The Role of Transport in Climate Policy

Kenneth Small
University of California at Irvine
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Outline:

- Importance to greenhouse-gas mitigation
  - Abatement cost curve
  - Transport cost components
- Alternative fuels
  - Biofuels
  - Electricity
- Promoting fuel efficiency
  - Demand for fuel efficiency – consumer myopia
  - Rebound effect
  - Are fuel efficiency standard beneficial?
- Overall conclusions

Importance of transport for greenhouse gas (GHG) emissions

Global emissions, 2013:

Transport = **15.0%** of total

– Center for Climate and Energy Solutions, "Global manmade greenhouse gas emissions by sector, 2013"

Global transport emissions, 2010:

Road transport = **71.1**% of total transport

– Intergovernmental Panel on Climate Change (IPCC), *AR5 Climate Change 2014: Mitigation of Climate Change*, Figure 8.1.

Therefore road transportation is **10.7%** of total GHG emissions.

Importance of transport for greenhouse gas (GHG) emissions

But it is the marginal impacts that matter.

So what role will (or should) transport play in climate policy?

Two approaches explored here:
Roughly:

1. How important is transport to climate policy?

    Abatement cost curve:
    Where does transport fall in a rational abatement plan?

2. How important is climate policy to transport?

    Transport cost components:
    Within the factors affecting transport policies, how important are greenhouse gases?
    This will tell us whether climate is likely to be (or should be) a swing factor in transport policy decisions

How important is transport to climate policy?

1. Abatement cost curve:

Where does transport fall in a rational abatement plan?

Note: "rationale" abatement plan requires a "social cost of carbon" (SCC);
More specifically, a (rising) schedule of SCC over time

And what about the individual policies that are part of a transport abatement plan?

Equivalently: Use cost-benefit approach:

Given a schedule of SCC, when would individual policies pay off?

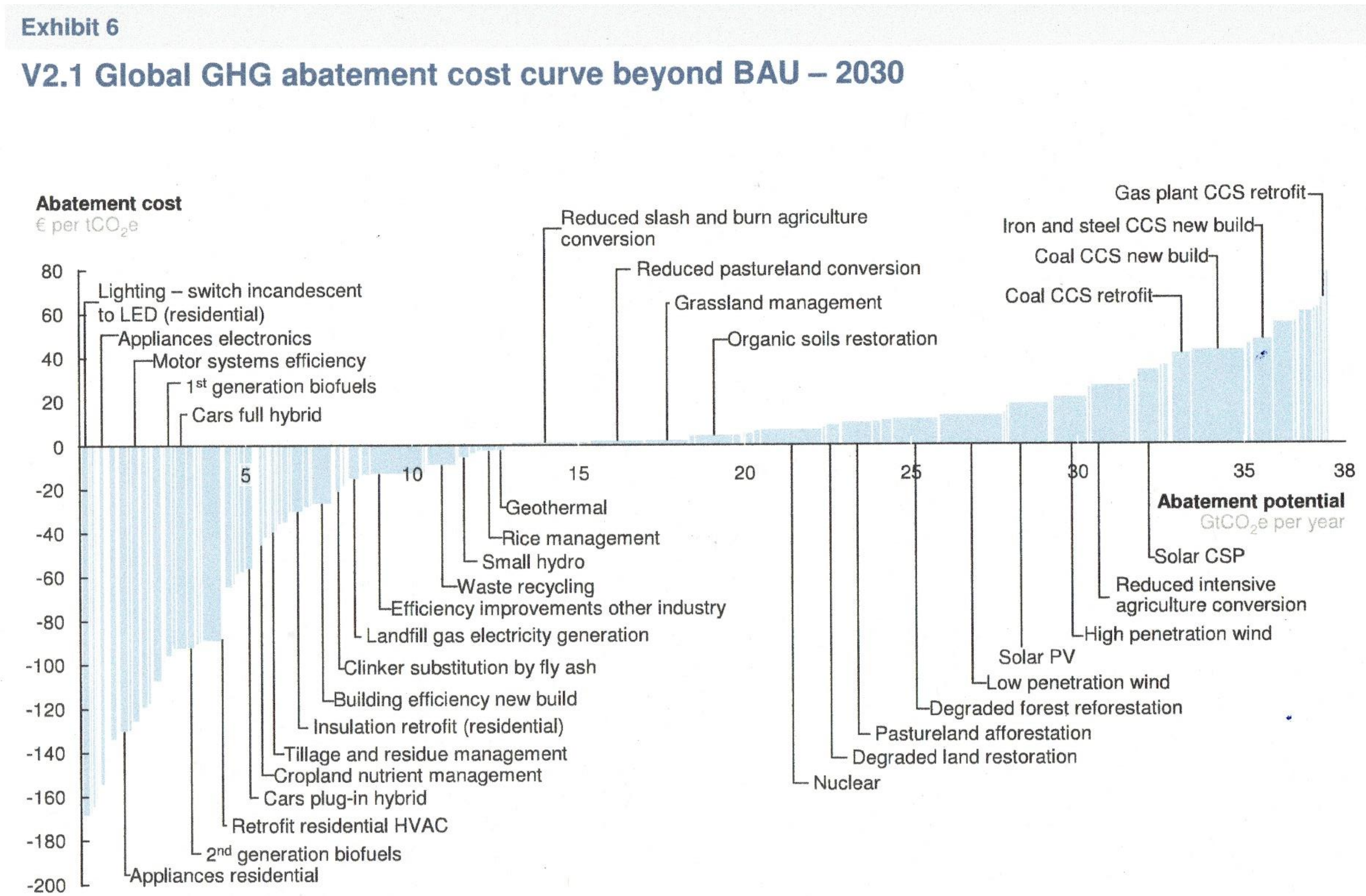
How important is transport to climate policy?

1. Abatement cost curve:

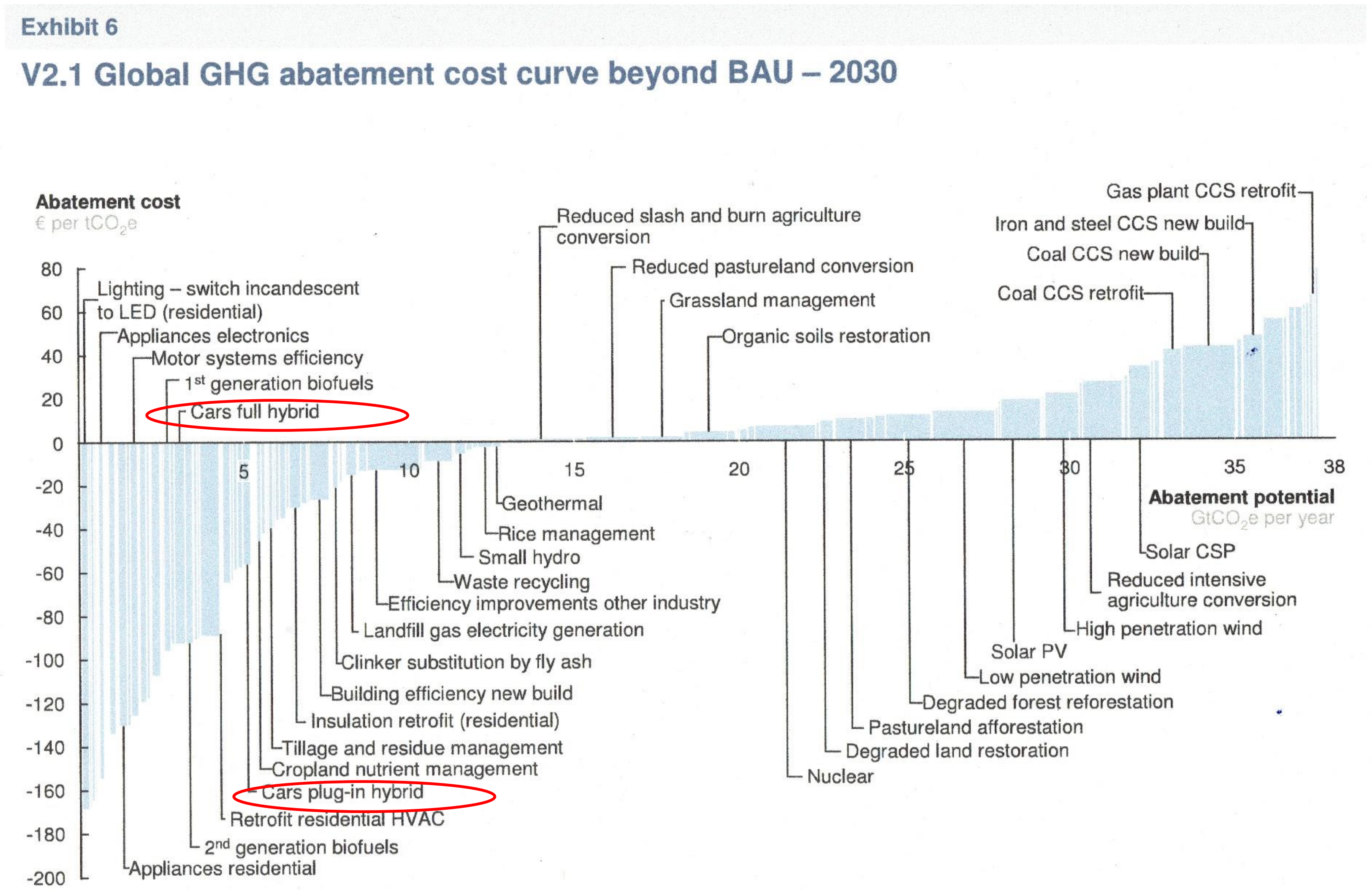
McKinsey study:

Original version:
Per-Anders Enkvist, Tomas Nauclér, and Jerker Rosander (2007) “A cost curve for greenhouse gas reduction,” *McKinsey Quarterly*.

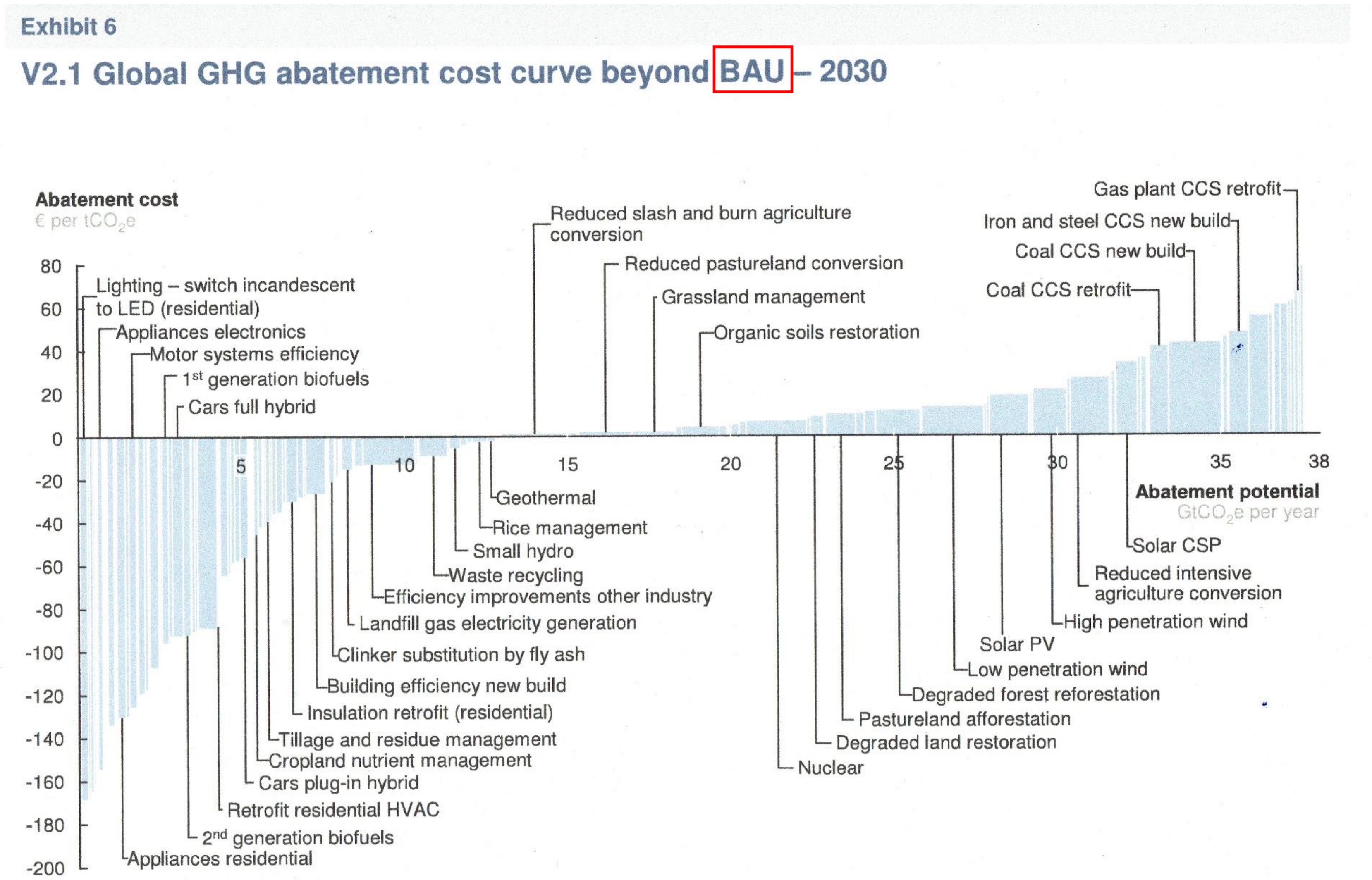
Updated version:
Per-Anders Enkvist, Jens Dinkel, & Charles Lin, McKinsey (2010), “Impact of the financial crisis on climate economics: Version 2.1 of the global greenhouse gas abatement cost curve,” McKinsey & Co.



©McKinsey & Co., 2010, "Impact of the financial crisis on climate economics: Version 2.1 of the global greenhouse gas abatement cost curve"



“Cars full hybrid”; “Cars plug-in hybrid”



BAU = "Business as usual" (baseline scenario)

Points to consider:

Points to consider:

a. Transport measures are among the most cost-effective of all considered.

b. Negative costs are highly dependent on assumptions about "myopia" – we'll come back to that.

c. Abatement potential (width of bar) is small

From their Exhibit 7:

Here are several sectors with their "abatement potential" (at < €80/tCO_2e) in <u>GtCO_2e per year in 2030</u>:

Road transport:	-2.6 (35% decrease)
Buildings:	-3.0 (75% decrease)
Agriculture:	-4.6 (58% decrease)
Forestry:	-7.8 (108% decrease)
Power generation:	-9.7 (54% decrease)

Cost-effective road transport measures (i.e. <€80/ton) are not enough: will need to focus on other sectors, exp. elec. power

Points to consider:

d. Investment cost (not shown in graph, but in their Exhibit 8):

These two transport measures have the highest investment cost of any sector: €245 billion/year in 2030, cf.:

Buildings: 207
Power generation: 182
Forestry: 43
Industry incl. cement, petroleum, iron & steel, chemicals: 162

Low abatement & high investment cost together suggest that these measures are not very cost-effective without non-climate benefits (due to climate policies offsetting myopic decision making).

For comparison, Heal (2017) estimates annual investment cost for full decarbonization of electric power generation by 2050:

~ 42–151 (€ billions/year)

Heal, Geoffrey (2017) "What would it take to reduce U.S. greenhouse gas emissions 80 percent by 2050?" Review of Environmental Economics and Policy 11(2): 319-335.

How important is transport to climate policy?

1. Abatement cost curve:

Tentative conclusions:

Road transport contributes significantly to greenhouse gases, but has smaller potential for cost-effective abatement than other sectors.

The most promising measures are probably enhancements to vehicle efficiency.

How important is transport to climate policy?

2. Transport cost components

From Parry and Small (2015):

Parry, Ian W.H., and Kenneth A. Small (2015) "Implications of carbon taxes for transportation policies," in Ian W.H. Parry, Adele Morris and Roberton C. Williams III (eds.) *Implementing a US Carbon Tax: Challenges and Debates*, Routledge, Chapter 12.

Main externalities from motor vehicle travel are proportional to distance, not fuel. Let's express them in $/liter gasoline, using average fuel effic.

For CO2 emissions, value at social cost of carbon (SCC) of $44/t$CO_2$e, the central estimate from Nordhaus' assessment for year 2025.

Nordhaus, William D. (2017) "Revisiting the social cost of carbon," *Proceedings of the National Academy of Sciences* 114(7): 1518-1523 (Feb. 7).

Note: tCO_2e = metric ton of carbon dioxide or greenhouse-gas equivalent
Estimate is in 2010 US$

How important is transport to climate policy?

2. Transport cost components

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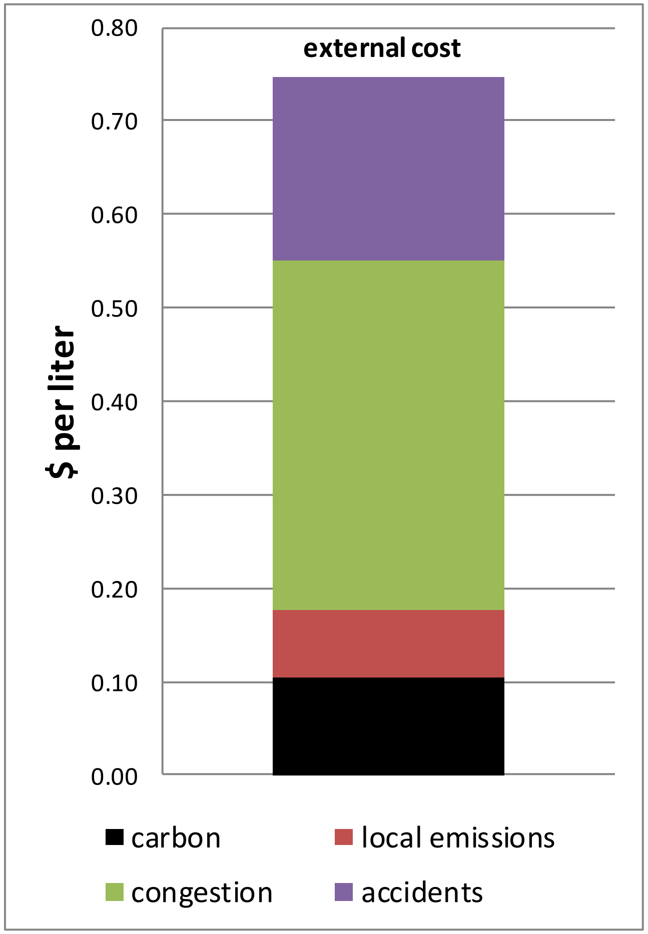
For CO2 emissions, value at social cost of carbon (SCC) of $44/t$CO_2$e, the central estimate from Nordhaus' assessment for year 2025.

Result for USA, at 2010 prices & values for other externalities (next slide):

External costs of motor vehicles, US 2010:



Note that CO_2 externality (bottom component on graph) is smaller than either congestion (green) or accidents (purple).

How important is transport to climate policy?

What about an optimal tax rate?

Parry and Small (2005) show that for externalities that are proportional to distance traveled, the optimal Pigouvian tax is "diluted" by a factor η equal to the fraction of reduced fuel use that comes about through less driving.

I.e., η is the ratio of price-elasticity of driving to that of fuel use.

Rationale: For these externalities, it is only through reduced driving that the tax is effective. The response through improved fuel efficiency has no impact.

Indeed, for those externalities, improved fuel efficiency can be viewed as tax avoidance!

Note: This conclusion depends on the externalities being constant – would not hold if damage function for CO_2 from motor vehicles is sharply rising in amount emitted.

How important is transport to climate policy?

What about an optimal tax rate?

We assumed this dilution factor is:

0.00 for carbon (since the externality is proportional to fuel use)

0.50 for local pollution & accidents

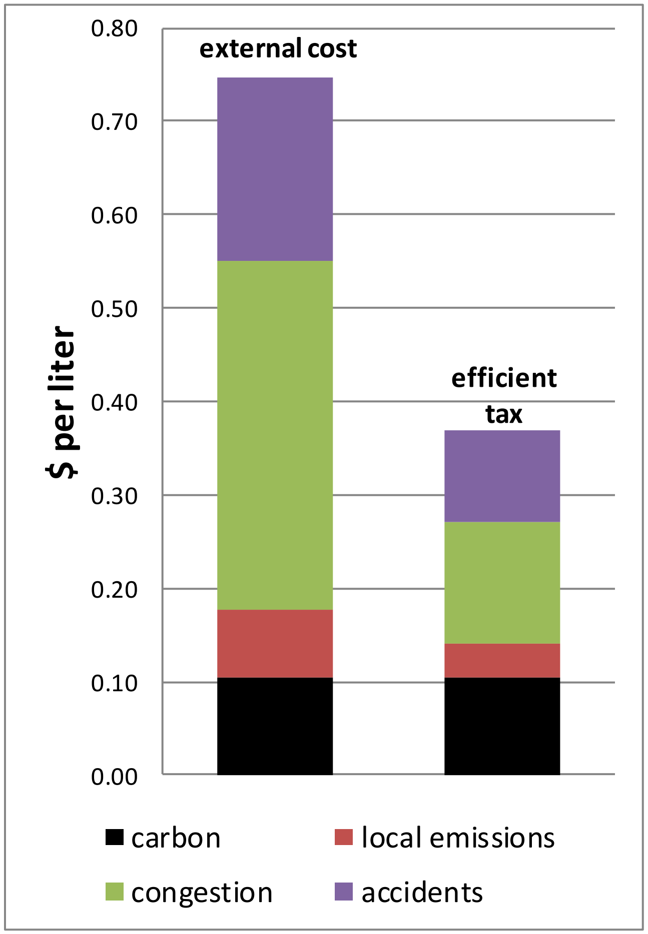
(based on response of overall VKT to a fuel tax)

0.65 for congestion

(based on response of congested VKT to a fuel tax)

Result (next slide):

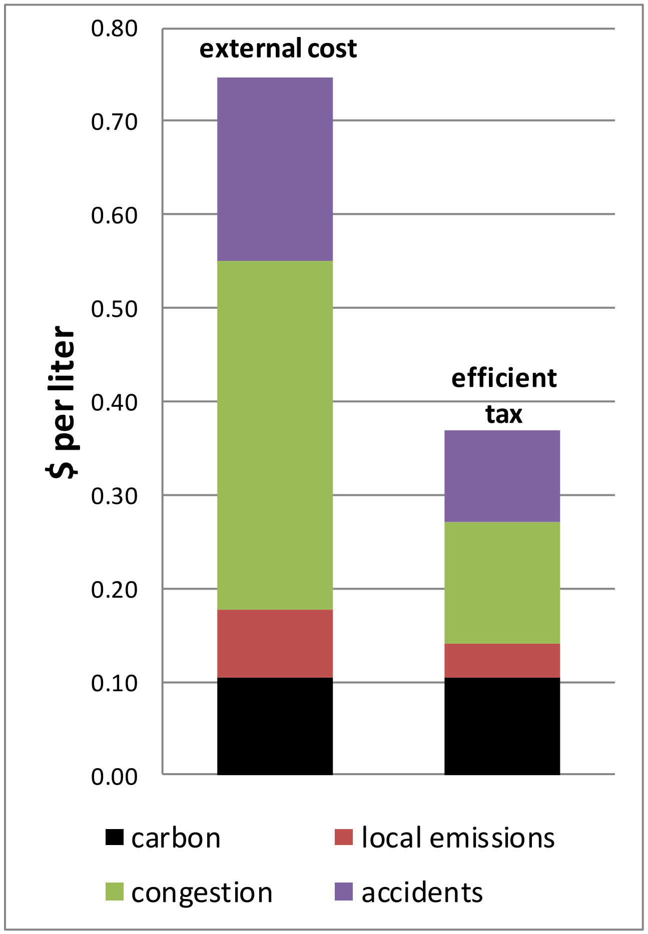
External costs & optimal tax components for motor vehicles, US 2010:



Notes:

- CO_2 still contributes less than congestion, and accounts for less than 1/3 of an efficient tax.
- The efficient tax is about four times the actual fuel tax in the US, but is comparable to that in many other countries.
- Based on historical experience, it is unlikely that such a tax would result in drastic restructuring of the transport system or of urban structure.

External costs & optimal tax components for motor vehicles, US 2010:



Other Notes:

● The main benefit of the tax is probably through reducing vehicle-kilometers traveled (VKT), hence congestion & accidents.

● This benefit is lost if fuel efficiency is reduced through regulations or technological subsidies.

– in fact, VKT might be *increased* via the "rebound effect".

How important is transport to climate policy?

Tentative conclusion:

Climate policy affects optimal policy toward road transport, but it is not the dominant influence. Instead, transportation policy needs to focus primarily on traditional factors (congestion, safety) as well as newly emerging factors (automation, ride-hailing businesses).

The primary mandate from climate policy on road transport is greater vehicle efficiency, which includes planning for an electric charging infrastructure.

Tentative conclusions from the two approaches (summary):

1. Road transport contributes significantly to greenhouse gases, but has smaller potential for cost-effective abatement than other sectors.

   The greatest potential may be through enhancements to vehicle efficiency.

2. Climate policy affects optimal policy toward road transportation, but it is not the dominant influence. Instead, transportation policy needs to focus primarily on traditional factors (congestion, safety) as well as newly emerging factors (automation, ride-hailing businesses).

   The primary mandate from climate policy on road transport is greater vehicle efficiency, which includes planning for an electric charging infrastructure.

Alternative fuels

Can we use alternative fuels as a substitute for fuel efficiency?

Consider two possibilities:

a. Biofuels
b. Electricity

Alternative fuels

a. Biofuels

Current policy in many countries: promote ethanol or biodiesel, from

(1) Agricultural sources ("first generation")
Ethanol: from sugar cane, corn, or sugar beets
Biodiesel: from palm fruits, soybeans, and rapeseed

Wise and Cole (2015) document 22 countries plus the European Union with biofuel mandates in place

Wise, Timothy A., and Emily Cole (2015) "Mandating food insecurity: The global impacts of rising biofuel mandates and targets," Working paper No. 15-01, Global Development and Environmental Institute, Tufts University.

(2) Cellulose (e.g. grasses) ("second generation")

Alternative fuels

a. Biofuels

Problems:

(1) First generation (agricultural):

Production competes with agriculture for food, so conflicts with policy to relieve food shortages.

Note title of Wise & Cole (2015): "Mandating food insecurity"

Production also uses lots of energy – especially for corn.

Chakravorty et al. (2017) suggest current first-generation biofuel policies actually *increase* CO2 emissions – especially if results in forest clearing!

Chakravorty, Ujjayant, Marie-Hélène Hubert, Michel Moreaux and Linda Nøstbakken (2017) "The Long-Run Impact of Biofuels on Food Prices," *Scandinavian Journal of Economics* 119(3): 733-767.

(2) Second generation (cellulosic):

Not yet close to commercial feasibility.

Also requires a lot of land, though not typically productive farmland.

Alternative fuels

a. Biofuels

My conclusions:

- Policies promoting first-generation biofuels for transport are mostly not cost-effective, and are adopted mainly for political purposes
- Significant role for second-generation biofuels awaits breakthroughs in technology for production.

Alternative fuels

b. Electric vehicle propulsion

Includes: plug-in hybrids, fully electric vehicles
Excludes: conventional hybrids (a technology for achieving efficiency with conventional fossil fuels)

Question: What are the emissions from a battery-powered vehicle?

What are the emissions from a battery-powered vehicle?

Graff Zivin et al. (2014) examine the sources of electric power used to charge vehicles in various US locations, and the GHGs generated.

Graff Zivin, Joshua S., Matthew J. Kotchen, and Erin T. Mansur (2014) "Spatial and temporal heterogeneity of marginal emissions: Implications for electric cars and other electricity-shifting policies," *Jour. of Econ. Behavior and Organization* 107: 248-268.

Methodology: track sources by season, day, & time of day as power is moved across networks

Findings:

(1) Emissions vary enormously across regions.

(2) In Western US, CO_2 from electric car is ~ 20% lower than from a Toyota Prius

(3) In upper Midwest of US, charging during night, CO_2 from electric car is *greater* than from US fleet average!

What are the emissions from a battery-powered vehicle?

Graff Zivin et al. (2014)

Caveats:

- What we really need are *long-term marginal* sources as fleet penetration by electric vehicles is increased.
- If green sources are being introduced as fast as possible, the marginal source could be coal-fired power plants, via delayed retirement.

My conclusions:

(1) For now, electric vehicles are just one possible source of increased fuel efficiency.

(2) Research is urgently needed on long-term marginal CO_2 emissions from electric vehicles.

(3) Eventually, if electric power generation is more fully decarbonized, electric vehicles can play an important role in the transport sector.

Policies to promote vehicle efficiency

Factors to consider:

a. Fuel efficiency and consumer myopia
b. Rebound effect
c. Are fuel efficiency standards beneficial?

a. Fuel efficiency and consumer myopia

Many studies have looked at whether people who purchase consumer durables undervalue the future savings from energy efficiency.

Demand-side studies: e.g. consumer choice among car models.
Many find high implicit discount rates, hence “myopia”.

More generally, is there an “energy efficiency gap”?
Helfand and Wolverton (2011), Gerarden et al. (2017) review possible theoretical reasons for a gap:

a. Fuel efficiency and consumer myopia

Possible sources of energy efficiency gap (demand side):

- Inattention
- Information
- Limited ability to calculate

  Documented by Turrentine and Kurani (2007), Larrick and Soll (2008), Allcott (2013)

  Example: 57 interviews of California households.

  - Very few mention fuel efficiency as a factor in vehicle purchase decisions
  - When prompted, none could formulate or calculate an estimated present value of future fuel savings
  - Stated willingness to pay for 50% increase in fuel economy: $0 – $10,000

a. Fuel efficiency and consumer myopia

Possible sources of energy efficiency gap (demand side):

- Inattention
- Information
- Limited ability to calculate

  Documented by Turrentine and Kurani (2007), Larrick and Soll (2008), Allcott (2013)

  Example: "mpg illusion" [mpg = miles per gallon]:

  Consumers systematically underestimate the fuel savings from a given change in fuel efficiency at low levels (e.g. 10 to 12 mpg) relative to high levels (e.g. 40 to 42 mpg)

a. Fuel efficiency and consumer myopia

Possible sources of energy efficiency gap (demand side):

- Inattention
- Information
- Limited ability to calculate
- Reaction to uncertainty of future fuel savings
- Impulsiveness (see Thaler 2017 in more general context)
- Positional goods

My conclusion: A “null hypothesis” of zero for the energy efficiency gap ignores virtually all the direct evidence about consumer behavior

a. Fuel efficiency and consumer myopia

Possible sources of energy efficiency gap (supply side):

- Principal-agent problems (company cars, rentals)
- Adverse selection in used vehicles
- Manufacturer incentives (marketing, imperfect competition)

a. Fuel efficiency and consumer myopia

Supply-side studies:

Econometric: e.g. Langer and Miller (2013), Busse, Knittel and Zettelmeyer (2013), Knittel (2012)

–Generally find manufacturers adjust prices and/or add new technologies.

But would they do so efficiently?

Evidence is spotty; seems likely they would emphasize those features for which they spend lavishly on advertising: namely, style & performance.

Leard, Linn & Zhou (2017): consumers overvalue performance and manufacturers follow these preferences

Leard, Benjamin, Joshua Linn, and Yichen Christy Zhou (2017) “How much do consumers value fuel economy and performance? Evidence from technology adoption,” Report , Resources for the Future (June).

a. Fuel efficiency and consumer myopia

Supply-side studies:

Engineering design: e.g. Whitefoot, Fowlie and Skerlos (2013).

–Has advantage that can investigate adoption of technologies not seen in any existing market data.

–Can create a cost function, to be combined with a separately estimated demand function for policy analysis.

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

– Observe market results, infer consumer and/or supplier behavior.

– Much like hedonic analysis

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

Knittel (2012); Leard, Linn and Zhou (2017)

- Measure expansion of production frontier due to new technology
- Most or all of the fuel efficiency gains achieved by diverting technological gains that otherwise would have been used for enhanced performance
- Implies strong substitutability within the production function between fuel efficiency and performance
  - This raises a red flag: We don't expect consumers to react rationally to performance (a central tenet of car advertising)

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

Busse, Knittel & Zettlemeyer (2013)

– Busse, Meghan R., Christopher R. Knittel, and Florian Zettelmeyer (2013), "Are Consumers Myopic? Evidence from New and Used Car Purchases," *American Economic Review* 103: 220-256.

Econometric results support range of implicit discount rates from -6.8 percent to +20.9 percent (their Table 9).

Based on range of assumptions:

* 3 fuel-efficiency quartile comparisons
* 2 markets (used, new)
* 4 alternate demand elasticities for new vehicles
* 3 alternate usage source of vehicle usage & survival rates

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

Busse, Knittel & Zettlemeyer (2013)

They compare this range of implicit discount rates:

-6.8% – +20.9% (their Table 9)

to 10th & 90th percentiles of real consumer loan rates calculated for their sample:

-0.9% – +16.9% (their text, p. 246)

Their conclusion (widely cited):

"the discount rates people use to evaluate future fuel costs are generally comparable to interest rates they pay when they buy a car"

and therefore

"there is little evidence that consumers dramatically undervalue … fuel costs"

My conclusion: this approach can accept any null hypothesis you start with – it does not provide evidence for full valuation.

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

Alcott & Wozny (2014)

– Allcott, Hunt, and Nathan Wozny (2014) "Gasoline Prices, Fuel Economy, and the Energy Paradox," *Review of Economics and Statistics*, 96(5): 779-795.

Characterize in terms of "valuation ratio" of fuel savings:

Consumers' implicit PV / objective PV (at market interest rate)

(No efficiency gap <=> val. ratio = 100%)

Results at central assumptions:

Val. ratio = 76%

Note this is significant "myopia"

Busse *et al*. result at Alcott-Wozny's central assumptions:

Implicit discount rate = 13%

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

- Leard, Linn & Zhou (2017) (unpublished)
  - Result: “undervaluation of fuel cost savings and high valuation of performance”

a. Fuel efficiency and consumer myopia

Market equilibrium studies:

Busse, Knittel & Zettlemeyer (2012)
Alcott & Wozny (2014)
Leard, Linn & Zhou (2017) (unpublished)

My conclusion:

* There is no reason to take 100% valuation as a null hypothesis
* Best evidence is consumers undervalue by ~24%

b. Rebound effect

All economists can agree that the demand for vehicle travel is downward-sloping in price of travel.

An exogenous change in fuel efficiency E changes the fuel component p_M of the price of driving:

$$p_M \equiv p_F/E$$

(where p_F is the price of fuel.)

Therefore increasing E will cause an increased driving M.

Called “rebound effect” because this offsets some of the energy savings from the increase in E (the object of much policy!)

b. Rebound effect

All economists can agree that the demand for vehicle travel is downward-sloping in price of travel.

An exogenous change in fuel efficiency E changes the fuel component p_M of the price of driving:

$$p_M \equiv p_F/E$$

(where p_F is the price of fuel.)

Therefore increasing E will cause an increased driving M.

But what is the magnitude of the response?
Commonly summarized as the elasticity:

$$\varepsilon_{M,E} \equiv \frac{E}{M}\frac{\partial M}{\partial E} = -\frac{p_M}{M}\frac{\partial M}{\partial p_M} \equiv -\varepsilon_{M,p_M}$$

b. Rebound effect

Difficulties in measurement of elasticity of driving:

- Efficiency *E* is chosen endogenously
- Response is inherently dynamic
- Results depend on whether data are cross-sectional or time-series
- Insufficient variation in *E* in many data sets; so results depend largely on variation in p_F. (Hence depends on $\varepsilon_{M,E} = -\varepsilon_{M,p_M}$).
- But the hypothesis that $\varepsilon_{M,E} = -\varepsilon_{M,p_M}$ is not empirically verified

b. Rebound effect

Gillingham (2016) review: studies range from 0.04 to 0.46.
A depressing range for policy analysts!

b. Rebound effect

Small & Van Dender (2007):
Find long-term elasticity ~0.22 over 36 years; but declining to 0.11 in 1997-2001.
Explained by modeling $\varepsilon_{M,PM}$ as function of income & fuel cost.
Implication: Can expect it to decline further as incomes rise.

Hymel & Small (2015):
Verifies functional relationship to income & fuel cost, but adds two new factors:
(i) There is a step up in 2004 – partially explained by fuel-price volatility and news media coverage of fuel prices
(ii) Elasticity is asymmetric: <u>much</u> larger for increase in p_M than for decrease.

b. Rebound effect

Jeremy West, Mark Hoekstra, Jonathan Meer, & Steven Puller (*J Public Econ*, 2017):

Analyzed "cash for clunkers" program in U.S., July-Aug 2009:

- Program subsidized new vehicles with high *E*;
- Results show vehicles purchased had lower performance.
- Low performance decreased driving, thus offsetting rebound effect entirely.

b. Rebound effect

Conclusions:

Magnitude quite uncertain, but I believe it's small and getting smaller

Research priorities:

(i) Model dynamics more rigorously. Too many studies don't distinguish between short-run and long-run.

(ii) Model ways that consumers might respond to fuel efficiency and fuel price differently

(iii) Better understand asymmetric responses

(iv) See if dependence on income holds up to replication

c. Are fuel efficiency standards beneficial?

Standard economic reasoning:
Fuel efficiency standards (e.g. CAFE in U.S.) are inferior to a fuel tax. Many reasons, all basically because it is a blunt instrument:

- Fails to reduce driving
  - – In fact, increases it (rebound effect)
  - – This has both a benefit and a cost:
    - - Benefit: more driving is valued by consumers
    - - Cost: exacerbates externalities (congestion, accidents)

c. Are fuel efficiency standards beneficial?

Standard economic reasoning:
Fuel efficiency standards (e.g. CAFE in U.S.) are inferior to a fuel tax. Many reasons, all basically because it is a blunt instrument:

- Fails to reduce driving
- Cannot be fine-tuned to give constant incentive per fuel used
  - Applies to categories of vehicles (e.g. cars, light trucks)
  - Requires arbitrary test cycle to determine efficiency of vehicle model
  - Gives no incentive for fuel-conserving driving behavior
  - Does not account for different vehicle lifetimes

  (Jacobson *et al.* 2016 find this reduced benefits by 2/3)

Reference: Jacobsen, Mark R., Christopher R. Knittel, James M. Sallee, and Arthur A. van Benthem (forthcoming) "The Use of Regression Statistics to Analyze Imperfect Pricing Policies," Journal of Political Economy, https://doi.org/10.1086/705553

c. Are fuel efficiency standards beneficial?

Additional problems with efficiency standards:

- Fuel-price uncertainty makes it impossible to determine an optimal standard at the time a vehicle is purchased
  - – Optimal standard would be indexed to fuel prices
  - – If cannot index, optimal standard is likely more lenient than under calculation in which
    expected marginal compliance cost = marginal control cost.
    - Optimal standard may not bind even under average fuel prices.
    - This is an example of standards vs. prices (Weitzman)
    - A "feebate" policy (tax/subsidy based on vehicle fuel efficiency relative to a standard) solves this problem

Reference: Kellogg, Ryan (2018) "Gasoline price uncertainty and the design of fuel economy standards," *Journal of Public Economics* 160: 14-32.

c. Are fuel efficiency standards beneficial?

Additional problems with efficiency standards:

- Fuel-price uncertainty makes it impossible to determine an optimal standard at the time a vehicle is purchased
- No “revenue recycling effect” to counter the welfare loss due to distortion on consumer choices
- Design dilemmas:
  - Size- or weight-based standards encourage larger vehicles
    - Documented in U.S., Japan
    - Creates ‘arms race’
    - Special treatment of ‘light trucks’ in U.S. encouraged the growth of large sport utility vehicles (SUVs)
  - Trading across models, manufacturers, times?

c. Are fuel efficiency standards beneficial?

On the other hand:
Some economic factors favor standards:

- Welfare effects on individuals are small, don't depend on how tax revenues are spent
  - Less likely to have drastic distributional implications
  - Prevents perverse uses of revenues from a tax
- Appropriate policy response to energy efficiency gap ('myopia') if it exists
  - Quantitatively, this item dominates the regulatory analyses of the 2016-2025 Obama-era CAFE standards in the U.S.
  - Shows up as fuel savings <u>much</u> greater than vehicle technology costs

c. Are fuel efficiency standards beneficial?

How might all these factors add up quantitatively?
Many studies on this. I'll just mention two:

1) Simulations by Small (2012):

Small, Kenneth A. (2012) "Energy Policies for Passenger Motor Vehicles," Transportation Research Part A: Policy and Practice, 46(6): 874–889.

Part of larger study at Resources for the Future, Washington, D.C.:
Krupnick, Alan J., Ian W.H. Parry, Margaret Walls, Tony Knowles, and Kristin Hayes. 2010.
Toward a New National Energy Policy: Assessing the Options – Executive Summary.
http://nepinstitute.org/wp-content/uploads/2010/06/RFF-NEPI-Executive-Summary.pdf

c. Are fuel efficiency standards beneficial?

1) Simulations by Small (2012):

Uses National Energy Modeling System (NEMS) of US Dept. of Energy

Simulates “Pavley CAFE” policy: mimics California standards, further strengthened after 2020:

Standard for new light-duty vehicle:

2016: 35 mi/gal (already in baseline)
2020: 40 mi/gal
2030: 52 mi/gal

Fuel savings valued alternately assuming:

(a) Myopia: market failure in consumer vehicle purchases
→ value fuel savings at true veh lifetimes & social discount rate

(b) No myopia: instead consumer reluctance is due to hidden amenity costs.
→ value savings at consumers’ time horizon & discount rate

(Average of two is shown here as “central estimate”)

c. Are fuel efficiency standards beneficial?

Light-duty vehicles in energy policy – Simulation results

	Exclude external costs of driving: Central estimate	Exclude external costs of driving: Myopia (no hidden amenities)	Exclude external costs of driving: No myopia	Include external costs of driving
Welfare cost ($Billions 2007$)	44.6	-31.7	120.8	80.0
Cost-effectiveness ($/ton CO2e)	31	-22	85	56

Note: costs shown are net present values over years 2010-2045

So are they beneficial? (cf. 2025 SCC of $44/ton)

Depends crucially on myopia and on external cost

c. Are fuel efficiency standards beneficial?

2) Bento *et al.* (*Science*, 2018):

- Consider the regulatory analyses done in 2016 and 2018 in support of Obama fuel standards for 2022-2025.
- 2016 analysis was favorable, 2018 unfavorable (led to rollback).
- Both omit important factors and overestimate compliance costs, but 2018 is worse.
- Authors imply that 2016 results are credible.
- Suggest keep standard but with “safety valve”, i.e. with compliance credits available at preset price

Reference: Bento, Antonio M., Kenneth Gillingham, Mark R. Jacobsen, Christopher R. Knittel, Benjamin Leard, Joshua Linn, Virginia McConnell, David Rapson, James M. Sallee, Arthur A. van Benthem, and Kate S. Whitefoot (2018) “Flawed analyses of U.S. auto fuel economy standards,” Science 362 (6419): 1119-1121 (Dec. 7).

Overall conclusions

- Transport is important to climate change, but …
  - It won't play a proportionate role in mitigation
  - Other factors should continue to dominate transport planning

- Cost-benefit analysis is a good guide to policy, but …
  - We will probably never resolve uncertainty in SCC
  - Instead, use estimates to assess policies under alternate scenarios

- Carbon tax is probably the best approach, but …
  - It may never be politically feasible
  - It can be dominated by fuel efficiency standards provided:
    - (i) "Energy efficiency gap" is strong & involves market failure
    - (ii) Rebound effect is not too large; and
    - (iii) Other motor vehicle externalities are controlled through other policies