Economic and Greenhouse Gas Analysis of Some Key US Energy Policies

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Outline

- CO2 emissions and global climate negotiations
- Evaluation of US energy policies
- Shale oil and gas
- Renewable energy
- Forest carbon sequestration
- Private sector initiatives
- Conclusions

Data comes from DOE, IEA, BP, and other sources.
Total CO2 Emissions, 2012 (Million Metric Tons).

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>5000</td>
</tr>
<tr>
<td>China</td>
<td>8000</td>
</tr>
<tr>
<td>India</td>
<td>1000</td>
</tr>
<tr>
<td>Europe</td>
<td>6000</td>
</tr>
</tbody>
</table>

CO2 Emissions Capita, 2012 (Tons/Person).

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>16.0</td>
</tr>
<tr>
<td>China</td>
<td>18.0</td>
</tr>
<tr>
<td>India</td>
<td>2.0</td>
</tr>
<tr>
<td>Europe</td>
<td>8.0</td>
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</table>
Climate Change Impacts

- Increased temperature and variability in rainfall
- Sea level rise
- Increased incidence of diseases and higher health costs
- Reduced agricultural yields in many areas including Indiana
- Damage to infrastructure and higher costs to maintain infrastructure
- Others
**GE, Jeff Immelt** - Industry must now lead and not depend on government.

**Goldman Sachs, Lloyd Blankfein** - Today’s decision is a setback for the environment and for the U.S.’s leadership position in the world.

**IBM** - Climate change is an international problem that requires an international solution, and we believe it is important for the world to reduce greenhouse gas emissions. Therefore IBM supported - and still supports - U.S. participation in the Paris accord.

**Cargill** - We have no intention of backing away from our efforts to address climate change in the food and agriculture supply chains around the world and in fact this will inspire us to work even harder.

**ExxonMobil** - led the charge of private companies supporting Paris
Scope

- Climate policies
  - Clean Energy Standard (CES)
  - Renewable Fuel Standard (RFS)
  - Corporate Average Fuel Economy Standard (CAFE)
  - Combined, these essentially achieve the emissions reductions agreed to in the Paris accord

- Equivalent Emission Tax Policy

- Implications of combining climate policies
  - Sectoral and overall emissions
  - Abatement amounts and costs
  - Resulting primary energy mix
  - Electricity price
  - Effect on the economy
MARKAL-Macro

- Technology and sectoral detail rich bottom-up MARKAL
- Use of a neoclassical growth model (Macro)
- Incorporates macroeconomic feedbacks into an integrated bottom-up MARKAL model
- Aggregated endogenous energy demand structure
- Calculation of GDP, consumption, and investment.
The US has subsidized ethanol since 1978 with a subsidy ranging between 40 and 60 cents per gallon.

The ethanol subsidy ended in 2011, but there is still a subsidy for biodiesel and cellulosics.

The price of crude oil ranged between $10 and $30/bbl. between 1982 and 2003.

With these crude prices, the ethanol subsidy did not put undue pressure on corn prices.

However, once crude oil prices rose, so did ethanol production.
The Renewable Fuel Standard (RFS) provides for 36 billion gallons (ethanol equivalent) by 2022.

There are four categories:
- Biodiesel
- Cellulosic advanced
- Other advanced
- Conventional.

It is a nested structure, so only corn ethanol counts for conventional, but biodiesel, other advanced, or cellulosic can fill the conventional as well.
The original maximum mandate for biodiesel was 1 BG, but EPA has now increased that level to 2.1 BG.

Must reduce greenhouse gas (GHG) emissions by at least 50%

It can be transportation fuel, transportation fuel additive, heating oil, or jet fuel. It can be ester based diesel (e.g., from soybean oil), or non-ester renewable diesel (e.g., from cellulosic feedstocks).

Biodiesel (as defined here) is required for the biodiesel part of the RFS.
Only biofuels produced from cellulosic feedstocks such as corn stover, miscanthus, switchgrass, forest residues, or short rotation woody crops can count in this category.

Cellulosic biofuels must be shown to reduce GHG emissions by 60%.

EPA has waived most of the RFS for this category and will continue to do so.
This category can be a wide range of biofuels that reduce GHG emissions at least 50%.

Sugarcane ethanol that meets the GHG reduction standards qualifies.

Biodiesel qualifies. Cellulosic biofuels can be used.

EPA has also approved sorghum ethanol produced under certain conditions.
This category is the only one that permits corn based ethanol.

It requires a reduction in GHG emissions of at least 20%. However, ethanol plants that were in operation or under construction as of December 2007 are grandfathered.

The RFS legislated level is 15 BG in 2015 and after. EPA set the 2016 level at 14.5 BG, but increased it back to 15 BG afterwards.
The RFS is enforced by creating obligations for each type of biofuel.

- Obligated parties generally are refiners (only the product for the domestic market) and importers.
- For example, if you are a refiner, and you have 10% of the total domestic market (domestic plus imported) for gasoline, for 2017 with a 15 BG total obligation for corn ethanol, you would incur obligations for 1.5 BG.
- The traded fraction is 15-25% of total RINs.

<table>
<thead>
<tr>
<th>RIN Code</th>
<th>Fuel Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3</td>
<td>cellulose</td>
<td>$2.71</td>
</tr>
<tr>
<td>D4</td>
<td>biodiesel</td>
<td>$1.10</td>
</tr>
<tr>
<td>D5</td>
<td>advanced</td>
<td>$1.08</td>
</tr>
<tr>
<td>D6</td>
<td>ethanol</td>
<td>$0.71</td>
</tr>
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</table>
The blend wall refers to a physical limit on blending of ethanol.  It is derived from the U.S. practice of blending gasoline at 10%.  2016 U.S. consumption of gasoline type fuel will be about 142 BG per year, highest since 2007. In fact, 2016 was the first year consumption surpassed the 2007 level.  

- With ethanol being blended at 10%, the max ethanol that can be blended is 14.2 BG.  
- There are small amounts of ethanol blended as E85 and as E15, but they are really too small to matter for this purpose.
Second Generation Economic and Policy Issues

- Blend wall
- Market uncertainty
- Technology uncertainty
- Feedstock supply
- Interaction among all these factors
All of the processes have a high degree of technical uncertainty.

While in most cases, it is known that we can produce energy products using the technology, the question is at what cost.
The RFS is important to the biofuels sector.

Because of the blend wall and other issues, the RFS has now come under increased attack.

Eliminating the RFS would kill renewable fuel growth, but ethanol could hold its ground in the short run.

Cellulosic biofuels and biodiesel are not economic and need the RFS to continue being produced and consumed.
Corporate Average Fuel Economy
- Previous CAFE fuel economy standard was 27 MPG
- Increases the fleet average fuel economy for new passenger cars and light duty truck vehicles 5% per year between now and 2025 to reach the target of 54.5 mpg.
- Is being reviewed by the Trump administration
Clean Energy Standard (Clean Power Plan)

- Electricity sector would move from the current 40 percent clean to 80 percent clean by 2035
- Clean electricity:
  - Coal with carbon capture and sequestration,
  - Nuclear electricity
  - Renewable electricity generation (Hydro, solar, wind, and biomass).
- Natural gas is considered 50 percent clean.
Results
Results (contd.)

Total Abatement Breakdown

million tonne CO₂

-100  0  400  900  1,400  1,900  2,400  2,900

2015  2020  2025  2030  2035  2040  2045

CAFE  RFS  CES  Interaction effect  Total Abatement

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Results (Electricity)
Results (Electricity)

CES + CAFE + RFS

CES + CAFE + RFS equivalent CO₂ Tax Scenario

TWh

2015 2020 2025 2030 2035 2040 2045

Coal  Natural Gas  Oil  Nuclear  Hydro  Wind  Waste  Biomass  Geothermal  Solar  Imports
Results (Electricity)

![Electricity Price Chart]

- CES - CAFE - RFS
- Equivalent Emission Tax scenario
- Reference

2010 $ per MWh

2010 2015 2020 2025 2030 2035 2040 2045
Results (Transport)

Reference Scenario

- Fuel oil
- Electricity
- LPG
- CNG
- Bio diesel
- Thermochemical Diesel
- Diesel
- Thermochemical gasoline
- Ethanol
- Gasoline

billion gallon gasoline equivalent

2015 2020 2025 2030 2035 2040 2045
Results (Transport)
Results (Transport)

Transportation - Energy Consumption Change

[Caxis: billion gallon gasoline equivalent]

[Year: 2015, 2020, 2025, 2030, 2035, 2040, 2045]

[CAFE, RFS, CES, Interaction Effect, CES - CAFE - RFS]
Results (Transport)

Transportation - Abatement Breakdown

- CAFE
- RFS
- CES
- Interaction effect
- Total Abatement

million tonne CO2

2015, 2020, 2025, 2030, 2035, 2040, 2045
Results (Overall)

Net Decrease in Crude Oil Imports

- Policy case (CAFE)
- Policy case (RFS)
- Policy case (CES)
- Interaction Effect
- Policy case (CES + RFS + CAFE)
- Equivalent emission tax policy

Million barrel oil equivalent

Year: 2015, 2020, 2025, 2030, 2035, 2040, 2045
Emissions Reduction and Cost

Total Abatement Breakdown

2010 US $ per tonne CO₂

Policy case (CES)
Policy case (CAFE)
Policy case (RFS)
Interaction Effect
Equivalent emission tax policy

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Policy Impact on GDP

GDP change compared to reference (%)

-2.5% -2.0% -1.5% -1.0% -0.5% 0.0% 0.5%

2015 2020 2025 2030 2035 2040 2045

Policy case (CES) Policy case (CAFE) Policy case (RFS) Interaction Effect Policy case (CES + RFS + CAFE) Equivalent Carbon Tax
Primary energy use is found to be the least with a carbon tax because all producers and consumers have an incentive to use less.

CES is found to be cost effective for reducing GHGs coupled with high electricity prices.

RFS contributes significant amount of GHGs abatement coupled with reduction of oil imports at a low cost.
Conclusions (contd.)

- CAFE policy offers significant GHG abatement for a very high cost.
- CAFE is more effective (lower cost) than other policies (CES, RFS, equivalent emission tax) for oil import reduction.
- Combined policy set would reduce GDP by 2%, which is higher higher than tax case reduction of 1.2%.
- However, policy makers might be willing to pay that cost to use the regulatory instead of tax approach.
Shale Oil and Gas Benefits

• Shale oil and gas are a game changer.
• It is part of the reason behind the manufacturing resurgence in the U.S.
• It will stimulate much more conversion of old coal fired electric power plants in the U.S. to natural gas, thereby providing environmental benefits.
• The IEA estimates that shale gas done right is only 7% more expensive than business as usual, so it can be done with minimal adverse environmental impact.
Projections of US Natural Gas Production

- Shale Gas
- Tight Gas
- Coalbed Methane
- Offshore Gas
- Conventional Gas

Million barrels oil equivalent

- 2010: 1000
- 2015: 2000
- 2020: 3000
- 2025: 4000
- 2030: 5000
- 2035: 6000
- 2040: 7000
US Shale Gas Plays

Lower 48 states shale plays

Source: Energy Information Administration based on data from various published studies. Updated: May 9, 2011
Major Global Shale Plays

Legend
- Assessed basins with resource estimate
- Assessed basins without resource estimate
- Countries within scope of report
- Countries outside scope of report
Expansion in shale oil and gas

Expected oil production

Expected gas production

Source: Annual Energy outlook 2013 (DOE)
The shale oil and gas boom is having a major impact on the US economy.

During the time period from 2008 through 2035 the US GDP on average would be 2.2% higher than its 2007 level with the expansion in shale resources,

The welfare gain from availability of the shale oil and gas technology averages $302 billion per year over this period.

One important question is do we use this gain just to produce and purchase more goods and services, or do we use part of it to help reduce GHG emissions.
Total Welfare Gain Under the Alternative Policies

- Shale exp
- Carbon tax: -41%
- Elec+trans: -51%
- Elec only: -50%
The depreciation benefit for solar installations is very important (worth 19% of capital cost)

- In Indiana, business installations have an 88% probability of being economic, whereas residential is 40%

- Solar leasing in California is soaring for this reason

- At low levels, solar and wind do not impose significant costs on the electric grid. However, because of the intermittency issue, at higher levels of penetration, we must have gas power plants ready to operate, and this imposes a “capacity cost” on the system.
With the crop yield shocks, more land is required for food production, and less is used for FCS.

The proportion of reduction is similar to the TAX case.

Tax only is $155, and tax plus FCS subsidy is $100

Substantial food price increases with FCS subsidy
Going to Scale with Renewables

- FCS has no impact at low levels, but huge impacts on food prices at high levels.
- Solar and wind impose little or no cost on the system at low penetration, but substantial capacity and grid costs at high penetration.
- Biofuels, even dedicated energy crop biofuels, can lead to commodity price increases at high levels.
Corporate Energy Economics

- Companies can both save money and appear greener.
- Converting to cheaper natural gas for fleets - UPS
- Energy efficiency is the low hanging fruit. The famous McKinsey carbon abatement curves show over 70 technologies that reduce energy consumption and at the same time actually save money, and most are increasing energy efficiency.
- A good case study is WalMart. Began as effort to increase sustainability, and now is driven as much by cost savings.
Alternative Fuel

As an industry leader in seeking alternative fuel opportunities for our worldwide fleet, we increased our commitment to renewable fuels in 2015, with plans to purchase up to an additional 60 million gallons of renewable diesel and renewable natural gas (RNG).

1 billion mile goal – Reset our 2017 goal for miles driven in alternative fuel/advanced technology vehicles, up from 400 million.

We take a comprehensive, global approach to reducing energy use and GHG emissions.
Reduce Carbon

Climate change and greenhouse gas emissions pose serious risk to the environment and global economy. We reduced our absolute carbon emissions from operations and purchased energy by 2.1 percent even with a 2.3 percent increase in shipping volume (over 2011).

70% of all U.S. routes are now equipped with ORION — On-Road Integrated Optimization and Navigation — our proprietary route optimization software. When it is fully deployed to all U.S. routes by the end of 2016, we expect to reduce the distance driven by our drivers by 100 million miles annually. 49
Walmart CEO - We made new commitments to increase the use of renewable energy, reduce greenhouse gas emissions in our operations and in our supply chain, to create zero waste in key markets, sell more products that sustain people and the environment and expand local sourcing.

Walmart Sustainability director - The capabilities of the private sector are unique, and complement what governments and civil society can do. Perhaps most importantly, we have the ability to help create market-based solutions—where the behaviors that result in better environmental and social outcomes are also the behaviors incented by the market.
LED lights in a Walmart store refrigerator case

Electricity represents the second-highest operating expense at the majority of our stores and clubs. So we discovered a game changer in 2005, when the installation of LED freezer case lighting at a store in McKinney, Texas, reduced energy consumption by 70%. Now LED freezer case lighting has become the industry standard, and we’ve adapted the technology to additional areas of our buildings, including parking lot lights and sales floor lighting.
Sustainability

REDUCE ENERGY INTENSITY AND EMISSIONS
• Be powered by 50 percent renewable energy by 2025
• Reduce emissions in our own operations by 18 percent

ELIMINATE WASTE
• Achieve zero waste to landfill in our own operations in the U.S., U.K., Japan, and Canada by 2025.

IMPROVE SUSTAINABILITY IN VALUE CHAINS
• Support measurement and transparency in our value chain
• Reduce environmental impacts
• Work with suppliers to reduce 1 Gigaton of emissions between 2015 and 2030
• Expand sourcing of commodities produced with zero net deforestation by 2020
• Expand and enhance more sustainable sourcing to cover 20 key commodities
• Walmart private brand products will use 100 percent recyclable packaging
Wal-Mart

10 years
2,100 stores
330 million SF
49% less wattage than ASHRAE 90.1

Interior with Sales Floor lighting in “full off” mode

Corporate Strategy & Business Sustainability
Some Conclusions

- US energy future unclear – depends on climate policy and the global race between supply and demand.
- Climate change is real and is caused by human intervention, but enforcing agreements will be difficult.
- A carbon tax is the most efficient way to go, and can be made revenue neutral.
- Shale oil and gas provide significant benefits for the US economy. It would take less than half those benefits to significantly reduce GHG emissions.
- In many ways, the private sector is ahead of the public sector. I think they will continue to lead.
- States and cities may lead the efforts to reduce emissions in the next few years.
Thanks very much!

Questions and comments.