Accelerating the popularization of electric and plug-in hybrid vehicles for realizing a low-carbon society in Japan

Smart Cities - A Convergence of People, Technologies and Big Data

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CRIEPI

(Central Research Institute of Electric Power Industry)

AVP, Materials Science Lab.

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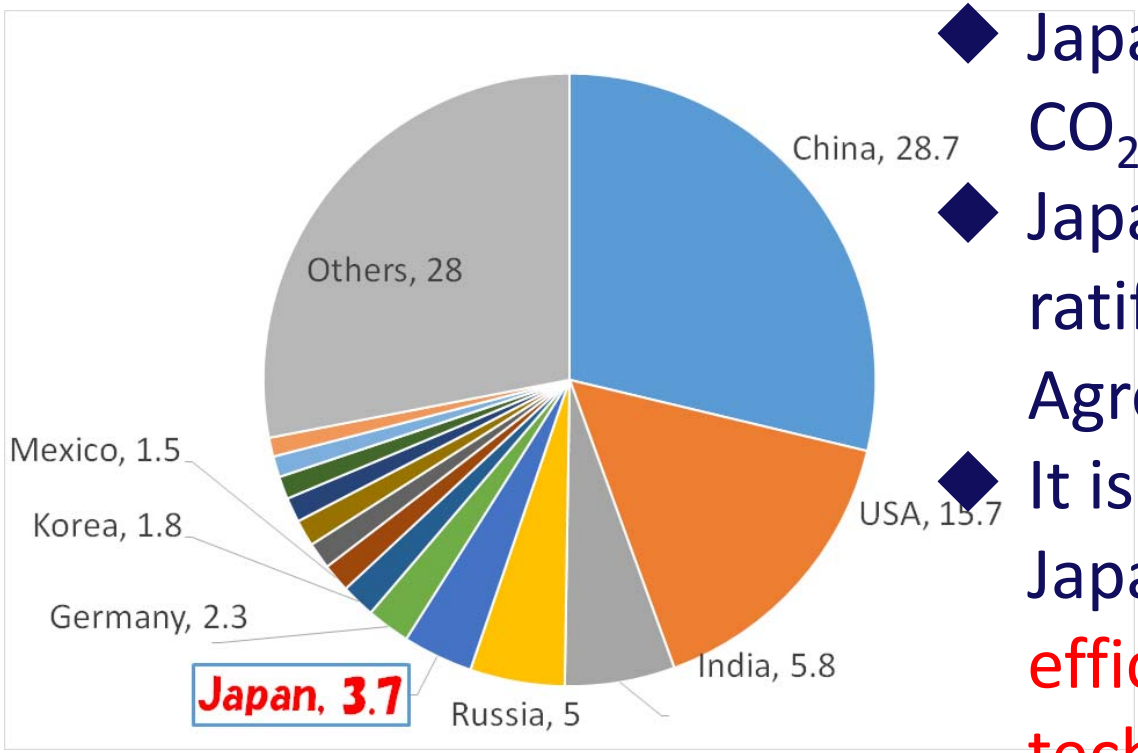
Outline

1. Background: Realizing a low-carbon society
2. Popularization of electric vehicles (EVs) and plug-in hybrid vehicles (PHVs) in Japan: Japanese government action
3. Obstacles to popularizing EVs & PHVs
4. Summary

1. Realizing a low-carbon society

- Energy storage is essential for a resilient and efficient power grid.
- Carbon dioxide (CO_2) emissions from power supply systems and energy demand must be reduced.
- Renewable energy power generation often provides a low-carbon but unstable electric power supply.
- Combining low-carbon electric power and high-efficiency electric technologies enhances CO_2 emission reductions.

Share of CO_2 emissions by country



- Japan emits about 4% of CO_2 emissions worldwide.
- Japan is expected to ratify in the Paris Agreement quickly.
- It is important to transfer Japanese high-energy-efficiency, low-carbon technologies worldwide.

Reduction targets for CO_2 emissions in various sectors in Japan

(set in July 2015, before the COP21 meeting)

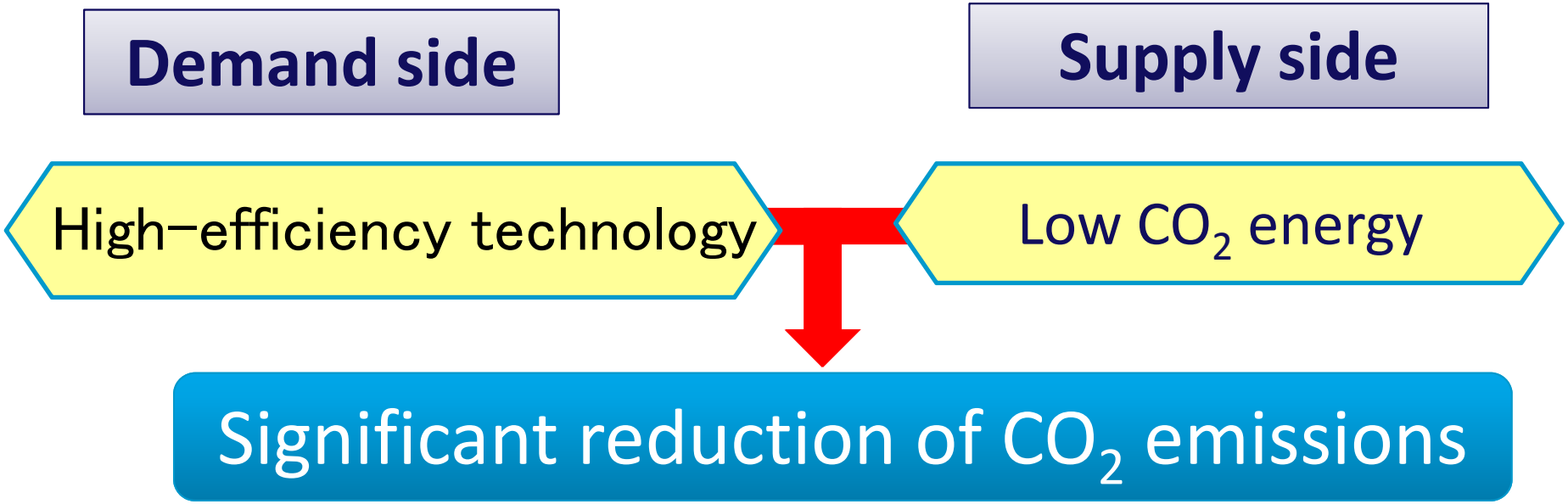
		Emissions target in 2030 (M ton-CO_2)	Estimated emissions in 2013 (M ton-CO_2)	Emission reductions (M ton-CO_2)	Reduction ratio (%)
CO_2 emissions from energy sources		927	1235	308	25%
	Industrial	401	429	28	7%
	Commercial and others	168	279	111	40%
	Residential	122	201	79	39%
	Transportation	163	225	62	**28%**
	Energy conversion	73	101	28	**28%**

- Emissions in the transportation sector are expected to be reduced by 28%. Popularization of the next-generation vehicles should be accelerated by improvements in energy efficiency to reduce CO_2 emissions.

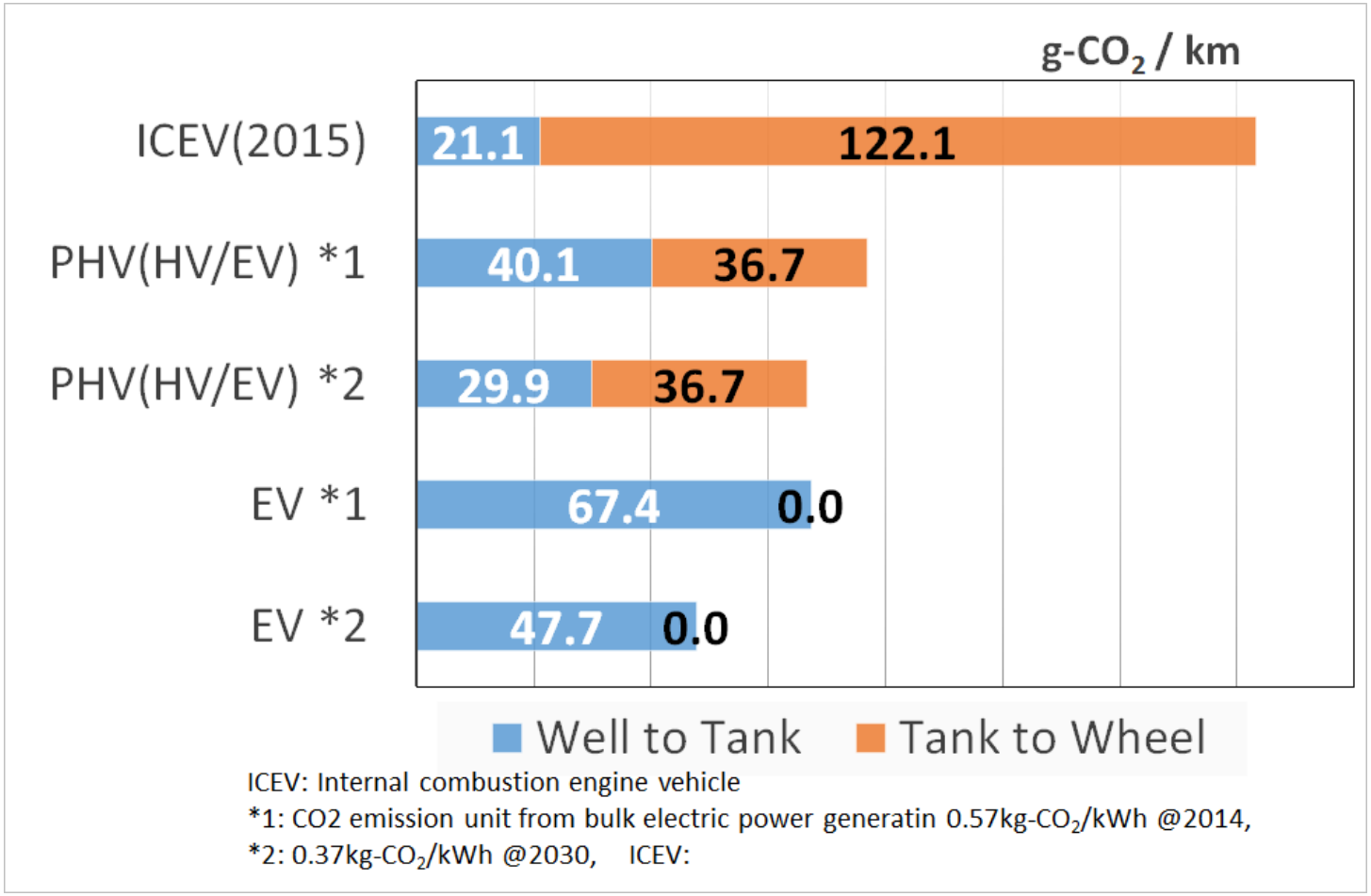
Realization of a low-carbon society

① Use of low-carbon electricity

② Use of energy-saving technologies



Well-to-Wheel comparison of CO_2 emissions from ICEVs, PHVs and EVs

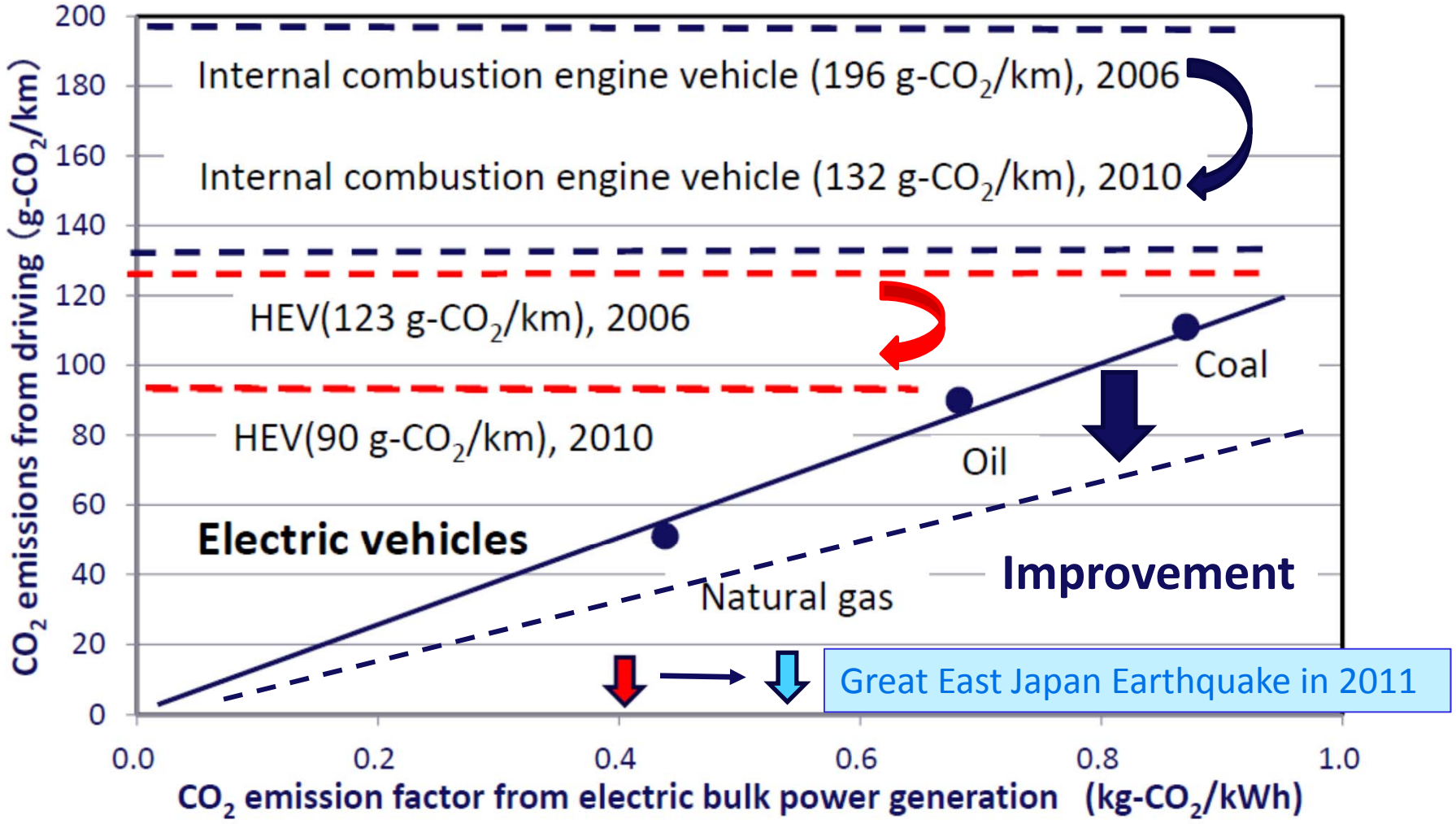


ICEV: Internal combustion engine vehicle

*1: CO2 emission unit from bulk electric power generatin 0.57kg-CO_2/kWh @2014,

*2: 0.37kg-CO_2/kWh @2030, ICEV:

CO_2 emissions reduction by combining high-efficiency technologies and low-carbon power generation



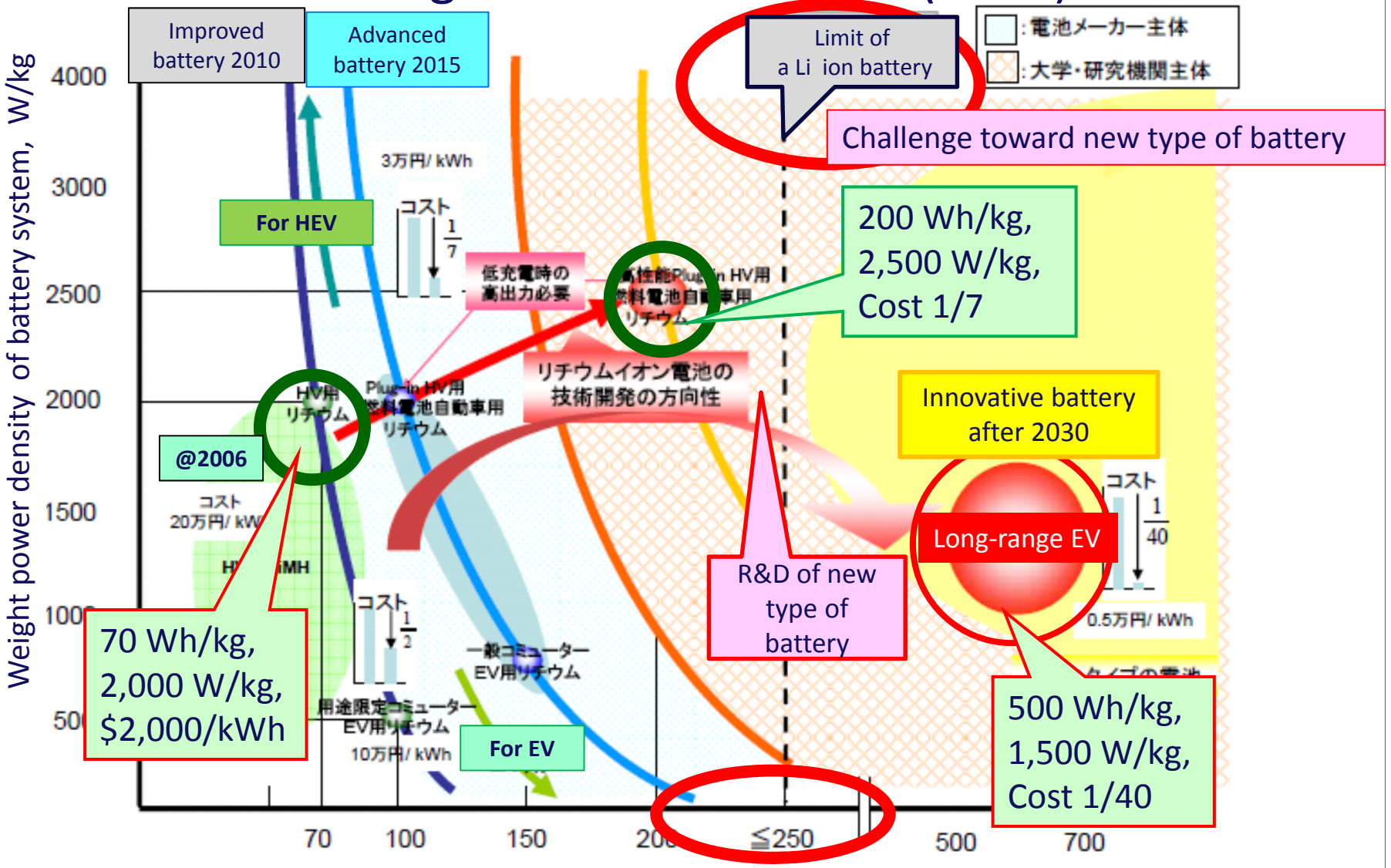
2. Popularization of EVs and PHVs in Japan

- Nissan and Mitsubishi have been selling “LEAF” and “iMiEV” EVs since 2010.
- The total number of EVs has surpassed 140,000 in Japan. The number of quick charging stations and normal charging stations has surpassed 5,500 and 8,500 in cities, as of August 2016.
- The Japanese government would like to accelerate the popularization of EVs and PHVs to reduce CO_2 emissions.
- CRIEPI has been cooperating in activities promoted by the government in various fields.

Japanese government actions for EVs & PHVs

- "EV & PHV roadmap" published in March 2016
- "Model planning to install charging infrastructure on roads and in cities" for quick-charging stations published in 2013
- "Guidelines for installing charging equipment at residential housing and parking lots for EVs and PHVs" for normal-charging published in 2010
- "R&D roadmap for high-performance secondary battery for next-generation vehicles" published in 2006

“R&D roadmap for high-performance secondary batteries for next-generation vehicles” (2006)



METI/自動車課「次世代自動車用電池の将来に向けた提言」(2006.8)より

Publication of Japan's "EV-PHV roadmap" (March 2016)

News Release

経済産業省
Ministry of Economy, Trade and Industry

Ministry of Economy, Trade and Industry, Japan

March 23rd, 2016

電気自動車・プラグインハイブリッド自動車の普
「EV・PHV ロードマップ」をとりまとめました

幅広い関係者で構成される「EV・PHV ロードマップ検討会」では、電気自動車（EV）やプラグインハイブリッド自動車（PHV）の普及に向けて必要な車両と充電インフラ等が連携した戦略を検討してまいりました。今般、検討結果が「EV・PHV ロードマップ」としてとりまとめられましたので、公表します。

METI summarized the EV-PHV roadmap towards the spread of EVs and PHVs. According to the EV-PHV roadmap, which was created by a committee composed of a wide range of stakeholders, we must consider a strategy of coordinating vehicles and charging infrastructure to support the popularization of EVs and PHVs.

http://www.meti.go.jp/press/2015/03/20160323002/20160323002.html

Summary of the EV-PHV roadmap (1)

The roadmap addresses the following main issues: vehicles, charging infrastructure, application of EVs and PHVs to vehicle-to-everything (V2X), and cooperation with local government.

Vehicles

- The percentage of EVs PVs in new car sales will be increased to 20%-30% by 2030.
- **An ambitious target has been set: reaching a maximum of 1 million units in 2020**, from the current cumulative sales 140,000 units.

Summary of the EV-PHV roadmap (2)

Charging infrastructure

- **En route charging** Much of the charging equipment is ready. To dispel concerns about a lack of charging facilities, charging equipment should be installed in prominent locations such as a roadside station and highway service areas, based on the best proposals in the model plan.
- **Destination charging** For convenience, charging equipment should be installed for large-scale parking lots to attract customers. By 2020, 20,000 charging points should be installed.
- **Basic charging at apartments** Chargers for apartments are not yet available, although about 40% of citizens live in this type of housing. Installing charging points in apartments is important for accelerating EV and PHV uptake.
- **Basic and destination charging at workplaces** Installing charge points at workplaces will encourage the spread of EVs and PHVs.

Summary of the EV-PHV roadmap (3)

Application of EVs & PHVs to V2X

- EVs and PHVs parked at home and work can be used as energy storage systems to stabilize the power grid and to smooth power demand. EVs and PHVs can be used as virtual power plants (**VPPs**).
- EVs and PHVs can be used for backup power supply in the event of a power outage. EVs and PHVs can supply electric power to a home for several days.

Cooperation with local government

- It should be made easy for local governments to incorporate EVs and PHVs into plans to reduce global warming.
- More active cooperation with local governments will be encouraged at the “EV and PHV town promotion” meeting held by METI.

Definition of chargers

(classification of charging infrastructure and its roles)

Type	Definition	Roles	Purpose	Places
Public charging	Available for all vehicles	**En route charging**	• Avoiding running out of charge during long-distance journeys • Quick chargers are often used.	• Highway service and parking areas • Stations on the way • Convenience stores • Car dealerships
		Destination charging	• Charge while parked at the destination. • Cheaper normal chargers are often used.	• Accommodations • Large-scale shopping centers
Private charging	Available for some vehicles	**Basic charging**	• Charge at parking lots of the vehicle owner's home and workplace. • Basic chargers are often used with AC 200V.	• Detached houses • Apartments • Workplaces

Guidelines for installing charging equipment at residential housing and parking lots for EVs & PHVs (2010)

- **Normal charging:** AC 100/200V, 3 kW. Dedicated plugs required for EVs.
- Ministry of Economy, Trade and Industry (METI), and Ministry of Land, Infrastructure, Transport and Tourism (MLIT) unveiled guidelines for normal charging infrastructure (http://www.meti.go.jp/press/20101207002/20101207002-2.pdf)

- **Quick charging**: DC 500V, -50 kW.

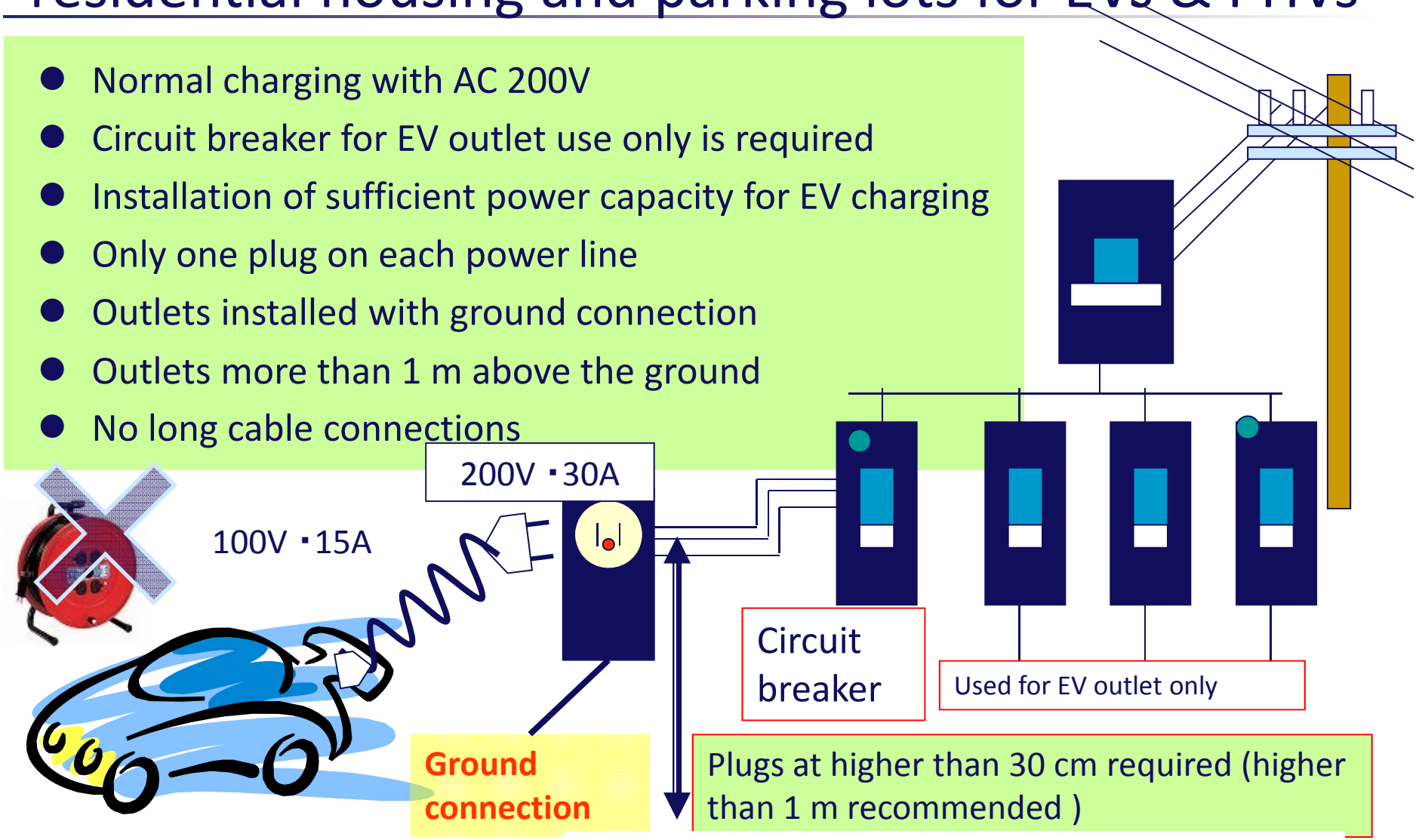
CHAdeMO is the standard for DC quick chargers.

"CHAdeMO" is a trade name of a quick charging method that the CHAdeMO Association is proposing as a global industry standard.

(http://www.chademo.com/jp/index.html) (CHAdeMO Association for EV quick charging infrastructure standards)

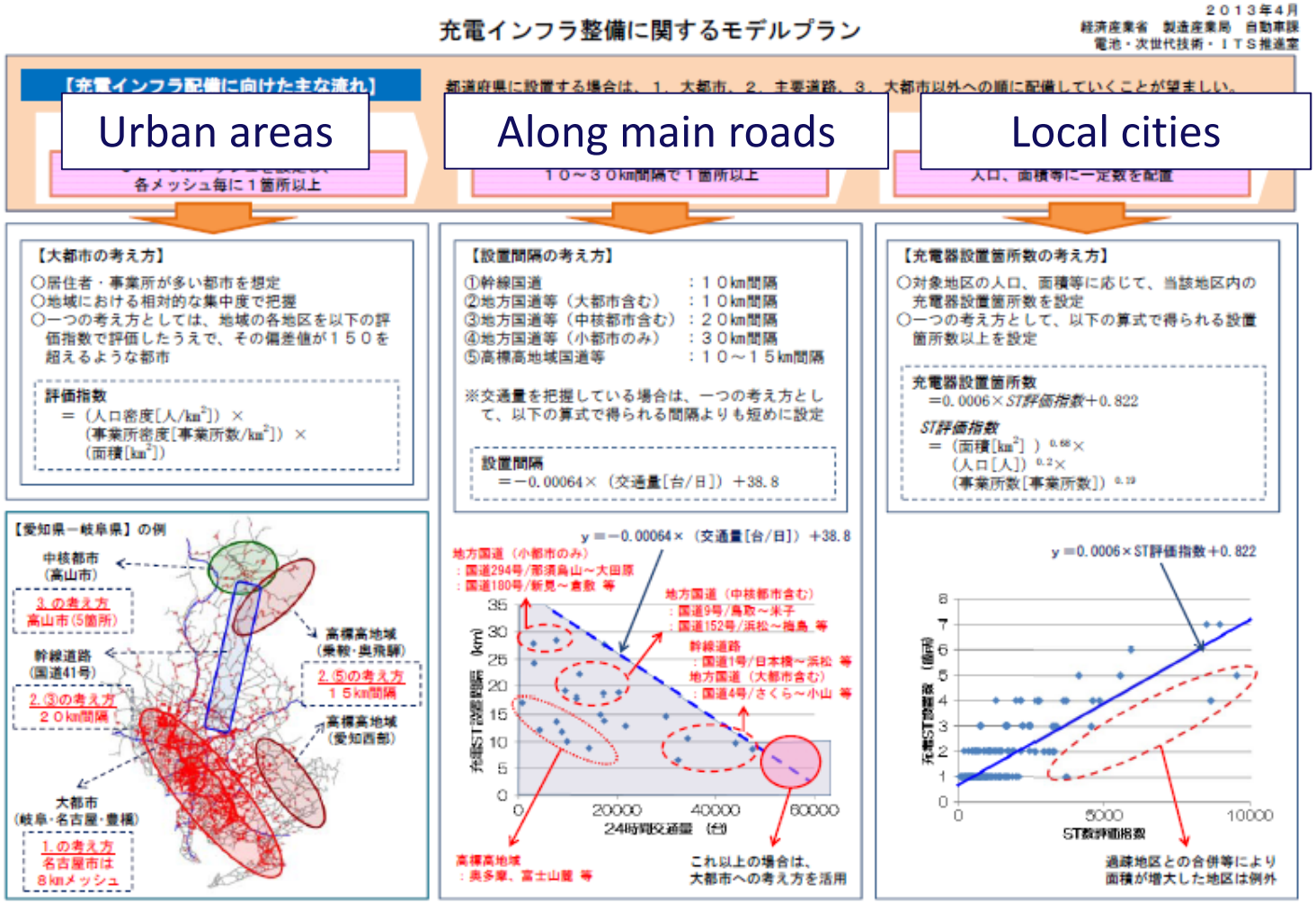
Guidelines for installing charging equipment at residential housing and parking lots for EVs & PHVs

- Normal charging with AC 200V
- Circuit breaker for EV outlet use only is required
- Installation of sufficient power capacity for EV charging
- Only one plug on each power line
- Outlets installed with ground connection
- Outlets more than 1 m above the ground
- No long cable connections



（T. Iwatsubo: **CRIEPI Report** M09006）

Model planning to install charging infrastructure on roads and in cities (2013)



（注）本モデルプランは、「クリーンエネルギー自動車等導入促進対策費補助金」の交付を受けて、一般社団法人次世代自動車振興センターが一般財団法人電力中央研究所に委託した「充電ステーション最適配置に関する解析調査」を元に、経済産業省が作成したものです。当該調査結果はある前提をおいた上で電欠発生率を最小化するために実施したシミュレーションに基づくものであり、本モデルプランを満たしていても必ずしも実際は電欠率がゼロとなるとは限らない点にご注意ください。
また、1つのシミュレーション結果に基づくものに過ぎないため、これ以外の考え方を否定するものではありません。

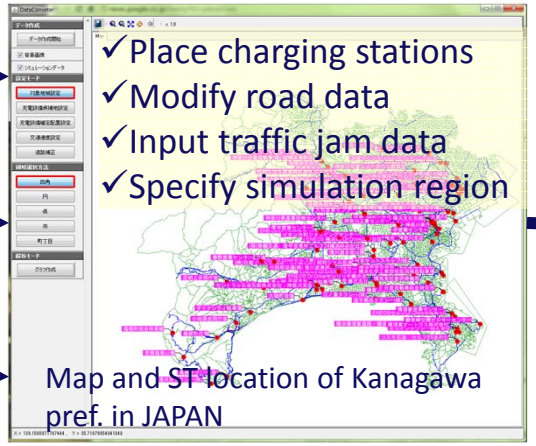
The EV-OLYENTOR © traffic simulator with multiple layers to analyze locations of quick charging stations for EVs

First layer: Pre-post tool

Map database
(Digital Map25000, etc)

Traffic data
(Traffic census etc.)

Census data
(e.g., employees, business facilities.)



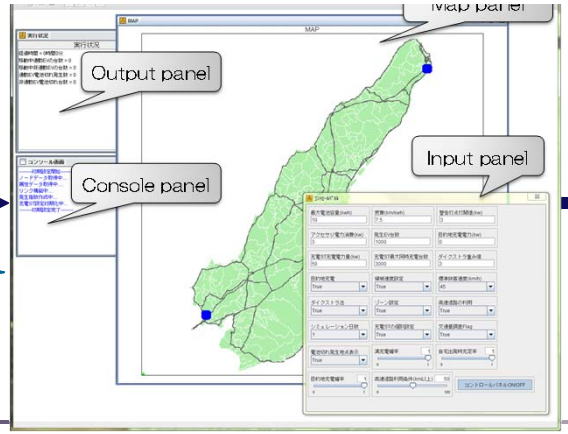
Input files
(Excel CSV files)
- Road map data
- Charging station data
- Trip data
- Traffic jam data
- Census data (e.g., employees, business facilities)

This system is developed under "artisoc@" (Kozokeikaku Engineering Inc.)

Display results

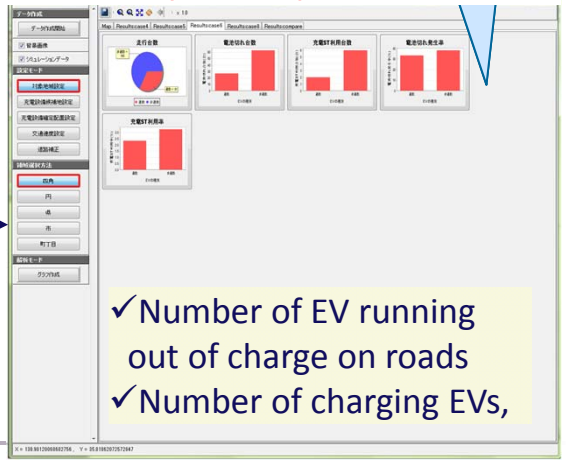
Set up input files for traffic simulator

Second layer: Traffic simulator



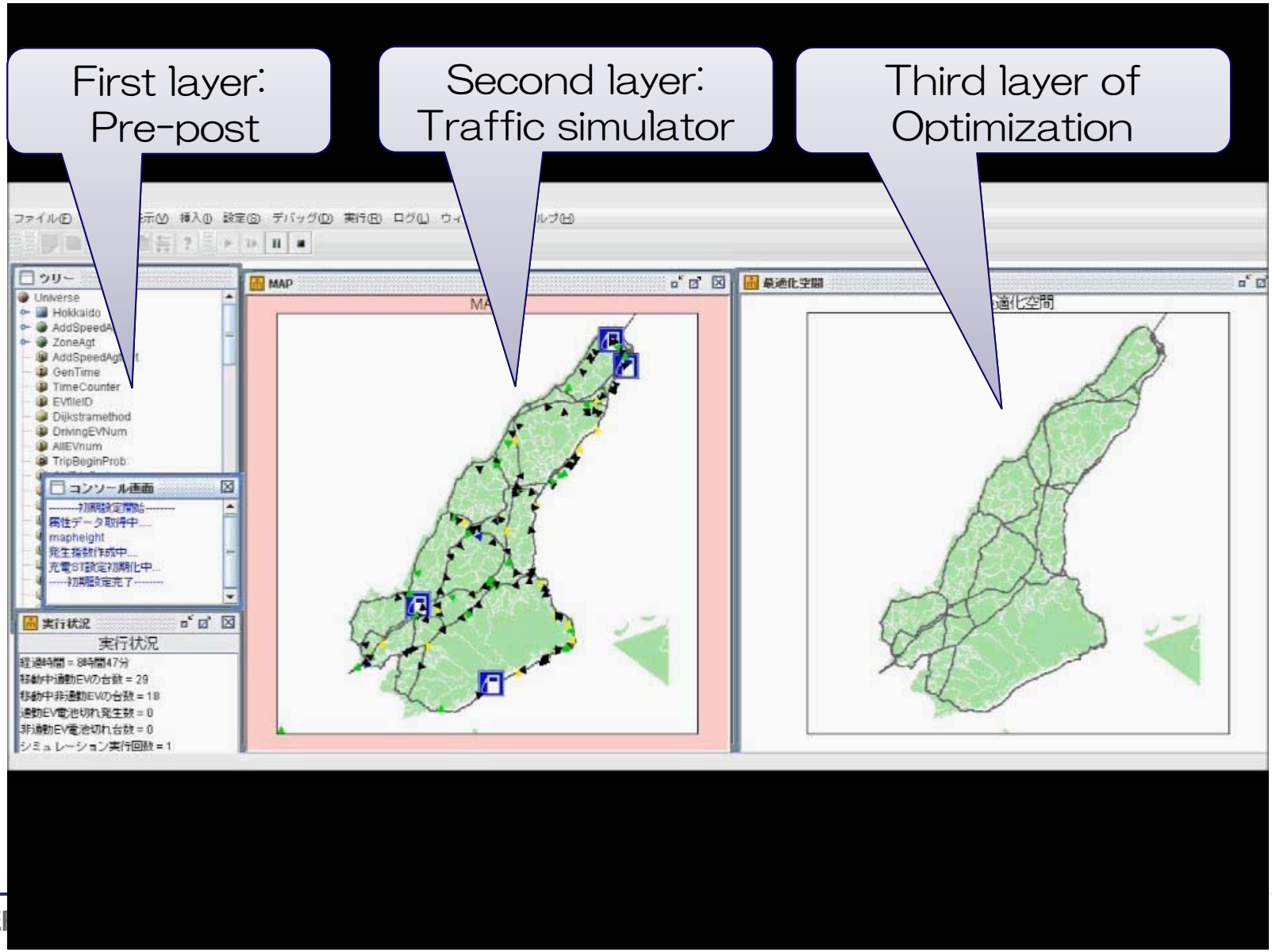
EV traffic simulation and optimization of location of quick charging stations

Third layer: Optimization



✓Number of EV running out of charge on roads
✓Number of charging EVs,

“EV-OLYENTOR ©“ with multiple layers



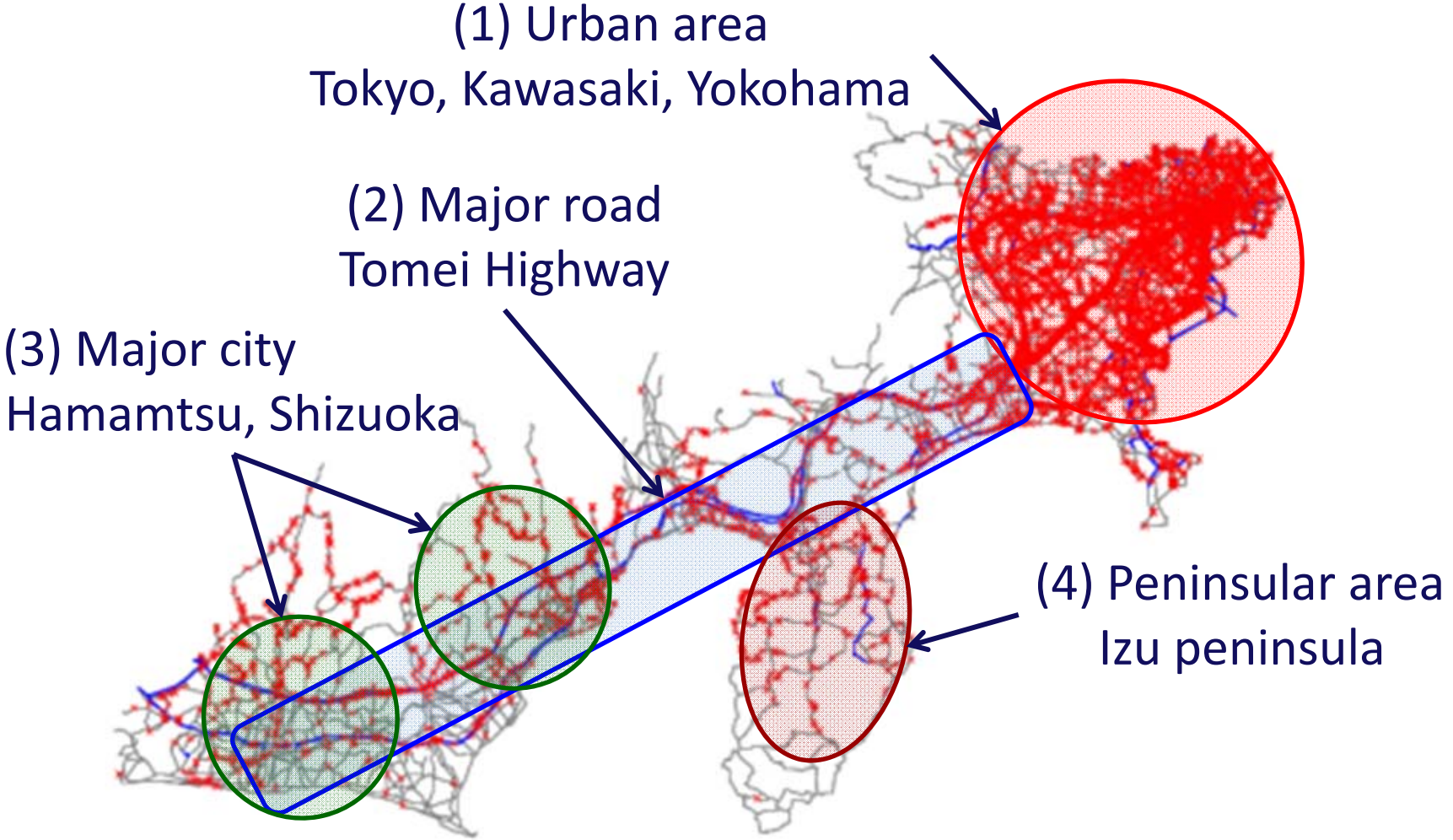
Three prefectures spanning about 200 km: Tokyo, Kanagawa and Shizuoka

Proposal of quick charging station layout in cities

Preferred placement:

1) In a grid-like pattern within urban areas **every 4 to 10 km^2**
2) On major roads connecting major cities **every 10 km**
3) On roads connecting local cities **every 30 km**
4) On roads around peninsular and highland areas **every 10 km**

In Tokyo, Kanagawa and Shizuoka prefectures



“Basic & destination charges at workplaces” and “Application of EVs & PHVs to V2X”

- Using EVs for commuting can reduce CO_2 emissions. EVs parked at workplaces can be charged by photovoltaics (PV) during the day.
- EVs parked at workplaces can be used for battery energy storage systems for load-leveling or preventing blackouts.
- EVs parked at workplaces can be used for V2X, and managed and controlled for use as VPPs. Wireless charging technology is expected to be used for VPPs.

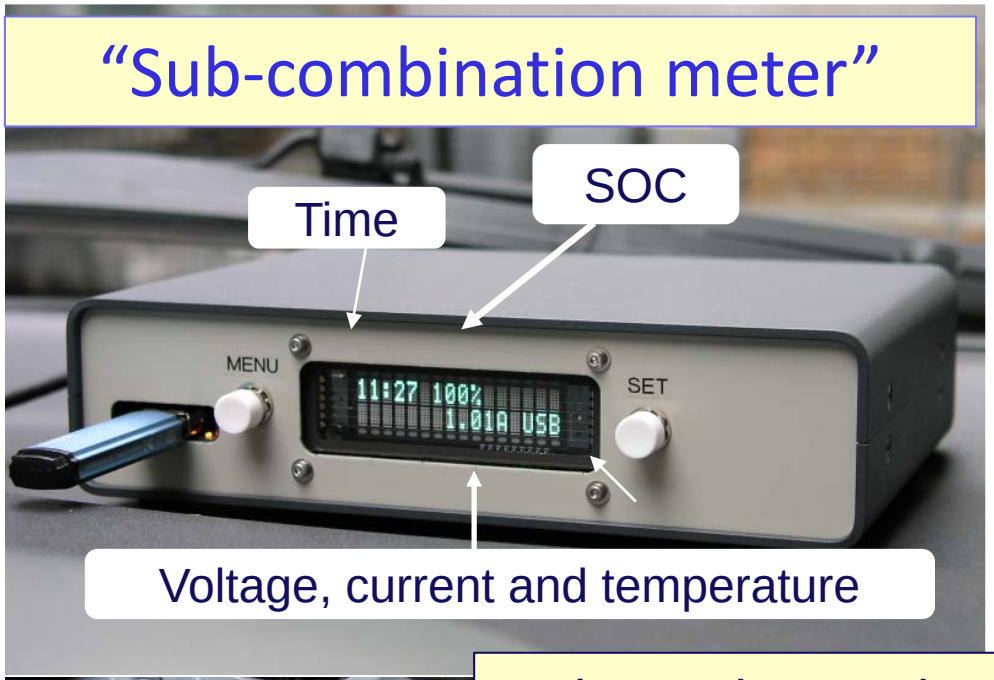
Charged by PV during the daytime at CRIEPI

Workplace charging and application to V2X at Mitsubishi

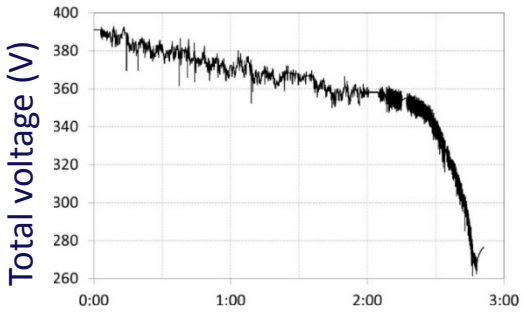
3. Obstacles to popularizing EVs and PHVs

- Improve battery performance for EVs to increase mileage per charge and cycle life to reduce EV cost.
- Create used car and re-use markets for energy storage systems to reduce cost of EV.
- These markets need a measure to estimate state of health and battery degradation
- Install normal and quick charging stations to make driving EVs in cities more convenient.

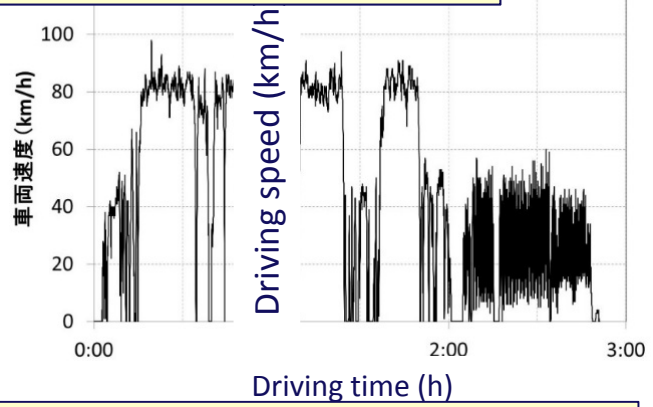
Estimating the state of health of a battery system



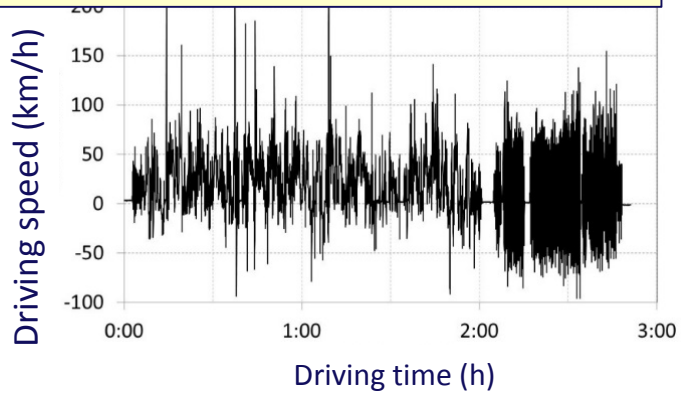
Voltage during driving



Driving speed



Current during driving



4. Summary

- METI has unveiled “High-performance secondary batteries for next-generation vehicles” and “Guidelines for installing charging equipment at residential housing and parking lots for EVs & PHVs” for normal charging, “**Model planning to install charging infrastructure on roads and in cities**” for quick charging stations, and the “**EV-PHV roadmap**”.
- CRIEPI has been conducting R&D of technologies to estimate the effects of charging infrastructure with the simulator **EV-OLYENTOR©**, to measure **battery performance and degradation** and for wireless charging of EV to help popularize EVs &PHVs.

Thank you for your kind attention.

Correspondence to ikeya@criepi.deken.or.jp

ACCELERATING THE POPULARIZATION OF ELECTRIC AND PLUG-IN HYBRID VEHICLES FOR REALIZING A LOW-CARBON SOCIETY IN JAPAN