Global Vehicle Fuel Economy and GHG emissions Regulations for Light- and Heavy-duty Vehicles
全球轻型、中重型车新车燃油经济性及温室气体排放标准法规

John German

MIIT Workshop, Beijing, China

工信部汽车油耗标准及财税政策国际研讨会

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

International Council on Clean Transportation
国际清洁交通委员会

- Goal of the ICCT is to dramatically reduce conventional pollutant and greenhouse gas emissions from all transportation sources in order to improve air quality and human health, and mitigate climate change.
- ICCT的目标是大幅削减交通运输造成的传统污染物和温室气体排放，以改善空气质量、促进人类健康和缓解气候变化。

- Promotes best practices and comprehensive solutions to:
- 在以下方面提供最佳政策和全盘解决方案
  - ☑ Improve vehicle emissions and efficiency
  - ☑ 改善机动车排放和效率
  - ☑ Increase fuel quality and sustainability of alternative fuels
  - ☑ 改善燃油品质和促进替代燃料可持续使用
  - ☑ Reduce pollution from the in-use fleet, and
  - ☑ 在用车减排
  - ☑ Curtail emissions from international goods movement.
  - ☑ 减少国际货运带来的排放

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Encouraging Technology Spread Across the Fleet
鼓励节能技术在各类型车辆上的应用推广

Direct and Indirect Influences on Transportation Sector GHG Emissions
对交通部门节能和温室气体减排上直接或间接的影响

Factor/Entity 因素／主体		Vehicle Miles Traveled 里程	Vehicle Efficiency 车辆能效			Carbon cont. 碳含量
Strategy 政策	Primarily affects 针对的主体		Leap-Forward Technology 技术进步	Technology spread 技术推广	Smaller vehicles 小型化	Alternative fuels 替代燃料
Fuel price (taxes) 燃油税	Consumers 消费者	+			+	+ (if fuel price difference)
Land Use & Infrastructure 土地使用、基建	Consumers 消费者	+				
Technology mandates/ incentives 技术要求、激励	Manuf. 生产厂商		+			+ (w/ enough dollars)
CAFE Or **Tech neutral incentives** **CAFE标准及技术中立的激励**	Manuf. 生产厂商		+	++	(possible, depending on design) 可能	+

Light-Duty Vehicle Standards

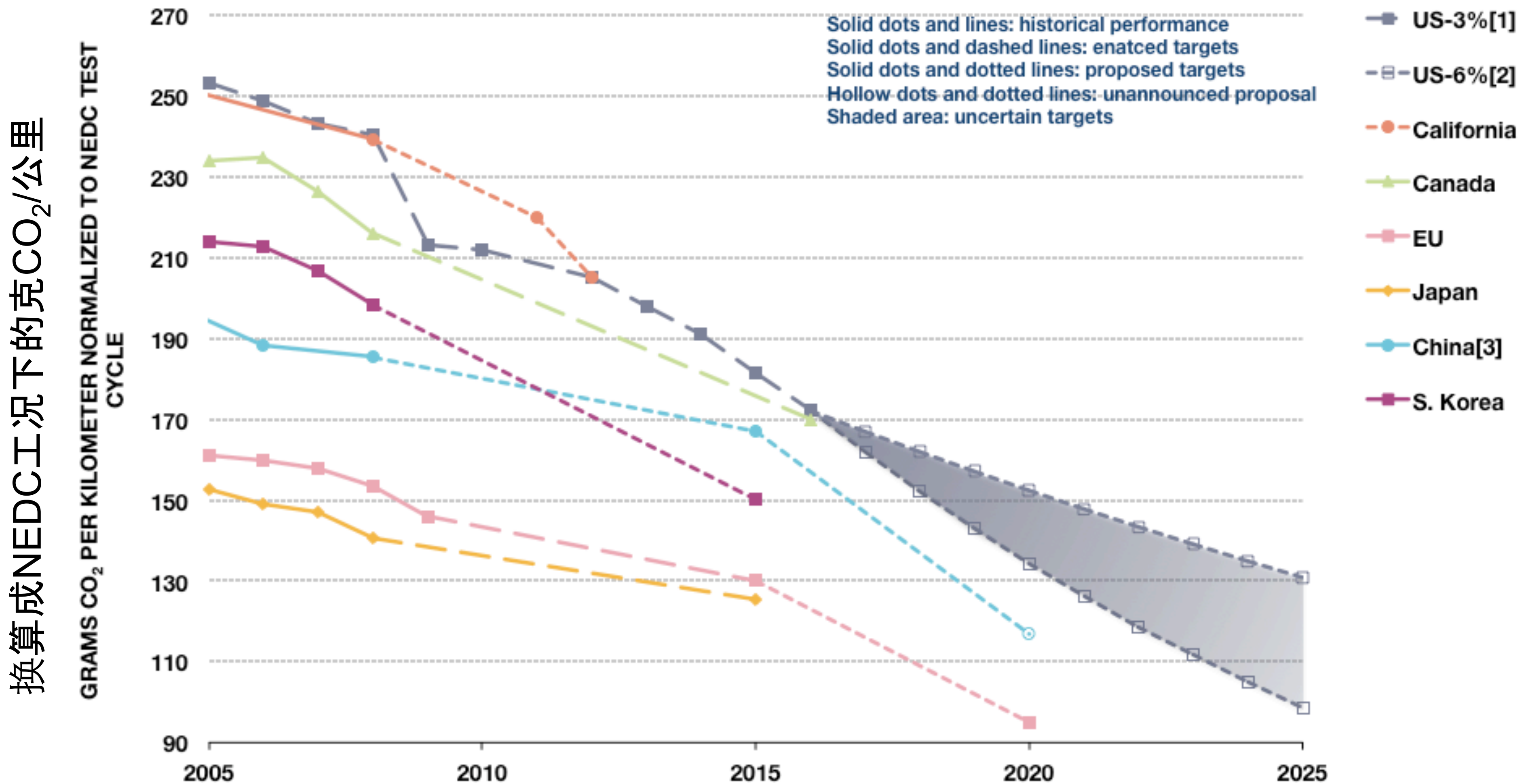
轻型车标准法规

Worldwide Automobile Efficiency/GHG Standards
全球轻型车燃油效率／温室气体标准一览

Country/Region 国家／地区	Regulated metric 标准类型	Program details, reduction in CO_2-per-distance emissions 减排目标，工况
European Union# 欧盟	CO_2 emissions (CO_2/km) CO2排放	40% reduction, MY 2008-2020 EU NEDC
United States 美国	Fuel economy (mi/gal) GHG emissions (CO_2e/mi) 燃油经济性和温室气体排放	24% reduction, MY 2009-2016 U.S. FTP
Japan# 日本	Fuel economy (km/L) 燃油经济性	19% reduction, MY 2010-2015 Japan JC08
China# 中国	Fuel consumption (L/100km) 燃油消耗量	14% reduction, MY2008-2015 EU NEDC cycle
Canada 加拿大	GHG emissions (CO_2e/mi) 温室气体排放	24% reduction, MY 2009-2016 U.S. FTP
South Korea 韩国	Fuel economy (km/L) CO_2 emissions (CO_2/km) 燃油经济性和CO2排放量	12% reduction, MY 2012-2015 U.S. FTP

#: Separate standards established for light-commercial vehicles

Comparison of passenger vehicle GHG standards
各国轻型车标准比较

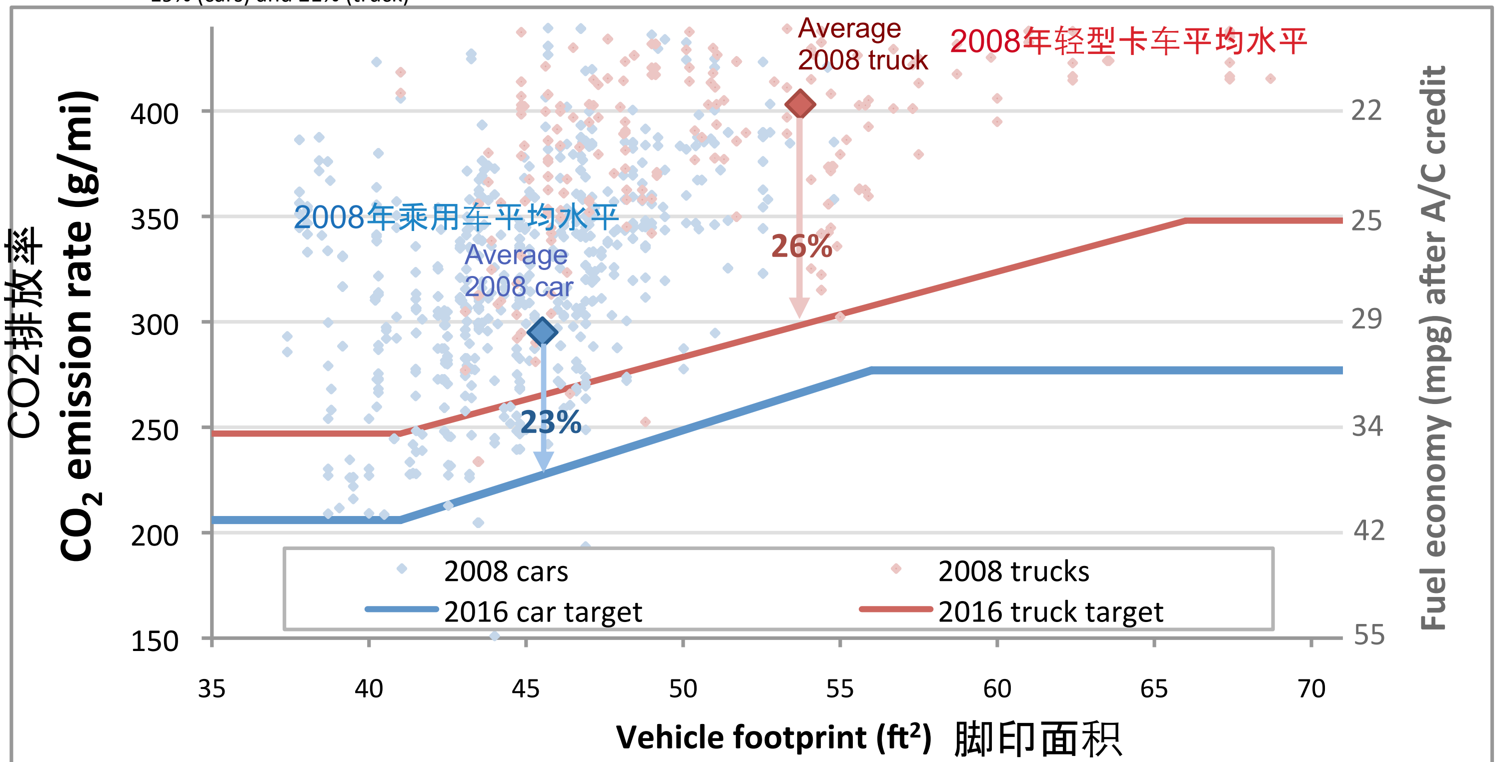


[1] Based on 3% annual fleet GHG emissions reduction between 2017 and 2025 in the September 30th NOI .
[2] Based on 6% annual fleet GHG emissions reduction between 2017 and 2025 in the September 30th NOI .
[3] China's target reflects gasoline fleet scenario. The target will be lower when other fuels are included.

Background: 2016 US Car and Truck Standards
美国2016年乘用车和轻型卡车标准

- Separate CO_2-indexed car and truck standards (with separate slopes)
  - By statute (EPCA 1975, EISA 2007), NHTSA must set separate *attribute-based* car, truck standards
  - Assuming no shifts in fleet composition and no trading → -24% gCO_2e/mile from 2008-2016
    - Cars and trucks would reduce gCO_2e/mile by 23% and 26%, respectively, from 2008 to 2016.
    - Excluding 10.6 gCO_2/mile from AC credits, CO_2 reductions are 19% (cars) and 21% (truck)

- 乘用车和轻型卡车分别制定标准
  - 法律规定NHTSA须为乘用车和卡车分别制定以脚印面积为基础的标准
  - 假设乘用车和卡车各自市场份额不变（也无交易），2016年将比2008年减排24％
    - •乘用车和卡车分别减排23％和26％
    - •如不算通过改善空调减少的10.6克／英里，乘用车和卡车将分别减排19％和21％



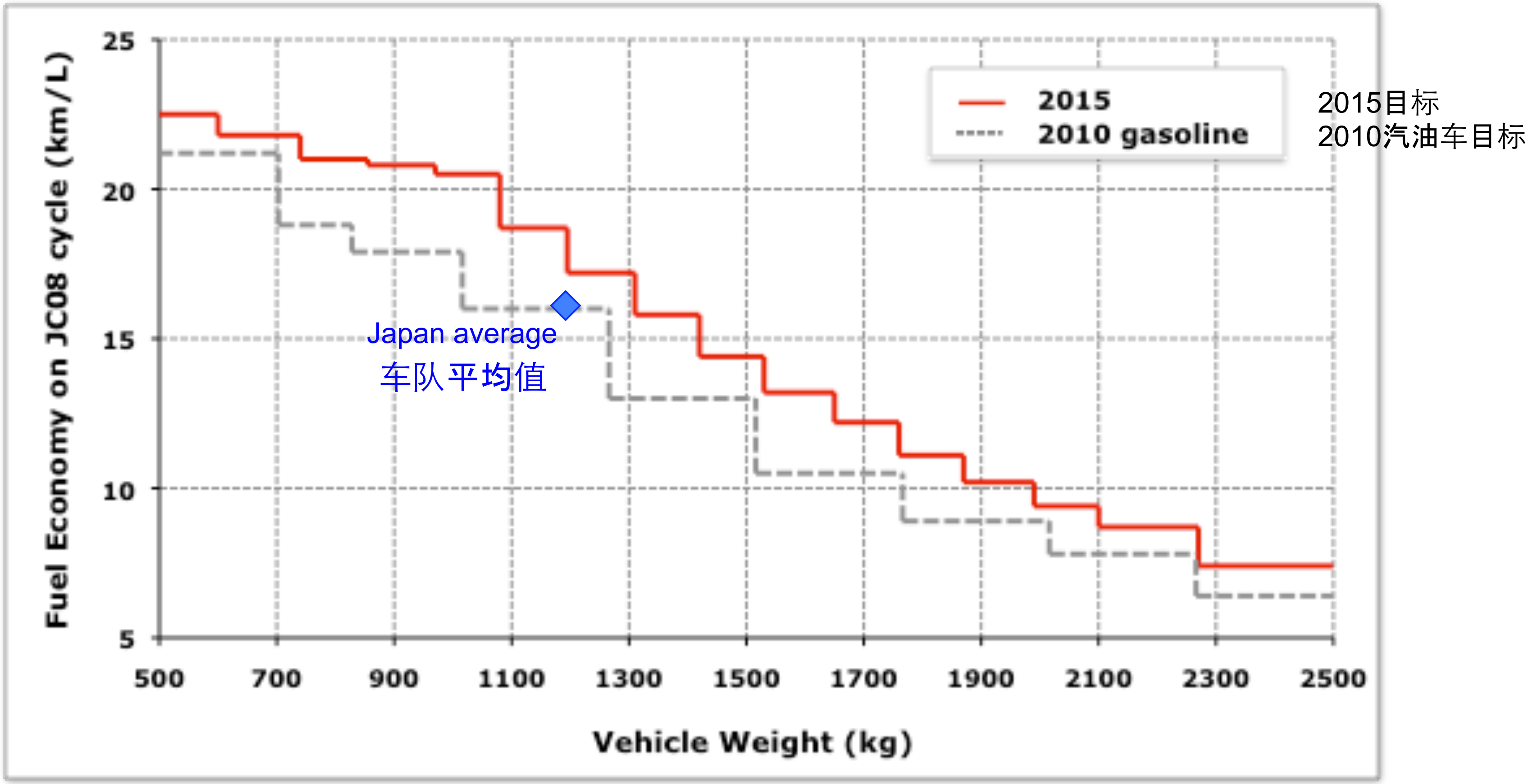
The equivalent lines for CAFE standards are slightly sloped (i.e., not perfectly linear) in fuel economy (mpg) space; note that EPA assumes some sales shift toward smaller car/trucks in 2016 timeframe in their analysis; in MY2012, 2WD SUVs shift from light truck to car category; the right y-axis is rated fuel economy after 10.6 g/mile A/C credits are utilized

Vehicle Fuel Economy: Japan
日本轻型车燃油经济性法规

Weight-based fuel economy standard with 16 discrete bins

- Japan's "front runner" weight-based fuel economy standards
- Target fuel economy improvements (on JC08 test cycle) in each weight class

- 按整备质量分为16个质量段的标准
  - 采取"领跑者"方法决定的以质量为基础的标准
  - 每个质量段内各有目标值



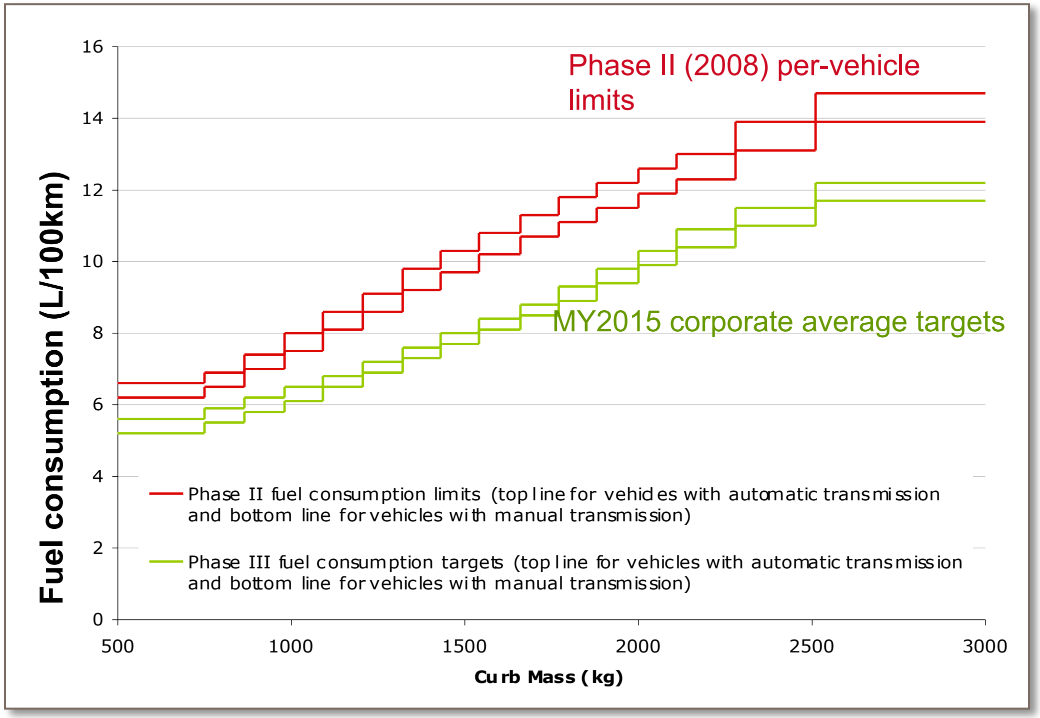
Vehicle Fuel Consumption: China
中国乘用车油耗标准

Mass-based fuel consumption standards and limits with bins

- Per-vehicle limits for Phase II (2008)
- Corporate average targets: 14% lower for MY2015

按整备质量分段的标准

- 前两期标准为单车最高限值
- 第三期（2015年）为公司平均标准：整体车队油耗约降低14%



Issues with per-vehicle limits:

- Relative ineffectiveness: Set at less stringent levels → only impacts "laggards"
- Uncertainty in national outcome: limited and unclear impact on majority of fleet
- Manufacturer inflexibility: per-vehicle limits are discrete yes/no; averaging allows flexibility in planning for overall sales of fleet of vehicles

单车最高限值可能存在的问题

- 对鼓励节油不是最有效：主要影响落后者
- 整体车队节油效果难预测
- 对厂商达标不灵活：厂商面临生产或不能生产两种选择；相反公司平均下，厂商可更自由地进行产品计划

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Characteristics of Worldwide Standards
各国标准的结构特点

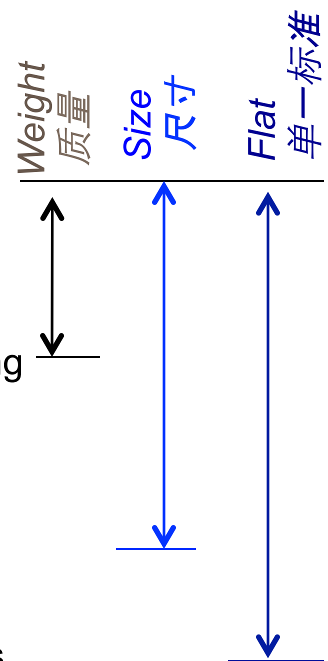
Country/ Region 国家／地区	Regulated metric 标准种类			Attribute 标准依据		Form 标准形式			Categories, classes, other provisions 其他规定
	Fuel Economy 燃油经济性	Fuel Consumption 油耗	CO_2/ GHG	Weight 质量	Footprint 脚印面积	Class 按车类	Continuous 连续	Bins 分段	
European Union# 欧盟			X	X			X		Eco-innovations, super-credits 创新环保手段信用额
United States 美国	X		X		X	X	X		2WD, AC credit, FFV/ E85, alternative fuels 对2WD，空调、替代燃料车的信用额
Japan 日本	X			X				X	Averaging within bins 段内平均
China 中国		X		X		X		X	Transmission, per-vehicle limits → corporate average 最高限值和公司平均
Canada 加拿大			X		X	X	X		AC credits, alternative fuels空调、替代燃料信用额
South Korea* 韩国	X		X	X			X		Eco-innovations 环保创新

#: CO_2 standards complemented by Air-conditioning, tyre pressure monitoring, gear-shift indicators etc.

* : FE/CO_2 standards include consideration for tyre pressure monitoring, gear-shift indicators

Standard Design: Available Tools
标准设计的方法

- What *strategies are promoted* by the various standard types?
  - → Flat offers the most compliance mechanisms to improve GHG/FE
  - → Weight-based standards are the most limited
  - → Size/footprint as an attribute is more versatile than weight
    - – Vehicle technology
      - Engine efficiency
      - Transmission efficiency
      - Per-vehicle engine downsizing
      - Per-vehicle mass-reduction
    - – Fleet composition
      - Selling vehicles with smaller engines
      - Selling smaller sized vehicles



- 各类标准分别有助于应用哪些节能策略
  - > 车队单一标准能有效鼓励最多的节能达标策略
  - > 基于车辆质量的标准支持的减排策略最有限
  - > 基于脚印面积（即尺寸）的标准比基于质量的标准略有优势
  - – 车辆能效技术
    - 发动机效率
    - 变速器效率
    - 单车发动机排量小型化
    - 单车轻量化
  - – 车队构成
    - 提高小排量车市场份额
    - 提高小型车市场份额

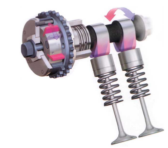
U.S. 2017-25 Vehicle Standard Development

美国2017－2025年标准的意向研究

Efficiency, Low-CO_2 Technologies
提高燃油效率和CO_2减排技术

- There are many different technologies available to reduce vehicles' CO_2 emissions 现阶段有很多技术可供选择
- Technical efficiency, low-CO_2 options
  - Petroleum efficiency
  - 基于石油燃料效率的提高
    - Gasoline 汽油
    - Diesel 柴油
    - Hybrid 传统混合动力
  - Alternative fuels
  - 基于替代燃料效率的提高
    - Compressed natural gas 压缩天然气
    - Biofuels 生物燃料
  - Electric-drive 基于电动技术
    - Plug-in hybrid electric 插入式混合动力
    - Electric 纯电动
    - Fuel cell electric 燃料电池


Direct injection


Variable valve controls

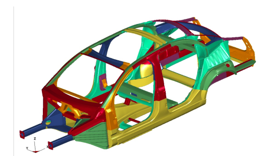

6+ Speed


Aerodynamics

HFO 1234yf


Turbo

Low-friction lubricants


Advanced materials and design

Efficient accessories


Stop-start


Low rolling resistance tires


Diesel

CNG

E85


Hybrid


Electric


Plug-in hybrid


Fuel cell

Joint-Agency TAR: Scenarios 技术支持报告中的情景

- A range of scenarios was considered:
  - 2017-2025: target of 3-6%/year improvement in gCO_2/mile Below shows the target CO_2 emission rates of 143-190 gCO_2/mile CO_2
    - These equate to about 4.3-5.2 L/ 100km on the US FTP test procedure

- 情景包括
  - 从2016年起每年按3％－5％车队平均CO_2减排程度进行目标的预期
    - CO_2目标值为143－190克／英里，如下表
    - 或相当于 4.3–5.2升／百公里（按FTP测试工况）

Case 情景	GHG Emissions GHG值		Fuel Consumption 油耗值	
	Rated gCO_2/mile [a]	Annual improvement from 2016 年减低率	Rated L/100 km [b]	Annual improvement from 2016 年减低率
Baseline (2008) 基准年（2008）	339	-	9.0	-
Baseline (2016)) 基准年（2016）	250	-	7.2	-
New vehicle target in 2025 2025年标准	190	3%	5.6	2.8%
	173	4%	5.2	3.6%
	158	5%	4.8	4.5%
	143	6%	4.3	5.4%

[a] *Rated emissions and mpg based on official combined city/hwy test procedure (consumer label values ~25% higher)*
标准值按市区、高速工况值计算得出综合值（比标识值要高最多达25%）
[b] *Rated L/100km is based conversion for gasoline vehicles with 8887 gCO_2/gallon gasoline assumed, without any adjustment or conversion from the US to the NEDC test cycle; includes air conditioning credits (10.6 g/mi in 2016; 21 gCO_2/mi 2025) and assume no use of other crediting provisions (electric vehicles are not included)*
油耗值是按每加仑汽油排放8887克CO2的假设计算，并包含了改善空调的信用额值credits (10.6 g/mi in 2016; 21 gCO_2/mi 2025) 未转换成NEDC工况值，也未包含其他信用额度（未包括电动车）。

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Joint-Agency TAR: Results
技术支持报告结论

- Costs and consumer impacts for scenarios for <175 gCO_2/mile
  - Consumer benefits greatly outweigh the technology costs, by factor of ~2-4
  - \$1400-\$3500 cost → \$5300-\$7400 consumer lifetime fuel saving benefit
  - All the different technology scenarios offer 2-4 year payback period:

- 达到175g/mi的成本和对消费者的影响
  - 消费者收益大于成本2－4倍
  - 成本增量在\$1400－3500之间，全使用周期收益为\$5300－7400
  - 所有技术情景成本收回期在2－4年

Scenario[a] 年改善率情景	Rated new vehicle gCO_2/mile 目标值	Rated new vehicle L/100km[b] 目标值	Technology Path 技术路线	Per-Vehicle Cost Increase (\$) 每车成本增加	Payback Period [c] (years) 成本收回期	Net Lifetime Owner Savings [c] (\$) 全使用周期净收益
4%/year	173	5.2	A	\$1,700	2.5	\$5,900
			B	\$1,500	2.2	\$6,000
			C	\$1,400	1.9	\$6,200
			D	\$1,900	2.9	\$5,300
5%/year	158	4.8	A	\$2,500	3.1	\$6,500
			B	\$2,300	2.8	\$6,700
			C	\$2,100	2.5	\$7,000
			D	\$2,600	3.6	\$5,500
6%/year	143	4.3	A	\$3,500	4.1	\$6,200
			B	\$3,200	3.7	\$6,600
			C	\$2,800	3.1	\$7,400
			D	\$3,400	4.2	\$5,700

[a] The TAR also analyzed a 3% per year CO_2 emission reduction scenario
[B] Based on gasoline conversion of 8887 gCO_2 per gallon, no conversion/adjustment from US FTP to NEDC test procedure
[c] Consumer payback period based on 3% discount rate, 2008 baseline, AEO2010 reference fuel prices (e.g., \$3.49/gal in 2025)

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Incorporation of Electric Vehicles into Standards

将电驱动车纳入到标准体系内

PV GHG Standard Metrics
轻型电驱动车温室气体标准

- U.S. CAFE/GHG standards through 2025 assign zero upstream GHG emissions to EVs, including fuel cells
  - Creates additional incentive for EVs, but reduces fleet GHG reductions
- In long-term, GHG standards need to account for upstream emissions
  - A number of accounting issues need to be evaluated and resolved
- Stringent fleet average targets needed in long-term to support transition away from programs like the California ZEV requirement in the long term

- 美国CAFE标准在2025年前将电动车和燃料电池车（一定销售量之内）上游排放暂计为零
  - 虽鼓励了电动车，但不利于温室气体减排
- 从长远看，需要计算电动车上游温室气体排放
  - 仍有一些评估计算问题有待解决
- 美国加州目前有零排放车计划，未来如果制定足够严格的温室气体排放标准，就可以渐渐不依赖类似加州这样的销售量标准

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Heavy-Duty Standard Development

重型车标准的发展

Policy landscape: timelines across regions
各国政策时间表

Country/ Region	Regulation Type 法规类型	2005	2006	2007	2008	2009	2010	2011	2012
Japan 日本	Fuel economy 燃油经济性	Reg. adopted 标准实施							
China 中国	Fuel consumption 油耗						Test procedure proposal 测试程序提案	Final test procedure standard 最终测试程序标准	Final Standard 最终法规
United States 美国	GHG/Fuel economy 温室气体／燃油经济性			EISA 2007 法案颁布	EPA Advance Notice of Proposed Rulemaking EPA 草案制定通知		Standard proposal (Oct) 标准草案	Final rule (July) 最终标准	
European Union 欧盟	GHG 温室气体						Technical studies 技术研究		Standard/ label proposal? 标准/标识草案？
California 加州	End-user purchase requirements 消费者购车要求						Phase-in of SmartWay tractors (MY 2011+) and all MY trailers SmartWay2011车型年及以后的牵引车，所有年份的挂车		

Japan: "Top Runner" Efficiency targets
日本："领跑者"重型车能效标准

Summary of 2015 fuel economy targets and percent improvement by vehicle type and class
2015年标准及各类车型的改善率

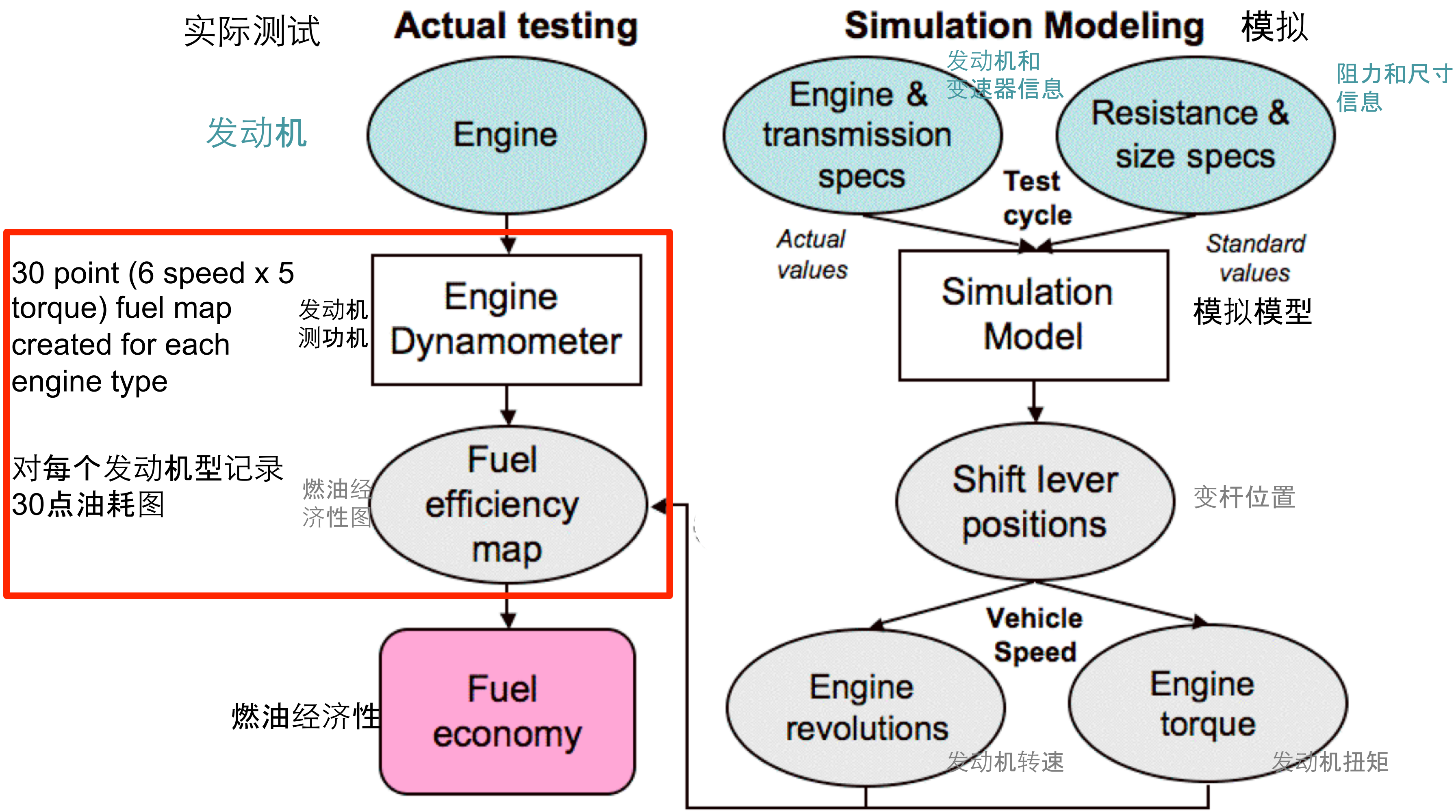
Vehicle Type 车型	Vehicle Class 类别	Fuel economy (km/L) 2002 baseline 2002基准值	Fuel economy (km/L) 2015 target 2015目标值	Improvement (%) 改善率
Truck 卡车	Tractor 牵引车	2.67	2.93	9.7
	Other truck 其他类卡车	6.56	7.36	12.2
	Total 全体	6.32	7.09	12.2
Bus 巴士	Urban 市内巴士	4.51	5.01	11.1
	Other bus 其他巴士	6.19	6.98	12.8
	Total 全体	5.62	6.3	12.1

- Both the 2015 average target and relative improvement assume a constant 2002 vehicle sales mix
- 2015目标值和改善率都假设各类车的市场份额保持2002年的水平

Japan: Targets by vehicle type, GVWR, cargo load
日本根据车型、总质量和负载决定的目标值

Vehicle Class 车辆类别	GVW (kg) 总质量(kg)	Cargo Load (kg) 额定载货(kg)	FE Target (km/L) 燃油经济性目标值
Other Truck 其他卡车	3,500-7,500	< 1,500	10.83
		1,500 - 2,000	10.35
		2,000 - 3,000	9.51
		> 3,000	8.12
	7,501-8,000	----	7.24
	8,001-10,000	----	6.52
	10,001-12,000	----	6.00
	12,001-14,000	----	5.69
	14,001-16,000	----	4.97
	16,001-20,000	----	4.15
	20,001+	----	4.04
Tractor 牵引车	up to 20,000	----	3.09
	20,001+	----	2.01
Route Bus 市区巴士	6,000-8,000	----	6.97
	8001-10,000	----	6.3
	10,001-12,000	----	5.77
	12,001-14,000	----	5.14
	14,001+	----	4.23
Other Bus 其他巴士	3,500-6,000	----	9.04
	6,001-8,000	----	6.52
	8,001-10,000	----	6.37
	10,001-12,000	----	5.7
	12,001-14,000	----	5.21
	14,001-16,000	----	4.06
	16,001-20,000	----	3.57

Japan: Scheme for fuel economy determination
日本重型车油耗测试方法



JE05 (transient) cycle and a Interurban (steady-state) cycle weighted according to vehicle application

JE05（瞬态）工况和城市间（稳态）工况由车辆使用情况来加权计算

US: HDV fuel efficiency standard
美国重型车燃油经济性标准

- December 2007: Energy Independence and Security Act
  - Requires the Department of Transportation (DOT) to establish fuel efficiency standards for medium and heavy-duty vehicles
  - National Academy of Science study on technology potential (March 2010)
- Joint rulemaking effort by National Highway Traffic Safety Administration (NHTSA) and Environmental Protection Agency (EPA)
  - Proposal released Oct 25, 2010 Final Rule due by July 30, 2011
  - Standards for fuel use (NHTSA authority) and GHGs (EPA authority)
  - Full coverage of all heavy-duty vehicles (Class 2b through 8)

- 2007年12月颁布了能源独立与安全法案
  - 要求交通部为中、重型车制定燃油经济性标准
  - 国家科学院完成对技术潜力的研究（2010年3月）
- 令交通部国家高速公路交通与安全局与环保署联合制定
  - 草案于2010年10月25日发布
  - 最终稿于2011年7月30日发布
  - 标准既包括油耗（由NHTSA负责），又包括温室气体排放（由EPA负责）
  - 标准涵盖所有重型车等级（从2b到8）

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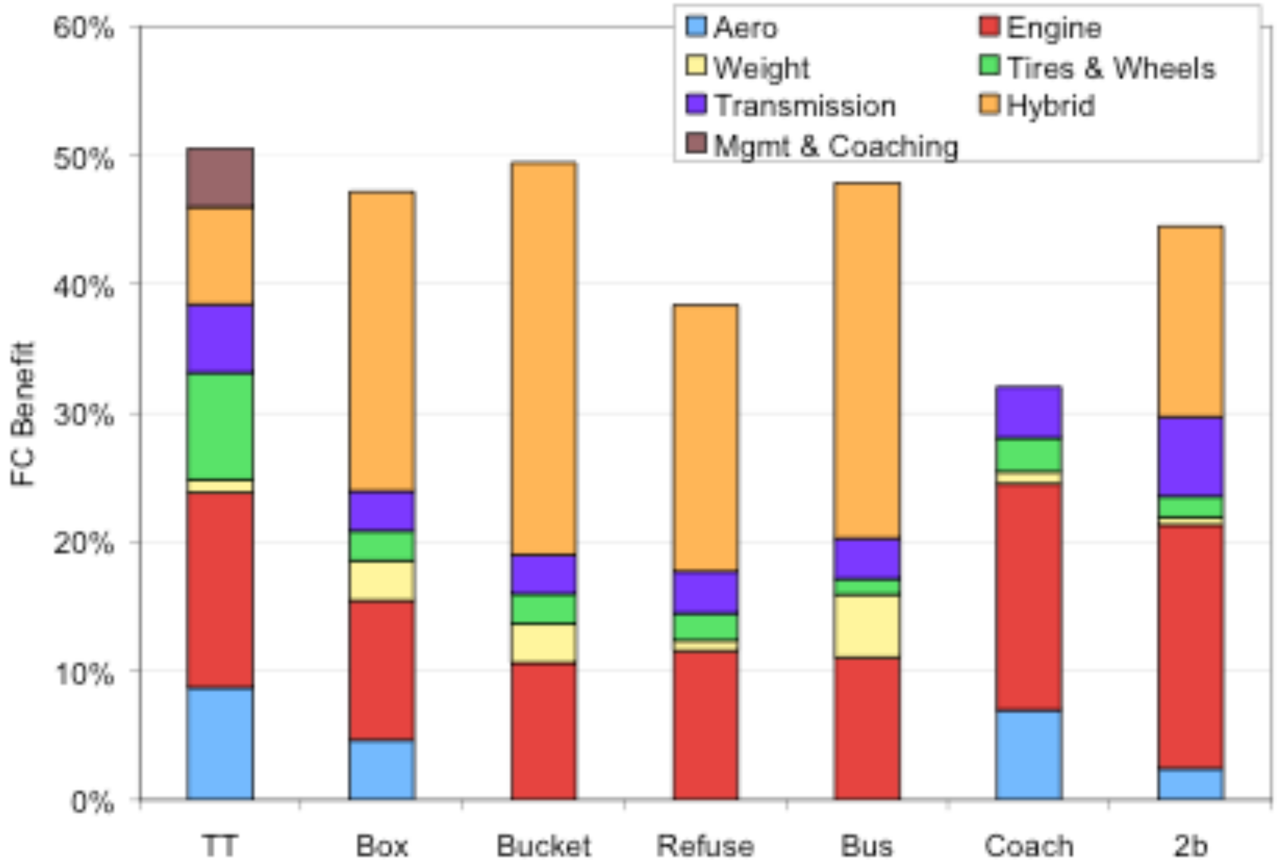
US: National Academy of Sciences study 国家科学院的研究

- NAS study (March 2010) was commissioned as a result of the EISA
- Fuel consumption reduction potential close to 50% for most vehicle types

- 此研究（2010年3月已完成）是能源独立和安全法案的要求
- 研究结果表明大部分种类的车油耗减排潜力接近50%



Potential fuel savings for new vehicles in 2015-2020 各类别车通过各种技术节油潜力

Source: TIAX (2009) Assessment of Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles.
来源：TIAX（2009）对中、重型车燃油经济性技术的评估

US HD National Program: Vehicles Included 美国重型车标准涵盖的车辆种类

- Three distinct regulatory programs:
  1. Class 2B and 3 heavy-duty pickup trucks and vans
  2. Class 2B-8 vocational vehicles and separate engine standard
  3. Class 7-8 tractor trucks and separate engine standard

- 针对不同车型有3个内容
  1. 针对2b和3类的重型皮卡车和vans
  2. 针对2b-8类的特殊车辆和发动机标准
  3. 针对7—8类牵引卡车和发动机标准

Rule category	Vehicle classes	Weight (GVWR)	Typical vehicle	Regulated entity	Requirement (metric)
Heavy-duty pickup trucks and vans	Selected class 2B and 3 vehicles	8,501 – 14,000 lbs. (3.9 – 6.4 tonnes)		Vehicle manufacturer	Whole vehicle GHG and fuel consumption standard (g CO_2/mile, gallon/100 mile)
Vocational vehicles and engines	- Light HDVs (Class 2B though 5) - Medium HDVs (Class 6 and 7) - Heavy HDVs (Class 8)	- 8,501 – 19,500 lbs. (3.9 – 8.8 tonnes) - 19,501 – 33,000 lbs. (8.8 – 15 tonnes) - 33,001 lbs and over (> 15 tonnes)		- Vehicle manufacturer (chassis) - Engine manufacturer	- Whole vehicle GHG and fuel consumption standard (g CO_2/ton-mile, gallon/1,000 ton-mile) - Engine standard (g CO_2/bhp-hr, gallon/100 bhp-hr)
Combination vehicles and engines	Class 7 and 8 tractors	- 27,000 – 33,000 lbs. (12 – 15 tons) - 33,001 lbs. and over (15 tons and over)		- Tractor manufacturer - Engine manufacturer	- Whole vehicle GHG and fuel consumption standard (g CO_2/ton-mile, gallon/1,000 ton-mile) - Engine standard (g CO_2/bhp-hr, gallon/100 bhp-hr)

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US Proposal: Costs and Benefits 美国提案:成本收益研究

Vehicle Category	Additional Cost per Truck (MY 2018)	Lifetime Fuel Savings (3% Discount Rate)	Estimated Payback Time
Tractor Trucks	$5,901	$79,699	< 1 year
HD Pickups and Vans	$1,411	$3,996	< 1 year
Vocational Vehicles	$359	$4,360	~ 5 years

Over lifetime of vehicles sold between MY 2014 and 2018:

- Total additional costs to industry estimated at $7.7 billion
- Societal benefits estimate at $49 billion Net benefit of $41 billion
- 500 million barrels of oil saved over lifetime of vehicles sold between model year
- 250 million metric tons of avoided CO_2-equiv emissions

在2014-2018车型年间售出车辆的全使用周期中

- 对汽车业的额外成本为77亿美元
- 社会收益估计为490亿美元
  - 净收益为410亿美元
- 将节省5亿桶石油
- 将减少2.5亿吨二氧化碳当量

China: HDV fuel consumption standard
中国重型车油耗标准的进展

- Rulemaking process:
  - China Automotive Technology and Research Center (CATARC) develops test procedure (3 drafts before finalized by Ministry)
  - Test procedure implemented voluntarily for a year while standards are developed
  - Standard proposed (2013) and implemented (2015 at earliest)
- Test procedure first draft released in June 2010, final draft approved in Jan 2011.
  - Structured on base vehicle testing and variant vehicle modeling
  - CATARC developed simulation model

- 标准制定进展
  - 中国汽车技术研究中心研制了测试程序
  - 在标准制定未完成前，测试程序将实行自愿执行
  - 标准年预计在2013年提出，最早2015年实施
- 标准测试程序第一稿于2010年6月发布，最终稿将在今年内审查通过
  - 基于对基本车型测试和对变形车型模拟
  - 中国汽车技术研究中心开发模拟模型

EU: HDV GHG standard 欧盟重型车温室气体标准

- Euro VI regulation requires establishing labeling methodology and public information on vehicle performance
  - Potential for standard to be established once labeling program is in place
- European Commission leading two in-depth consulting studies that will be the foundation of a future HDV labeling program/standard
- Market study and strategy support
  - Characterizing the HD fleet, market structure and function, manufacturers
  - Develop fuel use and CO_2 emission inventory and scenarios for the future
  - Survey current and emerging vehicle technologies and their potential for reducing fuel use
  - Qualitative assessment of policy options
- Development and testing of a certification procedure for CO_2 emissions, fuel consumption of HDVs
  - Led by all the major type approval agencies in Europe
  - Considering simulation modeling as an important component
  - Report completion ~ end of 2011/early 2012
- Proposal in 2012/2013

- 欧VI法规要求制定车辆能效标识和公共信息体系
  - 一旦标识确立则有可能制定标准
- 欧盟委员会牵头进行的两项研究将为重型车标识和标准出台奠定基础
- 市场研究和战略支持
  - 分析重型车车队、市场构成、功能和厂商
  - 建立油耗和CO_2数据库和未来的情景
  - 调研目前和新型的汽车技术和它们的节油潜力
  - 对各种政策手段进行定性分析
- 开发并测试重型车CO_2和油耗的认证程序
  - 由欧洲主要的认证机构牵头
  - 正在考虑将模拟模型作为重要内容
  - 报告将于2011年底－2012年初完成
- 2012－2013年提出草案

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Recommendations (1) 建议

- China needs to set stringent long-term fuel consumption targets
  - Base targets on careful technology/cost feasibility assessments
  - Encourage industry to adopt advanced technologies in order to achieve China's carbon and energy reduction goals
- Strong enforcement programs and non-compliance penalties needed to ensure compliance
- Adequate fiscal penalties needed to ensure compliance
  - Fiscal incentives are useful, but are not a substitute for non-compliance penalties
- Extra care needed to account for upstream emissions of e-drive vehicles
- In the long-term, stringent fleet average fuel consumption targets are needed to promote truly low emission technologies

- 中国需要严格的远期油耗标准
  - 标准设定应基于细致系统的技术成本可行性分析
  - 鼓励生产厂商采用先进的能效技术已达到节能和温室气体减排目标
- 需要强有力的保障体系来实施标准，对不达标的生产厂商施以惩罚
  - 财税政策可用于保障实施
- 对消费者的财税激励对节能和厂商达标有帮助，但不能替代保障体系中的惩罚手段
- 需谨慎计算电驱动车上游温室气体排放
- 在远期，需制定足够严格的油耗标准来鼓励低碳排放技术的应用

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Recommendations (2) 建议（续）

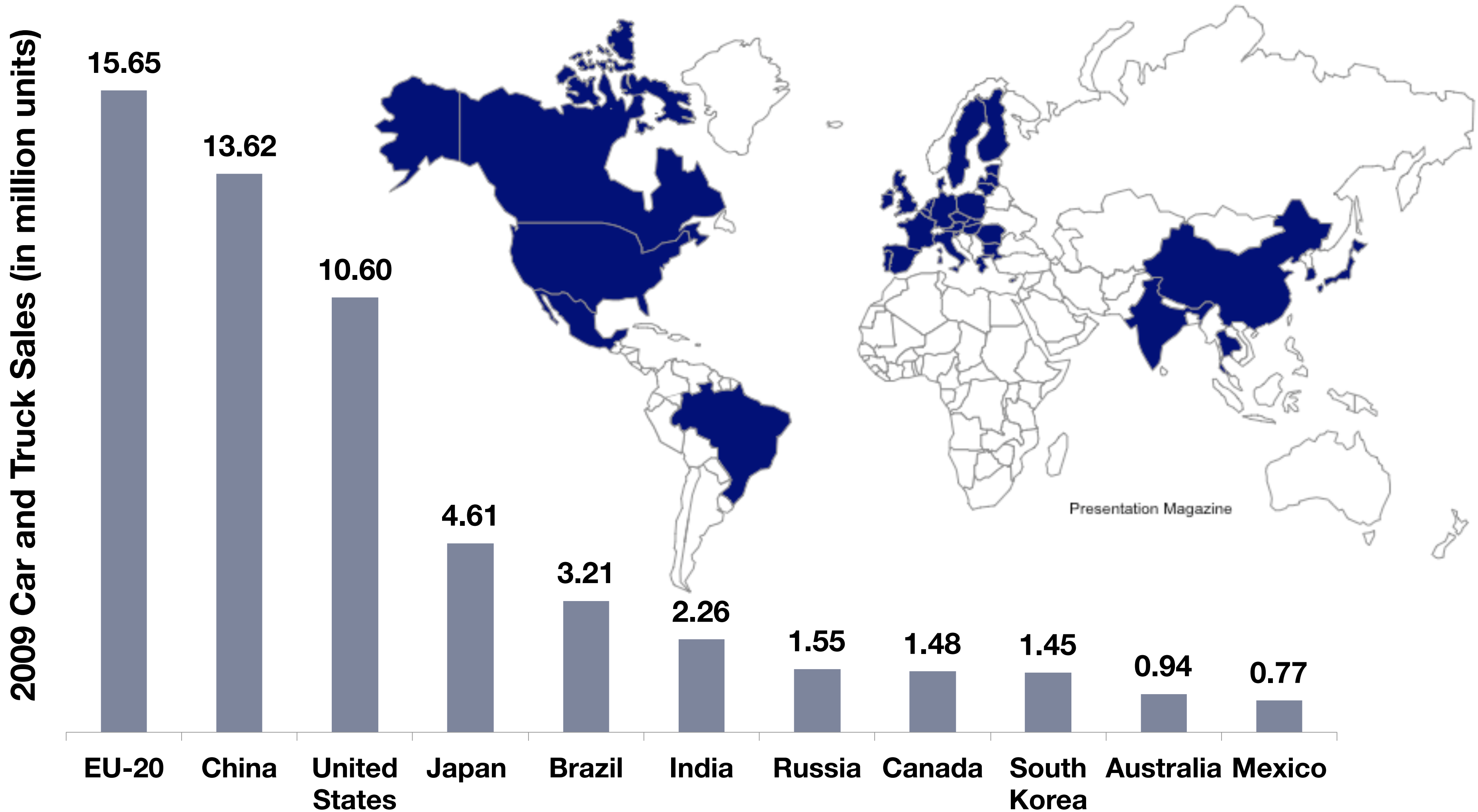
- China's existing fuel consumption standards could be further improved
  - One set of standards for all light vehicles
  - Performance-based standards
  - Size-based standards are superior to weight-based standards
  - Continuous structure is superior to bins

- 中国的车辆油耗标准可在以下方面进一步改善
  - 对所有轻型车使用统一标准
  - 采用直接基于油耗的标准
  - 如必须采用以车辆属性为基础的标准结构，车辆尺寸优于车辆质量
  - 连续的标准优于分段标准

Thank you!

谢谢！

Top ~~Ten~~ Eleven Vehicle Markets, 2009



Source: Ward's Automotive

Advantages (+) & disadvantages (–) of different standard forms

		Attribute			
		Flat	Category/ Class	Footprint/ Pan Area	Weight
The potential for compliance benefits from given strategies	Powertrain efficiency	+	+	+	+
	Engine downsizing	+	+	+	+
	Mass reduction (per-vehicle light-weighting)	+	+	+	
	Downsizing sales-shift	+			
Potential disadvantages in loss of intended benefits	Backsliding due to Category sales shift		–		
	Backsliding due to vehicle sales shift		–	–	–
	Backsliding due to vehicle weight creep				–
Potential for equitable technology-based obligated reductions across automakers with different vehicle types and classes		–	–	+	+
Simplicity, transparency of standards; outcome certainty		+	–	–	–

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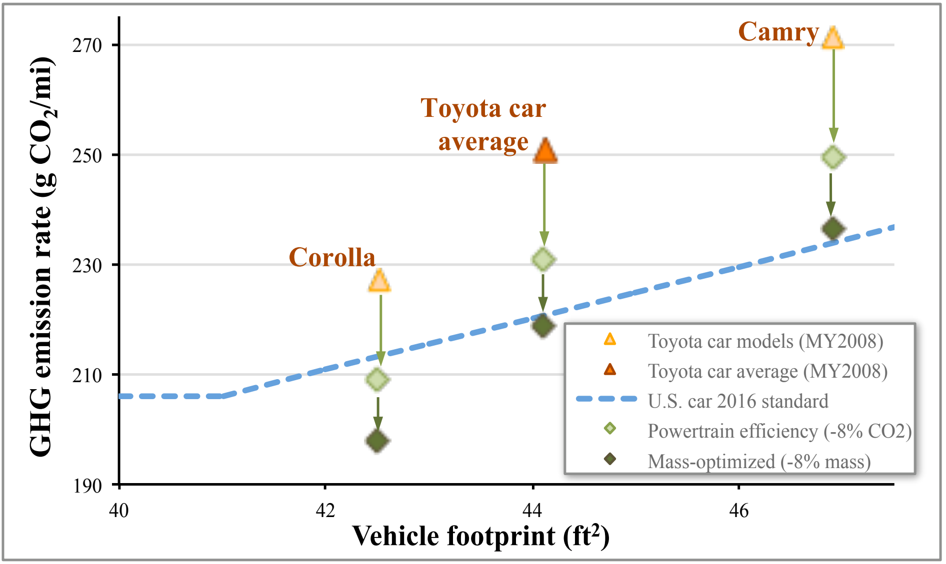
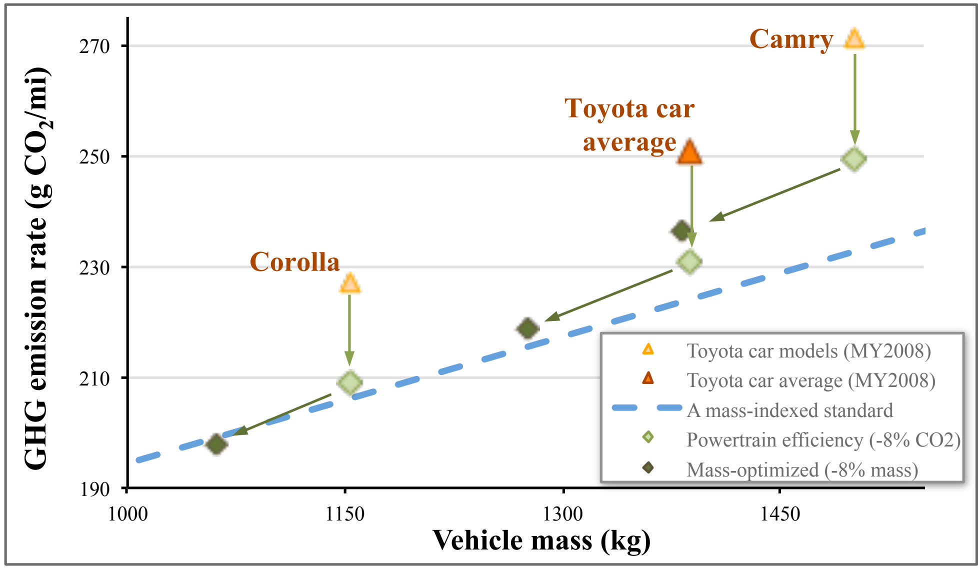
A size-based standard fully captures benefits of lightweighting

- Size-based design:
  - Efficiency: 11-14 g CO_2/km benefit
  - Lightweighting: 7-8 g CO_2/km *actual* benefit

- Mass-based design:
  - Efficiency: 11-14 g CO_2/km benefit
  - Lightweighting: only 2-3 g CO_2/km *compliance* benefit





ICCT (2010) Size or Mass? - The Technical Rationale for Selecting Size as an Attribute for Vehicle Efficiency Standards
http://www.theicct.org/2010/08/size-or-mass/

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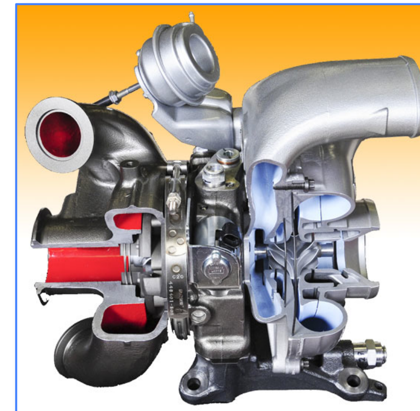
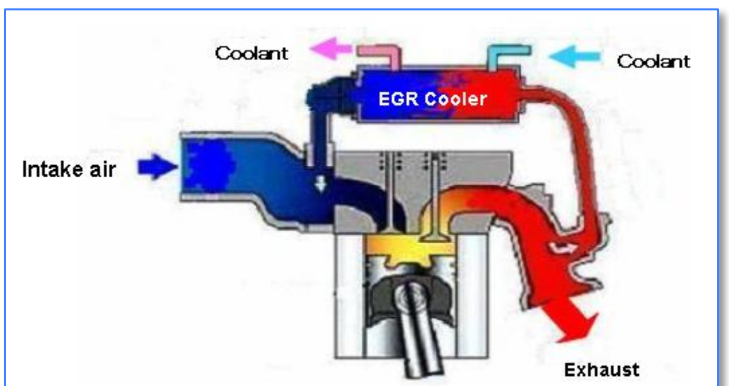
Next-generation Gasoline Engines

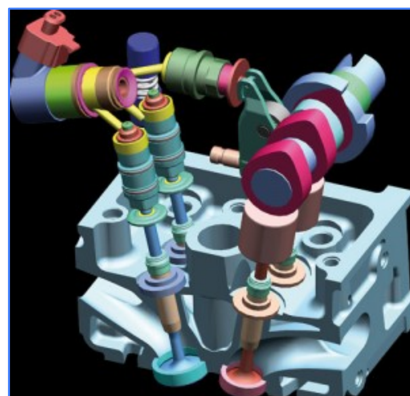
- Turbo direct injection
- Next generation engines push efficiency frontier:
  - Dual-stage turbocharging: High BMEP
  - Dual-loop high/low pressure cooled exhaust gas recirculation (EGR) systems
  - Digital valve actuation



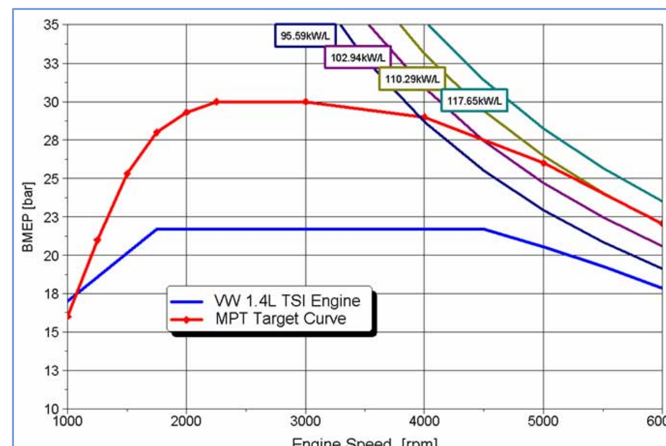
Ford/Honeywell sequential turbo with EGR



Exhaust gas recirculation



Fiat MultiAir

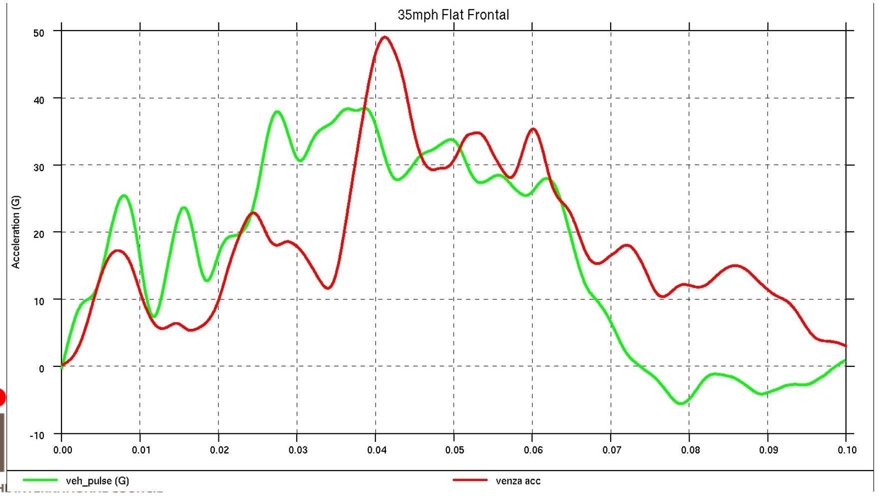


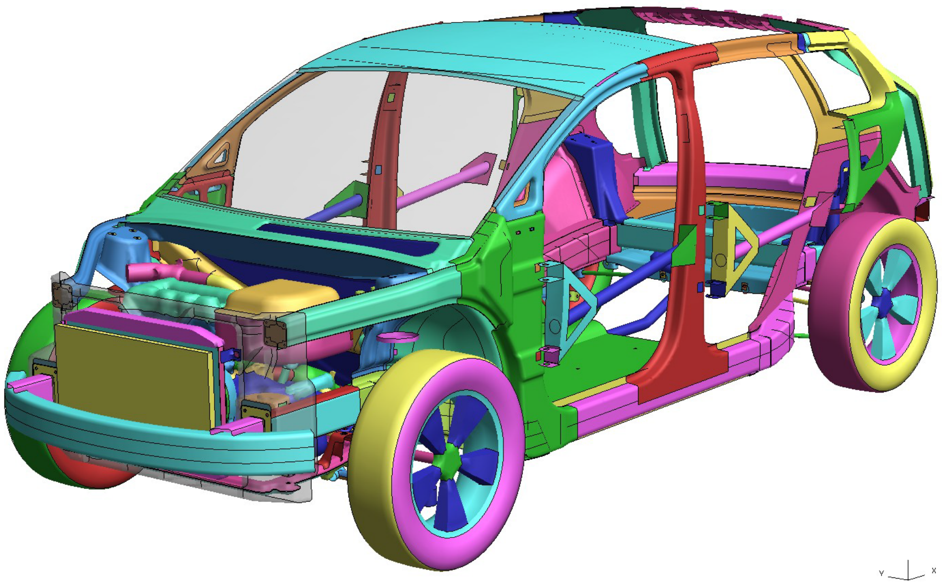
Mahle twin sequential turbo

Sources:
Exhaust gas recirculation: http://images.dailytech.com/nimage/14218_large_egr.png
Ford/Honeywell: http://www.dieselplace.com/forum/showthread.php?t=327289
Mahle: http://www.ae-plus.com/Key%20topics/kt-Powertrain-news20.htm
Fiat: http://fiat500usa.blogspot.com/2009/05/new-fiat-technology-coming-to-america.html

Lightweight Material Development

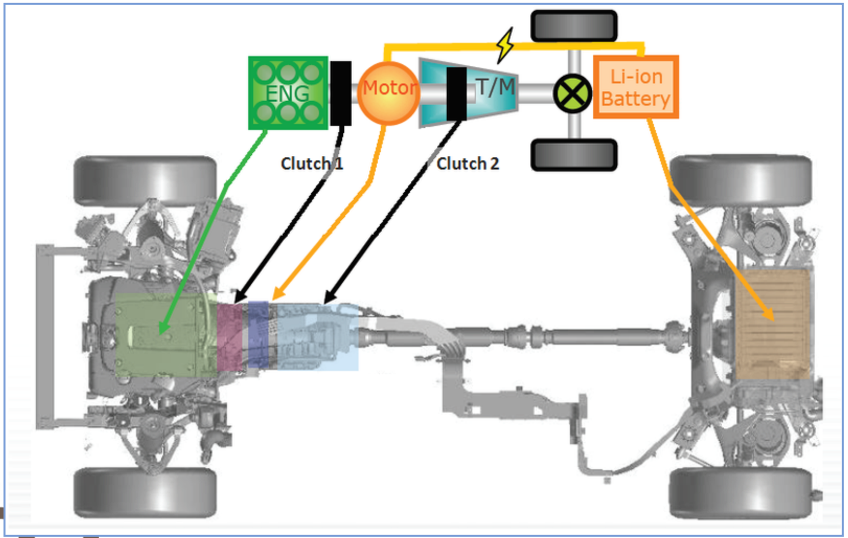
- Lotus mass-reduction crash simulation work
  - CARB/EPA/NHTSA collaboration
  - Computer-Aided Engineering (CAE)
  - Simulate vehicle in front, side, offset crashes
  - Validate crashworthiness of 30%+ mass-reduced vehicle
  - Completion in winter/spring 2011



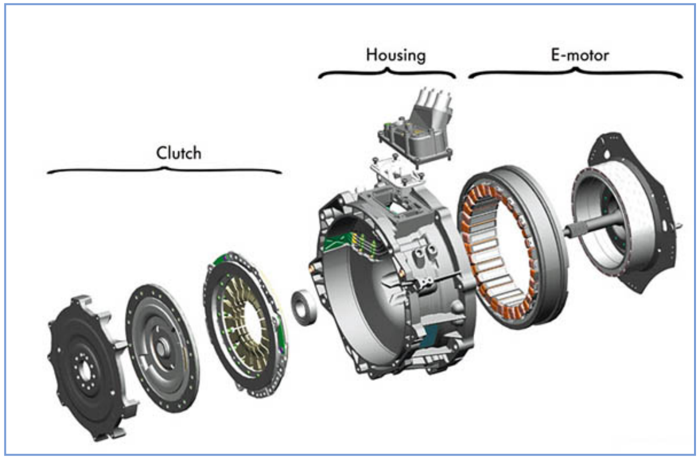


Hybrid Technology Advances

- Synergies with other technologies
  - Engine (Atkinson, Miller, lean-cruise, digital valve); optimization of engine operation; mass-reduction; dual-clutch transmission
- New hybrid types, improved optimized control strategies
  - Pre-transmission clutch: increased engine decoupling (Nissan, VW, Hyundai)
  - High-power Li-ion batteries – smaller, lighter, and lower cost
  - Smaller motors and batteries
  - Reduced city and highway CO_2 emissions



Nissan Fuga/M35 parallel hybrid layout



VW Touareg hybrid module

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Technology Cost and Benefit – US Work

▪ Ricardo simulation study – Efficiency benefit of advanced engine and hybrid technologies – $1.5 million ($1.4m EPA, $120k ICCT)	Nov 2009 - May 2011
▪ New FEV/Monro teardown cost information – First time for detailed and transparent costs – ICCT will use as the basis for our own cost work – About $2 million (EPA)	Sep 2009 - summer 2011
▪ Advanced lightweight materials studies – Crash simulations and costs (ICCT, EF, and EPA) – $2.8 million ($400k CW, $600k EF, $1.8m EPA)	Jan-Dec 2011
▪ Updated analyses of fatalities vs. size/weight – $330k ($150k Honda, $100k EF, $80k ICCT)	Fall 2010 - Fall 2011
▪ Supplemented by existing technology costs and benefits studies	Done

T&I Assisted Deliverables for Europe 2011

- **EPA-Ricardo US simulation work to be transferred to EU market**
  - Additional simulation runs for diesel vehicles, small cars, NEDC cycle
    - $350k (ICCT)
- **EPA-FEV US detailed costing analysis to be transferred to EU market**
  - Add new technologies that have not been analyzed by EPA
  - Scale results to Europe: conditions (wages, capitol costs, etc.) and vehicle size
    - $450k (ICCT)
- **Deliverable: Report with compilation of technology potentials & costs**
- **White paper on the effects of downsizing** without balancing power output on CO_2 emissions (making use of Ricardo RSM)
- **Additional Analyses:** EU vehicle market statistics (technical parameters and emissions), attribute parameter and target line (weight vs. size, etc.)
- **Other deliverables tentatively planned for later in 2011/12:** EVs / FCVs (summary of available tech/cost information), eco-innovation technologies, effects of CO_2 taxation/labeling in EU, vehicle testing compliance

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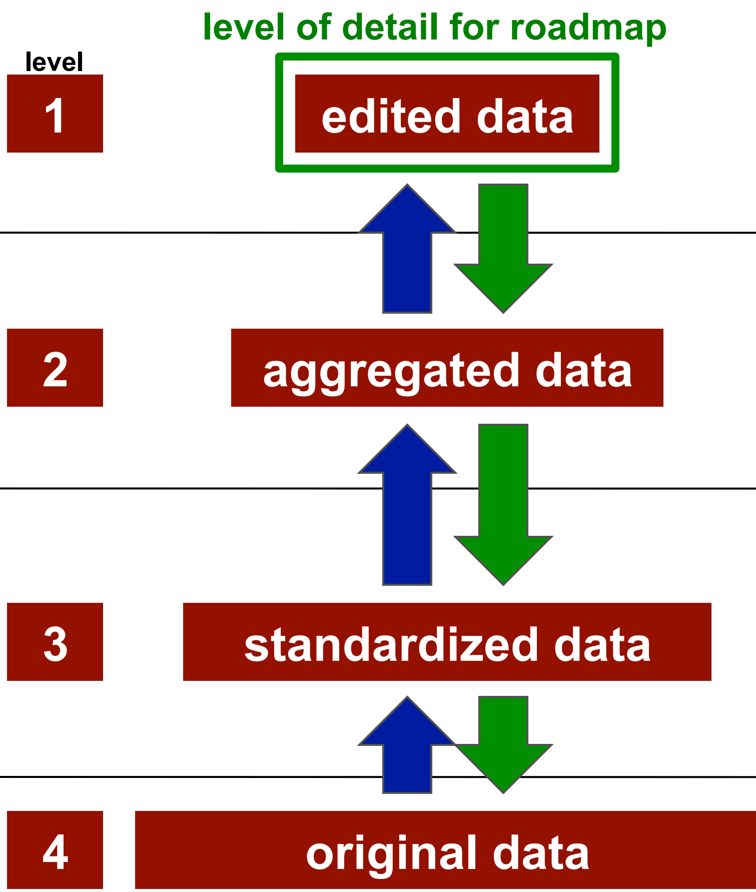
Longer-Term: Public Database



Data that has been edited further by ICCT staff to allow not only looking at specific costs and effectiveness of individual technologies but also absolute values, therefore requiring definition of packages etc.

Data from several sources aggregated by ICCT to arrive at our best-guess range for each technology. For the general user who is interested in an assessment for each technology and trusts ICCT's opinion (can have a look at original sources our assessment is based on if wanted).

Original data but (automatically via conversion tables) standardized e.g. to use same currency and base year for costs. Also some classifications (manually by ICCT staff) added to categorize e.g. what countries and years data is applicable for. For those who would like to see some details.

Original data directly taken from the sources. For those who would like to see all the details. Important for database: Transparency (what data is original, what was edited by ICCT?)

direction to set up the database

direction for general user to navigate through the database

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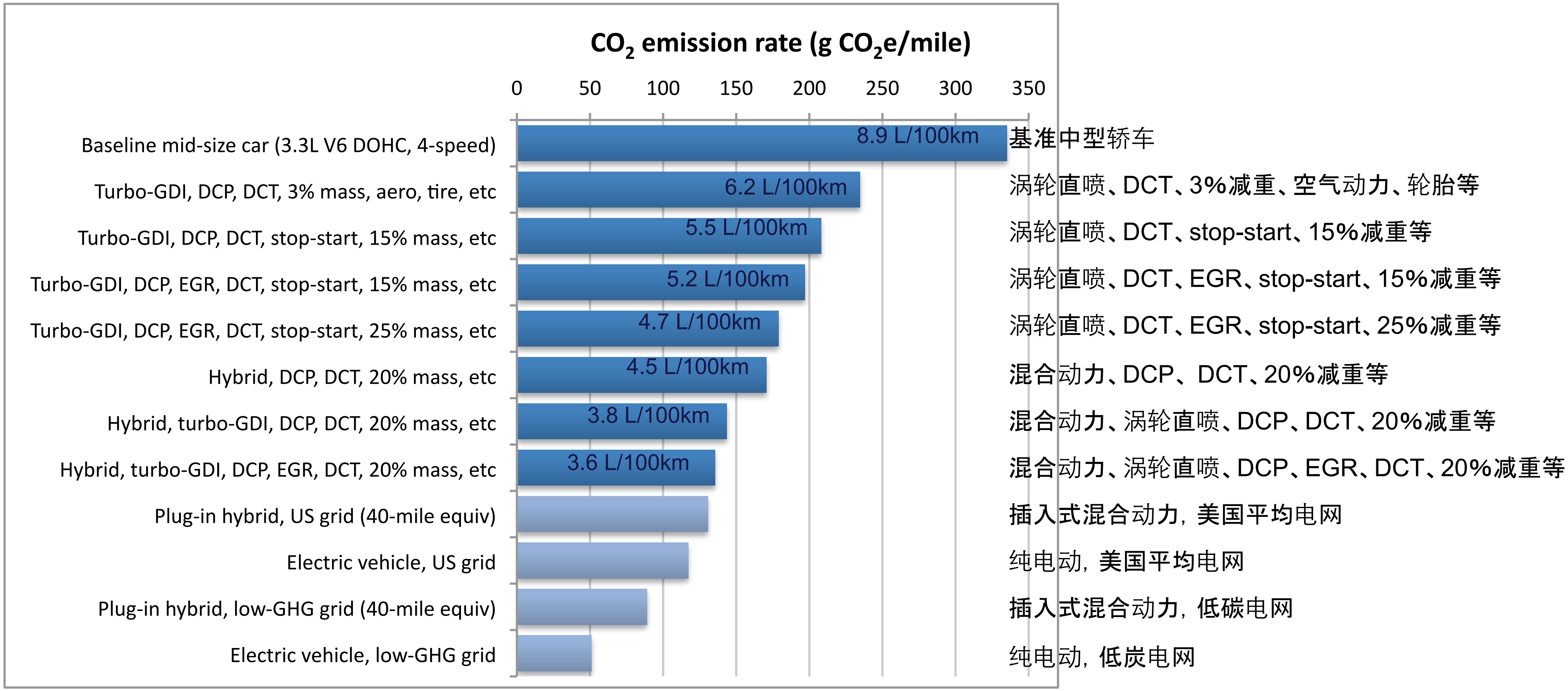
Joint-Agency TAR: Technology Packages 技术包裹

- What did the TAR find regarding levels of CO_2 emission reduction? 技术支持报告中关于减排潜力的结论
  - Many available drivetrain technologies; also hybrids, plug-in hybrids, electric 现已有多项动力系统技术
  - Selected packages for baseline mid-size sedan (e.g., Toyota Camry), 1 of 19 classes 以中型轿车为基准的特定技术包裹，分析了1－19等级



Technology packages also include other technologies (including aerodynamics, engine friction reduction, improved accessory efficiency, low rolling resistance tires); 技术包裹还可包括其他技术（改进空气动力、减低发动机摩擦、附件改进、低滚动阻力轮胎）

GDI=汽油直喷； DCP= 双凸轮相控; DCT= 双模变速; EGR= 废气循环;

CO_2 and mpg values from rated combined city/highway test cycle (i.e., are not adjusted for consumer on-road labels or A/C credits); assumed average US electric grid emissions are 558 gCO_2/kWh with EPA accounting method; "low-GHG" grid are California 2020 33% RES assumptions

CO2和mpg值采用未经调整的市区、高速综合值；假设美国电网排放为558克／千瓦时；假设低碳电网为加州2020年33%可再生能源标准规定的水平，大约为268克／千瓦时

Joint-Agency TAR: Technology Results
技术支持报告;技术分析结论

- What did the TAR find regarding future technologies?
  - Emerging technologies would be required to achieve 2025 targets 要达到2025年标准需要使用最新出现的技术
    - Engine, transmission, mass reduction are primary technologies 发动机、变速器、减重技术仍作为主导技术
    - Hybrid electric vehicle technology expected to have much greater penetration 混合动力技术采用率预计将提高
    - Electric vehicles (EVs) and plug-in hybrids (PHEVs) will emerge 纯电动车和插入式混合动力车将出现
  - For example, for 2025 vehicle emission levels below 160 gCO_2/mi (i.e., for the 5-6%/yr target scenarios): 举例在2025年达到160g/mi的情况，即年减排率5－6%
    - Advanced engine 先进发动机 **near-universal** turbocharging, direct injection 近乎普及的涡轮增压和直喷
    - Advanced drivetrain 先进动力系统: **near-universal** 6+ speed, dual-clutch, stop-start 近乎普及的6速变速、双模变速和stop-start
    - Advanced material/design 先进材料和设计: **14-26%** mass reduction average per-vehicle 平均每车需达到14%－26%的减重
    - Hybrid technology 混合动力技术: **25-68%** hybrid technology share 混合动力达到25%－68%的采用比例
    - Electric vehicles 电动车: **0-16%** electric and plug-in-hybrid share 达到0－16%的比例

Post-TAR: Ongoing Work 现阶段工作

- Agencies' continuing work on future technologies 仍在进行未来技术的分析
  - Technical feasibility, costs, impacts 技术可行性、成本、消费者及厂商影响
  - Continued one-on-one dialogue with automakers and other stakeholders 仍在与厂商进行沟通
- Ongoing work elements include… 具体包括
  - Technology package potential (i.e., % CO_2 reduction) 技术包裹减排潜力
    - Simulation modeling of engine, hybrids (e.g., with Ricardo) 建模模拟发动机、混合动力改善潜力（如Ricardo项目）
  - Technology cost evaluation 技术成本评估
    - Costs of engine, drivetrain, battery, technologies (e.g., with FEV, Munro) 发动机成本、动力系统、电池等成本
  - Mass-reduction feasibility, simulation 模拟减重可能性
    - Follow-up to Lotus study (peer review, cost, crashworthiness) Lotus研究的后续工作
    - New NHTSA solicitation on mass reduction feasibility NHTSA新的减重可行性研究
  - Safety: Statistical, compatibility studies on mass, size, safety 安全性：重量、尺寸和安全性的统计学和兼容性研究
  - Continued multi-agency collaboration in all technical, cost areas 成本研究

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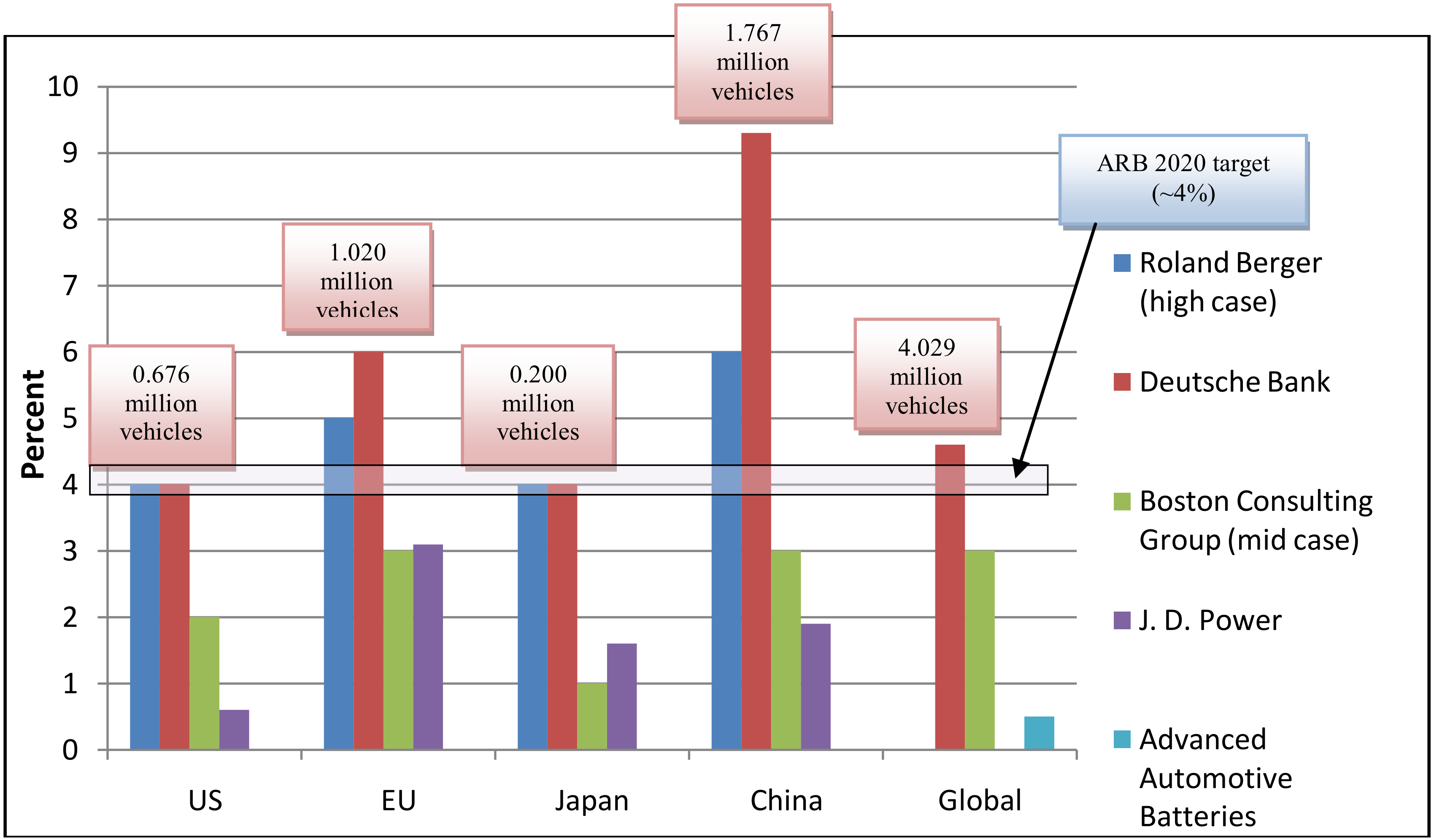
Figure 2. Projected BEV Penetration Rates, in 2020 (Percentage of Annual Sales)



Red box= Roland Berger percentage estimate times estimated Passenger Vehicle sales

Top Level Messages

- Unprecedented Global Interest in Vehicle Electrification
- Policies and programs largely in place for "early adopters"
- Need to Plan for "Second Wave" Customers
  - Mainstream customers are risk averse, new emphasis needed
- Additional focus on fleets warranted
- California Program Still Critical
  - ZEV regulation uniquely able to sustain progress during uncertainty and market challenge

Infrastructure

- Finding solutions for public hydrogen fueling is crucial for fuel cells
- Caution on going beyond current plans for public infrastructure for plug-in
- Financing options for chargers at homes and/or businesses
- Increasing renewables increases GHG & air quality benefits – need “green electrons”

International Lessons Learned

- Main driver for vehicle electrification is support for domestic auto industries
- Top down push – concern about a letdown
- City EVs good for European applications
- Vehicle deployment targets should be viewed with caution
- CA ahead of the curve

Japan: "Top Runner" HDV fuel economy standard
日本"领跑者"重型车燃油经济性标准

- November 2005: Japan introduced world's first fuel economy standard for HDVs
- Vehicles included: 2005年11月，日本开始实施全世界第一个重型车燃油经济性标准
  - Commercial vehicles with gross vehicle weight rating (GVWR) > 3.5 metric tons
  - 应用于总质量在3.5吨以上的营运车辆
  - Buses with carrying capacity > 11 people 和可承载11人以上的巴士
- Metric: fuel economy → km/liter 计量单位为 公里／升
- Targets disaggregated by vehicle type, class, and weight
  标准因车型、等级和质量而不同
- Most efficient vehicle ("top runner") in MY 2002 set as baseline
  将2002车型年最节油的车辆（即"领跑者"）作为基准参考值
  - Hybrid vehicles were excluded when determining the top runner
    当时未将混合动力车作为"领跑者"
- Manufacturers must meet targets starting in MY 2015 厂商须在2015车型年时达标
- Efficiency technologies incorporated into vehicles must be displayed prominently in catalogs starting in 2006
- 从2006年起必须将车辆使用的节油技术明显显示在产品目录上
  - Incentives for early compliance including tax reductions
    辅之以财税激励政策以鼓励提早达标

Japan: Parameters and settings for simulation model 日本模拟模型的参数和设定

Parameter 参数		Setting 设定	
Engine 发动机	Full load torque 满载扭矩	Actual value 实际值	For each engine type 每个发动机型
	Engine friction torque 发动机摩擦力矩		
	Idling engine revolution 发动机空转		
	Max output engine revolution 最大输出功率发动机转速		
	Max engine revolution (w/load) 最大发动机转速(无负载)		
Drivetrain 传动系统	Number of transmission gears 变速箱齿轮数	Actual value 实际值	For each transmission type 每个变速器型
	Transmission gear ratios变速箱齿轮比		
	Final reduction gear ratio 最终减速比	(Average) actual value (平均)实际值	For each engine and transmission type 每个发动机和变速器型
	Tire dynamic load radius 轮胎动载荷半径		
Driving resistance 行驶阻力	Rolling resistance 滚动阻力	Standard values 标准值	By each fuel efficiency category 每个燃油经济性类别
	Air resistance 空气阻力		
Chassis size 底盘尺寸	Kerb weight 整备质量	Standard values 标准值	By each fuel efficiency category 每个燃油经济性类别
	Maximum load 最大负载		
	Riding capacity 载客量		
	Full height 全高		
	Full width 全宽		

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Japan: Test procedure advantages and disadvantages 日本测试程序的优势和劣势

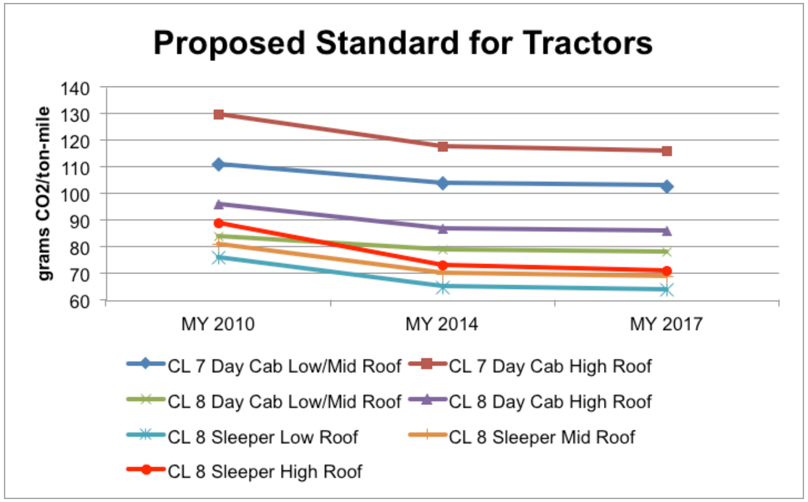
Advantages 优势

- Simultaneous testing of fuel economy and criteria emissions under identical cycles 在同样工况下测试油耗和常规污染物排放
  - Reduced costs for industry 减少厂商成本
  - Minimizes opportunity to optimize emissions and fuel economy differently on separate test cycles 将根据不同工况优化油耗和常规污染物结果的可能降到最底
- Wide range of engine-transmission-chassis combinations can be estimated without expensive testing 可以以较少的成本测试多种发动机ー变速器ー底盘的组合

Disadvantages 劣势

- Constrains compliance options to engine efficiency only 限制了达标手段，仅从提高发动机效率来达标
  - Assigns standard values by fuel efficiency category and chassis size 根据燃油经济性类别和底盘大小决定标准值
  - Changes in these variables within a fuel economy bin will not count towards compliance 在特定油耗段内如上述变量发生变化并不算作达标
  - Constrains stringency of the rule 限制了法规的严格程度
- Transmission efficiency gains seem to be poorly represented in the model 模型不能充分变速器效率的改善
- Not clear how efficiency improvements from hybrid drivetrains are incorporated in the model 不确定混合动力传动系效率的提高如何反映在模型上
- Uncertain accuracy vs. chassis dyno tests due to low sample size (n=4) 对比测功机测试，此模型准确率不确定，因为样本数目小(4个)

US Proposal: Class 7 and 8 Tractor Trucks 美国针对7－8类牵引卡车的提案

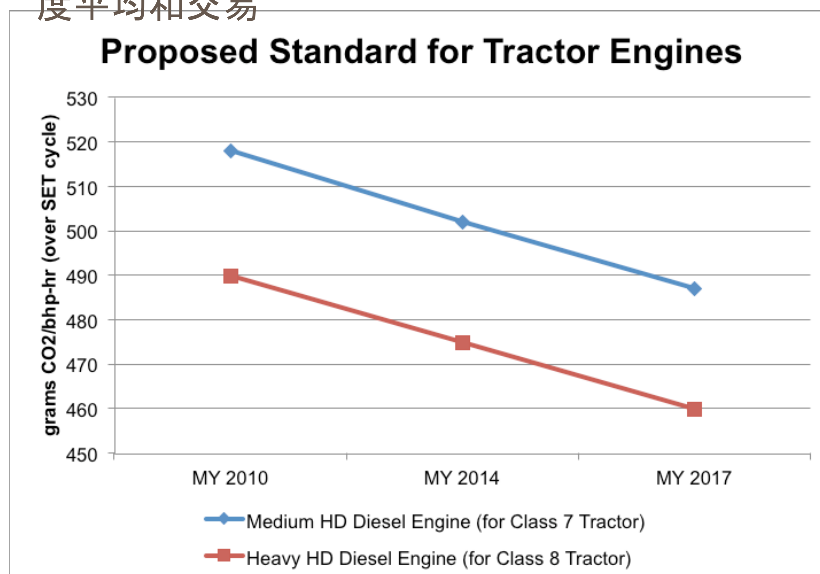


Engine program 发动机标准

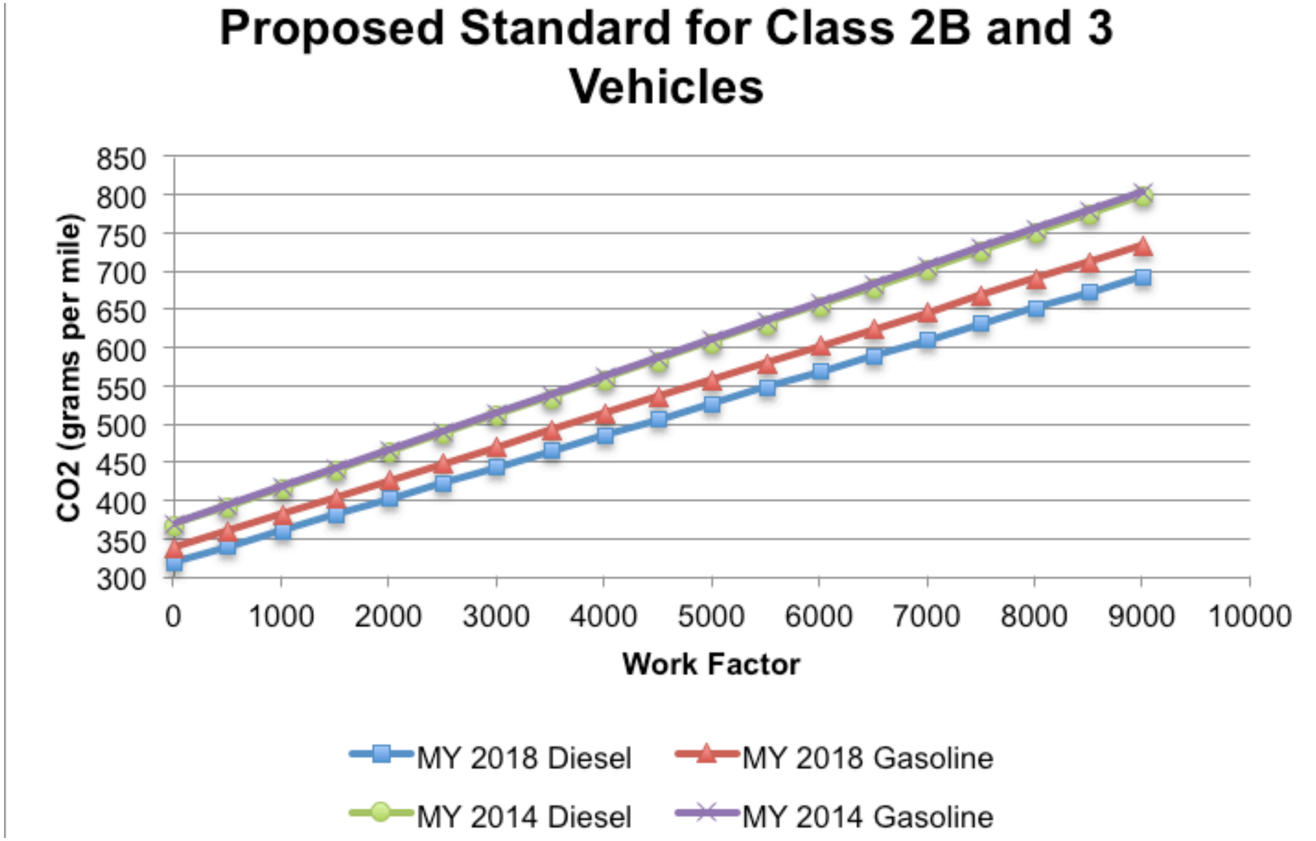
- Designed to align with current criteria pollutant regulation: adds CO2, CH4, N2O 与现有常规污染物法规相结合，加入了CO2, CH4, N2O
- 2 regulatory subcategories: one for engines in Class 7 tractors, one for Class 8 2个亚类：分别是7类牵引车和8类车
- Engine dynamometer testing over SET (steady-state) cycle 对发动机进行稳定状态工况的测功机测试
- ABT within subcategories only仅允许在亚类内进行信用额度平均和交易

Vehicle program 整车标准

- 7 regulatory subcategories based on Class (7 or 8), configuration (sleeper or day cab), and roof height (low, mid, or high) 针对不同车型配置和顶高有7个亚类
- Trailers not included 挂车不包括在内
- Full vehicle testing on newly developed Greenhouse gas Emissions Model (GEM) 整车进行新开发的温室气体排放模型测试
- Manufacturers input data for aerodynamics, tire rolling resistance, weight reduction 厂商输入车体空气动力设计、轮胎滚动阻力、减重情况的数据
- Averaging, banking, and trading (ABT) within subcategories only 仅允许在亚类内进行信用额度平均和交易

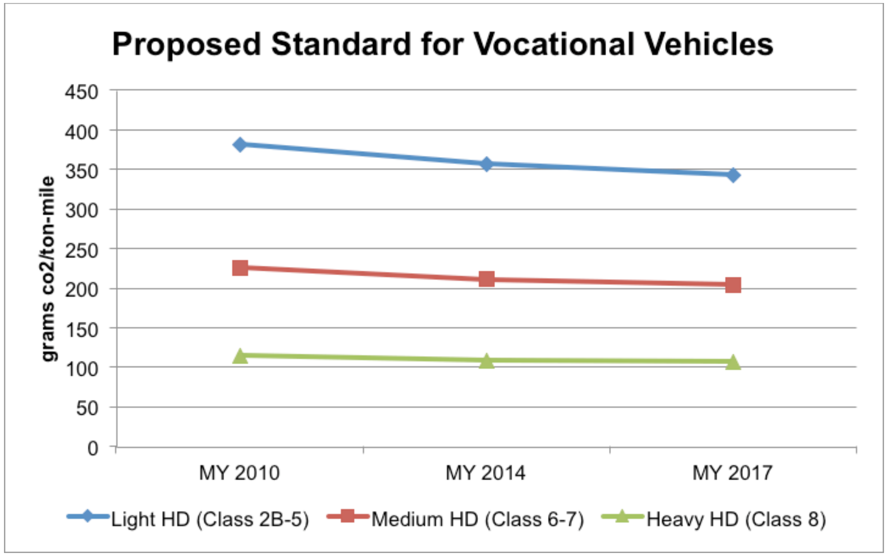


US Proposal: Class 2B and 3 HD Pickup Trucks, Vans
美国对2b和3类皮卡车和van的提案



- Designed to align with current light-duty vehicle regulation 与现行轻型车法规相结合
- Full vehicle testing on chassis dynamometer 整车进行底盘测功机测试
- Averaging, banking, and trading (ABT) across entire category 允许在整体类别内进行信用额度平均与交易

US Proposal: Class 2B-8 Vocational Vehicles 美国对2b-8类特殊车辆的提案

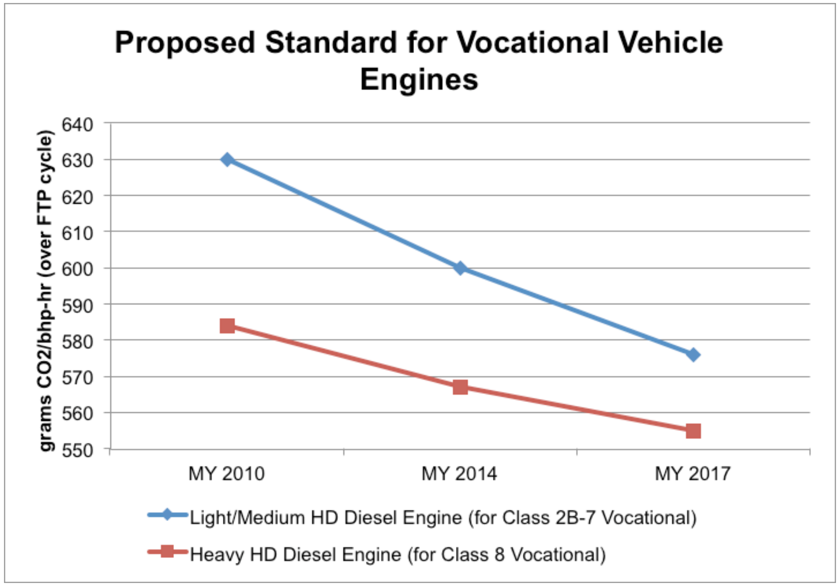


Vehicle program 整车标准

- 3 regulatory subcategories based on Class (2B-5, 6 and 7, 8) 针对2b-5类、6和7类、及8类设三个亚类
- Full vehicle testing on GEM software 整车进行GEM测试
- Manufacturers input data for tire rolling resistance ONLY 厂商仅输入轮胎滚动阻力的数据
- Averaging, banking, and trading (ABT) within subcategories only仅允许在亚类内进行信用额度平均和交易

Engine program 发动机标准

- Designed to align with current criteria pollutant regulation: adds CO2, CH4, N2O与现有常规污染物法规相结合，加入了CO2, CH4, N2O
- 3 regulatory subcategories: one each for engines in Class 2B-5, 6-7, and 8 vehicles 3个标准亚类：分别是2b-5, 6-7和8类车
- Engine dynamometer testing over FTP (transient) cycle 发动机进行FTP工况测功机测试
- ABT within subcategories only仅允许在亚类内进行信用额度平均和交易



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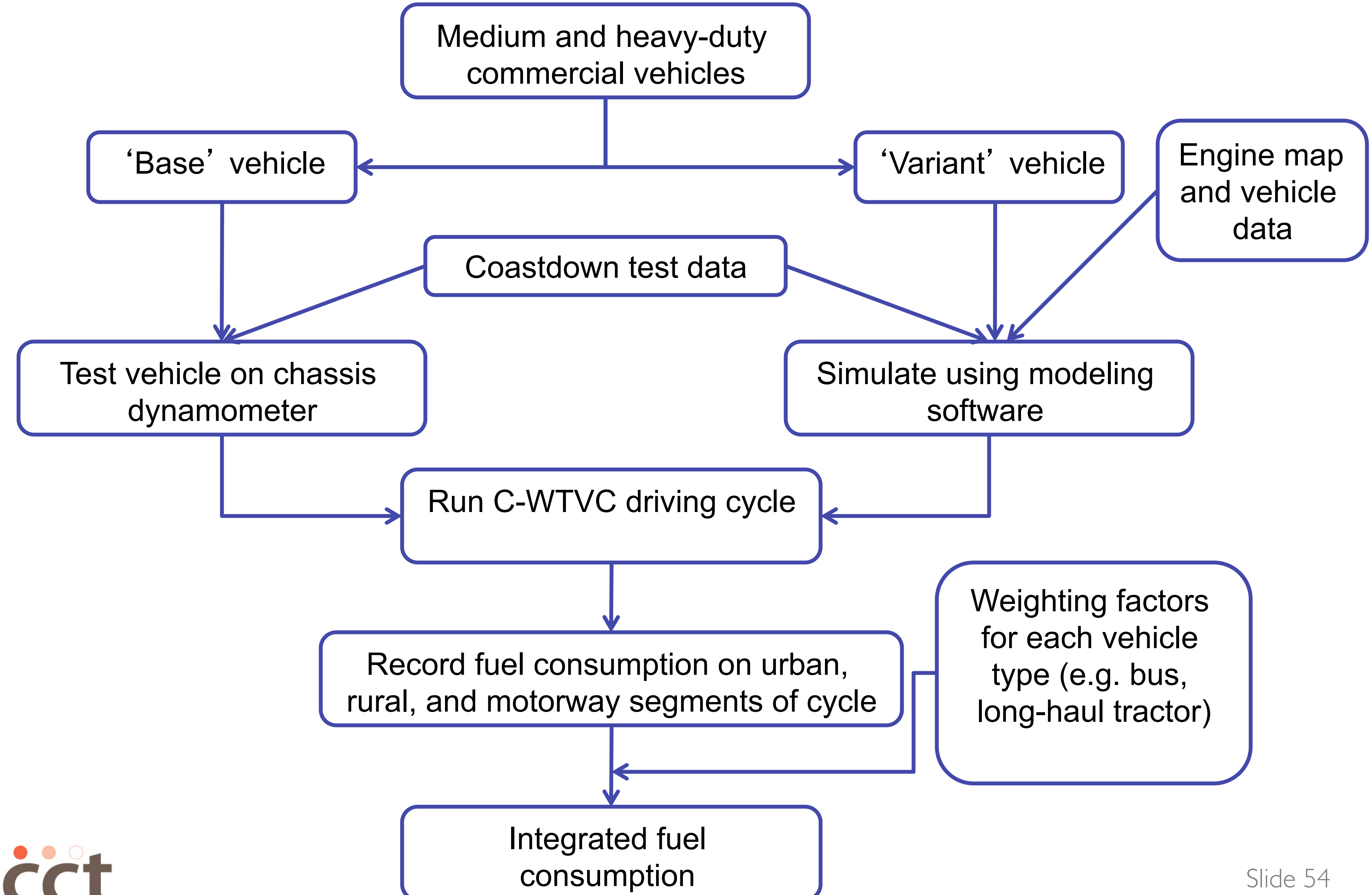
China: HDV fuel consumption test procedure



California: HDV greenhouse gas regulation 加州：重型车温室气体排放标准

- December 2008: adopted new regulation to reduce GHG emissions by improving the FE of HD tractors that pull 53-ft or longer box type trailers 2008年12月实施了重型牵引卡车（可牵引53英尺以上的挂车）的燃油经济性标准，从而间接地起到温室气体减排标准的作用
- Affected entities → anyone who **operates** in California: 实施对象为所有在加州行驶的该类车辆，包括
  - Owners of HD tractors that pull 53-ft or longer trailers 可牵引53英尺以上挂车的牵引车
  - Owners of 53-ft dry-van and refrigerated box-type trailers 53英尺以上的箱式冷藏车
- Two basic technology requirements: 两个基本技术要求
  - Compliant aerodynamic technologies 需达到车体空气动力学设计标准
  - Low rolling resistance tires 需使用低滚动阻力的轮胎

The regulation does NOT apply to the following 标准不作用于以下车辆	
Custom extended sleeper cab tractors 订制有卧铺的驾驶室的牵引车	Curtain side vans
Military tactical vehicles 军事用车	Solid waste vehicles 垃圾车
Authorized emergency vehicles 持证的急救车	Container chassis 集装箱底盘
Drayage tractors and trailers that operate within a 100 mile radius of a port or intermodal rail yard 在港口或铁路联运站附近（100英里内）运行的牵引车和挂车	Drop frame vans 低架挂车

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