Fuel Economy Trends in Industrialized Countries
When the Rubber Hits the Road
Sneak Preview of a Spring ’09 Course

Lee Schipper, Ph.D.
Senior Project Engineer
Precourt Institute for Energy Efficiency
Stanford University

Also
Global Metropolitan Studies,
Univ. of California, Berkeley CA 94707 USA
Global Carbon (and Oil) Problems

• The US Is Still the Big Boy on the Block
  – Most important oil user, also per capita or per GDP (PPP)
  – Oil worries might help or hinder CO2 worries
  – Little meaningful change under Bush - Backwards to the rear!

• China, India, others – Unsustainable Transport
  – Very low emissions per capita, but rising rapidly
  – Cities bogged down in impossible traffic and air pollution
  – CO2 not of interest there, but energy and transport woes important

• The Global Nature – Savings Valuable World Wide
  – Oil and CO2 are global and fungible – anywhere you save matters
  – Fuels, technology are global – for better or worse
  – Motor vehicles (and US/EU lifestyles) global – for better or worse

Drill Drill Drill? No Clean, Low CO2 Substitutes for $130 Oil (>5 mn bbl/day) Except More Efficient Energy Use?
WORLD ENERGY AND OIL USE: THE RISING ROLE OF TRANSPORT

- All Other Primary Energy Use
- All Other Oil
- Other transport oil (incl bunkers)
- Road Transport Oil

Millions of Barrels per Day oil Equivalent

Billions of Tonnes of Oil Equivalent

WORLD CARBON EMISSIONS: TRANSPORT

Roughly 35% of Transport Emissions in/around Cities
Oil or CO2 Emissions from Road Transport
Rising Income Leads to Slower Growth in Emissions

–Source:IEA
The Oil-Carbon Challenge: View as Transport, Not Just an Oil-Carbon Problem
"The Road From Kyoto":
Transport/CO2 Policies in 6 IEA Countries
“Saving Oil And Reducing CO2 Emissions In Transport”

• Potential Large, Progress Slow, Risks High
  • Technology getting better there but economic signals still weak;
  • Political will missing in 2000, stronger now
  • Absence of meaningful initial progress in the US notable

• Main Elements Still Important Today
  • Transport sector reform as umbrella for process
  • Voluntary agreements (soon mandatory) on car fuel economy important
  • Fuel pricing also important (except US, which is in denial)

• Hard Lesson: Many Years to See Impacts
  • Countries moved weakly towards better transport policies
  • Voluntary agreements achieved half their goals
  • Threats from distractions (bio-fuels, oil-price fluctuations, CO2 denials)

Oil and CO2 more important in 2008 than before: What are the next steps?
Integrated View of Transport Problems
The ASIF Decomposition for Fuel and Emissions

Fuel Use and Emissions from

\[ A \times S_i \times I_i \times F_{i,j} \]

Total Transport Activity

Vehicle fuel intensity

Occupancy/Load Factor

Veh-km and pass-km by mode

Technological energy efficiency

Modal Energy Intensity:

Emissions per unit of energy or volume or km from fuel J in mode I

Real drive cycles and routing, driver behavior

Lesson: Attack All Components of the Problem
Fuel Economy and Vehicle Use
The Double Challenge

• “I” “On Road” Fuel Intensity (20-25% Higher than “test”)
  – US, (incl. 80% of light trucks), CDN well above Europe, slightly above Japan
  – US fell recently, Japan and Europe falling steadily
  – We don’t have a clue any more what US on-road fuel economy is

• “I” New Car Test Fuel Economy - Size over Technology
  – US new SUV fuel economy improving slowly, Japan and EU improving more
  – US cars bigger each year, Japan 1/3 mini cars, EU only slow increases
  – US passed new fuel economy standards – impacts uncertain

• “AS” Total Travel
  – Car use per capita flat or falling in most industrialized countries
  – Transit ridership up
  – Increased congestion slowing travel, worsening fuel economy, raising pollution

Until Now Focus was on I, but AS is on the Table
Real Automobile Fuel Intensity – All Fuels
When the Rubber Hits The Road

(10 l/100 km = 23.65 MPG)
140 gm/km CO2 = 35 MPG or 6.8 L/100 km gasoline

Diesel and LPG converted to equivalent gasoline on an energy content basis.
Source, L Schipper, based on official national data
New Vehicle Fuel Economy Standards and Targets: Converted to Estimated “On Road” Values

Source, L Schipper, GMS, based on official national data
Saving Emissions From Transport –
Three Parts to Technology

• Traditional Technology – 40-60 MPG or 2.5-4 l/100km?
  – Less power, lighter materials, lower drag, CVT, cold cylinders
  – Gasoline or clean diesel hybrids
  – End to the power and weight chase?

• Other Approaches - Cost, Time to Deploy
  – City cars vs. long distance cars?
  – Plug in hybrids – most driving is for local, short trips
  – Fuel cells? Many cost, feedstock, materials challenges

• Alternative or Bio-Fuels – What are They Worth?
  – US Corn ethanol a dead end, other biofuels increasingly uncertain
  – True low carbon fuels not here, won’t arrive under present policies
  – Non-oil always possible, but always expensive and higher CO2

Should the Government Pick Winners like Today
Or Declare Losers (Oil, CO2 Tax)?
“Efficiency” Improving Everywhere
Efficiency Only Feeding Pep
Zip (power/weight) and Weight Look the Same
Diesels Close to 50% of New Car Market in Europe: Yet Savings of CO2 from Diesel Small or Absent

• Nine Countries Show Little Savings (Counting emissions, not gallons!)
  • On road diesel fleet emissions (gm/km) slightly (<5%) lower than gasoline
  • New vehicle test diesel emissions slightly (<5%) lower than gasoline
  • Diesel cars driven 50-100% more per year than gasoline cars

• Huh?
  • Cheaper diesel in Europe raises use, backfires on diesel policies
  • Diesels more powerful than gasoline equivalent, buyers choose bigger cars
  • Liter of diesel has 12% more energy, 18% more CO2 than gasoline

• But Diesel Drivers Are Different -- That’s the Point
  • Long distance drivers buy more expensive diesels with lower fuel costs
  • Increased switching to diesel stimulated by price – switchers drive more
  • Diesel SUVs increase attractiveness of SUVs (“Gelaendewagen”)

Drive Down Costs and Drive up Emissions: Subsidizing “Winners” Rarely Pays
# Dieselization in Europe: Backfire?

Story the same for A, B, E, I, Nl, S, Uk

Source, L Schipper, EMBARQ, based on official national data

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<thead>
<tr>
<th></th>
<th>France</th>
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<th>Germany</th>
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<tr>
<td><strong>New Diesels</strong></td>
<td></td>
<td></td>
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<tr>
<td>Share of Sales</td>
<td>%</td>
<td>46.5%</td>
<td>69.2%</td>
<td>14.6%</td>
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<td>Test Fuel Economy</td>
<td>L/100 km</td>
<td>6.60</td>
<td>5.60</td>
<td>6.5</td>
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<tr>
<td>Relative to gasoline</td>
<td>%</td>
<td>88.0%</td>
<td>82.4%</td>
<td>85.5%</td>
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<tr>
<td>Rel. to gasoline, CO2/km</td>
<td>%</td>
<td>104%</td>
<td>97%</td>
<td>101%</td>
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<tr>
<td><strong>Stock of Diesels</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Share of Stock</td>
<td>%</td>
<td>26.2%</td>
<td>46.6%</td>
<td>13.7%</td>
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<tr>
<td>Yearly Distance</td>
<td>KM/ car</td>
<td>15,704</td>
<td>16,736</td>
<td>17,980</td>
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<tr>
<td>Distance, Rel. to Gasoline</td>
<td>%</td>
<td>130%</td>
<td>164%</td>
<td>144%</td>
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<td><strong>On Road Fuel Economy</strong></td>
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<tr>
<td>Fuel Economy</td>
<td>l/100 km</td>
<td>6.67</td>
<td>6.43</td>
<td>7.47</td>
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<td>Relative to gasoline</td>
<td>%</td>
<td>78.6%</td>
<td>83.9%</td>
<td>81.7%</td>
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<td>Rel. to gasoline, CO2/km</td>
<td>%</td>
<td>92.7%</td>
<td>99.0%</td>
<td>96.4%</td>
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<tr>
<td>COMBINED FLEET FUEL ECONOMY</td>
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<td>8.05</td>
<td>7.33</td>
<td>9.00</td>
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<td><strong>US FIGURES</strong></td>
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9.00%
Car Use, Fuel Intensity vs. Fuel Price, 1998

Source IEA - See also Johansson and Schipper 1997 JTEP (SJ)

JS (1997) - Overall Price elasticity of **car fuel** close to -1: Mostly Fuel Economy, 0.3 VKT, -0.1 ownership.
Econometric Study: Cross Sectional Times Series (Johansson and Schipper JTEP Sept 1997)

• Data
  • US, Canada, Japan, Australia, 8 European countries 1970-1992
  • Stocks, distance/vehicle, stock fuel economy for gasoline, diesel LPG
  • Real prices and incomes measured in purchasing power parity

• Results for Fuel Demand Synthesized from Six Models
  • Strongly dependent on income (+1.2) but value falls as car ownership rises
  • Negatively dependent on fuel price (-0.7) and non-fuel taxation (-0.11)
  • Strong negative dependence on population density (-1.0)

• Interpretation for US
  • Income elasticity should be lower as cars/driver is greater than 1
  • VMT elasticity < -0.1 large: Fewer modal choices than in EU, Japan
  • High prices -> fuel share of budget or fuel cost/km close to 1980 maximum

Would be Valuable to Repeat This Analysis Including Impacts of Recent High Prices
Car Fuel Use and Per Capita GDP 1970 -2005/6: Is Growth Reversing after 50 years?

1/3 Fuel Economy
2/3 Distance/per cap.,
Driving and Per Capita GDP 1970 -2005/6

Source, L Schipper, based on official national data
Car and Personal Truck VKT/GDP And Fuel Cost
1960-2006 (2007-8 est)

2007 Expense
Share 5.3%
US Car and Fuel Use Trends
Why So Little Change in Fuel Use in Short Term?

• **Short Term Price Elasticity of Vehicle Use**
  – Van Dender and Small – Price Elasticity < -0.1 (aka rebound effect)
  – Present fuel cost/km, fuel cost share of consumption approaching 1981/2 peak
  – Still, Veh-km/GDP off its historical growth (below elasticity of +1)

• **Little Short Term Change in New Vehicle Fuel Economy**
  – Present fuel price close to equilibrium with CAFÉ standard?
  – Car producers have not had time to really bring efficiency on to market
  – Consumers value power/weight/features more than saved fuel

• **Additional Factors**
  – Fuel economy not offered as “feature” until hybrids appeared
  – Americans are wealthy – can afford even today’s fuel prices?
  – American car buyers, car market stuck in large car rut?

Now that Fuel Prices have Crashed
Should the Government Raise Taxes?
Reducing Car Use: Necessary? Desirable? Possible?

• Reducing Car Use Necessary for CO2/Oil Saving
  – Dearth of affordable low oil or low carbon fuels
  – Efficiency kicks in too slowly to mitigate oil dangers in short run
  – Reduced use contributes to cleaner air, lower congestion

• Reduced Car Use Desirable? By How Much
  – Economics – car use under-priced and distorted
  – PAYD insurance, shifting some fuel taxes to km taxes for
  – Raising cost of using cars politically difficult

• Reduced Car Use -- Possible
  – US travel patterns show considerably flexibility
  – Aging of boomers might lead to lower car use
  – Impact of information vs travel small so far, could grow

Balance of US and Local Policies Has Increased Car Use
Need to Re-examine Land Use and Transport Policies
–Mal-Asia?
Jakarta and Dozens of other Asian and Latin
Hyper-Motorization Poised to Capture India

Cheap Two Wheelers, but No Sidewalks

The Peoples’ Car (which people?)
Choices: Will Asia Carbonize? Car Ownership is Low: How Much Must it Rise?

• Present Situation – Feet and Buses for 7.5-10 km/day
  – 40-50% of trips on foot or pedals
  – 30-50% buses, some rail and metro
  – 10-20% two wheeler, private cars or taxi (exceptions – 50% 2w in Viet Nam)

• Strong Urban Transport is the Umbrella
  – Make room for 300 million more urbanites – land use planning
  – Scale up of bus rapid transit, some metro
  – Next steps – restraints on car use (congestion pricing?)

• Fuel Economy and Alternative Fuels
  – Fuel economy is necessary but not sufficient – fuel too cheap in China, India
  – Alternative fuels prospects grim – competition for land
  – Main threat/hope – Mini-cars under strong policy regime

Avoiding the Multiple Problems of Too Many Cars
Is Much Easier than Mitigating them when it's too late!
Urban Mobility Patterns: The Mobility Ladder

- Passenger-Km per capita

-16000
-12000
-8000
-4000
0

- Car
- Two Wheeler
- Metro, Urban Rail
- City Bus
- Mini Bus, Taxi
- Walking, Bike

- LOW
- MIDDLE
- HIGHER MIDDLE
- IEA EUROPE
- US CANANZ

Precourt Institute for Energy Efficiency
EMBARQ’s Scenarios for China (2005)

• **Base Case – China has Korean car/GDP ratio in 2020**
  – 120-160 million cars, 12,000 km/car
  – 8-8.5 L/100 km if no new measures
  – Closer to 2 mn bbl/day oil in 2020

• **Oil Saving Scenario – 40% as much oil, some CNG**
  – Japanese/Euro level of fuel prices
  – 110-130 million cars, but less driving/car
  – Fuel economy standards, some hybrids and CNG

• **Integrated Transport - Livable cities with good transport**
  – Much lower car ownership and use—avoiding the plague
  – Very small cars (incl. slow electrics, hybrids) to avoid space and congestion problems in cities
  – Serious BRT, car-use restraint, land-use planning
Sustainable Transport for China: Cars and CO\textsubscript{2} Emissions in 2020

- Sustainable Urban Mobility Saves Cities, Fuel, and Greenhouse Gas Emissions

Energy Use for Cars, by source, MTOE

2003: Road Ahead

2010

2020

Oil Saved

2010

2020

Integrated Transport

2010

2020

- Electricity, as Primary Energy
- CNG
- Oil in Hybrids
- Oil in Conventional Gasoline Cars

Total Carbon Emissions (Mn Tonnes)

- CO\textsubscript{2} Emissions

Oil Saved

Oil in Hybrids

Oil in Conventional Gasoline Cars

Electricity, as Primary Energy
Scenarios and Assumptions for India

- **Business as Usual (BAU)**
  - Unconstrained development of road traffic and vehicle demand
  - Infrastructure is assumed to not be a constraint

- **Energy Efficiency**
  - Higher fuel efficiency

- **Clean Two and Three wheelers**
  - Cleaner fuels and two and three-wheelers
  - Increases in two and three wheeler modal shares
  - Reduction in all other types of private transport modes

- **Sustainable Cities/Urban Transport (SUT)**
  - Demand management and modern mass transit
  - Regulation of private car use reflected by reduction in modal share
  - Widespread implementation of BRT systems

- **Extra Effort -- All of the above**
India: CO₂ Emissions by Transport Mode
Energy and Emissions From Transport – The Hard Policy Lessons

• Prices and Incomes Matter – in the Long Run
  – Fuel economy and car characteristics related to fuel prices
  – Car use, power and size related to incomes and fuel prices
  – Fuel choice related to fuel prices

• Policies Matter, Like Them or Not
  – Mandatory (US CAFÉ) worked, voluntary (Japan, EU) working now
  – Congestion pricing, km-taxes do restrain individual vehicle use
  – Urban transport policies with teeth matter

• Transport Policy Matters Even More
  – Strong urban transport policies/congestion pricing reduce car use
  – Better inter-modal facilities reduce car use, delays,
  – Better traffic management/congestion pricing reduces idling fuel losses

As Much as High Fuel Prices Hurt Some
They Are Causing Unimagined Changes
Reducing Emissions
Important Research for Better Policy

• **Monitoring**
  – Clear picture of vehicle use, fuel economy, emissions
  – Who moves, how, from where, to where?
  – How people really choose home location, cars

• **Political and Economic Issues**
  – Alleviation of access difficulties of the poor
  – Understanding of the ongoing 50-year fight over energy
  – Future of car industry in a CO2 constrained world

• **Long Term Global Transport Policies**
  – Land use and NIMBY – Who is really in control?
  – Low impact, low travel communities - do they work?
  – New paradigm for developing world – avoid hyper-motorization?

*The US Has A lot of Homework to Do*
Conclusions: The Slow Path for the Globe

• Fuel Economy Trends
  – On road F.E. improving in Europe, Japan, and finally (slowly) in the US
  – New US Standards will bring us in 2030-35 to present EU levels!
  – Weight, power increases must stop for meaningful improvements

• Vehicle Use - on the Table?
  – Car use fell with higher prices – but much more VMT to be saved
  – Increasing congestion talking a small toll in higher fuel use
  – Future of car use depends on transport policies, not CO2 policies alone

• Policies
  – As painful as it seems, higher fuel prices working a transformation
  – CAFÉ standards due for a tightening now, not in 30 years
  – Get subsidies and “incentives” out before backfires hurt

The Key Issue for Developing Countries: Can They Learn by our Mistakes?
Car that absorbs its own carbon?

Thank You
Lee Schipper – mrmeter@stanford.edu

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