Economic Impact of the Energy Security Leadership Council's *National Strategy for Energy Security*

FEBRUARY 2009

A STUDY COMMISSIONED BY

ENERGY SECURITY LEADERSHIP COUNCIL

Securing America's Future Energy

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1. Letter of Introduction

The Interindustry Forecasting Project at the University of Maryland (Inforum) and Keybridge Research LLC are pleased to release the following study, which measures the long-term economic effects of policies designed to enhance U.S. energy security. This study was commissioned by the Energy Security Leadership Council (ESLC), a project of Securing America's Future Energy (SAFE), and reflects the policy proposals detailed in the ESLC's National Strategy for Energy Security, released in September 2008.

The National Strategy is designed to reduce the oil intensity of the U.S. economy, thereby strengthening the overall economy and reducing U.S. vulnerability to the increasingly serious volatility of the global oil market. The central feature of the ESLC report is the electrification of short-haul ground transportation. The report identifies a wide range of public policies needed to support electrification over the coming decades, including government fiscal support, research expenditures, and improvements in the robustness of the U.S. electric power sector. Additionally, the report identifies measures to enhance U.S. energy security during the interim years. These include implementation of aggressive fuel-economy standards for all on-road transport, increased production of domestic energy resources, revisions to the existing biofuels program, and expanded and reformed public spending on energy-related research, development, deployment and commercialization.

The University of Maryland/Keybridge Research modeling team collectively has many decades of experience building and performing simulation studies with large-scale econometric models and conducting public policy research on energy and macroeconomic issues. This study relies upon a comprehensive simulation analysis employing the highly respected Inforum LIFT model, a general equilibrium econometric model of the U.S. economy. The point of departure for the study was to develop a baseline scenario over the period 2009 to 2050 that was generally consistent with the forecast contained in the U.S. Department of Energy's Annual Energy Outlook 2008 (AEO 2008).

A second scenario for the same time period was then developed incorporating central components of the ESLC's National Strategy. This second scenario required assumptions regarding the composition of future electric power generation, the cost of policy compliance, the pace of technological innovation based on public spending, and a number of other key inputs. The assumptions were drawn from, or corroborated by, well-respected sources, such as reports by the Energy Information Administration and the National Academy of Sciences. The two scenarios were then compared to quantify the changes in energy and oil intensity, oil imports, energy production, employment, and income that result from the ESLC policy package.

The study finds that, if implemented today, the ESLC policy package results in a wide range of beneficial impacts to the U.S. economy between now and 2050. With reduced oil intensity, household income and American employment will be higher and the U.S. trade deficit will be smaller. And even after paying for subsidies and other measures to implement these policies, the U.S. government budget balance is expected to improve, because economic activity and income levels will be higher. Probably the single most important conclusion of the study is that by substantially reducing America's oil dependence, the economy will be much better prepared to withstand a future oil shock such as those that affected the U.S. economy and contributed to recessions in 1973–74, 1980–81, 1991, 2000–01 and 2008–09. That is, the ESLC energy package can be thought of as a self-financing insurance policy that will make the economy more robust in good times and more resilient when subjected to energy shocks.

Robert F. Wescott, Ph.D.
President
Keybridge Research LLC
Washington, DC

Jeffrey F. Werling, Ph.D.
Executive Director
Inforum, Department of Economics
University of Maryland
College Park, MD

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III. Summary of the ESLC's *National Strategy*

The University of Maryland Inforum LIFT model was used to perform a detailed examination of the Energy Security Leadership Council's *National Strategy for Energy Security*, and its policies to reduce America's oil dependence. The policy components of the ESLC's *National Strategy* can be summarized as follows:

- Diversifying energy supplies for the transportation sector
- Enhancing the nation's electrical system
- Improving energy efficiency
- Reforming the biofuels program
- Expanding domestic energy production
- Increasing/reforming public spending on research, development and deployment

The stated purpose of the *National Strategy* is to reduce U.S. oil dependence. Approximately 40 percent of U.S. primary energy consumption is currently petroleum-derived.[1] Total consumption volume averaged 19.5 million barrels per day (MB/D) in 2008, and has averaged more than 20 MB/D since 2003—about one-fourth the world total.[2] Sixty-nine percent of U.S. oil consumption occurs in the transportation sector, which is 97 percent reliant on petroleum-based fuels for delivered energy.[3] Petroleum prices are generally volatile, and have historically imposed significant damage on the U.S. economy.[4] In 2007, petroleum products accounted for approximately 40 percent of the U.S. trade deficit.[5]

The ESLC identifies diversification of energy supplies in the transportation sector as its primary strategy to reduce America's reliance on petroleum. Specifically, the plan outlines a path toward widespread electrification of short-haul ground transportation in the United States. This approach has the substantial benefit of decoupling passenger vehicles from the world petroleum market—and its attendant price volatility—and instead using the electric grid to supply fuel to Americans' cars and trucks. The domestic grid is powered by a diverse portfolio of largely domestic fuels which are less subject to the geopolitical-induced price volatility that affects the global oil market. In fact, because the price of fuel is a relatively small part of the cost of delivered electricity, the price of electricity is less volatile than the price of fuels used to generate it. Moreover, in much of the country, the price of electricity remains largely regulated.

To promote electrification, the *National Strategy* includes strong incentives for the production and purchase of electric vehicles (either fully electric or plug-in-hybrid electric), incentives for the construction public recharging stations, a minimum of $500 million in annual public spending on battery research, and $30 billion for retooling of automobile manufacturing facilities in the U.S.

Of course, electrification of 100 million vehicles will create challenges. An obvious source of concern is the state of the existing electric grid, which suffers from stagnant growth in generation capacity, a balkanized transmission structure, and perverse pricing incentives. The ESLC plan stresses the importance of not, "trading one national security risk for another."

1 BP p.l.c., *Statistical Review of World Energy 2008*
2 U.S. Department of Energy, Energy Information Administration, *Weekly Petroleum Status Report* (Feb 4, 2009), Table H1
3 U.S. Department of Energy, *Energy Information Administration, Annual Energy Outlook 2008*. Henceforth cited as EIA, AEO (2008)
4 Greene, David L., Oak Ridge National Laboratory, Economic Costs of U.S. Oil Dependence (2005)
5 U.S. Department of Commerce, Bureau of Economic Analysis; U.S. Department of Energy, *Annual Energy Review 2007* (2008)

To support the additional electricity demand arising from the increased use of electric vehicles (PHEVs or EVs), the *National Strategy* includes incentives to stimulate the development of new generating capacity, including both baseload and renewable energy production. Specific policies include expanding the federal loan guarantee program for nuclear power plants and extending tax credits for renewable generation. The ESLC plan also includes regulatory measures to improve the siting process for interstate transmission lines and proposes increasing the rate of return on investments in modernizing the grid. To reform electricity pricing, the plan recommends that states implement time-of-day pricing and utilities be required to install smart meters over a fixed time period.

The ESLC is cautious in emphasizing that electrification of transportation is not an instant fix for energy security. Fleet rollover and infrastructure build-out—along with the incremental nature of technological development—are factors that dictate a long-term national transition. In the interim, the *National Strategy* includes measures to improve energy security in less transformative, but still critical, ways.

First, the *National Strategy* includes alternative liquid fuel supply enhancements designed to offset petroleum consumption. Largely, these policies relate to reforming the existing biofuels program to make it less costly and less focused on corn ethanol. Specific policies include increased public spending to accelerate development of cellulosic ethanol and other advanced biofuels. (Ultimately, non-alcohol biofuels such as biocrude from algae offer the promise of displacing petroleum use in a broader range of transportation modes, including air travel.) In order to efficiently absorb the ethanol production levels mandated by the existing renewable fuels standard, the ESLC plan recommends accelerating Department of Energy and Environmental Protection Agency testing and validation of intermediate biofuel blends in conventional engines (up to E15 and E20).

Second, the plan makes recommendations that highlight the importance of efficiency, particularly in ground transport. Based on provisions in the Energy Independence and Security Act of 2007, light duty fleetwide fuel-economy standards are set to reach 35 miles per gallon by 2020. The *National Strategy* recommends annual improvements of no less than 4 percent annually from 2020 to 2030. It also recommends that the National Highway Traffic Safety Administration (NHTSA) proceed expeditiously with rule-making for medium- and heavy-duty truck standards.

Third, the *National Strategy* differs from many other proposals to improve U.S. energy security in the sense that it focuses not just on reduced energy demand and fuel alternatives, but also on increased production of conventional energy supplies. The ESLC outlines a series of measures for increasing oil and natural gas production through expanded access to resources beneath the Outer Continental Shelf (OCS), increased production in Alaska, and the promotion of CO_2 enhanced oil recovery.

In support of all its policies, short-, medium-, and long-term, the ESLC outlines a series of reforms in federal spending on research, development, and deployment. The centerpiece of these reforms is a nearly 10-fold increase in spending—to $30 billion annually. Other policy steps include the reform of existing R&D institutions to streamline spending, and the creation of new institutions that leverage market-based incentives to accelerate commercialization of critical energy technologies.

Note: Section Five of this report discusses the *National Strategy* in greater detail and fully outlines the methodology employed by Inforum LIFT for modeling each of the ESLC policies.

IV. Summary of Findings

The study simulates the economic effects of the ESLC policy package on the U.S. economy over the period 2009 to 2050. The Inforum LIFT model is an extremely detailed economic forecasting model that captures the effects of purchases and sales between industries. It is especially suitable for a study of this kind because it models the interaction between detailed industry flows in the economy, such as energy use, and macroeconomic aggregates, such as GDP, consumption, employment and the trade balance.

The following list summarizes the main findings of the LIFT simulation. Results are a comparison of the ESLC policy case to a status quo base case (see Section Five). All dollar figures are constant 2008 dollars unless otherwise noted:

- **ANNUAL HOUSEHOLD INCOME:** By 2050, the typical U.S. household would have $4,046 more income with the ESLC policy case than it would have in the base case. This is an increase of nearly 2.1 percent in annual income.

- **CUMULATIVE HOUSEHOLD INCOME:** Cumulatively, during the 2009-2050 period, households would experience an increase of $13.9 trillion in aggregate income because of the ESLC policy package—money that could be spent on goods and services, or saved for a more comfortable retirement.

- **TRANSPORTATION COSTS:** By 2050, the typical U.S. household would be spending less per year on energy for transportation in the ESLC policy case. The combination of higher income and less spending on energy means that the average household would be able to enjoy about $5,025 more in consumption of consumer goods and services (or personal savings).

- **REDUCED OIL IMPORTS:** The U.S. would experience a significant reduction in oil imports in the ESLC policy case, with oil imports lower by 6.6 million barrels per day in 2050 than they would be without the package. Cumulatively, during period 2009 to 2050, the U.S. would import nearly 60 billion fewer barrels of foreign oil.

- **IMPROVED TRADE DEFICIT:** In the ESLC policy case, the U.S. trade balance would improve by about $275 billion dollars, (nominal terms) or about 0.3 percent of GDP, by 2050. (The benefits of the ESLC policy package on the U.S. petroleum trade balance are even more substantial. However, higher economic growth in the ESLC policy case leads to greater imports of non-petroleum goods and services.)

- **HIGHER FEDERAL REVENUES:** Because of the higher levels of income and GDP in the ESLC policy case, net U.S. federal revenues would be a cumulative $1.46 trillion higher than in the base case (nominal terms).

- **LOWER GLOBAL DEMAND FOR OIL:** The ESLC policies would lead to lower world demand for oil, and therefore lower world oil prices. Outside commodity price experts have estimated that the price of oil would be 11 percent lower by 2050 than it would be without the package.

- **REDUCED CARBON EMISSIONS:** In the ESLC policy case, system-wide CO2 emissions are lower than in the base case. In the ESLC case, emissions are 5.9 percent lower in 2030, 13.2 percent lower in 2040, and 19.1 percent lower in 2050.

- **REDUCED OIL INTENSITY:** Compared to 2008 estimated GDP and oil consumption levels, the ESLC policy case reduces U.S. oil intensity by 40 percent in 2030 and 60 percent in 2050.

- **HIGHER OVERALL EMPLOYMENT:** By 2050, total employment is 3.0 million jobs higher in the ESLC policy case. Of note, there would be 225,000 more manufacturing jobs, 514,000 more jobs in travel and tourism, 108,000 more jobs in professional services and 44,000 more jobs in agriculture. Employment in the motor vehicle industry, including motor vehicle parts, is about the same as the base. However, the industries that supply key electric and electronic components to electric vehicles would see increases in employment of 42,000 jobs.

- **GREATER RESILIENCE TO FUTURE PRICE SPIKES:** In addition to the economic benefits of the ESLC policy package, reduced dependence on imported oil is expected to ameliorate the negative economic impacts of future oil price volatility. By 2040, the ESLC policy package acts as a $400 billion insurance policy for the U.S. economy, saving 1.8 million jobs in the event of an oil shock.

v. Findings in Detail

The following section provides details on the results of the Inforum LIFT modeling. As a preface, it should be noted that the base case is a steady state model of the U.S. economy over roughly 40 years. In other words, it does not explicitly factor in short-term anomalies like the current economic recession and emerging fiscal imbalance (the base case is described in greater detail in Section Five). In this sense, the base case is not designed to predict conditions, but rather provides a useful benchmark against which to compare policy scenarios.

All dollar figures are constant 2008 dollars unless otherwise noted.

Increase in Real Income

U.S. households experience an increase in real income under the ESLC plan. Furthermore, because of savings in the household use of transportation fuels, there is more income available for the purchase of other goods. Table 1 shows the total increase in real disposable income, as well as the total increase in the consumption of non-oil goods and services for selected years. Over the entire interval of the simulation, cumulative real disposable income is $13.9 trillion higher in the ESLC policy case. Personal consumption of non-oil goods and services is $17.4 trillion higher.

By 2050, the typical household would have $4,046 more income with the ESLC policy package than in the base case. This is an increase of 2.1 percent. Since expenditures on gasoline will fall relative to the base case, the typical household will have a total of approximately $5,025 of extra income to enjoy on goods and services, or savings. (See Table 1.)

TABLE 1: DIFFERENCE IN DISPOSABLE INCOME & INCOME AFTER ENERGY EXPENDITURES (BILLIONS OF 2008 DOLLARS EXCEPT WHERE NOTED)

		2010	2020	2030	2040	2050
Base	Disposable Income	11,255	14,806	19,000	23,988	30,806
	Income after Energy Expenditures	10,748	14,272	18,432	23,383	30,154
ESLC	Disposable Income	11,321	15,060	19,300	24,387	31,463
	Income after Energy Expenditures	10,832	14,568	18,815	23,903	30,970
Total Difference	Disposable Income	66	254	300	399	657
	Income after Energy Expenditures	84	296	383	520	816
Difference Per Household (whole Dollars)	Disposable Income	549	1,944	2,127	2,624	4,046
	Income after Energy Expenditures	701	2,274	2,713	3,422	5,025
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Reduction in Crude Oil and Refined Product Imports

Enhancing supply and reducing petroleum-based transportation energy use will result in a significant reduction in crude oil and refined product imports. Table 2 compares petroleum imports over the interval in the base case with the ESLC policy case.

TABLE 2: OIL IMPORTS (MBD)

	Base Case	ESLC Policy Case	Difference
2010	13.1	13.2	0.1
2020	14.1	12.0	(2.1)
2030	15.7	11.5	(4.2)
2040	17.8	11.6	(6.2)
2050	20.2	13.6	(6.6)
Cumulative Import Reduction (2009–2050):			58.9 Billion Barrels

The combined effects of the transportation fuel savings and the enhancements in domestic supply result in a reduction of imports of about 4.2 MB/D by 2030 and about 6.6 MB/D by 2050. The cumulative reduction over the period of the simulation is about 58.9 billion barrels. Note that the total reduction in imports is less than might be expected given the transportation energy savings and the enhancements to domestic supply. This is due to a stronger economy in the ESLC scenario, which generates demand for more goods and services and broadly influences the demand for oil. These effects are only identified by using a dynamic model such as the Inforum LIFT model, and would not be discovered in a static calculation.

Reduced U.S. Trade Deficit

Crude oil and refined petroleum products constitute a significant portion of the U.S. trade deficit. In 2007, the total U.S. trade deficit was approximately $701 billion, of which trade in petroleum accounted for $295 billion (42 percent).[6] Initial estimates for 2008 place the net value of U.S. petroleum imports at more than $350 billion.

The reduction in oil imports that derives from the ESLC package has a significant impact on the U.S. trade balance in future years. (See Figure 1.) The base case projects strong growth in exports

6 U.S. Department of Energy, *Annual Energy Review 2007;* U.S. Bureau of Economic Analysis

(5.3 percent average annual growth from 2008 to 2050) and slower growth in imports (4.3 percent). The base case projects an improvement in the current account balance through roughly 2040, after which it goes into deficit again. In the ESLC case, although there is still a deficit by 2050, the trade balance improves with respect to the base as illustrated in Figure 1 and Table 3.

FIGURE 1: U.S. TRADE BALANCE

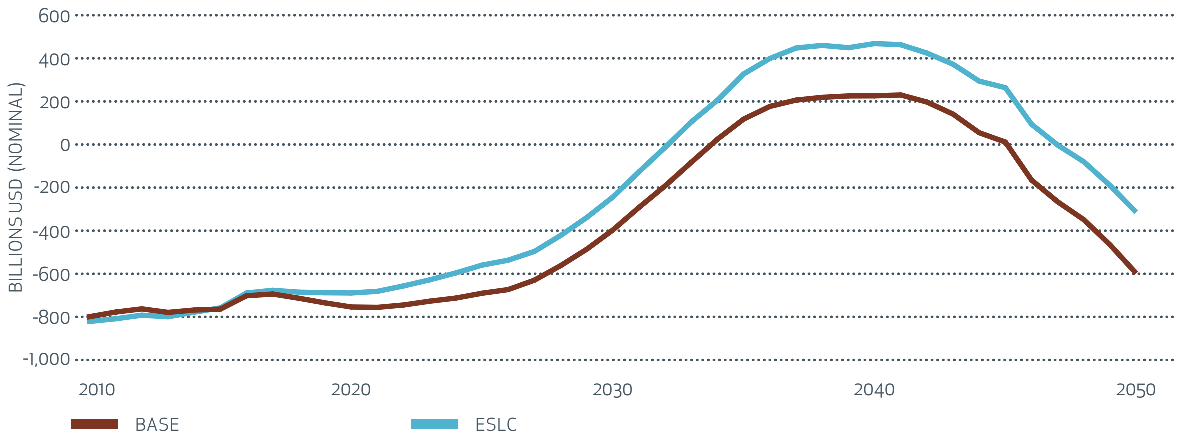


TABLE 3: U.S. TRADE BALANCE (NOMINAL $ BILLIONS AND PERCENT OF GDP)

	Base Case	ESLC Policy Case	Difference	Percent of GDP
2020	(735.0)	(688.0)	47.0	0.20%
2030	(486.1)	(339.0)	147.0	0.41%
2040	225.5	449.3	223.8	0.40%
2050	(465.5)	(190.2)	275.3	0.32%

Federal Revenues and the Deficit

The base case has an average GDP growth rate of 2.3 percent from 2008 to 2050. The base case assumes slower long-term growth (averaging 1.3 percent) in government spending than in GDP, so the base case shows a government surplus by 2015, which grows to $907 billion by 2050 (nominal terms), or about 1 percent of GDP. (Please note again that the base case is a steady-state model of the U.S. economy against which policy cases can be compared. It is not designed to reflect or respond to events, such as the current recession and fiscal imbalance.)

In the ESLC case, the fiscal picture is improved in all years of the simulation, due primarily to higher economic growth. (See Table 4.) The improvement is smaller in the early years, when there is fairly generous government spending on electric vehicles, public charging stations, auto industry retooling, and renewable power generation. For the cumulative simulation period, the increase in federal revenue in the ESLC policy case is $1.46 trillion.

TABLE 4: FEDERAL DEFICIT (-) / SURPLUS (+) (NOMINAL $ BILLIONS)

	Base Case	ESLC Policy Case	Difference
2010	(208.0)	(183.1)	24.9
2020	63.2	83.4	20.2
2030	21.6	64.9	43.3
2040	177.2	185.6	8.4
2050	907.2	1075.0	167.8
Cumulative: 2009–2050			1457.8

Lower World Oil Price

As discussed above, the combination of transportation oil demand reductions and enhancements to domestic supply result in a total reduction of 6.6 MB/D in U.S. oil imports by 2050. This is fundamentally equivalent to an increase in supply of 6.6 MB/D for the rest of the world market. The DOE reference case published in the *International Energy Outlook 2008* projects a world production capacity for liquid fuels of about 112.6 MB/D in 2030; for modeling purposes, that number was extrapolated to a capacity of 120 MB/D by 2050.

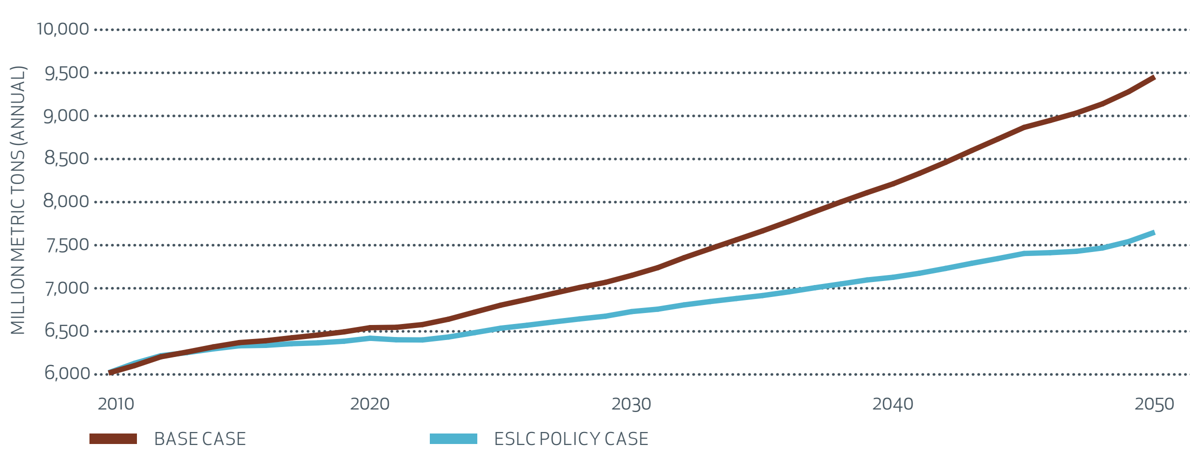
DOE also shows a low price case in which petroleum supply is 15 percent higher than the reference, with a resulting 40 percent lower world oil price. The DOE high price case shows petroleum supply 15 percent lower than the reference, with the oil price about 70 percent higher. DOE's implied world demand elasticity (the ratio of the percentage change in supply over the percentage change in price) is between -0.1 and -0.35. A literature search by Inforum found that assumed world long-term demand elasticities ranged between -0.1 and -0.5. To be conservative, these scenarios assume the highest elasticity (-0.5), which would result in the smallest decline in world price.

The nominal price in the base case is assumed to reach $238/BBL by 2050. The 6.6 MB/D extra supply on the world oil market due to the reduction in U.S. net demand represents about 5.5 percent of the total. Therefore, assuming a world demand elasticity of -0.5, global price of oil would be about 11 percent less than the base case.

Impact on CO_2 Emissions

The net reductions in oil consumption, growth of cellulosic ethanol use, and the increase in electricity demand from electric vehicles in the ESLC policy package result in a significantly lower rate of growth in CO_2 emissions compared to the base case, as depicted in Figure 2. In the ESLC case, emissions are 5.9 percent lower than the base in 2030, 13.2 percent lower in 2040, and 19.1 percent lower in 2050.

FIGURE 2: SYSTEM-WIDE CO_2 EMISSIONS

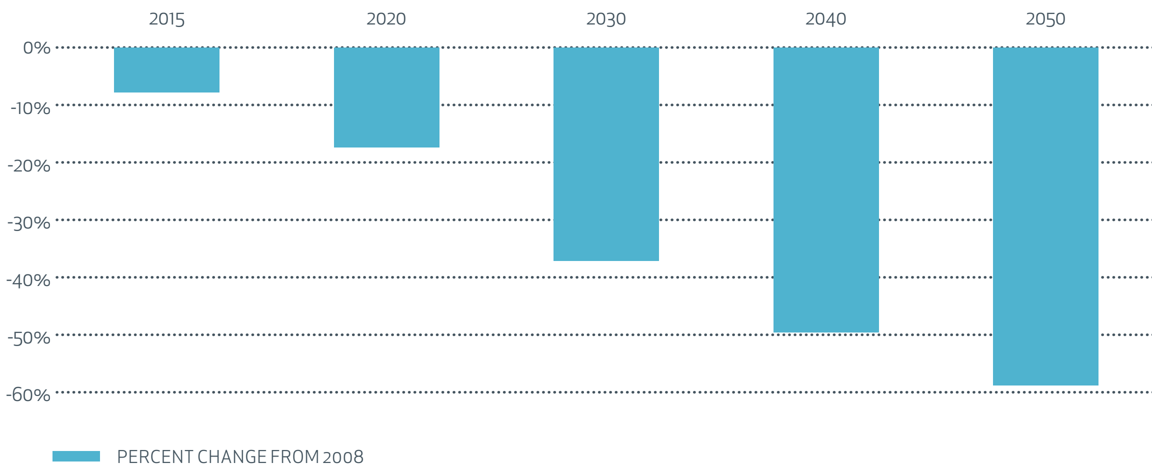


While the ESLC policy package should not be viewed as a climate change mitigation tool, it is important to note that the Inforum LIFT model has made no assumptions regarding additional policies to reduce or manage CO_2 emissions, particularly in the electric power sector, where such policies will likely prove most cost effective. (For example, though new coal plants are assumed to be IGCC and carbon capture ready, the model has not assumed actual carbon reductions from capture.)

In other words, while the ESLC policy package has only a modestly positive direct impact on emissions, it opens the door to much more significant and economically sound reductions. This is due to the ESLC plan's structural consolidation of transportation emissions away from diffuse tailpipe emissions and into a more limited number of stationary emissions sources in the electric power sector. In a sense, the ESLC package "sets the table" for other policies to deal more directly with CO_2 emissions.

Oil Intensity of the U.S. Economy

FIGURE 3: REDUCTION IN OIL INTENSITY UNDER THE ESLC PLAN



The ESLC policy package results in a reduction in the oil intensity of the U.S. economy during the forecast period. (Oil intensity is defined as the amount of oil required to produce a specified unit of GDP.) As depicted in Figure 3, by 2030, U.S. oil intensity is reduced by nearly 40 percent from 2008 levels in the ESLC policy case. By 2050, the reduction is 60 percent.

The reduction in oil intensity in the ESLC policy case can be attributed to two primary factors. The first factor that contributes to lower oil intensity in the ESLC policy case is reduced oil consumption compared to the base case. The reduction in oil consumption is the result of policies outlined above, including substantial rates of electrification in short- haul ground transportation, increases in medium- and heavy-duty truck efficiency, and deployment of advanced biofuels.

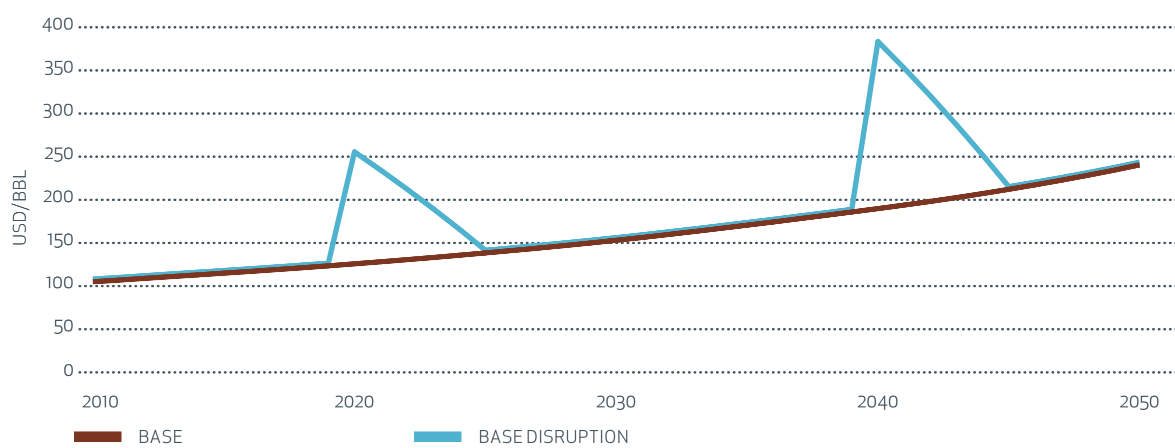
The second factor is stronger overall economic growth in the ESLC policy case compared to the base case. Although rates of economic growth and oil consumption growth tend to track each other, the ratio is less than 1:1 in industrialized economies. In other words, a 1 percent increase in economic output yields less than a 1 percent increase in oil consumption. Therefore, in principle, developed economies tend to become less oil intensive with growth over time.

The ESLC Package as an Insurance Policy

In addition to the above-mentioned long-term economic benefits of the ESLC policy package, there is another important benefit: reduced dependence on imported oil can ameliorate the negative economic impacts of future acute oil price volatility. A large oil price increase normally will have significant negative effects on GDP and real income. The increased cost of imported oil worsens the terms of trade and reduces the standard of living. In an economy less dependent on oil, these negative effects are still felt, but to a lesser extent.

The Inforum LIFT model was used to quantify this 'insurance' benefit by running additional simulations that featured significant future oil shocks in both the base case and the ESLC policy case. These simulation exercises included two oil price shocks. (See Figure 4.) The first takes place in 2020, before many of the effects of the policy package have yielded the greatest benefits. The second shock takes place in 2040, when the ESLC policy elements are implemented at their full level. For each shock, a doubling of the real oil price was assumed, returning to the base level within 5 years. Figure 4 shows the resulting path of the nominal oil price, in the base case and the base disruption case.

FIGURE 4: NOMINAL OIL PRICES—BASE & BASE DISRUPTION CASES

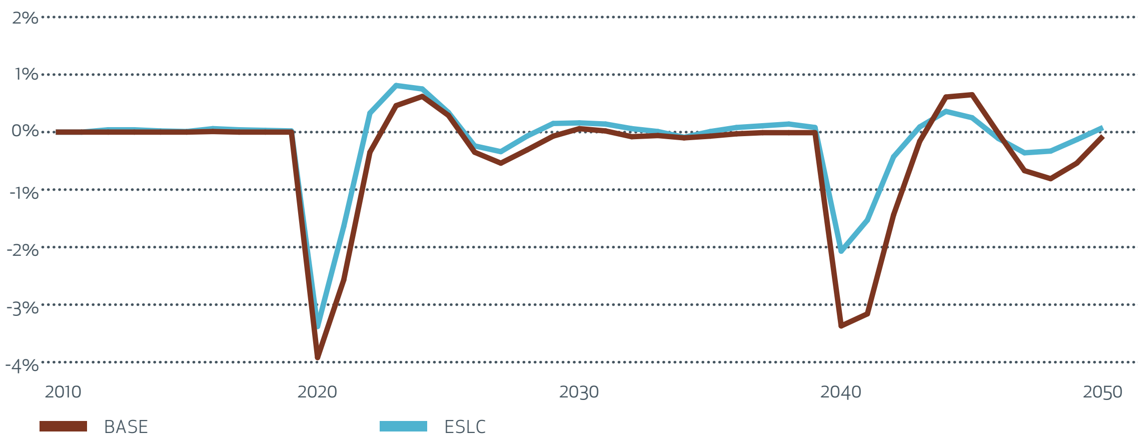


GDP Effects

Each disruption from the baseline causes a short recession, but then the economy returns to its long-run growth path. In fact, there are usually short periods of "overshooting" where shortfalls of accumulation of investment and consumer durable goods are partially made up. The pattern of response is best illustrated by comparing the percentage changes from the disruptions in both the base and ESLC policy case.

Figure 5 plots percentage differences in GDP after each shock in the base case and the ESLC policy case. The decline in GDP in the base case is 4 percent (-$768 billion) in 2020, and 3.4 percent (-$1,042 billion) in 2040. The decline in GDP in the ESLC policy case is 3.4 percent (-$668 billion) in 2020, and 2.1 percent (-$646 billion) in 2040. In other words, the "economic buffering" from the ESLC policy package is 0.6 percent ($100 billion) in 2020, and increases to 1.3 percent ($396 billion). That is, by 2040, the ESLC policy package can be thought of as a nearly $400 billion insurance policy for the U.S. economy.

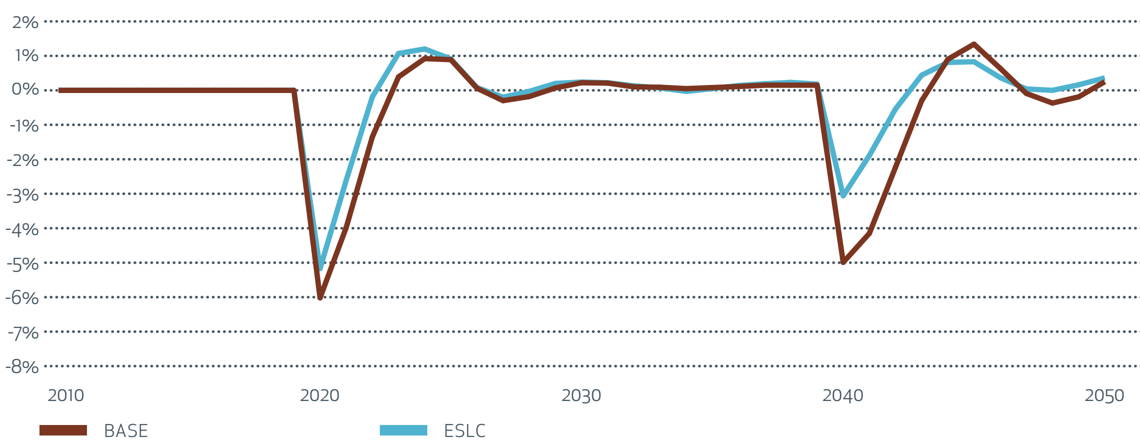
FIGURE 5: CHANGES IN REAL GDP DUE TO OIL SHOCKS



Real Disposable Income

Figure 6 shows a parallel comparison for real disposable income. The decline in real disposable income in the base case is 6.2 percent (-$887 billion) in 2020 and 5.1 percent (-$1,190 billion) in 2040. The decline in real disposable income in the ESLC policy case is a smaller 5.3 percent (-$775 billion) in 2020, and 3.1 percent (-$742 billion) in 2040. That is, the "economic buffering" is 0.9 percent ($112 billion) in 2020, and it increases to 2.2 percent ($448 billion) in 2040.

FIGURE 6: CHANGES IN REAL DISPOSABLE INCOME DUE TO OIL SHOCKS

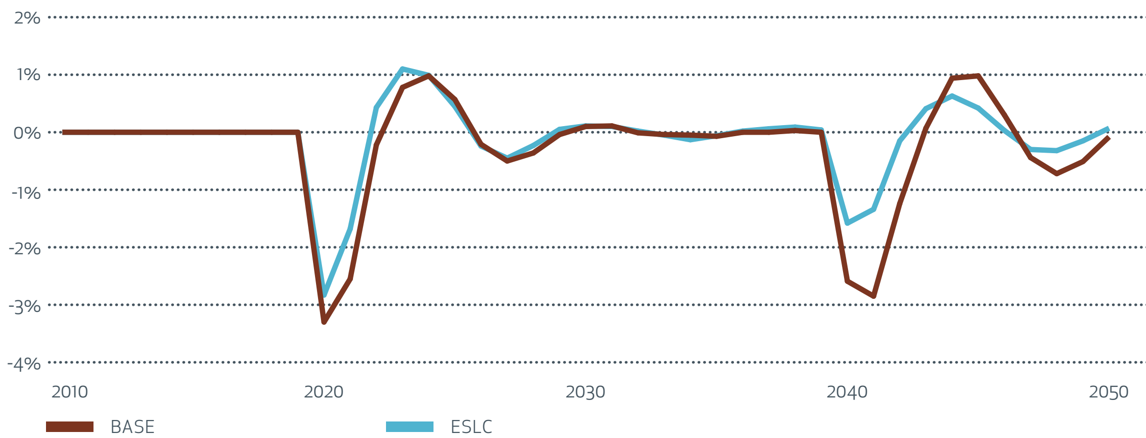


It is also instructive to compare the difference in the effects of a disruption over time. If we consider the differences from 2040 to 2043, the total GDP loss in the base case is $2.6 trillion. In the ESLC policy case, however, the total GDP loss falls to just $1.2 trillion, a difference of $1.3 trillion—more than 50 percent. The cumulative real disposable income loss from 2040 to 2043 in the base case is $2.8 trillion versus $1.3 trillion for the ESLC policy case—this represents a difference of $1.6 trillion, or 57 percent.

Employment

The pattern of employment shows a similar picture, as depicted in Figure 7. The decline of employment in the base case in 2020 is 3.3 percent (5.4 million jobs), while the decline in the ESLC policy case is 2.8 percent (4.7 million jobs). For the disruption in 2040, the decline in the base case is 2.6 percent (4.7 million jobs), whereas the decline in the ESLC policy case is 1.6 percent (2.9 million jobs), a savings of 1.8 million jobs.

FIGURE 7: CHANGES IN TOTAL EMPLOYMENT DUE TO OIL SHOCKS



Tables 5 and 6 summarize the dynamic behavior of the effects of the two disruptions in the base and ESLC policy cases. These tables show the percent difference from the respective baseline run for various figures in case of the oil shocks. In Table 5, we see that the two simulations posited a similar percentage shock of 100, 80, 60 and 40 percent in oil prices in 2020, 2021, 2022, and 2023, respectively. Table 6 shows similar impacts for 2040-2043. Impacts on GDP, real income and employment are as discussed above.

These tables also include the effect of the oil price shocks on average consumer prices. Reduced dependence on oil in the ESLC policy case mitigates the inflationary effect of the oil price shock. In the baseline disruption of 2020, consumer prices increase by 4 percent, compared to just 3 percent in the ESLC policy case. In the 2040 disruption, the price differences are 4.5 percent for the base, compared with 4.2 percent for the ESLC policy case. This smaller effect on consumer prices is one of the contributing factors to the reduced loss of real disposable income under the ESLC policy case.

TABLE 5: OIL PRICE SHOCKS: CONTRASTING BASELINE AND ELSC POLICY 2020 OIL SHOCK

			2020	2021	2022	2023	2020–2023 Cumulative
World Oil Prices	Percent	Both	100.0	80.0	60.0	40.0	
GDP	Percent	Baseline	-3.9	-2.6	-0.3	0.5	
		ESLC	-3.4	-1.6	0.3	0.8	
	Bil 2008 $	Baseline	-767.9	-514.2	-71.2	95.3	-1257.9
		ESLC	-668.6	-331.4	67.9	170.6	-761.4
Real Disposable Income	Percent	Baseline	-6.0	-4.0	-1.3	0.4	
		ESLC	-5.2	-2.6	-0.2	1.1	
	Bil 2008 $	Baseline	-886.9	-599.4	-207.1	60.8	-1632.6
		ESLC	-776.1	-401.1	-29.4	172.0	-1034.7
Employment	Percent	Baseline	-3.3	-2.6	-0.2	0.8	
		ESLC	-2.8	-1.7	0.4	1.1	
	Millions	Baseline	-5.4	-4.2	-0.4	1.3	
		ESLC	-4.7	-2.8	0.7	1.8	
Consumer Prices	Percent	Baseline	4.5	4.4	3.9	3.1	
		ESLC	4.2	4.0	3.7	3.0	

TABLE 6: OIL PRICE SHOCKS: CONTRASTING BASELINE AND ELSC POLICY 2040 OIL SHOCK

			2040	2041	2042	2043	2040–2043 Cumulative
World Oil Prices	Percent	Both	100.0	80.0	60.0	40.0	
GDP	Percent	Baseline	-3.4	-3.2	-1.4	-0.2	
		ESLC	-2.1	-1.5	-0.4	0.1	
	Bil 2008 $	Baseline	-1042.2	-998.1	-464.9	-54.0	-2559.3
		ESLC	-646.3	-488.7	-139.1	30.6	-1243.6
Real Disposable Income	Percent	Baseline	-5.0	-4.1	-2.2	-0.3	
		ESLC	-3.1	-1.9	-0.5	0.4	
	Bil 2008 $	Baseline	-1190.9	-1012.4	-558.7	-77.5	-2839.9
		ESLC	-742.9	-470.1	-137.4	115.9	-1234.5
Employment	Percent	Baseline	-2.6	-2.8	-1.2	0.1	
		ESLC	-1.6	-1.3	-0.2	0.4	
	Millions	Baseline	-4.7	-5.2	-2.3	0.1	
		ESLC	-2.9	-2.5	-0.3	0.8	
Consumer Prices	Percent	Baseline	4.0	3.7	3.2	2.5	
		ESLC	3.0	2.8	2.5	2.0	

VI. Modeling Assumptions

The Base Case ("Business as Usual")

The base case was developed to be consistent in a broad sense with the Department of Energy's *Annual Energy Outlook* 2008 (revised) base. In this scenario, real GDP growth averages 2.4 percent over the period 2008 to 2050. The average growth of the GDP deflator over this period is 2.1 percent, and the crude oil price grows 0.3 percent slower than this, for an average of 1.8 percent. This results in a light sulfur crude price of about $237 per barrel by 2050, or about $100 per barrel in constant 2008 dollars.

To replicate the macroeconomic growth and energy use indicated by the AEO forecast, the LIFT model was calibrated in terms of productivity and labor force trends, final demand projections, and input-output coefficients for transportation sectors. Personal consumption expenditures for gasoline were adjusted accordingly.

The model contains equations that translate the energy consumption in constant dollars to quadrillion British thermal units (BTUs) and million barrels per day. These are consistent with AEO 2008. Although the Inforum simulation does not match the AEO projection exactly, the results were quite close. The AEO baseline was extended to 2050, using standard Inforum assumptions on the growth in the labor force, labor productivity, input-output coefficients and other variables. Energy efficiency trends from the AEO were also extended to 2050.

The ESLC Policy Case

The ESLC policy case was developed starting with the extended AEO baseline. The base simulation was then used as a control against which the effects of the elements of the policy package could be evaluated, either individually or collectively. The following sections discuss how each major element of the package was modeled in the Inforum LIFT model.

Electrification of Transportation

The central feature of the ESLC report is a set of policies designed to encourage widespread electrification of U.S. short-haul ground transportation. Electrification improves energy security by replacing oil, whose price is highly volatile, with the diverse, largely domestic portfolio of fuels used to generate electricity in the United States. Electrification reduces overall oil consumption, reduces the cost of travel to consumers, and stimulates the development of a modern efficient electric grid.

In 2007, light-duty vehicles accounted for roughly 40 percent of total U.S. oil consumption, or about 8.3 million barrels per day (MB/D).[7] Over time, improvements in automotive fuel economy can improve the efficiency of these vehicles. For example, the 2007 Energy Independence and Security Act mandates a roughly 40 percent increase in fleetwide fuel economy by 2020. This is expected to reduce oil consumption from these vehicles by nearly 1.0 MB/D by 2020 and potentially higher amounts thereafter, depending on the aggressiveness of the rulemaking process.[8]

7 EIA, AEO (2008), online supplemental tables 1, 2, and 36
8 EIA, AEO (2007), Table A35; EIA, AEO (2008), Table A35; SAFE analysis

Ultimately, however, without access to a broader range of fuel sources, these vehicles will continue to rely heavily on petroleum for delivered energy. Today, the transportation sector is 97 percent reliant on petroleum-based fuels for energy. Biofuels have thus far served primarily as a blending component for gasoline, and at levels not exceeding 10 percent as of 2008. While there is certainly room for growth, biofuels would only provide an additional 1.5 MB/D of oil equivalent liquid fuels by 2022 based on the existing renewable fuels standard (RFS).

Electrification of transportation would allow light-duty vehicles to access the fuel diversity of the electric power sector. Delivered energy for cars and trucks would no longer be petroleum based. Instead, these vehicles would be powered by the same fuels and technologies that generate electricity in the United States: natural gas, nuclear, coal, hydro, wind, solar, and geothermal. Petroleum currently provides less than 2 percent of U.S. electricity generation.

ESLC policy recommendations regarding electrification of transportation were modeled as described below. All dollar figures are constant 2008 dollars unless otherwise noted:

RECOMMENDATION: Establish development of advanced battery technology as a top research priority and spend at least $500 million per year toward its development.

This recommendation was modeled as an increase of federal non-defense spending of $500 million in 2009, increasing linearly by $100 million per year through 2014 and remaining flat thereafter. The model assumes that, going forward, it will always be in the national interest to invest in efficient energy storage, just as we now invest in a range of technologies deemed vital to the U.S. economy.

RECOMMENDATION: Replace existing vehicle tax credits with new tax credits of up to $8,000 per vehicle for the first two million domestically produced highly-efficient vehicles.

This recommendation was modeled as a $3,500 credit on the first two million EV/PHEVs sold. After that, the market for electric vehicles is assumed to be strong enough to continue to develop without tax credits. The model does not apply the full $8,000 credit, because it assumes that the initial stock of electric vehicles available to consumers will not all qualify for the full credit due to initial battery constraints.

RECOMMENDATION: Provide grants to municipalities and tax credits to commercial developers to encourage the development of public charging stations.

This recommendation was modeled assuming one public charging station will be required for every 10 electric vehicles sold—at a cost of $1,000 per station. The investment was allocated evenly between three sectors: electric utilities, retail trade (service stations and shopping malls), and automotive services (parking garages and auto repair shops). The federal government is assumed to fully finance the first 1 million charging stations via tax credits and grants to municipalities. (Note: The model makes no assumption about battery exchange stations, which have been proposed as an alternative/supplement to public recharging infrastructure.)

RECOMMENDATION: Provide $30 billion in federal assistance for retooling of the domestic auto industry. These funds are targeted to stimulate the production of plug-in hybrids and other energy efficient vehicles.

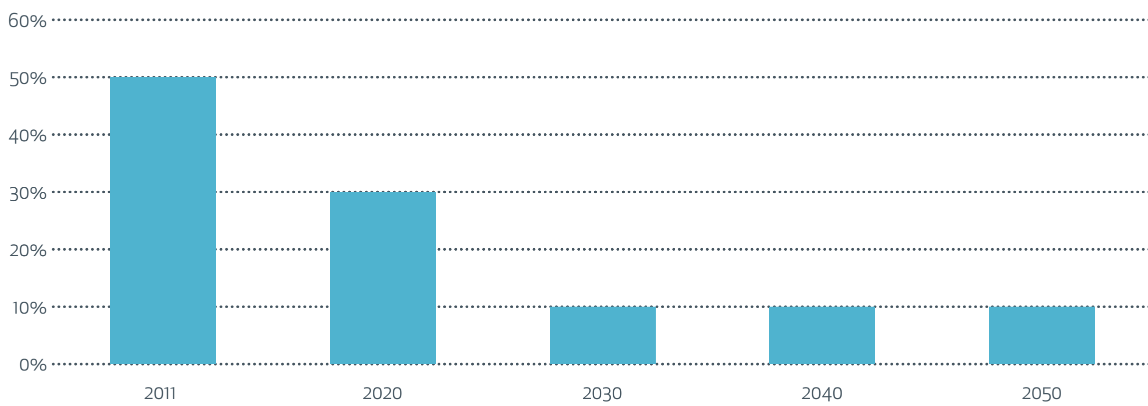
This recommendation was modeled as a direct federal subsidy to the motor vehicle industry from 2009 to 2014 at $5 billion per year. Investment by the motor vehicle industry is increased by an equal amount.

Table 7 shows the projection of electric vehicle (EV/PHEV) sales and stock—both in raw numbers and as a percentage of the total light-duty vehicle fleet—both in the base scenario and in the ESLC policy scenario. In the ESLC policy scenario, electric vehicles are projected to reach 70 percent of total passenger vehicle sales by 2030 and remain at that share through 2050.

TABLE 7: ELECTRIC VEHICLE SALES AND VEHICLE STOCK

		2010	2020	2030	2040	2050
EV/PHEV Sales (thous)	Base Case	–	236	402	802	1,217
	ESLC Policy Case	–	2,492	13,000	14,308	15,787
Share of New LDV	Base Case	0.0%	1.4%	2.2%	4.0%	5.5%
	ESLC Policy Case	0.0%	15.0%	70.0%	70.0%	70.0%
EV/PHEV Stock (thous)	Base Case	–	928	3,022	6,251	11,209
	ESLC Policy Case	–	11,623	77,263	145,864	166,977
Share of LDV Stock	Base Case	0.0%	0.4%	1.1%	2.0%	3.3%
	ESLC Policy Case	0.0%	4.3%	25.5%	45.4%	52.7%

FIGURE 8: PERCENTAGE OF ELECTRIC VEHICLE MILES FUELED BY GASOLINE IN THE ESLC POLICY CASE



The model assumes 12,000 miles traveled per vehicle annually, held constant over time. It assumes that vehicles powered by electricity will consume electricity at the rate of 3 miles per kilowatt hour (kWh) for all vehicle-miles-travelled fueled by electricity, again held constant over time. For plug-in hybrids—which retain use of an onboard liquid fuel generator for extended range—the model assumes that for those miles per gallon of those miles powered by gasoline or other liquid fuels, the vehicle would achieve 10 percent higher fuel efficiency than conventional internal combustion engine (ICE) vehicles.

The model also assumes that initially, 50 percent of the electric vehicle-miles-travelled will be fueled by gasoline. Over time, the proportion falls as battery size increases, public recharging becomes more accessible, and fully electric vehicles enter the market in greater numbers (See Figure 8).

These assumptions, combined with the sweeping changes in the composition of the vehicle fleet, imply much higher average miles traveled per gallon of liquid fuel used. Table 8 shows the changes in total liquid motor fuel consumption (billions of gallons of gasoline equivalent) and electric vehicle electricity consumption in the base case and the ESLC policy scenario.

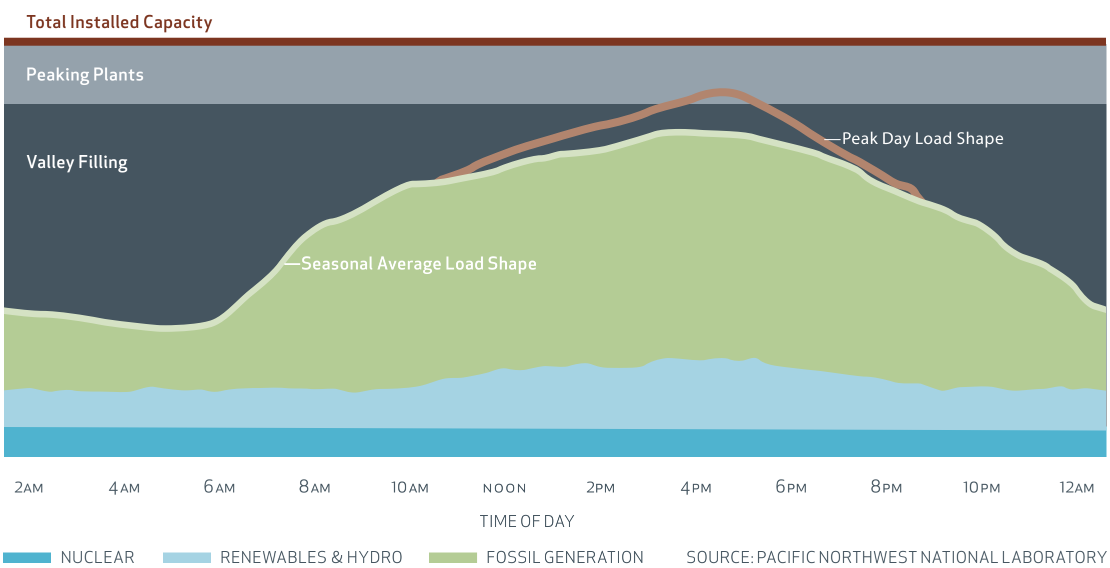
TABLE 8: MOTOR FUEL AND EV/PHEV ELECTRICITY CONSUMPTION

		2010	2020	2030	2040	2050
Motor Fuel Consumption (billion gal)	Base Case	128.5	125.8	125.3	127.2	133.1
	ESLC Policy Case	128.5	113.7	86.9	63.8	51.8
EV/PHEV Electricity Consumption (billion kWh)	Base Case	–	2.6	10.9	22.5	40.4
	ESLC Policy Case	–	32.5	278.1	525.1	601.1

Enhancing the Nation's Electrical System

The enhancement of the electric power sector is a key component of the ESLC plan. The pace of electrification envisioned by the ESLC will entail significant additional electric power generation, reaching 278 billion kWh by 2030. As noted in the *National Strategy* report, it is possible that policies such as time-of-day pricing could be employed to promote off-peak charging.[9] During off-peak hours, substantial spare capacity exists in the nation's electric power generation sector. (See Figure 9). By charging electric vehicles during these times, the need to construct additional infrastructure would be minimized, as would upward pressure on electric power prices.

FIGURE 9: STYLIZED LOAD SHAPE FOR 1 DAY DURING PEAK SEASON, GENERATION DISPATCH, AND INSTALLED CAPACITY



In the short and medium term, sizeable challenges exist with regard to deploying the technology and infrastructure required for time-of-day (TOD) pricing and, ultimately, a smart grid. As a result, it is likely that many EV/PHEV drivers will choose to charge during the daytime. Moreover, even in the event that TOD pricing is successfully implemented, many drivers will still prefer to charge vehicles during peak hours. In part, this will result from the fact that the price differential between gasoline and electricity—even highly priced electricity—is likely to strongly favor electricity.

Perhaps more fundamentally, the ESLC's policies will help ensure that the nation meets anticipated growth in electricity demand over the coming decades—above and beyond that

9 Energy Security Leadership Council, *A National Strategy for Energy Security*, 36.

which would result from electrification of transportation. In its recently released AEO 2009, the Department of Energy has forecast a 22 percent increase in electricity demand between 2008 and 2030 based on the expected rate of economic growth.[10] Given concerns regarding greenhouse gas emissions, energy security, and the economy, it is increasingly important that today's investment in the grid be conceived as part of a long-term strategy to build a robust and resilient electric power system.

Therefore, the ESLC report proposed a number of policies for increasing power generation capacity, expanding transmission capacity, and modernizing the management of the overall electrical grid. ESLC recommendations regarding enhancing the nation's electrical system were modeled as described below:

RECOMMENDATION: Remove regulatory hurdles to building new transmission lines, by improving the planning, approval and siting process; and require the Federal Energy Regulatory Commission to approve enhanced rates of return on investments to modernize the electrical grid system.

This was modeled as an additional $8 billion of investment by electric utilities in 2009, followed by $10 billion per year thereafter. Additional investments required in the electric utility sector result in marginally higher system-wide electricity prices. Electricity prices are 13 percent higher than the base by 2050, although aggregate energy costs for the average American family are still reduced, compared to the base.

RECOMMENDATION: Extend the deadline and increase funding levels for loan guarantees for new nuclear generation.

This was modeled essentially as the lifting of a political constraint on nuclear generation. In the ESLC policy case, the loan guarantee program is extended to at least 2011 and the cap is raised to $30 billion. This is sufficient funding for at least four—and perhaps as many as six—new nuclear power plants.

RECOMMENDATION: Significantly increase investment in advanced coal R&D, including development for carbon capture and storage technology, and increase funding for loan guarantees for advanced coal generation.

These two proposals were modeled first as part of the increase in overall R&D expenditures in the ESLC plan, which is discussed in greater detail below. They were also modeled as a constraint on the deployment of new coal-fired generation, which is assumed to be 100 percent integrated gasification combined cycle (IGCC) and carbon-capture-ready in the ESLC policy case. The additional investment required for IGCC relative to conventional coal-fired generation was assumed to be at 30 percent.[11] According to the International Energy Agency, IGCC coal generation has the potential to achieve efficiency gains beyond those of advanced pulverized coal technologies, including supercritical and ultra-supercritical generation.[12]

RECOMMENDATION: Reform and extend the production tax credit (PTC) and the investment tax credit (ITC) through 2013.

This was modeled as a 2.1 cent-per-kWh credit (rising with inflation) until 2020, at which point renewables are assumed to be cost-competitive.

10 U.S. Department of Energy, *Annual Energy Outlook 2009*, Supplemental Table 85

11 Based on data from: United Nations Intergovernmental Panel on Climate Change, *Carbon Capture and Storage* (2007)

12 International Energy Agency, *Clean Coal Technologies: Accelerating Commercial and Policy Drivers for Deployment* (2008)

In the base, overall nuclear production is projected to remain flat, implying a steadily decreasing share of total power generation. In the ESLC policy scenario, production climbs to 2,043 billion kWh by 2050, more than double the production level in the base case.

By 2050, coal generation is lower in the ESLC policy case due in large part to two factors. First, the incremental capital constraints and higher cost of power associated with IGCC coal act as a moderating factor, as do the costs of carbon capture and sequestration Second, the increase in nuclear power as an alternative source of baseload power generation offsets the need for new coal generation in much of the country.

FIGURE 10: U.S. ELECTRIC POWER GENERATION—2030

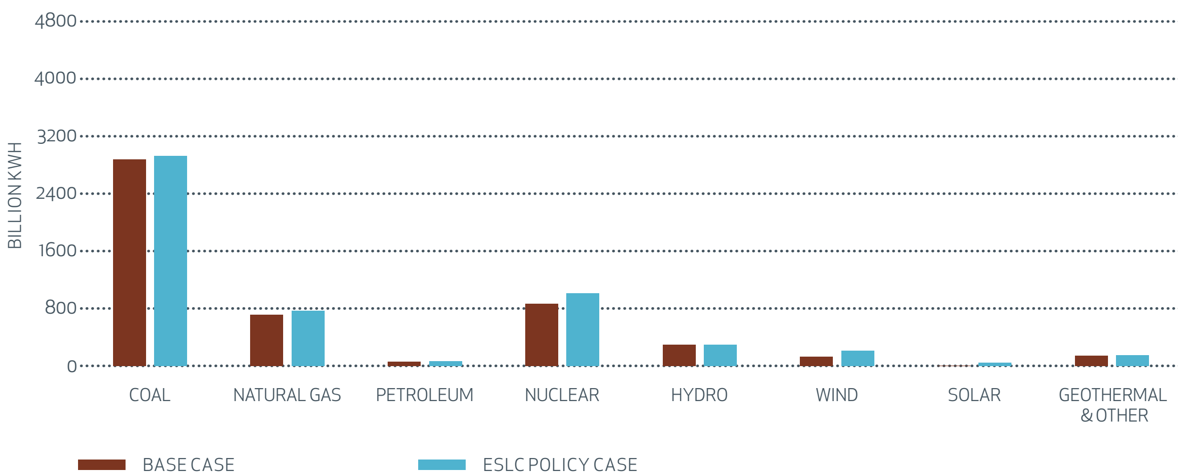
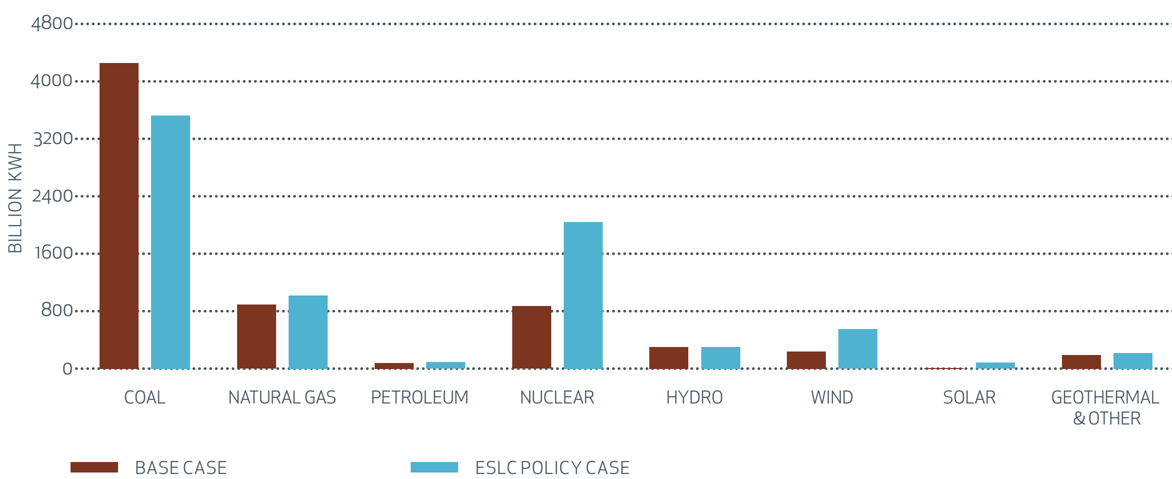


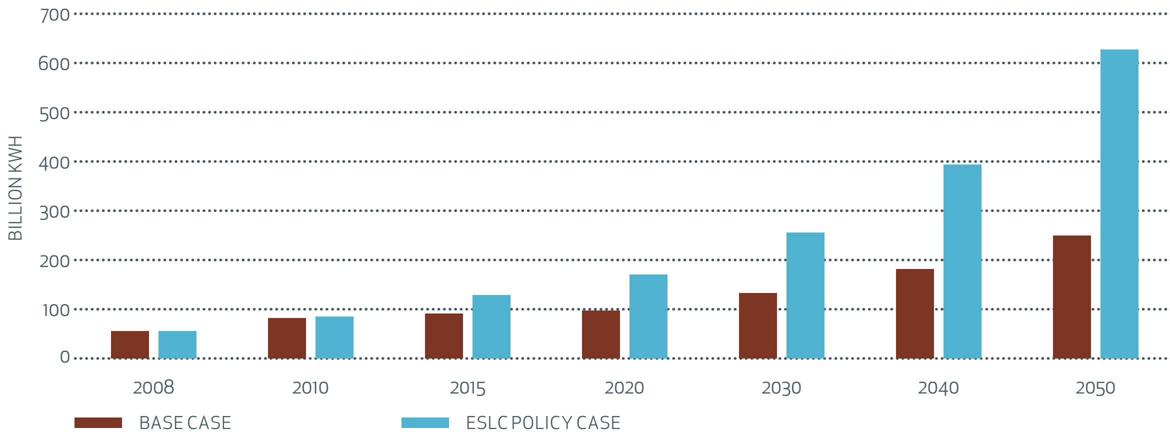
FIGURE 11: U.S. ELECTRIC POWER GENERATION—2050



Regarding renewables, solar generating capacity is expected to remain a miniscule portion of total electric power capacity in the base case, about 0.1 percent of the total. The ESLC policy scenario envisions an 8-fold increase in solar production and capacity over the base case, reaching a total production level of 80.7 billion kWh by 2050, or about 1 percent of total electricity generation.

Wind generation is expected to increase significantly in the base case, from a current level of under 100 billion kWh to 239.1 billion kWh hours in 2050. The ESLC policy case envisions that with the proper policy stimulus, this development can be accelerated to reach a total level of 546.6 billion kWh by 2050, or 7 percent of total production.

FIGURE 12: AGGREGATE WIND AND SOLAR POWER GENERATION



Reforming the Biofuels Program

Biofuels are an important component of the ESLC policy package: they provide a reduction in oil imports, a stimulus to the domestic agricultural sector, and potentially help to improve carbon emissions if a significant level of cellulosic ethanol capacity can be developed at reasonable cost.

It is important to note that the most notable aspect of the ESLC policy package with regard to biofuels is reform, as opposed to expansion, of the existing program. By 2050, total biofuels production reaches 42.8 billion gallons annually, a 19 percent gain over the existing RFS mandate of 36 billion gallons in 2022.

In the base case, the model projects that biofuels production will consist largely of corn ethanol, which reaches its RFS maximum of 15 billion gallons by 2020. Cellulosic ethanol reaches 7.7 billion gallons, and there are low levels of production of biodiesel and other advanced biofuels.

ESLC policy recommendations regarding reforming the biofuels program were modeled as described below. All dollar figures are constant 2008 dollars unless otherwise noted:

RECOMMENDATION: Accelerate Department of Energy and Environmental Protection Agency testing and performance validation of unmodified gasoline engines running on intermediate-level first- and second-generation biofuels.

Because it does not support the construction of a national alcohol-fuel-based infrastructure, the ESLC has recommended that certification of ethanol blends beyond 10 percent (E15 and possibly E20) be accelerated as long as federal government research shows this that such blends will not damage vehicles or fueling infrastructure.

This was incorporated into the modeling by assuming that ethanol production is not stalled by the 'blend wall' in the ESLC policy case. Indeed, unless significant infrastructural and policy changes are made, the production level of domestic ethanol will exceed that which can be blended into gasoline as early as 2010, and probably not later than 2013.

RECOMMENDATION: Require increased production of flex-fuel vehicles (FFVs).

This was modeled as a 10 percent increase in the portion of new vehicle sales that are FFVs until 100 percent of new light-duty vehicles are flex fuel in the ESLC policy case. This includes PHEV backup engines. The incremental cost per vehicle for FFV components was assumed to be $100.

RECOMMENDATION: Shift the focus of biofuels deployment by concentrating R&D and commercialization efforts on next generation biofuels.

This recommendation was modeled as part of the overall increase in federal spending on R&D discussed in greater detail below. In the ESLC policy case, the effect of greater R&D expenditures on advanced biofuels was assumed to be increased deployment of cellulosic and other advanced biofuels.

In the ESLC policy case, cellulosic ethanol production is accelerated. In fact, cellulosic ethanol production is assumed to grow fast enough to replace some corn ethanol, thereby freeing up more corn for agricultural feed and consumption—both domestic and for export. Advanced biofuels and biodiesel also grow more rapidly in the ESLC case. Total biofuels production by 2050 reaches 42.8 billion gallons in the ESLC case, compared to 24.2 billion gallons in the base.

TABLE 9: BIOFUELS PRODUCTION (BILLION GALLONS)

		2010	2020	2030	2040	2050
Corn	Base Case	12.0	15.0	15.0	15.0	15.0
	ESLC Policy Case	12.0	15.0	12.3	9.5	7.4
Cellulosic	Base Case	0.1	5.4	7.7	7.7	7.7
	ESLC Policy Case	0.1	10.5	18.7	22.9	27.9
Biodiesel	Base Case	0.7	1.3	1.3	1.3	1.3
	ESLC Policy Case	0.7	1.3	1.7	2.0	2.3
Other Advanced	Base Case	–	0.2	0.3	0.3	0.3
	ESLC Policy Case	0.2	3.3	3.9	4.6	5.3
Total	Base Case	12.8	21.8	24.2	24.2	24.2
	ESLC Policy Case	13.0	30.0	36.6	38.9	42.8

Expanding Domestic Supply of Oil and Natural Gas

The ESLC plan includes policies designed to stimulate a substantial increase in the domestic production of oil and gas. Chiefly, these policies relate to reforming regulations related to development in certain geographic areas. For example, at the time the ESLC report was finalized (September 2008), long-standing Congressional moratoria restricted access to approximately 85 percent of the Outer Continental Shelf (OCS) acreage in the contiguous United States.[13] Additional provisions restricted access to areas in Alaska, including the 1002 Area of the Arctic National Wildlife Refuge (ANWR).

In the base case, no new production occurs from areas previously held off limits. These include: the Eastern Gulf planning area, the entire Atlantic coast, and the entire Pacific coast. As a result, domestic oil production—including natural gas liquids—plateaus at roughly 2020 levels throughout the projection period.

13 After the ESLC report was finalized, Congress allowed the remaining OCS moratoria to expire as part of the Continuing Resolution that extended budget authority through March 2009. However, as of the release of this report, no clear legal structure exists with regard to the OCS, and a number of issues remain outstanding on which Congress and the Administration are expected to signal intent.

ESLC policy recommendations regarding expanded access to domestic oil and gas resources were modeled as described below. All dollar figures are constant 2008 dollars unless otherwise noted:

RECOMMENDATION: Increase access to U.S. oil and gas reserves on the Federal Outer Continental Shelf.

This recommendation was modeled as an increase in domestic oil production consistent with the ESLC's OCS production profile. For its OCS scenario, the ESLC considered the UK offshore production profile as a proxy development path for expanded OCS production. The UK's offshore geography includes environmentally sensitive shallow water coastal projects (like Poole Harbor) as well as technologically complex deepwater offshore projects in the North Sea.

In 1987 the UK had 5.2 billion barrels of proved reserves. Between 1987 and 1997, however, the UK produced roughly 9 billion barrels of oil. Moreover, the UK still had 5.2 billion barrels of proved reserves in 1997 due to additional exploration and technological improvement. Furthermore, while UK production began to decline after 15 years, rising prices and new technology enabled a second peak and extended the UK's lifetime as an oil producer by 20 years.

Such a scenario is easily imaginable for the OCS as well. The ESLC production profile peaks first in 2023 and again in 2037. Both peaks are roughly 1.4 MB/D of incremental OCS production from the Eastern Gulf of Mexico, the Atlantic coast, and the Pacific coast.

RECOMMENDATION: Increase access to U.S. resources in the Arctic and Alaska.

This recommendation was modeled as an increase in oil production consistent with access to estimated resources in the 1002 Area of ANWR. The underlying fundamentals for the ESLC's Alaska production trajectory were taken from a May 2008 study produced by the Energy Information Administration (EIA).[14] The production profile assumed the United States Geological Survey (USGS) mean estimate for federal, state and native lands in 1002.

The EIA production profile peaks at 780,000 barrels per day in 2027. The post-peak decline rate is assumed at 9 percent annually, which is generally consistent with the mid-range for mature large fields as reported by the International Energy Agency.[15]

RECOMMENDATION: Target federal policy and resources to encourage the expanded use of carbon dioxide for enhanced oil recovery.

This recommendation was modeled as an increase in domestic oil production from enhanced oil recovery consistent with the ESLC's EOR production profile. The ESLC scenario assumed that dwindling access to new domestic conventional resources and oil prices averaging $100/BBL throughout the projection period would provide ample financial incentive for miscible CO_2 EOR.

The incentive is not, however, limitless. Logistical and financial constraints of CO_2 access, competition from deep saline reservoirs, and oilfield geology ultimately constrain CO_2 EOR. Therefore, production plateaus in later years, asymptotic to 1.4 MB/D in the ESLC case.

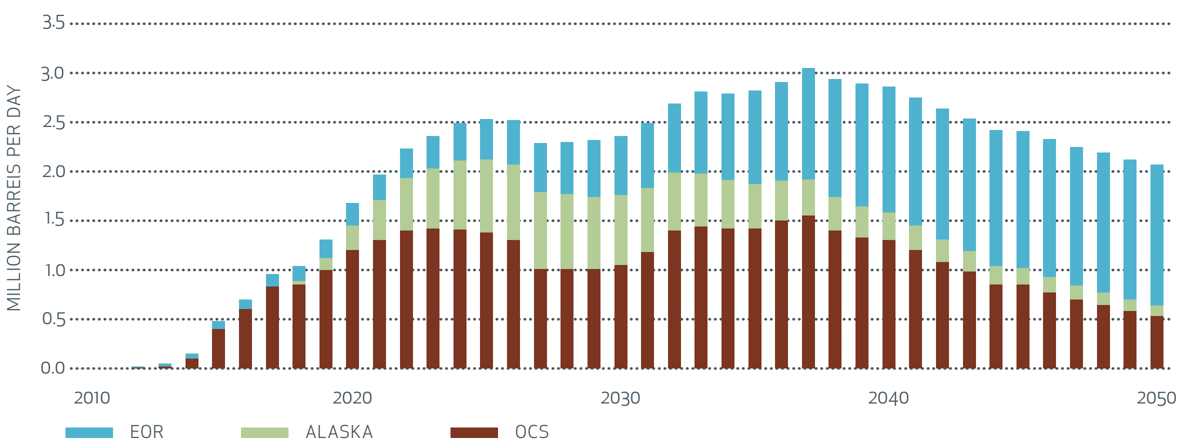
14 Energy Information Administration, *Analysis of Crude Oil Production in the Arctic National Wildlife Refuge* (May 2008)
15 International Energy Agency, *World Energy Outlook 2008* (November 2008)

The total expansion of oil production capacity in the ESLC policy case is projected to be about 2.36 MB/D in 2030 and 2.07 MB/D in 2050, with higher peaks in interim years (see Figure 13).[16] In addition to other benefits, this expansion of production capacity provides additional revenue to the federal government in the form of royalties, lease rents, and bonuses. Based on a review of existing literature regarding provisions similar to those proposed by the ESLC, the model assumes an additional $250 billion in federal revenues over the course of the production period 2010 to 2050.

TABLE 10: ESLC POLICY CASE—DOMESTIC OIL PRODUCTION

Enhanced Oil Production Policy Element	Projected Increase in Oil Production (mb/d)	
	2030	2050
Arctic and Alaska	0.71	0.11
Enhanced Oil Recovery (EOR)	0.60	1.43
Outer Continental Shelf (OCS)	1.05	0.53
Total	**2.36**	**2.07**

FIGURE 13: INCREMENTAL OIL PRODUCTION IN THE ESLC POLICY CASE



Accelerating the Development and Deployment of New Energy-Related Technology

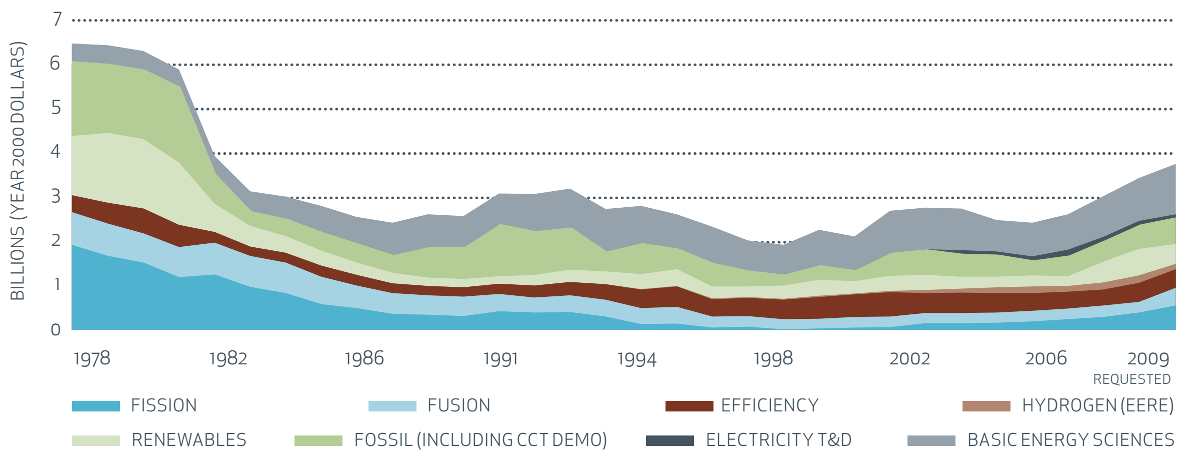
The ESLC plan includes policies designed to reform and increase public spending on research, development and deployment in the United States. The ESLC *National Strategy* notes that a robustly funded federal program of R&D will likely be necessary to accelerate the development and deployment of new energy-related technologies.

Indeed, greatly expanded public spending on research, development, deployment and commercialization is a critical component for many of the ESLC proposals outlined above. The market success of technologies such as carbon capture and storage for fossil-fuel combustion power generation, widespread deployment of plug-in hybrid vehicles, and concentrated solar-thermal power generation will depend on a confluence of factors, but surely research and development will play a crucial role.

16 It should be noted that the ESLC also envisions increases in natural gas production due to its policy proposals. Those increases are captured to some extent in the LIFT model, but the model's sensitivity to changes in oil consumption/production is much greater. Therefore, attention here is focused largely on liquid fuels. At a minimum, the incremental natural gas production envisioned by the ESLC proposal would result in downward pressure on natural gas prices and ultimately electric power prices. It would also increase federal royalties.

Today, the United States ranks 22nd among developed nations in the fraction of GDP that is devoted to non-defense research.[17] Shortly after the energy crisis of 1973, U.S. energy R&D soared from $2 billion annually to more than $14 billion, with public-sector investment peaking at just over $6 billion and private-sector investment topping out at more than $5 billion. By 2004, private-sector energy R&D funding was below $2 billion and government funding had dropped to roughly $3 billion (see Figure 14).

FIGURE 14: U.S. DOE BUDGET AUTHORITY FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION (HISTORICAL)



In the base case, public investment in R&D does not increase substantially from current levels. For the ESLC policy case, the central component of the ESLC plan was incorporated as follows. All dollar figures are constant 2008 dollars unless otherwise noted:

> **RECOMMENDATION:** Annual public investment in energy R&D should be increased roughly 10 times, to approximately $30 billion.
>
> This was modeled as an increase in federal non-defense spending starting at $6 billion in 2009, and ramping up to $30 billion by 2015, and remaining at that level thereafter.

Improving Efficiency

The 2007 Energy Independence and Security Act mandated a roughly 40 percent increase in light duty fleetwide fuel-economy standards to 35 miles per gallon by 2020. Beyond 2020, the improvements annual improvements are required to be implemented at the "maximum feasible rate." The LIFT base case incorporates AEO 2008 assumptions regarding the implementation of fuel-economy standards.

The 2007 energy bill also included the issuance of fuel-economy standards for medium- and heavy-duty trucks for the first time in U.S. history. This structural reform is of great importance for reducing fuel demand in the transportation sector, because medium- and heavy-duty trucks account for nearly one-fifth of transportation fuel demand. However, the legislation did not set specific standards for these vehicles as it did for cars and light trucks. Instead, the bill left the National Highway Traffic Safety Administration with statutory authority for setting the medium- and heavy-duty fuel-economy standard as part of its rule-making process.

17 Norman R. Augustine, *Is America Falling off the Flat Earth?* (Washington, D.C.: National Academies Press, 2007), 55.

The following ESLC policy recommendation regarding improving efficiency was modeled:

RECOMMENDATION: Aggressively implement fuel-economy standards for medium- and heavy-duty vehicles.

Truck fuel efficiency in the current Annual Energy Outlook (and the LIFT base case) grows at about 0.5 percent per year. In the ESLC policy case, the model projects new medium- and heavy-duty truck fuel economy to accelerate to 4 percent per year through 2030, with much lower annual improvements thereafter.

New medium- and heavy-duty fuel truck economy only reaches 7.6 MPG (gasoline equivalent) by 2050 in the base case, while it climbs to 19 MPG in the ESLC case. Because of the lag in replacement of old trucks with new models, the stock MPG grows more slowly, but reaches a respectable 17.3 gallons in the ESLC case. This results in a savings of 35 billion gallons of fuel by 2050, an improvement of more than 50 percent.

TABLE 11: TRUCK FUEL EFFICIENCY

		2010	2020	2030	2040	2050
New Truck MPG	Base Case	6.0	6.5	6.8	7.2	7.6
	ESLC Policy Case	6.0	7.7	11.0	15.0	19.0
Truck Stock MPG	Base Case	6.0	6.3	6.7	7.0	7.4
	ESLC Policy Case	6.0	6.6	9.5	13.2	17.3
Fuel Consumption (Billion Gal)	Base Case	41.6	47.8	53.1	58.3	62.3
	ESLC Policy Case	41.8	45.9	37.7	31.5	27.2

VII. Macroeconomic & Energy Accounting Summary

APPENDIX A-1 (For each quantity, the second line represents the ESLC case in absolute difference from the baseline figures displayed in the first line.)

		2010	2015	2020	2030	2040	2050	08-30	08-50
GDP & Components (Billions of 2008$)	Gross Domestic Product	15116.6	17548.4	19587.7	24768.6	30903.7	38207.4	2.5	2.3
		86.1	144.9	215.5	247.5	335.6	671.8	0.1	0.1
Components of Real Gross Domestic Product	Personal Consumption	10850.6	12517.4	14049.5	17449.0	21793.7	27916.4	2.4	2.4
		36.2	53.2	83.8	92.7	200.2	401.5	0.0	0.0
	Non-oil Consumption	10547.2	12201.4	13731.2	17111.5	21429.1	27510.4	2.4	2.4
		64.8	95.8	142.4	206.9	370.3	619.1	0.1	0.1
	Gross Private Fixed Investment	2265.4	2772.2	2957.6	3746.9	4469.7	5523.6	2.5	2.3
		39.9	85.6	106.4	146.7	105.6	153.6	0.4	0.2
	Government Spending	2838.5	2967.5	3134.3	3568.5	4090.1	4763.7	1.1	1.3
		0.1	-4.6	-4.8	-13.1	1.2	18.0	-0.0	0.0
	Exports	2102.5	2970.5	4049.1	7108.1	11038.9	15990.4	6.4	5.3
		-3.8	-22.2	-43.5	-138.5	-229.7	-110.5	-0.1	-0.0
	Imports	2891.9	3612.1	4518.6	6883.4	10062.9	15719.5	4.4	4.3
		26.3	13.6	-17.0	-55.5	-82.2	59.2	-0.0	0.0
Price Indices	GDP Chain Price Index	1.29	1.42	1.55	1.88	2.32	2.92	1.9	2.1
		-0.0	0.01	0.02	0.04	0.05	0.03	0.1	0.0
	Import Price Index	1.33	1.41	1.51	1.71	1.93	2.16	1.2	1.2
		-0.0	-0.01	-0.01	-0.01	-0.02	-0.03	-0.0	-0.0
	Consumer Price Index	1.29	1.42	1.55	1.85	2.26	2.78	1.8	1.9
		-0.0	0.01	0.02	0.03	0.04	0.03	0.1	0.0
Oil Prices	Nominal	104.23	114.08	124.75	151.62	187.79	237.76	1.4	1.8
		-1.48	-4.50	-6.97	-14.63	-22.48	-32.50	-0.4	-0.3
	Real (2008$)	99.76	99.11	98.99	99.42	99.90	100.39	-0.5	-0.3
		-1.31	-4.59	-6.77	-11.49	-13.71	-14.58	-0.5	-0.4
	Real Disposable Personal Income	11255	13190	14806	19000	23988	30806	2.6	2.5
		65	188	253	300	399	657	0.1	0.1
	Trade Balance	-799	-764	-754	-397	226	-598	-3.6	-0.9
		-22	6	65	153	243	283	-2.1	-1.5
	Federal Deficit/ Surplus	-208	53	63	22	177	907	-0.0	-0.0
		25	19	20	43	8	168	0.0	0.0
Unemployment Rate		6.1	4.2	4.7	5.6	5.7	4.5	0.4	-0.3
		-0.6	-0.9	-1.0	-0.6	-0.0	-0.1	-0.9	-0.2
Total Employment MANUFACTURING EMPLOYMENT	Motor Vehicles Employment	485.2	523.8	479.4	429.1	391.6	354.4	-0.4	-0.7
		1.9	1.1	9.1	-2.7	-4.8	-1.7	-0.0	-0.0
	Motor Vehicle Parts Employment	308.2	253.7	179.7	94.4	51.4	22.5	-5.6	-6.2
		-1.2	-4.3	0.6	-0.5	0.6	3.1	-0.0	0.3
	Electric Motors, Batteries, Electronic	529.6	359.2	261.1	204.8	143.9	74.7	-5.3	-5.1
		12.5	61.3	89.6	97.2	82.1	42.5	1.7	1.0
	Engines and Turbines	72.4	67.8	58.1	40.9	29.0	22.9	-2.7	-2.8
		0.2	0.6	0.7	0.8	0.7	0.2	0.1	0.0
	Other instruments	275.2	293.0	284.0	271.9	265.8	258.6	0.3	0.0
		4.3	7.8	7.6	3.1	-2.3	-3.6	0.1	-0.0
	Plastic Products	601.5	567.3	494.4	388.0	313.3	230.9	-2.2	-2.4
		4.1	9.0	10.1	8.4	3.8	4.4	0.1	0.0
Total Employment PROFESSIONAL SERVICES		5945.9	6203.7	6299.0	6754.6	7339.0	8304.8	0.6	0.8
		53.8	108.0	122.9	115.4	72.5	107.9	0.1	0.0
Total Employment AGRICULTURAL EMPLOYMENT		3864.8	3881.4	3737.0	3362.9	3063.3	2869.5	-0.6	-0.7
		12.0	29.2	37.4	28.5	22.8	43.6	0.0	0.0
Total Employment TRAVEL & TOURISM*		15994.4	17378.5	18336.8	19684.1	20898.2	22490.5	1.0	0.9
		87.3	134.7	172.7	199.9	298.7	514.7	0.0	0.1

* Travel & Tourism Industry includes Air Transportation (62), Eating & Drinking places (71), Hotels (75) and Movies and Amusements (82).

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1111 19th Street, NW, Suite 406 | Washington, DC 20036
T 202-461-2360 | W SecureEnergy.org