic production and sales of electric two wheelers and tricycles can improve urban and rural mobility without compromising local air quality. Additional policy measures that can support the market penetration of electric two-wheelers, tricycles and small and small e-cars should be considered.

3.3 City initiatives and the role of local authorities

The review of the various countries and case studies has provided ample evidence of the important role of local authorities in the implementation of local sustainable transport policies, including electric mobility demonstration projects. Local municipalities and their agencies have the mandate and the authority over land use planning, and the definition of specific geographical zones, such as inner city air quality protection zones. The same authorities also determine parking rules, availability of parking spaces, as well as other potential additional local economic incentives (or disincentives), and thus hold the key to future progress in successful demonstration and implementation of e-mobility initiatives.

4. Conclusions and recommendations: E-mobility as a next generation solution for clean air and sustainable transport in Asia

Electric vehicle technologies, including battery technologies and drivetrains, have seen significant advances and improvements in recent years. Manufacturing and distribution costs of electric vehicles have also started to gradually decrease, although at the retail level most electric vehicles still remain significantly more expensive than comparable conventional gasoline, diesel, or CNG powered cars. However, electric vehicles can offer significant potential environmental advantages, more especially if the electric power used for battery charging is generated from renewable sources of energy in a sustainable manner. Depending on the relative local costs of motor fuels and electricity, electric vehicles that are used intensively in urban areas on a daily basis, tend to have relatively lower operating costs per kilometer than vehicles which use conventional fuels. In recent years, electric mobility has proven itself in several cases as a commercially viable alternative in specific urban transport applications, such as urban shuttle buses, delivery vans or passenger taxis.

In several countries, including developing countries in Asia, electric two wheelers have rapidly become popular, as they are affordable, easy to operate and can be recharged from any electric outlet without any special recharging infrastructure. E-bicycles and E-scooters offer individual mobility options appreciated by consumers, in particular in locations and in situations where public transport is overcrowded or not available. Electric scooters accelerate well and also offer an environmentally preferable alternative to motorcycles and conventional scooters.

Electric mobility has been successfully tested, demonstrated and introduced in several Asian developing countries. However, electric mobility is still a relatively novel and a niche transport technology and fuel option. Any wider use of electric mobility in Asia in the future will significantly depend on the related government policies.

As presented in the above sections 2 and 3, several governments of the Asia-Pacific region have already established dedicated policies and plans to expand the use of electric mobility. Other countries of the region are, however, still considering potential costs and benefits of the various policy options.

It should be noted that there is no standard "one size fits all" development recommendation on electric mobility and its expanded use in Asia. Asia's developing countries and their national economies (as well as their cities, their local economies and their cultures) differ considerably from one to another. Resource endowments, access to natural resources and capital, policies and regulatory frameworks, economic systems, mentalities and consumer demands, expectations, preferences and purchasing power can also vary, as does the existing transport and energy infrastructure. Policies on electric mobility will therefore always need to be determined by the relevant policy makers and national and local authorities, taking into account the respective local needs and circumstances.

Electric mobility should be seen as a possible additional integral component of transport and infrastructure policies and systems. Any formulation of national development plans and strategies on electric mobility and any eventual policy decision on financial incentives, investments or pilot projects will need to be carefully aligned with pre-existing national, regional or municipal development plans, and will have to be based on integrated planning, taking economic, social, and environmental considerations into account. E-mobility projects or programmes should not be misrepresented or misunderstood as by themselves offering superior "zero emission" solutions. Rational transport policy making needs to be in line with the corresponding energy policies and should be based on long-term comparative life cycle assessments of the various technology options available.

Some countries may be more proactive than others in promoting electric mobility. Proactive support for the development of a local electric mobility service, assembly or component manufacturing industry may be an option of interest, in particular for those countries which already have a diversified manufacturing and/or transport services sector. Today, electric vehicles are produced and marketed not only in Japan and in the Republic of Korea, but also in People's Republic of China, India and Thailand. Other Asian developing countries, including Indonesia, Bangladesh, Nepal, Sri Lanka, and the Philippines, also have local small-scale assemblies of low cost electric vehicle, as well as electric scooters. However, except for People's Republic of China and India, the numbers of domestically produced units in Asia are still comparatively low.

In light of the rapidly growing fossil fuel use in urban transportation and its associated negative impacts on air quality, public health and climate change, Asia's transport policy makers face very challenging tasks and may well have to choose between various transport policy options, such as curbing private motor vehicle use, raising fuel prices, restricting use of old, inefficient and highly polluting vehicles, or other measures. Rapid expansion and improvement of public transport will, however, remain the main key to addressing Asia's urban transport challenge. Promoting electric mobility may offer a new and additional option to alleviate the urban transport challenge, but it can only complement other measures, and not replace them.

Asia's developing countries and their city administrations may wish to further explore options for promoting electric mobility. In this regard, and as a first step, countries and cities in the Asia-Pacific region, which have not yet done so, may wish to consider launching (a) own independent or joint research and study programmes on sustainable transport and electric mobility, together with (b) more active regional and international exchanges of experiences, and (c) the establishment of practical testing, demonstration and pilot projects. Practical project implementation, even on a small scale, can bring significant experiences and in-sights.

Asian developing countries interested in promoting electric mobility may consider and define their own combination of promotional policy measures, which may be based on and could include some, most, or all of the following policy elements:

1) Policy interventions in favour of electric mobility will need to be planned and implemented in an integrated manner taking into account the entire framework of existing transport, energy, environment and urban development policies. Independent electric mobility plans or investments may not achieve the desired results.

2) Promotion of electric mobility will need to go hand in hand with local plans for expanding the use of renewable sources of energy, and promoting efficiency in electricity generation, transmission and distribution systems. Promotion of electric mobility will also need to include measures to ensure the collection and the safe handling, recycling, and/or disposal of used vehicle batteries.

3) Countries which place differentiated trade and import restrictions and/or import duties and tariffs on electric vehicles and/or electric vehicle components and parts (e.g. as luxury goods) may consider an easing or lifting of such trade restrictions.

4) City administrations and other local municipalities may consider (temporary) technical or financial support for e-mobility pilot or demonstration projects. E-mobility in urban areas can serve as a useful integrated component in interconnected multi-modal transport systems.

5) National and local authorities may consider to standardize or to facilitate regulations and

procedures for the registration and licensing of electric vehicles, as appropriate.

6) Electric mobility has proven increasingly popular in public-private partnership programmes such as urban car-sharing and bike-sharing schemes. The relevant authorities may consider to facilitate or to support the scaling up of existing schemes or the replication of such schemes in new locations.

7) Electric vehicles have demonstrated their advantages and proven commercially viable when used in urban passenger transport fleets, such as taxi fleets, urban delivery vans, and in public transportation. Policies and programmes to promote electric mobility may initially focus on specific applications and user groups.

8) Developing countries with industrial capacities for the manufacture or assembly of motor vehicles may consider to provide start-up support for e-mobility related products and projects, in particular for electric two-wheelers, e-tricycles, and micro e-cars.

9) National and local authorities may consider interventions and policy options to restrict the use of highly polluting fuels, engines or vehicles in specific designated inner-city commercial or residential zones. Such measures can provide indirect support to alternative electric mobility options.

10) National and local authorities may consider public information and public education programmes to enhance consumer awareness of electric mobility options. Where they exist, fuel economy labelling programmes should be expanded to include electric vehicles.

National transport policy decision makers and local governments will need to decide if and which types of electric mobility may be appropriate under the respective prevailing local circumstances and conditions, and which types of electric mobility may deserve any direct or indirect support.

Market interventions in favour of electric mobility should demonstrate economic, social and environmental advantages, at least in the intermediate and in the long term. E-mobility projects should be tailored to meet expressed needs and preferences of specific consumer or user groups, and should preferably be modular, so that they can be scaled up easily once successful. Any eventual subsidization in favour of electric mobility projects should only be temporary. It is essential not to inadvertently create expectations or needs for recurrent long-term subsidization of any (private sector) e-mobility projects by public funds.

Expanded use of electric mobility can pose its own challenges for electricity networks. Environmental advantages of electric mobility can only be realized if the share of renewable sources of energy in total power supply is increased significantly. Furthermore, it is essential to plan appropriate vehicle and battery recycling methods and facilities.

The popularization of electric mobility requires the development and dissemination of practical and viable business models and concepts that attract investors and electric mobility service professionals.

Social aspects of image marketing of electric mobility also need to be studied carefully if electric mobility and electric vehicles are to be popularized successfully.

Existing and planned e-mobility projects and initiatives in developing countries of the Asia-Pacific region can significantly benefit from further international networking among e-mobility professionals and from international information exchange and capacity building programmes. The Environmentally Sustainable Transport (EST) Programme of the United Nations Centre for Regional Development (UNCRD) provides a significant contribution in this regard.

Together with partners among national and local governments, as well as the private sector, UN Habitat has recently embarked on a new Urban Electric Mobility Initiative (UEMI) which aims to increase the number of electric vehicles in cities to at least 30 percent of all new vehicles sold on annual basis by 2030, while simultaneously developing the enabling infrastructure for their effective use. Asia's nascent electric mobility industry may consider joining and supporting the UEMI and similar initiatives in the future.

References and sources of additional information

Aguirre, Kimberly; Eisenhardt, Luke; Lim, Christian; Nelson, Brittany; Norring, Alex; Slowik, Peter; Tu, Nancy (2012) (UCLA Advisor: Rajagopal, Deepak): *Lifecycle Analysis Comparison of a Battery Electric Vehicle and a Conventional Gasoline Vehicle* (paper prepared for California Air Resources Board), online: http://www.environment.ucla.edu/media/files/BatteryElectricVehicleLCA2012-rh-ptd.pdf.

Cuenca, R.M., Gaines, L.L., and Vyas A.D. (Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 6043) (1999): *Evaluation of Electric Vehicle Production and Operating Costs*, e-publication: http://www.transportation.anl.gov/pdfs/HV/14.pdf.

Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises, Government of India: *National Electric Mobility Mission Plan 2020,* online: http://natrip.in/download/NEMMP2020.pdf.

Dijk, M., et al., *The emergence of an electric mobility trajectory*. In: Energy Policy (2012), http://dx.doi.org/10.1016/j.enpol.2012.04.024, online: http://www.icis.unimaas.info/wp-content/uploads/2010/05/Electric_Mobility_2012.pdf (accessed December 2014).

Ghent University (UGhent) [De Mol, Johan; Gillis, Dominique; Gautama, Sidharta; Giuseppe Pace, Guiseppe; Semanjskie, Ivana]- E-Mobility NSR North Sea region: *Technical Report on EV Field tests* (10 October 2014), online: http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/info-pool/E-MobilityNSR_WP5._R2.pdf (accessed December 2014).

Helms, H.; Pehnt, M.; Lambrecht, U.; Liebich, A. (2010): *Electric vehicle and plug-in hybrid energy efficiency and life cycle emissions*, Proceedings of 18th International Symposium Transport and Air Pollution, Ifeu – Institut für Energie- und Umweltforschung, Heidelberg, Germany.

International Energy Agency (IEA), Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (March 2010): *Hybrid and electric vehicles: The elctric drive advances,* 362 pages.

International Enegry Agency (IEA), Electric Vehicles Initiative (April 2013) *Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020,* online: http://www.iea.org/publications/globalevoutlook_2013.pdf (accessed December 2014).

Iqbal, Mohammad, Salma Akhter, Salma, and Ahmad Shibbir ( ) *Study on Merits and Demerits of Two Transport Systems: Battery Operated Easy Bike with CNG Operated Auto Rickshaw at Sylhet City in*

Bangladesh, in: IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684 Volume 5, Issue 5 (Mar. - Apr. 2013), pp 25-32, also online under: http://www.iosrjournals.org/iosr-jmce/papers/vol5-issue5/D0552532.pdf (accessed December 2014).

Roland Berger Strategy Consultants – Automotive Competence Center & Forschungsgesellschaft Kraftfahrwesen mbH Aachen (Bernhart, Wolfgang, Schlick, Thomas, Olschewski, Ingo, Thoennes, Markus, Garrelfs, Jens) (2013): *E-mobility index for Q3 2013,* online: http://www.rolandberger.com/media/pdf/Roland_Berger_E_Mobility_Index_Q3_E_20130905.pdf (accessed December 2014).

Sauer, … , Institute for Power Electronics and Electrical Drives (ISEA), RWTH Aachen University, and German co-authors, and Zhou, Rong, China Automotive Technology & Research Center (CATARC) (November 2011) *Analysis and Comparison of Norms and Standards for the Application of Electric Vehicles and Vehicle Batteries in China and Germany/Europe*, Report commissioned as part of the German-China Sustainable Fuel Partnership, online: http://www.dena.de/fileadmin/user_upload/Projekte/Verkehr/Dokumente/GCSFP_Study_EV-Norms_and_Standards.pdf (accessed December 2014).

Tagscherer, Ulrike; Frietsch, Rainer (February 2014): *E-Mobility in China - Chance or daydream?* Fraunhofer ISI Discussion Papers, Innovation Systems and Policy Analysis, ISSN 1612-1439, Karlsruhe, Germany, online: http://www.isi.fraunhofer.de/isiwAssets/docs/p/de/diskpap_innosysteme_policyanalyse/discussionpaper_40_2014.pdf (accessed December 2014).

United Nations Department of Economic and Social Affairs (UN DESA) (prepared by Earley, Robert, Kang, Liping, An, Feng, and Green-Weiskel, Lucia, The Innovation Center for Energy and Transportation (iCET), Beijing, Los Angeles, New York (2011) *Electric vehicles in the context of sustainable development in China,* United Nations Background Information Paper for 19th session of UN Commission on Sustainable Development (CSD19/2011/BP9), online: http://www.un.org/esa/dsd/resources/res_pdfs/csd-19/Background-Paper-9-China.pdf (accessed December 2014).

United Nations Habitat; Action Platform on Urban Electric Mobility, online: http://unhabitat.org/action-platform-on-urban-electric-mobility-initiative-uemi/ (accessed December 2014).

United States Environmental Protection Agency (2011): *New Fuel Economy and Environmental Labels for a New Generation of Cars*, online: http://www.epa.gov/otaq/carlabel/regulations.htm (accessed December 2014).