Reducing Our Carbon Footprint: Fact and Fiction

SUNIL SOMALWAR
DEPARTMENT OF PHYSICS
RUTGERS UNIVERSITY

March 9, 2011
Is the Greenhouse Effect a Good Thing or Bad?
What is the Greenhouse Effect?

Sunlight (visible)

Infrared

Sunlight (visible)

Infrared

Greenhouse gases

T = 0°F

T = 59°F (Observed)

Greenhouse Effect
Venus & Mars (and Earth)

Venus: Runaway Greenhouse Effect: no water, atmosphere of poisoned clouds, 900F temp
CO2 vs Temperature:
Correlation implies CO2 etc feedbacks play a big role in the temp variations
CO2 vs Temperature:
CO2 etc feedbacks very important!

We are here!!
CO2 vs Temperature: IS92a in 2100 → A likely scenario

We are here!! →
CO2 vs Temperature: IS92a in 2100

A likely scenario

Note where agriculture (civilization) resides in this chart

We are here!!
Scared enough?

I will skip the rising temperatures, changing seasons, rising sea levels, melting glaciers, disappearing arctic ice, Greenland melting, permafrost collapsing, global heat conveyor belt slowing…

(Leave that to climatologists.)
How did we get in this mess?

Energy usage: Electric, Transport and other

→ Our carbon footprint.
How do we fix it?

Everybody has a favorite answer!

Photovoltaics, solar thermal, wind, flex-fuel, ethanol, biodiesel, switchgrass, algae geothermal, tidal, ZEV, clean diesel, amtrak, MagLev, energy star, fusion, nuclear, sequestration, aquifer, oceans, Ocean seeding, hydrogen economy(?), fuel cells, tidal power,

(add your favorite idea here)
An alcoholic asks the doctor

Rum is destroying my life. What do I do?
An alcoholic asks the doctor

Rum is destroying my life. What do I do?

Try vodka, whisky, gin, tequila…
An alcoholic asks the doctor

Rum is destroying my life. What do I do?

Try vodka, whisky, gin, tequila…

(Government subsidizes whisky if it is made from corn.)
An alcoholic asks the doctor

Rum is destroying my life. What do I do?

Try vodka, whisky, gin, tequila…

(Government subsidizes whisky if it is made from corn.)

When we consume so much, is “Supply Side” the right approach?
How do we fix it?

Everybody has a favorite answer!

Photovoltaics, solar thermal, wind, flex-fuel, ethanol, biodiesel, switchgrass, algae geothermal, tidal, ZEV, clean diesel, amtrak, MagLev, energy star, fusion, nuclear, sequestration, aquifer, oceans, Ocean seeding, hydrogen economy(?), fuel cells, tidal power,

(Add your favorite idea here)

So many ideas, so many passionate proponents. What to believe? **Ask first what not to believe!**
Greenhouse Emission Challenge in the Electric Sector

- *Electricity is a premier form of energy because Carnot inefficiency (at the power plant) is already built in.*
  (Not all BTU’s are created equal)
- *Coal emits twice as much CO2 per kwhr as natural gas*
Emissions: Where to?

- Today: *Five out of every six* CO2 molecules from electric sector come from Coal.
- Tomorrow: Given the global population and economic growth, situation does not change despite significant technological progress. *This is the challenge.*
- For this talk, note just the timescale: 50 years (= lifetime of a coal plant).
A Proposed Solution:
Plug-in Electric Car

Perception:
- “Green” technology
- Zero emissions. 100 “mpg”!!!
- High volume media coverage
  → Real Government Subsidies

1996 General Motors EV1
Road: Plug-in Car

- Tesla sports car available.
- 2010-11: GM Volt, Toyota plug-in, Renault
- China’s national goal: Commoditization of plug-in cars

BYD
(Warren Buffet Investment)
$22,000
← Oct 2008
Plug-in Car Causes Electric Greenhouse Emissions

- *Five out of every six* CO2 molecules from electric sector come from coal
- Maybe literally true, but what about the greenhouse (CO2) emissions?
- Einstein: Do a thought experiment.
Plug-in Car Emissions: Einstein Meets Oprah

- 2004: Oprah gave away brand new GM cars to 276 members of her studio audience.
Plug-in Car Emissions: Meet Bob Lutz

Former GM Vice-Chairman in-charge of Chevy Volt plug-in car, Bob Lutz has one free Chevy Volt for each of you.

(Remember the name for later)
Plug-in Car Emissions: What Actually Happens?

- Plug your brand new Chevy Volt into the wall outlet and charge it ~8 kWh for a 25-30 mile ride. (http://gm-volt.com/full-specifications/)

- Burn extra coal (or get a neighboring coal state to do it for you) to generate the 8 kWh, emitting

  \[ 8 \text{kwhr} \times 2.5 \text{ lbs/kWh} = 20 \text{ lbs CO}_2. \]

  (DOE-EIA coal electricity numbers + ~10% transmission loss.)
Plug-in Car Emissions: The Numbers

- 25-30 mile ride costs 20 lbs CO2 (at the power plant).
- But 20 lbs CO2 = One gallon of gasoline

*Chevy Volt is a 25-30 miles per gallon car.*
(As far as CO2 emission goes)

The battery does not discharge completely, but many inefficiencies are also NOT included:

- Battery charger and charging inefficiencies (laptop best: ~75%)
- Rapid battery charging inefficiency
- Li-ion battery aging inefficiency (increased internal resistance)
- Passenger comfort (ohmic heating in winter)
- Lifecycle (manufacture) footprint of the extra batteries….
Good Hybrid vs. Bad Plug-In
How does the plug-in compare to hybrid in terms of emissions?

- Gasoline Hybrid
- Plug-in Electric
Four Arguments Against Plug-in Vehicles

1. Promotes coal
   - Coal, the dirtiest energy source, is the backbone of a tight electric grid. New load → difficult to decarbonize.

2. Disincentive to fuel conservation in the transportation sector
   - Increases fuel supply base in transportation, frees up gasoline for other inefficient vehicles. Same as liquid coal.

3. Inefficient
   - A factor of two more emissions/mile than a comparable gasoline hybrid. (Again, same as liquid coal.)

4. Regulatory loophole
   - Trojan horse allows other inefficient cars thru the CAFE gate (next slide).
Plug-in car loophole in action:

Say 35 mpg required average efficiency.

One “100 mpg” plug-in + one 20mpg gas guzzler ➔ 35 mpg average (CAFE)
→ Actual result is two 20 mpg vehicles on road.
Plug-in car loophole in action:

Say 35 mpg required average efficiency.

One “100 mpg” plug-in + one 20mpg gas guzzler → 35 mpg average (CAFE)

→ Actual result is two 20 mpg vehicles on road.

Plug-in’s encourage Inefficient vehicles
Plug-in Car Conclusion

Hybrid cars like the Toyota Prius are good, but a vehicle like the GM Volt is a
Plug-in Car Conclusion

Hybrid cars like the Toyota Prius are good, but a vehicle like the GM Volt is a

**Plug-in Car(T) Before the Horse.**
Plug-in Car Conclusion

Hybrid cars like the Toyota Prius are good, but a vehicle like the GM Volt is a **Plug-in Car(T) Before the Horse.**

GM’s **Bob Lutz:** global warming a "total crock of xxxx."
Trains, Buses and Planes
What is the most efficient intercity passenger transport?
Freight Trains vs. Passenger Trains

- Freight Trains are more efficient than trucks at goods transportation because of low steel-on-steel resistance.
- However, efficiency of freight trains does not transfer to passenger trains.
- Passenger trains
  - Need instantaneous acceleration
  - Have higher peak and variable speeds
  - Carry high rolling dead-weight per passenger
    (Acela: 2 tons/seat)
## Intercity Transportation Efficiency

<table>
<thead>
<tr>
<th>Transportation Mode</th>
<th>Passenger-miles/ gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amtrak</td>
<td>20-40</td>
</tr>
<tr>
<td>Jet (600 miles)</td>
<td>40-45</td>
</tr>
<tr>
<td>German Intercity Trains</td>
<td>55-60</td>
</tr>
<tr>
<td>Prius Hybrid (gasoline, 2 passengers)</td>
<td>90-100</td>
</tr>
<tr>
<td>Intercity Bus (Bolt, Megabus, Peter Pan &amp; “Chinatown” Buses)</td>
<td>130-200</td>
</tr>
</tbody>
</table>

1) A gallon equals 20 lbs CO2 emission assuming coal electricity
2) Amtrak’s electric/diesel breakdown not known, hence the uncertainty.
3) Aviation: Southwest Airline data.

Somalwar (Mar-2011)
A Case for Intercity Express Buses

- Short-Medium haul – Express coach buses running from Boston to DC are **substantially more efficient** than Amtrak and 3-4 times more efficient than German ICE’s. (and I’m a trainiac!)

- Superfast train network is not a good option at this stage.

- Wide-body long-haul jets to hubs with intercity express bus network most efficient (but planes are too convenient – carbon pricing a must!)

- Infrastructure exists!

Somalwar (Mar-2011)
Intercity Express Buses
(3-4 times cheaper than Amtrak)

4.2 mpg (200 pmpg) ← (China)

Somalwar (Mar-2011)
Start Your Own Intercity Express Bus Service
(OR - An idea for retooling Detroit)

A9 Luxury Bus YCK6140HGN

Company: Zhongda Industrial Group
Membership: YES BEST YES Member since Jan 15, 2009
Country/Region: China
Address: No.100 KaiFang Road, YanCheng, Jiangsu, China 224003
Contact: Mrs. Jonny Wang (Mobil: 86 13921807218)
Phone: 86-515-6666-6666
Fax: 86-515-8818-8444
Tags: bus, automobile, vehicle
Online Postings: More 20 Trade Leads, Product Catalog(s)

Contact Now Add to Cart

Official Ford® Site
Official Site. Exclusive Offers. Research the 35 MPG Ford Focus. FordVehicles.com/Focus

Get 90 MPG 868-437-7795
Buy Our Install Kit Today-Only $375 Get 70 MPG In A Diesel or Unleaded! www.EIISOLUTION.com

Calculate Mileage
Find Calculate Mileages at Great Prices. www.Pronto.com

Product Description
A9 classical bus adopt advanced International D technology and its distinguished visual conception to design the top and button windshield, collect the latest fashionable information, After been put into market, it sell swell both in domestic and overseas. The total selling amount pass three thousand units. It got favourable reputation from domestic and international customers.

Product Feature
Low fuel consumption: The whole bus fuel oil consumption is decreased up to 20%, and the fuel consumption of 100 km is only 26L. Special streamline body structure effectively limits resistance and improves fuel efficiency.

Extra large luggage space: 12 cubic meter luggage space is 20% larger than the one of other bus, which realizes max co-traveling of person and luggage. Integral electric parallel ascending side door, remote control...
More fact vs fiction

- Auto efficiency standards (CAFE)
- Superfast Intercity trains vs freight by rail
- In our own backyard: Livingston Solar vs Busch Cogeneration
So Professor Somalwar, what is your solution?

Don’t have one: Right policy framework needed.
  → Polluter pays
  → Make greenhouse emissions expensive
    (but don’t raise overall taxes!)

- Avoid specific proposals and reserve political capital for a slowly increasing carbon price signal such as Cap & Trade or pollution fees.

- Only a large carbon price signal will alter consumption patterns
  → Greenhouse revenues should be fully refunded to entice the consumer.
So Professor Somalwar, what is your solution?

Don’t have one: Right policy framework needed.
  → Polluter pays
  → Make greenhouse emissions expensive
    (but don’t raise overall taxes!)

- Avoid specific proposals and reserve political capital for a slowly increasing carbon price signal such as Cap & Trade or pollution fees.

- Only a large carbon price signal will alter consumption patterns
  → Greenhouse revenues should be fully refunded to entice the consumer.

But who is going to listen to an ivory tower professor, so let us turn to making good personal choices……..
Conclude with the Discussion Topic:
My List for Reducing Carbon Footprint

• Spend less! (Unpatriotic these days.) In a perfect world, your spending will correspond to your carbon footprint.

• Live close to work, drive less, buy a hybrid (optional), but don’t go for the latest gadget (plug-in car). Live in a small house with a small yard.

• Use electricity sparingly. Less air conditioning, more ventilation, more compact fluorescent bulbs. Extra: NJ Clean energy program.

• Preaching to the choir: Be (politically) involved. Even better, be policycally (!) involved. Most energy experts are shallow.

• Eat lower on the food chain (land and water as well). Stay healthy!

• Get 90%, don’t worry about the 10% which takes 90% effort.