7. Toolkit:

Policy instruments available to improve the fuel economy of cars

Transport: Session 7
Jacob Teter - IEA
Jakarta, 19 July 2018

#energyefficientworld
What is fuel economy?

Fuel economy: the relationship between the fuel used and distance travelled by a vehicle.

This map is without prejudice to the status of or sovereignty over any territory, to the delineation of international frontiers and boundaries, and to the name of any territory, city or area.
What is fuel economy?

Important relationship:
About 2.4 kg of CO$_2$ emitted per litre of gasoline burned, 2.6 for diesel.
- For gasoline vehicles, 8 L/100 km = 189 g/km CO$_2$ emissions, 7 L/100 km = 165 L/100km, etc.
- It’s a fixed relationship.
  So the only way to cut CO$_2$ emissions is to burn less fuel (you can’t capture it at the tailpipe).

If you improve vehicle fuel economy, you:
- Save fuel
- Reduce costs
- Cut CO$_2$ emissions
- Don’t help air quality very much (though complex and important topic)
What is fuel economy?

Fuel economy improvements can be achieved through:

- Technical changes to vehicles
- Changing the types of vehicles bought
- Improving vehicle maintenance
- Changing the way vehicles are driven (ecodriving)
- Reducing traffic congestion

Fuel economy improvement to vehicles should be part of a broader strategy:

- Traffic management
- City and regional planning
- Promotion of public transit
- And many others...(avoid-shift)
How to improve vehicle fuel economy

• The average 2015 car, at 15-25% efficiency, has many energy losses – and many efficiency opportunities

Types of Air Pollutants

Air quality pollutants affect human health
- NOx
- Non-methane hydrocarbons
- Particulate matter (PM)
- carbon monoxide
- Toxic emissions (e.g. benzene)
- Heavy metals

Air pollutants affect the climate
- Methane
- Black carbon
- N\textsubscript{2}O
- CO\textsubscript{2}

Fuel quality / tailpipe controls

Fuel economy improvement
## GFEI Targets

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Cars</strong></td>
<td>30% reduction* in L/100km compared to 2005</td>
<td>50% average improvement globally</td>
<td>50% + globally</td>
</tr>
<tr>
<td></td>
<td>Engines, drive-trains, weight, aerodynamics.</td>
<td>Hybridisation of most models.</td>
<td>Significant contributions from Plug-in vehicles</td>
</tr>
<tr>
<td><strong>Total fleet</strong></td>
<td>20% reduction</td>
<td>35% reduction</td>
<td>50by50</td>
</tr>
<tr>
<td></td>
<td>With lag time for stock turnover; includes eco-driving, maintenance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fuel economy improving, but not fast enough...

Table 1 • Global fuel economy developments, 2005-15

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OECD and EU average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average fuel economy (L/mile)</td>
<td>8.8</td>
<td>8.2</td>
<td>7.8</td>
<td>7.6</td>
<td>7.4</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>annual improvement rate (% per year)</td>
<td>-2.3%</td>
<td>-2.8%</td>
<td>-1.6%</td>
<td>-1.3%</td>
<td>-0.5%</td>
<td></td>
<td>-1.8%</td>
</tr>
<tr>
<td><strong>Non-OECD average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average fuel economy (L/mile)</td>
<td>8.5</td>
<td>8.5</td>
<td>8.4</td>
<td>8.2</td>
<td>8.0</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>annual improvement rate (% per year)</td>
<td>-0.1%</td>
<td>-0.3%</td>
<td>-1.4%</td>
<td>-1.2%</td>
<td>-1.6%</td>
<td></td>
<td>-0.8%</td>
</tr>
<tr>
<td><strong>Global average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>8.8</td>
<td>8.3</td>
<td>8.1</td>
<td>7.8</td>
<td>7.6</td>
<td>7.6</td>
<td>4.4</td>
</tr>
<tr>
<td>annual improvement rate (% per year)</td>
<td>-1.8%</td>
<td>-1.6%</td>
<td>-1.3%</td>
<td>-1.3%</td>
<td>-1.1%</td>
<td></td>
<td>-1.5%</td>
</tr>
</tbody>
</table>

**GFEI target**

<table>
<thead>
<tr>
<th></th>
<th>2005 base year</th>
<th>2015 base year</th>
</tr>
</thead>
<tbody>
<tr>
<td>required annual improvement rate (% per year)</td>
<td>-2.8%</td>
<td>-3.7%</td>
</tr>
</tbody>
</table>
• Significant fuel economy improvement if policies are in place
• Size shift vs. technology evolution moderates Non-OECD improvement
• Growth of markets with worse fuel economy affects global trend
### Light duty vehicle efficiency improvements

Even ICE LDVs still have tremendous potential:

**ICE potential, through hybridization and light-weighting (NRC, 2013)**

<table>
<thead>
<tr>
<th>CO2 g/km</th>
<th>Litres / 100km</th>
<th>Gals / 100 mi</th>
</tr>
</thead>
<tbody>
<tr>
<td>386</td>
<td>16.4</td>
<td>7</td>
</tr>
<tr>
<td>331</td>
<td>14.1</td>
<td>6</td>
</tr>
<tr>
<td>276</td>
<td>11.7</td>
<td>5</td>
</tr>
<tr>
<td>221</td>
<td>9.4</td>
<td>4</td>
</tr>
<tr>
<td>165</td>
<td>7.0</td>
<td>3</td>
</tr>
<tr>
<td>110</td>
<td>4.7</td>
<td>2</td>
</tr>
<tr>
<td>55</td>
<td>2.3</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>

*FIGURE 2.1 Historical and projected light-duty vehicle fuel economy. NOTE: All data is new fleet only using unadjusted test values, not in-use fuel consumption.*
What can the GFEI targets achieve?

Meeting GFEI targets can stabilize global light-vehicle CO$_2$ emissions, despite more than a doubling of vehicle fleet.

Meeting GFEI global target can reduce a total of 33 Gt CO$_2$ emissions beyond already adopted policies between 2015-2050.

Adopted policies include vehicle efficiency standards adopted as of February 2014.

GFEI Target aims to reduce fuel consumption of all vehicles in half by 2050.

Source: ICTR Roadmap Model
Four key fuel economy policies

I. Fuel economy labeling
   - Based on tested fuel economy
   - Need to make available to consumers before purchase (internet, car window stickers)

II. Fuel pricing
   - Taxation system should at least internalize externalities
   - CO$_2$ tax will help diversify fuels as well as encourage fuel economy

III. Fuel Economy Standards
   - Typically corporate average standards
   - Typically either vehicle mass or size based
   - Can be applied to 2$^{nd}$ hand vehicles

IV. Vehicle purchase taxes
   - Sales tax, registration tax, import duties
   - Can be differentiated by fuel economy or CO2 emissions
   - Germany also differentiates by pollutant emissions levels
Four key fuel economy policies

I. Fuel economy labeling
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Fuel Economy Standards

- Global fuel economy standards for passenger cars (left) and light trucks (right), normalized to NEDC
Fuel Economy Standards

Key elements to consider when introducing fuel economy standards

1. Regulated metric
2. Form of target curve + underlying attribute
3. Target timeframe/limit value
## 1. Regulated metric

<table>
<thead>
<tr>
<th>Country or Region</th>
<th>Target Year</th>
<th>Regulated metric</th>
<th>Unadjusted Fleet Target/Measure</th>
<th>Form of target curve</th>
<th>Test Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>2015-2021</td>
<td>CO₂</td>
<td>130 gCO₂/km 95 gCO₂/km</td>
<td>Weight-based</td>
<td>NEDC</td>
</tr>
<tr>
<td>China</td>
<td>2015-2020</td>
<td>Fuel consumption</td>
<td>6.9 L/100km 5 L/100km</td>
<td>Weight-class based</td>
<td>NEDC</td>
</tr>
<tr>
<td>U.S.</td>
<td>2016-2025</td>
<td>Fuel economy/GHG</td>
<td>36.2 mpg or 225 gCO₂/mi 56.2 mpg or 143 gCO₂/mi</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>Canada</td>
<td>2016-2025</td>
<td>GHG</td>
<td>217 gCO₂/mi N/A</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>Japan</td>
<td>2015-2020</td>
<td>Fuel economy</td>
<td>16.8 km/L 20.3 km/L</td>
<td>Weight-class based</td>
<td>JC08</td>
</tr>
<tr>
<td>Brazil</td>
<td>2017</td>
<td>Fuel consumption</td>
<td>1.82 MJ/km</td>
<td>Weight-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>India</td>
<td>2017-2022</td>
<td>CO₂</td>
<td>130 g/km 113 g/km</td>
<td>Weight-based</td>
<td>NEDC for low-powered vehicle</td>
</tr>
<tr>
<td>South Korea</td>
<td>2015-2020</td>
<td>Fuel economy/GHG</td>
<td>17 km/L or 140 gCO₂/km 24 km/L or 97 gCO₂/km</td>
<td>Weight-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>Mexico</td>
<td>2016</td>
<td>Fuel economy/GHG</td>
<td>39.3 mpg or 140 g/km</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>2020</td>
<td>Fuel economy</td>
<td>17 km/L</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
</tbody>
</table>
# 2. Form of target curve and underlying attribute

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Attribute</th>
<th>Form</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Footprint</td>
</tr>
<tr>
<td>European Union#</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Japan</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>South Korea*</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>India</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
3. Target timeframe / limit value

US fuel economy standard curves

- Fuel economy (km/l)
- Vehicle footprint (m²)

- 2012 Fusion
- 2016 Accord
- 2014 Mazda 6
- 2013 Mazda 6 i-eLOOP
- 2013 Altima

- 2010 4-cylinder sedans
- 2014 4-cylinder sedans

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3. Target timeframe / limit value

European Standards: CO$_2$ Emissions of Selected Vehicle Models by Technology (2013)
3. Target timeframe / limit value

China standards curves
### Baseline analysis

- Basic specifications: engine size, curb weight, footprint...
- Utility: power, max speed...
- Fuel consumption, CO\(_2\) emissions...
- Technology adoption: fuel type, transmission, air intake...

#### China 2010 passenger car data

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mini</th>
<th>Small</th>
<th>Lower medium</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market share</td>
<td>6%</td>
<td>15%</td>
<td>32%</td>
<td>10%</td>
<td>4%</td>
</tr>
<tr>
<td>Representative model</td>
<td>Chery QQ3</td>
<td>BYD F3</td>
<td>Hyundai Elantra</td>
<td>Honda Accord</td>
<td>Audi A6</td>
</tr>
<tr>
<td>Diesel share</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Cylinder</td>
<td>3.5</td>
<td>3.9</td>
<td>4.0</td>
<td>4.1</td>
<td>5.0</td>
</tr>
<tr>
<td>Displacement [L]</td>
<td>1.1</td>
<td>1.4</td>
<td>1.6</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Power [kW]</td>
<td>50</td>
<td>71</td>
<td>84</td>
<td>112</td>
<td>141</td>
</tr>
<tr>
<td>Auto. transmission share</td>
<td>17%</td>
<td>26%</td>
<td>44%</td>
<td>67%</td>
<td>89%</td>
</tr>
<tr>
<td>Curb weight [kg]</td>
<td>918</td>
<td>1080</td>
<td>1258</td>
<td>1464</td>
<td>1684</td>
</tr>
<tr>
<td>CO(_2) [g/km] (NEDC)</td>
<td>150</td>
<td>157</td>
<td>173</td>
<td>199</td>
<td>211</td>
</tr>
</tbody>
</table>
Technology feasibility

Top runner (e.g. Japan)
- Best available technology

Technology forcing
- Emerging off-the-shelf technology now; advanced technology later

Emission rates are test-cycle (not adjusted real world);
China cost curve
C class vehicle
Cost-benefit analysis

Net cost:
Investment cost

Net benefit:
Lifetime fuel cost saving
Environmental benefit (climate change)
Oil security

\[
\text{CO}_2\text{-abatement costs} = \frac{\text{investment} - \text{NPV (lifetime fuel cost savings)}}{\text{lifetime CO}_2\text{-reduction}}
\]

\(\text{CO}_2\text{ abatement of 2015 EU regulation evaluation is: -101 EUR/t CO}_2\)
Regulation evaluation: estimates vs. reality

Passenger cars

Ex-ante vs. Ex-post

- Ex-ante: 130 g/km by 2015 (TNO, 2006), AEA, 2015

- Future target: 68 g/km by 2025 (IKA, 2015)

Estimated additional manufacturing cost [EUR] vs. g/km CO2 reduction compared to 2010 baseline
Conclusions

• Fuel economy improvement is very cost effective; using social discount rates the GFEI targets are cost effective

• Strong fuel economy improvements will save enormous amounts of energy, CO$_2$ and fuel costs over the next 35 years

• Fuel economy could get us half way to a low carbon LDV system, but we will likely need PEVs and other solutions to get the rest of the way, especially after 2030.

• Enacting and progressively strengthening strong policies around the world will be the key
## Fiscal Measures

<table>
<thead>
<tr>
<th>Fiscal policy type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel taxes, CO2 taxes</td>
<td>Set by fuel type; paid upon refueling</td>
</tr>
<tr>
<td>VMT taxes</td>
<td>Typically paid at annual registration; could be CO2-adjusted</td>
</tr>
<tr>
<td>Road pricing</td>
<td>Paid by km of driving or when passing a cordon line</td>
</tr>
<tr>
<td>Vehicle purchase taxes/feebates</td>
<td>Paid at time of purchase; can be differentiated by fuel economy or CO2</td>
</tr>
</tbody>
</table>
Role of fiscal policies in promoting fuel efficiency

- Encourage manufacturers to adopt technologies to improve fuel efficiency and reduce emissions
- Send consumers appropriate price signals to purchase fuel-efficient and low carbon vehicles
- Support fuel efficiency and emission regulatory targets
  - Regulatory standards set the minimum requirement and need to be strengthened over time
  - Fiscal policies provide continuous incentive to improve
  - Easy to establish, does not require detailed knowledge of vehicles and technology costs, only needs to establish “rate, or value of fuel or GHG savings”, “revenue target”, and “test method and enforcement”
Role of fiscal policies in promoting fuel efficiency

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Feebates – what are they?

**Feebate = Fee + Rebate**

• Market-based policy that shifts consumer purchases (and potentially manufacturer production) by encouraging GHG reductions by placing a fee on higher-emitting vehicles and providing a rebate to lower-emitting vehicles

• Based on fuel economy or CO2 differential between vehicles

• Could also take into account vehicle attributes like size or weight
How to design a feebate system

- The slope determines marginal costs and benefits.
- The pivot point can be designed to meet revenue goals.
Design elements for effective incentives

- Base fiscal charges directly on vehicle fuel consumption levels, instead of vehicle physical attribute, avoid fixed charges. Mandatory labeling for fuel consumption is an enabler.
- Apply the incentive widely across fleet, instead of limiting to a portion of the fleet.
- Provide continuous incentive on every fuel consumption or fuel consumption level.
- Targeted incentive programs should also be linked to fuel consumption.

A targeted incentive program refers to incentive provided to vehicles with special features (such as a certain fuel type, or vehicles equipped with certain technologies).
Important to have a continuous slope, no steps

- Toyota Yaris – 6.4 l/100km
  - Sales +49%
- Honda Fit – 6.6 l/100km
  - Sales +3%

Example: Canada
An example: French feebate schedule, 2015

The only vehicles that receive rebates have CO$_2$ emissions of 60 g/km or less.
An example: French feebate schedule, 2015

The only vehicles that receive rebates have CO$_2$ emissions of 60 g/km or less.
The French feebate schedule over time

The fees have risen and the rebates declined...
The French feebate system led to drop in CO₂ emissions

- 2001–2007 avg. reduction new vehicle CO₂ = 1 g/km per year
- 2008: emissions drop 9 g/km and 2009 by 7 g/km,

The Ministry of Transport attributes this to introduction of the bonus/malus system

Source: Les véhicules particuliers en France (Ademe), March 2011
## Standards versus feebates

<table>
<thead>
<tr>
<th>Standards</th>
<th>Feebates</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Guarantee&quot; a minimum level of fuel economy</td>
<td>Do not guarantee level</td>
</tr>
<tr>
<td>No incentive to go beyond minimum</td>
<td>On-going incentive</td>
</tr>
<tr>
<td>Must be regularly updated to maintain pressure</td>
<td>Must be regularly updated to meet revenue targets</td>
</tr>
<tr>
<td>No cap on costs</td>
<td>Provide a cap on cost</td>
</tr>
<tr>
<td>Could ban some vehicles</td>
<td>Wouldn't ban any vehicles</td>
</tr>
<tr>
<td>No clear price signals</td>
<td>Clear price signals to consumers and producers</td>
</tr>
</tbody>
</table>