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POLICY BRIEF
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UNCONVENTIONAL SHALE OIL AND GAS PRODUCTION AND GREENHOUSE GAS REDUCTION: CAN WE HAVE BOTH?

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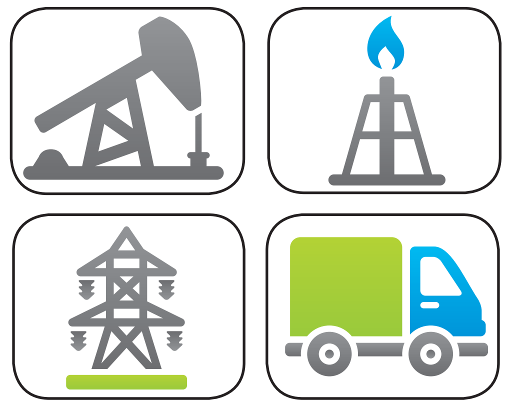
The U.S. Department of Energy projects that by 2030 North America will be self-sufficient in petroleum due to the shale oil and gas revolution. We estimate that shale technologies will provide a welfare increase of about $300 billion/year. We evaluate what happens to this gain if we "spend" part of it on reducing greenhouse gas (GHG) emissions. A carbon tax that achieves a 27 percent reduction in GHG emissions reduces the gain by 41 percent, and a policy of regulating transportation and electricity takes about half the gain. In both cases, we can retain a large part of the shale dividend while at the same time reducing GHG emissions.



Improvement in hydraulic fracturing (fracking) and horizontal drilling technologies has increased access to the U.S. shale oil and gas resources and led to increases in supplies of these fuels in this country in recent years. The U.S. Department of Energy (2013) projections suggest that by 2030 North America will be self-sufficient in petroleum. Currently, the U.S. is the only country that extracts oil and gas from shale resources. However, these resources are available in many countries in significant quantities around the world.

The purpose of this policy brief is to evaluate the economic and environmental impacts of simultaneous expansion of shale oil and gas resources and policies aimed at reducing greenhouse gas (GHG) emissions. We use a computable general equilibrium (CGE) model (GTAP) to perform the analysis. A computable general equilibrium model is simply one that has all the economic sectors and factor markets included within its scope. The GTAP model is a global CGE model with as many as 113 regions and 57 sectors, although it is commonly simulated with greater aggregation to simplify the analysis. The main reason for using a CGE model is that one can examine all the interrelationships within an economy. As the saying goes, "everything is related to everything else," and CGE models perform well at capturing these complex relationships. Details on the model (Hertel, 1997) or recent work in this area (Taheripour et al., 2014; Taheripour et al., 2013) are available in the references.

We report on several simulations of the impacts of the shale oil and gas technology with no environmental measures in place, with a carbon tax, and with environmental regulations on the electricity and transportation sectors in the United States. Finally, we present some conclusions from this analysis.

The first policy is a carbon tax applied to the entire economy. In the U.S., at least in the near term, it is not likely that a carbon tax will be implemented. Therefore, we also apply two other policies that are closer to what may be possible in the United States.

At present, the U.S. has a Corporate Average Fuel Economy Standard (CAFE) that takes fleet fuel economy from 27.5 miles per gallon (MPG) today to 54 MPG by 2025. This is a huge change in fuel economy, and therefore would imply a very large reduction in emissions in the transportation sector. In addition, the nation has a policy of significantly reducing GHG emissions from the electricity sector. Under this policy, essentially no new coal-fueled power plants will be constructed, and many older plants will be phased out. The electricity and transportation sectors are the major GHG emitters in the U.S. with 40 and 34 percent of total emissions respectively (EIA, 2011). Thus it is understandable that these sectors would be targeted by current U.S. policy. The existing regulatory policies (including the average fleet efficiency (CAFE) standard, renewable fuel standard (RFS), and clean energy standard (CES) for electricity could reduce CO_2 emissions in 2035 by 26.5 percent, compared to 2007 (Sarica et al., 2011). Here we focus on electricity and transportation because the RFS has a much smaller impact than the other policies.

POLICY ANALYSIS RESULTS

As mentioned above, we present the results of four cases in this brief:

CASE ONE
Expansion of shale oil and gas resources with no environmental policy

CASE TWO
Shale expansion with an economy-wide carbon tax

CASE THREE
Shale expansion with a carbon tax equivalent applied only in the electricity and transportation sectors. The implementation would be through regulations, but it is modeled as a tax with the same quantitative impact in emission reductions.

CASE FOUR
Shale expansion with emission reduction targets only for the electricity sector

For cases two-four, the emission reduction level in 2035 is targeted to be 26.5 percent less than 2007.

IMPACT OF DEPLOYMENT OF SHALE OIL AND GAS RESOURCES

The shale oil and gas expansion has a very large impact on the U.S. economy. The nation's welfare increases over $300 billion per year relative to the 2007 level with the shale expansion. This is not an annual increase but an average level difference between a given year and 2007. Similarly US GDP is, on average, 2.2 percent higher each year than in 2007 due to the shale oil and gas development. What is fascinating about this large benefit is that in 2007, just seven years ago, it was hardly on the radar screen. Thus, in a sense, it could be viewed as a windfall. The main global regions negatively impacted by U.S. shale oil and gas development are the Middle East and Russia – significant oil and gas exporters. The European Union is positively impacted. In total, the U.S. shale oil and gas expansion reduces welfare by about $14 billion in all of the rest of world, a comparatively small amount. So the bulk of the impact of the U.S. shale oil and gas expansion is within the United States.

As would be expected, the biggest changes associated with deployment of shale oil and gas resources are in output, prices, and trade of oil and gas. Oil and gas production are expected to increase by 31 percent and 39 percent, respectively. Their prices fall 8 percent and 12 percent correspondingly. The trade balance also improves significantly for both oil and gas. The only other major change on the trade side is a worsening in the trade balance for all the industrial sectors. The major driver of this change is the increase in GDP and welfare induced by the shale oil and gas expansion, which increases the demands for industrial output, which leads to more imports of industrial products.

SHALE OIL AND GAS EXPANSION ALONG WITH A CARBON TAX

We will briefly describe what happens in the other three cases and then turn to a comparison of the four cases. For the shale expansion with economy-wide carbon tax, the annual average welfare gain falls from $302 to $178 billion, a drop of 41 percent. The GDP level increase drops from 2.2 to 1.2 percent. This may seem like a large loss, but it is a glass half empty or glass half full question. Yes, 41 percent of the shale gain is lost, but substantial reduction in GHG emissions has been achieved. While we do not have quantitative estimates of the benefits of avoiding the adverse impacts of climate change, they clearly cannot be ignored, and every day we see increasing evidence of the consequences of climate change. Another way to interpret these results is that we can at the same time increase fossil energy availability and achieve substantial economic gains while also reducing GHG emissions 27 percent from the 2007 base. In other words, we can use part of the shale oil windfall to pay for a lower carbon future.

Other important differences between this case and the expansion only case are as follows:

- Coal output fell 1.4 percent in case one, and it falls 35.1 percent in the carbon tax case. This result is consistent with prior research on the carbon tax (Sarica et al., 2011), using a completely different modeling framework.
- Electricity output increased 2.4 percent in case one, but falls 4.6 percent with the carbon tax
- While all the industrial sectors grew in the shale expansion case, they all contract a bit in the carbon tax case
- Coal price was relatively flat in the shale expansion case but falls 4.7 percent with the carbon tax
- Electricity price fell 1.3 percent in case one but increases 9 percent with the carbon tax
- The industrial trade balance improves relative to the shale expansion case because incomes are not rising as much.

REGULATIONS ON ELECTRICITY AND TRANSPORT SECTOR EMISSIONS

Now we consider an option that approximates current U.S. energy policy; that is, expansion of shale oil and gas resources along with regulations on electricity and transport emissions that together achieve the 26.5 percent reduction gained with the carbon tax in case two. In essence, this policy concentrates all the emission reduction in the two sectors that together represent 71 percent of all GHG emissions. With this policy, the welfare gain falls from $302 billion in case one and $178 billion in case two to $148 billion. Cases one and two had GDP gains of 2.2 and 1.2 percent, whereas case three has a gain of 1 percent. The welfare gain in case three is less than half the original gain from shale expansion. Another way to interpret this case is that by refusing to go with the more efficient economy-wide carbon tax and instead using regulatory measures to achieve the same objective, the welfare cost to the economy is about $30 billion/year.

Other interesting results from the emission regulations on electricity and transportation are as follows:

- Coal output falls even further to -39 percent. This difference is to be expected since more of the emission reduction is forced on the electricity sector.

- All the fossil energy prices fall significantly.
- Electricity price goes up 12.5 percent compared with 9 percent in the carbon tax case.
- All the industrial prices go up more than in the carbon tax case.
- The industrial trade balance improves a bit compared with the carbon tax case because less industrial products are demanded with the lower level of economic activity.

SHALE EXPANSION WITH ELECTRICITY EMISSION REDUCTION ONLY

This case warrants a look because some observers in the U.S. believe that the nation's fuel economy standards may be weakened as a result of the upcoming 2018 review. If so, much of the remaining emissions reduction policy would be on the electricity sector. There is actually a small difference between cases three and four. The welfare increase goes up from $148 to $151 billion. Prior research (Sarica et al., 2011) shows it is more expensive to reduce emissions in the transport sector than electricity. The GDP change rounded is the same 1 percent. However, there are some differences in the other outputs:

- Coal output falls further by 42.6 percent of the base case. Coal price actually falls less at 7.8 percent.
- Electricity output falls more as would be expected, down 9.6 percent, while electricity price jumps by 15.7 percent.
- Industrial output is either decreasing less or increasing more than in the previous case.

All the changes are in the expected directions. This last policy concentrates all the emission reductions in the electricity sector, so most of the impacts are on coal, electricity, and industry.

SUMMARY AND CONCLUSIONS

Now we turn to some closer examination of key differences among the four policy alternatives. Figure 1 provides a comparison of the welfare gains under the alternative policies. In all cases there is a welfare gain for the U.S. economy. For the shale expansion only, the gain is on average $302 billion/year. In the other three cases there is a lower economic gain but also a substantial reduction in GHG emissions. Clearly the carbon tax is the most efficient means of accomplishing that GHG reduction. Case three with all the reduction coming from transportation and electricity costs the U.S. economy about $30 billion/year compared with the carbon tax approach. As would be expected, an economy-wide carbon tax that spreads the cost of emission reductions and achieves the reductions at lowest cost to the economy is the most efficient.

Coal and electricity output and prices are significantly impacted by the policy differences as illustrated in Figures 2 and 3. With shale expansion alone electricity output actually grows a bit while price declines. For coal there is almost no change with shale expansion alone. The big changes, of course, occur with the emission policy implementations. Electricity output declines, and price increases under all three policy options with the largest changes under the policy targeted at electricity exclusively, and the smallest for the economy-wide carbon tax. Interestingly, oil and natural gas prices decline

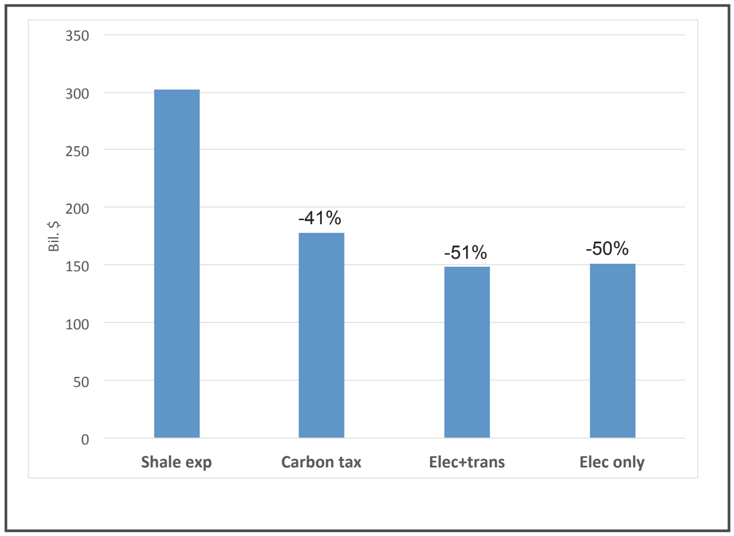


Figure 1. Welfare Gains Under Alternative Policies and % Change from Shale Expansion Alone.

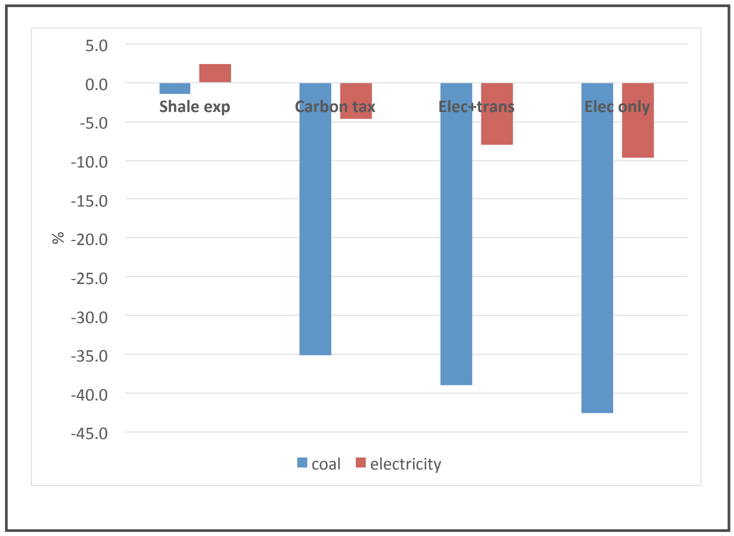


Figure 2. Changes in Coal and Electricity Output Under Alternative Policies.

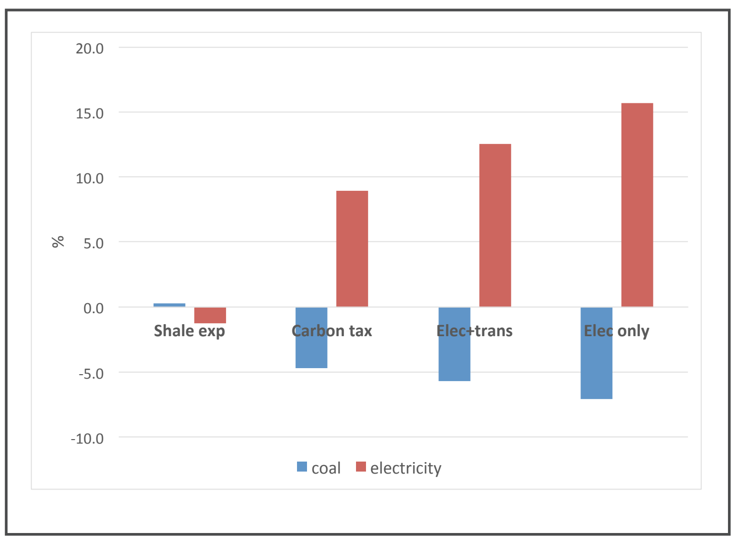


Figure 3. Coal and Electricity Price changes Under the Policy Alternatives.

about the same under all policy measures. Basically, the decline in income would depress prices, but the emission's policies would increase them, so the two effects basically offset each other. Most of the other price and quantity changes move in the directions one would expect.

Equally interesting, though, is that policies that welcome shale oil and gas development and at the same time cause substantial reduction in GHG emissions still result in a substantial welfare and GDP gain for the economy. In a sense, we can more than pay for the reduction in GHG emissions with the economic gains from shale oil and gas. Of course, some will argue that we should forego the shale oil and gas and achieve the GHG reductions regardless of the cost to the economy. What we have attempted to do here is to highlight the alternative policy options and the consequences of each. The shale "dividend" is large. The question is do we use it all for higher economic growth or do we allocate part of it for reducing future global warming?

If we view the large shale oil gain as an unanticipated windfall for the economy, it may well be reasonable to use part of that dividend to pay for GHG reduction. If we do, the most efficient way to do it is with a carbon tax. If for political reasons, we cannot do a carbon tax, we can get the same GHG reduction at an increased annual cost to the economy of $30 billion. Even in this case we still retain half the shale oil dividend while reducing GHG emissions substantially. In today's lingo, we use the dividend to "pay forward."

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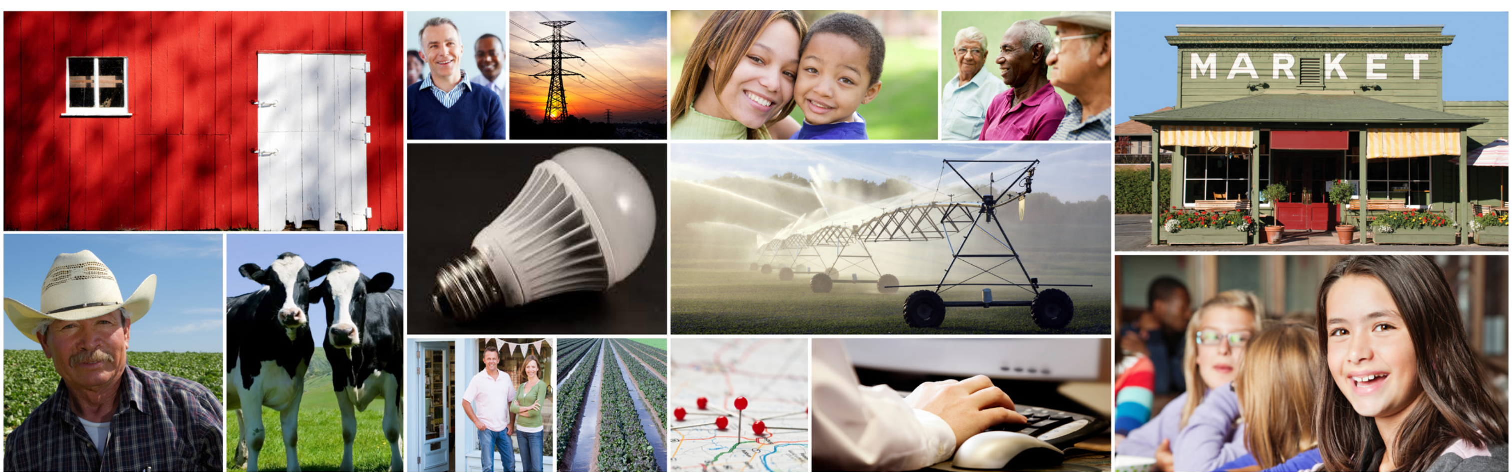

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