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19 - 20 June 2014

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Study of Fuel Economy Standard and Testing Procedure for Motor Vehicles in Thailand

THAILAND AUTOMOTIVE INSTITUTE
สถาบันยานยนต์

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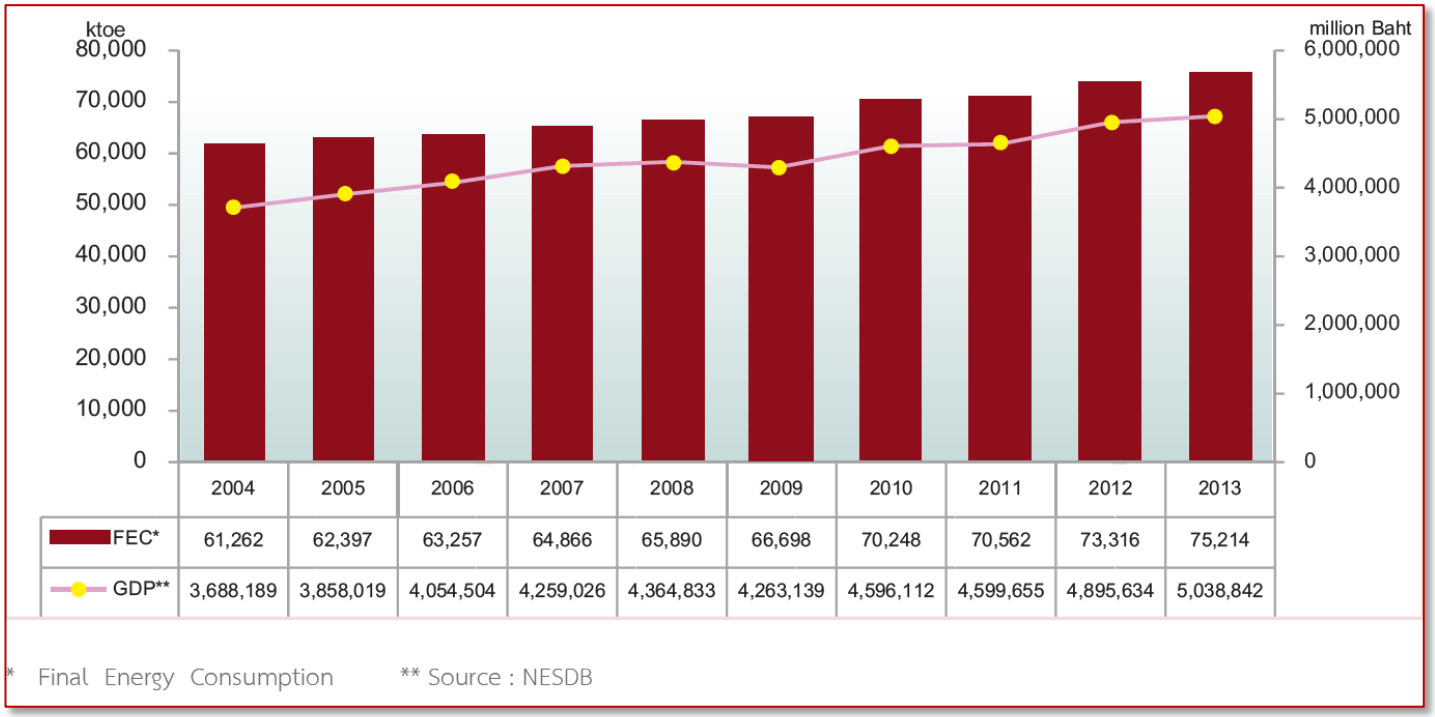
THAILAND AUTOMOTIVE INSTITUTE
June 20th, 2014

Overview

- ❑ Background
- ❑ Terminology
- ❑ Scope of the Study
- ❑ Exhaust Emission Standard
- ❑ Testing Standard
- ❑ Gathering Fuel Economy Data
- ❑ Simple Regression Analysis
- ❑ Results & Comparison to other Standard
- ❑ Example of Labeling
- ❑ Conclusion

Thailand's Final Energy Consumption 2004-2013

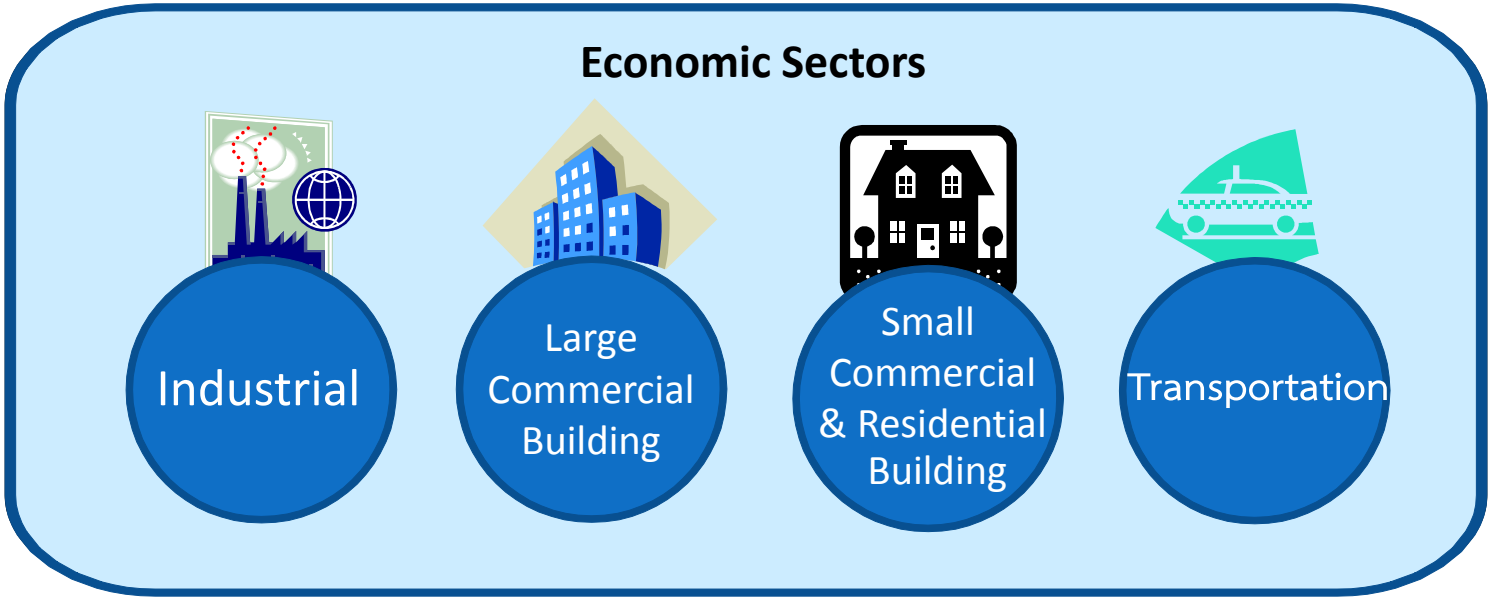


	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
FEC*	61,262	62,397	63,257	64,866	65,890	66,698	70,248	70,562	73,316	75,214
GDP**	3,688,189	3,858,019	4,054,504	4,259,026	4,364,833	4,263,139	4,596,112	4,599,655	4,895,634	5,038,842

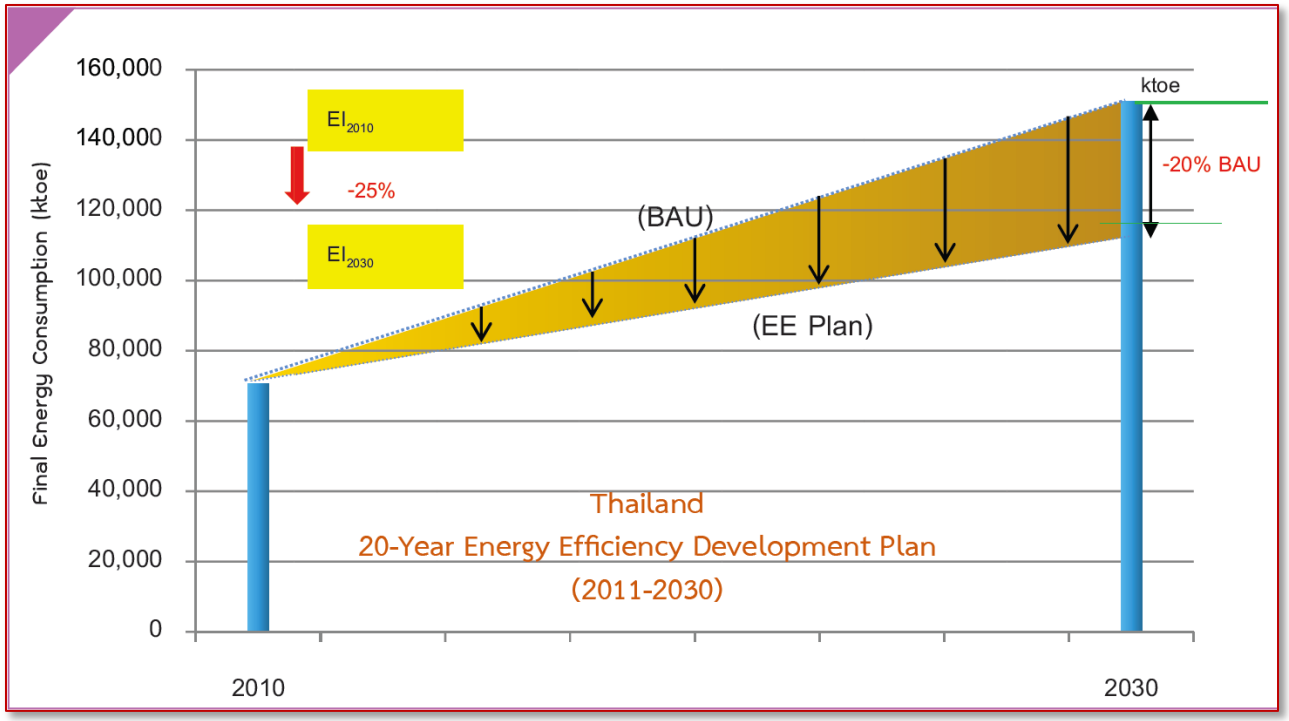
* Final Energy Consumption ** Source : NESDB

Source: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy

Thailand 20-Year Energy Efficiency Development Plan (2011 - 2030)

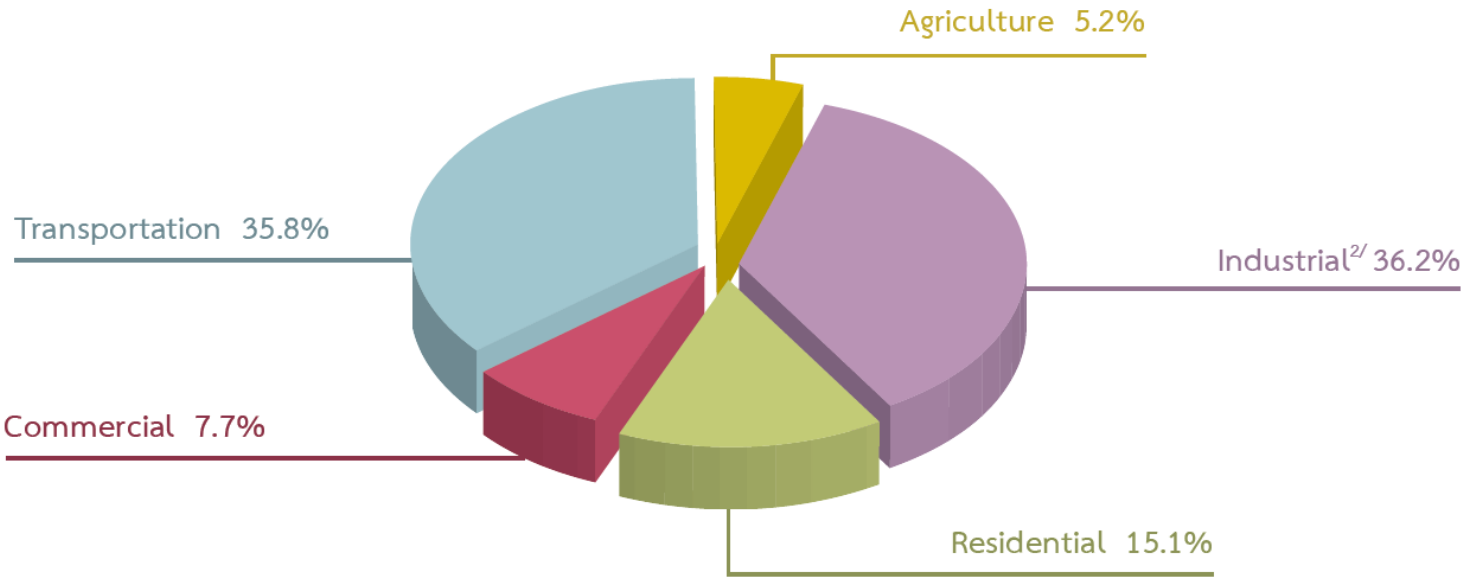


Energy Conservation Target



Source: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy

Final Energy Consumption by Economic Sectors 2013



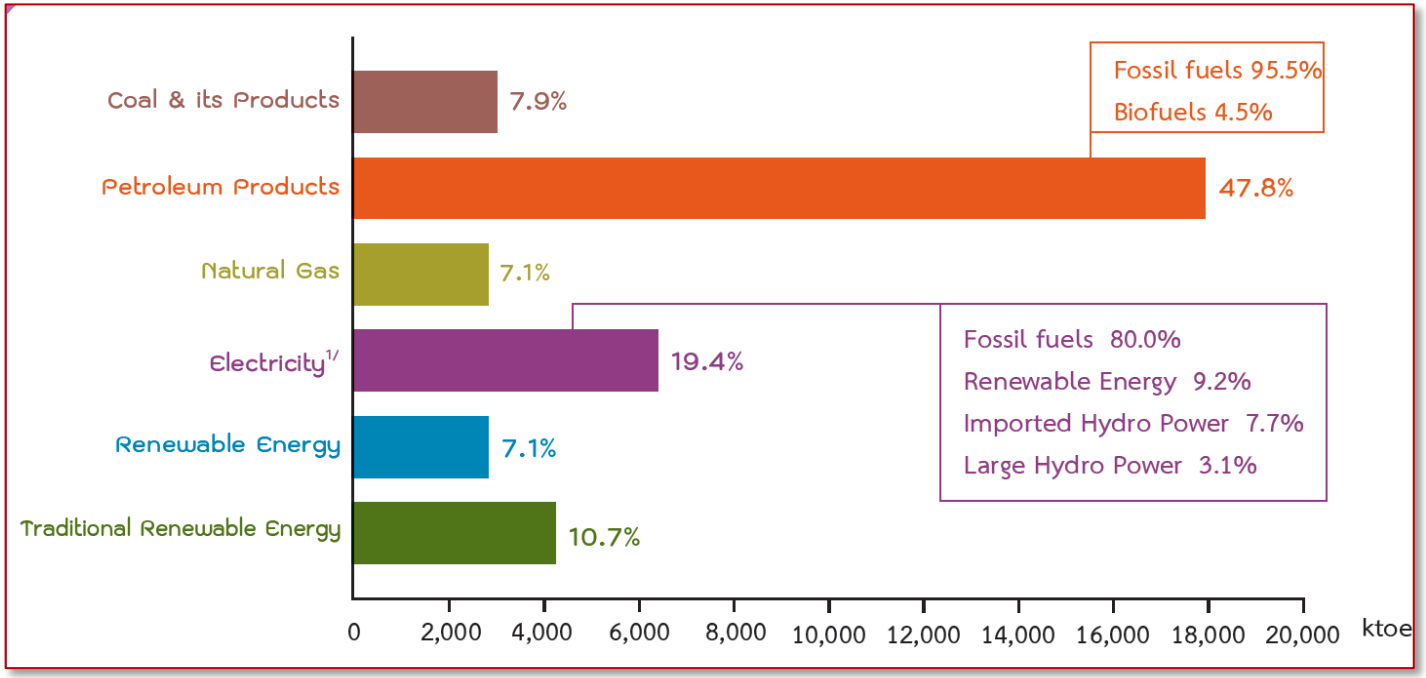
Source: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy

Final Energy Consumption by Economic Sectors 2013

Final Energy Consumption	Agriculture	Industry[2/]	Residential	Commercial	Transportation	Total
Coal & its Products	-	5,947	-	-	-	5,947
Petroleum Products	3,876	5,041	1,903	908	24,220	35,948
Natural Gas	-	2,629	-	1	2,709	5,339
Electricity[1/]	30	6,470	3,220	4,892	14	14,626
Renewable Energy	-	5,274	-	4	-	5,278
Traditional Renewable Energy	-	1,832	6,244	-	-	8,076
Total	3,906	27,193	11,367	5,805	26,943	75,214

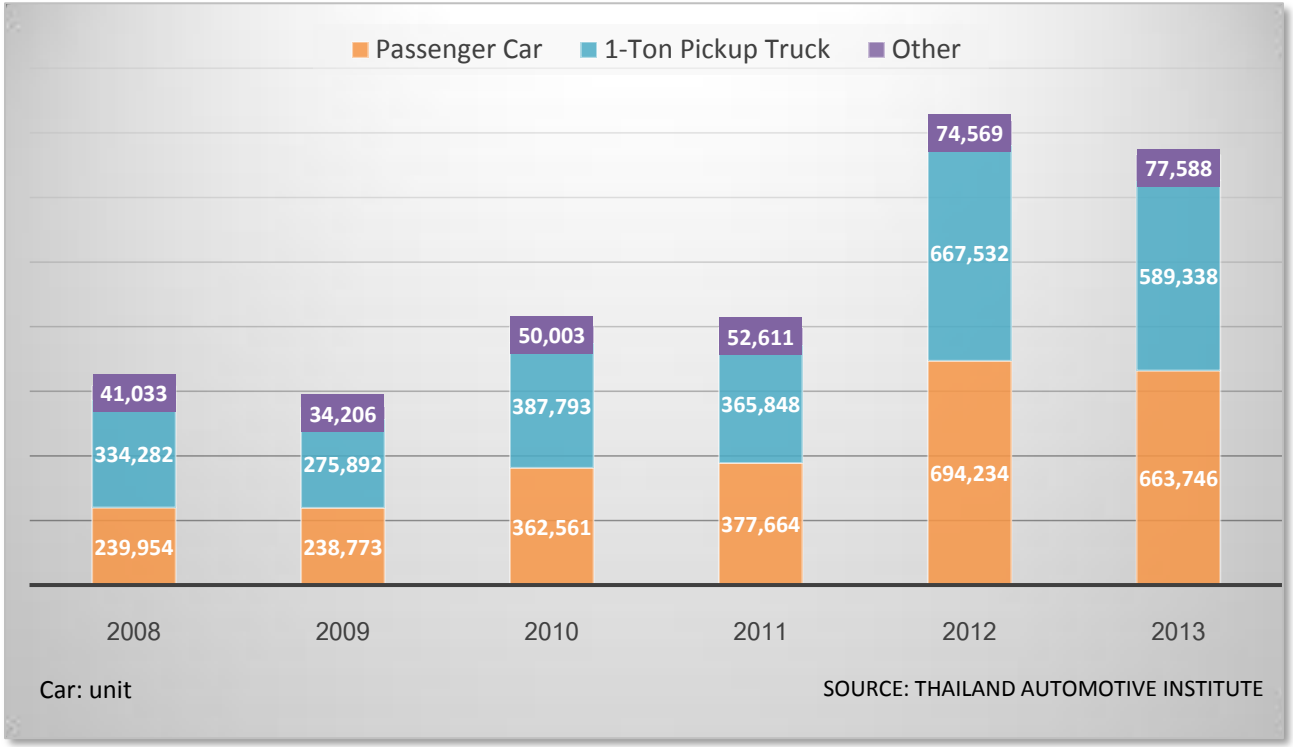
Source: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy

Final Energy Consumption by Fuels 2013



Source: Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy

Thailand Domestic Vehicle Sales (2008-2013)



Car: unit

SOURCE: THAILAND AUTOMOTIVE INSTITUTE

Two Strategy Approaches to Promote High Fuel Efficiency's Motor Vehicles

กระทรวงอุตสาหกรรม Ministry of Industry

กระทรวงพลังงาน MINISTRY OF ENERGY

Mandatory

Law & Regulation

Voluntary

Promoting High Energy Efficiency Vehicles

Industrial Standards Act
Ministry of Industry

Energy Conservation Promotion Act
Ministry of Energy

Project of the study of Motor Vehicle's Fuel Efficiency

THAILAND AUTOMOTIVE INSTITUTE สถาบันยานยนต์ ⟷ Department of Alternative Energy Development and Efficiency MINISTRY OF ENERGY

In 2012, The Project Funded by Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy with Thailand Automotive Institute (TAI) as an Advisor of the project.

"To establish an appropriated draft of fuel efficiency standard for motor vehicles to support the energy efficiency labeling and enforcement of Minimum Energy Performance Standards".

Terminology

Fuel Efficiency

Fuel Economy (FE)

km/L

Fuel Consumption (FC)

L/100 km

Objectives

MEPS = Minimum Energy Performance Standard

"Minimum energy efficiency required for any vehicles to be permissible for sale"

TISI
Thai Industrial Standards Institute
Ministry of Industry

HEPS = High Energy Performance Standard

"Minimum energy efficiency required for any vehicles to get tax promotion"

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

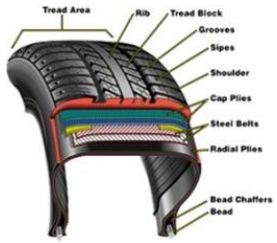
Target Vehicle

- Internal Combustion Engine

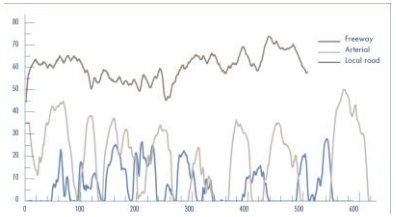
- Hybrid Vehicle
- Electric Vehicle

Target Vehicles

Factors that influence fuel economy



- **Vehicle's Technology**
- **Driving Condition**
- **Vehicle's Mass + Loading**



Vehicle's Fuel Economy Measurement Methods

Real Road Condition **VS** **Laboratory Controlled Condition**

Measuring Methods

- Volume Method
- Flow Method
- Scale Method
- Exhaust Gas Analysis Method (Carbon Balance Approach)

Why choose Carbon Balance Method?

- ❑ Accurate
- ❑ Reproducible
- ❑ Inexpensive

Scope of the study

- The testing standard shall compatible with the current motor vehicles emissions standard enforced by Thailand Industrial Standard Institute (TISI) which equivalent to Euro 4 standard.
- Passenger cars and 1 ton pick-up truck that complied with current exhaust emission standard are the target vehicles of the study.
- The evaluation of vehicle's fuel economy will be done separately between gasoline and diesel vehicle, which each of them will be classified by vehicle's mass to set an appropriate criteria of fuel economy for each level of the vehicle's mass.

History of Thailand motor vehicle's emission standard

Date	EU Reference Standard	Thai Standard
1997	Euro 1	TIS. 1440-2540 Gasoline Vehicle
		TIS. 1435-2540 Diesel Vehicle
1999	Euro 2	TIS. 1870-2542 Gasoline Vehicle
		TIS. 1870-2542 Diesel Vehicle
2006	Euro 3	TIS. 2160-2546 Gasoline Vehicle
		TIS. 2155-2546 Diesel Vehicle
2012	Euro 4	TIS. 2540-2554 Gasoline Vehicle
		TIS. 2550-2554 Diesel Vehicle

Thailand motor vehicle's emission standard & Type of Test

Gasoline Vehicles TIS. 2540-2554	*Light Duty Diesel Vehicles TIS 2550-2554*
Type I : Verifying the average tailpipe emission after a cold start *Type II : Carbon monoxide emission test at idling speed* *Type III : Verifying emissions of crankcase gases* *Type IV : Determination of evaporative emission from vehicles with positive ignition engines*	*Type I: Verifying the average tailpipe emission after a cold start)*

Testing Standards

TIS 2560-2554

Exhaust emissions from motor vehicles: Test method

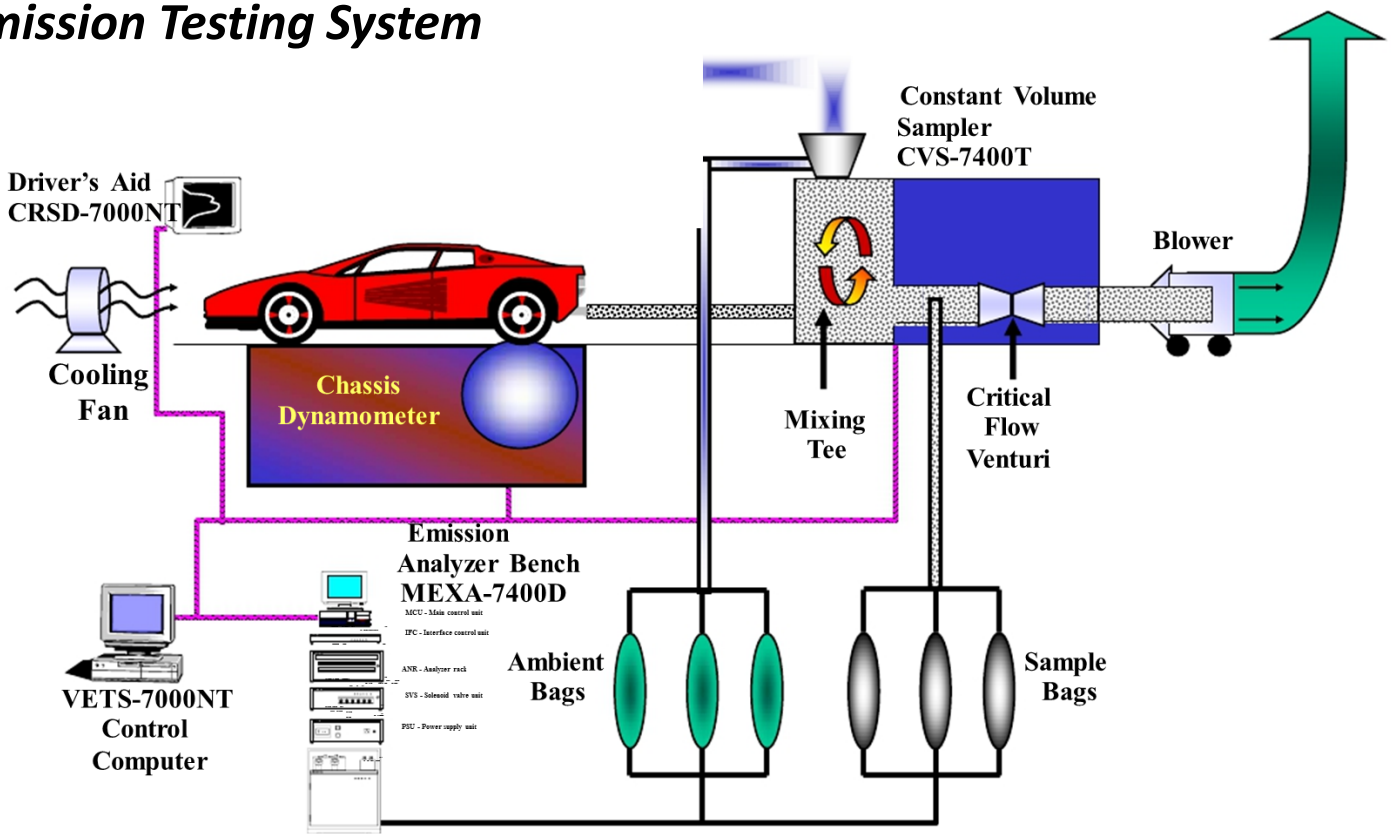
Equivalent to ECE R.83

TIS 2335-2550

Passenger cars powered by an internal combustion engine or hybrid cars, M1 and N1 vehicles powered by electric: Emission of carbon dioxide Fuel Consumption, Electric energy consumption and electric range

Equivalent to ECE R.101

Exhaust Emission Testing System

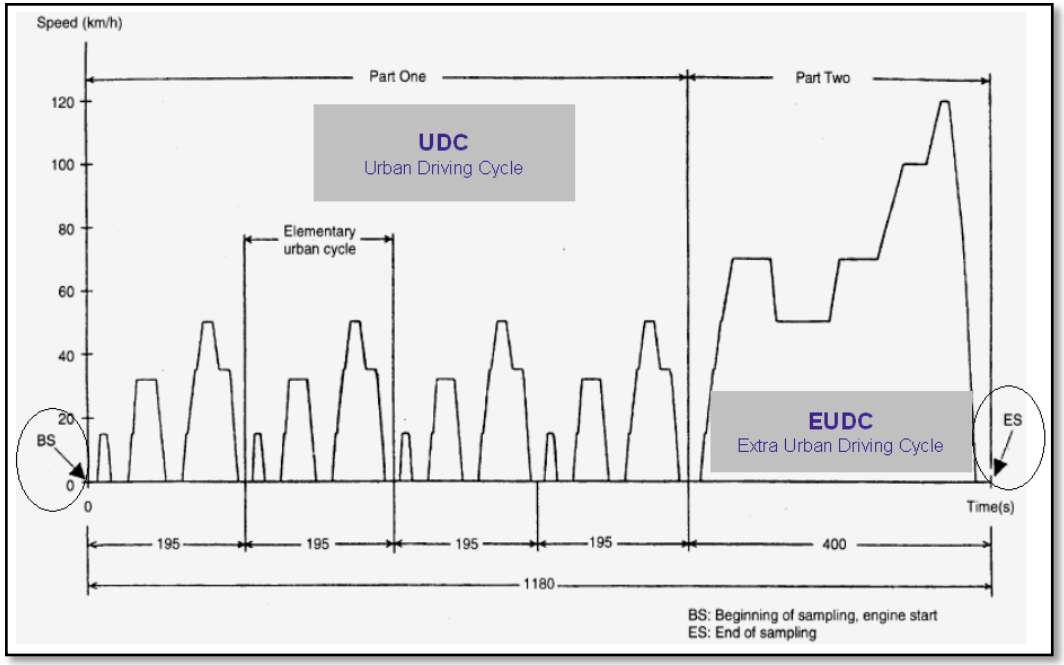


The equivalent inertia mass of the chassis dynamometer

Test mass M_{HP} (kg)	Equivalent inertia I (kg)
$M_{HP} \leq 480$	455
$480 < M_{HP} \leq 540$	510
$540 < M_{HP} \leq 595$	570
$595 < M_{HP} \leq 650$	625
$650 < M_{HP} \leq 710$	680
$710 < M_{HP} \leq 765$	740
$765 < M_{HP} \leq 850$	800
$850 < M_{HP} \leq 965$	910
$965 < M_{HP} \leq 1,080$	1,020
$1,080 < M_{HP} \leq 1,190$	1,130
$1,190 < M_{HP} \leq 1,305$	1,250

Test mass M_{HP} (kg)	Equivalent inertia I (kg)
$M_{HP} \leq 480$	1,360
$480 < M_{HP} \leq 540$	1,470
$540 < M_{HP} \leq 595$	1,590
$595 < M_{HP} \leq 650$	1,700
$650 < M_{HP} \leq 710$	1,810
$710 < M_{HP} \leq 765$	1,930
$765 < M_{HP} \leq 850$	2,040
$850 < M_{HP} \leq 965$	2,150
$965 < M_{HP} \leq 1,080$	2,270
$1,080 < M_{HP} \leq 1,190$	2,270
$1,190 < M_{HP} \leq 1,305$	2,270

New European Driving Cycle (NEDC)



Mode	Urban Cycle	Extra-Urban Cycle
Cycle	4	1
Average Speed (km/h)	19	62.6
Max Speed (km/h)	50	120
Distance/cycle (km)	1.013	6.955
Distance (km)	4.052	6.955
Total Distance (km)	11.007	
Time/cycle (sec)	195 (3 min 15 sec)	400 (6 min 40 sec)
Time (sec)	780 (13 min)	400 (6 min 40 sec)
Total Time	1,180 (19 min 40 sec)	

Carbon Balance Formulation

"Based on TIS.2335-2550 which is equivalent to UN-ECE Reg.101"

Gasoline Vehicle FC = (0.1154/D)*((0.866*HC)+(0.429*CO)+(0.273*CO2))

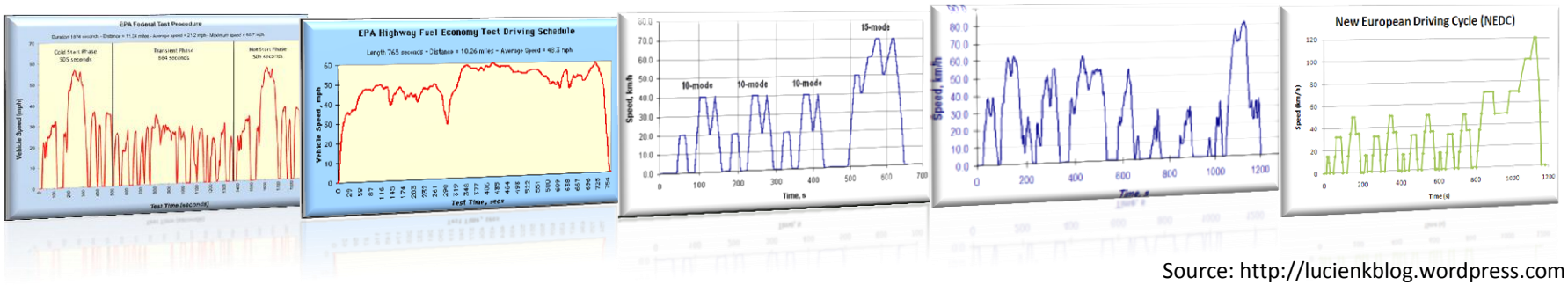
Diesel Vehicle FC = (0.1155/D)*((0.866*HC)+(0.429*CO)+(0.273*CO2))

FC = Fuel Consumption (L/100 km)
D = Fuel Density
HC = Hydro Carbon (g/km)
CO = Carbon monoxide (g/km)
CO2 = Carbon Dioxide (g/km)

Fuel economy and GHS emission standards for vehicles around the world

Country/region	*Type*	*Measure*	*Structure*	*Test Method*	**Implementation**
United States	Fuel	mpg	Footprint-based value curve	US CAFE	Mandatory
California	GHG	g/mile	Car/LDT1	US CAFE	Mandatory
European Union	CO_2	g/km	Weight-based limit value curve	EU NEDC	Voluntary for now, Mandatory by 2012
Japan	Fuel	Km/L	Weight-bin based	Japan 10-15/JC08	Mandatory
China	Fuel	L/100-km	Weight-bin based	EU NEDC	Mandatory
Canada	Fuel	L/100-km	Cars and light trucks	US CAFE	Voluntary
Australia	Fuel	L/100-km	Overall light-duty fleet	EU NEDC	Voluntary
Republic of Korea	Fuel	Km/L	Engine size	US CAFE	Mandatory

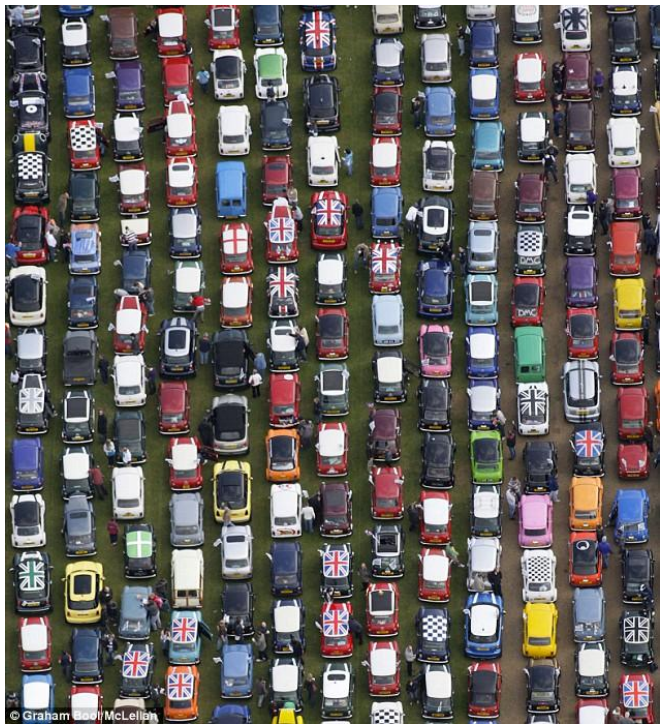
Fuel economy testing standard



Source: http://lucienkblog.wordpress.com

USA	Europe	China	Japan	Korea	Canada	Australia	Thailand
US CAFE	EU NEDC	EU NEDC	Japan 10-15 JC08	US CAFE	US CAFE	EU NEDC	EU NEDC

Population of Car's Model (EURO4 Spec)



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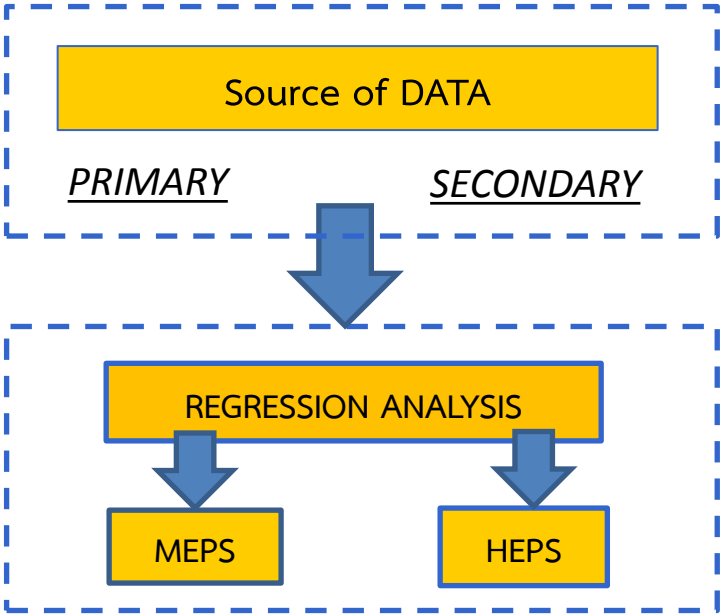
Gathering Fuel Economy Data



Source of fuel economy's data

LABORATORY ACCREDITATION ISO|IEC17025

"All data come from TISI's certified laboratory or accredited by ISO/IEC 17025"

PRIMARY

24 Cars were tested at Thailand Automotive Institute's Laboratory

+

SECONDARY

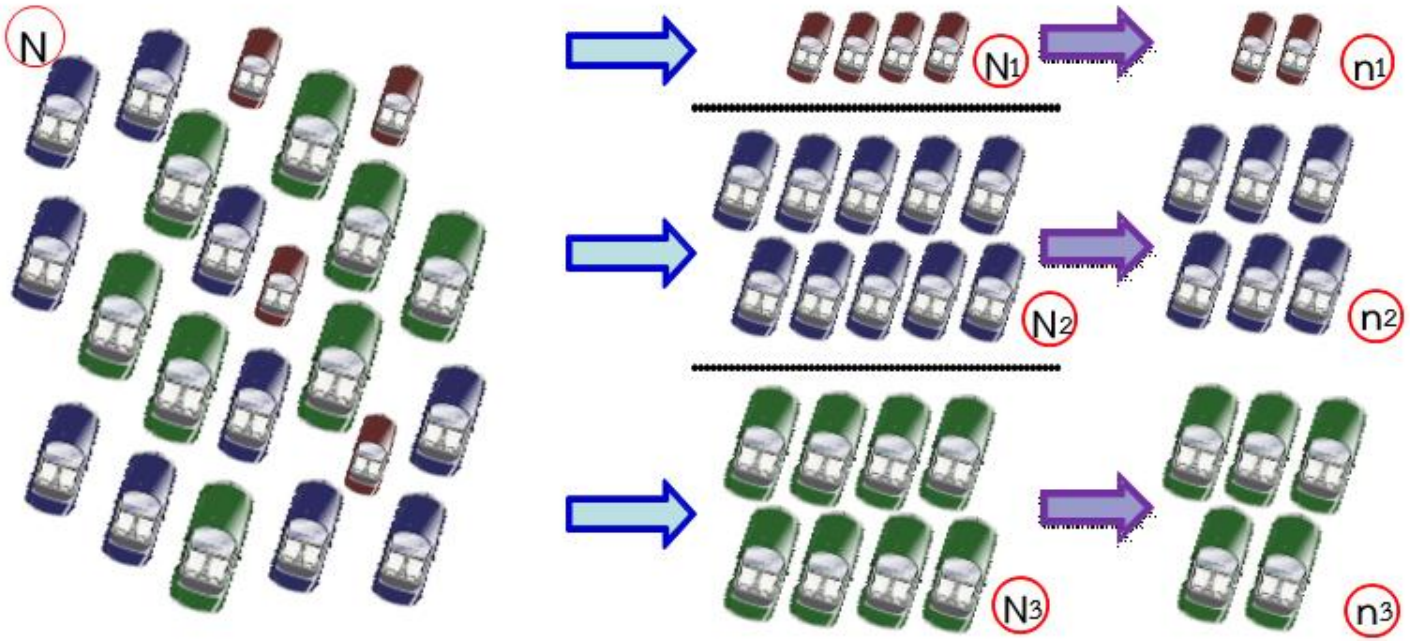
"Car Manufacturer's Test report apply to TISI for permission"

Vehicle is grouped by reference mass according to TIS.2560-2554 standard

Group No.	Reference Mass (kg)
1	<480
2	>480-540
3	>540-595
4	>595-650
5	>650-710
6	>710-765
7	>765-850
8	>850-965

Group No.	Reference Mass (kg)
9	>965-1,080
10	>1,080-1,190
11	>1,190-1,305
12	>1,305-1,420
13	>1,420-1,530
14	>1,530-1,640
15	>1,640-1,760
16	>1,760-1,870
17	>1,870-1,980
18	>1,980-2,100
19	>2,100-2,210
20	>2,210-2,380
21	>2,380-2,610
22	>2,610

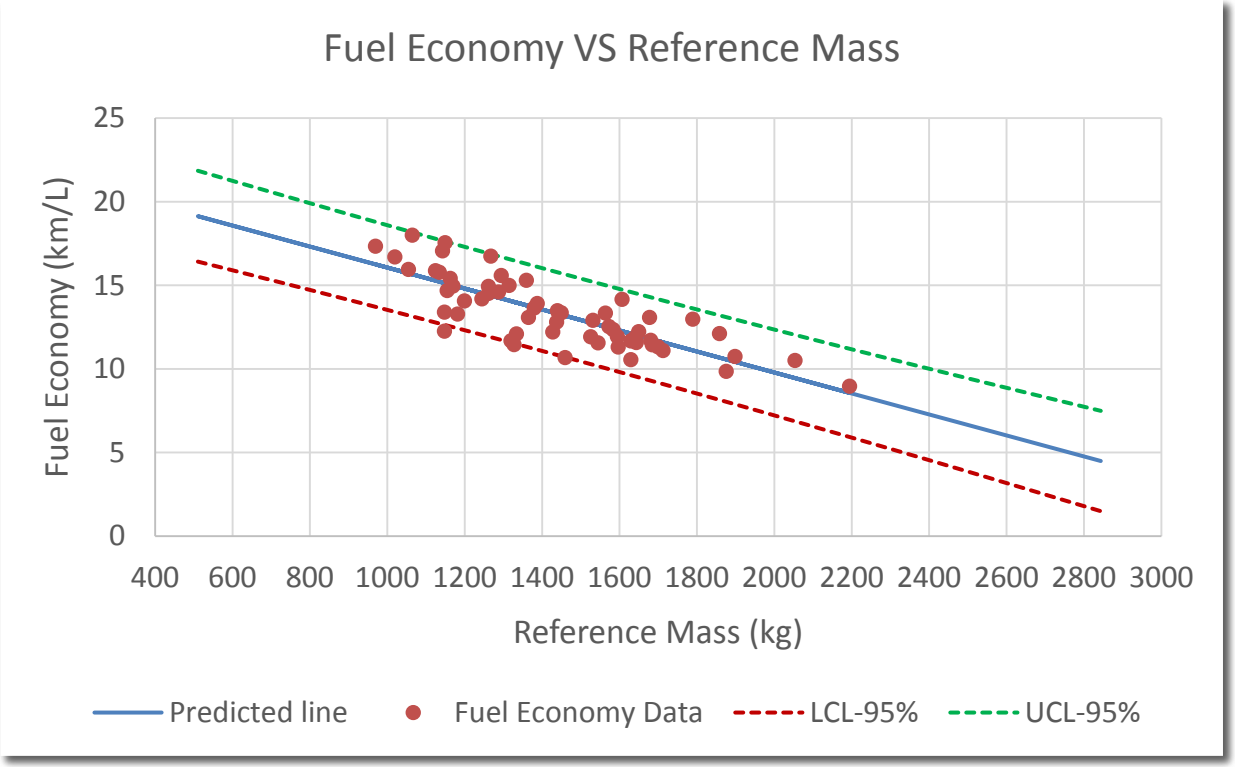
Stratified Sampling & Allocation of sample size



Simple Regression Analysis

- Verify that reference mass of vehicles is the major parameter of fuel economy (>50%)
- Determine that the fuel economy and reference mass have linear correlation and what is their correlation equation.

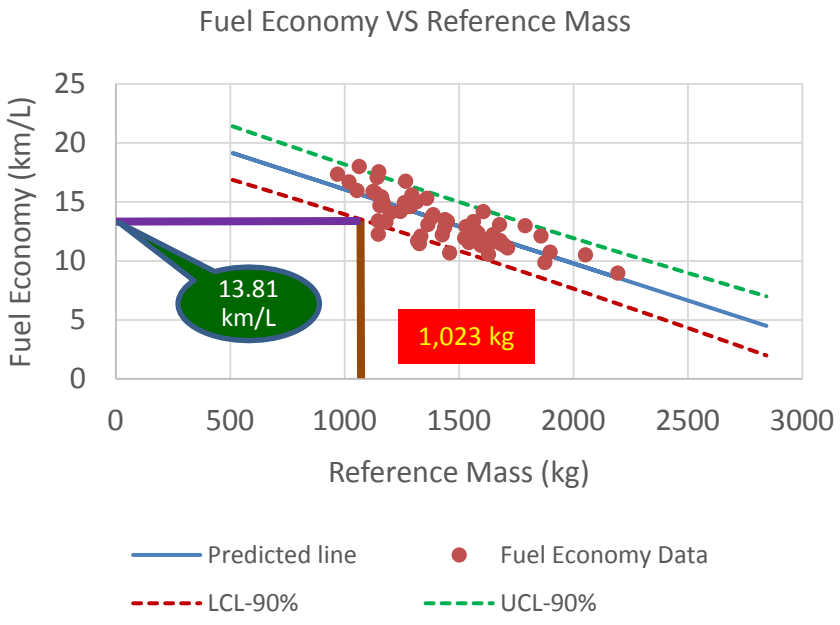
Lower Confidence Limit (LCL) and Upper Confidence Limit (UCL)

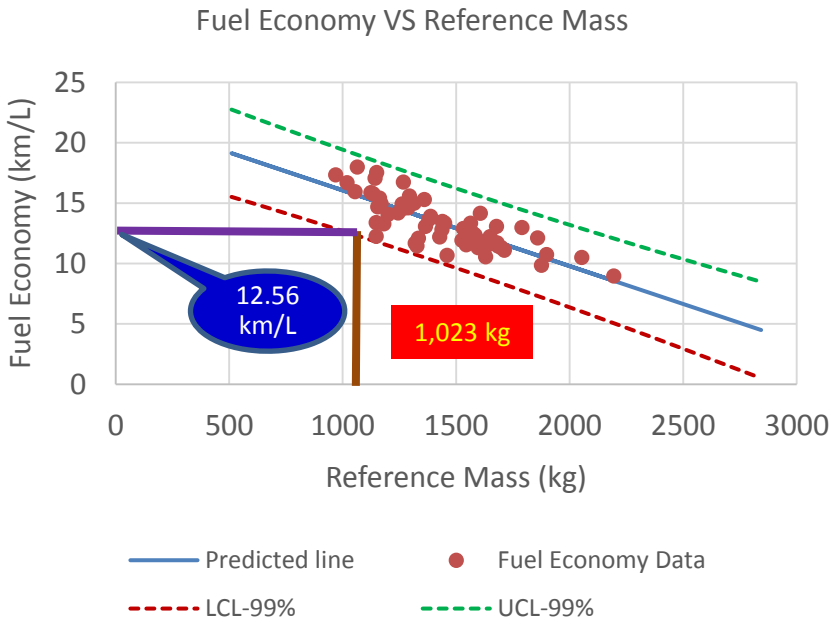


"LCL and UCL are used as a tool to set a criteria value for fuel economy standard."

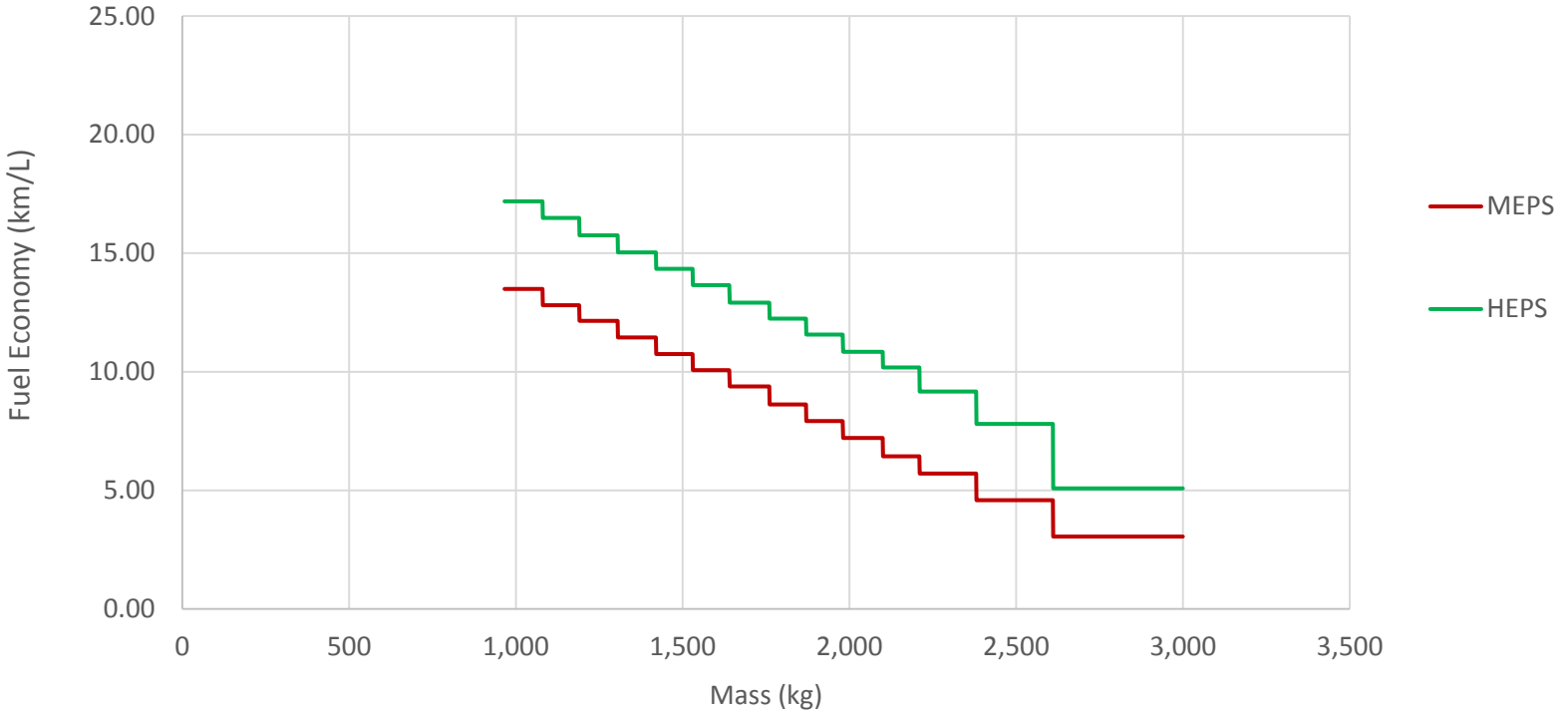
"LCL is used to determine MEPS while UCL is used to determine HEPS".

Example: Comparison of LCL & UCL at different level

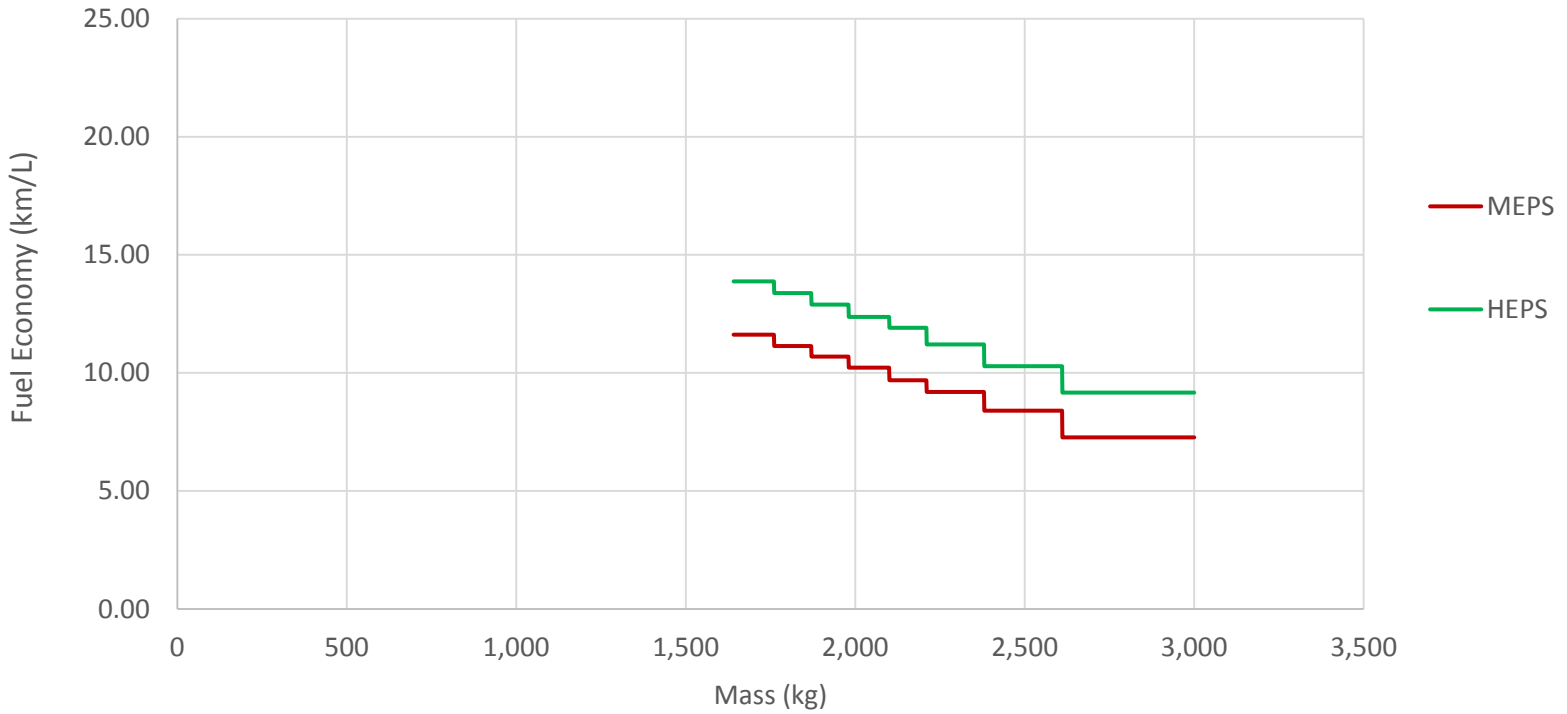




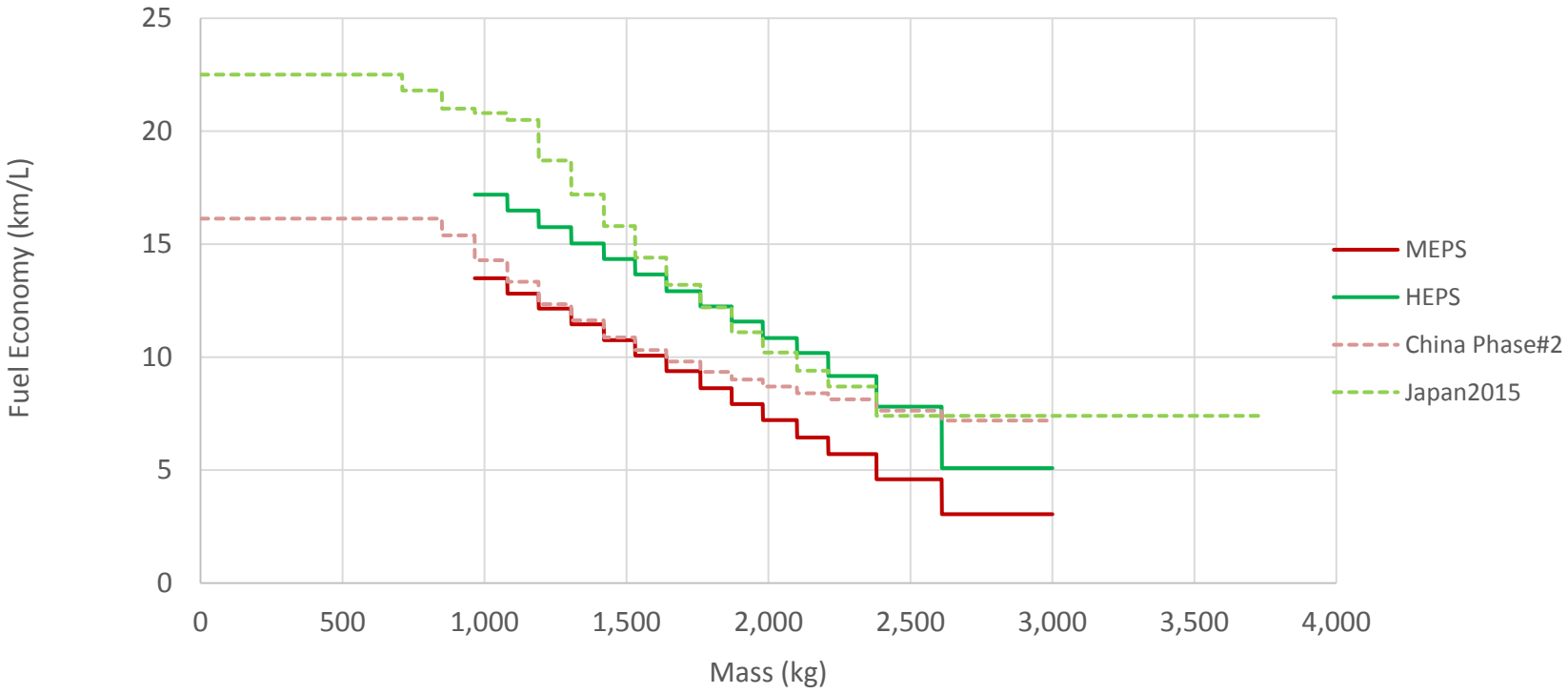
MEPS & HEPS Plot of Gasoline Vehicle



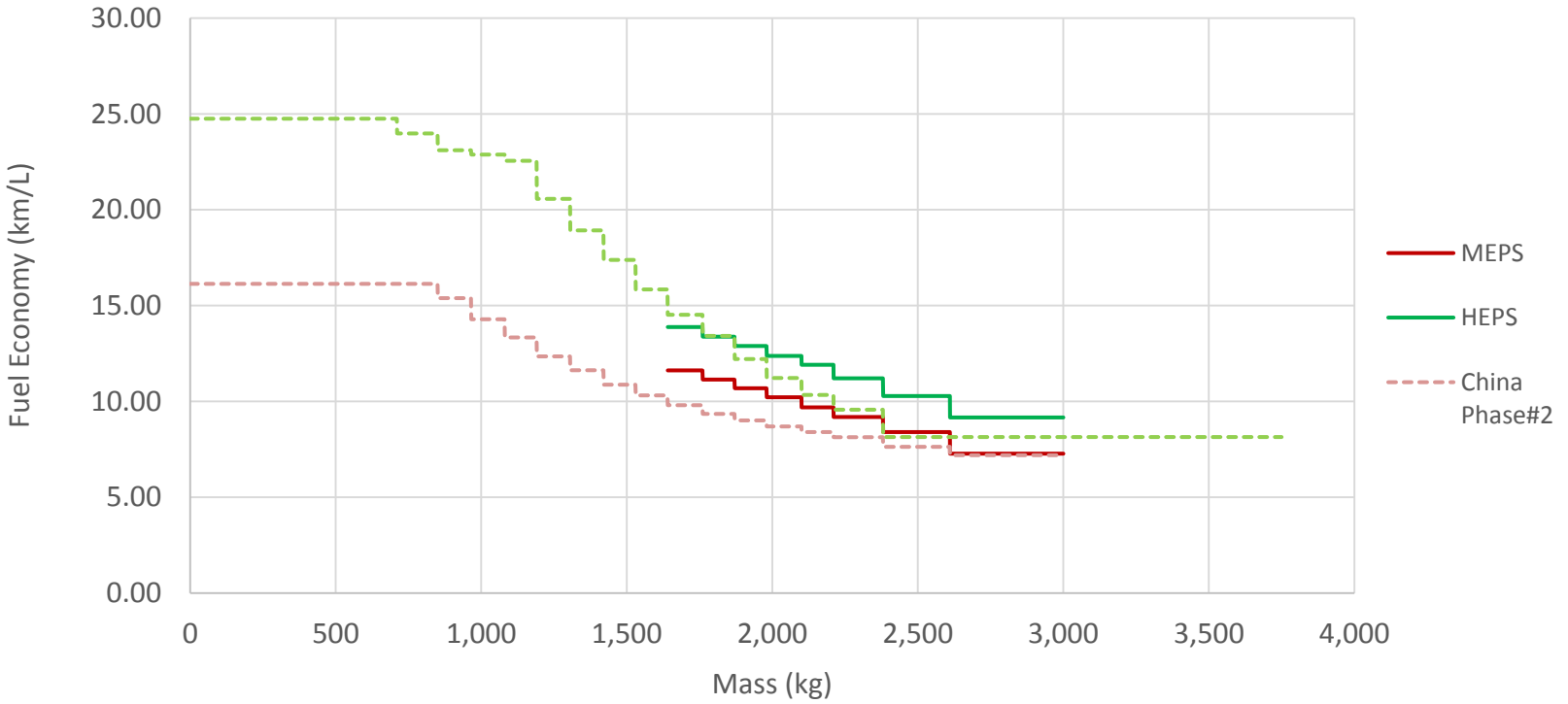
MEPS & HEPS Plot of Diesel Vehicle



Comparison with other standards (Gasoline MEPS HEPS)



Comparison with other standards (Diesel MEPS HEPS)



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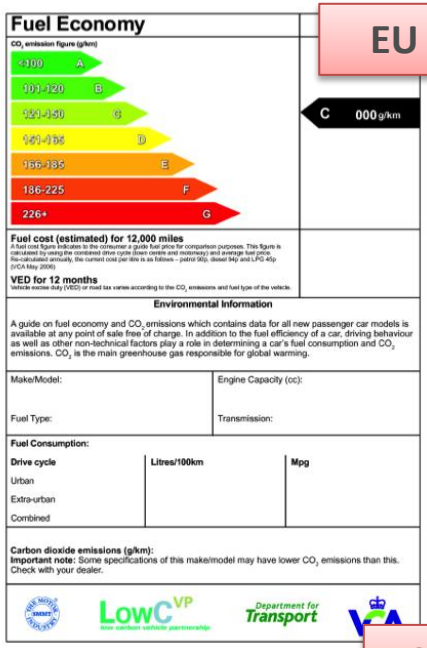
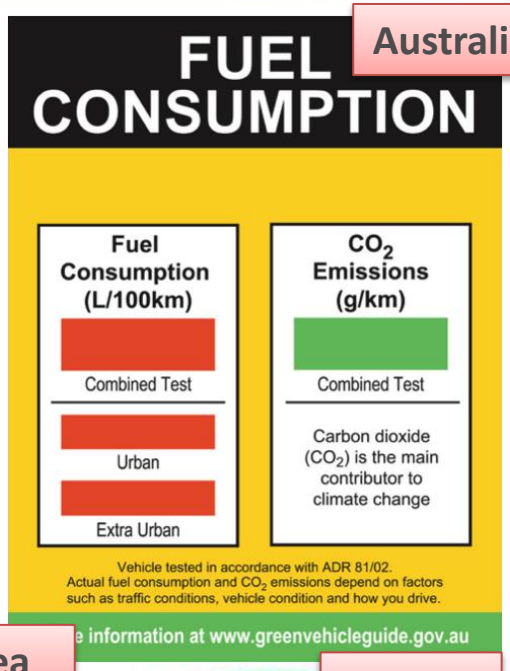


Australia



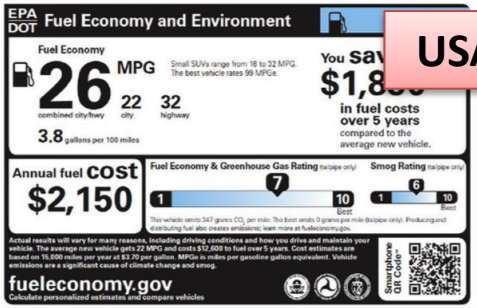
China

South Korea

GRADE	1	2			
~2011 (FTP-75)	≥ 15	14.9~12.8	12.7~10.6	10.5~8.4	≤ 8.3
2012~ (US Combined Mode adjusted)	≥ 16	15.9~13.8	13.7~11.6	11.5~9.4	≤ 9.3
Label	1	2	3	4	5

Japan

USA



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Conclusion

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