POLICY UPDATE

DECEMBER 2014

PROPOSED SAUDI ARABIA CORPORATE AVERAGE FUEL ECONOMY STANDARD FOR NEW LIGHT-DUTY VEHICLES (2016–2020)

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

The Kingdom of Saudi Arabia (KSA), through the Saudi Standards, Metrology and Quality Organization (SASO), announced new light-duty vehicle (LDV) fuel economy standards on Monday, November 17, 2014. The proposed standards apply to all new and used passenger vehicles and light trucks, whether imported from outside or manufactured in Saudi Arabia. They will be effective as of January 1, 2016, and will be fully phased in by December 31, 2020. A review of the targets will be carried by December 2018, at which time targets for 2021–2025 will be set.

The standards for new vehicles are patterned after the U.S. Corporate Average Fuel Economy (CAFE) standard structure, including test cycle and flexibility mechanisms. Flexibility mechanisms include off-cycle credits, air-conditioning efficiency credits, and phase-in flexibilities. To benefit from these credits, manufacturers must register in a SASO administered data sharing program, and submit vehicles sales plans and actual sales reports on a regular basis.

Imported used vehicles are treated differently. Each used vehicle must comply with a minimum fuel economy standard, set separately for cars and light trucks. The standards are independent of vehicle attributes such as weight or size, sales-weighting and other flexibilities are not allowed, and the standards do not change over time.

A Fuel Economy Committee, made up of representatives of Saudi Energy Efficiency Center (SEEC), SASO, the Ministry of Transport (MoT), the General Department of Traffic, and the Gulf Cooperation Council Standards Organization (GSO) will assess the impact of the fuel economy standard, propose any necessary modifications to the program, and resolve any disputes.

NEW VEHICLE FUEL ECONOMY TARGET DESIGN CHARACTERISTICS

The fuel economy targets for new light duty vehicles (gross vehicle weight rating of less than 3500 kilograms or 7716 pounds) are defined based on the corporate average concept, similar to the system used in the U.S., Canada, and Mexico. Targets are defined

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separately for passenger cars and light-duty trucks and adjusted based upon vehicle size. The fuel economy targets follow the design of the U.S. 2012–2016 fuel economy standards closely, except for a three- to four-year delay. As in the U.S. program, the fuel economy targets are adjusted based on vehicle footprint.[1] Footprint was selected over vehicle weight for the standards as a way to incentivize the deployment of lightweighting materials.[2]

FUEL ECONOMY TARGETS

Fuel economy targets are defined as a function of vehicle footprint and change according to yearly "enforcement cycles," as shown in Table 1.

Table 1. Proposed FE Standards Enforcement cycles

Enforcement Cycle No	Start Date	End Date
EC No 1	January 1, 2016	December 31, 2016
EC No 2	January 1, 2017	December 31, 2017
EC No 3	January 1, 2018	December 31, 2018
EC No 4	January 1, 2019	December 31, 2019
EC No 5	January 1, 2020	December 31, 2020

Individual vehicles are not required to meet their specific targets. These target values are combined with vehicle sales to calculate an overall sales-weighted average fuel economy standard for each manufacturer. This allows manufacturers and importers great flexibility, as there is no per-vehicle standard.

The mathematical function for passenger-car target values is defined as:

$$\text{Target } FE_{PC} = \frac{1}{MIN\left[MAX\left(c * FOOTPRINT + d, \frac{1}{a}\right), \frac{1}{b}\right]} \qquad \textbf{Eq. 1}$$

where

a = fuel economy upper limit (km/L)

b = fuel economy lower limit (km/L)

c = slope (L/km/m^2)

d = intercept (L/km)

Table 2 shows the parameters defining the proposed fuel economy target curves for passenger cars.

1 Vehicle footprint is defined as average track width multiplied by the wheelbase, or in simpler terms as the area between the four wheels.

2 For a detailed discussion of the benefits of basing fuel economy and CO2 emission standards on footprint instead of vehicle weight, see John German and Nic Lutsey, "Size or Mass? The Technical Rationale for Selecting Size as an Attribute for Vehicle Efficiency Standards," available at www.theicct.org/size-or-mass-technical-rationale-selecting-size-attribute-vehicle-efficiency-standards.

Table 2. Equation 1 Coefficients by Enforcement cycle

Coefficient	EC No1	EC No2	EC No3	EC No4	EC No5
a (km/L)	15.28393	15.64530	16.04919	17.46917	18.54053
b (km/L)	11.88277	12.09960	12.34193	13.16246	13.88095
c (L/km/m²)	0.013439	0.013439	0.013439	0.013439	0.012991
d (L/km)	0.014247	0.014247	0.011114	0.006052	0.004460

The mathematical function for light trucks is defined as:

$$Target\ FE_{LT} = MAX\left(\frac{1}{MIN\left[MAX\left(c * FOOTPRINT + d, \frac{1}{a}\right), \frac{1}{b}\right]}, \frac{1}{MIN\left[MAX\left(g * FOOTPRINT + h, \frac{1}{e}\right), \frac{1}{f}\right]}\right)$$

Eq. 2

where

a = fuel economy upper limit (km/L)

b = fuel economy lower limit (km/L)

c = slope (L/km/m²)

d = intercept (L/km)

e = fuel economy upper limit (km/L) of "floor"

f = fuel economy lower limit (km/L) of "floor"

g = slope (L/km/m²) of "floor"

h = intercept (L/km) of "floor"

Table 3 shows the parameters defining the proposed fuel economy target curves for light trucks.

Table 3. Equation 2 Coefficients by Enforcement cycle

Coefficient	EC No1	EC No2	EC No3	EC No4	EC No5
a (km/L)	12.67779	13.03916	13.34102	14.63346	15.41572
b (km/L)	9.467960	9.667770	9.833580	10.51806	10.66686
c (L/km/m²)	0.011510	0.011510	0.011510	0.011510	0.013885
d (L/km)	0.035047	0.032855	0.031107	0.024493	0.011989
e (km/L)	1	1	1	1	14.92255
f (km/L)	1	1	1	1	10.66686
g (L/km/m²)	0	0	0	0	0.011510
h (L/km)	0	0	0	0	0.023171

Comparing the U.S. CAFE program and the KSA proposal, it is clear the targets are identical to those for U.S. NHTSA CAFE standards covering 2012–2017 new vehicle models. As shown in Table 4, the proposed KSA standards aim to increase the fuel economy of new light-duty vehicles by 4% a year between 2016 and 2020. The reason why the fuel economy values are not perfect matches for the same vehicle type is because each fleet has a different fleet average footprint, resulting in different targets according to the fuel economy target functions. Note that the KSA proposal skips one of the U.S. cycles, 2015.

Table 4. Estimated Targets assuming constant footprint

Enforcement Cycle	KSA	KSA FE target value, km/L		U.S. CAFE	U.S. FE target value, km/L	
		Passenger Vehicles	Light Trucks		Passenger Vehicles	Light Trucks
EC No 1	2016	14.2	11.4	2012	14.2	10.8
EC No 2	2017	14.5	11.7	2013	14.5	11.1
EC No 3	2018	14.9	11.9	2014	14.8	11.3
EC No 4	2019	16.7	13.0	2016	16.1	12.2
EC No 5	2020	17.0	13.2	2017	17.0	12.5

Figures 1 and 2 show how the KSA proposed standards compare to those enacted or proposed by other governments worldwide.

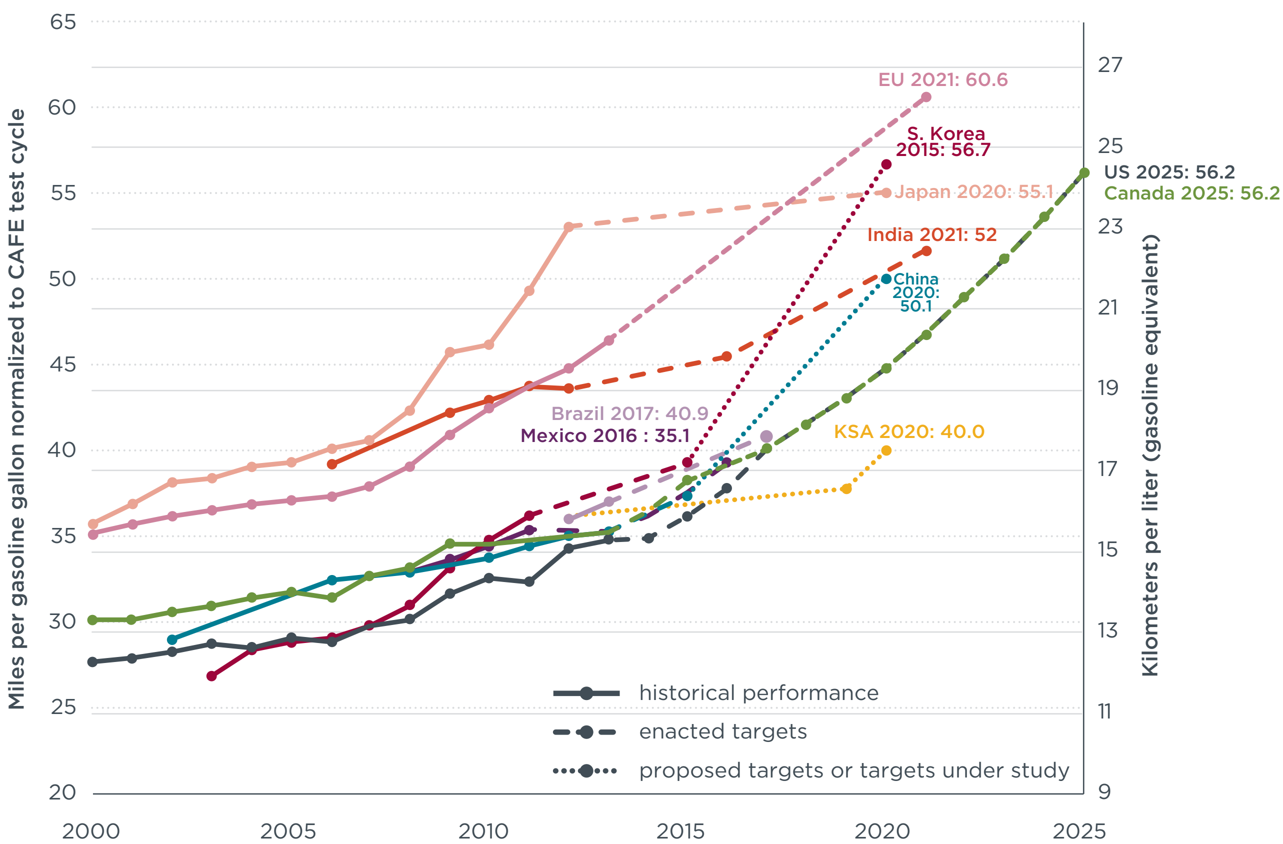

Figure 1. Global Fuel Economy Standards for Passenger Cars

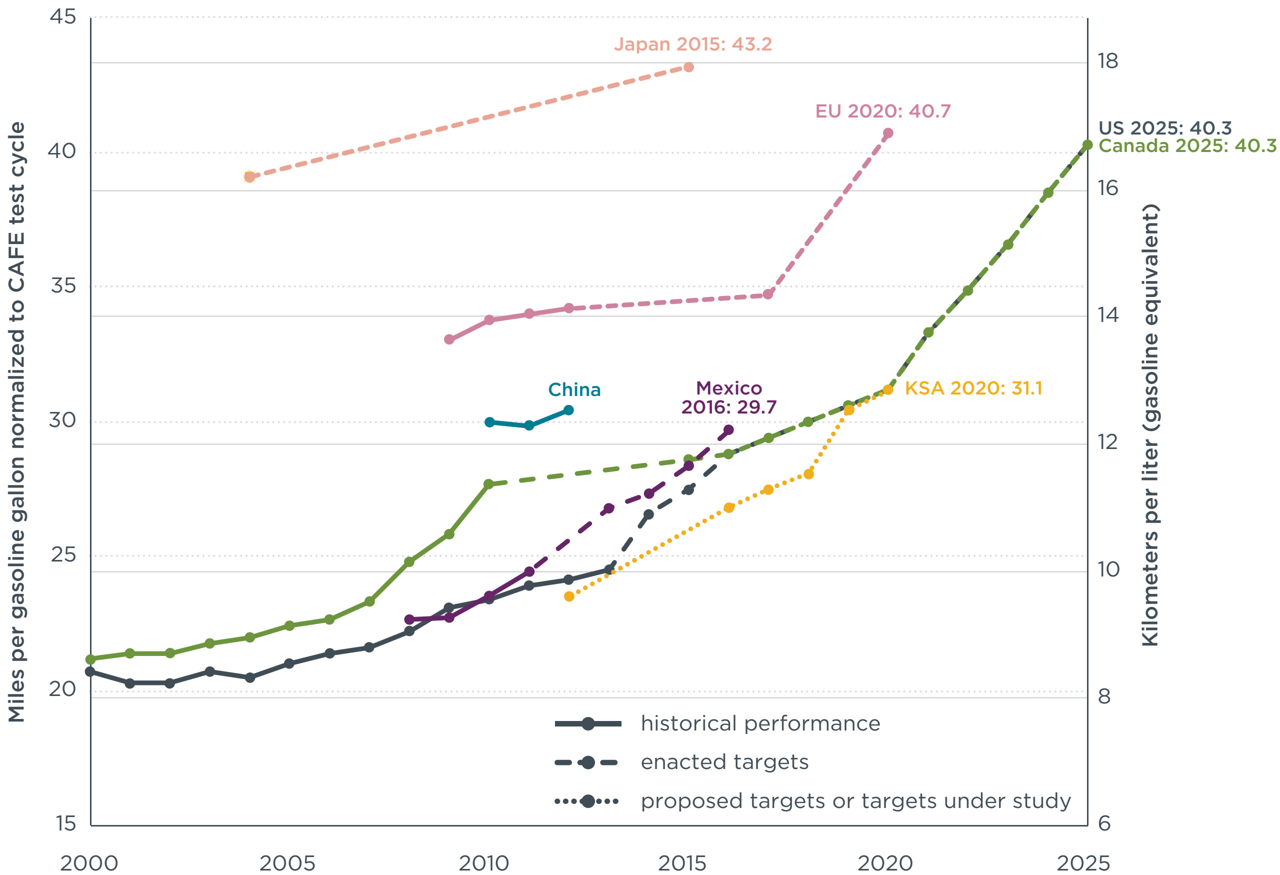

Figure 2. Global Fuel Economy Standards for Light-Duty Trucks

COMPLIANCE ASSESSMENT

Each manufacturer must calculate actual fuel economy value for its passenger fleet and separately for its light truck fleet. The actual fuel economy value is calculated as a sales-weighted harmonic average of all vehicles sold during the compliance cycle, using the formula below.

$$CAFE_{actual} = \frac{\sum_i SALES_i}{\sum_i \frac{SALES_i}{ACTUAL\ FE_i}} \qquad \textbf{Eq. 3}$$

where

$CAFE_{actual}$ is the actual Corporate Average Fuel Economy

$SALES_i$ is the number of vehicles intended for sale within Saudi Arabia of each i^{th} unique footprint within each model type

ACTUAL FE_i is the reported actual fuel economy value of each i^{th} unique footprint within each model type

Fuel economy is measured based on the U.S. Environmental Protection Agency testing procedures: FTP-75 for the city driving cycle, plus the Highway Fuel Economy Test (HWFET). The Combined Fuel Economy, referred in this document as "fuel economy," is calculated per the following formula:

$$\text{Combined Fuel Economy} = \frac{1}{\dfrac{0.55}{\text{City Fuel Economy}} + \dfrac{0.45}{\text{Highway Fuel Economy}}}$$

Under the current KSA proposal a manufacturer can test the fuel economy of a vehicle using the New European Driving Cycle (NEDC) testing procedure, then convert the value obtained to CAFE values using a table provided in the regulations. The use of a cycle conversion factor for fuel economy regulation purposes is unusual.

To determine compliance and any credits or deficits, the actual values are compared against an individual manufacturer's CAFE standard calculated from its CAFE target values. The calculation of the standard from the CAFE targets (eq. 4) is the same as equation 3, except that the $ACTUAL\ FE_i$ value is replaced with the $TARGET\ FE_i$ value that is obtained by using the vehicle footprint data in equations 1 or 2 .

$$CAFE_{Target} = \frac{\sum_i SALES_i}{\sum_i \dfrac{SALES_i}{TARGET\ FE_i}} \qquad \textbf{Eq. 4}$$

FLEXIBILITIES

The proposal allows manufacturers flexibilities to meet their targets. These include accumulation of excess credits with respect to targets, trading between cars and trucks, off-cycle credits, air-conditioning credits, and phase-in provisions.

Manufacturers that exceed their annual targets would be able to accumulate the exceedance as a credit. The roll-over of credits can be applied for up to five enforcement cycles. Credits can also be carried backwards for three enforcement cycles, which means that a deficit in one year can be covered by generating credits in the next three years. Credits can be transferred between passenger car and light-duty trucks, for a single manufacturer. Transfer of credits across enforcement cycles and vehicle categories requires adjustment factors that are provided by the regulation.

OFF-CYCLE CREDITS

Starting with the third enforcement cycle (EC No3), manufacturers can apply for off-cycle credits from deployment of advanced technologies designed to reduce real-world fuel consumption under conditions which cannot be completely measured during the CAFE (or NEDC) testing. Three mechanisms are provided:

a. Credits derived from specific technologies in agreement with the U.S. Code of Federal Regulations Title 40 CFR 86.1869 — 12(b)(1), such as waste-heat recovery, high-efficiency lightning, solar panels, active aerodynamic improvements, engine-idle start-stop, active transmission warm up, and thermal control technologies.

b. For technologies not covered in the provision above and verifiable by the five-cycle testing methodology,[3] automotive manufacturers may generate off-cycle credits in agreement with U.S. Code of Federal Regulations Title 40 CFR 86.1869 — 12 (c). In this case the emission benefit of a technology is determined by testing both with and without the off-cycle technology operating on both the standard compliance cycle(s) and the five-cycle methodology.

c. For technologies not covered in the provision above and not verifiable by the five-cycle testing methodology, automotive manufacturers may generate off-cycle credits in agreement with U.S. Code of Federal Regulations Title 40 CFR 86.1869 — 12 (d)(1). This mechanism implies a demonstration program, and it can use modeling, on-road testing, on-road data collection, or other approved analytical or engineering methods. It should be robust, verifiable, and capable of demonstrating real world benefits.

AIR-CONDITIONING CREDITS

Starting with the third enforcement cycle (EC No3), automotive manufacturers will be allowed to generate credits for the use of air-conditioning systems that incorporate technologies designed to reduce air-conditioning-related fuel consumption by improving system efficiency. The menu of technologies that an automotive manufacturer may utilize to generate air-conditioning efficiency credits is similar to that defined in the U.S. fuel economy regulation.[4] It includes variable displacement compressor, default control of recirculated air supply, improved evaporators and condensers, and more efficient blower motors. The air-conditioning efficiency credits are capped at 0.0026 L/km for passenger cars and 0.0037 L/km for light trucks.

PHASE-IN

Manufacturers are also allowed to apply for a phase-in compliance mechanism during the first two years. In this case, the actual fleet average (CAFE actual) applies only for the percentage of sales of its most efficient vehicles, as defined in Table 5. This feature was also employed in the Europe Union during the introduction of CO_2 standards there. The most efficient vehicles are defined as those with the highest differential between actual fuel economy and target fuel economy (i.e., actual fuel economy minus target fuel economy)

Table 5. Phase in Flexibility for Compliance

EC No1	EC No2	EC No3	EC No4	EC No5
80%	90%	100%	100%	100%

VEHICLE DATABASE

SASO has established a database to manage the vehicle technology and fuel economy data required by the regulation. A manufacturer must submit an annual sales plan with vehicle model type approval details including fuel economy, as well as a mid-year review of the sales plan along with an year-end actual sales report for the additional credits described in this section.

3 Five-cycle testing is methodology described in 40 CFR Part 600

4 U.S. Code of Federal Regulations 40 CFR Part §86.1868-12 CO_2 credits for improving the efficiency of air conditioning systems.

IMPORTED USED VEHICLES

Per-vehicle fuel economy standards are applied to imported used vehicles. This differs from the new vehicle requirements, as the used vehicle standards are independent of vehicle attribute, sales-weighting and other flexibilities are not allowed, and the standards do not change over time.

There are two different standards, one for passenger cars and another for light trucks, as shown in Table 6. Each vehicle imported would have an actual fuel economy value based on the SASO fuel economy database referenced in the preceding section, or results of a fuel economy test conducted by a SASO or International Laboratory Accreditation Cooperation (ILAC) accredited laboratory.Initial minimum fuel economy values are to be adopted by January 1, 2016, and will be subject to amendment.

Table 6. Per vehicle Fuel Economy standards for used Imported Vehicles

Vehicle type	Minimum fuel economy (CAFE combined)
Passenger cars	10.3 km/L (24.2 mpg)
Light-duty trucks	9.0 km/L (21.2 mpg)

ENFORCEMENT MECHANISMS

For new vehicles, standard enforcement is verified for each manufacturer at the end of an enforcement cycle by comparing actual CAFE to target CAFE according to the manufacturer's fleet average footprint and corresponding target curves. If the manufacturer fails to meet the target, it must submit a sales plan that will generate enough credits in the succeeding enforcement cycle to offset the deficit. Moreover, the manufacturer must comply with a per-vehicle standard in the enforcement cycle following one in which it missed its target, based on the corresponding target curves. This requirement only expires once enough credits are accumulated to offset the deficit.

This is similar to China's enforcement proposal for its fuel economy regulation. In that case, if a manufacturer fails to meet its target, the Ministry of Industry and Information Technology will not accept vehicle fuel-consumption type-approval applications for models that exceed their weight-based fuel consumption limits specified in GB27999-2011 (Phase 3 standard).[5] The Chinese proposal also restricts expansion plans for manufacturers that fail to comply with the standards.

5 See "China Phase 3 new passenger car fuel consumption: Proposed implementation rule," ICCT policy update, available at www.theicct.org/china-phase-3-new-passenger-car-fuel-consumption-proposed-implementation-rule.