8. What are the steps?

How to develop policies? Which steps are necessary?

Transport: Session 8
Jacob Teter, 19 July 2018
Jakarta 19 July 2018

#energyefficientworld
What are the main steps?

**STEP 1:** Benchmarking historical fuel economies

**STEP 2:** Setting targets (incl. cost-benefit assessment)

**STEP 3:** Assessing policy options to enforce targets

**STEP 4:** Monitoring, compliance and enforcement
1. Benchmarking historical fuel economies
1. Benchmarking historical fuel economies

What is a fuel economy baseline?

• The fuel economy baseline is the weighted average fuel economy of all vehicles registered for the first time in a given year in a country

• The weighted average fuel economy: calculated using model specific fuel economy values and the number of registered vehicles as weight

• Typically, the baseline is set on vehicles registered for the first time
1. Benchmarking historical fuel economies

Status of fuel economy (FE) standards around the world

- **2/3 wheelers**
  - UN regulation for FE/emission measurement are in place
  - China is the only country having mandatory FE standards for two wheelers in place (implemented 2009)
  - FE data not easy to get from public sources
  - This will be a priority for Southeast Asia

- **Light duty vehicles (passenger cars)**
- **Heavy duty vehicles**
1. Benchmarking historical fuel economies

Status of fuel economy (FE) standards around the world

- **2/3 wheelers**
- **Light duty vehicles (passenger cars)**
  - UN regulation for FE/CO2 emission measurement are in place
  - Testing procedures have a long history
  - FE policies widespread
  - FE data is relatively easy to get from public sources
  - This **will be our focus, and we’ll relate this to 2/3 wheelers**
- **Heavy duty vehicles**
1. Benchmarking historical fuel economies

Status of fuel economies (FE) around the world

- 2/3 wheelers
- Light duty vehicles (passenger cars)
- Heavy duty vehicles
  - Large variety of HDV models and mission profiles
  - More complex than LDVs, requires dedicated software
  - FE policies only in 4 countries – but standards started in India in April 2018, and are coming online now in the European Union
  - UN regulation for FE/CO2 emission measurement yet
  - We’ll have a deep dive on HDVs
1. Benchmarking historical fuel economies

Minimum data to develop baseline

- Vehicle make and model (e.g. Toyota Corolla)
- Year of first registration
- Model production year (important for used imports)
- Engine displacement (liters or cubic centimeters)
- Engine power (kW or HP)
- Fuel type (e.g. gasoline, diesel, LPG, CNG, electricity)
- Number of vehicles registered
- Rated fuel economy (Lge/100km, alternatively CO$_2$ emission, gCO$_2$/km) and test cycle (NEDC, FTP, JC08)
1. Benchmarking historical fuel economies

Nice to have...

- Transmission type (automatic, number of gears)
- Vehicle footprint (wheelbase x track width)
- Vehicle weight (mass in running order)
- Axle configuration (4x2, 4x4)
- Vehicle price
1. Benchmarking historical fuel economies

Once you have the data, a simple equation...

- From vehicle registration database, calculate your benchmark
- Sales-weighted average **Fuel Economy**

\[
FE = \frac{\sum^n_{i=1} Sales_i \times FE_i}{\sum^n_{i=1} Sales_i}
\]

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Vehicle Type</th>
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<th>Engine ccm</th>
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<td>EURO5</td>
<td>61</td>
<td>8.0</td>
</tr>
</tbody>
</table>
1. Benchmarking historical fuel economies

Challenges: How to get the data?

- Who owns the data we need? Can the data be shared?
  - Need for cooperation with relevant stakeholders (car manufacturers, retailers)

- What **institutional framework** is needed to continuously collect and develop data?
  - Need for **legal framework to enable access to information**

- Vehicle market structure
  - Is the share of used imported vehicles significant?
  - Implications on stakeholders involved and data availability
1. Benchmarking historical fuel economies

Challenges: Quality of data, gaps, imports vs sales

- Level of detail available
  - Accuracy depends on level of detail
- Quality of the data available
- Used imports vs. new sales
- Availability of alternative sources to fill gaps
  - example: FE data by model
  - FE data: EEA, EPA, Chinese government website
1. Benchmarking historical fuel economies

Challenges: Where to get data if there are gaps?

- Public databases (thanks to legal framework of other countries requiring it)

- Similar cars and models could be found in these databases, but not always!

<table>
<thead>
<tr>
<th>Country</th>
<th>Data source</th>
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<tbody>
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</tbody>
</table>
### Challenges: Where to get data if there are gaps?

- **REMEMBER:** Gaps could be in terms of the variables placed (year, make, model, etc.)
- The larger the number of variables available, the more accurate will be the baseline estimate...

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</table>
1. Benchmarking historical fuel economies

Watch out for: Test Cycle Methods and Conversion Factors

- Methods:
  - Europe – NEDC
  - United States – CAFE
  - Japan – JC08

- Identical cars show different fuel economy values under different test conditions (up to 20% difference)
- Results need to be normalized

<table>
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<th>Unit: gCO₂ per km</th>
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<td>NEDC to CAFE</td>
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<td>NEDC to CAFE</td>
<td>CAFE = 0.8658</td>
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<td>CAFE to NEDC</td>
<td>NEDC = 1.1325</td>
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<tr>
<td>JC08 to CAFE</td>
<td>CAFE = 0.7212</td>
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<td>CAFE to JC08</td>
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<td>JC08 to NEDC</td>
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<td>NEDC to JC08</td>
<td>JC08 = 1.1430</td>
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Diesel to CAFE:
- NEDC = 1.1325 * CAFE + 14.076
- JC08 = 1.2749 * CAFE + 36.736

CAFE to Diesel:
- NEDC = 1.1325 * CAFE - 13.739
- JC08 = 1.2749 * CAFE - 38.423

JC08 to NEDC:
- NEDC = 0.8457 * JC08 + 24.840
- JC08 = 1.1430 * NEDC - 24.907

NEDC to JC08:
- NEDC = 1.1325 * JC08 + 14.076
- JC08 = 1.2749 * NEDC - 36.736

CAFE to JC08:
- CAFE = 0.7212 * JC08 + 36.736
- JC08 = 1.2749 * CAFE - 38.423

JC08 to CAFE:
- CAFE = 1.1325 * JC08 + 14.076
- JC08 = 1.2749 * CAFE - 38.423

CAFE to NEDC:
- CAFE = 0.8658 * NEDC + 14.076
1. Benchmarking historical fuel economies

Watch out for: Impact of retrofits on fuel consumption

- **Important to account for same energy content of fuels**
- The first conversion factor accounts for the different energy densities of gasoline and diesel to convert L/100km to LGE/100km

<table>
<thead>
<tr>
<th>L/100km to Lge/100km</th>
<th>Diesel</th>
<th>FE*1.08</th>
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<td>CNG</td>
<td>FE*1.12</td>
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<td>LPG</td>
<td>FE*1.15</td>
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- The retrofit adjustment accounts for the efficiency losses of cars when retrofitted to LPG or CNG.
1. Benchmarking historical fuel economies

**Summary: Is this just about benchmarking?**

- **No:** the same calculations allow you to **monitor progress** over time!
- Setting up the **necessary legal requirements** is not just for a one-off type of efforts
- These same data are very useful to:
  - Develop fuel economy standards
  - Monitor their progress
  - Develop fiscal measures (feebates, differentiated taxes)
  - Monitor their development and revise the policy over time
2. Setting targets
What are the main steps?

**STEP 1:** Benchmarking historical fuel economies

**STEP 2:** Setting targets (incl. cost-benefit assessment)

**STEP 3:** Assessing policy options to enforce targets

**STEP 4:** Monitoring, compliance and enforcement
2. Setting Targets

Conduct stakeholder engagement

- Assess stakeholder capacity
  - Manufacturers
  - Distributors
  - Refiners
  - Other government agencies
## 2. Setting Targets

Conduct stakeholder engagement: Who are they?

<table>
<thead>
<tr>
<th>ASEAN Countries</th>
<th>Vehicle Emissions Standards</th>
<th>Fuel Quality</th>
<th>Vehicle Tarrifs &amp;Taxes; Fuel Subsidies &amp; Taxes</th>
<th>EE and fuel economy</th>
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<td>Brunei</td>
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2. Setting Targets

Make a cost-benefit analysis

Set targets based on impact assessment: accounting for the effect of a policy, taking into considerations costs and benefits

- Compliance costs
  - Auto and fuel industries

- Health benefits
  - Reductions in local air pollutants

- Climate benefits
  - Reductions in carbon emissions

- Oil savings
  - Including improved energy security
2. Setting Targets

Make a cost-benefit analysis

- Benefits are more complicated to estimate than costs
  - Some climate variables are difficult to quantify and/or monetize

- Direct impacts (vehicle costs vs. fuel savings are a good start)
  - Co-benefits can further support the results

- Payback time is often used as criterion for determining policy ambition (especially in countries where changing administrations are common)
2. Setting Targets

Make a cost-benefit analysis: Payback time

• Payback time function of several parameters
  - Technology cost
  - Fuel saving potential of technologies
  - Fuel cost (including taxes...)
  - Vehicle mileage (the more you travel, the more an energy efficient technology will allow you to save...)

<table>
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<tr>
<th>Rule</th>
<th>Per-Vehicle Cost</th>
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<td>US LDV 2017-2025¹</td>
<td>$1,800</td>
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<td>US LDV 2012-2016²</td>
<td>$950</td>
<td>3 years</td>
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<td>US HDV Phase 1 2014 – 2017³</td>
<td>$378-$6,215</td>
<td>1-2 years</td>
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<tr>
<td>California Advanced Clean Cars Program 2017 – 2025⁴</td>
<td>$1,340-$1,840</td>
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<tr>
<td>Canada LDV 2017-2025⁵</td>
<td>$2,095</td>
<td>2 to 5 years</td>
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<td>Canada LDV 2011-2016⁶</td>
<td>$1,195</td>
<td>1.5 years</td>
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<tr>
<td>European 95g CO₂/km Standard 2020⁷</td>
<td>€1,300</td>
<td>4-5 years</td>
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<td>India LDV 2020⁸</td>
<td>$400 to $600</td>
<td>2-3 years</td>
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</table>
2. Setting Targets

Cost-benefit analysis: Case study

- **European Union (2009-2015)**
  - CO₂ Regulation is likely to have accounted for 65-85% of the reductions in tailpipe emissions.
  - The Regulations were found to have been more successful in reducing CO₂ emissions compared to voluntary agreements from industry,
    - Improvement of 1.1 to 1.9 gCO₂/km compared to the rate achieved by the Regulations of 3.4 to 4.8 gCO₂/km

- In terms of efficiency both of the Regulations have generated net economic benefits to society. The car CO₂ Regulation has abatement costs of **-€46.4** per t of CO₂ abated.

- Costs to manufacturers have been much lower than originally anticipated, because emissions abatement technologies have, in general, proved to be less costly than expected.

3. Assessing different policy options to enforce targets
What are the main steps?

**STEP 1:** Benchmarking historical fuel economies

**STEP 2:** Setting targets (incl. cost-benefit assessment)

**STEP 3:** Assessing policy options to enforce targets

**STEP 4:** Monitoring, compliance and enforcement
3. Assess policy options

What are the policy options?

- **Go to our Toolkit in Session 7**
  - Fuel economy standards
  - Feebates
  - Vehicle taxes
  - What else? Can you remember some of the options?
### 3. Assess policy options

#### Now make a framework to assess policy options

### Policy effectiveness

<table>
<thead>
<tr>
<th>Policy measure</th>
<th>Cost/cost effectiveness</th>
<th>Scale of applicability</th>
<th>Effectiveness in addressing energy issues</th>
<th>Effectiveness in addressing other transportation issues</th>
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<tbody>
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<td>Oil use reduction</td>
<td>GHG reduction</td>
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<td>Fuel economy regulations</td>
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### Considerations of feasibility for implementation

<table>
<thead>
<tr>
<th>Policy measure</th>
<th>Rate of implementation</th>
<th>Scale of implementation</th>
<th>Flexibility</th>
<th>Political acceptability</th>
<th>Level of co-operation needed between agencies</th>
<th>Technological change</th>
<th>Degree of lifestyle change required</th>
<th>Other factors</th>
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<td>Fuel economy regulations</td>
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4. Monitoring, compliance and enforcement
What are the main steps?

**STEP 1:** Benchmarking historical fuel economies

**STEP 2:** Setting targets (incl. cost-benefit assessment)

**STEP 3:** Assessing policy options to enforce targets

**STEP 4:** Monitoring, compliance and enforcement
4. Monitoring, compliance and enforcement

What are the problems in monitoring, compliance and enforcement?

- Lack of adequate government resources and legal authority to ensure compliance with motor vehicle emission standards.

- Applies to real world emissions of all pollutants (e.g., NOx, CO$_2$), light and heavy-duty vehicles, and diesel and petrol vehicles.

- Dieselgate continues to be a “wake up call” - highlighting major deficiencies in government programs to ensure compliance with emission standards.

- Non-compliance is used broadly to mean excessive real world emissions independent of legality with the law.

- Europe is highly relevant to these discussions because of its status as the de facto standard setter for most countries outside of the US and Japan.

- Much progress is underway in key markets, but there is much more to accomplish.
4. Monitoring, compliance and enforcement

Real-world emissions have not necessarily reflected test-cycle emissions

- ICCT White Paper: Real-world exhaust emissions from modern diesel cars: A meta-analysis of PEMs emissions data from US and EU passenger diesel cars (October 2014)

Average on-road emissions of NO\textsubscript{X} and CO\textsubscript{2}, by vehicle

- On-road emission results, by vehicle

- Average NO\textsubscript{X} [g/km]
- Average CO\textsubscript{2} (as % of type-approval [g/km])

15 test vehicles in total (6 manufacturers), with different NO\textsubscript{X} control technologies:
- 10 selective catalytic reduction (SCR)
- 4 exhaust gas recirculation (EGR)
- 1 lean NO\textsubscript{X} trap (LNT)

- Average Euro 6 NO\textsubscript{X} conformity factors (ratio of on-road emissions to legal limits):
  - all cars: 7.1
  - best performer (Vehicle C, SCR): 1.0
  - bad performer (Vehicle H, LNT): 24.3
  - worst performer (Vehicle L, SCR): 25.4

http://www.theicct.org/real-world-exhaust-emissions-modern-diesel-cars
4. Monitoring, compliance and enforcement

Different emissions led to real road testing...

- Real-world testing of light-duty diesels in U.S. led to CARB / EPA investigations and legal action

![Bar chart showing average NOx emissions in g/km](http://www.theicct.org/use-emissions-testing-light-duty-diesel-vehicles-us)

![Vehicle photos unrelated to the results](http://www.theicct.org/use-emissions-testing-light-duty-diesel-vehicles-us)
4. Monitoring, compliance and enforcement

Remote sensing data shows historic trends in NOx

• Remote sensing data shows historic trends in NOx emissions from diesel and petrol cars in Switzerland

Source: Chen & Borken-Kleefeld, Real-driving emissions from cars and light commercial vehicles - Results from 13 years remote sensing at Zurich/CH Atmospheric Environment, 88:157-164 (May 2014)
Remote sensing provided evidence of gross noncompliance by HDVs in U.S. in 1990s

Adapted from Bishop & Stedman. Env. Sci. and Technol. (2015)
4. Monitoring, compliance and enforcement

Not just NOx, Real-world CO₂ in EU is also 30+% higher than rated by the NEDC test-cycle

Source: www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf
4. Monitoring, compliance and enforcement

Growing gap of real vs test

- Growing gap in real world v. type approval emissions cut expected gains from European CO₂ standards more than half.

Source: www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf
4. Monitoring, compliance and enforcement

Compliance regimes that you can follow

Compliance Regimes in the US and Europe

- Test cycles and protocols
- Recall and penalty authority and actions
4. Monitoring, compliance and enforcement

Studies from Europe that you can follow on how to best do this

- ICCT White Paper - The future of vehicle emissions testing and compliance (November 2015)
  - Objective is to compare and contrast the current vehicle testing and compliance schemes in the EU and the United States.
  - The fundamental difference is not so much actual vehicle testing but the strong focus on independent conformity testing coupled with enforcement authority in the US.
  - In the EU, by contrast, this element of independent re-testing is largely absent from the regulations, and the involved regulatory bodies are more restricted with respect to their enforcement authority.

Source: www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf
4. Monitoring, compliance and enforcement

More on compliance systems: US vs EU

Historically, about 3 million recalls annually in the US (~ 1% of total vehicle population @ 250 million)
4. Monitoring, compliance and enforcement

Guidelines for Effective Compliance Programs

1. **Certification testing** – The test cycle must be representative of real world driving, and test procedures must help ensure that test conditions match normal driving situations.

2. **Real-world testing** – As a check on representative nature of the certification test, and to identify defeat devices, real world testing is essential. Europe is developing a “real world driving emission” test protocol and EPA and CARB now include random real world testing as part of certification testing.

3. **Vehicle recalls** – Recall authority is an essential element of effective enforcement. Historically, EPA issues 3 million recalls each year.

4. **Data transparency** – All certification test results, recalls and penalties should be publicly available. Most is available in the US, very little is available elsewhere.
4. Monitoring, compliance and enforcement

Guidelines for Effective Compliance Programs

5. **Warranty** – Manufacturers should be required to guarantee to the consumer that emission control technologies are effective and durable over vehicle lifetime (e.g., in the U.S., it’s currently 8 years or 80,000 miles).

6. **Financial penalties** – Financial penalties should be large enough to deter illegal behavior (e.g., US and China – and proposed in Europe – penalties at $30 – 40,000 per vehicle).

7. **Political autonomy** – Government officials responsible for taking decisions that affect major corporations must be shielded from political influence.

8. **Resources** – US EPA and CARB have long-established compliance programs with substantial technical capabilities, expert staff, and strong legal authority that will be challenging to replicate in the rest of the world.