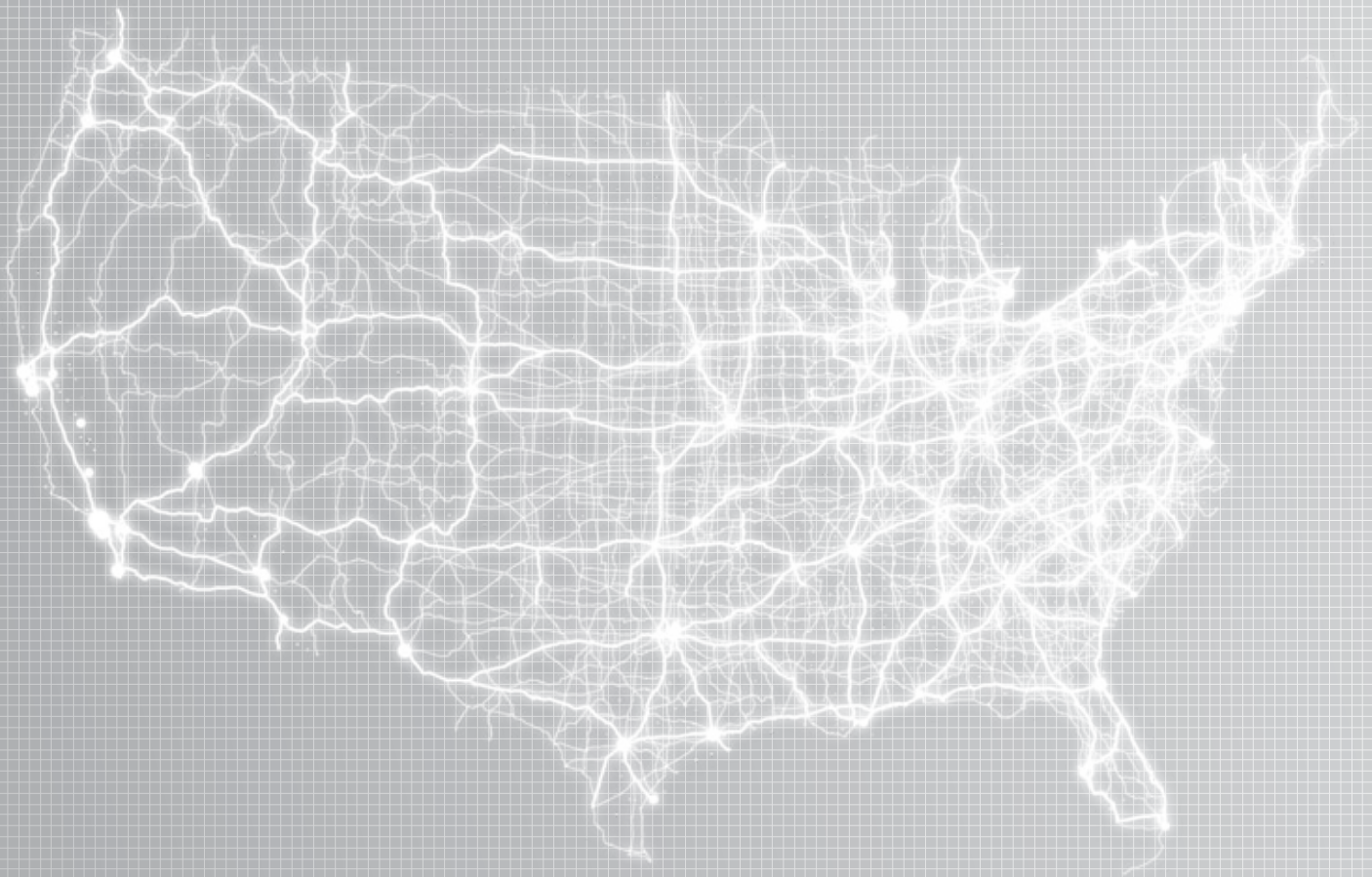


# Economic Impact of the *Electrification Roadmap*

APRIL 2010



A STUDY COMMISSIONED BY THE



Electrification  
Coalition

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## 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 macro-economic impact of policies designed to transform the U.S. light-duty vehicle fleet from one fueled by petroleum to one powered largely by electricity. This study was commissioned by the Electrification Coalition (EC) and reflects the policy proposals detailed in the Coalition's *Electrification Roadmap*, released in November 2009.

The *Roadmap* targets a transition to electric vehicles until, by 2040, 75 percent of U.S. passenger vehicle miles traveled would be 'electric miles.' The sharp reduction in petroleum consumption associated with such a shift would strengthen the overall economy and reduce U.S. vulnerability to the increasingly serious volatility of the global oil market.

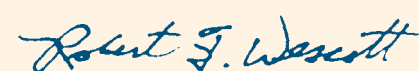
To facilitate this transition, the Roadmap identifies a number of public policies necessary to support the development of a robust electric vehicle marketplace, including early government financial incentives for consumers, automakers, infrastructure providers, and utilities. The central policy proposal outlined in the Roadmap is a government-funded program managed by the Department of Energy through which public sector spending would be targeted in a finite number of geographic areas, or clusters, deemed "electrification ecosystems."

By focusing its efforts in limited regions, the federal government would leverage public spending to drive dense concentrations of infrastructure, vehicles, and IT network support into electrification ecosystems. A handful of concentrated deployments between 2010 and 2020 could demonstrate the viability of electrified transport to consumers while also driving scale in infrastructure and vehicle manufacturing and facilitating important data aggregation. The *Roadmap* concludes that this cluster approach would lay the groundwork for widespread adoption of grid-enabled vehicles beyond 2020, when the primary obstacles to high rates of penetration would be the size and slow turnover rate of the U.S. light-duty vehicle fleet.

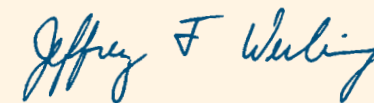
The University of Maryland/Keybridge Research modeling team collectively has many decades of experience building and performing simulation studies with large-scale econometric models and conducting public policy research on energy and macroeconomic issues. This study relies upon a comprehensive simulation 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 a baseline scenario over the period 2009 to 2030 that was generally consistent with the forecast contained in the Department of Energy's Revised *Annual Energy Outlook* 2009. A second scenario for the same time period was then developed incorporating central components of the *Electrification Roadmap*. 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, employment, and income that result from the Electrification Coalition policy package.

The study finds that, if implemented today, the Electrification Coalition policy package would result in a wide range of beneficial impacts to the U.S. economy between now and 2030. With reduced oil intensity, household income and employment will be higher and the U.S. trade deficit will be smaller. After including outlays for subsidies and other measures to implement these policies, the U.S. federal budget balance is expected to improve due to increased economic activity and income levels. 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 contributed to recessions in 1973-74, 1980-81, 1991, 2000-01 and 2007-09. That is, the policy 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.



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## I. Executive Summary

In order to conduct this study, the University of Maryland Inforum LIFT model was used to perform a detailed examination of the Electrification Coalition (EC) recommendations as proposed in the November 2009 *Electrification Roadmap*. The Inforum LIFT model is an extremely detailed economic forecasting model, which captures, among other things, 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) with macroeconomic aggregates (such as GDP, consumption, employment and the trade balance).

The *Electrification Roadmap* targets reductions in liquid fuel demand through large-scale electrification of the light-duty vehicle fleet, which currently accounts for roughly 60 percent of U.S. transportation oil demand.<sup>1</sup> The report identifies key challenges to the deployment of electric vehicles, such as high battery costs and a lack of publicly available refueling infrastructure, and recommends policies to overcome these challenges. The central policy initiative proposed in the *Roadmap* is a federal government-managed program designed to drive high concentrations of electric vehicles, refueling infrastructure, and supporting IT networks in a limited number of geographic areas called ‘electrification ecosystems.’ Ecosystems are essentially large-scale projects designed to overcome early obstacles to commercialization of electric vehicle technology—such as high battery costs and underdeveloped infrastructure—and to learn how to refine future deployments in new communities.

The modeling exercise was developed by beginning with a ‘business-as-usual’ baseline outlook for the U.S. economy, referred to in this paper as the base case. The base case was then used as a control against which the effects of the various elements of the *Roadmap* policy package were evaluated. This comparative simulation was carried out over the period 2010 to 2030. For the purposes of this modeling exercise, the primary measurable components of the EC policy initiatives are:

- › Targeted incentives for the purchase of electric vehicles and plug-in hybrid electric vehicles in electrification ecosystems;
- › Targeted incentives for the deployment of charging infrastructure in electrification ecosystems;
- › Targeted incentives for utility IT upgrades needed to support electrified transportation in electrification ecosystems;
- › Incentives for accelerated domestic production and purchase of batteries for electric vehicles; and,
- › Government financial support for automakers to retool and re-equip automotive production facilities needed to manufacture electric vehicles.

The EC policy package results in significant economic benefits for the United States over the simulation period. In general, these benefits are derived from policy incentives that replace internal

<sup>1</sup> U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2010*, Table A7

combustion engine vehicles with vehicles that derive their energy from the electric power sector. This gradual shift results in decreased oil consumption (and therefore oil imports) as well as increased domestic production of vehicles, batteries, and other electrical components. Our main findings are:

#### › Employment

By 2030, total employment would increase by 1.9 million jobs. Among the interesting industry effects: by 2030 there would be 560,000 more manufacturing jobs, 276,000 more jobs in travel and tourism, and 73,000 more jobs in professional services. Employment in the motor vehicle industry (including motor vehicle parts) would be about 106,000 jobs higher than the base. Employment in the industries that supply key electric and electronic components to electric vehicles would increase by 112,000 jobs.

#### › Federal Revenues

Over time, the federal budget deficit would improve as a result of the policies in the *Roadmap*. Because of the higher levels of income and GDP resulting from the policies, the U.S. federal budget deficit would improve by a cumulative (2010 to 2030) \$336 billion, net of policy costs.

#### › Annual Household Income

By 2030, the typical U.S. household's annual income would rise by \$2,763 (2008 dollars). This represents an increase of about 2.2 percent.

#### › Cumulative Household Income

Cumulatively, during the 2010-2030 period, households would experience an increase of \$4.6 trillion (2008 dollars) in aggregate income—money that can be saved or spent on other goods and services.

#### › Transportation Costs

By 2030, the typical U.S. household would spend less per year directly on energy for transportation. The combination of higher income and less spending on energy means that the typical household would be able to enjoy about \$3,687 (2008 dollars) more in consumption of goods and services (or personal savings).

#### › Oil Imports

U.S. crude oil and petroleum product imports would fall sharply, by 3.2 million barrels per day by 2030. Cumulatively, between 2010 and 2030, the United States would import nearly 11.9 billion fewer barrels of foreign oil. This compares to estimated reserves of 4.3 billion barrels for Prudhoe Bay, and slightly less than 30 billion barrels for total U.S. proved reserves.

#### › Trade Deficit

By 2030, the U.S. trade balance would improve by about \$127 billion dollars (2008 dollars).

#### › Global Demand for Oil

World demand for oil would fall, leading to lower world oil prices. Outside commodity price experts have estimated that the price of oil would be almost 7 percent lower by 2030 than it would be without the EC policy package.

#### › Resilience to Future Price Shocks

The U.S. economy will be stronger and more resilient. The Electrification Coalition policies—once fully implemented—would mitigate roughly one-third of the economic losses caused by a future oil price shock. By 2025, the EC policies would prevent the loss of 1.4 million jobs in the first year alone of a price shock-induced recession.

## II. The Modeling Exercise

### 2.1 THE BASE CASE

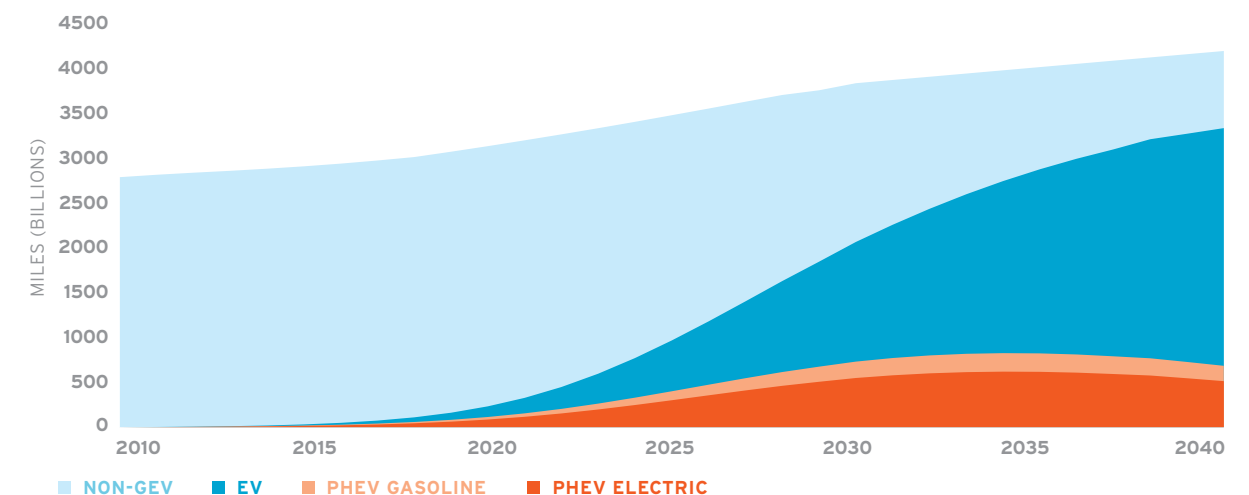
The modeling exercise begins with a base case outlook for the U.S. economy over the period 2010 to 2030. The base case was developed to be generally consistent with the Department of Energy's *Annual Energy Outlook 2009* (revised) Reference Case (AEO 2009). In the base case, real GDP growth averages 2.5 percent over the period 2008 to 2030. The average growth of the GDP deflator over this period is 2.1 percent, and the price of crude oil grows 1.1 percent faster than this, for an average of 3.2 percent. (This results in a nominal crude oil price of \$233 per barrel by 2030, or about \$149 per barrel in constant 2008 dollars.)

To replicate the rates of economic 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 functions that translate the energy consumption in constant dollars to quadrillion Btu and million barrels per day (mbd). These are consistent with AEO 2009. Although the Inforum simulation does not match the AEO projection exactly, it is quite close.

### 2.2 THE ELECTRIFICATION COALITION POLICY PACKAGE

The *Electrification Roadmap* sets a specific goal as a framework for its policy proposals: by 2040, 75 percent of passenger vehicle miles traveled should be electric miles. Based on data from the Department of Energy and the automotive industry, the *Roadmap* projects total light-duty vehicle miles traveled to reach 4.2 trillion in 2040. Therefore, as depicted in Figure 1, total electric miles traveled would need to reach approximately 3.2 trillion in that year to achieve the stated goal. In general, displacing 75 percent of petroleum-fueled vehicle miles traveled should result in displacing approximately 75 percent of petroleum consumption in the light-duty vehicle fleet by 2040—a savings of about 6.0 million barrels per day, all things being equal.

FIGURE 1 Targeted Vehicle Miles Traveled



Source: Electrification Coalition

There are two primary technologies expected to be available to consumers in the near term that will utilize electricity drawn from the grid to power vehicles: pure electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs). Both EVs and PHEVs store energy from the grid in on-board batteries. Energy from the battery powers a highly efficient electric motor that propels the vehicle. EVs substitute an electric drivetrain for all conventional drivetrain components. PHEVs either blend mechanical power produced by a battery-powered electric motor and a down-sized internal combustion engine or rely on an electric drivetrain whose power is provided by a battery while also incorporating a small internal combustion engine that generates electricity solely to recharge the battery. The *Electrification Roadmap* refers to both technologies as grid-enabled vehicles (GEVs).

The first PHEVs to reach U.S. markets will have an all-electric driving range of approximately 40 miles. When the battery's energy is depleted, these vehicles will either function as traditional hybrid vehicles, or rely on the downsized internal combustion engine to power an electric drivetrain and charge the battery. PHEVs therefore provide drivers with extended range and the ability to refuel using existing refueling infrastructure. However, to the extent that PHEVs are operated using gasoline to power the drivetrain or charge the battery, they offer reduced petroleum savings.

The first mass-produced EVs to reach U.S. markets will have an all-electric driving range of approximately 100 miles. When the battery is depleted, an EV must be recharged before the vehicle can be operated.

The *Electrification Roadmap* identifies four categories of challenges that can be expected to hinder the adoption of grid-enabled vehicles. These are:

1. The current high cost of batteries;
2. The current lack of reliable access to refueling infrastructure for GEVs;
3. Regulatory and coordination problems that will complicate interface with the electric power sector; and
4. Consumer acceptance issues.

In order to address these challenges, the *Roadmap* proposes a comprehensive slate of public policies. Some of these policies are intended to be implemented throughout the United States and can broadly be defined as market creation mechanisms for the nascent electric vehicle marketplace. These policy recommendations include:

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**POLICY ONE**      *Establish tax credits for installing automotive grade batteries in stationary applications to help drive scale. This recommendation was modeled as a government tax credit to electric utilities, as well as additional investment undertaken by electric utilities.*

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**POLICY TWO**      *Establish loan guarantees for retooling automotive assembly lines and manufacturers of GEV components. This was modeled as a subsidy to the motor vehicles industry by the federal government.*

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**POLICY THREE**      *Establish a guaranteed residual value for used large-format automotive batteries. This policy was also modeled as a subsidy to the motor vehicle industry.*

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The central policy initiative proposed by the EC is a DOE-managed program designed to achieve high penetration rates of grid-enabled vehicles and charging infrastructure in a limited number of geographic areas called electrification ecosystems. Essentially, the *Electrification Roadmap* calls for a series of large-scale demonstration projects. As the report itself notes, “demonstration projects are used to overcome the final hump in the innovation pathway. Their purpose is to stimulate the adoption and use of a particular technology by proving that it works.” Of course, not all demonstration projects depend on public funding. However, when deployment of a technology that has a compelling national interest has high upfront costs or risks that the private sector is unable to overcome, it is reasonable for the government to assume some of the initial risk.

The *Roadmap* proposes a dual-phased approach to the rollout of electrification ecosystems. At the outset, the Department of Energy would be charged with managing a competitive bidding process through which cities or regions would apply to be selected as ecosystems. The *Roadmap* identifies a series of criteria that could be considered as distinguishing factors for successful bids, including the strong support of state and local government, a progressive regulatory environment and the endorsement of the applicable public utility commission (PUC), and participation of large local employers. The *Roadmap* suggests that DOE should proactively seek to build a portfolio of candidates characterized by diverse geography and business models.

The first phase of deployment envisions six to eight selections as ecosystems. Over a four-year period, these cities or regions would benefit from targeted incentives including:

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**POLICY FOUR**      *Modify electric vehicle tax credits to make them variable such that the upfront cost of a new PHEV or EV is equal to a comparably sized conventional vehicle. The tax credits can also be claimed at the point of sale. This was modeled as tax credits as well as increased penetration of EVs and PHEVs into the light-duty vehicle stock.*

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**POLICY FIVE**      *Establish business tax credits equal to 75 percent of the cost to construct public charging infrastructure. This was modeled as tax credits as well as additional investment by firms building and installing electric charging stations.*

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**POLICY SIX**      *Extend consumer tax credits for home charging equipment. This was modeled as a tax credit to consumers, as well as additional household spending on residential durables.*

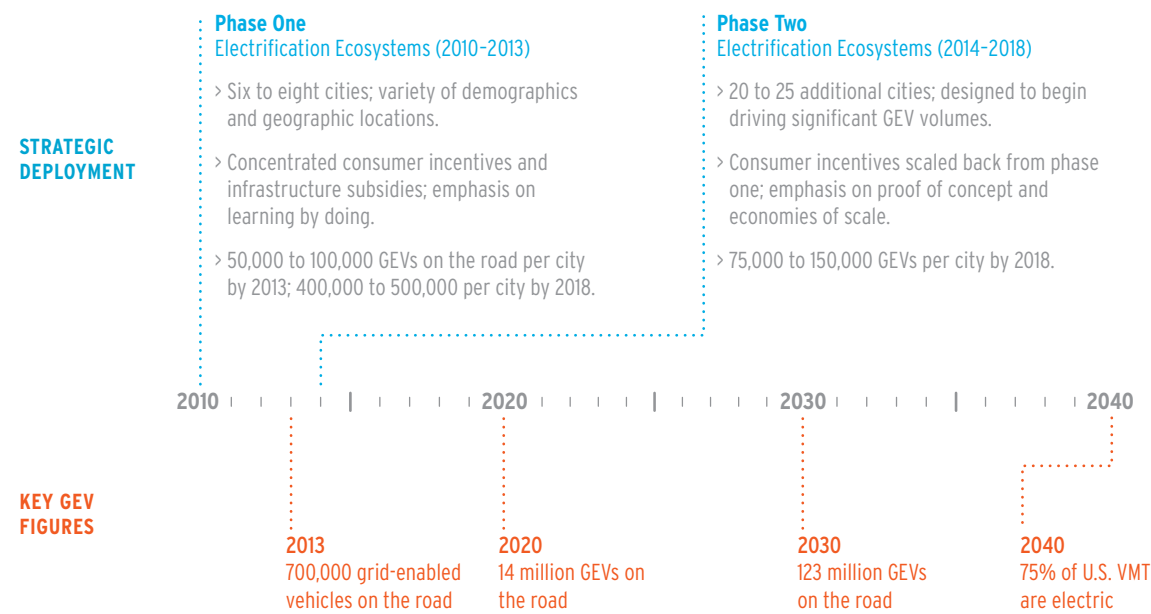
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**POLICY SEVEN**      *Establish utility tax credits for up to 50 percent of the costs of the necessary IT upgrades to sell power to electric vehicle consumers. This was modeled as a tax credit to the electric power industry, as well as additional investment.*

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At the end of phase one, incentives in the initial six to eight ecosystems are scaled down and extended to an additional 20 to 25 cities. The incentives listed above were, therefore, modified and extended in the modeling exercise.

**FIGURE 2** Timeline



Source: Electrification Coalition

In total, the *Electrification Roadmap* outlines programs that would cost approximately \$120 billion in government spending over eight years. Table 1 provides a summary of these costs broken out according to individual policies. It is important to note that approximately 70 percent of the potential cost to the federal government is related to tax credits for vehicles and infrastructure in electrification ecosystems. These costs result from assumed penetration rates multiplied by recommended tax credits. In other words, the government only bears the full costs if the *Electrification Roadmap* succeeds in driving very high concentrations of grid-enabled vehicles. To the extent that the program falls short of its targeted penetration rate, its costs will be significantly lower than expected.

**TABLE 1** EC Policy Cost Summary

EC POLICY RECOMMENDATION	ESTIMATED COST (\$BILLIONS)
<b>Policy One</b> – Establish tax credits for installing automotive grade batteries in stationary applications.	\$13.75
<b>Policy Two</b> – Establish loan guarantees for retooling automotive assembly lines.	10.0
<b>Policy Three</b> – Establish a guaranteed residual value for batteries.	9.7
<b>Policy Four</b> – Modify electric vehicle tax credits to make them variable such that the upfront cost of a new PHEV or EV is equal to a comparably sized conventional vehicle.	74.1
<b>Policy Five</b> – Establish business tax credits equal to 75 percent of the cost to construct public charging infrastructure.	12.6
<b>Policy Six</b> – Extend consumer tax credits for home charging equipment.	0.8
<b>Policy Seven</b> – Establish utility tax credits for up to 50 percent of the costs of the necessary IT upgrades to sell power to electric vehicle consumers.	0.16
<b>Total Cost</b>	<b>121.1</b>

It is also critical to note that the status quo is not free. That is, oil dependence, driven largely by the U.S. transportation sector, inflicts significant economic damage on the United States each year. During times of high and volatile oil prices, the damage is particularly striking. For example, researchers at the Oak Ridge National Laboratory estimate the combined economic costs of U.S. oil dependence to be more than \$5 trillion (2008 dollars) since 1970. In 2008 alone, the combined cost was nearly \$600 billion.<sup>2</sup> In 2009, a year in which oil prices averaged just \$62 per barrel and U.S. oil consumption was significantly reduced compared to 2005-2007 levels, the United States still ran a \$200 billion trade deficit in crude oil and petroleum products. In that context, the government spending of \$120 billion over 8 years—particularly as it is directly tied to high penetration rates of grid-enabled vehicles—can be thought of as a relatively affordable down payment on future economic stability.

The results of the EC policy package are an accelerated penetration of EVs and PHEVs into the automobile stock. Table 2 shows the targets for grid-enabled vehicle sales and stock both in the base scenario and in the EC policy scenario. The last two columns in each section of the table show the percentage of sales and stock in the total vehicle fleet. In the EC policy scenario, sales of GEVs reach a proportion of 91.2 percent of total light-duty vehicle sales by 2030.

We assume that the average miles traveled per vehicle starts at about 11,500 miles in 2010, and rises to 13,300 miles by 2030. For all GEVs, we assume that efficiency will steadily increase, starting at 4 miles per kWh in 2010 and reaching 5.5 miles per kWh by 2030. The miles-per-gallon (mpg) efficiency for PHEVs when fueled by gasoline or other liquid fuel is assumed to be 10 percent higher than conventional internal combustion engine (ICE) vehicles. The share assumed for miles fueled by gasoline in PHEVs is a constant 25 percent.

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 3 shows the changes in total liquid motor fuel consumption (billions of gallons of gasoline equivalent) and GEV electricity consumption in the base case and the EC policy scenario.

**TABLE 2** GEV Sales and Vehicle Stock

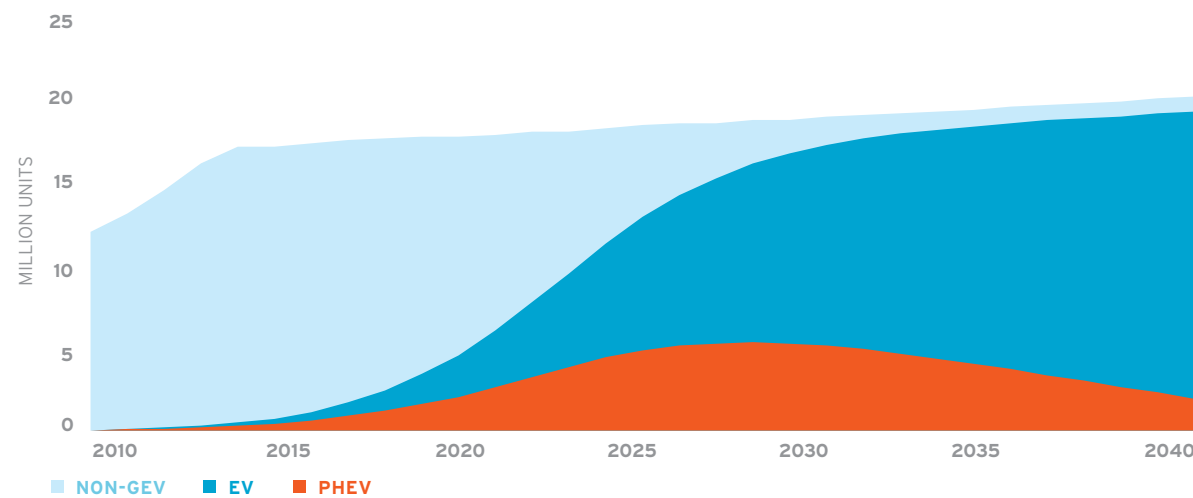
	BASE CASE				EC POLICY CASE			
	GEV SALES (THOUSANDS)	GEV STOCK (THOUSANDS)	GEV SALES SHARE	GEV STOCK SHARE	GEV SALES (THOUSANDS)	GEV STOCK (THOUSANDS)	GEV SALES SHARE	GEV STOCK SHARE
<b>2010</b>	-	1	0.0%	0.0%	-	-	0.0%	0.0%
<b>2015</b>	258	142	1.5%	0.1%	769	1,892	4.5%	0.7%
<b>2020</b>	290	254	1.6%	0.1%	4,543	14,216	25.7%	5.3%
<b>2025</b>	388	384	2.1%	0.1%	12,740	57,322	69.9%	20.6%
<b>2030</b>	485	575	2.6%	0.2%	17,139	122,721	91.2%	42.4%

<sup>2</sup> U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Costs of Oil Dependence 2008*. Available online at: [http://www1.eere.energy.gov/vehiclesandfuels/facts/2008\\_fotw522.html](http://www1.eere.energy.gov/vehiclesandfuels/facts/2008_fotw522.html)

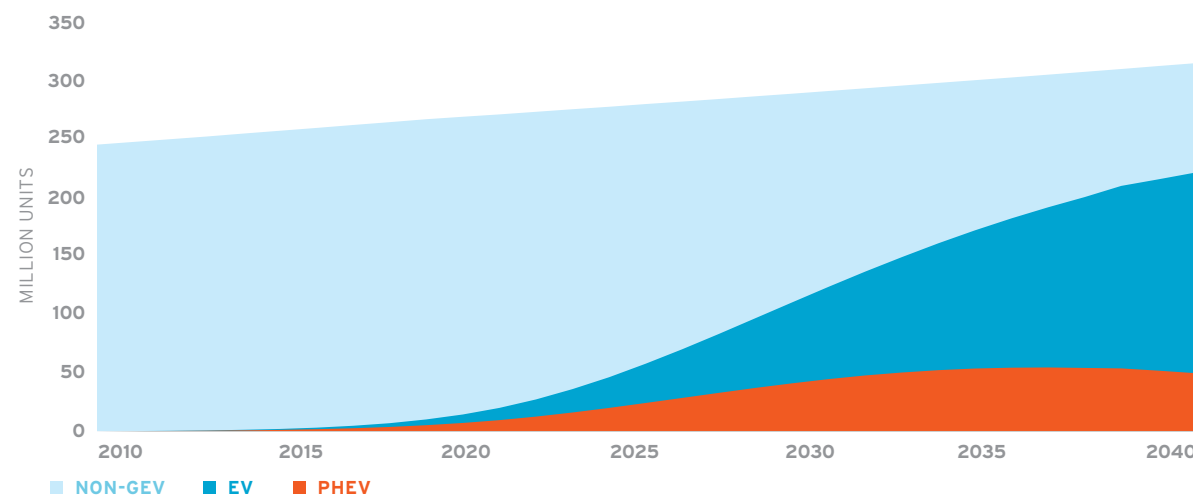
**TABLE 3** Motor Fuel and GEV Electricity Consumption

	BASE CASE		EC POLICY CASE	
	MOTOR FUEL CONSUMPTION (BIL GAL)	GEV ELECTRICITY CONSUMPTION (BIL KWH)	MOTOR FUEL CONSUMPTION (BIL GAL)	GEV ELECTRICITY CONSUMPTION (BIL KWH)
2010	133.8	-	133.8	-
2015	129.2	0.3	117.8	3.9
2020	123.9	0.7	100.6	25.0
2025	123.9	1.4	82.2	102.5
2030	125.8	2.3	63.6	222.1

**FIGURE 3** Assumed GEV Sales



**FIGURE 4** GEV Fleet Penetration



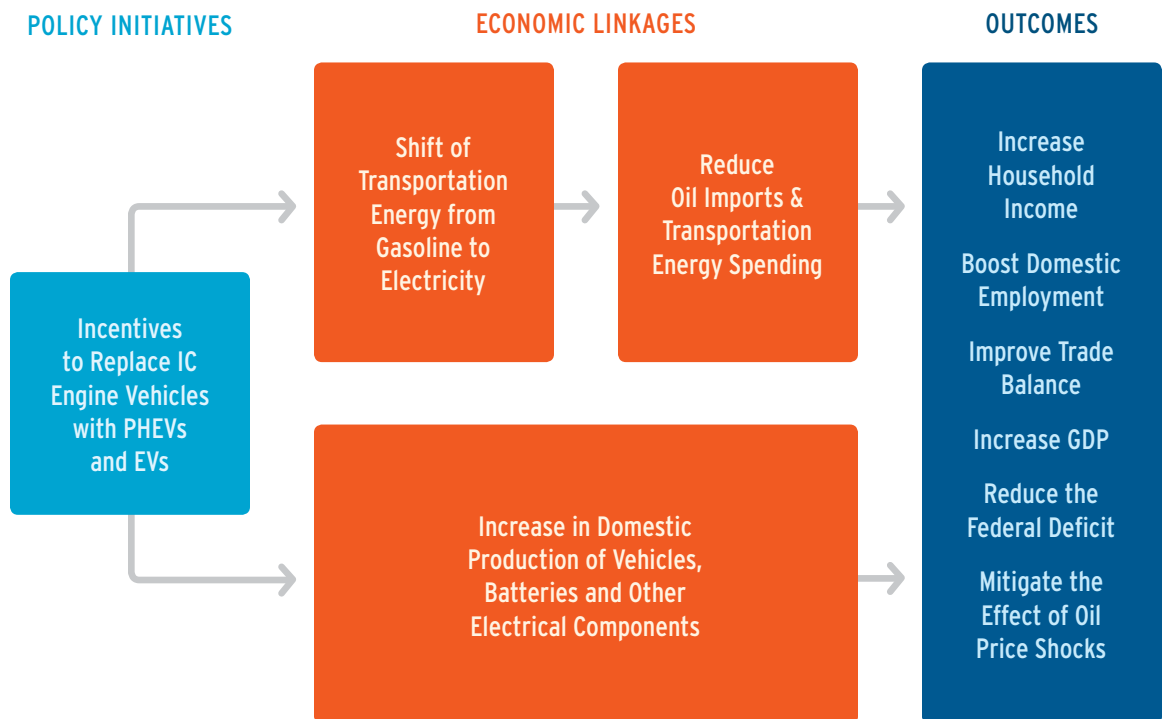
### III. Findings in Detail

#### 3.1 INTRODUCTION

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 20 years (2010-2030). The baseline scenario is built upon current and expected conditions based on the AEO 2009 forecast, which includes the current economic recession and projected budget deficits. However, the model does not explicitly or implicitly factor in other anomalies that may or may not occur. In this sense, the base case is not designed to predict future economic conditions, but rather acts as a useful benchmark against which to compare policy scenarios. All dollar figures are constant 2008 dollars unless otherwise noted.

The EC policy case results in significant economic benefits for the United States over the simulation period. In general, these benefits are derived from policy incentives that replace internal combustion engine vehicles with vehicles that derive their energy from the electric power sector. This gradual shift results in decreased oil consumption (and therefore oil imports) as well as increased domestic production of vehicles, batteries, and other electrical components.

**FIGURE 5** Effects of Electrification Coalition Policies

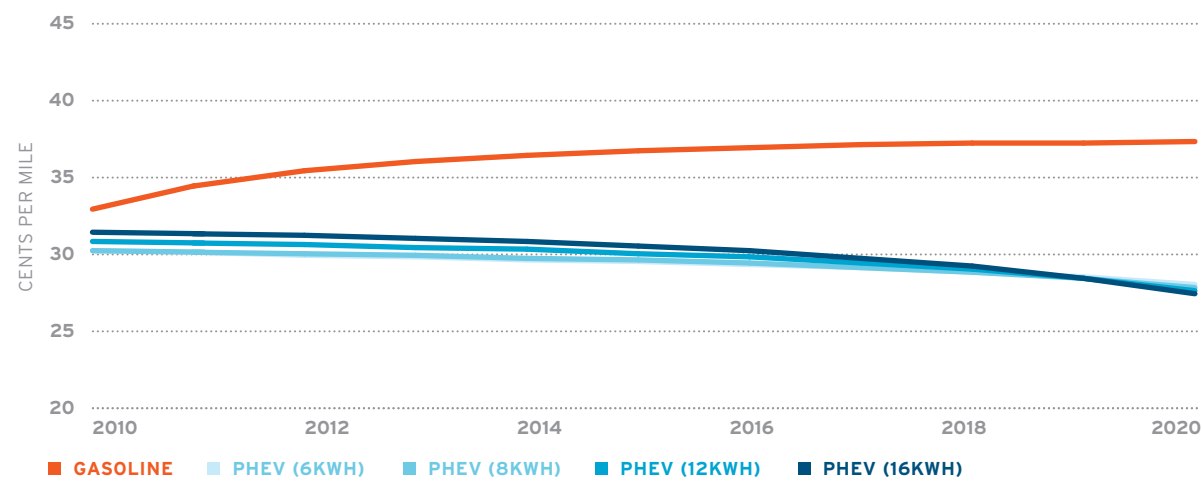


Over the long term, substantial consumer energy savings are derived from the fact that operating a vehicle on electricity in the United States is considerably less expensive than operating a vehicle on gasoline. In large part, this is due to the high efficiency of electric motors, which can turn 90 percent of the energy content of electricity into mechanical energy. In contrast, today's best internal combustion (IC) engines have efficiency ratings of just 25 to 27 percent, which is further reduced by inefficiencies in the transmission. With gasoline at \$3.00 per gallon, the fuel costs of a highly efficient IC engine vehicle (30 miles per gallon) is 10 cents per mile. Assuming an average electricity price of 10 cents per kilowatt hour, fuel costs for the earliest mass-production pure electric vehicles will be just 2.5 cents per mile.

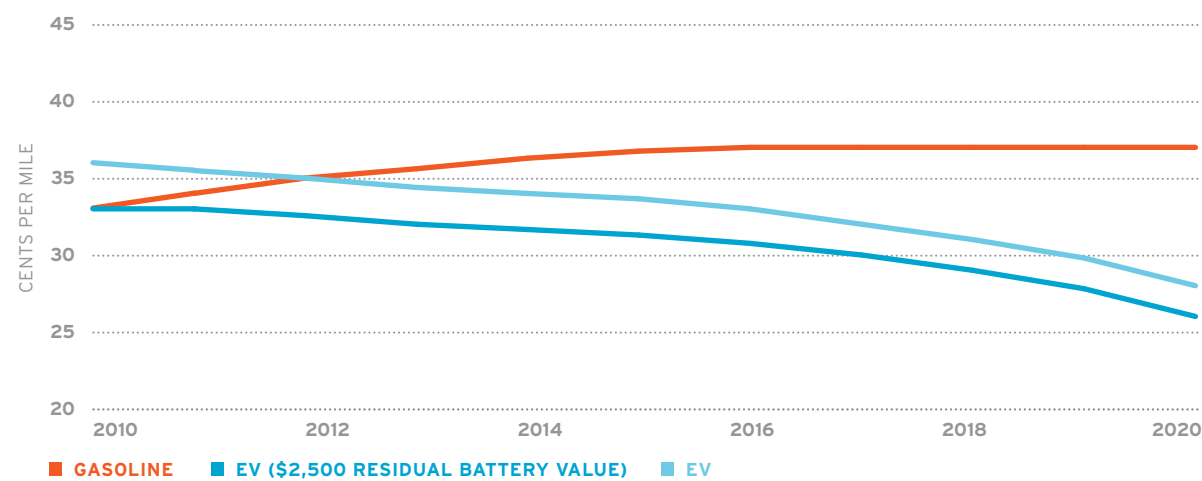
It is important to note that, today, the comparatively higher purchase cost of a grid-enabled vehicle offsets the lifetime fuel savings for consumers. This is certainly true in the absence of government financial incentives, which currently include a maximum \$7,500 tax credit for the purchase of a plug-in electric drive vehicle. Even with the maximum tax credit, a PHEV with 40 miles of all-electric range today would offer only a marginal economic benefit over the life of the vehicle. A fully electric vehicle with 100 miles of driving range would probably cost consumers more over its lifetime than a comparably-sized internal combustion engine based on current fuel prices.

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**FIGURE 6** PHEV Total Cost of Ownership (Including ARRA Tax Credit)



**FIGURE 7** EV Total Cost of Ownership (Including ARRA Tax Credit)



However, declining battery costs and rising oil prices are expected to substantially improve the cost-benefit analysis for consumers over the next several years. Based on an analysis performed for the *Electrification Roadmap*, total cost of ownership (TCO), the fully burdened cost of purchasing, owning, and operating a grid-enabled vehicle, is already positive for PHEVs based on existing tax credits and will turn positive without tax credits by 2015. The TCO of EVs will turn positive by 2012 based on existing tax credits. If it is assumed that EV batteries have value in secondary markets—such as stationary power storage—and that vehicle owners can capture some of that value, mass-produced EVs could be cost competitive as soon as they enter the market. Figures 6 and 7 present analyses of PHEV and EV total cost per mile (from the *Electrification Roadmap*) including the receipt of the tax credit by the vehicle owner.

As depicted in Figure 5, EC policy incentives stimulate the economy through the combination of reduced oil intensity, increased vehicle manufacturing, and lower household spending on energy. In turn, these economic linkages produce measurable effects on GDP, employment, the trade balance, and household income, all while improving the budget balance over the long term. The federal government essentially assumes a leadership role in market coordination and investment in the early years of a technology that has clear long-term benefits but high upfront costs. Over time, the reduction in exposure to oil price volatility, coupled with the comparatively low and stable costs of electrified transport, pays back the government's initial investment.

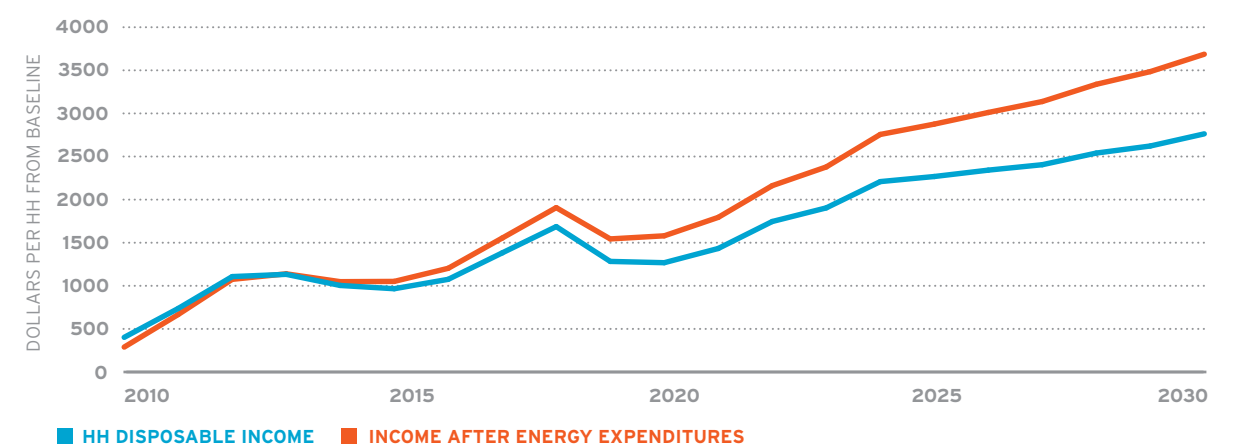
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### 3.2 INCREASE IN REAL INCOME

By 2030, the typical household would benefit from \$2,763 more in annual income with the EC policy package than in the base case. This 2.2 percent increase in real income is the result of stronger economic growth under the EC policy package. Because expenditures on total energy products will fall relative to the base case, the typical household would ultimately benefit from \$3,687 of extra disposable income to spend on non-energy goods and services, or savings.

Table 4 shows the increase in household income (resulting from higher economic growth) and the larger increase in disposable income (resulting from that growth combined with lower household spending on energy) for selected years. Over the entire interval of the simulation, household disposable income is \$5.6 trillion higher in the EC policy case, and personal consumption of non-oil goods and services is \$7.9 trillion higher than the base case.

**FIGURE 8** Impact to Disposable Income by the EC Policy Package



**TABLE 4** Change in Household Income and Disposable Income

	HOUSEHOLD INCOME (2008 DOLLARS)				DISPOSABLE INCOME (2008 DOLLARS)			
	BASE CASE (\$BIL)	EC POLICY CASE (\$BIL)	DIFFERENCE (\$BIL)	PER HOUSEHOLD (\$)	BASE CASE (\$BIL)	EC POLICY CASE (\$BIL)	DIFFERENCE (\$BIL)	PER HOUSEHOLD (\$)
2010	10,584	10,632	48	402	10,253	10,287	35	289
2015	12,337	12,457	120	966	12,012	12,144	131	1,051
2020	14,190	14,355	165	1,268	13,865	14,071	206	1,580
2025	15,955	16,264	310	2,268	15,622	16,014	393	2,876
2030	18,194	18,589	395	2,763	17,856	18,383	527	3,687
<b>Cumulative Total 2010-2030</b>			<b>4,578</b>				<b>5,572</b>	

### 3.3 REDUCTION IN CRUDE OIL AND REFINED IMPORTS

Reducing transportation petroleum use would result in a significant reduction in U.S. imports of crude oil and refined petroleum products. Table 5 presents petroleum imports between 2010 and 2030 in the base case compared to imports in the EC policy case. The reduced imports are due primarily to energy savings in the transportation sector.

**TABLE 5** Oil Imports (mbd)

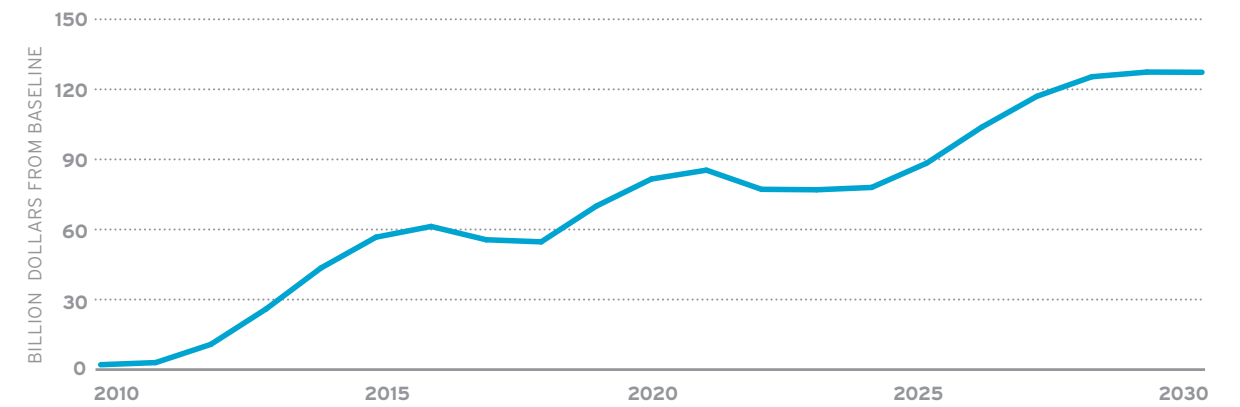
	BASE CASE	EC POLICY CASE	CHANGE
2010	11.9	11.7	(0.2)
2015	12.5	11.7	(0.9)
2020	12.4	11.0	(1.5)
2025	11.8	9.5	(2.2)
2030	12.1	8.9	(3.2)
<b>Cumulative Reduction 2010-2030</b>			<b>11,908 Million Bbl</b>

The effect of the transportation fuel savings is a reduction in oil imports of about 3.2 mbd by 2030. The cumulative reduction over the period of the simulation is approximately 11.9 billion barrels. Note that the total reduction in imports is less than might be expected given the transportation energy savings and the enhancements to supply. This is due to a stronger economy in the EC scenario, generating demand for more goods and services, which all influence the demand for oil indirectly. These effects are the result of using a dynamic model such as the Inforum LIFT model and would not be discovered in a static calculation.

### 3.4 BALANCE OF TRADE

Because crude oil and refined products constitute a significant portion of the value of all U.S. imports, the reduction in oil imports would have significant effects on the U.S. trade balance. The base case projects strong growth in exports (5.3 percent average annual growth from 2008 to 2030) and slower growth in imports (3.8 percent). The base case also projects a continuing worsening of the current account. In the EC case, although there is still a deficit by 2030, the trade deficit has improved by \$127 billion compared to the base case.

**FIGURE 9** Impact to Trade Deficit



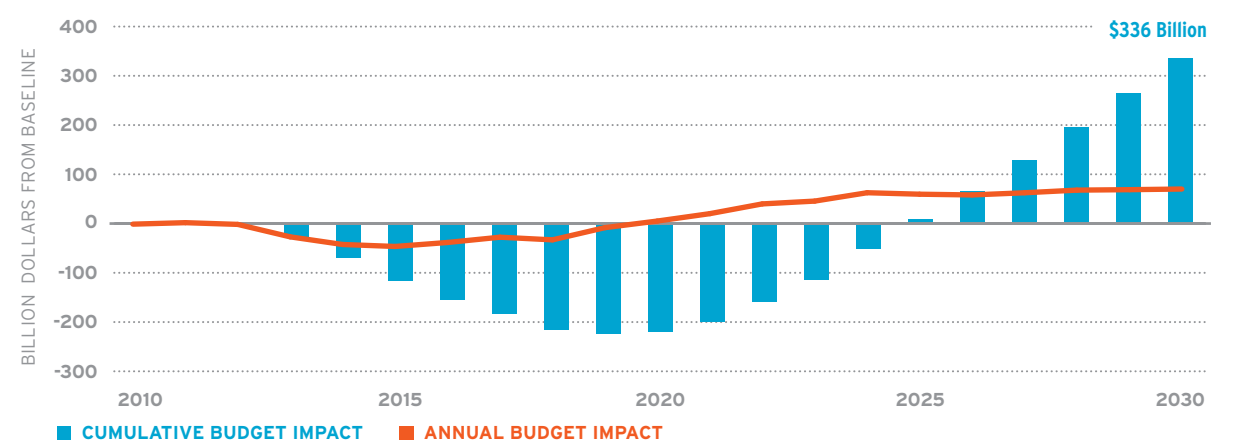
### 3.5 FEDERAL REVENUES AND THE DEFICIT

The base case assumes an average GDP growth rate of 2.5 percent from 2008 to 2030. The base case also assumes slower long-term growth (average 1.4 percent) in government spending than in GDP. However, because receipts grow more slowly than spending, the deficit continues to increase, expanding to \$2.7 trillion by 2030, or about 7 percent of GDP.

**TABLE 6** Federal Budget Deficit/Surplus (-/+) (\$bil)

	BASE CASE	EC POLICY CASE	CHANGE
2010	-663.7	-665.0	-1.3
2015	-826.0	-872.5	-46.5
2020	-1,451.6	-1,446.6	5.0
2025	-1,965.3	-1,905.8	59.5
2030	-2,737.5	-2,667.4	70.1
<b>Cumulative 2010-2030</b>			<b>\$336 Billion</b>

**FIGURE 10** Federal Deficit/Surplus



Over a 20-year period, the policy scenario improves the federal budget deficit compared to the base case. As depicted in Figure 10, the annual budget impact of EC policies turns positive in 2020 and the cumulative impact turns positive in 2025. Higher deficits in the near term give way to an improved fiscal picture in the later years of the simulation, due primarily to higher economic growth. Initial deficits are partly due to tax credits available for GEVs, and other tax credits and subsidies for charging stations and electric utility upgrades. For the overall time period, the difference is a cumulative \$336 billion improvement in the budget balance in the EC policy case. In present value terms, this is equivalent to about \$135 to \$156 billion (using a 3.5 percent to 3.0 percent discount rate, respectively).

### 3.6 LOWER WORLD OIL PRICE

As discussed above, the energy demand reductions in the transportation sector would result in a total reduction of 3.2 mbd in U.S. oil imports by 2030. This is roughly equivalent to an increase in supply of 3.2 mbd for the rest of the world market. The DOE reference case published in the International Energy Outlook 2009 projects a world production capacity for liquid fuels of about 106.6 mbd in 2030. DOE also shows a low price case in which the supply is 15 percent higher than the reference, with a resulting 40 percent lower world oil price. The DOE high price case has supply 15 percent lower than the reference, with the oil price about 70 percent higher.

Based on these figures, DOE’s assumed world demand elasticity 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, we chose the higher 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 per barrel by 2050. In the EC case, the extra supply on the world oil market due to the reduction in U.S. net demand is 3.2 mbd in 2030, or about 3.3 percent of the world total. Therefore, assuming that the demand elasticity of the rest of the world is -0.5, oil prices in the EC policy case would be about 6.6 percent lower than the base case.

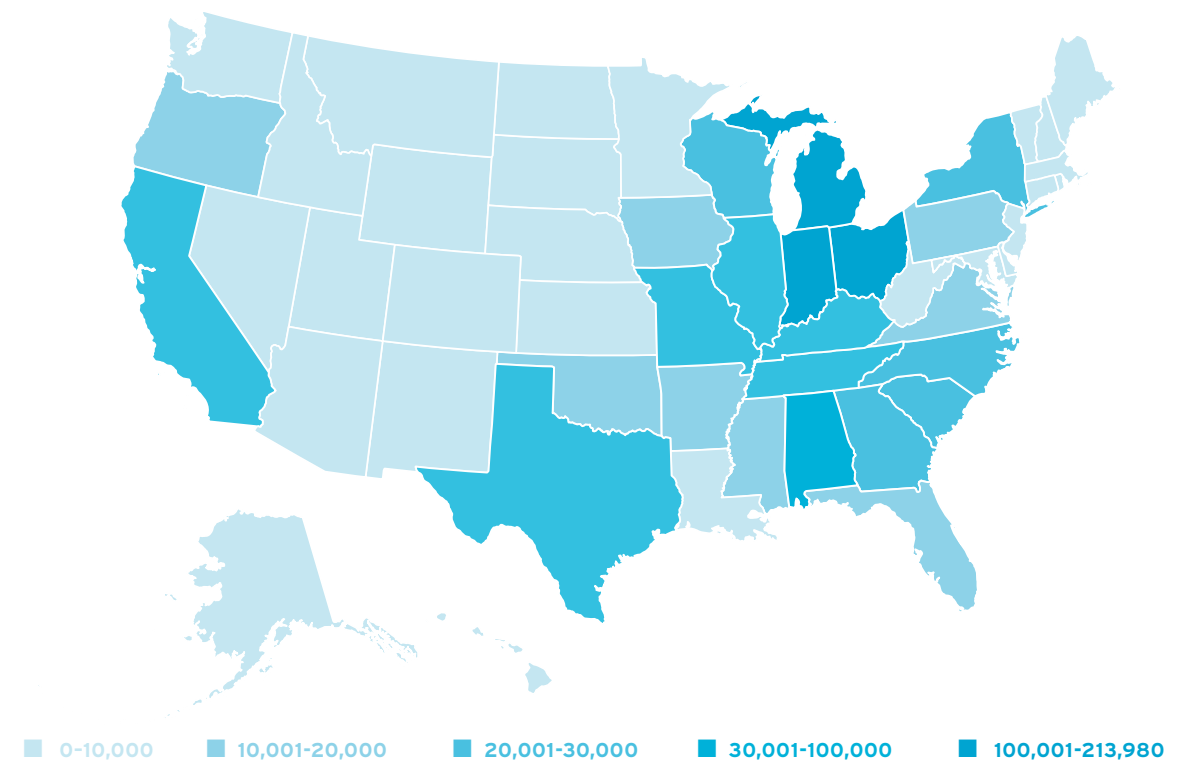
### 3.7 EMPLOYMENT IMPACT

If implemented, the policies in the EC policy case would increase total U.S. employment by approximately 1.9 million jobs in 2030 compared to the base case. This is equivalent to reducing the unemployment rate by more than 1 percent. While this increase is significant, it is also useful to note the geographic diversity across which employment status is likely impacted. Given the concentration of federal incentives for electrification ecosystems, one might expect employment benefits to be concentrated in these regions as well. We do not believe, however, that will be the case.

There is no question that infrastructure deployment and the increased role for power providers will create new jobs in electrification ecosystems. But it is critical to recognize that deployment of GEVs and establishment of electrification ecosystems will increase demand for GEVs and their components. They also will increase the need for refueling infrastructure and other associated materials. As depicted in Figure 11, companies that manufacture cars and their parts have expansive and geographically diverse supply chains, a pattern that should continue with the expanded manufacture of GEVs and their infrastructure components, and which therefore should provide employment benefits nationwide.

This point is reinforced by patterns in recently announced government programs to promote electrification of transportation. In August 2009, the Obama Administration announced \$2.4 billion in

**FIGURE 11** U.S. Motor Vehicle Manufacturing Employment by State



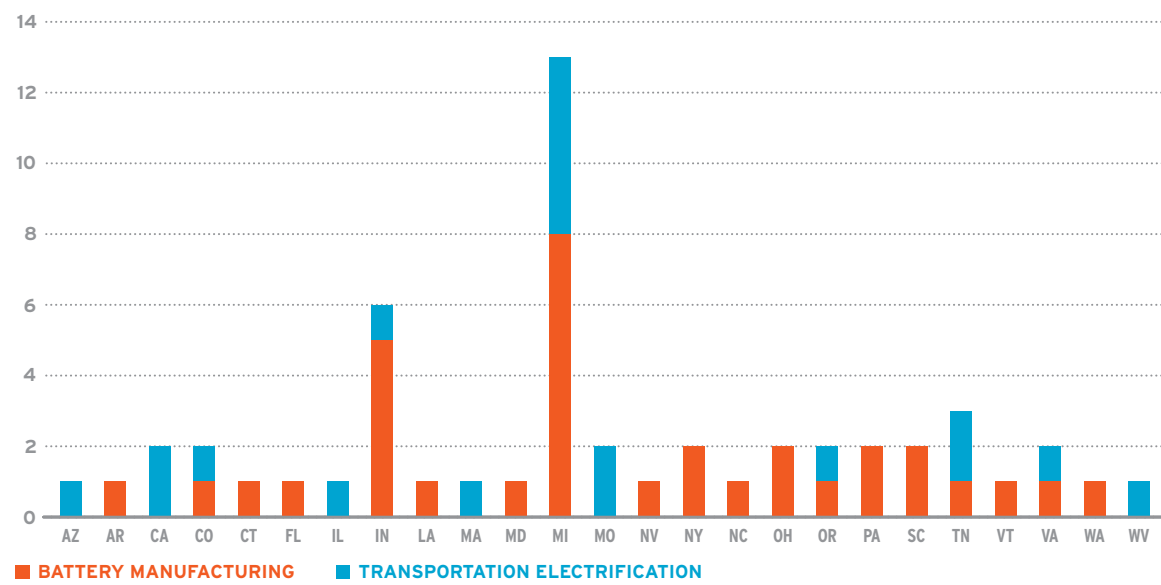
Source: Congressional Research Service (2006 Data)

funding for advanced battery manufacturing and electric drive programs. Of these funds, approximately \$1.9 billion was allocated to battery manufacturing and \$500 million was allocated to electric drive infrastructure and demonstration projects. As depicted in Figure 12, this funding supported 53 individual projects in 25 states. The preponderance of battery funds—more than \$1 billion—went to projects in Michigan. However, Indiana received more than \$300 million for battery manufacturing; Florida approximately \$100 million; and Oregon more than \$20 million for high-performance electrodes. Projects for battery recycling in Ohio received more than \$30 million; production of lithium carbonate from mines in Nevada received \$28 million. These figures help demonstrate that the increase in demand for electric vehicles and their components resulting from EC policies is likely to drive employment gains in a range of geographic areas.

**TABLE 7** U.S. Unemployment Rate & Total Employment

	BASE CASE		EC POLICY CASE	
	UNEMPLOYMENT RATE	TOTAL EMPLOYMENT (THOUSANDS)	CHANGE IN UNEMPLOYMENT RATE	CHANGE IN TOTAL EMPLOYMENT (THOUSANDS)
2010	7.7%	145,583	-0.10%	+227
2015	5.5	154,565	-0.40	700
2020	4.4	161,799	-0.50	900
2025	4.9	165,127	-1.20	2,006
2030	4.8	171,095	-1.10	1,894

**FIGURE 12** Number of Electrification Projects by State



### 3.8 CHANGES IN AUTOMOBILE PRODUCTION TECHNOLOGY

The Inforum LIFT model combines elements of an input-output or interindustry model with those of a macro model. The input-output table enables modeling of the structure of inputs required to produce the products of any given industry. In the current analysis, we made estimates of the production structure of conventional IC engine vehicles and of EVs and PHEVs. The weights of sales of PHEVs, EVs and IC engine vehicles were then used to obtain a weighted production structure for the motor vehicle industry. For example, this production structure shows a sharply increasing use of batteries, electric motors and electronic components, and a reduction in the traditional IC motor vehicle and motor vehicle parts inputs. Table 8 shows the aggregate use of inputs by the motor vehicle industry in 2020 and 2030 for the base case and the EC policy case.

**TABLE 8** Use of Selected Inputs by the Motor Vehicle Industry (\$bil)

	2020		2030	
	BASE CASE	EC POLICY CASE	BASE CASE	EC POLICY CASE
Textiles and Knitting	2.3	2.3	2.9	2.2
Apparel	9.7	9.4	12.4	9.0
Rubber Products	6.6	6.5	8.4	6.2
Miscellaneous Plastic Products	19.7	14.8	34.9	18.5
Primary Ferrous Metals	1.3	1.2	1.7	0.7
Primary non-Ferrous Metals	1.0	1.3	1.3	2.2
Metal Products	32.7	34.2	42.0	39.5
Engines and Turbines	5.1	3.8	9.3	1.6
General and Misc Industrial Equipment	1.4	1.4	1.8	1.3
Service Industry Machinery	4.2	4.2	5.4	4.0
Electric Lighting and Wiring Equipment	7.3	30.7	9.4	111.6
Electronic Components	15.1	44.9	25.3	151.6
Motor Vehicles	7.9	7.8	10.1	7.0
Motor Vehicle Parts	103.0	95.2	139.4	85.8

### 3.9 INSURANCE BENEFITS OF THE EC POLICY CASE

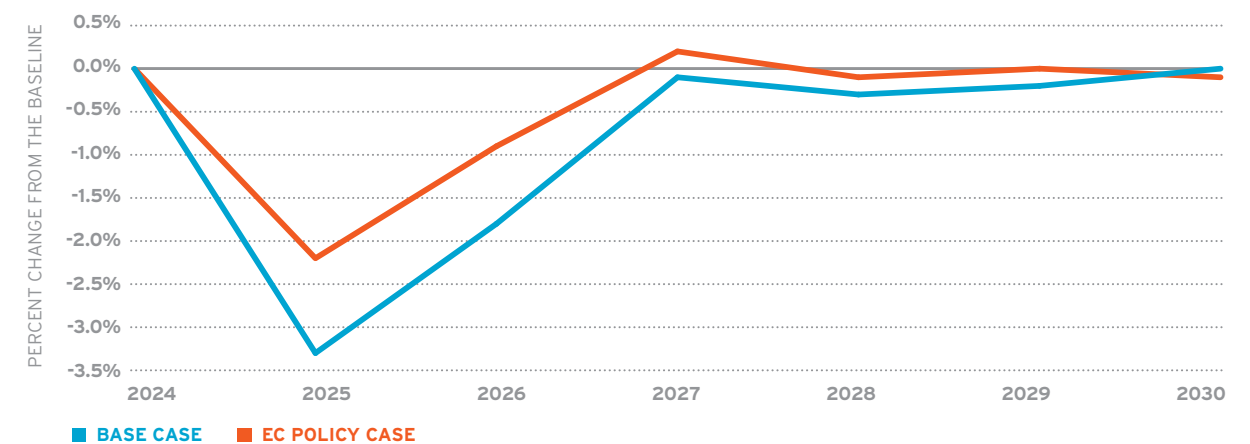
In addition to the economic benefits of the EC policies, reduced oil imports and lower oil intensity of the U.S. economy would mitigate the negative impacts of future oil price shocks. The U.S. economy is sensitive to oil prices, as evidenced by contribution of oil price shocks to the recessions in 1973-74, 1980-81, 1991, 2000-01, and 2008-09. To estimate the ability of the EC policies to mitigate the impact of oil price shocks on the U.S. economy, a spike in oil prices was applied starting in 2025 in which the real oil price doubled and returned to the base level within five years.

The analysis indicates that the EC policies would mitigate roughly one-third of the GDP and employment losses caused by an oil price shock. In the first year of an oil price-led recession, the EC policies prevent the loss of:

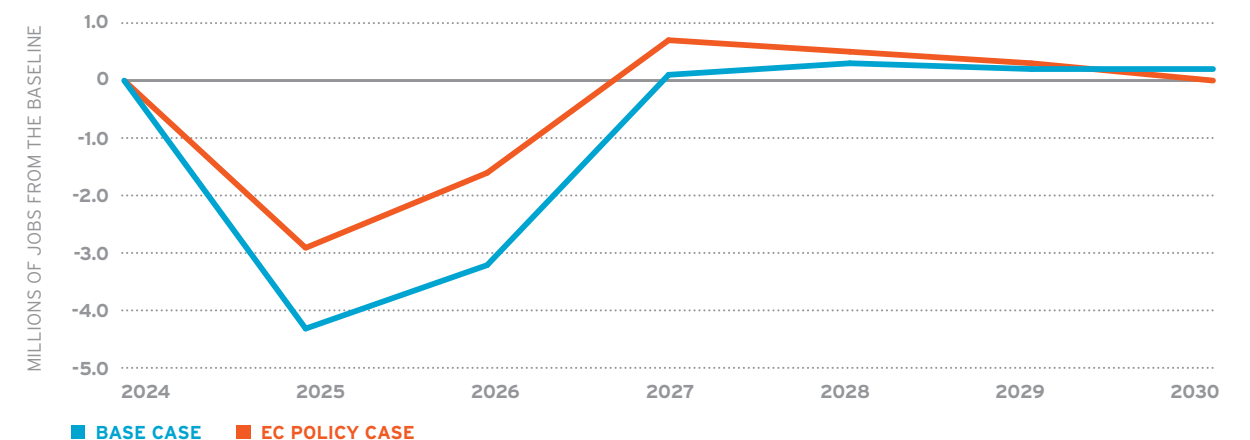
- ▶ 1.05 percent (\$213 billion) of real GDP;
- ▶ 1.6 percent (\$253 billion) of real disposable income; and
- ▶ 0.9 percent (1.4 million jobs) of employment.

From 2025 to 2030, the EC policies prevent the loss of a cumulative \$505 billion in GDP and \$758 billion in real disposable income (in 2008 dollars).

**FIGURE 13** Annual Impact on GDP from an Oil Shock



**FIGURE 14** Annual Impact on Employment from an Oil Shock



## IV. Macroeconomic Summary

**TABLE 9** Macroeconomic and Energy Accounting Summary

	2008	2010	2015	2020	2025	2030	2008-2030
<b>GDP and Components (Billions of 2008\$)</b>							
Gross Domestic Product	14292	14213	16649	19055	21468	24554	2.49
EC Policy Case Variance	2	46	111	126	256	281	0.05
<b>Components of Real Gross Domestic Product</b>							
Personal Consumption	10045	10107	11493	13000	14660	16656	2.33
EC Policy Case Variance	0	36	64	76	140	176	0.05
Gross Private Fixed Investment	2064	1720	2539	3057	3511	4289	3.38
EC Policy Case Variance	2	4	15	23	96	79	0.08
Government Spending	2877	2986	3092	3305	3585	3887	1.38
EC Policy Case Variance	1	5	7	11	21	34	0.04
Exports	1852	1844	2597	3448	4411	5821	5.34
EC Policy Case Variance	-2	-1	-3	-22	-50	-183	-0.15
Imports	2554	2461	3104	3743	4605	5834	3.83
EC Policy Case Variance	2	0	-23	-27	-26	-116	-0.1
<b>Price Indices</b>							
GDP Chain Price Index	1.22	1.23	1.34	1.53	1.72	1.91	2.07
EC Policy Case Variance	0	0	0.01	0.01	0.01	0.01	0.02
Import Price Index	1.32	1.25	1.52	1.74	1.94	2.14	2.23
EC Policy Case Variance	0	0	-0.01	-0.01	-0.02	-0.03	-0.06
Consumer Price Index	1.2	1.21	1.34	1.56	1.76	1.96	2.23
EC Policy Case Variance	0	0	0	0	0	0	-0.02
<b>Oil Prices</b>							
Nominal	116.74	60.2	129.46	172.18	196.22	233.06	3.19
EC Policy Case Variance	0	-1.09	-4.84	-6.69	-9.82	-15.45	-0.32
Real (2008\$)	116.74	59.41	117.81	136.94	138.99	148.57	1.1
EC Policy Case Variance	0	-1.05	-4.84	-6.18	-7.81	-10.58	-0.34
Real Disposable Personal Income	10535	10584	12337	14190	15955	18194	2.51
EC Policy Case Variance	0	48	121	165	310	395	0.1
Trade Balance	-723	-510	-947	-1212	-1680	-2346	5.5
EC Policy Case Variance	-4	2	57	82	88	127	-0.3

**TABLE 10** Macroeconomic and Energy Accounting Summary

	2008	2010	2015	2020	2025	2030	2008-2030
<b>Federal Budget</b>							
Federal Deficit/Surplus	-427	-664	-826	-1452	-1965	-2738	8.81
EC Policy Case Variance	-3	-1	-46	5	60	70	-0.16
<b>Employment</b>							
Unemployment Rate	5.5	7.7	5.5	4.4	4.9	4.8	-0.6
EC Policy Case Variance	0.1	-0.1	-0.4	-0.5	-1.2	-1.1	-1.2
Total Employment	148284	145583.3	154564.5	161799	165127.1	171094.7	0.65
EC Policy Case Variance	-109	226.8	700.3	899.6	2005.7	1894.3	0.05
Manufacturing Employment	14783.5	13849.3	14586.6	14727.5	14169.5	13823	-0.3
EC Policy Case Variance	-13.6	11.8	180.5	267.3	501.5	560.2	0.18
Motor Vehicles Employment	413.6	362.2	385.7	420.1	434.6	453.7	0.42
EC Policy Case Variance	-1.1	1	33.9	52	83.8	106.1	0.98
Motor Vehicle Parts Employment	301.3	276.8	226.2	187.8	147.5	115.2	-4.28
EC Policy Case Variance	-0.7	0.4	3.2	1.1	-1.5	0.4	0.02
Electric Motors, Batteries	170.1	140.4	123.7	111.5	90.7	71.1	-3.89
EC Policy Case Variance	-0.1	-1.1	14.7	20	32	44.1	2.14
Engines and Turbines	77.8	69.7	66.1	60.8	53.6	47.4	-2.23
EC Policy Case Variance	0	-0.1	0.7	0.3	0.3	0.5	0.05
Electronic Components	364.3	298.4	301.8	224.4	159.3	114.9	-5.11
EC Policy Case Variance	-2	4.8	20.6	36.2	65.1	69.4	2.08
Other instruments	275	247.4	269.3	274	279.8	300.4	0.4
EC Policy Case Variance	-0.1	-0.2	4	2.7	1.9	-7.8	-0.12
Plastic Products	584.2	523	511.2	482.4	435.3	392.5	-1.79
EC Policy Case Variance	-0.4	0	0.1	-2.1	-0.1	-1.7	-0.02
Professional Services	6004.3	5783.6	6000	6089.5	5995	6046	0.03
EC Policy Case Variance	-4.8	9.3	33.8	38.6	83.3	73.4	0.06
Agricultural Employment	3621.9	3523.9	3715.7	3889.1	3977.6	4109.5	0.58
EC Policy Case Variance	-2.8	2.3	8.6	2.4	8	-3.8	0
Travel & Tourism [1]	15525.1	15779.3	16622	17283.8	17587.3	17964.6	0.67
EC Policy Case Variance	-14	35	98.1	123.2	218.7	275.9	0.07

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