

LOW CARBON BUSES IN CHINA AND  
E-MOBILITY OPTIONS FOR DEVELOPING-MEMBER  
COUNTRIES OF ADB

中国的低碳公交和亚行发展中成员国的电动交通方案

KI-JOON KIM

Principal Transport Specialist

Climate Change and Sustainable Development Department

Asian Development Bank

首席交通专家

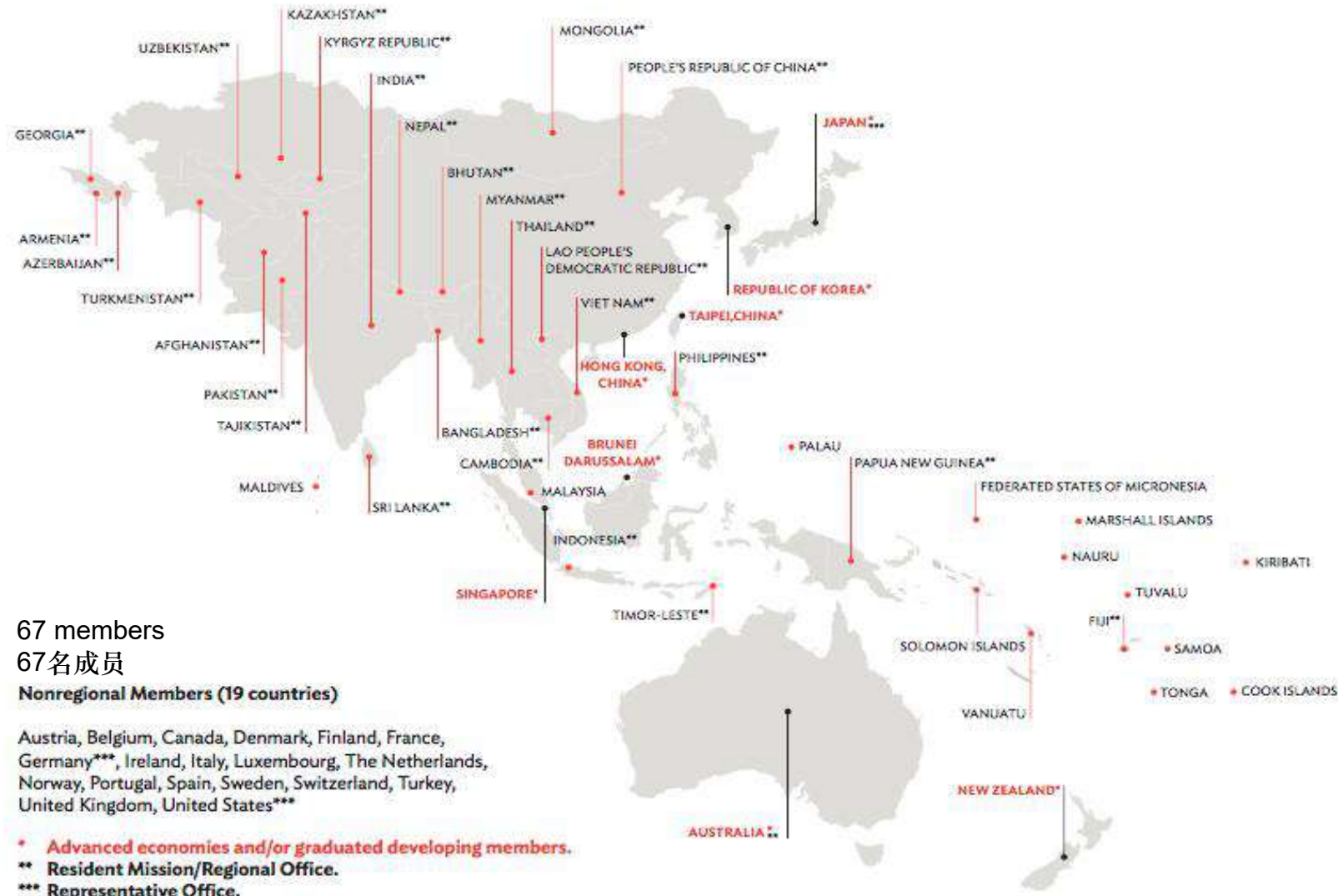
可持续发展和气候变化局

亚洲开发银行

WWW.ADB.ORG

KJKIM@ADB.ORG

# Asian Development Bank (ADB) 亚洲开发银行



67 members

67名成员

**Nonregional Members (19 countries)**

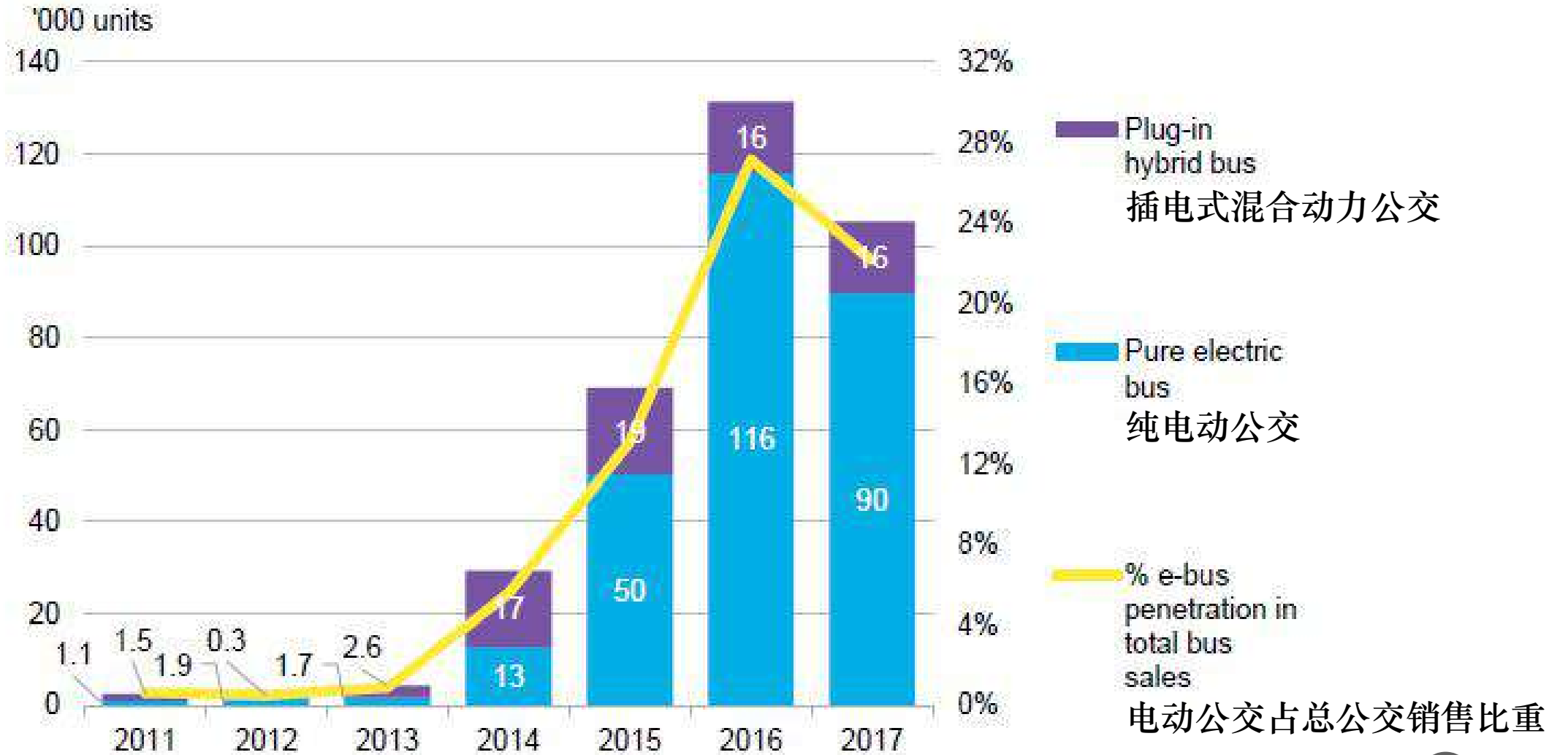
Austria, Belgium, Canada, Denmark, Finland, France, Germany\*\*\*, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States\*\*\*

\* Advanced economies and/or graduated developing members.

\*\* Resident Mission/Regional Office.

\*\*\* Representative Office.

- International development finance institution
- Dedicated to reducing poverty in Asia and the Pacific through loans, grants, research and technical assistance to its member countries, as well as investments in private companies.
- Lending \$25B in 2017
- 国际开发金融机构
- 致力于通过向其成员国提供贷款, 赠款, 研究和技术援助, 并投资私营公司, 以减少亚洲及太平洋地区的贫困。
- 2017年提供贷款250亿美元
- 总部位于菲律宾马尼拉

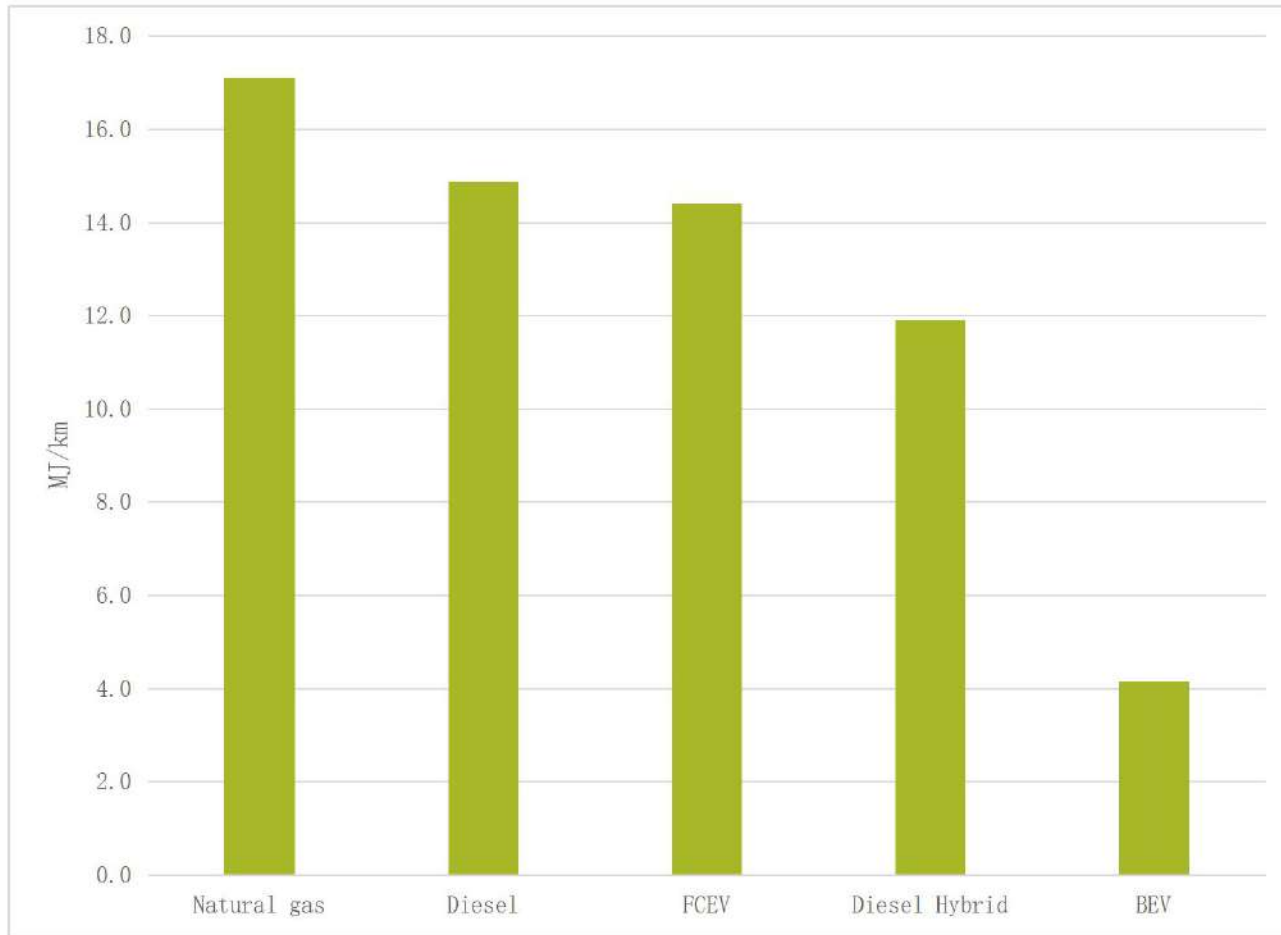


# Plug-in Hybrids and BEBs Dominate 插电式混合动力公交和纯电动公交占主导



- Plug-in hybrids basically 10-12m but also 18m
- Diesel, CNG and LNG plug-in hybrids
- BEBs basically 6 / 8 / 10/ and 12m
- Majority electric buses are BEBs plus some trolleybuses; few opportunity charge systems
- 插电式混合动力充电公交车一般10-12米，有的18米
- 柴油、压缩天然气、液化天然气插电式混合动力公交车
- 纯电动公交车基本6/8/10/12米
- 大多数电动公交车是纯电动公交车，加上一些无轨电车; 机会充电系统很少，基本没有

# Performance LCBs 低碳巴士性能



天然气

柴油

燃料电池电动

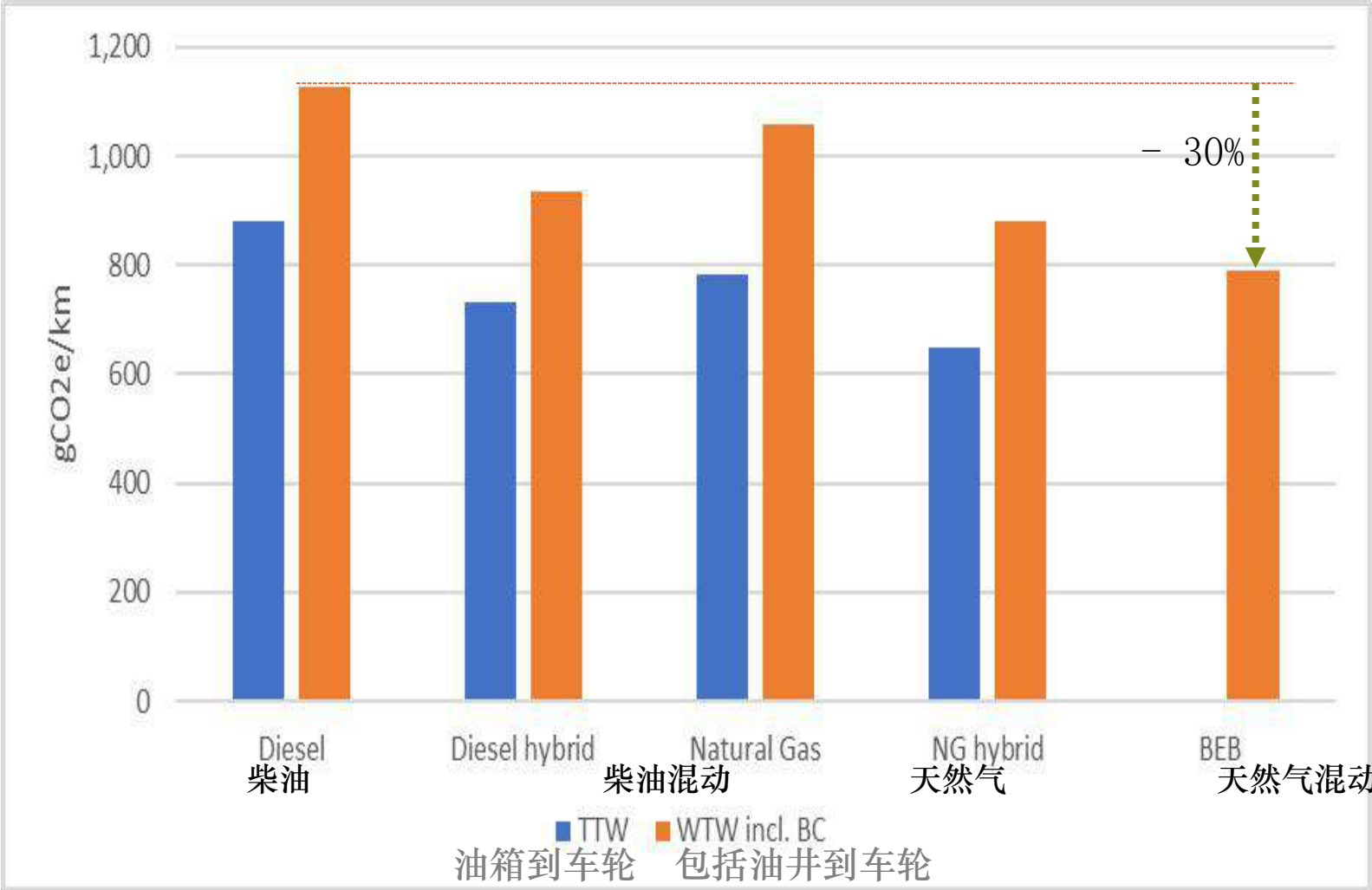
柴油混动

纯电动

## Energy usage 12m urban bus 12米城市公交能耗

- Hybrids 20% less fuel consumption
- Plug-in hybrids are not re-charged and thus operate as hybrids
- BEBs use 3-4 times less energy than diesel or natural gas units
- 混合动力公交能耗少20%
- 插电式混合动力车并未重新充电，因此可视为混合动力车
- 柴油或天然气公交能耗是纯电动公交的3-4倍

# GHG Emissions 温室气体排放



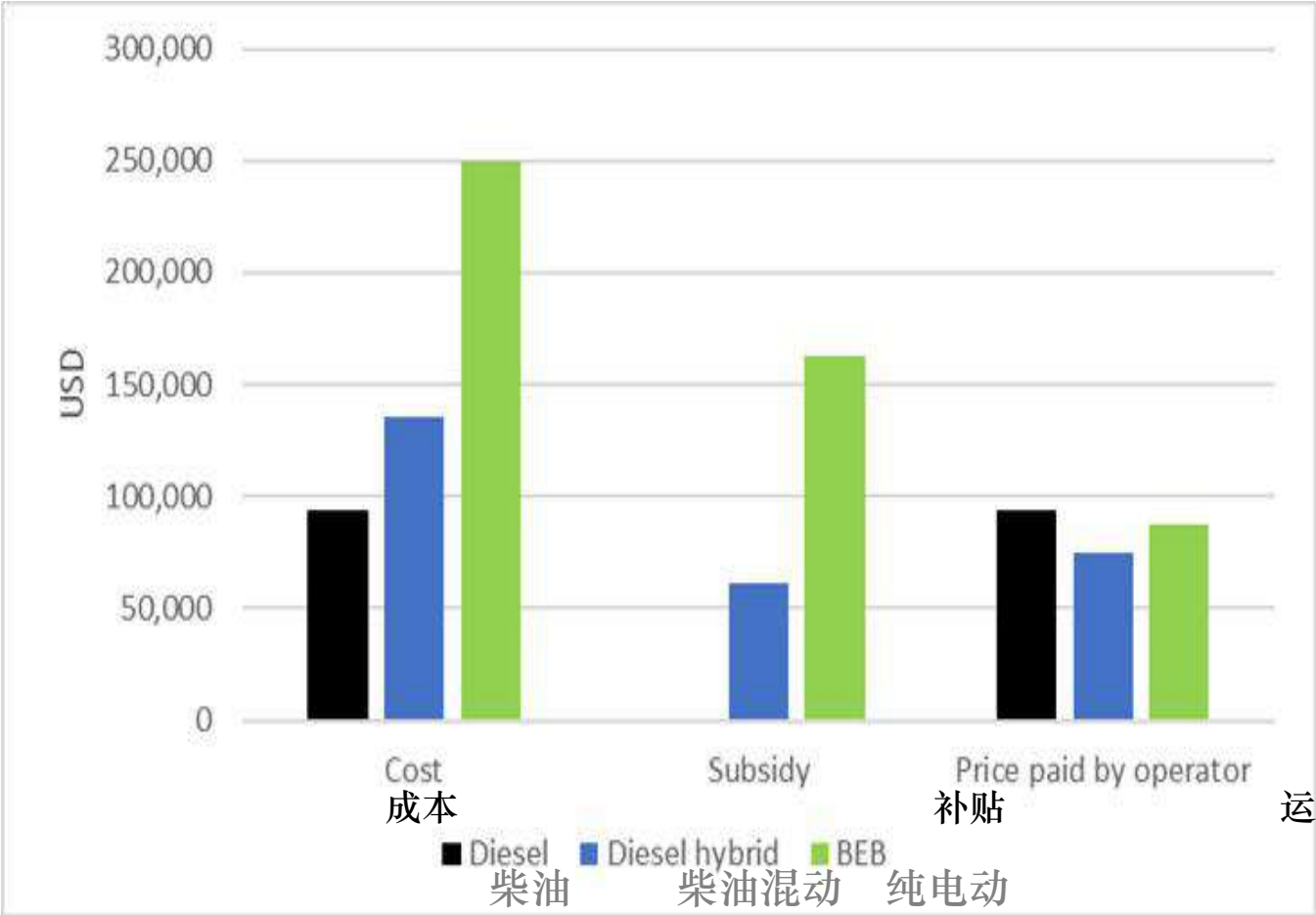
- GHG emissions 12m urban bus with Chinese average grid emissions included under well-to-wheel emissions
- 12米城市公交温室气体排放量，按照油井到车轮排放计算，包含中国平均电网排放因子

# Electric Bus Technology 电动公交技术

- Electric trolleybus are not very frequent
- Opportunity charge only few systems
- Basically BEBs with battery set of 150–200 kWh for 12m bus and slow charging at night plus fast charging during the day
- Many cities operate fast chargers of up to 400 kW with charging times of 10–30 minutes
- Battery swap is no longer used due to costs
- Battery guarantee today is for 8 years or 500,000km and 80% SOC
- Battery recycling is made as well as 2<sup>nd</sup> life of battery in stationary applications
- Buses in PR China are used in general 8 years, 400–500,000km
- 无轨电车未广泛使用
- 机会充电系统很少
- 基本上12米纯电动公交车的电池组为150–200千瓦时，夜间慢速充电，白天快速充电
- 许多城市的快速充电桩功率高达400千瓦，充电时间为10–30分钟
- 出于成本原因，不再更换电池
- 现今电池可以保质8年或50万公里，保持80%荷电状态
- 电池回收利用以及固定式应用给旧电池带来新生

# Economics of BEBs 纯电动公交车的经济性能

12米城市公交  
12m urban bus



- 20-30% lower maintenance cost but fleet size dependent
- 5-30% lower availability but manufacturer dependent
- Total cost of ownership of BEBs in PR China still higher without subsidies
- 降低20-30%的维护成本，但取决于车队规模
- 可用性降低5-30%，但取决于制造商
- 没有补贴，中国的纯电动公交车总体拥有成本仍然较高

运营商支付费用



# EV Market Overview 电动交通工具市场概述

## EVs

- By 2017: 3 million electric and plug-in hybrid cars in the world
  - 80% of all EVs being sold just in 3 countries: People's Republic of China (PRC), the USA and Norway.
- By 2020 : 4.5 million EVs could be sold i.e. around 5% of the global passenger car sales
- By 2030 : EV will reach over 20% of global vehicle sales.

## Chargers

- In 2017 : around 3 million chargers installed
  - 330,000 units were publicly available slow or fast chargers (2/3<sup>rd</sup> slow and 1/3<sup>rd</sup> fast chargers).

## e 2-Wheels

- The PRC dominates the electric 2-wheeler market : estimated at 200-230 million units.
- Other countries in Asia with notable shares of electric 2- and 3-wheelers include Bangladesh, India, Nepal and Vietnam.

## 电动车

- 至2017: 全球300万辆电动和插电式混合动力车
  - 80%的电动车销量集中在3个国家: 中国、美国和挪威
- 至2020: 电动车销量可达450万辆, 约占全球乘用车销量的5%
- 至2030: 电动车将占全球汽车销量的20%以上

## 充电桩

- 2017年: 安装了约300万个充电桩
  - 33万个充电桩是对公众开放的慢速或快速充电桩 (2/3慢速充电桩, 1/3快速充电桩)。

## 电动自行车

- 中国在电动自行车市场占主导地位: 估计保有量达2到2.3亿辆。
- 亚洲其他电动2轮和3轮车保有量较大的国家有孟加拉国, 印度, 尼泊尔和越南。

# EV Market Overview 电动交通工具市场概述

## e-Buses

- In 2017 : 400,000 electric buses operating, with 99% of the total located in the PRC.
  - E-buses in the PRC made up around 17% of the total bus fleet
  - 22% of new bus sales, many cities will have 100% e-buses within the next few years.

## e-Trucks

- Electric trucks only circulate in small numbers, but electric urban delivery trucks have recently surged as a viable alternative
- After 2025 light and medium duty electric trucks could start to penetrate the market massively, Heavy Duty Trucks will following later

## e-Vessels (Boats)

- Still in experiment/pilot stage, Small boats have more opportunities

## 电动公交

- 2017年：服役中的电动公交达40万辆，其中99%在中国。
  - 中国的电动公交约占公交车队总数的17%
  - 占新公交销售的22%，许多城市将在未来几年内100%使用电动公交。

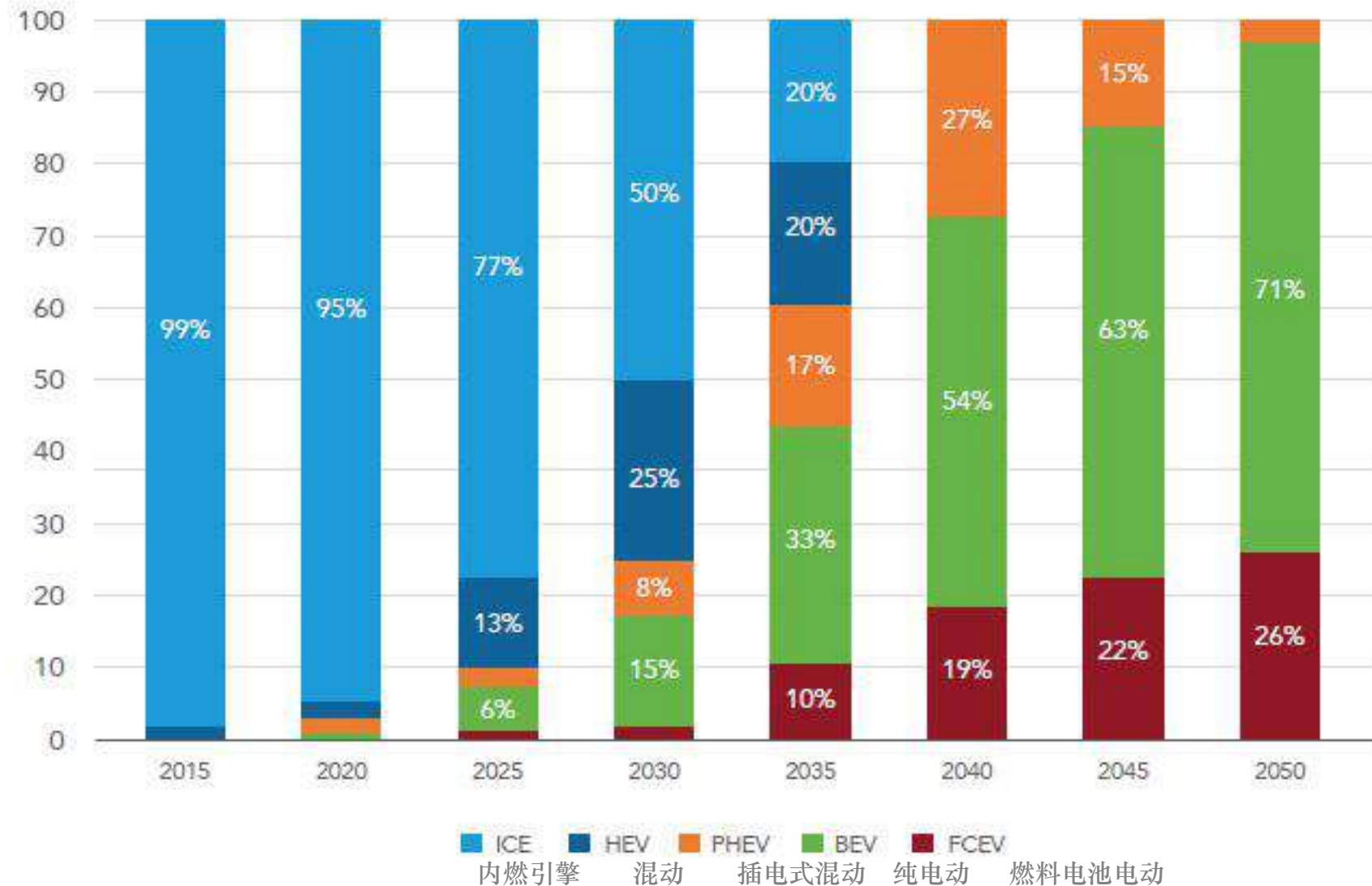
## 电动卡车

- 电动卡车使用量小，但最近电动城市货运卡车成为可行的替代方式
- 2025年之后，轻型和中型电动卡车将开始大规模进入市场，重载电动卡车将在之后推出

## 电动船舶

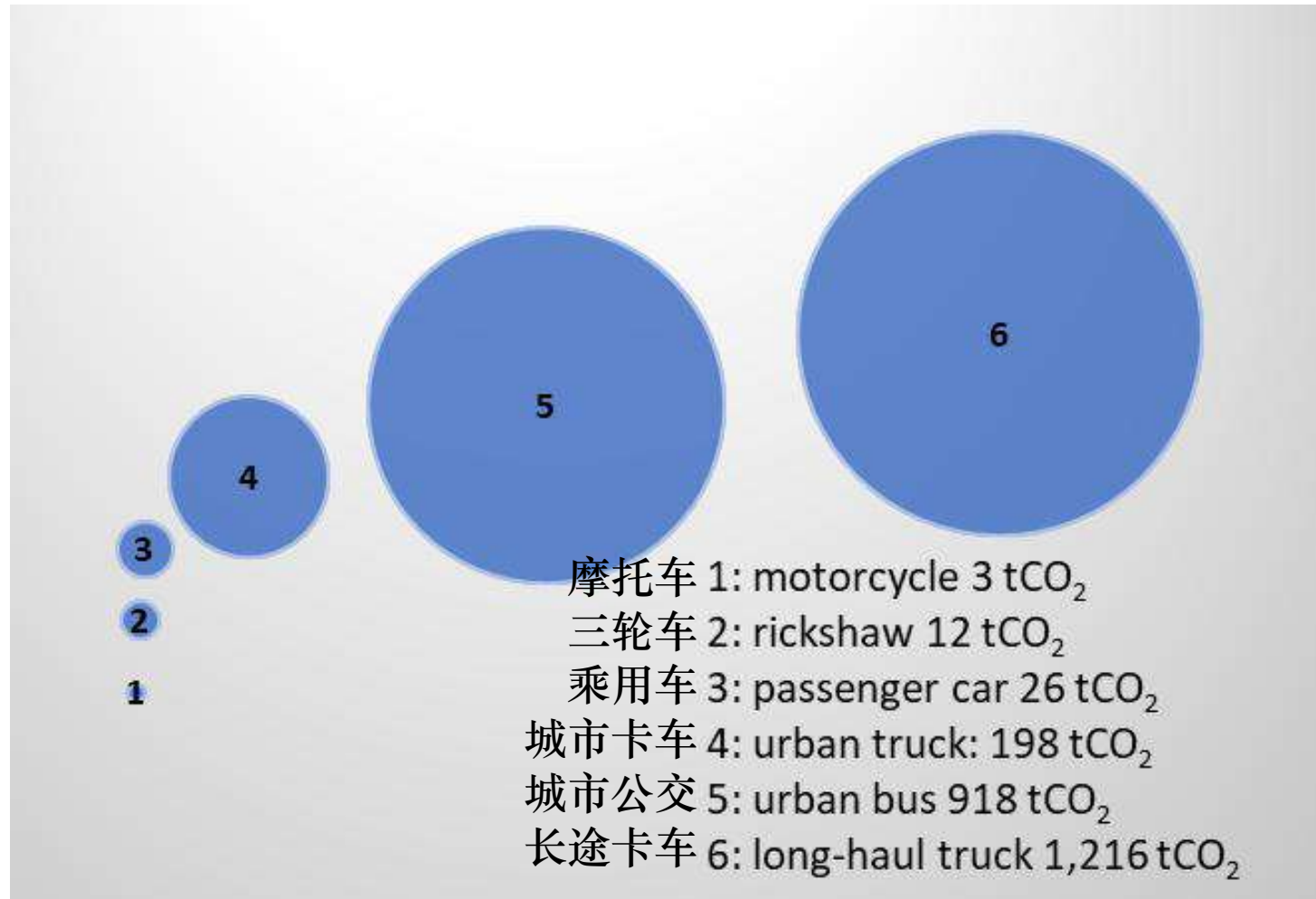
- 仍在实验/试行阶段，小型船只更有希望

# Projected Vehicle Sales per Powertrain 按动力系统计算的预计车辆销售额



Source来源: Harrison 2018

# CO<sub>2</sub> Emissions of Fossil Vehicles 化石燃料交通工具二氧化碳排放量

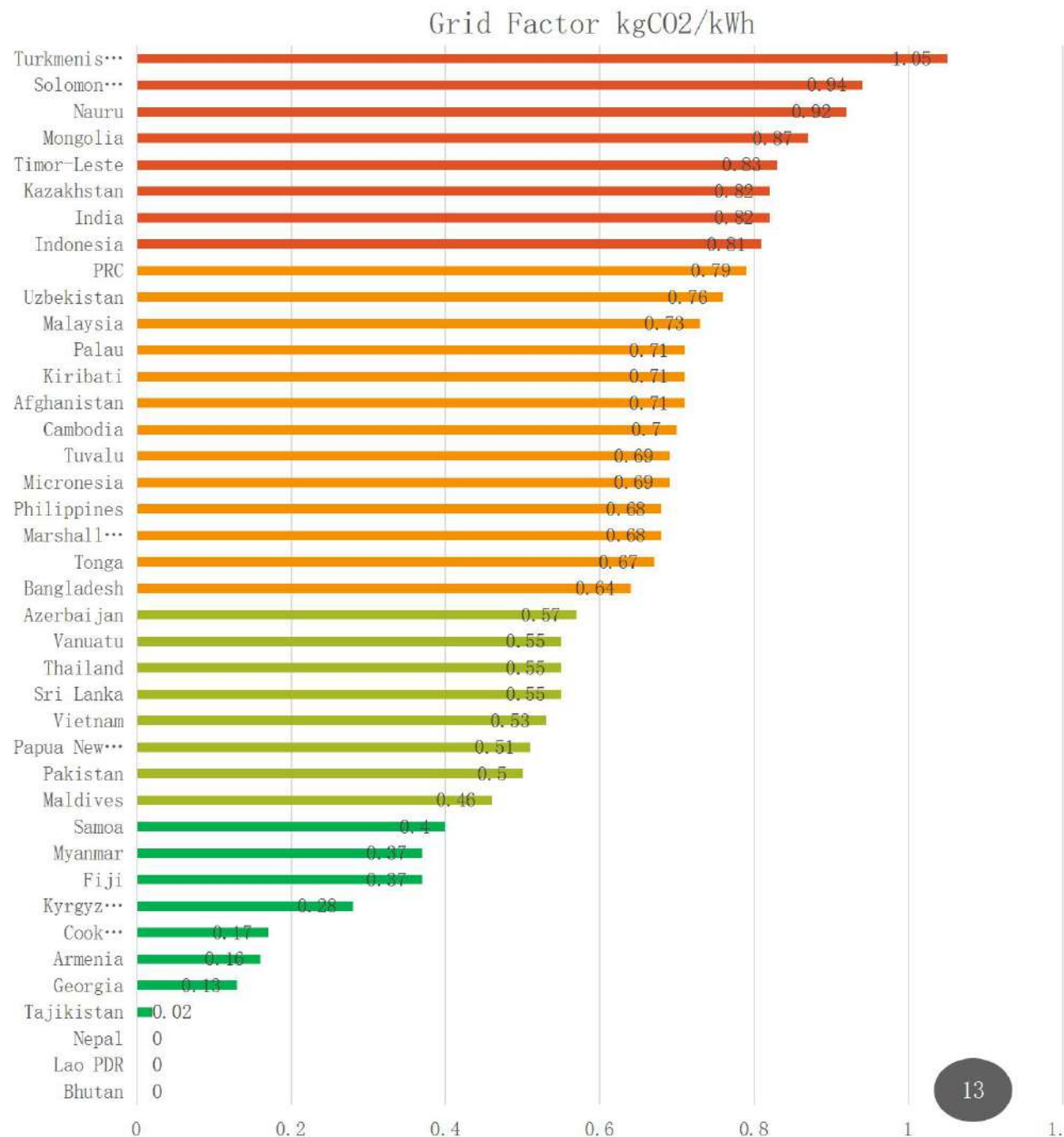


- Replacing 1 diesel bus with an electric unit has the same impact as replacing 35 passenger cars or 300 motorcycles
- 用1辆电动公交替换1辆柴油公交车等同于替换35辆乘用车或300辆摩托车

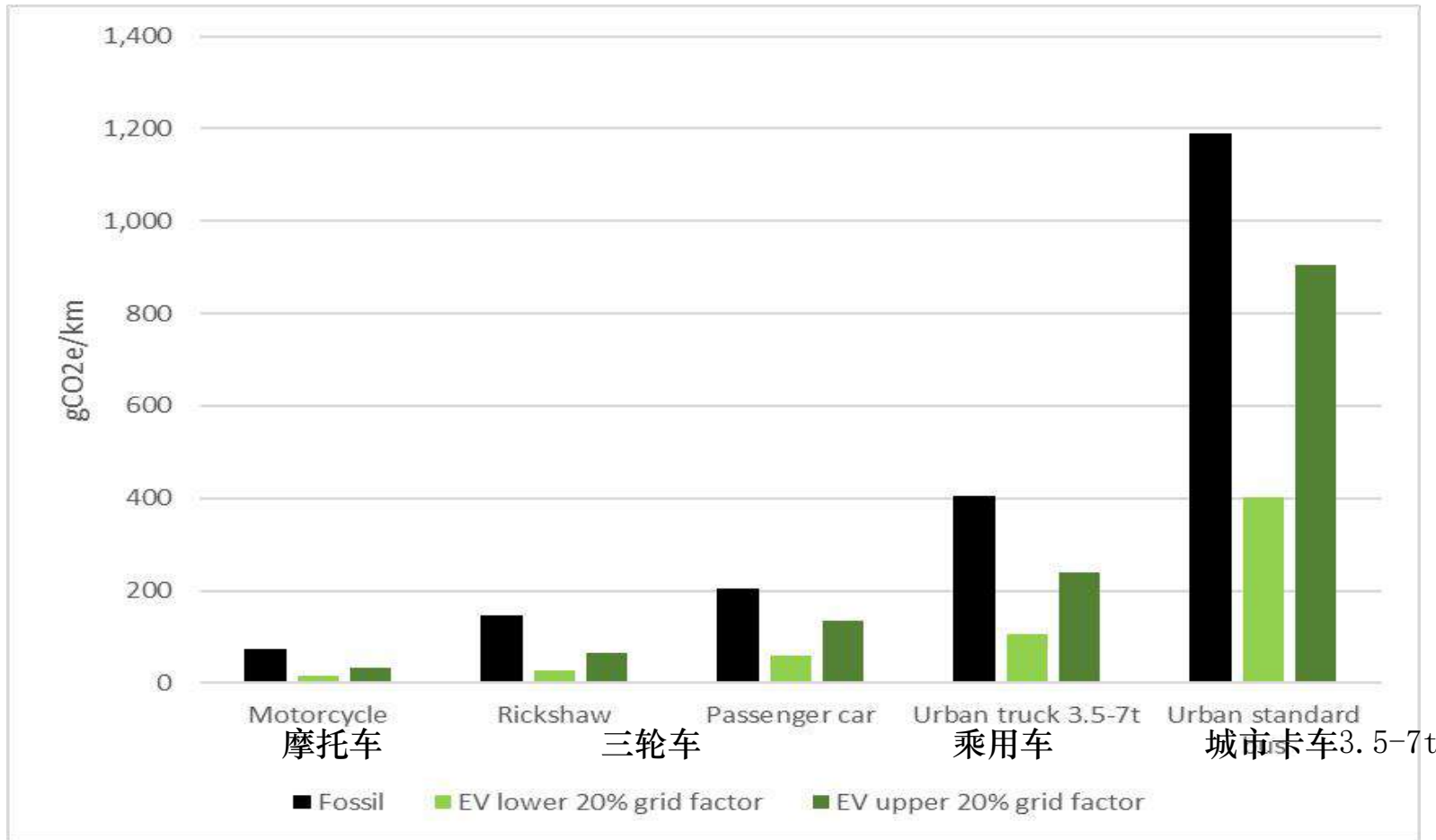
# Grid Factor : ADB MDCs

## 电网因子：亚行发展中成员国

- EVs have lower GHG emissions than fossil comparable vehicles up to a grid factor of **1.2** kgCO<sub>2</sub>/kWh
- 电网因子低于**1.2**kgCO<sub>2</sub>/kWh，电动车的温室气体排放量低于可比化石燃料车
- EVs will result in significant GHG reductions if the grid factor is below **0.8** kgCO<sub>2</sub>/kWh.
- 如果电网因子低于**0.8**kgCO<sub>2</sub>/ kWh，电动车可显著减少温室气体排放。



# EVs and CO<sub>2</sub> Emissions 电动车和二氧化碳排放



- **Facts:**
- EVs reduce CO<sub>2</sub> emissions even in countries with highly fossil grids
- If the grid is > 0.8 kgCO<sub>2</sub>/kWh greening the grid first is imperative to reap substantial CO<sub>2</sub> impacts
- **事实:**
- 即使在高度依赖化石燃料发电的国家，电动车也能减少二氧化碳排放
- 如果电网因子 > 0.8 kgCO<sub>2</sub> / kWh，首先必须绿化电网，才能显著减少二氧化碳排放

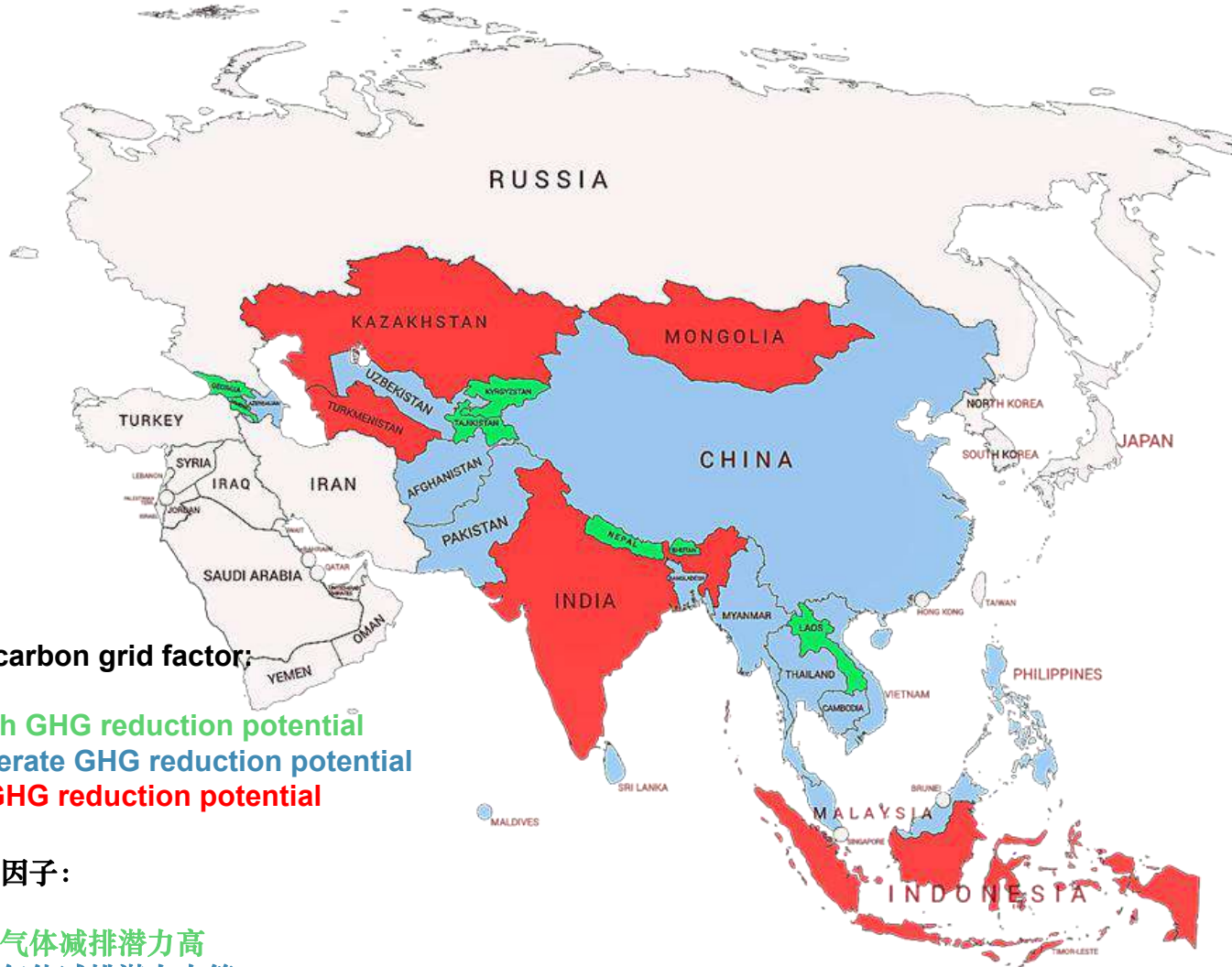
Grid factor lower 20 percentile of DMCs: 0.35 kgCO<sub>2</sub>/kWh

Grid factor upper 20 percentile of DMCs: 0.79 kgCO<sub>2</sub>/kWh

电网因子最低的20%发展中国家: 0.35kgCO<sub>2</sub>/kWh

电网因子最高的20%发展中国家: 0.79kgCO<sub>2</sub>/kWh

# GHG Reduction Potential with EVs 电动车温室气体减排潜力



Based on carbon grid factor:

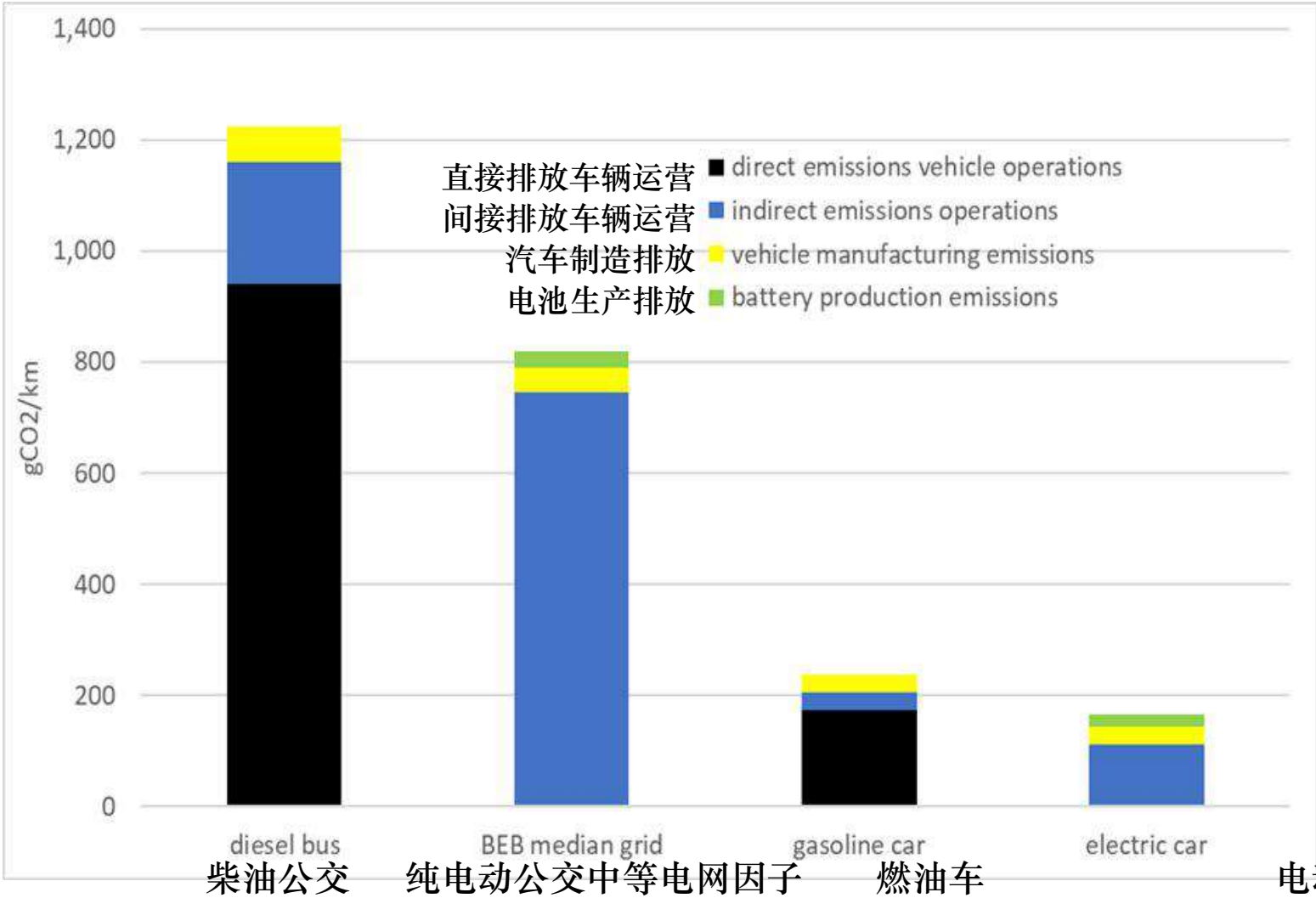
Green: high GHG reduction potential  
Blue: moderate GHG reduction potential  
Red: low GHG reduction potential

按照电网碳因子:

绿色: 温室气体减排潜力高  
蓝色: 温室气体减排潜力中等  
红色: 温室气体减排潜力低

- Largest GHG impact by EVs: high share of renewable electricity - Armenia, Bhutan, Georgia, Kirgizstan, Laos, Tajikistan and Nepal
- Countries with a high carbon factor in electricity production - India, Indonesia, Kazakhstan, Mongolia and Turkmenistan will only result in limited GHG reductions by deploying EVs.
- 电动车对温室气体排放的影响最大: 可再生能源比重大 - 亚美尼亚, 不丹, 格鲁吉亚, 吉尔吉斯斯坦, 老挝, 塔吉克斯坦和尼泊尔
- 发电碳因子较高的国家 - 印度, 印度尼西亚, 哈萨克斯坦, 蒙古和土库曼斯坦部署电动车减少的温室气体排放有限。

# Life-Cycle Emissions 生命周期排放



- EVs are much greener than fossil vehicles also when including life-cycle emissions
- 考虑生命周期排放时，电动车也比化石燃料车更环保



## Other Benefits of EVs 电动车的其他优点

- Lower air pollution levels (NO<sub>x</sub>, PM, SO<sub>2</sub>): this is especially relevant for cities
- Air pollution impact depends on current vehicle and fuel emission standards
- Less noise: On average 50% lower noise level compared to fossil unit
- 空气污染少（氮氧化物，PM，二氧化硫）：这对城市尤为重要
- 空气污染影响取决于当前车辆和排放标准
- 噪音更低：与化石燃料车相比，噪音水平平均低50%

## Major Policy Options 主要政策方案

- Subsidies or fiscal benefits (reduced tax) → fiscal benefits in general favor private vehicles
- Charging infrastructure and electric price subsidies (public goods partially) e.g. no power charge; subsidized public fast chargers
- Set EV targets e.g. 10% of bus fleet electric by 2020
- Use non-financial incentives e.g. 10% more points in public biddings if EVs are offered; free parking; unrestricted city access; new routes reserved for BEBs; new taxi licenses reserved for Evs
- 补贴或财政优惠（减税）→ 财政优惠一般倾向私家车
- 充电基础设施和电价补贴（部分公共产品），例如不收电费；补贴公共快速充电桩
- 设置电动车目标，例如到2020年，公交车队10%为电动公交车
- 使用非财务奖励，例如如果提供电动汽车，公开招标积分增加10%；免费停车场；市区无通行限制；为纯电动公交车保留新路线；为电动车预留新的出租车许可证

# Policy Actions 政策行动

Focus	焦点
- high-mileage vehicle	高里程车辆
- cities	城市
- large fleets	大型车队



Optimize	优化
- charging infrastructure	充电基础设施
- battery policy	电池政策
- green your grid	绿化电网

- reduce fossil fuel subsidies	激励机制
- creative incentive package	减少化石燃料车补贴
- include non-financial	创建激励方案
	加入非财政激励



## Examples for EV Policy Options 电动车政策方案示例

- Focus on buses: leasing systems, large fleets, optimized charging system
- Focus on urban trucks: preferential access to urban areas, leasing system, delivery trucks
- Option for motorcycles: regulated phase out of fossil units - economic incentives are costly and will not work well; do not go for low-cost lead based units
- Option for 3-wheelers: ditto motorcycles; ask the question if you really need 3-wheelers except for last-mile connectivity (e-pedicabs)
- Focus on cities with investments in smart public fast chargers which can be used by buses, urban trucks and taxis
- If grid is carbon intensive link with PV panel on rooftops of charging stations, bus depots, bus stations
- 专注公交车：租赁系统，大型车队，优化充电系统
- 专注城市卡车：城区优先卡车使用的区域，租赁系统，货运卡车
- 摩托车可选择：逐步淘汰化石燃料摩托 - 经济激励措施成本高，且效果不佳；避免使用基于低成本的摩托车
- 三轮车可选择：同上；除了最后一公里的连接，是否真的需要三轮车（电动三轮）
- 投资城市智能公共快速充电桩，可供公交车，城市卡车和出租车使用
- 如果电网碳排放高，可连接充电站，公交总站，公交车站屋顶的太阳能板

# EV Study Reports by ADB (Dec. 2018) 亚行电动车研究报告 (2018年12月)

**Sustainable Transport Solutions:  
Low-Carbon Buses in the People's Republic of  
China  
October 2018**

[Chapter 1. Low-Carbon Bus Technologies](#)  
[Chapter 2. Environmental Performance of Low-Carbon Buses](#)  
[Chapter 3. Financial Performance of Low Carbon Buses](#)  
[Chapter 4 Low-Carbon Bus Promotion Policies](#)  
[Chapter 5. Challenges for the Future](#)  
[Chapter 6. Conclusions and Recommendations](#)  
[APPENDIX 1: Methodological Aspects](#)  
[APPENDIX 2: Low-Carbon Bus Incentive Schemes](#)

**可持续交通解决方案：  
中国的低碳公交  
2018年10月**

[第1章 低碳公交技术](#)  
[第2章 低碳公交的环境效益](#)  
[第3章 低碳公交的经济效益](#)  
[第4章 低碳公交推广政策](#)  
[第5章 未来的挑战](#)  
[第6章 结论和建议](#)  
[附录1：方法](#)  
[附录2：低碳公交激励方案](#)

# EV Study Reports by ADB (Dec. 2018) 亚行电动车研究报告 (2018年12月)

## E-Mobility Options for Developing- Member Countries of ADB

### 亚行发展中成员国的电动交通方案



Includes:

- Market and technology overview
- Environmental impact
- Finance
- Policies
- Case studies in Asia: buses in PR China, car-sharing in Singapore, motorcycles in Taiwan, 3-wheelers in Nepal
- Country/city potentials for specific vehicle categories e.g. buses in Yerevan/Tbilisi, 3-wheelers in Dhaka/Udaipur, urban trucks in Bangkok, cars in Fiji etc.

包括:

- 市场和技术概述
- 环境影响
- 金融
- 政策
- 亚洲案例研究: 中国公交, 新加坡共享汽车, 中国台湾摩托车, 尼泊尔三轮车
- 国家/城市特定车辆类别的潜力, 例如埃里温/第比利斯的公交车, 达卡/乌代布尔的三轮车, 曼谷的城市卡车, 斐济的汽车等。

# Further EV Study by ADB (2018-2019)

## 亚行进一步的电动车研究（2018-2019）

### Electric Mobility Policy and Strategy for ADB DMC Cities (18 Countries 23 Cities)

#### 亚行发展中成员国城市电动交通政策与战略 (18个国家23个城市)

- Short overview of relevant national EV, energy and transport policies;
- Identification of actors within the city involved in EV promotion;
- Prioritization of an EV intervention strategy for the city based on identified criteria (cost effectiveness, environmental impact, policy priority, level of influence);
- Identify possible business models and financial structuring options;
- Outline of the proposed EV strategy including actions to be realized, environmental impact, grid impact, potential business and financial models, potential involvement of local industry, required resources, and timeline.
- 简述相关国家电动车、能源和运输政策；
- 明确城市内推动电动车使用的参与者；
- 根据既定标准（成本效益，环境影响，政策优先级，影响程度）确定城市电动车干预战略的优先顺序；
- 确定可能的商业模式和财务结构方案；
- 提议的电动车战略概要包括需要实施的行动，环境影响，电网影响，潜在商业和财务模型，当地行业的可能参与，所需资源和时间表。