EPAct Project:
Valuing Domestically Produced Natural Gas and Oil
Final Report

DOE/NETL-2009/1355

December 31, 2008

Disclaimer

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Executive Summary

In accordance with research called for under Section 999 of the Energy Policy Act (EPAct) of 2005, the National Energy Technology Laboratory (NETL) collaborated with West Virginia University (WVU) to develop and conduct this project – EPAct Project: Valuing Domestically Produced Natural Gas and Oil.

The primary goal of this project was to develop a model that facilitates a national and regional economic analysis of the potential impacts of offsetting oil and/or natural gas foreign imports by increasing domestic natural gas and/or oil production in areas that are likely to be impacted by EPAct 999 related technologies. The development of these models allows NETL to analyze increases in domestic production using present-day technologies to serve as a baseline for potential future impacts.

This report documents the development of the model that incorporates input output modeling frameworks for five sub-national regions and one national region consisting of the US Lower-48. Because the model was developed to identify and quantify the potential impacts of increasing domestic production of oil and natural gas to offset foreign imports, the sub-national regions represent areas in the US with large reservoirs and production levels.

This project expands NETL's analytical capabilities by producing an economic model that allows for the calculation of direct, indirect and income-induced impacts to both output and employment as well as tax impacts. The model also lays the groundwork for future analyses through extensions and additions to the already existing consistent framework.

The economic modeling framework developed within this project provides a user friendly, flexible interface that allows for a wide range of target audiences – government officials, industry researchers and decision makers, and energy researchers. These audiences can use this model to conduct their own impact analyses on one region or the nation as a whole. Constructing a modeling framework that consistently models import substitution and structural change within an economy presented three key challenges:

- Identifying a sensible industry aggregation scheme that maintained detail in all energy-related production and support industries while aggregating other industries to keep the model manageable.
- Selecting a definition of the five sub-national regions so that they coincide with large production basins of the US and allow for data collection on all relative economic parameters.
- Selecting a methodology that would allow import substitution and structural changes without sacrificing consistency or theoretical foundation.

As noted, this project uses input-output (IO) models as the foundation of the modeling framework. In developing the model, the project team compiled resource production and processing data that reflect region-specific domestic production and trade levels and developed a consistent approach to modeling import substitution within the IO framework. As opposed to

conventional, final demand driven impacts assessments, import substitution is modeled through a table editing procedure that allows the model to be driven by unchanged final demand. Differences between the unedited and edited solutions reflect the impacts of substituting increased domestic production for imports. More detail on the table-editing procedure and the modeling framework in general is given in Section 6 of this report.

To generate the regional tables for the five sub-national regions of the US, the average regional purchase coefficient (RPC) method was used in conjunction with region-specific data on many of the production and economic parameters. The RPC method estimates trade flows based on econometric equations that rely on a number of regional-to-national variables including wage, output, and commodity weight/value ratios, the ratio of the number of users of a good, the ratio of the number of producers of a good, and the land area ratio.

Results are reported within two contexts. The first represents estimating the impacts of a standardized 10 percent change in production. These impacts are shown in two parts, an analysis of a 10 percent increase in oil production and an analysis of a 10 percent increase in natural gas production. These impacts provide a benchmark to facilitate comparisons of impacts within and across regions.

The second context reflects the production level changes forecasted by the Energy Information Administration's National Energy Modeling System (NEMS) in 2010, 2020 and 2030 assuming the implementation of the Lieberman-Warner Climate Security Act of 2007 (S.2191). Under this context, forecasted regional production impacts were compared to production levels forecasted under a business-as-usual (BAU) scenario, also through the NEMS. When forecasted production under S.2191 was lower than the BAU levels, the impacts are reported as an opportunity cost of implementing the legislation. In contrast, when forecasted production under S.2191 was higher than the BAU levels, the impacts are reported as a benefit of implementing the legislation. The analysis under this context was conducted to illustrate the potential uses of the model developed under this project and to provide guidance on how to model projected production declines.

The impact analyses results under the two contexts described above are listed in Section 9.2 of this report.

Section 1:0 Objective, Scope, and Key Assumptions of the Impact Analysis Project

1.1 Objective

In August 2005, President Bush signed the Energy Policy Act (EPAct) into law; EPAct was the first national energy legislation in more than a decade. EPAct Sections 965, 968 and 999 all support oil and gas research and development (R&D). Sections 965 and 968 relate to programs that DOE's Office of Fossil Energy and the National Energy Technology Laboratory (NETL) are already implementing. Section 999 (EPAct 999), however, adds a new dimension to the overall DOE oil and gas R&D effort, enhancing opportunities to demonstrate ultra-deepwater and unconventional technologies in the field and accelerate their implementation in the marketplace.[1] In addition to the direct support of technology development, Section 999 also provides for benefits and impact analyses to be conducted in support of the technology development programs.

Technologies supported and advanced by EPAct 999 funding are expected to increase the United States' natural gas and oil production while lowering production costs. The goal of this project is to develop a model that will facilitate a national and regional economic analysis of the potential impacts of offsetting natural gas and or oil imports by increasing domestic natural gas and oil production in areas likely to be impacted by this R&D program. Because this project is conducted prior to the development of EPAct 999-related technologies, it does not intend to capture the impact of deploying new, potentially game-changing technologies into the market. Rather, this analysis intends to serve as a baseline of potential impacts that could be derived using present-day technologies.

Ultimately, this project is aimed at capturing the economic impacts of industry-based activity associated with converting new and existing reserves into production and moving this product to the point of refinement or processing. In the case of natural gas, processing is included within the scope of this project. The incremental value of these activities is defined as the net value of the new domestic production activities less the value of imported supply activities within the United States.[2]

This research is distinguished from other research efforts in three major dimensions. First, this project rests on a foundation of comprehensive oil and gas production-and-demand data specific to five primary production basins. Model data are drawn from a wide range of sources and compiled under a comprehensive framework. Second, this project conjoins the foundation data

[1] NETL, 2007, p. 10.

[2] Earlier definitions of incremental value included the possibility of incorporating an aspect of loss of economic activity associated with imports-handling activities such as operation and maintenance of liquefied natural gas (LNG) facilities, natural gas pipelines and port off-loading of crude oil. Subsequent research, however, suggests they not be incorporated for two reasons. First, many of the related imports-handling activities are insubstantial, such as coupling a pipeline connector and throwing a switch. Activity levels this small, in and of themselves, are effectively beyond the accuracy of most macroeconomic models and would be completely overwhelmed by the positive impacts of increased domestic production. Second, even if the associated direct impacts were more substantial, there is effectively no data available with which to quantify them.

above with a macroeconomic modeling framework at both national and sub-national regional scales. Third, the method of modeling import substitution that was developed and implemented in this project differs from previous approaches, both by the design and of the focus on sub-national regional economic impacts.

1.2 Scope

The scope of the project is the economic analysis of regional and national impacts of the substitution of domestic oil and natural gas production for imports on a variety of economic factors, including output, jobs, income and Federal and State taxes. The impacts will cover those derived from direct, indirect and induced economic activity. Additionally, if possible, the model will estimate level changes to total governmental spending (due to increased tax and/or royalties revenue[3]) and consumer expenditures. This analysis will be conducted for five state or multi-state sub-national regions and for the United States as a whole. Detailed discussion concerning the selection of the sub-national regions can be found in Section 4.0.

This project is focused on capturing the incremental, comparative value of replacing imports with domestically sourced onshore oil and natural gas in various regions of the United States as well as in the national context. Because the goal of this project is specific, the project must employ scope boundaries. Thus, a critical decision point in this project is the determination of what will and will not be included in the model and the resulting analysis.

For both natural gas and oil, the project boundary encompasses raw material extraction and transmission of this raw material to a processing facility. It is acknowledged that increased domestic production of natural gas and oil may overwhelm existing transportation modes that move supply from new or existing extraction sources to the processing site. Therefore, the analysis will incorporate pipeline construction costs on a per-well and average-distance basis.[4]

Because additional domestic production is displacing current dry natural gas and crude oil production in a 1:1 ratio, new transportation infrastructure is not expected to be required to move processed natural gas or processed crude oil out of a refinery. Should such infrastructure be required by the region, this impact is not captured within the boundary of this project. For this reason, the existing transportation system (pipelines, trucks, etc.) will be analyzed to determine if additional resources would be needed to satisfy only the movement of natural gas and crude oil to a processing plant or refinery.[5] The costs of land acquisition and subsequent impacts on real estate and development values, however, lie beyond the project scope.

[3] Royalties revenue will not be calculated as part of this project. Should royalties revenue be reported with this project's results, they will be an exogenous input from the presently on-going DOE/NETL project 402.02.01.
[4] Operation and maintenance (O&M) costs for pipelines are embedded into the production function of the natural gas and oil extraction industry and therefore will automatically be captured in the analysis of increased production.
[5] Data required to incorporate pre-processing transportation impacts include, but may not be limited to, existing refinery and pipeline capacity locations and utilization rates and distinct construction and O&M costs. Consideration of impacts on the trucking industry may be limited to capacity additions in the form of demand for additional tanker trucks and possibly fuel demand. Modeling the impacts of increased truck transportation comprehensively can be an exceedingly complex process, the majority of which lies beyond the scope of this project.

Because domestically produced natural gas is oftentimes less pure than imported natural gas, it is important to include the gas processing facility within the boundary of the project.[6,7] A portion of marketed natural gas does not require processing and is sent straight to the transmission and distribution system. Pipelines that move unprocessed natural gas to end users are outside the scope of this project.

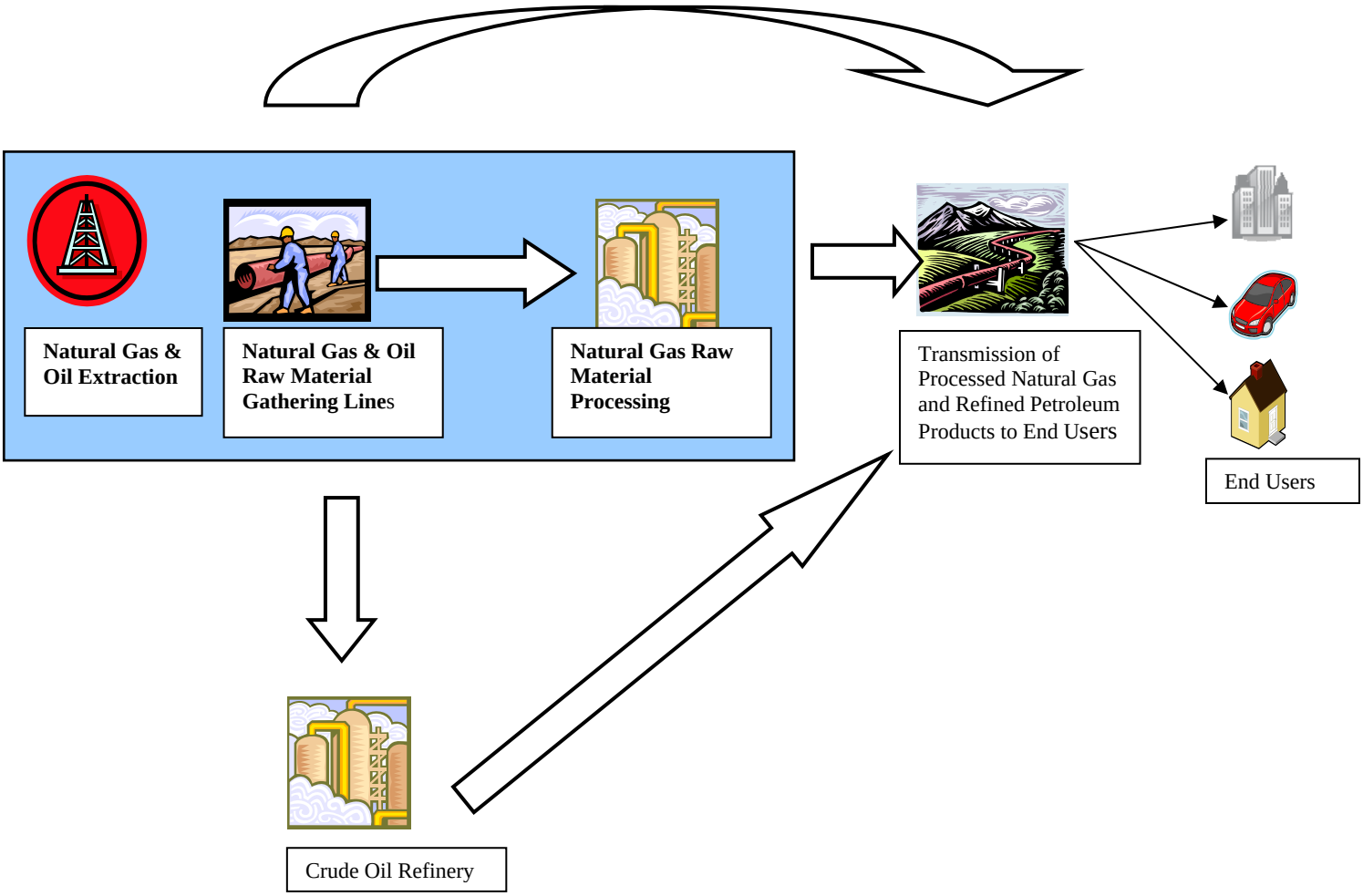
For the purposes of this study, we assume that domestically produced crude oil is immaterially different from imported crude oil with respect to the amount of processing required and thus is processed with the same level of ease or difficulty as current imported volumes. This assumption supports the exclusion of refineries from the project boundary. Shipments of crude oil from the field to a collection station, however, are still within project bounds. Pipelines that move crude oil from a collection station to the refinery are outside the project boundary.

Once natural gas is cleaned at a processing plant or crude oil is refined at a petroleum refinery, these products are considered ready for distribution to end users. At this point in the life cycle of natural gas and oil, no distinction is made between domestic and imported supplies. Therefore, because shifting supply from imported to domestic sources has no bearing on the post-processing system, the transportation system that moves supply from the processing site to the end user is not within the system boundary.

[6] Gas-processing plants yield by-products that can be sold and thus increase total gas processing industry output. This output will be higher when domestic natural gas production increases because imported LNG has been processed prior to shipment to remove impurities.

[7] Imported LNG is received at pipeline quality and does not require further processing at domestic natural gas processing plants.

Figure 1. System Boundary for Valuing the Incremental Value of Producing Natural Gas and Oil Domestically



The scope of this project is also bounded by assumptions on supply displacement. In the model constructed and the subsequent analysis, it is assumed that domestic production will only displace natural gas imported via pipelines or as liquefied natural gas (LNG) and crude oil and will not impact refined oil product imports. A review of major project assumptions is provided in Section 1.3.

The project will also incorporate an element of time. EPAct 999 activities began in 2007, though many of the technologies aimed at increasing domestic production are not expected to become commercially available until after 2009. However, this project is focused on impacts of increasing production in regions that are home to resources targeted by EPAct 999, such as unconventional natural gas and oil reserves and does not attempt to estimate the impacts derived from EPAct 999 technologies, per se. Although EPAct 999, in part, focuses on the development of technologies for use in ultra-deep water (UDW) extraction, impacts of increased production

from UDW activities are not analyzed in this study due to project resource constraints. There is, however, a potential area for future work following the demonstration of the methodology developed here for onshore production impacts. The analysis conducted through this project covers increased production that begins prior to EPAct technology deployment. As a result, the scenario impact analysis, presented in Section 9.0 presents an analysis of incremental production impacts for the years 2010, 2020 and 2030. This section also presents the results of an alternative production forecast.

As an additional point, effects on prices and behavioral responses to relative price changes lie outside the project system boundary. Furthermore, electric power industry employment and output data are typically reported for the industry as a whole. It is reasonable to assume that changes in fuel prices due to increased domestic fuel production would lead to shifts in electric generation shares from one fuel to another, potentially leading to impacts on end-user average electricity prices. However, given the level of industry aggregation, the shift in generation shares would occur within the same aggregate sector, thus no impact could be detected. Impacts on end-user average electricity prices therefore will not be captured.

1.3 Design Parameters and Assumptions

This section provides information on various components of the study process and model design that must be clearly defined to ensure the goals of the project are met. Some study parameters are discussed in other sections of this report. Specifically, Section 1.2 lists the economic variables that will be analyzed by the model. Section 4.0 discusses the geographic level of detail that will be used in this study and presents map-based presentations of the project's analysis regions. Appendix B defines the industry detail that is maintained in the model. Lastly, a list of preliminary data sources is presented in Section 5.0, while Section 6.0 discusses the project methodology and Section 7.0 reviews the model construction and calculation methodology.

This project incorporates several assumptions into the study design. These assumptions impact the results and should be taken into consideration when analyzing, interpreting and applying the results generated from the project model.

To isolate the value of increasing domestically produced natural gas and oil, a primary assumption is that increased domestic production replaces imported supplies in a one-to-one relationship, thus leaving the total supply of energy resources within a region and/or the United States unaffected by increased domestic production.

Specifically, the modeling approach assumes the following:

- Domestic crude displaces imported crude only.
- Domestic crude is materially equivalent to imported crude in terms of processing requirements.
- Domestic natural gas displaces imported LNG and pipeline imports.[8]

[8] Energy Information Administration (EIA) data show that none of the sub-national regions currently import LNG and only California has LNG exports.

- New regional production will be used within the region to the extent that the region is under-supplied; beyond this point, new production will be exported beyond the region's borders in proportion to the existing export destination distribution.

Average transportation distances will be applied to the analysis to facilitate the calculation of required pipeline distances for new and displaced oil and natural gas supplies. These averages were developed during the course of the project and are based on a review of available data and literature.

This project's researchers recognize that oil and natural gas supplies are often purchased from suppliers through long-term contracts. Therefore, to accommodate the injection of new domestic supply and the displacement of imports, it is assumed that a significant portion of imported supply is held under short- to medium-range contracts such that new domestic supply can displace imports without causing implied contractual infractions.

It is also assumed that resources exist to meet employment, material and service demand of increased domestic production. Other assumptions consistent with the economic input-output (IO) modeling framework will be adopted for this analysis.

The output of the model will be in monetary terms. It is expected that all output will be in 2006 constant dollars, which is consistent with the model's input data. If, and as needed, deflators will be based on IMPLAN[9] data.[10]

Section 2.0 Comparison to Other Production Impact Studies

Agencies such as the Interstate Oil and Gas Compact Commission (IOGCC) and the Independent Petroleum Association of America (IPAA) conduct single-year studies on the economic activity and resulting economic impacts of activity within the oil and natural gas industries. While the project outlined in this report addresses issues within the same problem domain as research reported in the IOGCC and IPAA reports, this project does not intend to duplicate these external efforts but rather aims to complement and expand the information and insights provided by them. This project quantifies the impacts of import substitution (a) with a different geographical breakdown and coverage, and (b) by using a fundamentally different methodological approach than the studies accessed and reviewed to date. Without exception, the studies reviewed use final demand-based estimates to drive their assessment models. The approach used here relies more directly on table editing procedures that emphasize the impacts of domestic output changes rather than changes in final demand (although the latter also enter into our analyses, as described in greater detail in later sections).

[9] IMPLAN (IMpact analysis for PLANning) is an input-output-based analysis framework produced by the Minnesota IMPLAN Group (MIG), Inc.

[10] IMPLAN provides deflator estimates through 2020. These deflators will be extrapolated to estimate deflators for later years.

The IOGCC publishes an annual report on the number of and production from marginal oil and gas wells. These reports, entitled *Marginal Wells*,[11] focus on the availability and production of oil and gas resources from marginal wells[12] as well as the economic activity that arises from increasing production from these marginal wells. Two key differences between the IOGCC report and DOE's project *Valuing Domestically Produced Natural Gas and Oil* are (a) the geographic breakdown and coverage and (b) the production process coverage.

In the IOGCC report, production and economic impacts are reported on a state-level basis for 11 states. The 11 states selected for the IOGCC study are those deemed to be the top oil producers in the country, excluding Alaska. These states are responsible for more than 90 percent of marginal oil well production.[13] When marginal gas production was added to the IOGCC study, the 11 states selected based on oil production were maintained for consistency, even though they only have about 43 percent of the total marginal gas wells in the United States.[14] Furthermore, the 11 states selected exclude the Appalachian states even though the Appalachian Basin accounts for about 51 percent of the marginal gas well count and almost 29 percent of the marginal gas produced.[15]

In contrast, all contiguous continental United States will be included in the research area for the DOE project – some are covered through single- or multi-state regions, while all are covered in the U.S.-Lower 48 model region. This difference will allow for a more comprehensive coverage of both oil and gas production, though this is more notable for gas production. Additionally, in the DOE project, selected states will be grouped into five state or multi-state sub-national regions of particular interest.

The IOGCC report includes production and activity data for marginal wells. According to the latest IOGCC report, these wells contributed 18 percent of oil and 9 percent of natural gas produced in this country in 2006.[16] The DOE report will provide a broader view of impacts from increased activity in the oil and natural gas industries by modeling impacts derived from increased domestic oil and natural gas production, regardless of reserve type or production method.

The IPAA publishes an annual report[17] detailing domestic oil and natural gas production, cost, price, consumption and other economic data. The IPAA report provides these data on a state and national level. The primary distinctions between this project and the IPAA report are the goals of the projects and consequently, the reported data. The IPAA report provides point information on the number of wells, levels of production and reserves, unit costs for drilling wells and selling a barrel of oil or mcf of gas, average number of employees per related sector and so on. This

[11] IOGCC. *Marginal Wells: 2007 Report,* August 2007. http://www.iogcc.state.ok.us/PDFS/2007-Marginal-Well-Report.pdf.
[12] Marginal oil wells are those producing 10 or fewer barrels of oil per day. Marginal gas wells are those producing 60 or fewer thousands of cubic feet of gas per day.
[13] IOGCC, 2007. p. 24.
[14] IOGCC, 2007. p. 25.
[15] IOGCC, 2007. p. 25.
[16] IOGCC, 2007. p. 6.
[17] IPAA, *The Oil and Gas Producing Industry in Your State*, July 2005. http://www.ipaa.org/reports/econreports/IPAAOPI.pdf.

project, *Valuing Domestically Produced Natural Gas and Oil*, will use such data as guidance and calculation inputs for the valuation of domestic production that will be conjoined with a macroeconomic modeling framework. This approach will provide both point impacts and downstream impacts of increased production at both national and sub-national regional levels. Furthermore, the IPAA report reflects the industries' current production and market status while this project aims to estimate the incremental value of increasing domestic production as an offset to imports, thus capturing potential benefits from altering industries' current production.

Section 3.0 Model Evaluation and Selection

3.1 Model Review

A review of general modeling frameworks and several specific models ultimately led to the selection of the IO model as the analysis framework for this project. In addition to the IO framework and IO models such as the Job and Economic Development Impact Model (e.g., JEDI and JEDI II), the computable general equilibrium framework and existing models, such as the All-Modular Industry Growth Assessment Model (AMIGA) and National Energy Modeling System (NEMS) were also evaluated. Each of these frameworks and specific models were evaluated along a number of dimensions, including methodological basis, strengths, weaknesses, geographical scale, data requirements, model outputs and representative applications. The following section presents a brief description of the input-output modeling framework to be used in this project. A general and comprehensive introduction to and description of the fundamental input-output model is included as an Appendix to this report.[18]

The description below extends that description to more accurately reflect the specific data that forms the IO foundation of the analyses of this project.

3.2 The Input-Output Model and Accounting Framework

The foundation for an input-output (IO) model is an accounting framework that characterizes the purchases and sales of industries within an economy. Early input-output accounting frameworks divided the activities in an economy into industries, final demand activities and payment sectors. Final demand activities include consumption, investment, government expenditures and net exports. Payments sectors are those activities to which industries make payments and include households, profits, indirect business taxes and imports. Both final demands and payments sectors can be more finely disaggregated. One difficulty in characterizing purchase and sales relationships for modeling purposes is that industries often produce more than a single commodity output. Most will produce a dominant commodity output along with some number of secondary commodity byproducts. In 1972, governments began to publish IO accounting data in a commodity-by-industry format to provide a more comprehensive and accurate mechanism for modeling the relationships among industries and activities. This section presents an overview

[18] The appendix and complete evaluation of alternative modeling frameworks can be found in NETL DOE/NETL-404.03.02/020408, *Modeling Options for EPAct Project: Valuing Domestically Produced Natural Gas and Oil*.

of this framework and of the computational algorithms that produce the kinds of impact analyses on which this project focuses.

The table below is a schematic diagram of the generalized commodity-by-industry accounting framework.

Table 1. Commodity-by-Industry Accounting Framework

	Commodities	***Industries***	***Final Demand***	***Total Output***
Commodities		U	E	q
Industries	V			g
Value Added		W		
Total Input	q'	g'		

Four tables define the information generally included in published data sources. These are *U*, *V*, *E*, and *W*. *U* is called the Use table—all of these tables are generally represented in matrix format, so are often referred to as matrices rather than tables—and represents the use of commodities by industries. The number of industries and commodities is not required to be equal, but in practice there is a one-to-one correspondence among them. Table *V* is called the Make table and represents the commodities produced by industries. (The Use table is also called an absorption table, and the Make table is often called the byproducts table.) The sum across any commodities row of *U* and *E* equals total commodity output. The sum down any industry's column of *U* and *W* equals total industry input. The sum across an industry row of the Make table equals total industry output, while the sum of any commodity column of the Make table equals total commodity output. By definition, total commodity or industry inputs equal total commodity or industry output. These identities are reflected mathematically in the first six equations below:

1) $Ui + E = q$
2) $Vi = g$
3) $V'i = q$
4) $B = U\hat{g}^{-1}$
5) $U = B\hat{g}$
6) $q = Bg + E$
7) $D = V\hat{q}^{-1} \rightarrow d_{ij} = v_{ij} / q_j$

B is a standardized version of the Use table that depicts dollars worth of commodity input per dollar of industry output. Its use embodies the linear technology assumption and defines the input-output coefficients. Equation 7 reflects the industry-based technology assumption, which implies that an industry's output product mix is variable, and that the total output of a commodity is produced by industries in fixed proportions. Hence, *D* is the standardized version of *V* that describes the commodity output distribution of industries.

The total commodity or industry requirements to satisfy a given level of commodity or industry final demand can be derived from these basic equations. For example, the total commodity requirements necessary to meet a given commodity final demand can be derived as:

8) $V = D\hat{q}$

9) $D\hat{q}i = g$ (from 2)

10) $g = Dq$

11) $q = BDq + E$ (from 6)

12) $\left(I - BD\right)^{-1} E = q$

Likewise, total commodity requirements to meet a specified industry-based final demand are derived as:

13) $Y = DE$

14) $E = D^{-1}Y$

15) $\left(I - BD\right)^{-1} D^{-1}Y = q$

Total industry requirements to meet a specified commodity final demand are shown in equation 17 and total industry requirements to meet industry-based final demand are shown in equation 21, below.

16) $\left(I - BD\right)^{-1} E = D^{-1}g$

17) $D\left(I - BD\right)^{-1} E = g$

18) $E = (I - BD)D^{-1}$ (from 16)

19) $E = (D^{-1} - B)g$

20) $DE = \left(I - DB\right)g$

21) $\left(I - DB\right)^{-1} Y = g$ (from 13: $Y = DE$)

The formats in which the data are published therefore provide a great deal of flexibility in modeling choices. The expression most compatible with and supportive of the analysis for this project is the industry-by-commodity relationship represented in equation 17. Our base model will provide commodity final demand and the Use and Make tables that will be edited as described in Section 6.2 on the table-editing procedures for the model.

Section 4.0 Definitions of Regions Used in the Model

The analysis conducted through this project will explore the potential impacts of domestic natural gas and oil production on a regional and national basis. Therefore, a key decision point in this project was the definition of analytical regions. The project models six U.S. regions—five sub-national regions and one national region. The nation as a whole is modeled separately because there are interregional interactions that are not captured when modeling impacts within one region. Thus, the sum of the impacts over the five sub-national regions will not correspond to the sum of the impacts on the nation. The difference between the national impacts estimate and the sum of the region-specific impacts is attributable to interregional economic interaction.

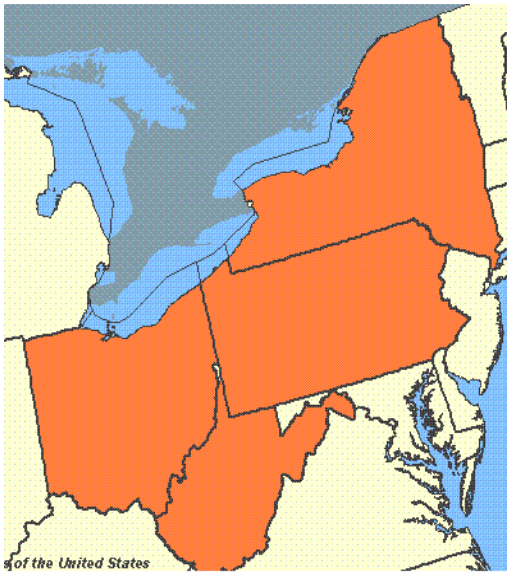
The results of this analysis include incremental impacts of producing natural gas and oil domestically on gross output, jobs and taxes. Current data on these economic factors are generally reported on a state-level basis. Additionally, natural gas and oil supply and demand data are also on a state-level basis. As such, it was important to define the analytical regions along state lines.

The primary focus of this analysis is the impacts associated with increased domestic natural gas and oil production. Therefore, the regions, in addition to following state lines, also needed to represent states with large reservoirs and production levels. The primary resource used to guide the construction of the regions was the "Major Oil and Natural Gas Basins of the United States" map[19] that is based on data from the Energy Information Administration (EIA). Additionally, resource areas that are the focus of EPAct 999-directed research were also considered in the development of the final regions. To the greatest extent possible, large resource reservoirs that cross state lines were kept within the same region, although this wasn't always feasible. States with little or no natural gas or oil production were not included in any of the sub-national regions and will only be included in the national-level analysis.

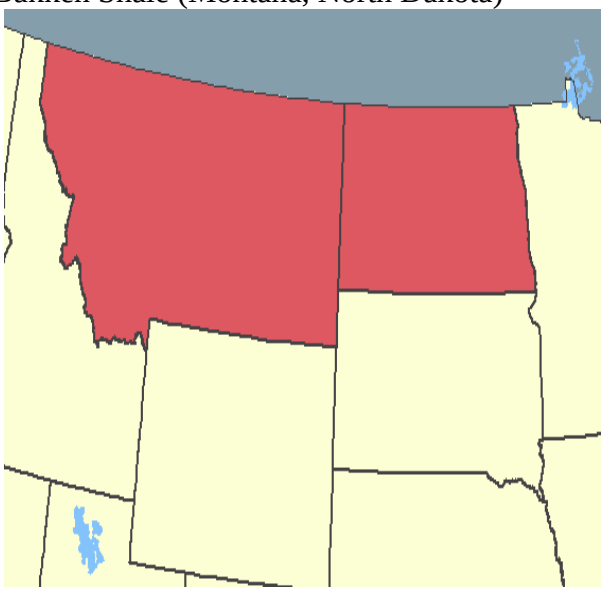
[19] The "Major Oil and Natural Gas Basins of the United States" map is Figure 9 in the Design Basis Document.

The final regional delineation is shown in the region-level maps below.

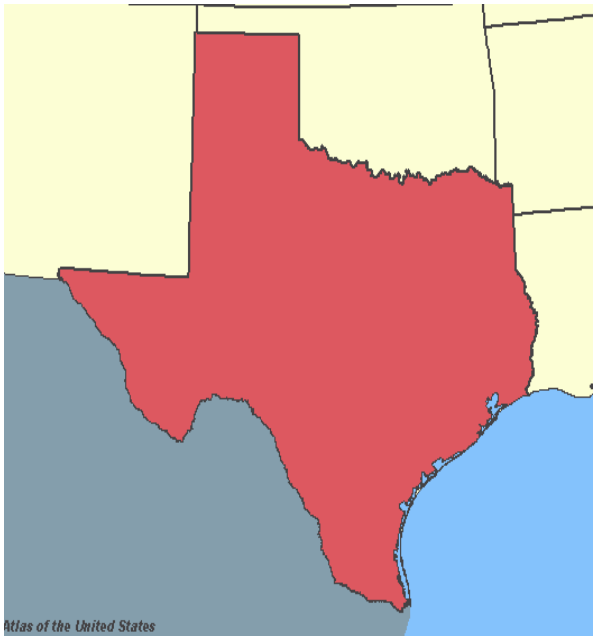
Region 1. Marcellus Shale (New York, Pennsylvania, Ohio, West Virginia)



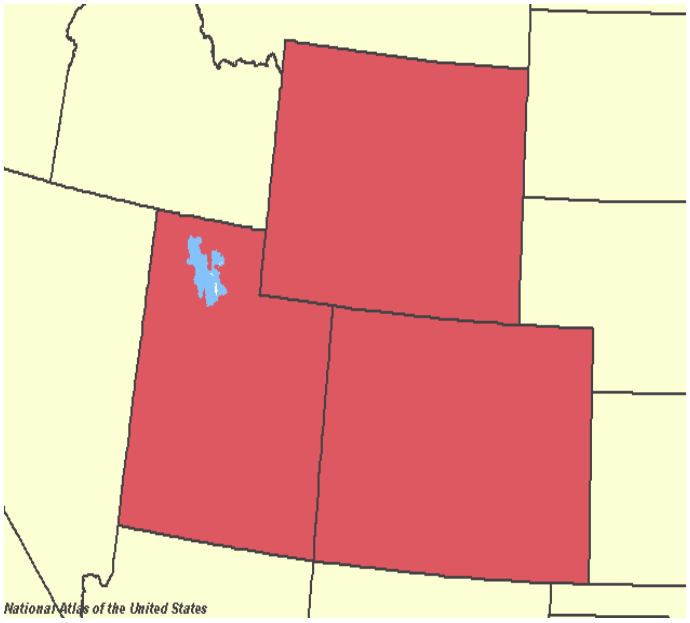
Region 2. Bakken Shale (Montana, North Dakota)



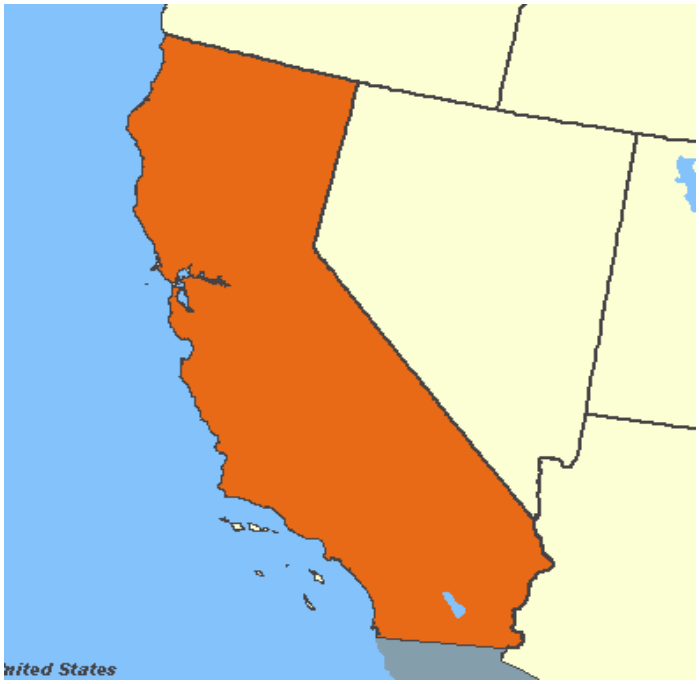
Region 3. Barnett Shale (Texas)



Region 4. Greater Green River/Pinedale Anticline/Jonah Field (Wyoming, Colorado, Utah)



Region 5. California (California)



Region 6. United States – Lower 48

Section 5.0 Model Data Sources

As noted in Section 1.0, this project will analyze potential impacts from increased domestic natural gas and oil production using the IMPLAN input-output database. This project uses the latest version of IMPLAN, which is for 2006. More information on the IMPLAN model and its use in this project is provided in Section 6.0.

To assess potential impacts from increased domestic natural gas and oil production, it is imperative to understand the regions' current activities related to demand, production, supply, prices, and employment, as well as the natural gas and oil industry's inter-industry relationships. Because they provide the majority of natural gas and oil market data (demand, production, supply and prices), the EIA is the primary data source for this project. Annual 2006[20] data were collected and aggregated to the regional level for inclusion in the model. Import and export data were arranged to identify the volumes of interregional and international flows and average trade prices were calculated by aggregating and averaging state-level data as shown in Table 2.

Table 2. Example of International Trade Price Calculations

Region	*State*	*Import Volume (Natural Gas, MMcf/yr)*	*Import Price ($/tcf)*	*Value of Imported Natural Gas (volume x price) (thousand $)*	*Regional Average Import Price ($/tcf)*
2	Montana	684,279	$6.75	$ 4,616,768	Calculated as regional value divided by regional volumes
2	North Dakota	514,053	$6.71	$ 3,451,307	
2		**1,198,332**		**$ 8,068,074**	**$6.73**

Market prices for processing plant byproduct output were drawn from Barnes & Click, Inc. and margin ratios for converting producer and purchaser prices were extracted from the Bureau of Economic Analysis' (BEA) 2002 Benchmark Input-Output Tables.

The boundaries for this study, as noted in Section 1.2, extend from the field to the back end of the processing plant for natural gas that requires processing and from the field to the gathering center for natural gas not requiring processing, as well as for crude oil. Once production increases, impacts on field-level activity and the industry's supporting infrastructure will be calculated. These calculations, more thoroughly discussed in Section 7.1, are based on data such as per well production levels; processing plant capacity and utilization rates; oil pipeline capacity and utilization rates; and construction data for wells, processing plants and pipelines. As with the market data, the EIA serves as the primary data source for production rates, well counts and plant and pipeline capacities and utilization rates.

[20] 2006 data were used because these are consistent with the data in the model's framework data from IMPLAN and because 2006 is the most current complete year available for nearly all required data sets required for this study.

Construction data for natural gas and oil wells are derived from the 2003 Joint Association Survey on Drilling Costs (JAS). These costs are provided by state and by well depth. In IO accounts, such as those provided by BEA, well construction is part of fixed investment. Following BEA's approach of using the Producer Price Index (PPI) to deflate costs associated with well construction, the 2003 drilling costs provided by the JAS were inflated to 2006 costs using the PPI for industry 213111 (Drilling Oil and Gas Wells), product 213111213111 (Drilling Oil and Gas Wells).

Gathering pipeline costs are based on onshore data provided in the *O&G Journal's* 2007 U.S. Pipeline Costs Survey. These data (capital cost/well) are combined with data on existing gathering pipeline mileage,[21,22] EIA data on onshore wells and production and an estimate for the percent of existing lines that are useful (set at 80 percent for calculation purposes).

State-level data on processing plant construction costs are derived from cost data in Kidnay and Parrish, *Fundamentals of Natural Gas Processing*, 2006; EIA's *U.S Crude Oil, Natural Gas, and Natural Gas Liquids Reserves Report;* and the United States Geological Survey's *2006 Mineral Yearbook (Sulfur).*

Section 6.0 Regional and National Table Construction Methodology

6.1 Input-Output Model Obtained from IMPLAN

Software and data purchased from the Minnesota IMPLAN Group, Inc. forms the foundation for the regional IO models and for the national IO model. All of the models have been constructed with the IMPLAN software, using 2006 structural and region-specific data.

Within each model, trade flows—the transfer of goods and services between the region and the rest of the world—are estimated using the average regional purchase coefficient (RPC) method. The RPC method estimates trade flows based on econometric equations internal to IMPLAN. These equations are based upon a number of regional-to-national variables, including the wage ratio, "other costs" ratios, output ratios, the commodity weight/value ratio, the ratio of the number of users of a good, the ratio of the number of producers of a good and the land area ratio. The baseline and impacts estimates of relevant variables will be generated using the independent modeling framework developed in this project. The following data are extracted from IMPLAN and saved in spreadsheet form for use in the impacts assessment model:

- Regional Use Table – contains information on the use of commodities by industry (the dollar value of purchases of goods and services by each industry for use in the production process)

[21] Natural Gas: http://www.naturalgas.org/naturalgas/processing_ng.asp and Pipeline and Hazardous Materials Safety Administration, US DOT http://ops.dot.gov/stats/stats.htm.
[22] Oil: http://www.pipeline101.com/Overview/crude-pl.html.

- Regional Make Table – contains the information on the output distribution of commodities by industry (the dollar value of each good and service produced by each industry)
- Total Commodity Imports – sum of intermediate and institutional imports of commodities (goods and services)
- Total Commodity Final Demand – institutional demand for the final use of commodities (includes the household consumption portion of final demand)
- Employment by Industry – total employment (number of jobs) for each industry (sector)
- Tax Multipliers – multipliers for all tax variables, including business taxes (expressed in dollars by type per dollar of industry output)

6.2 Table Editing Procedure

The IO modeling framework forms the analytical basis for this project. However, unlike most conventional final demand-driven IO applications, this project focuses on the changes that can be expected to occur in response to increased domestic (intraregional) production replacing previously imported oil and gas (commonly referred to as *import substitution*). Whereas the former analyses are implemented by driving an existing structural model with a new final demand or final demand change vector, the latter are implemented by driving a model based on an edited IO structure by unchanged final demand. Our analytical model will accommodate both modes of analysis, along with combinations of modes when needed. Import substitution impacts will be computed as differences in model outputs between the initial baseline outputs and those of the edited model.

There are two general categories of impacts our model will assess. These are the impacts of increased domestic production and the impacts of any new construction necessitated by the shift from imports to domestic production. Whereas construction impacts are associated with one-time events, production impacts are considered to be long run and annually recurring. Hence, the two impacts categories are reported separately. The modeling approach for each of these impacts categories will be addressed separately below.

6.2.1 Import Substitution Impacts

As domestic production increases, the first and most direct impact will be on the output-increasing industry (or industries). This output increase results in greater numbers of employees and their associated income in the producing industry (and region), and it results in increased demand for intermediate materials and supplies used in the industry's production process. A second impact will be reflected in larger dollar transactions associated with sales from the output-increasing industry to any other domestic sectors that previously had to import supplies now available from domestic sources. The latter changes also imply potential changes in transport costs (margins), particularly when transportation distances have changed markedly. However, margins were also associated with the previous import purchases. Hence, there may in fact be no detectible change in the margins associated with import substitution. Were cases to arise in which there is high confidence that margins associated with domestic production are substantially

different from those associated with imports, and in instances where these differences were quantified with high levels of certainty, the table could be edited to reflect the new margin values. To date, however, no such instances have been identified. Therefore, this mechanism is not included in the prototype model and not expected to be a feature of the final model.

Sub-national regional IO models differ most markedly from national IO models in their greater reliance on imports because sub-national regions are typically more open to trade than their national counterparts. This is reflected through the values in supplying rows of the regional IO coefficients table being less than (or at most equal to) their national counterpart values, such that the regional trade coefficient plus the imports coefficient equals the corresponding national coefficient. Table editing for import substitution therefore proceeds by effectively increasing the intraregional coefficients in the output-increasing row in proportion to the increases in domestic supply. These regional trade coefficient increases will continue until the point at which they equal their national counterpart values. At this point, all domestic (intraregional) demand for the industry's output will have been satisfied. Any additional output over and above the intraregional demand will be added to the baseline final demand vector in the appropriate industry row. The appropriately adjusted baseline, final demand vector will then be used to drive the newly edited model.

In actual implementation, table editing takes place in a byproducts matrix. Modern IO accounts are published in what is known as commodity-by-industry format; this is also the format of the IMPLAN data that forms the basis of our analyses. Rather than the more traditional inter-industry IO tables, the foundations of the commodity-by-industry accounts are the Use and Make tables. The Use table is organized as a series of columns, one per industry, with each row corresponding to a commodity used as an input to the column industry's production process. Commodities and industries generally share common names, with the industry being named according to its primary commodity output. This table, populated by the dollar value of commodities used by each industry, represents the technical requirements of each industry for the production of its output over the course of a one-year period. When the columns of the Use table are standardized by corresponding industry output values, the values in each cell of the table can be interpreted as cost shares and can be referred to as input-output technical coefficients.

The Make table is also referred to as a byproducts table. The rows of this table refer to industries, while the columns refer to commodities. The dollar values along any row represent the primary and secondary commodities produced by the row industry. In addition to the regional industries represented as rows in a byproducts table, there will be a final row that refers to a rest-of-world industry, which is the source of commodity imports. Because this row is present, the sum of the values in any commodity column will be equal to the total supply of the commodity available for the satisfaction of regional and export demand. As an industry increases domestic (regional) production and reduces its imports of a commodity, the element in that industry's row for the commodity whose output is being increased will take on a larger value, and the rest-of-

world industry value for that commodity will be decreased. When used to generate an inter-industry table, the mathematical operations will have the effect of increasing intraregional cost shares for the strengthening domestic industry and decreasing import cost shares, which is the goal of modeling import substitution.

Should the commodity output increase exceed the amount of commodity formerly imported for satisfying regional demand, the excess will be added to the baseline final demand vector. The edited IO matrix will be post-multiplied by the final demand vector to generate a counterfactual activity level, which will be compared to the baseline activity level to estimate the impacts of the import substitution. Activity levels will include industry output, employment, income and tax revenues.

A final consideration in the substitution of domestic production for imports concerns the characteristics of the domestically sourced natural gas. Imported natural gas is considered "clean." Domestically produced gas requires an additional processing step to separate byproduct gases in the cleaning process. This results in a moderate shift in the distribution of outputs of the gas processing sector away from the dominant output and toward the byproducts. This shift can be reflected in an edited Make table to the extent that this shift can be quantified.

6.2.2 Construction Impacts

Because the IO model is a current accounts modeling framework, the investment in construction of new production facilities should not be included in a model intended to identify ongoing, annually recurring impacts. The impacts of these investments, however, can be captured separately. These impacts will occur once, but not continue in subsequent years. To model these construction impacts, total construction dollar investments are translated into final demands for goods and services necessary for the particular kinds of production facilities involved. For this model, we are interested in the construction impacts associated with natural gas and oil wells. Final demand vectors constructed in this way drive the IO model computation in the conventional fashion.

While there will be new operating and maintenance expenditures associated with the operation of the new natural gas and oil wells, these expenditures are already effectively captured by increased output values that result from the increases in intraregional inter-industry interaction. They are implicitly embedded in the IO structure for the region and need not be handled separately.

6.3 International Trade Feedback Effects

As U.S. imports of oil and gas are offset by increased domestic production, countries that formerly exported to the United States will either export to other countries or will simply export less. In the latter case, the loss of income to such countries could result in decreased imports of U.S. goods. The maximum decrease in their imports from the United States would correspond to a U.S. export decline equal to the value of the formerly imported oil and gas. The maximum possible impact is unlikely, since those countries would be expected to find other markets for some portion of the oil and gas formerly sold to the United States, and since some portion of the

declines in their imports would be expected to impact countries other than the United States. Even with detailed historical trade data, the proportion of the displaced import value not received and consequently not re-spent by foreign countries on U.S. goods would be virtually impossible to predict with accuracy. Hence, the model allows for this proportion to be specified by the user, with values ranging from zero to a maximum of 20 percent of the value of displaced imports. Let P^X denote this "feedback" proportion, whose default value will be set at 0.2.

The value of the reduction in U.S. exports will equal the product of the feedback proportion and the value of displaced imports. We assume that the reduction in national exports of each commodity will be proportionate to each commodity's share of total base year national exports. The region's share of the reduction in foreign exports for a given commodity will be proportionate to the region's share of national exports of that commodity. If we let Δ denote *change in*, X_i^r denote region, r be commodity i exports, X_i be commodity i national exports, and X be total national exports, then

$$\Delta X_i^r = \left(P^X\right)\left(IS_i\right)\left(\frac{X_i^r}{X_i}\right)\left(\frac{X_i}{X}\right) = \left(P^X\right)\left(IS_i\right)\left(\frac{X_i^r}{X}\right)$$

where IS_i is the value of displaced imports. Changes in exports are then subtracted from the baseline final demand vector to generate the impact final demand vector in non-oil and gas commodity sectors.

Section 7.0 Spreadsheet Model Construction

The model used to assess the impacts of increased natural gas and oil production is an Excel spreadsheet model. The model is comprised of a region map sheet, a user-interface sheet, a results sheet and multiple data and calculation sheets. All data, unless otherwise noted, are for calendar year 2006. Natural gas is presented in million cubic feet per year (MMcf/yr) and oil is presented in thousand barrels per year (thbbls/yr) unless otherwise noted.

The user interface tab, "Inputs," allows the user to select the region for analysis and enter the volumes of increased wellhead production and the well depth for the region. As the user makes selections on well depth, the model presents the per-well drilling costs for that region (thousand $/well). Producer prices for natural gas and oil are also presented to the user. Lastly, this portion of the model presents the user the option to set an international trade feedback rate. This percentage, bound to a range of 0 percent to 20 percent reflects the impacts of increased regional production that leads to a decline in international natural gas and/or oil import. These reduced imports could cause a decline in revenue by the exporting country. The decline in international revenue could then cause a downstream decline in imports of U.S. goods by impacted countries.

Below the user input section of this tab, data on the current (2006) state of activity within the region are presented to the user as guidance for the user's selection of increased regional production. The data presented as informational guidance and the calculations used to convert user production inputs into model inputs (converting production volumes into dollars) are based on data held in the tabs "NG Data Sheet" and "Oil Data Sheet." The following section details how the informational values and the model input values are calculated (more information on the

base data in tabs “NG Data Sheet” and “Oil Data Sheet” will be explained in greater detail later in this section). Detailed instructions for this tab are in the section *User Instructions*.

7.1 Calculations

7.1.1 Regional Information

The box “Regional Information” on the tab “Inputs” provides the user with information on the current industry-related activities within the region. These data are provided to inform the user’s entries for increased production based on the region’s current supply-and-demand balance.

a. Regional Demand: $\sum_{S1}^{Sx} C$ where C = consumption in all sectors, S = state within region

b. Regional Imports: $\sum_{R1}^{R5} M$ where M = imports from all other regions and international sources, R = importing region. Imports between states in the same region are considered regional production and are not counted as regional imports.

c. Current Well Withdrawals:

   Natural Gas: $\sum_{S1}^{Sx} NGPng, o$ where NGP = wet production of natural gas, ng = gas wells, o = oil wells, S = state within region

   Crude Oil: $\sum_{S1}^{Sx} OPng, o$ where OP = crude production of oil, ng = gas wells, o = oil wells, S = state within region

d. Number of Wells: $\sum_{S1}^{Sx} W$ where W = fuel specific producing wells, S = state within region

e. Current Marketed Production (applies only to natural gas): $\sum_{S1}^{Sx} Pg - PLg$ where Pg = wet production of natural gas from gas and oil wells, PLg = production losses from re-pressuring, venting/flaring and removal of non-hydrocarbon gases, S = state within region

f. Natural Gas Processing Plant Capacity: $\sum_{S1}^{Sx}\left(\sum_{Plant1}^{Plantx} NGC * 365\right)$ where NGC = natural gas processing capacity per day, Plant = processing plant facility, S = state within region

g. Average Utilization Rate: $\left(\sum_{S1}^{Sx}(NGProcessed)\right) \Big/ NaturalGasProcessingPlantCapacity$

h. Current Dry Production (applies only to natural gas): $\sum_{S1}^{Sx} Pg - PLg - NGLg$ where Pg = wet production of natural gas from gas and oil wells; PLg = production losses from re-pressuring, venting/flaring and removal of non-hydrocarbon gases; NGLg = natural gas liquid constituents such as ethane, propane and butane removed at natural gas processing plants; S = state within region

i. Average Natural Gas Processing Plant Capacity: $\sum_{S1}^{Sx}\left(\sum_{Plant1}^{Plantx} NGC * 365\right) \Big/ \sum_{S1}^{Sx}(Plants)$

7.1.2 Production Results

Input values for input-output-based models must be in dollar format and in producer's prices. Therefore the production level values entered by a user must be converted to producer's price dollars to drive the impacts assessment model. Calculations shown in Sections 7.1.2 through 7.1.4 provide a walk-through of the calculations used to do this production-to-value conversion.

As noted in Section 1.3, the scope of this project includes natural gas processing. This allows the impacts to encompass the production of natural gas liquids that are produced when wet natural gas is cleaned to pipeline quality levels. Prior to the production-to-value conversion, the volume of additional natural gas produced at the wellhead must be converted to the volume of natural gas that reaches the processing plant market (marketed production). This volume must then be stripped of natural gas liquids, leaving the volume of natural gas that will enter the transmission and distribution system (dry natural gas).

a. Increased Marketed Production (natural gas): Increased market production is defined as the gross withdrawals of natural gas less gas used for re-pressuring, quantities vented and flared and non-hydrocarbon gases removed in treating or

processing operations.[23] The EIA provides state-level data on gross withdrawals and process losses. These data were aggregated into the model regions and the regional process-losses percentage, the parameter directly used by the model, was calculated as a percent loss of regional wet production volumes.

$$\text{Source Data Process Losses}_R = \sum_{S1}^{Sx} ProcessLosses$$

$$\text{Source Data Marketed Production}_R = \sum_{S1}^{Sx} Current\ Well\ Withdrawal s - ProcessLos ses$$

$$\text{Source Data Regional Process Loss Percent} = ProcessLoc\ sses_R \Big/ Marketed\ Production_R$$

In the model, increased marketed production from increased regional natural gas production is calculated as:

Increased Marketed Production = Increased Regional Production$_{NG}$ * (1- Regional Process Loss Percent)

b. Natural Gas Sent to Processing: According to EIA data, 23.5 Tcf[24] of wet natural gas was produced in the United States in 2006. This production yielded 19.4 Tcf[19] of marketed production of which 14.7 Tcf[25] (76 percent) was sent to natural gas processing plants for further processing. These data were also available on a state level and were used to calculate the regional volumes of marketed production that were and were not sent to natural gas processing plants.

$$\text{Source Data Processed Volumes}_R = \sum_{S1}^{Sx} (ProcessedVolumes)$$

NG Not Requiring Processing$_R$ = *Increased Marketed Production * [1-(Source Data Processed Volumes$_R$ ÷ Source Data Marketed Production$_R$)]*

Processed NG$_R$ = *Increased Marketed Production * (Source Data Processed Volumes$_R$ ÷ Source Data Marketed Production$_R$)*

[23] EIA Glossary, Marketed Production, http://www.eia.doe.gov/glossary/glossary_m.htm.
[24] EIA. Natural Gas Gross Withdrawals and Production. http://tonto.eia.doe.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm.
[25] *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves Report*. Appendix E, Table E4. Natural Gas Processed and Liquids Extracted at Natural Gas Processing Plants, 2006.

c. Natural Gas Processing Plant Output: Once the volume of natural gas that is sent to processing is determined (by calculation of Processed NG_R), the volumes of extraction losses,[26] extracted liquids and dry natural gas[27] output must be calculated. EIA presents state-level data on the volume of natural gas processed (MMcf), the total liquids extracted (thbbls) and the extraction loss (MMcf) of natural gas.[28] The relationship between these data is used to calculate the losses, liquids and dry natural gas from the increased natural gas sent through a processing plant.

Extraction $Loss_R$ = *Processed* NG_R * *(Source Data Extraction* $Loss_R$ ÷ *Source Data Processed* $Volumes_R$)

where Source Data Extraction $Loss_R$ = $\sum_{S1}^{Sx} ExtractionLosses$

Extracted $Liquids_R$ = *Extraction* $Loss_R$ * *Percent Liquids-to-Extracted* $Liquids_R$

where Percent Liquids-to-Extracted $Liquids_R$ = *Source Data Extracted* $Liquids_R$ ÷ *Source Data Extraction* $Loss_R$

where Source Data Extracted $Liquids_R$ = $\sum_{S1}^{Sx} ExtractionLiquds$

Dry Natural Gas from Processing $Plants_R$ = *Processed* NG_R - *Extraction* $Loss_R$

d. Total Dry Natural Gas to Market: The amount of dry natural gas that is sent to the natural gas transmission and distribution market represents both the volumes that did not require additional processing and the dry natural gas output by the processing plant industry.

Total Dry Natural Gas to $Market_R$ = *NG Not Requiring* $Processing_R$ + *Dry Natural Gas from Processing* $Plants_R$

[26] Extraction losses are the reduction in volume of natural gas due to the removal of natural gas liquid constituents such as ethane, propane and butane at natural gas processing plants. http://tonto.eia.doe.gov/dnav/ng/TblDefs/ng_prod_sum_tbldef2.asp.

[27] Dry natural gas is consumer-grade natural gas and is the natural gas which remains after the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field and/or plant separation) and any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. EIA Glossary, Marketed Production, http://www.eia.doe.gov/glossary/glossary_d.htm.

[28] EIA, Natural Gas Processing. http://tonto.eia.doe.gov/dnav/ng/ng_prod_pp_dcu_nus_a.htm.

e. Crude Oil Production: As previously noted, the boundary of this project, with respect to crude oil production, ends at the gathering line that then sends crude oil to the refinery. Therefore, the only production volume reported for crude oil is the increase in crude oil production without any processes having taken place.

$$\text{Crude Oil Production}_R = \text{Increased Regional Production}_O$$

7.1.3 Impact on Supply Allocation

Once the conversion of increased wellhead production to increased marketed production is complete, the role of this increased production must be determined.

a. Allocation of Increased Production to Regional Demand: A key assumption to this portion of the model is that total regional demand is constant. Given constant demand, increases in production either meet current demand, thus offsetting current imports, or increase regional exports. The allocation of increased production to current demand or increased exports is determined by the region's ability to meet demand given baseline (current) production. Therefore, if regional demand exceeds baseline dry production (natural gas) or well withdrawals (crude oil), then increased production goes toward meeting regional demand up to the point that regional demand is satisfied. The volume applied to regional demand offsets regional imports while any excess production volumes are exported (see Example 1).

Example 1: Regional Demand (D) = 500,000 MMcf/yr
Regional Production (P) = 375,000 MMcf/yr
Regional Production Variance = 500,000
- 375,000
= 125,000 MMcf/yr

Increased Regional Production set at 300,000 MMcf/yr
Increased Production to Regional Demand
= Region Production Variance
= Offset Imports
= 125,000 MMcf/yr

Increased Production Exported = 300,000
- 125,000
= 175,000 MMcf/yr

If baseline production levels already satisfy the regional demand, then any increase in regional production is exported (see Example 2).

Example 2: Regional Demand (D) = 300 thbbl/yr
Regional Production (P) = 475 thbbl/yr
Regional Production Variance = 300
- 475
= -175 thbbl/yr

Increased Production Exported = 175 thbbl/yr

b. Determining Interregional and International Shares of Offset Imports and Increased Exports: Each sub-national model region is supplied by regional and/or imported natural gas and oil.[29] Additionally, each sub-national region exports natural gas and oil to other sub-national regions and to international markets. When increased domestic production meets the regional demand, thus offsetting imports, it must be determined whether these offset imports are imported from other sub-national U.S. regions or if they are international imports. Additionally, when increased production within a region exceeds the region's demand (e.g., Example 1 above) or when the increased production is not needed within the region(e.g., Example 2), the excess supply will be exported and it must be determined whether these exports will supply other sub-national U.S. regions or if they will enter the international markets. The split between sub-national and international markets for both offset imports and increased exports is determined by the aggregation of state-level proportions as reported by the EIA.

Example 3. From Example 1, offset imports = 125,000 MMcf/yr and EIA data show that in 2006, Region X imported 775,000 MMcf/yr from other sub-national regions and 1,120,000 MMcf/yr from the international market, for total imports of 1,895,000 MMcf/yr.
Region X regional imports = 775,000/ 1,895,000 = 41%
Region X international imports = 1,120,000/1,895,000 = 59%

Given these data points, the model will calculate:
Offset imports (U.S. Regions) = 51,121 MMcf/yr, (125,000*41%)
Offset imports (International) = 73,879 MMcf/yr, (125,000*59%)

[29] For the United States-Lower 48 region, all imports and exports are sourced from and sent to the international market with no allocations to sub-national regions.

Example 4. From Example 2, increased exports = 175 thbbl/yr and EIA data show that in 2006, Region X exported 250 thbbl/yr to other sub-national regions and 75 thbbl/yr to international markets, for a total exported volume of 325 thbbl/yr.

Region X regional exports = 250/325 = 77%
Region X international exports = 75/325 = 23%

Given these data points, the model will calculate:
Increased exports (U.S. Regions) = 135 thbbl/yr, (175*77%)
Increased exports (International) = 40 thbbl/yr, (175*23%)

7.1.4 Calculating Increased Regional Industry Output and Reduced Import Payments

The calculations shown in steps 7.1.2 and 7.1.3 move the production volumes from raw production to volumes that will either enter the transmission and distribution system (natural gas) or be sent to a refinery (crude oil). The final step needed before executing the model is to convert both the production volumes used to meet demand and the volumes being exported into industry output valued in producer prices (million $). Additionally, the value of offset imports must be captured by converting offset import volumes to offset import payments.

a. Natural Gas Industry Output: Output for the natural gas industry is comprised of three components – natural gas sold for regional consumption, natural gas exports and sales of natural gas liquids.

NG Regional Demand (Million $) = *Total Dry Natural Gas to Market$_R$ (MMcf/yr) * (Imputed Wellhead Price$_R$ ($/tcf)*[30,31] ÷ 1,000

NG Regional Exports (Million $) = *[(Increased exports (United States Regions) + Increased exports (International)) * (Imputed Wellhead Price$_R$ ($/tcf))] ÷ 1,000*

NG Plant Liquids (Million $) = [*Extracted Liquids$_R$ (th bbls/yr)* Avg. NGPL Market Value$_R$($/bbl)*[32] * Avg. Industry Ratio of Producer's Prices to Purchaser's Prices (%)*[33]] ÷ 1,000*

[30] EIA. Natural Gas Prices, wellhead price. http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_a_EPG0_FWA_DMcf_a.htm.
[31] No adjustment is made to wellhead prices – assumed to be producer prices.
[32] Regional average NGPL production: EIA, Natural Gas Plant Field Production, state-level data; NGPL prices: Barnes and Click: http://www.engineers1.com/pdf/PriceCorr.pdf.
[33] Bureau of Economic Analysis (BEA), Benchmark Input-Output Data, Table 2. "The Use of Commodities by Industries before Redefinitions, 2002 Benchmark, at the detail level." Average United States Purchaser-to-Producer ratio for purchases of NAICS 211000 (Oil & Natural Gas Extraction) by chemical industries; NAICS 324191 (Petroleum Lubricating Oil and Grease Manufacturing); 324199 (All Other Petroleum and Coal Products Manufacturing); 325110 (Petrochemical Manufacturing); and 325190 (Other Basic Organic Chemical Manufacturing).

b. Reduction in NG Import Payments: This value represents the value of a region's reduced payments for natural gas imports from other sub-national regions and the international market.

Reduced NG Import Payments$_1$ (Million $) =
$\sum_{R1}^{R6}(OffsetImports(MMcf / yr) * ImputedWellheadPrice(\$ / tcf)) * Avg.$ *Industry Ratio of Purchaser's Prices to Producer's Prices (%)*[34] [35] ÷ 1,000

Reduced NG Import Payments$_2$ (Million $) = [*Offset imports (International) * Avg. Natural Gas Import Price$_R$ ($/tcf)*[36]] ÷ 1,000

c. Oil Industry Output: Output for the oil industry is comprised of two components – oil sold for regional consumption and oil for export.

Oil Regional Demand (Million $) = [*Crude Oil Production$_R$ (thbbl/yr) * Domestic Price to Refiners$_R$ ($/bbl)*[37] * Avg. Industry Ratio of Producer's Prices to Purchaser's Prices (%)*[38]] ÷ 1,000

Oil Regional Exports (Million $) =

i. *[Increased exports (U.S. Regions) * Domestic Price to Refiners$_R$ ($/bbl) * Avg. Industry Ratio of Producer's Prices to Purchaser's Prices (%)] ÷ 1,000* +
ii. *[Increased exports (International) * F.O.B. Costs of Imported Crude Oil$_{US}$ ($/bbl)*[39]] ÷ 1,000*

[34] BEA, Benchmark Input-Output Data, Table 2. Average U.S. Producer-to-Purchaser ratio for purchases of NAICS 211000 (Oil & Natural Gas Extraction) by NAICS 211000 (Oil & Natural Gas Extraction).
[35] Import payments must be in purchaser prices, so wellhead prices had to be increased to account for transportation margins (largely pipeline transportation costs).
[36] EIA, United States Natural Gas Imports by Point of Entry, Pipeline Prices and LNG Prices.
[37] EIA. Refiner Acquisition Cost of Crude Oil, domestic. http://tonto.eia.doe.gov/dnav/pet/pet_pri_rac2_a_EPC0_PDT_dpbbl_a.htm.
[38] BEA, Benchmark Input-Output Data, Table 2. Average U.S. Purchaser-to-Producer ratio for purchases of NAICS 211000 (Oil & Natural Gas Extraction) by NAICS 324110 (Petroleum Refineries).
[39] EIA, F.O.B. Costs of Imported Crude Oil by Area, http://tonto.eia.doe.gov/dnav/pet/pet_pri_imc1_k_a.htm.

d. Reduction in Oil Import Payments: This value represents the value of a region's reduced payments for oil imports from other sub-national regions and the international market. The calculations are done similarly to the reduced natural gas import payment calculations.

Reduced Oil Import Payments$_1$ (Million $) =

$$\sum_{R1}^{R6}\left(OffsetImports(thbbl/yr) * Domestic\ Price\ to\ Refiners_R\ (\$/bbl)\right) \div 1{,}000$$

Reduced Oil Import Payments$_2$ (Million $) = [*Offset international imports (thbbl/yr) * Landed Cost of Imported Crude Oil$_{US}$ ($/bbl)*[40]] ÷ *1,000*

7.1.5 Construction Cost Results

a. Number of New Wells: Increased domestic production will lead to the construction of new wells given the assumption that none of the new production is due to increased recovery rates from existing wells. Additionally, although each region obtains both natural gas and oil from the wells within the region, the model calculates the number of new wells needed using the assumption that only natural gas wells will produce natural gas and only oil wells will produce oil.

New Natural Gas Wells (#) =

$$\text{Increased Regional Production}_{NG} \Big/ \left(\sum_{S1}^{Sx} GasWithdrawals \Big/ \sum_{S1}^{Sx} GasWells \right)$$

New Oil Wells (#) =

$$\text{Increased Regional Production}_{O} \Big/ \left(\frac{\sum_{S1}^{Sx} OilWithdrawals}{1{,}000} \Big/ \sum_{S1}^{Sx} OilWells \right)$$ [41]

[40] EIA, Landed Costs of Imported Crude by Area. http://tonto.eia.doe.gov/dnav/pet/pet_move_land1_k_a.htm.

[41] Oil well withdrawals are divided by 1,000 because regional withdrawals in the source data are in thousand bbls/yr while increased regional production held in the model are in million bbls/yr.

b. New Well Construction: Total construction costs for new natural gas and oil wells are derived by multiplying the number of new wells required by the average regional construction costs per well, plus any cost adjustment entered by the user.

Well Construction $Costs_R$ (Million $) = (New Natural Gas Wells (#), New Oil Wells (#)) * Avg. By-depth Well Construction $Cost_R$ (thousand $/well) ÷ 1,000

c. New Gas Processing Plants (#): In 2006, there were 491 natural gas processing plants across 22 states.[42] These processing plants had a reported daily processing capacity that was extrapolated to an annual processing capacity for use in the model.[43] State-level processed volumes were used along with the capacity data to generate regional plant utilization rates and maximum regional utilization rates. The number of new processing plants required in each model region is a function of the region's processing plant maximum utilization rate, the new volume of natural gas requiring processing (see function Processed NG_R [step 2.b. shown above]) and the displaced processed inter-regional imports. The calculation for the number of new natural gas processing plants is a two-step process. The first step compares the excess regional processing capacity and the volume of inter-regional natural gas that is processed within the region to the new volume of natural gas. If the new volume exceeds the displaced imports or the excess regional capacity, the second step then determines the number of new plants required within the region.

i. New Natural Gas Processing Plants Required (yes/no):
If Processed $NG_R \leq$ Source Data Inter-Region Processed Import $Volumes_R$
OR Processed $NG_R \leq$ Excess Processing Capacity,
Then no new plants are required; Else

ii. New Natural Gas Processing $Plants_R$ (#) =
If *Processed* $NG_R >$ *Source Data Inter-Region Processed Import* $Volumes_R$
Then

$$\frac{\left(\mathrm{Pr}\,ocessedNG_R - SourceDataInter\,\mathrm{Re}\,gional\,\mathrm{Pr}\,ocessed\,\mathrm{Im}\,ports_R\right)}{\left(\frac{MaxUtilizationVolume_R}{Plants_R}\right)}$$

Else $\dfrac{\left(\mathrm{Pr}\,ocessedNG_R\right)}{\left(\frac{MaxUtilizationVolume_R}{Plants_R}\right)}$

[42] *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves Report*. Appendix E, Table E5. Form EIA-64A 2006 Plant Frame Activity.

[43] *Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market*, Table 1. Natural Gas Processing Plant Capacity in the Lower 48 States, 1995 and 2004. These data were extrapolated to 2006 based on the capacity-to-plant ratio in 2004.

d. New Gas Processing Plant Construction: Total construction costs for new natural gas processing plants are derived by multiplying the net volume of new natural gas requiring processing by the average regional construction costs per MMcf processed per day.

   Gas Plant Construction $Costs_R$ (Million $) = *Net Natural Gas Requiring New Processing* $Capacity_R$ *(MMcf/yr) /365/ Max Plant Utilization* $Rate_R$ ** Avg. construction costs per MMcf* $Capacity_R$ *(Million $)*

e. Pipeline Construction: Pipeline construction cost source data are based on the national average capital cost per well.[44] Therefore, pipeline construction costs due to the construction of new wells is calculated as the number of new wells multiplied by the average regional pipeline construction cost per well.

   Pipeline Construction $Costs_R$ (Million $) = (*New Natural Gas Wells (#), New Oil Wells (#)) * Avg. Pipeline Construction Cost per* $Well_R$ *(Million $)*

7.2 Results Presentation

The third tab in the model, "Results," presents a summary of the user inputs and both a summary and detailed listings of the results of the import substitution and construction impacts by aggregated industries. Examples of the four results tables are shown below (Tables 3–6). The tables shown here correspond to the prototype model using aggregated sample data from Region 1: New York, Ohio, Pennsylvania, and West Virginia. The prototype model and its corresponding results tables were aggregated into 6 industries, but the final model for this project and its corresponding results include 33 industries (see Appendix B).

Table 3 reports import substitution impacts. This includes total output impacts for each industry, which are divided into the two components of intermediate inputs and value added. Value added is further sub-divided into its separate components of employment compensation, proprietor's income, other property type income and indirect business taxes.

[44] See Section 5 for data source references.

Table 3. Import Substitution Impacts

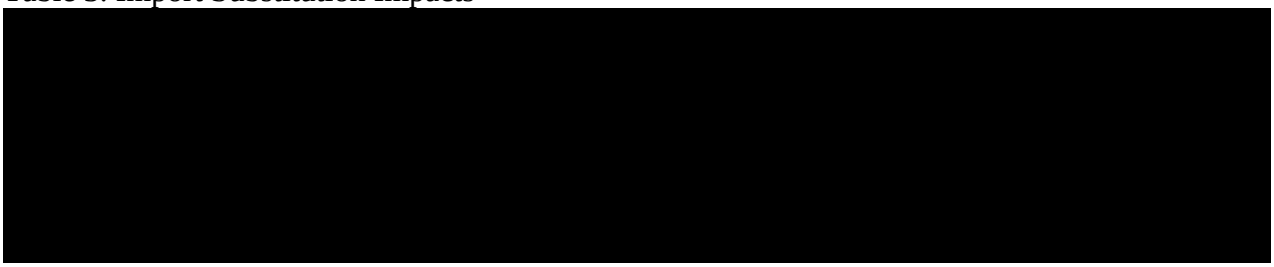
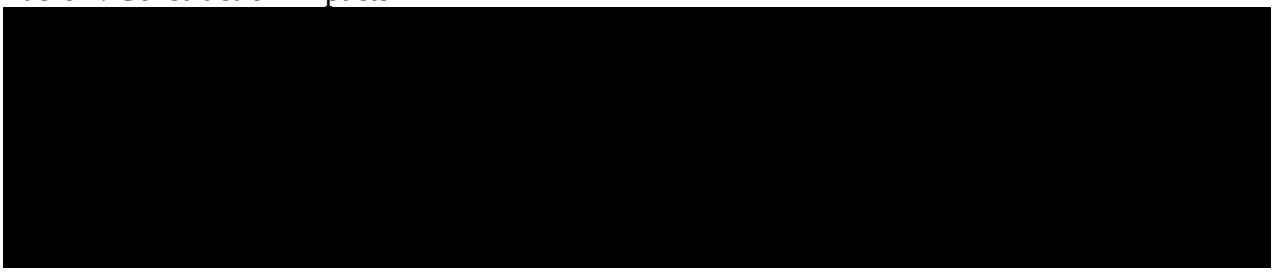


Table 4 reports construction impacts. Once again, results are reported for total output impacts but have also been sub-divided into their respective components as in the table above.

Table 4. Construction Impacts



Tables 5 and 6 report the tax impacts for import substitution and construction, respectively. Impacts are given for enterprises (corporations), Federal Government Non-Defense, and State/Local Government Non-Education categories. The sources of these impacts are given in the columns and include employee compensation, proprietary income, household expenditures, enterprises and indirect business taxes which can be summed to get the total tax impact.

Table 5. Import Substitution Tax Impacts

Table 6. Construction Tax Impacts

7.3 Other Model Tabs

There are two primary data tabs, "NG Data Sheet" and "Oil Data Sheet." These tabs hold state-level source data on production volumes, prices, well counts, trade activity and processing capacities, all of which have been aggregated to the model regions. These tabs also hold industry-level data used to transform producer prices to purchaser prices and vice versa.

The "Data Link" tab is used as the bridge between the user inputs entered on the "Inputs" tab and the IO modeling which occurs within the model. A key component of this tab is the Oil and Gas Price Ratio (cells B9:C9). This ratio is necessary to adjust the composite price of oil and natural gas used in the model. The total consumption of oil and natural gas in the original setup is made up of both domestic oil and natural gas and internationally imported oil and natural gas. Domestic prices are not equal to the prices of the international imports; therefore, the overall price of oil and natural gas is a weighted average of the domestic price and the price of international imports. When the model is run to determine potential impacts, the overall price of oil and natural gas will change because the amount of domestic oil and natural gas being produced is now larger and international imports have declined. Thus, the weights on the overall price of oil and natural gas will be different. These changes should be reflected in an adjustment of the overall price. The calculation for the ratio is: $\frac{P_n}{P_0}$ where $P_n =$ $\left[\frac{Pi(Qi+\Delta Qi)+Pd(Qd+\Delta Qd)}{(Qi+Qd)}\right]$ and $P_0=\left[\frac{PiQi+PdQd}{(Qi+Qd)}\right]$

Table 7. Price Ratio Parameter Definitions

	Natural Gas	Oil
Pi	Weighted Average of Domestic and International Import Prices	
Qi	Demand - Domestic Production	
Pd	Wellhead Price	Refiner Price minus Margins
Qd	Minimum of Domestic Production and Domestic Demand	
ΔQi	Offset Imports	
ΔQd	Domestic Production minus Change in Exports	

All remaining tabs represent various steps in the IO modeling of the impacts related to increased natural gas and oil production and the generation of the results tabs presented above.

Section 8.0 User Instructions

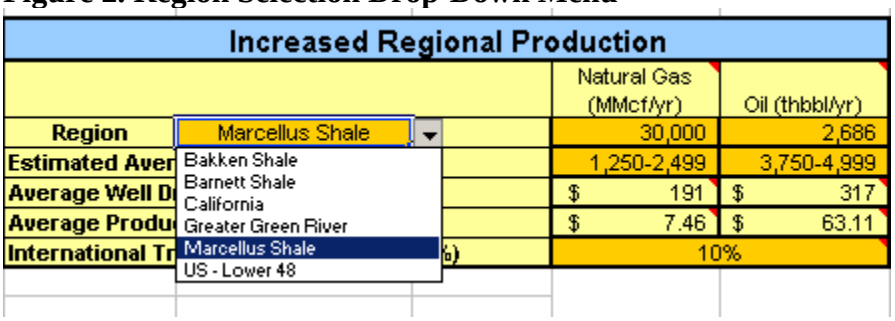
The model allows for the analysis of increased natural gas and/or oil production within a single region. The current version of the model, as noted in Section 4.0, does not capture the impact on a region caused by production increases in a different region. Therefore, the model is run, and the impacts should be assessed, on an isolated, single-region basis.

Exercising the model requires five steps:

1. Select a region.
2. Enter levels of increased natural gas and/or oil production.
3. Select average well depths for natural gas and/or oil.
4. Enter rate for international trade feedback percentage.
5. Generate and view results.

To begin using the model, users have two options. First, the user can select a region map shown on the tab titled "Regions." This will jump the user to the region selection drop-down on the "Inputs" tab, but will not alter the region selection based on the map selected; the user still must select a region. Alternatively, as shown in Figure 2, the user can begin on the "Inputs" tab in cell F10 (located in the box "Increased Regional Production") and select an analysis region from the drop-down menu.

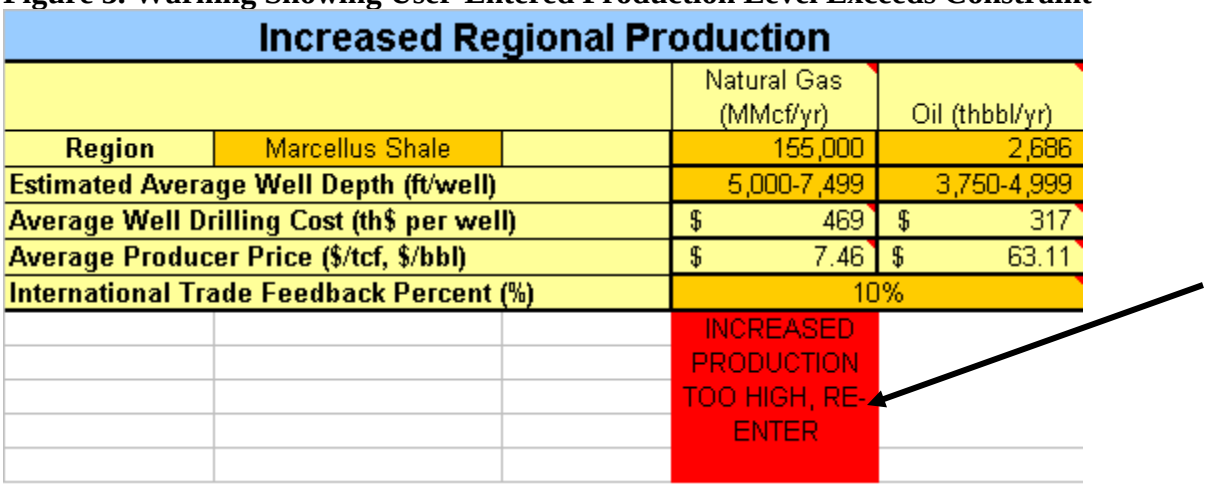
Figure 2. Region Selection Drop-Down Menu



All user inputs are entered in the box "Increased Regional Production" located on the "Inputs" tab. In this box, all cells requiring user inputs are highlighted in orange; yellow fields represent source and/or calculated data.

To calculate the potential impacts of increased domestic natural gas and oil production within the selected region, users first determine the level of increased production for which they want to assess the impacts and enter these values in cells H10 and I10 for natural gas (MMcf/yr) and/or oil (thbbl/yr), respectively. It is important to note that the values to be entered are levels of production *increases* and are not levels of total production. Additionally, the model limits production increases to 25 percent of 2006 well withdrawals (cells I23:I24). If the user enters a production increase that is greater than 25 percent of the existing well withdrawals, the model provides a warning that a new production level must be entered (Figure 3).

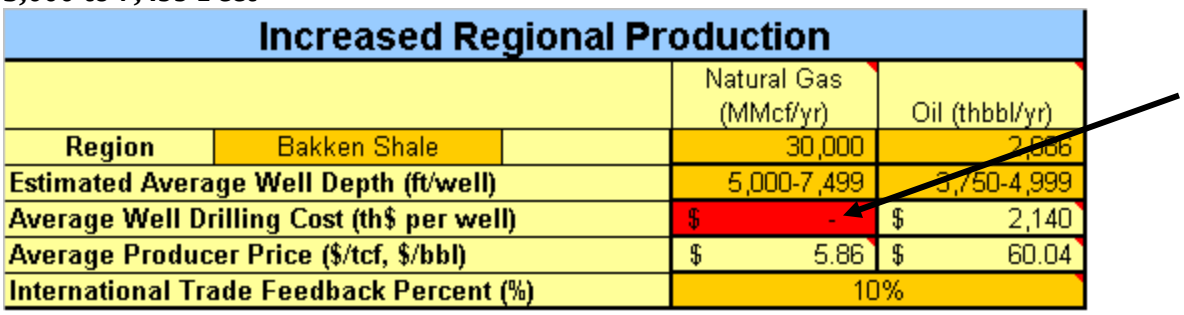
Figure 3. Warning Showing User-Entered Production Level Exceeds Constraint



Increased Regional Production				
			Natural Gas (MMcf/yr)	Oil (thbbl/yr)
Region	Marcellus Shale		155,000	2,686
Estimated Average Well Depth (ft/well)			5,000-7,499	3,750-4,999
Average Well Drilling Cost (th$ per well)			$ 469	$ 317
Average Producer Price ($/tcf, $/bbl)			$ 7.46	$ 63.11
International Trade Feedback Percent (%)			10%	
			INCREASED PRODUCTION TOO HIGH, RE-ENTER	

In the next row down (cells H11:I11), the user can select the average well depth for the analysis region from a drop-down list. For natural gas wells, there are 11 depth options ranging from 0–20,000+ feet/well as well as the option of a coal bed methane (CBM) site. For oil wells, the user can select from the same well depth options available under natural gas. Once the user selects the average well depth for the region, the model returns the regional average well construction cost (thousand $/well) for the selected depth (cells H12:I12). This cost information will flow to the new-well-construction cost calculations that drive the construction impacts in the model. If the underlying source data indicate that the selected region does not have any wells at the selected depth, cost per well cell will be shaded in red (Figure 4). If this should happen, the user must select an alternate average well depth.

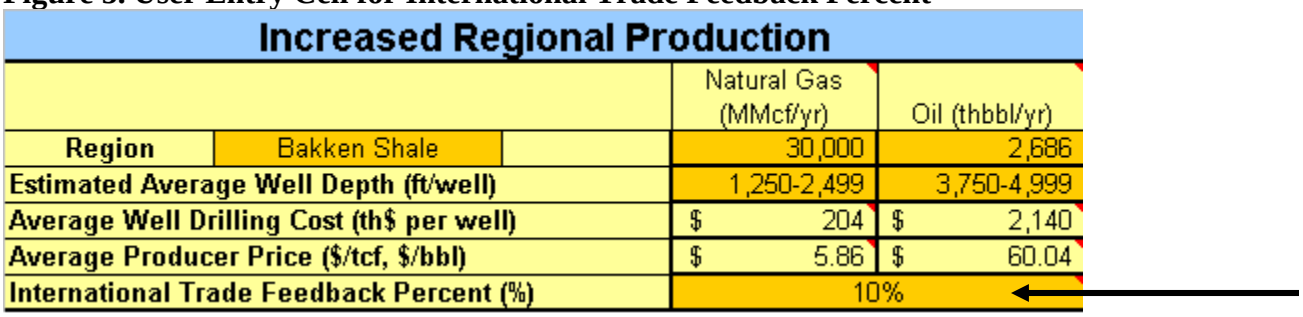
Figure 4. Example of Region with No Data to Support Selection of Depth Ranging from 5,000 to 7,499 Feet



Increased Regional Production				
			Natural Gas (MMcf/yr)	Oil (thbbl/yr)
Region	Bakken Shale		30,000	2,666
Estimated Average Well Depth (ft/well)			5,000-7,499	3,750-4,999
Average Well Drilling Cost (th$ per well)			$ -	$ 2,140
Average Producer Price ($/tcf, $/bbl)			$ 5.86	$ 60.04
International Trade Feedback Percent (%)			10%	

Lastly, the user enters the international trade feedback percent (H14). This rate is arbitrarily set to a range of 0–20 percent. The model applies this rate to the value of offset international imports and reduces the region's foreign export final demand for each of the modeled industries (see Section 6.3).

Figure 5. User Entry Cell for International Trade Feedback Percent



Increased Regional Production			
		Natural Gas (MMcf/yr)	Oil (thbbl/yr)
Region	Bakken Shale	30,000	2,686
Estimated Average Well Depth (ft/well)		1,250-2,499	3,750-4,999
Average Well Drilling Cost (th$ per well)		$ 204	$ 2,140
Average Producer Price ($/tcf, $/bbl)		$ 5.86	$ 60.04
International Trade Feedback Percent (%)		10%	

As noted in the previous section describing the construction of the model, data on regional production, supply and demand are located in the box "Regional Information." Calculation steps that convert user-entered production increases (volume units) to industry output (dollars) that will drive the model are in the box "Production Results." Lastly, information on new wells and plants, as well as construction costs, is in the box "Construction Cost Results." It is important to note that the values presented in "Production Results" and "Construction Cost Results" do not represent full production impacts.

To calculate economy-wide potential impacts of increased natural gas and/or oil production and related construction costs, the user must click the button "Generate & View Impact Results" located at the top of the "Inputs" tab. This button runs the IO model to estimate total impacts and redirects the user to the top of the "Results" tab. While users can view results without clicking the "Generate & View Impact Results" button, clicking this button allows the spreadsheet model to (1) access the input data from previous computations, (2) edit the appropriate Use and Make tables along with appropriate final demand and output values, and (3) carry out the computations described in the above Input-Output Model and Accounting Framework section to generate the total impacts of the increase in domestic production.

As shown in Section 7.2, the "Results" tab summarizes the results in tabular form. One set of output tables will present annually occurring impacts by industry,[45] and a second set will present construction impacts stimulated by the initial expansion in domestic output. Output table information includes:

1. Input data summary
2. Summary impact results
3. Output impacts by industry
4. Value added by industry
5. Income impacts by industry
6. Employment impacts by industry
7. Tax effects by type and source of tax

[45] The prototype model and its corresponding results tables are aggregated into 6 industries, but the final models for this project and their corresponding results will include 33 industries. Industry aggregation schema is detailed in Appendix B.

Section 9.0 Scenario and Results Analysis

This section provides an overview of the two impacts estimation contexts used to demonstrate the model, a summary analysis and interpretation of the results.

9.1 Scenarios

The large volume of output data from the impacts model presents a challenge for presentation. However, impacts distributions across industries and tax types are relatively consistent for oil and gas productions within a region, and indeed across regions and over time. Based on this realization, the impacts subsections are organized by region and provide results from two types of analyses.

The first context for analysis represents estimating the impacts of a standardized 10 percent change in production. The impacts from these modeled impacts, shown in two parts, represent analyses of a 10 percent increase in oil, and then a 10 percent increase in natural gas production, respectively, to provide a benchmark for and to facilitate comparisons of impacts within and across regions. This context corresponds directly to, and can be most accurately interpreted as the impacts of the substitution of domestic production for previously imported oil or gas.

The second estimation context involved developing a production baseline and alternative level forecasts. This context allowed for the analysis of potential impacts due to changes in forecasted production levels.

9.1.1 The Baseline

For this context, which demonstrates the versatility of the model developed, the EIA's Annual Energy Outlook, 2008 (AEO2008), serves as a baseline estimate of future regional natural gas and oil production levels. Because the model is founded on EIA's 2006 disposition and price data and 2006 economic data, industry characterization and regional proportions of supply sources are held constant.[46] The AEO2008 was selected as the baseline scenario for a number of reasons. First, as noted in Section 5.0, the EIA serves as the primary data source for this project and the model. The data collected from EIA for this project is also represented in the AEO2008, so using this forecast series enhances data consistency. Second, the AEO2008 constitutes EIA's projection of production, total supply (including trade), demand and prices of the various fuel and energy sources produced and/or consumed within the United States. Hence, it provides annual forecasts through 2030 under the assumption of continuing the existing regulatory framework. This assumption means that any legislation that has been enacted at the time of the AEO's development is incorporated and any pending or potential legislation is excluded. In addition, the AEO assumes technologies will continue to develop at established learning rates and that no additional resource sinks will be discovered. These characteristics allow scenario analysis to cover an array of years and potential production levels and support the general definition of a baseline (i.e., a control data set used for

[46] Estimating future impacts based on a static industry and economic framework is not ideal. FY 2009 plans for extending this project include incorporating price sensitivities and final demand forecasts into the model.

comparison). The third reason the AEO2008 was used as a baseline is because it is generated through the National Energy Modeling System (NEMS)[47] and regional disposition data were available, thus supporting the regional aspect of this project.

AEO2008 regional natural gas and oil production data are generated in NEMS' Oil and Gas Supply Module (OGSM) and reported by three prime regions: Lower-48 onshore, Lower-48 offshore and Alaska.[48] The Lower-48 data were used in the lower-48 region of the model and the sub-regional data, based on the regional delineation shown in Figure 1, were collected for use in the sub-national regions of the model. The 2006 sub-national data were then mapped to the state level to match the data used as the model base data. The state-level production forecasts were then aggregated to match the model's regional definitions and 2006 production levels, which are equal to EIA state-level reports. The ratios developed in mapping the lower-48 OGSM regional data to the state level were held constant across all forecast years.

Figure 6. OGSM Lower-48 Regions

The last steps in establishing the baseline were to define the regions' average well depths for natural gas and oil wells and to set the international trade feedback share.[49] In order to maintain consistency with the model's source data, well depth data by state (as provided by the Joint Association Survey [JAS]) serve as the basis for setting each region's average well depth for both natural gas and oil in the baseline scenario. Table 8 illustrates how the regional average well depths were calculated in Region 5 for natural

[47] EIA. "Overview of NEMS." March 4, 2003. http://www.eia.doe.gov/oiaf/aeo/overview/overview.html. Annually updated module documentation: http://tonto.eia.doe.gov/reports/reports_kindD.asp?type=model%20documentation.
[48] EIA. "Documentation of the Oil and Gas Supply Module (OGSM)." DOE/EIA-M063(2008). October 2008. p. 2-1.
[49] The international feedback share represents the decline in exports of all U.S. goods caused by the decline in revenue from countries whose exports of crude oil and natural gas to the U.S. are displaced by domestic production.

gas; the same methodology was applied to oil wells. The regional average well depths were held constant across all forecast years.

Table 8. Regional Average Well Depth Calculation

Region	Well Type	Depth Range (ft)	Number of Wells	Total Footage (ft)	Average Footage (ft)
CA	NATURAL GAS	2,500 – 3,749	10	33,075	
CA	NATURAL GAS	3,750 – 4,999	10	44,538	
CA	NATURAL GAS	5,000 – 7,499	26	149,459	
CA	NATURAL GAS	7,500 – 9,999	3	24,296	
CA	NATURAL GAS	10,000 – 12,499	1	10,550	
CA	**NATURAL GAS**	**----------**	**50**	**261,918**	**5,238; Range 5,000 – 7,499**

For the baseline, the international trade feedback share was set at 10 percent. The model is set to accept a share ranging from 0 to 20 percent. Ten percent was selected for the baseline run to serve as a mid-point estimate (neither liberal nor conservative in estimation).

9.1.2 The Counterfactual

The original plan for this project indicated that the alternative, or production impact, scenario would reflect production changes due to the deployment of EPAct-999 supported technologies, provided these data were available. The original plan also recognized that these data may not yet be available and offered an alternative analysis of running varying rates of production increases to exemplify the potential applications of the model. Because data on new technologies is not yet available, the latter alternative was taken and the results are shown in subsequent subsections. The alternative scenario generated through the NEMS model provides a realistic demonstration of the model application.

The alternative production scenario, or "counterfactual," reflects the estimated impact of America's Climate Security Act of 2007 (or S.2191) coupled with (1) advanced nuclear technology total plant costs set to approximately $4,000/kW[50] and (2) the availability of CO_2 capture retrofit technology for existing pulverized coal power plants beginning in 2014—this case's acronym is S2191HNR. The S.2191 bill proposed establishing a carbon trading system, beginning in 2012, aimed at reducing greenhouse gas (GHG) emissions from facilities within the electric power and industrial sectors. Additionally, the legislation covered GHGs emitted from facilities that produce, or entities that import, petroleum- or coal-based transportation fuel or chemicals; this legislation specifically covers natural gas and oil suppliers.[51] Both natural gas and oil domestic production decline in nearly all years and in all regions as end users reduce their demand for both natural gas and oil, due to rising prices created by legislation costs passed down from

[50] The increased capital cost price point is based on the capital cost range of $3,108/kW and $4,540/kW estimated by Florida Power & Light for Turkey Point units 6 and 7. Florida Public Service Commission, Docket 070650-EI, p. 24.

[51] U.S. Library of Congress, THOMAS, S.2191 summary, http://thomas.loc.gov/cgi-bin/query/z?c110:S.2191.

suppliers. See Table 9 for examples of the national level impact of the legislation on natural gas and oil product prices, domestic production and consumption.

Table 9. Natural Gas and Oil Price and Consumption Data, AEO2008 and S2191HNR

	2010		2020		2030	
	AEO2008	S2191HNR	AEO2008	S2191HNR	AEO2008	S2191HNR
Delivered Energy Prices						
Motor gasoline, transport (per gallon)	2.55	2.54	2.36	2.58	2.45	2.85
Jet fuel (per gallon)	2.13	2.12	1.79	2.09	2.07	2.66
Diesel (per gallon)	2.70	2.82	2.50	2.82	2.68	3.26
Natural gas (per thousand cubic feet)						
Residential	12.52	12.47	11.74	13.81	13.30	18.29
Electric Power	7.16	7.10	6.11	7.90	7.13	11.44
Domestic Production[52]						
Natural gas (dry, tcf/yr)	19.29	19.20	19.67	18.92	19.43	19.05
Crude oil (MMbbl/yr)	1,133	1,133	1,197	1,192	1,233	1,229
Energy Consumption (Quads)						
Liquid Fuels	40.5	40.4	42.2	41.2	44.0	42.0
Natural Gas	23.9	23.8	24.0	22.9	23.4	22.7
Electricity Generation (BkWh)						
Petroleum	57	55	60	33	66	27
Natural Gas	908	894	832	832	737	896

The S2191HNR scenario average natural gas and oil well depths are set equal to those used in the baseline (AEO2008) scenario. Additionally, the international feedback loop was also set equal to the baseline scenario at 10 percent. With the baseline and alternative scenarios defined and developed, impact estimates reflecting the change in production become possible.

9.2 Model Analysis Results

To address both scenario contexts developed above and to demonstrate the flexibility and utility of the model, impact results from the scenarios described above are reported and analyzed in this subsection. Results for those industries most heavily affected are presented in detail, which also identifies those industries with the strongest intra-regional, inter-industry relationships within the oil and gas economy. For the standardized 10-percent analyses, no international trade feedback effects are included (feedback effect set equal to zero) and baseline values are used for average

[52] Natural Gas production presented here reflects national, dry production from onshore, offshore and Alaska; oil production presented here reflects national withdrawals from onshore sources only.

well-depth by region.[53] Disaggregated results tables of output and employment impacts for strongly linked industries are presented for both import substitution and construction.

Each counterfactual scenario represents the impacts differences to the AEO baseline due to the adoption of America's Climate Security Act of 2007, or S.2191. Along with summary input data, summary results are presented for the resulting import substitution and construction impacts for each region for the years 2010, 2020, and 2030.[54] These results are reported as either legislation benefits or the opportunity costs of legislation. When the production levels in the baseline scenario (AEO2008) are less than those in the S.2191 scenario, the resulting impacts are considered to be legislation benefits that would not have occurred absent the 2007 legislation. However, when the production levels in the S.2191 scenario are less than those in the AEO baseline scenario, the resulting impacts represent opportunity costs of legislation, in the form of impacts that do not occur as a result of passing this particular legislation.

The results for Region 1, the Marcellus Shale region, are presented in greatest detail. Impacts distributions across industries, tax types and regions are quite similar. This result reflects the fact that the industries most strongly linked to the energy economy are the same from region to region. Industry impacts across regions differ primarily in the extent to which this set of industries is present or absent within each region. Likewise, the distribution of tax impacts across tax types will appear strongly similar from region to region. For this reason, discussion of subsequent regions will be limited to a description of the nature of the impacts scenarios in terms of benefits versus opportunity costs.

9.2.1 Region 1 (Marcellus Shale) – Standardized Production Increase

Oil. In 2006, onshore oil withdrawals for the Marcellus Shale Region totaled 11,116 kbbl/yr. A 10 percent increase in this value yields a new production level of 12,228 kbbl/yr, or an increase of 1,112 kbbl/yr. Table 10 reports the regional impacts from import substitution for this particular increase in domestic production ranked by output impact.

[53] The interregional feedback effect used in the subsequent scenario analyses is quite small and has very little impact on the industry or tax-type distribution of impacts.

[54] Scenario analyses tables for which results are effectively zero are not reported in the document. This occurred for Bakken Shale, 2010 (Oil Only) and Greater Green River, 2010 (Oil Only).

Table 10. Major Import Substitution Impacts from a 10 Percent Oil Increase for Region 1

Import Substitution Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$70	$27	$43	$3	$15	$22	$4	124
Finance and Insurance, Real Estate, Rental and Leasing Services	$4	$1	$3	$1	$0	$1	$0	16
Other Manufacturing	$4	$3	$1	$1	$0	$0	$0	10
Other Professional, Scientific & Tech Services	$1	$0	$1	$0	$0	$0	$0	7
Educational Services, Health Care, and Social Assistance	$1	$0	$0	$0	$0	$0	$0	9
Operations	$1	$0	$1	$0	$0	$0	$0	4
Enterprises	$1	$0	$0	$0	$0	$0	$0	3
Government & Non NAICs	$1	$0	$1	$0	$0	$0	$0	6
Wholesale Trade	$1	$0	$0	$0	$0	$0	$0	3
Information	$1	$0	$0	$0	$0	$0	$0	1
Total	$86	$34	$52	$7	$15	$25	$5	216

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

As expected, “Oil and Gas Extraction” is the most heavily impacted sector both in terms of output and employment import substitution impacts. While it might appear counter-intuitive at first glance, other detailed oil and gas industries, such as “Drilling Oil and Gas Wells” and “Support Activities for Oil and Gas Operations,” have little to no impact based on this analysis. However, this result is due first to the fact that the import substitution impacts do not include the construction impacts of increased production; the impacts identified here are annual and ongoing. Second, support activities for oil and gas operations simply do not account for a large portion of average annual costs per dollar of sector output.

Industries that are somewhat more heavily impacted both in terms of output and employment are “Finance and Insurance, Real Estate, Rental and Leasing Services” and “Other Manufacturing,” which account for much larger cost shares per dollar of oil and gas sector output. The “Leasing Services” category likely accounts for the bulk of the former impact, while the “Other Manufacturing” category includes a wide and varied set of industries in which its cumulative cost share is large enough to be noted. Together with “Oil and Gas Extraction,” these four industries account for over 90 percent of output impacts and 69 percent of employment impacts in the region. Indeed, few industries constitute major per dollar costs for this industry, reflecting the fact that this is a highly capital-intensive industry, with much of the production costs playing an early role during installation of the production facilities. The industry impacts of these one-time construction investment expenditures are shown in Table 11, again sorted by output impact size.

Table 11. Major Construction Impacts from a 10 Percent Oil Increase for Region 1

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Water, Sewer, and Pipeline Construction	$305	$160	$145	$94	$27	$22	$2	2,388
Drilling Oil and Gas Wells	$968	$691	$277	$77	$19	$148	$32	1,687
Other Manufacturing	$483	$344	$140	$82	$7	$47	$4	1,273
Arts, Entertainment, Recreation, Accomodation, and Food Services	$65	$30	$35	$22	$2	$7	$4	1,138
Educational Services, Health Care, and Social Assistance	$69	$27	$42	$34	$4	$4	$0	865
Retail Trade	$54	$18	$36	$20	$2	$7	$7	770
Finance and Insurance, Real Estate, Rental and Leasing Services	$152	$54	$98	$47	$8	$35	$8	616
Other Professional, Scientific & Tech Services	$92	$37	$55	$34	$12	$8	$1	601
Government & Non NAICs	$55	$5	$50	$27	$0	$20	$3	493
Administrative and Support & Waste Managment and Remediation Services	$30	$11	$19	$13	$1	$3	$1	469
Total	$2,734	$1,578	$1,156	$594	$104	$376	$82	12,781

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Recall that construction impacts reflect the sum total of impacts from the construction investment activity and do not recur annually. Construction impacts clearly affect a larger proportion and more even distribution of industry sectors in the regional economy than do import substitution impacts. In terms of output, the directly linked "Drilling Oil and Gas Wells" sector has the largest impact, while "Water, Sewer and Pipeline Construction" yields the largest employment impact, with "Drilling Oil and Gas Wells" coming in second. "Drilling Oil and Gas Wells," "Water, Sewer and Pipeline Construction," and "Other Manufacturing" alone account for over 64 percent of output impacts and over 41 percent of employment impacts. It can also be seen from the table that a larger number of consumer-related sectors, such as "Educational Services, Health Care and Social Assistance" or "Wholesale" or "Retail" services are notably affected. This result is attributed to the large portion of construction expenditures that translate to income and subsequently income-induced impacts. The sector rankings differ when sorted by output or by employment. This result reflects inter-sectoral differences in wages per dollar of output.

Gas. In 2006, onshore natural gas withdrawals for the Marcellus Shale Region totaled 526,180 MMcf/yr. A 10 percent increase in this value yields a new production value of 578,798 MMcf/yr, or an increase of 52,618 MMcf/yr. Table 12 reports the regional impacts from import substitution ranked by output impacts.

Table 12. Major Import Substitution Impacts for a 10 Percent Natural Gas Increase for Region 1

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$386	$147	$239	$14	$81	$121	$23	684
Other Manufacturing	$50	$35	$14	$8	$1	$5	$0	131
Finance and Insurance, Real Estate, Rental and Leasing Services	$31	$11	$20	$10	$2	$7	$2	125
Educational Services, Health Care, and Social Assistance	$8	$3	$5	$4	$0	$1	$0	103
Retail Trade	$6	$2	$4	$2	$0	$1	$1	81
Arts, Entertainment, Recreation, Accomodation, and Food Services	$4	$2	$2	$1	$0	$0	$0	76
Other Professional, Scientific & Tech Services	$11	$4	$6	$4	$1	$1	$0	70
Government & Non NAICs	$7	$1	$6	$3	$0	$2	$0	60
Administrative and Support & Waste Managment and Remediation Services	$3	$1	$2	$1	$0	$0	$0	51
Wholesale Trade	$8	$3	$5	$3	$0	$1	$1	43
Total	$581	$246	$335	$66	$88	$150	$32	1,679

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Note that the top ranked sectors in the Gas Import Substitution table coincide approximately with the top import substitution sectors for oil import substitution, although "Natural Gas Distribution" rises in importance while "Support Activities for Oil and Gas Operations" falls in relative importance, and other minor re-orderings occur. The differences between the Oil and the Gas Import Substitution results tables are due primarily to the differences in sheer size of the dollar impact, which translates into much larger output impacts and payments to households in the form of employment compensation, which in turn translates to larger income-induced impacts.

Table 13. Construction Impacts from a 10 Percent Natural Gas Increase for Region 1

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Drilling Oil and Gas Wells	$5,023	$3,586	$1,437	$401	$99	$769	$168	8,753
Arts, Entertainment, Recreation, Accomodation, and Food Services	$274	$125	$149	$93	$10	$30	$16	4,800
Other Manufacturing	$1,813	$1,289	$523	$309	$27	$175	$13	4,774
Educational Services, Health Care, and Social Assistance	$231	$90	$141	$113	$12	$14	$2	2,910
Other Professional, Scientific & Tech Services	$397	$159	$238	$148	$51	$34	$4	2,597
Retail Trade	$178	$61	$118	$65	$6	$23	$24	2,537
Finance and Insurance, Real Estate, Rental and Leasing Services	$561	$198	$363	$175	$28	$129	$30	2,279
Management of Companies and Enterprises	$463	$169	$294	$229	-$1	$61	$5	1,975
Government & Non NAICs	$194	$18	$177	$95	$1	$70	$10	1,739
Administrative and Support & Waste Managment and Remediation Services	$106	$40	$66	$47	$5	$12	$2	1,652
Total	$10,617	$6,367	$4,250	$2,021	$314	$1,567	$348	41,470

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

As with the increase in oil production, the construction impacts are much larger overall in Table 13, and have larger relative effects on more regional industries than do the corresponding import substitution impacts. The natural gas import substitution impacts are also more widespread than the oil import substitution impacts. The directly linked "Drilling Oil and Gas Wells" still accounts for the largest impacts in terms of both output and employment.

Tax Impacts.
Tax impacts are estimated from data that relates regional tax receipts by type to output totals and to the various components of value added, including employee compensation, proprietary income (profit), other property income and indirect business taxes. Because these data are related at a highly aggregated level, they should be taken as coarse estimates of impacts on tax revenues. As was the case with industry impacts, the distribution of sizable tax impacts is wider ranging for construction compared to import substitution impacts.

IMPLAN provides the following definitions:[55]

> Employee Compensation in IMPLAN is the total payroll cost of the employee paid by the employer. This includes wage and salary, all benefits (e.g., health, retirement, etc.) and employer paid payroll taxes (e.g., employer side of social security, unemployment taxes, etc.).
>
> Proprietor income consists of payments received by self-employed individuals and unincorporated business owners. This income also includes the capital consumption allowance.
>
> Other property income represents property income minus proprietor income. It includes corporate profits, capital consumption allowance, payments for rent, and interest income. It may also be referred to as "other property type income."
>
> Indirect Business Taxes […] consist of tax and nontax liabilities that are chargeable to business expenses when calculating profit-type incomes and certain other business liabilities to government agencies that are treated like taxes. Thus, IBT includes taxes on sales, property and production, but it excludes employer contributions for social insurance and taxes on income. As part of the NIPA revision, this component was modified and termed “taxes on production and imports less subsidies.” The major differences between the two are attributable to the treatments of subsidies and non-taxes. (BEA)

[55] For complete definitions of types of taxes, see http://implan.com/index.php?option=com_glossary&Itemid=108. For a comprehensive treatment of the IMPLAN tax estimation procedures, see http://implan.com/index.php?option=com_docman&task=doc_download&gid=97&Itemid=65.

Table 14. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 1

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$2	$0	$2
	Personal Tax: Income Tax	$0	$0	$2	$0	$0	$2
	Social Insurance Tax-Employee Contribution	$0	$1	$0	$0	$0	$1
	Total	$1	$1	$2	$2	$1	$6
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$1	$0	$1
	Dividends	$0	$0	$0	$1	$0	$1
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$2	$2
	Personal Tax: Income Tax	$0	$0	$1	$0	$0	$1
	Total	$0	$0	$1	$1	$4	$7
Total		$1	$1	$3	$4	$5	$13

*Results are not displayed for tax categories that experience no impact.

Table 15. Construction Tax Impacts from a 10 Percent Oil Increase for Region 1

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$0	$0	$0	$1
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$36	$0	$36
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$5	$5
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$2	$2
	Personal Tax: Income Tax	$0	$0	$55	$0	$0	$55
	Social Insurance Tax-Employee Contribution	$34	$5	$0	$0	$0	$39
	Social Insurance Tax-Employer Contribution	$34	$0	$0	$0	$0	$34
	Total	$68	$5	$55	$36	$9	$174
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$10	$0	$10
	Dividends	$0	$0	$0	$12	$0	$12
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$1	$1
	Indirect Business Tax:	$0	$0	$0	$0	$6	$6
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$33	$33
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$31	$31
	Personal Tax: Income Tax	$0	$0	$22	$0	$0	$22
	Personal Tax: Motor Vehicle License	$0	$0	$1	$0	$0	$1
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$4	$0	$0	$4
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$2	$0	$0	$0	$0	$2
	Total	$3	$0	$27	$22	$73	$125
Total		$72	$5	$82	$58	$82	$299

*Results are not displayed for tax categories that experience no impact.

These general tax results hold with little variation for oil and gas, and across all regions.

Table 16. Import Substitution Tax Impacts from a 10 Percent Gas Increase for Region 1

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$3	$0	$0	$0	$0	$3
	Total	$3	$0	$0	$0	$0	$3
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$438	$0	$438
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$29	$29
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$77	$77
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$35	$35
	Personal Tax: Income Tax	$0	$0	$429	$0	$0	$429
	Social Insurance Tax-Employee Contribution	$182	$91	$0	$0	$0	$273
	Social Insurance Tax-Employer Contribution	$184	$0	$0	$0	$0	$184
	Total	$366	$91	$429	$438	$141	$1,465
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$73	$0	$73
	Dividends	$0	$0	$0	$112	$0	$112
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$9	$9
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$72	$72
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$395	$395
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$44	$44
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$446	$446
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$11	$11
	Personal Tax: Income Tax	$0	$0	$112	$0	$0	$112
	Personal Tax: Motor Vehicle License	$0	$0	$4	$0	$0	$4
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$26	$0	$0	$26
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$2	$0	$0	$2
	Personal Tax: Property Tax	$0	$0	$3	$0	$0	$3
	Social Insurance Tax-Employee Contribution	$2	$0	$0	$0	$0	$2
	Social Insurance Tax-Employer Contribution	$9	$0	$0	$0	$0	$9
	Total	$11	$0	$146	$185	$977	$1,320
Total		$381	$91	$575	$624	$1,118	$2,788

*Results are not displayed for tax categories that experience no impact.

Table 17. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 1

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$14	$0	$0	$0	$0	$14
	Total	$14	$0	$0	$0	$0	$14
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$1,214	$0	$1,214
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$73	$73
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$197	$197
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$89	$89
	Personal Tax: Income Tax	$0	$0	$1,286	$0	$0	$1,286
	Social Insurance Tax-Employee Contribution	$812	$77	$0	$0	$0	$890
	Social Insurance Tax-Employer Contribution	$824	$0	$0	$0	$0	$824
	Total	$1,637	$77	$1,286	$1,214	$359	$4,573
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$203	$0	$203
	Dividends	$0	$0	$0	$310	$0	$310
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$23	$23
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$183	$183
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$1,006	$1,006
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$111	$111
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$1,136	$1,136
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$29	$29
	Personal Tax: Income Tax	$0	$0	$336	$0	$0	$336
	Personal Tax: Motor Vehicle License	$0	$0	$18	$0	$0	$18
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$78	$0	$0	$78
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$6	$0	$0	$6
	Personal Tax: Property Tax	$0	$0	$8	$0	$0	$8
	Social Insurance Tax-Employee Contribution	$10	$0	$0	$0	$0	$10
	Social Insurance Tax-Employer Contribution	$40	$0	$0	$0	$0	$40
	Total	$50	$0	$446	$514	$2,487	$3,496
Total		$1,701	$77	$1,732	$1,728	$2,846	$8,084

*Results are not displayed for tax categories that experience no impact.

9.2.2 Region 1 (Marcellus Shale) – Scenario Analysis

Three scenario analyses for the Marcellus Shale Region are performed and reported, one for each time period, 2010, 2020, and 2030. For this region, future production in all time periods is expected to be less after adopting the S.2191 legislation in 2007 than it is for the AEO2008 estimate under the 2006 legislative environment. Therefore, all of the following impacts estimated for this region are considered opportunity costs of the S.2191 legislation.

In 2010, there is no difference in the future production of oil in the baseline (AEO2008) estimation and S.2191 estimation, but 2008 MMcf/yr of natural gas was not produced due to the new legislation. Table 18 gives a summary report of the data input and the total impacts from import substitution and construction that are not realized due to the adoption of S.2191.[56]

Table 18. Input Data and Summary Results for Marcellus Shale, 2010

Input Data Summary for Marcellus Shale		
	Natural Gas	Oil
Production Increases	2008 MMcf/yr	0 thbbl/yr
Estimated Average Well Depth	3,750-4,999 ft/well	2,500-3,749 ft/well
Well Construction Cost	352 th$/well	228 th$/well
Average Producer Price	7.46 $/tcf	63.11 $/bbl
Industry Output	16 Million $	0 Million $
Reduced Import Payments	15 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Marcellus Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$22	61	$3
Construction Impacts	$405	1,580	$43

In 2020, due to the new legislation, 22,370 MMcf/yr of natural gas and 6 thbbl/yr of oil are not produced. The following impacts, shown in Table 19, are not realized and reflect the opportunity costs of the legislation.

[56] With the duplication of input data included in this report and the ease of impacts model use, interested readers can easily duplicate any of the scenario analyses to obtain results at the level of industry detail. Likewise, the readers can contact the authors for more detailed and disaggregated results. Again, however, the distributions of impacts across industries and tax types will strongly resemble those of the standard 10 percent analyses presented for each region.

Table 19. Input Data and Summary Results for Marcellus Shale, 2020

Input Data Summary for Marcellus Shale		
	Natural Gas	Oil
Production Increases	22370 MMcf/yr	6 thbbl/yr
Estimated Average Well Depth	3,750-4,999 ft/well	2,500-3,749 ft/well
Well Construction Cost	352 th$/well	228 th$/well
Average Producer Price	7.46 $/tcf	63.11 $/bbl
Industry Output	177 Million $	0 Million $
Reduced Import Payments	172 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Marcellus Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$242	687	$36
Construction Impacts	$4,526	17,680	$478

Finally, a similar scenario exists for the year 2030. Once again, there is no difference in the amount of oil produced under the S.2191 legislation, but 3,982 fewer MMcf/yr of natural gas are produced. The results displayed below in Table 20 represent the opportunity costs in the year 2030 of the S.2191 legislation.

Table 20. Input Data and Summary Results for Marcellus Shale, 2030

Input Data Summary for Marcellus Shale		
	Natural Gas	Oil
Production Increases	3982 MMcf/yr	0 thbbl/yr
Estimated Average Well Depth	3,750-4,999 ft/well	2,500-3,749 ft/well
Well Construction Cost	352 th$/well	228 th$/well
Average Producer Price	7.46 $/tcf	63.11 $/bbl
Industry Output	31 Million $	0 Million $
Reduced Import Payments	31 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Marcellus Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$43	122	$6
Construction Impacts	$803	3,134	$85

9.2.3 Region 2 (Bakken Shale) – Standardized Production Increase

Oil.

Table 21. Major Import Substitution Impacts from a 10 Percent Oil Increase for Region 2

Import Substitution Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$457	$167	$291	$29	$87	$147	$28	781
Other Manufacturing	$62	$52	$10	$5	$1	$4	$0	122
Finance and Insurance, Real Estate, Rental and Leasing Services	$61	$25	$36	$9	$4	$19	$4	375
Other Professional, Scientific & Tech Services	$17	$8	$8	$5	$2	$1	$0	183
Educational Services, Health Care, and Social Assistance	$11	$5	$6	$5	$1	$1	$0	158
Support Activities for Oil and Gas Operations	$10	$1	$10	$3	$0	$6	$0	52
Management of Companies and Enterprises	$10	$5	$5	$4	$0	$1	$0	68
Wholesale Trade	$9	$3	$6	$3	$0	$1	$1	70
Government & Non NAICs	$9	$1	$8	$5	$0	$2	$0	114
Information	$8	$5	$4	$2	$0	$1	$0	39
Total	$705	$296	$409	$85	$97	$189	$37	2,551

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 22. Major Construction Impacts from a 10 Percent Oil Increase for Region 2

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Drilling Oil and Gas Wells	$2,668	$1,742	$926	$309	$14	$495	$108	4,051
Other Manufacturing	$1,375	$1,145	$230	$121	$20	$83	$6	2,693
Finance and Insurance, Real Estate, Rental and Leasing Services	$400	$163	$237	$60	$25	$126	$25	2,469
Management of Companies and Enterprises	$344	$171	$173	$135	$0	$36	$3	2,309
Other Professional, Scientific & Tech Services	$270	$136	$134	$81	$29	$21	$3	2,966
Wholesale Trade	$202	$66	$136	$70	$6	$30	$30	1,510
Arts, Entertainment, Recreation, Accomodation, and Food Services	$194	$103	$91	$55	$5	$21	$11	4,338
Educational Services, Health Care, and Social Assistance	$145	$63	$82	$65	$8	$9	$1	2,030
Information	$144	$83	$60	$30	$3	$23	$5	676
Retail Trade	$118	$42	$76	$41	$6	$13	$16	2,022
Total	$6,781	$4,142	$2,639	$1,221	$172	$1,011	$235	32,797

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Gas.

Table 23. Major Import Substitution Impacts from a 10 Percent Natural Gas Increase for Region 2

Import Substitution Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$93	$34	$59	$6	$18	$30	$6	160
Natural Gas Distribution	$30	$20	$10	$4	$1	$3	$3	40
Other Manufacturing	$17	$14	$3	$2	$0	$1	$0	34
Finance and Insurance, Real Estate, Rental and Leasing Services	$16	$6	$9	$2	$1	$5	$1	96
Other Professional, Scientific & Tech Services	$4	$2	$2	$1	$0	$0	$0	49
Educational Services, Health Care, and Social Assistance	$3	$1	$2	$1	$0	$0	$0	46
Management of Companies and Enterprises	$3	$1	$1	$1	$0	$0	$0	17
Wholesale Trade	$3	$1	$2	$1	$0	$0	$0	19
Support Activities for Oil and Gas Operations	$3	$0	$2	$1	$0	$1	$0	13
Pipeline Transportation	$2	$2	$1	$0	$0	$0	$0	4
Total	$191	$90	$101	$25	$21	$44	$11	686

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 24. Major Construction Impacts from a 10 Percent Natural Gas Increase for Region 2

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Drilling Oil and Gas Wells	$218	$143	$76	$25	$1	$41	$9	331
Other Manufacturing	$115	$95	$19	$10	$2	$7	$1	225
Finance and Insurance, Real Estate, Rental and Leasing Services	$33	$14	$20	$5	$2	$10	$2	206
Management of Companies and Enterprises	$28	$14	$14	$11	$0	$3	$0	189
Other Professional, Scientific & Tech Services	$22	$11	$11	$7	$2	$2	$0	245
Wholesale Trade	$17	$6	$11	$6	$1	$2	$2	126
Arts, Entertainment, Recreation, Accomodation, and Food Services	$16	$8	$8	$5	$0	$2	$1	359
Educational Services, Health Care, and Social Assistance	$12	$5	$7	$5	$1	$1	$0	170
Information	$12	$7	$5	$2	$0	$2	$0	56
Retail Trade	$10	$4	$6	$3	$0	$1	$1	170
Total	$564	$345	$220	$102	$15	$84	$19	2,759

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Tax Impacts.

Table 25. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 2

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$18	$0	$18
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$10	$0	$0	$10
	Social Insurance Tax-Employee Contribution	$5	$4	$0	$0	$0	$10
	Social Insurance Tax-Employer Contribution	$5	$0	$0	$0	$0	$5
	Total	$11	$4	$10	$18	$6	$49
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$3	$0	$3
	Dividends	$0	$0	$0	$3	$0	$3
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$15	$15
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$6	$6
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$5	$5
	Personal Tax: Income Tax	$0	$0	$3	$0	$0	$3
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$1	$0	$0	$1
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$1	$0	$0	$1
	Total	$0	$0	$4	$6	$32	$43
Total		$11	$4	$15	$24	$37	$92

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 26. Construction Tax Impacts from a 10 Percent Oil Increase for Region 2

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$0	$0	$0	$1
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$96	$0	$96
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$19	$19
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$9	$9
	Personal Tax: Income Tax	$0	$0	$74	$0	$0	$74
	Social Insurance Tax-Employee Contribution	$77	$8	$0	$0	$0	$85
	Social Insurance Tax-Employer Contribution	$79	$0	$0	$0	$0	$79
	Total	$156	$8	$74	$96	$35	$368
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$14	$0	$14
	Dividends	$0	$0	$0	$18	$0	$18
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$4	$4
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$9	$9
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$97	$97
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$19	$19
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$41	$41
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$30	$30
	Personal Tax: Income Tax	$0	$0	$22	$0	$0	$22
	Personal Tax: Motor Vehicle License	$0	$0	$3	$0	$0	$3
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$5	$0	$0	$5
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$4	$0	$0	$4
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$4	$0	$0	$0	$0	$4
	Total	$5	$0	$34	$33	$200	$271
Total		$162	$8	$107	$129	$235	$641

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 27. Import Substitution Tax Impacts from a 10 Percent Natural Gas Increase for Region 2

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$4	$0	$4
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$3	$0	$0	$3
	Social Insurance Tax-Employee Contribution	$2	$1	$0	$0	$0	$3
	Social Insurance Tax-Employer Contribution	$2	$0	$0	$0	$0	$2
	Total	$3	$1	$3	$4	$2	$12
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$1	$0	$1
	Dividends	$0	$0	$0	$1	$0	$1
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$5	$5
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$1	$0	$0	$1
	Total	$0	$0	$1	$1	$9	$12
Total		$3	$1	$4	$6	$11	$24

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 28. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 2

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$8	$0	$8
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$6	$0	$0	$6
	Social Insurance Tax-Employee Contribution	$6	$1	$0	$0	$0	$7
	Social Insurance Tax-Employer Contribution	$7	$0	$0	$0	$0	$7
	Total	$13	$1	$6	$8	$3	$31
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$1	$0	$1
	Dividends	$0	$0	$0	$2	$0	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$8	$8
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$3	$3
	Personal Tax: Income Tax	$0	$0	$2	$0	$0	$2
	Total	$0	$0	$3	$3	$17	$22
Total		$14	$1	$9	$11	$19	$53

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

9.2.4 Region 2 (Bakken Shale) – Scenario Analysis

Four scenario analyses were performed for the Bakken Shale Region, however, only three are reported. The analyses reported here are for natural gas impacts in 2010 and oil and gas impacts for both 2020 and 2030. Future production in these three analyses is expected to be less after adopting the S.2191 legislation in 2007 and all impacts reported for this region are considered opportunity costs of the legislation. For the oil industry in 2010, future production was expected to be greater after adopting the S.2191 legislation, but the analysis of this legislation benefit did not yield any significant results as the change in production was very small. Tables 29–31 give summary reports of the data inputs and the total impacts from import substitution and construction for Region 2 that are not realized due to the adoption of S.2191.

Table 29. Input Data and Summary Results for Bakken Shale, 2010 (Natural Gas Only)

Input Data Summary for Bakken Shale

	Natural Gas	Oil
Production Increases	1346 MMcf/yr	0 thbbl/yr
Estimated Average Well Depth	1,250-2,499 ft/well	12,500-14,999 ft/well
Well Construction Cost	204 th$/well	3496 th$/well
Average Producer Price	5.86 $/tcf	60.04 $/bbl
Industry Output	9 Million $	0 Million $
Reduced Import Payments	0 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Bakken Shale

(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$14	51	$2
Construction Impacts	$43	210	$4

Table 30. Input Data and Summary Results for Bakken Shale, 2020

Input Data Summary for Bakken Shale

	Natural Gas	Oil
Production Increases	9181 MMcf/yr	640 thbbl/yr
Estimated Average Well Depth	1,250-2,499 ft/well	12,500-14,999 ft/well
Well Construction Cost	204 th$/well	3496 th$/well
Average Producer Price	5.86 $/tcf	60.04 $/bbl
Industry Output	64 Million $	38 Million $
Reduced Import Payments	0 Million $	38 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Bakken Shale

(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$156	553	$20
Construction Impacts	$861	4,180	$81

Table 31. Input Data and Summary Results for Bakken Shale, 2030

Input Data Summary for Bakken Shale		
	Natural Gas	Oil
Production Increases	1050 MMcf/yr	741 thbbl/yr
Estimated Average Well Depth	1,250-2,499 ft/well	12,500-14,999 ft/well
Well Construction Cost	204 th$/well	3496 th$/well
Average Producer Price	5.86 $/tcf	60.04 $/bbl
Industry Output	7 Million $	44 Million $
Reduced Import Payments	0 Million $	44 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Bakken Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$77	267	$10
Construction Impacts	$689	3,334	$65

9.2.5 Region 3 (Barnett Shale) – Standardized Production Increase

Oil.

Table 32. Major Import Substitution Impacts from a 10 Percent Oil Increase for Region 3

Import Substitution Impacts (Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$2,364	$861	$1,503	$248	$354	$757	$144	2,658
Other Manufacturing	$724	$578	$146	$68	$15	$58	$5	952
Finance and Insurance, Real Estate, Rental and Leasing Services	$636	$249	$386	$112	$42	$193	$39	2,995
Other Professional, Scientific & Tech Services	$178	$74	$104	$67	$22	$14	$2	1,316
Government & Non NAICs	$123	$12	$111	$62	$0	$43	$6	1,271
Educational Services, Health Care, and Social Assistance	$119	$45	$74	$55	$9	$9	$1	1,491
Wholesale Trade	$116	$38	$78	$40	$4	$17	$17	590
Retail Trade	$110	$38	$73	$41	$5	$11	$15	1,603
Management of Companies and Enterprises	$107	$46	$61	$48	-$1	$13	$1	588
Information	$103	$53	$50	$19	$5	$21	$4	292
Total	$5,158	$2,230	$2,927	$920	$493	$1,256	$258	18,804

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 33. Major Construction Impacts from a 10 Percent Oil Increase for Region 3

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Drilling Oil and Gas Wells	$12,158	$7,508	$4,651	$1,489	$132	$2,488	$542	16,868
Other Manufacturing	$6,799	$5,425	$1,374	$638	$145	$547	$44	8,932
Finance and Insurance, Real Estate, Rental and Leasing Services	$1,990	$781	$1,209	$350	$133	$603	$123	9,378
Management of Companies and Enterprises	$1,562	$674	$888	$704	-$15	$185	$14	8,595
Other Professional, Scientific & Tech Services	$1,269	$526	$743	$474	$156	$99	$14	9,369
Water, Sewer, and Pipeline Construction	$1,154	$610	$544	$333	$121	$82	$8	9,158
Wholesale Trade	$1,027	$334	$692	$356	$33	$152	$152	5,241
Arts, Entertainment, Recreation, Accomodation, and Food Services	$850	$403	$446	$277	$27	$93	$50	15,672
Information	$728	$376	$352	$134	$37	$152	$29	2,070
Oil and Gas Extraction	$707	$257	$450	$74	$106	$226	$43	795
Total	$33,284	$18,932	$14,352	$6,526	$1,155	$5,435	$1,237	134,595

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Gas.

Table 34. Import Substitution Impacts for a 10 Percent Natural Gas Increase for Region 3

Import Substitution Impacts (Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Oil and Gas Extraction	$3,390	$1,235	$2,156	$355	$508	$1,086	$206	3,812
Other Manufacturing	$1,480	$1,181	$299	$139	$32	$119	$10	1,944
Finance and Insurance, Real Estate, Rental and Leasing Services	$1,247	$489	$758	$219	$83	$378	$77	5,878
Natural Gas Distribution	$1,046	$546	$500	$93	$106	$157	$144	894
Other Professional, Scientific & Tech Services	$359	$149	$210	$134	$44	$28	$4	2,653
Government & Non NAICs	$251	$24	$227	$126	$1	$88	$12	2,601
Educational Services, Health Care, and Social Assistance	$245	$93	$153	$113	$19	$19	$2	3,085
Wholesale Trade	$235	$77	$159	$82	$7	$35	$35	1,200
Retail Trade	$227	$78	$150	$84	$11	$23	$32	3,308
Information	$209	$108	$101	$39	$11	$44	$8	595
Total	$10,150	$4,594	$5,556	$1,817	$907	$2,247	$585	37,525

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 35. Construction Impacts from a 10 Percent Natural Gas Increase for Region 3

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Drilling Oil and Gas Wells	$14,568	$8,995	$5,572	$1,784	$159	$2,981	$649	20,210
Other Manufacturing	$7,868	$6,278	$1,590	$739	$168	$633	$51	10,336
Finance and Insurance, Real Estate, Rental and Leasing Services	$2,301	$903	$1,398	$405	$153	$698	$143	10,842
Management of Companies and Enterprises	$1,858	$802	$1,057	$837	-$17	$220	$17	10,226
Other Professional, Scientific & Tech Services	$1,489	$617	$872	$557	$183	$116	$16	10,997
Wholesale Trade	$1,190	$388	$803	$413	$38	$176	$176	6,076
Arts, Entertainment, Recreation, Accomodation, and Food Services	$997	$473	$524	$325	$31	$109	$58	18,395
Information	$845	$436	$409	$155	$43	$176	$34	2,402
Oil and Gas Extraction	$818	$298	$520	$86	$123	$262	$50	920
Government & Non NAICs	$738	$70	$667	$372	$3	$259	$34	7,650
Total	$38,047	$21,704	$16,344	$7,333	$1,231	$6,332	$1,448	148,450

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Tax Impacts.

Table 36. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 3

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$0	$0	$0	$1
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$120	$0	$120
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$20	$20
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$9	$9
	Personal Tax: Income Tax	$0	$0	$115	$0	$0	$115
	Social Insurance Tax-Employee Contribution	$50	$22	$0	$0	$0	$73
	Social Insurance Tax-Employer Contribution	$51	$0	$0	$0	$0	$51
	Total	$102	$22	$115	$120	$36	$395
State/Local Government NonEducation	Dividends	$0	$0	$0	$17	$0	$17
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$13	$13
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$99	$99
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$92	$92
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$9	$9
	Personal Tax: Motor Vehicle License	$0	$0	$1	$0	$0	$1
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$7	$0	$0	$7
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$1	$0	$0	$1
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$2	$0	$0	$0	$0	$2
	Total	$3	$0	$10	$17	$222	$251
Total		$105	$22	$125	$137	$258	$647

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 37. Construction Tax Impacts from a 10 Percent Oil Increase for Region 3

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$7	$0	$0	$0	$0	$7
	Total	$7	$0	$0	$0	$0	$7
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$520	$0	$520
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$35	$35
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$94	$94
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$43	$43
	Personal Tax: Income Tax	$0	$0	$615	$0	$0	$615
	Social Insurance Tax-Employee Contribution	$358	$52	$0	$0	$0	$410
	Social Insurance Tax-Employer Contribution	$363	$0	$0	$0	$0	$363
	Total	$721	$52	$615	$520	$172	$2,080
State/Local Government NonEducation	Dividends	$0	$0	$0	$74	$0	$74
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$9	$9
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$60	$60
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$476	$476
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$35	$35
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$442	$442
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$42	$42
	Personal Tax: Motor Vehicle License	$0	$0	$9	$0	$0	$9
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$40	$0	$0	$40
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$3	$0	$0	$3
	Personal Tax: Property Tax	$0	$0	$5	$0	$0	$5
	Social Insurance Tax-Employee Contribution	$4	$0	$0	$0	$0	$4
	Social Insurance Tax-Employer Contribution	$16	$0	$0	$0	$0	$16
	Total	$19	$0	$56	$74	$1,064	$1,214
Total		$747	$52	$671	$593	$1,237	$3,300

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 38. Import Substitution Tax Impacts from a 10 Percent Natural Gas Increase for Region 3

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$2	$0	$0	$0	$0	$2
	Total	$2	$0	$0	$0	$0	$2
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$215	$0	$215
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$17	$17
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$45	$45
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$20	$20
	Personal Tax: Income Tax	$0	$0	$222	$0	$0	$222
	Social Insurance Tax-Employee Contribution	$100	$41	$0	$0	$0	$141
	Social Insurance Tax-Employer Contribution	$101	$0	$0	$0	$0	$101
	Total	$201	$41	$222	$215	$82	$760
State/Local Government NonEducation	Dividends	$0	$0	$0	$30	$0	$30
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$4	$4
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$28	$28
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$225	$225
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$16	$16
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$209	$209
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$20	$20
	Personal Tax: Motor Vehicle License	$0	$0	$2	$0	$0	$2
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$14	$0	$0	$14
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$1	$0	$0	$1
	Personal Tax: Property Tax	$0	$0	$2	$0	$0	$2
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$4	$0	$0	$0	$0	$4
	Total	$5	$0	$19	$30	$503	$558
Total		$208	$41	$241	$245	$585	$1,320

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 39. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 3

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$7	$0	$0	$0	$0	$7
	Total	$7	$0	$0	$0	$0	$7
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$605	$0	$605
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$41	$41
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$111	$111
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$50	$50
	Personal Tax: Income Tax	$0	$0	$685	$0	$0	$685
	Social Insurance Tax-Employee Contribution	$402	$56	$0	$0	$0	$458
	Social Insurance Tax-Employer Contribution	$408	$0	$0	$0	$0	$408
	Total	$810	$56	$685	$605	$202	$2,358
State/Local Government NonEducation	Dividends	$0	$0	$0	$86	$0	$86
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$10	$10
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$70	$70
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$557	$557
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$40	$40
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$518	$518
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$50	$50
	Personal Tax: Motor Vehicle License	$0	$0	$10	$0	$0	$10
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$44	$0	$0	$44
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$3	$0	$0	$3
	Personal Tax: Property Tax	$0	$0	$5	$0	$0	$5
	Social Insurance Tax-Employee Contribution	$4	$0	$0	$0	$0	$4
	Social Insurance Tax-Employer Contribution	$17	$0	$0	$0	$0	$17
	Total	$22	$0	$63	$86	$1,246	$1,416
Total		$839	$56	$748	$691	$1,448	$3,782

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

9.2.6 Region 3 (Barnett Shale) – Scenario Analysis

Four scenario analyses were performed for the Barnett Shale Region and all are reported below. All analyses except for the Natural Gas Only scenario in 2030 are reported as opportunity costs of S.2191 legislation. The Natural Gas Only scenario in 2030 has impacts reported as benefits of the legislation. These analyses are included in Tables 40–43 where summary reports of the data inputs and the total impacts from import substitution and construction are given for Region 3.

Table 40. Input Data and Summary Results for Barnett Shale, 2010

Input Data Summary for Barnett Shale		
	Natural Gas	Oil
Production Increases	31658 MMcf/yr	45 thbbl/yr
Estimated Average Well Depth	7,500-9,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	1588 th$/well	758 th$/well
Average Producer Price	6.63 $/tcf	59.57 $/bbl
Industry Output	224 Million $	3 Million $
Reduced Import Payments	0 Million $	3 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Barnett Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$514	1,887	$67
Construction Impacts	$1,962	7,669	$195

Table 41. Input Data and Summary Results for Barnett Shale, 2020

Input Data Summary for Barnett Shale		
	Natural Gas	Oil
Production Increases	31658 MMcf/yr	45 thbbl/yr
Estimated Average Well Depth	7,500-9,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	1588 th$/well	758 th$/well
Average Producer Price	6.63 $/tcf	59.57 $/bbl
Industry Output	224 Million $	3 Million $
Reduced Import Payments	0 Million $	3 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Barnett Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$514	1,887	$67
Construction Impacts	$1,962	7,669	$195

Table 42. Input Data and Summary Results for Barnett Shale, 2030 (Oil Only)

Input Data Summary for Barnett Shale		
	Natural Gas	Oil
Production Increases	0 MMcf/yr	1473 thbbl/yr
Estimated Average Well Depth	7,500-9,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	1588 th$/well	758 th$/well
Average Producer Price	6.63 $/tcf	59.57 $/bbl
Industry Output	0 Million $	88 Million $
Reduced Import Payments	0 Million $	87 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Barnett Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$189	684	$24
Construction Impacts	$1,235	4,992	$122

Table 43. Input Data and Summary Results for Barnett Shale, 2030 (Gas Only)

Input Data Summary for Barnett Shale		
	Natural Gas	Oil
Production Increases	12954 MMcf/yr	0 thbbl/yr
Estimated Average Well Depth	7,500-9,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	1588 th$/well	758 th$/well
Average Producer Price	6.63 $/tcf	59.57 $/bbl
Industry Output	92 Million $	0 Million $
Reduced Import Payments	0 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Barnett Shale			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$208	763	$27
Construction Impacts	$786	3,072	$78

9.2.7 Region 4 (Greater Green River/Jonah Field/Pinedale Anticline) – Standardized Production Increase

Oil.

Table 44. Import Substitution Impacts from a 10 Percent Oil Increase for Region 4

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$5	$4	$1	$1	$0	$0	$0	50
Oil and Gas Extraction	$540	$197	$343	$44	$93	$173	$33	690
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$1	$1	$1	$0	$0	$0	$0	4
Drilling Oil and Gas Wells	$1	$1	$0	$0	$0	$0	$0	2
Support Activities for Oil and Gas Operations	$23	$1	$22	$7	$1	$13	$1	106
Power Generation and Supply and Water, Sewage and Other Systems	$9	$2	$7	$2	$0	$4	$1	18
Natural Gas Distribution	$2	$1	$1	$0	$0	$0	$0	2
Other New Construction, Including Maintenance and Repair Construction	$2	$1	$1	$1	$0	$0	$0	18
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Total	$1,129	$477	$653	$199	$119	$277	$58	4,518

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 45. Construction Impacts from a 10 Percent Oil Increase for Region 4

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$48	$35	$13	$5	$2	$4	$1	461
Oil and Gas Extraction	$121	$44	$77	$10	$21	$39	$7	155
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$14	$7	$7	$3	$1	$2	$1	41
Drilling Oil and Gas Wells	$2,718	$1,753	$965	$298	$38	$516	$112	4,045
Support Activities for Oil and Gas Operations	$59	$3	$55	$18	$2	$33	$2	272
Power Generation and Supply and Water, Sewage and Other Systems	$38	$7	$31	$7	$1	$18	$4	82
Natural Gas Distribution	$22	$12	$10	$4	$1	$3	$3	19
Other New Construction, Including Maintenance and Repair Construction	$17	$9	$8	$5	$2	$1	$0	127
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$178	$93	$86	$51	$21	$13	$1	1,379
Total	$7,416	$4,194	$3,222	$1,549	$237	$1,160	$276	33,443

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Gas.

Table 46. Import Substitution Impacts for a 10 Percent Natural Gas Increase for Region 4

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$24	$18	$7	$3	$1	$2	$0	234
Oil and Gas Extraction	$1,934	$704	$1,230	$157	$335	$620	$118	2,472
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$6	$3	$3	$1	$0	$1	$0	17
Drilling Oil and Gas Wells	$5	$3	$2	$1	$0	$1	$0	7
Support Activities for Oil and Gas Operations	$99	$5	$94	$30	$4	$56	$4	458
Power Generation and Supply and Water, Sewage and Other Systems	$39	$7	$32	$7	$1	$18	$4	84
Natural Gas Distribution	$303	$162	$141	$50	$9	$43	$39	273
Other New Construction, Including Maintenance and Repair Construction	$11	$6	$5	$3	$1	$1	$0	85
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Total	$4,968	$2,172	$2,797	$926	$463	$1,135	$272	20,515

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 47. Construction Impacts from a 10 Percent Natural Gas Increase for Region 4

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$65	$47	$18	$7	$3	$6	$1	627
Oil and Gas Extraction	$167	$61	$106	$14	$29	$54	$10	214
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$19	$9	$10	$4	$1	$3	$1	56
Drilling Oil and Gas Wells	$3,802	$2,452	$1,350	$417	$53	$722	$157	5,659
Support Activities for Oil and Gas Operations	$82	$4	$78	$25	$3	$46	$3	382
Power Generation and Supply and Water, Sewage and Other Systems	$52	$10	$42	$10	$2	$25	$6	112
Natural Gas Distribution	$32	$17	$15	$5	$1	$4	$4	29
Other New Construction, Including Maintenance and Repair Construction	$23	$12	$10	$6	$3	$1	$0	174
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$154	$80	$74	$44	$18	$11	$1	1,195
Total	$10,141	$5,744	$4,397	$2,103	$314	$1,599	$380	45,122

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Tax Impacts.

Table 48. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 4

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$26	$0	$26
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$5	$5
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$2	$2
	Personal Tax: Income Tax	$0	$0	$26	$0	$0	$26
	Social Insurance Tax-Employee Contribution	$11	$5	$0	$0	$0	$17
	Social Insurance Tax-Employer Contribution	$11	$0	$0	$0	$0	$11
	Total	$23	$5	$26	$26	$8	$89
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$2	$0	$2
	Dividends	$0	$0	$0	$5	$0	$5
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$17	$17
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$4	$4
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$23	$23
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$3	$3
	Personal Tax: Income Tax	$0	$0	$6	$0	$0	$6
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$1	$0	$0	$1
	Total	$0	$0	$8	$7	$49	$65
Total		$23	$5	$35	$33	$58	$154

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 49. Construction Tax Impacts from a 10 Percent Oil Increase for Region 4

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$2	$0	$0	$0	$0	$2
	Total	$2	$0	$0	$0	$0	$2
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$111	$0	$111
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$8	$8
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$22	$22
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$10	$10
	Personal Tax: Income Tax	$0	$0	$145	$0	$0	$145
	Social Insurance Tax-Employee Contribution	$87	$11	$0	$0	$0	$98
	Social Insurance Tax-Employer Contribution	$89	$0	$0	$0	$0	$89
	Total	$176	$11	$145	$111	$39	$482
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$7	$0	$7
	Dividends	$0	$0	$0	$22	$0	$22
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$83	$83
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$20	$20
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$111	$111
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$13	$13
	Personal Tax: Income Tax	$0	$0	$35	$0	$0	$35
	Personal Tax: Motor Vehicle License	$0	$0	$2	$0	$0	$2
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$7	$0	$0	$7
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$2	$0	$0	$2
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$3	$0	$0	$0	$0	$3
	Total	$4	$0	$46	$29	$236	$316
Total		$182	$11	$191	$140	$276	$799

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 50. Import Substitution Tax Impacts from a 10 Percent Natural Gas Increase for Region 4

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$0	$0	$0	$1
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$108	$0	$108
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$8	$8
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$21	$21
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$10	$10
	Personal Tax: Income Tax	$0	$0	$114	$0	$0	$114
	Social Insurance Tax-Employee Contribution	$52	$21	$0	$0	$0	$73
	Social Insurance Tax-Employer Contribution	$53	$0	$0	$0	$0	$53
	Total	$105	$21	$114	$108	$39	$388
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$7	$0	$7
	Dividends	$0	$0	$0	$21	$0	$21
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$82	$82
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$20	$20
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$109	$109
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$13	$13
	Personal Tax: Income Tax	$0	$0	$28	$0	$0	$28
	Personal Tax: Motor Vehicle License	$0	$0	$1	$0	$0	$1
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$5	$0	$0	$5
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$2	$0	$0	$2
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$2	$0	$0	$0	$0	$2
	Total	$2	$0	$36	$28	$233	$300
Total		$109	$21	$151	$137	$272	$689

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 51. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 4

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$2	$0	$0	$0	$0	$2
	Total	$2	$0	$0	$0	$0	$2
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$153	$0	$153
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$11	$11
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$30	$30
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$14	$14
	Personal Tax: Income Tax	$0	$0	$196	$0	$0	$196
	Social Insurance Tax-Employee Contribution	$119	$14	$0	$0	$0	$133
	Social Insurance Tax-Employer Contribution	$120	$0	$0	$0	$0	$120
	Total	$239	$14	$196	$153	$54	$656
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$10	$0	$10
	Dividends	$0	$0	$0	$30	$0	$30
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$10	$10
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$115	$115
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$28	$28
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$152	$152
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$18	$18
	Personal Tax: Income Tax	$0	$0	$47	$0	$0	$47
	Personal Tax: Motor Vehicle License	$0	$0	$2	$0	$0	$2
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$9	$0	$0	$9
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$3	$0	$0	$3
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$4	$0	$0	$0	$0	$4
	Total	$5	$0	$63	$40	$326	$434
Total		$246	$14	$258	$193	$380	$1,092

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

9.2.8 Region 4 (Greater Green River/Jonah Field/Pinedale Anticline) – Scenario Analysis

Three scenario analyses for the Greater Green River Region were performed and two are reported. The analysis for 2010 involved future production of oil that was not large enough to create any significant impacts. The two analyses reported below for oil and gas in 2020 and 2030 consider opportunity costs of the S.2191 legislation. Tables 52–53 give a summary report of the data inputs and the total impacts from import substitution and construction in Region 4 that are not realized due to the adoption of S.2191.

Table 52. Input Data and Summary Results for GGR/JF/PA, 2020

Input Data Summary for Greater Green River		
	Natural Gas	Oil
Production Increases	197733 MMcf/yr	786 thbbl/yr
Estimated Average Well Depth	3,750-4,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	699 th$/well	1099 th$/well
Average Producer Price	5.93 $/tcf	57.34 $/bbl
Industry Output	1200 Million $	45 Million $
Reduced Import Payments	0 Million $	48 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Greater Green River			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$2,721	11,121	$377
Construction Impacts	$6,044	26,883	$651

Table 53. Input Data and Summary Results for GGR/JF/PA, 2030

Input Data Summary for Greater Green River		
	Natural Gas	Oil
Production Increases	22623 MMcf/yr	910 thbbl/yr
Estimated Average Well Depth	3,750-4,999 ft/well	5,000-7,499 ft/well
Well Construction Cost	699 th$/well	1099 th$/well
Average Producer Price	5.93 $/tcf	57.34 $/bbl
Industry Output	137 Million $	52 Million $
Reduced Import Payments	0 Million $	56 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for Greater Green River			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$404	1,626	$56
Construction Impacts	$1,315	5,834	$142

9.2.9 Region 5 (California) – Standardized Production Increase

Oil.

Table 54. Import Substitution Impacts from a 10 Percent Oil Increase for Region 5

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$2	$1	$1	$1	$0	$0	$0	22
Oil and Gas Extraction	$1,197	$436	$761	$176	$129	$383	$73	2,033
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$0	$0	$0	$0	$0	$0	$0	1
Drilling Oil and Gas Wells	$0	$0	$0	$0	$0	$0	$0	1
Support Activities for Oil and Gas Operations	$8	$0	$7	$2	$0	$4	$0	36
Power Generation and Supply and Water, Sewage and Other Systems	$3	$1	$2	$0	$0	$1	$0	4
Natural Gas Distribution	$1	$1	$0	$0	$0	$0	$0	1
Other New Construction, Including Maintenance and Repair Construction	$1	$0	$0	$0	$0	$0	$0	6
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Other Manufacturing	$57	$43	$14	$10	$1	$4	$0	121
Construction and Mining Machinery Manufacturing	$2	$1	$0	$0	$0	$0	$0	2
Total	$1,439	$545	$894	$246	$141	$423	$83	3,500

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 55. Major Construction Impacts from a 10 Percent Oil Increase for Region 5

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$46	$21	$24	$12	$5	$7	$1	494
Oil and Gas Extraction	$95	$34	$60	$14	$10	$30	$6	161
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$9	$4	$5	$3	$0	$2	$0	43
Drilling Oil and Gas Wells	$3,539	$2,260	$1,279	$423	$23	$684	$149	5,184
Support Activities for Oil and Gas Operations	$77	$4	$73	$25	$1	$44	$3	362
Power Generation and Supply and Water, Sewage and Other Systems	$30	$6	$24	$4	$3	$14	$3	39
Natural Gas Distribution	$26	$15	$11	$3	$1	$3	$3	27
Other New Construction, Including Maintenance and Repair Construction	$17	$9	$8	$5	$2	$1	$0	115
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$318	$152	$166	$102	$36	$25	$2	2,173
Total	$8,345	$4,653	$3,692	$1,819	$254	$1,311	$307	33,102

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Gas.

Table 56. Major Import Substitution Impacts for a 10 Percent Natural Gas Increase for Region 5

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$2	$1	$1	$1	$0	$0	$0	27
Oil and Gas Extraction	$195	$71	$124	$29	$21	$62	$12	331
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$0	$0	$0	$0	$0	$0	$0	2
Drilling Oil and Gas Wells	$0	$0	$0	$0	$0	$0	$0	0
Support Activities for Oil and Gas Operations	$1	$0	$1	$0	$0	$1	$0	7
Power Generation and Supply and Water, Sewage and Other Systems	$1	$0	$1	$0	$0	$1	$0	1
Natural Gas Distribution	$47	$27	$20	$6	$3	$6	$6	48
Other New Construction, Including Maintenance and Repair Construction	$1	$0	$0	$0	$0	$0	$0	4
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Total	$365	$159	$206	$69	$30	$86	$22	1,089

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 57. Construction Impacts from a 10 Percent Natural Gas Increase for Region 5

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$6	$3	$3	$1	$1	$1	$0	61
Oil and Gas Extraction	$12	$4	$7	$2	$1	$4	$1	20
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$1	$0	$1	$0	$0	$0	$0	5
Drilling Oil and Gas Wells	$470	$300	$170	$56	$3	$91	$20	689
Support Activities for Oil and Gas Operations	$10	$1	$10	$3	$0	$6	$0	48
Power Generation and Supply and Water, Sewage and Other Systems	$4	$1	$3	$1	$0	$2	$0	5
Natural Gas Distribution	$3	$2	$1	$0	$0	$0	$0	3
Other New Construction, Including Maintenance and Repair Construction	$2	$1	$1	$1	$0	$0	$0	14
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$18	$9	$9	$6	$2	$1	$0	123
Total	$1,044	$586	$458	$222	$29	$167	$39	3,989

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Tax Impacts.

Table 58. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 5

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$40	$0	$40
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$6	$6
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$3	$3
	Personal Tax: Income Tax	$0	$0	$34	$0	$0	$34
	Social Insurance Tax-Employee Contribution	$15	$6	$0	$0	$0	$21
	Social Insurance Tax-Employer Contribution	$15	$0	$0	$0	$0	$15
	Total	$29	$6	$34	$40	$11	$121
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$10	$0	$10
	Dividends	$0	$0	$0	$15	$0	$15
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$6	$6
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$24	$24
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$37	$37
	Personal Tax: Income Tax	$0	$0	$11	$0	$0	$11
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$3	$0	$0	$3
	Social Insurance Tax-Employer Contribution	$1	$0	$0	$0	$0	$1
	Total	$2	$0	$15	$26	$72	$114
Total		$31	$6	$49	$66	$83	$235

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 59. Construction Tax Impacts from a 10 Percent Oil Increase for Region 5

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$2	$0	$0	$0	$0	$2
	Total	$2	$0	$0	$0	$0	$2
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$125	$0	$125
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$8	$8
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$23	$23
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$10	$10
	Personal Tax: Income Tax	$0	$0	$177	$0	$0	$177
	Social Insurance Tax-Employee Contribution	$108	$12	$0	$0	$0	$120
	Social Insurance Tax-Employer Contribution	$110	$0	$0	$0	$0	$110
	Total	$218	$12	$177	$125	$42	$573
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$33	$0	$33
	Dividends	$0	$0	$0	$47	$0	$47
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$24	$24
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$91	$91
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$11	$11
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$138	$138
	Personal Tax: Income Tax	$0	$0	$60	$0	$0	$60
	Personal Tax: Motor Vehicle License	$0	$0	$2	$0	$0	$2
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$16	$0	$0	$16
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$2	$0	$0	$0	$0	$2
	Social Insurance Tax-Employer Contribution	$9	$0	$0	$0	$0	$9
	Total	$11	$0	$79	$79	$266	$435
Total		$231	$12	$256	$204	$307	$1,010

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 60. Import Substitution Tax Impacts from a 10 Percent Natural Gas Increase for Region 5

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$8	$0	$8
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$9	$0	$0	$9
	Social Insurance Tax-Employee Contribution	$4	$1	$0	$0	$0	$5
	Social Insurance Tax-Employer Contribution	$4	$0	$0	$0	$0	$4
	Total	$8	$1	$9	$8	$3	$29
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$2	$0	$2
	Dividends	$0	$0	$0	$3	$0	$3
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$2	$2
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$7	$7
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$10	$10
	Personal Tax: Income Tax	$0	$0	$3	$0	$0	$3
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$1	$0	$0	$1
	Total	$0	$0	$4	$5	$19	$29
Total		$9	$1	$12	$13	$22	$58

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 61. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 5

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$16	$0	$16
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$1	$1
	Personal Tax: Income Tax	$0	$0	$21	$0	$0	$21
	Social Insurance Tax-Employee Contribution	$13	$1	$0	$0	$0	$15
	Social Insurance Tax-Employer Contribution	$13	$0	$0	$0	$0	$13
	Total	$27	$1	$21	$16	$5	$71
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$4	$0	$4
	Dividends	$0	$0	$0	$6	$0	$6
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$3	$3
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$12	$12
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$1	$1
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$18	$18
	Personal Tax: Income Tax	$0	$0	$7	$0	$0	$7
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$2	$0	$0	$2
	Social Insurance Tax-Employer Contribution	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$10	$10	$34	$55
Total		$28	$1	$31	$26	$39	$126

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

9.2.10 Region 5 (California) – Scenario Analysis

Three scenario analyses for California were performed and all are reported. These analyses for 2010 and 2020 are evaluated as opportunity costs of the S.2191 legislation whereas the 2030 scenario estimates impacts that are considered to be benefits of the legislation. Tables 62–64 give a summary report of the data inputs and the total impacts from import substitution and construction in Region 5.

Table 62. Input Data and Summary Results for California, 2010

Input Data Summary for California		
	Natural Gas	Oil
Production Increases	398 MMcf/yr	6 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	1,250-2,499 ft/well
Well Construction Cost	1014 th$/well	803 th$/well
Average Producer Price	7.31 $/tcf	57.43 $/bbl
Industry Output	3 Million $	0 Million $
Reduced Import Payments	3 Million $	0 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for California			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$5	15	$1
Construction Impacts	$15	58	$2

Table 63. Input Data and Summary Results for California, 2020

Input Data Summary for California		
	Natural Gas	Oil
Production Increases	2823 MMcf/yr	26 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	1,250-2,499 ft/well
Well Construction Cost	1014 th$/well	803 th$/well
Average Producer Price	7.31 $/tcf	57.43 $/bbl
Industry Output	23 Million $	1 Million $
Reduced Import Payments	20 Million $	2 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for California			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$36	106	$6
Construction Impacts	$108	415	$13

Table 64. Input Data and Summary Results for California, 2030

Input Data Summary for California		
	Natural Gas	Oil
Production Increases	487 MMcf/yr	1151 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	1,250-2,499 ft/well
Well Construction Cost	1014 th$/well	803 th$/well
Average Producer Price	7.31 $/tcf	57.43 $/bbl
Industry Output	4 Million $	66 Million $
Reduced Import Payments	3 Million $	68 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for California			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$83	198	$14
Construction Impacts	$479	1,896	$58

9.2.11 Region 6 (U.S. Lower 48) – Standardized Production Increase

Oil.

Table 65. Major Import Substitution Impacts from a 10 Percent Oil Increase for Region 6

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$20	$12	$7	$3	$2	$2	$0	233
Oil and Gas Extraction	$6,310	$2,398	$3,912	$538	$1,027	$1,973	$374	8,660
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$4	$2	$2	$1	$0	$1	$0	16
Drilling Oil and Gas Wells	$6	$4	$2	$1	$0	$1	$0	9
Support Activities for Oil and Gas Operations	$120	$6	$113	$37	$4	$67	$5	532
Power Generation and Supply and Water, Sewage and Other Systems	$47	$9	$39	$8	$3	$22	$5	79
Natural Gas Distribution	$8	$5	$3	$1	$0	$1	$1	10
Other New Construction, Including Maintenance and Repair Construction	$11	$6	$5	$3	$1	$1	$0	85
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Total	$9,277	$3,759	$5,518	$1,374	$1,147	$2,503	$494	26,944

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 66. Major Construction Impacts from a 10 Percent Oil Increase for Region 6

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$280	$174	$106	$37	$29	$35	$4	3,294
Oil and Gas Extraction	$632	$240	$392	$54	$103	$198	$38	868
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$79	$39	$41	$19	$4	$12	$5	281
Drilling Oil and Gas Wells	$38,236	$24,736	$13,499	$4,296	$410	$7,221	$1,572	57,195
Support Activities for Oil and Gas Operations	$768	$40	$728	$240	$24	$432	$32	3,421
Power Generation and Supply and Water, Sewage and Other Systems	$311	$58	$253	$50	$20	$147	$36	515
Natural Gas Distribution	$151	$92	$59	$17	$7	$18	$17	175
Other New Construction, Including Maintenance and Repair Construction	$121	$66	$55	$37	$11	$7	$1	956
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$3,024	$1,593	$1,431	$919	$276	$215	$20	23,895
Total	$75,623	$43,683	$31,939	$14,838	$1,928	$12,403	$2,770	288,466

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Gas.

Table 67. Major Import Substitution Impacts for a 10 Percent Natural Gas Increase for Region 6

Import Substitution Impacts (In Millions of US		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$83	$52	$31	$11	$9	$10	$1	976
Oil and Gas Extraction	$9,828	$3,735	$6,093	$838	$1,599	$3,073	$583	13,489
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$18	$9	$9	$4	$1	$3	$1	66
Drilling Oil and Gas Wells	$12	$8	$4	$1	$0	$2	$0	18
Support Activities for Oil and Gas Operations	$230	$12	$218	$72	$7	$130	$9	1,026
Power Generation and Supply and Water, Sewage and Other Systems	$112	$21	$91	$18	$7	$53	$13	185
Natural Gas Distribution	$2,131	$1,300	$831	$246	$98	$254	$233	2,468
Other New Construction, Including Maintenance and Repair Construction	$31	$17	$14	$9	$3	$2	$0	242
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$0	$0	$0	$0	$0	$0	$0	0
Total	$19,559	$8,649	$10,910	$3,188	$2,006	$4,598	$1,118	62,221

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Table 68. Major Construction Impacts from a 10 Percent Natural Gas Increase for Region 6

Construction Impacts (In Millions of US Dollars)		Output Components		Value Added Components				
Industry	Output	Intermediate Inputs	Value Added	Employment Compensation	Proprietor's Income	Other Property Type Income	Indirect Business Taxes	Employment (FTE's)
Ag, Forestry, Fish & Hunting	$267	$166	$101	$36	$28	$33	$4	3,142
Oil and Gas Extraction	$607	$231	$376	$52	$99	$190	$36	833
Coal, Metal Ores & Nonmetalic Mineral Mining, Quarrying & Support Activites	$79	$38	$40	$19	$4	$12	$5	279
Drilling Oil and Gas Wells	$41,394	$26,780	$14,614	$4,650	$444	$7,818	$1,702	61,919
Support Activities for Oil and Gas Operations	$831	$44	$787	$260	$25	$468	$34	3,701
Power Generation and Supply and Water, Sewage and Other Systems	$302	$57	$245	$49	$19	$143	$35	500
Natural Gas Distribution	$156	$95	$61	$18	$7	$19	$17	181
Other New Construction, Including Maintenance and Repair Construction	$116	$63	$53	$35	$11	$6	$1	917
Manufacturing and Industrial Buildings	$0	$0	$0	$0	$0	$0	$0	0
Water, Sewer, and Pipeline Construction	$795	$419	$376	$241	$73	$57	$5	6,279
Total	$75,540	$44,006	$31,534	$14,247	$1,699	$12,742	$2,846	268,136

*Results displayed for the top 10 sectors in terms of total output impacts. Total values still include all 33 sectors.

Tax Impacts.

Table 69. Import Substitution Tax Impacts from a 10 Percent Oil Increase for Region 6

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$1	$0	$0	$0	$0	$1
	Total	$1	$0	$0	$0	$0	$1
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$239	$0	$239
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$13	$13
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$34	$34
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$15	$15
	Personal Tax: Income Tax	$0	$0	$209	$0	$0	$209
	Social Insurance Tax-Employee Contribution	$78	$52	$0	$0	$0	$130
	Social Insurance Tax-Employer Contribution	$80	$0	$0	$0	$0	$80
	Total	$158	$52	$209	$239	$62	$720
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$40	$0	$40
	Dividends	$0	$0	$0	$61	$0	$61
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$4	$4
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$32	$32
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$175	$175
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$19	$19
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$197	$197
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$5	$5
	Personal Tax: Income Tax	$0	$0	$55	$0	$0	$55
	Personal Tax: Motor Vehicle License	$0	$0	$2	$0	$0	$2
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$13	$0	$0	$13
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$1	$0	$0	$1
	Personal Tax: Property Tax	$0	$0	$1	$0	$0	$1
	Social Insurance Tax-Employee Contribution	$1	$0	$0	$0	$0	$1
	Social Insurance Tax-Employer Contribution	$4	$0	$0	$0	$0	$4
	Total	$5	$0	$71	$101	$432	$609
Total		$164	$52	$280	$339	$494	$1,330

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 70. Construction Tax Impacts from a 10 Percent Oil Increase for Region 6

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$15	$0	$0	$0	$0	$15
	Total	$15	$0	$0	$0	$0	$15
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$1,182	$0	$1,182
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$71	$71
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$191	$191
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$87	$87
	Personal Tax: Income Tax	$0	$0	$1,353	$0	$0	$1,353
	Social Insurance Tax-Employee Contribution	$846	$88	$0	$0	$0	$934
	Social Insurance Tax-Employer Contribution	$859	$0	$0	$0	$0	$859
	Total	$1,705	$88	$1,353	$1,182	$349	$4,677
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$198	$0	$198
	Dividends	$0	$0	$0	$302	$0	$302
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$22	$22
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$178	$178
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$979	$979
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$108	$108
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$1,106	$1,106
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$28	$28
	Personal Tax: Income Tax	$0	$0	$353	$0	$0	$353
	Personal Tax: Motor Vehicle License	$0	$0	$19	$0	$0	$19
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$82	$0	$0	$82
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$6	$0	$0	$6
	Personal Tax: Property Tax	$0	$0	$8	$0	$0	$8
	Social Insurance Tax-Employee Contribution	$10	$0	$0	$0	$0	$10
	Social Insurance Tax-Employer Contribution	$41	$0	$0	$0	$0	$41
	Total	$52	$0	$469	$500	$2,421	$3,442
Total		$1,771	$88	$1,822	$1,682	$2,770	$8,133

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 71. Import Substitution Tax Impacts from a 10 Percent Natural Gas Increase for Region 6

Import Substitution Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$3	$0	$0	$0	$0	$3
	Total	$3	$0	$0	$0	$0	$3
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$438	$0	$438
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$29	$29
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$77	$77
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$35	$35
	Personal Tax: Income Tax	$0	$0	$429	$0	$0	$429
	Social Insurance Tax-Employee Contribution	$182	$91	$0	$0	$0	$273
	Social Insurance Tax-Employer Contribution	$184	$0	$0	$0	$0	$184
	Total	$366	$91	$429	$438	$141	$1,465
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$73	$0	$73
	Dividends	$0	$0	$0	$112	$0	$112
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$9	$9
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$72	$72
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$395	$395
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$44	$44
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$446	$446
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$11	$11
	Personal Tax: Income Tax	$0	$0	$112	$0	$0	$112
	Personal Tax: Motor Vehicle License	$0	$0	$4	$0	$0	$4
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$26	$0	$0	$26
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$2	$0	$0	$2
	Personal Tax: Property Tax	$0	$0	$3	$0	$0	$3
	Social Insurance Tax-Employee Contribution	$2	$0	$0	$0	$0	$2
	Social Insurance Tax-Employer Contribution	$9	$0	$0	$0	$0	$9
	Total	$11	$0	$146	$185	$977	$1,320
Total		$381	$91	$575	$624	$1,118	$2,788

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

Table 72. Construction Tax Impacts from a 10 Percent Natural Gas Increase for Region 6

Construction Tax Impact (In Millions of US Dollars)		Sources					
		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Tax	Total
Enterprises (Corporations)	Transfers	$14	$0	$0	$0	$0	$14
	Total	$14	$0	$0	$0	$0	$14
Federal Government NonDefense	Corporate Profits Tax	$0	$0	$0	$1,214	$0	$1,214
	Indirect Business Tax: Custom Duty	$0	$0	$0	$0	$73	$73
	Indirect Business Tax: Excise Taxes	$0	$0	$0	$0	$197	$197
	Indirect Business Tax: Fed Non Taxes	$0	$0	$0	$0	$89	$89
	Personal Tax: Income Tax	$0	$0	$1,286	$0	$0	$1,286
	Social Insurance Tax-Employee Contribution	$812	$77	$0	$0	$0	$890
	Social Insurance Tax-Employer Contribution	$824	$0	$0	$0	$0	$824
	Total	$1,637	$77	$1,286	$1,214	$359	$4,573
State/Local Government NonEducation	Corporate Profits Tax	$0	$0	$0	$203	$0	$203
	Dividends	$0	$0	$0	$310	$0	$310
	Indirect Business Tax: Motor Vehicle License	$0	$0	$0	$0	$23	$23
	Indirect Business Tax: Other Taxes	$0	$0	$0	$0	$183	$183
	Indirect Business Tax: Property Tax	$0	$0	$0	$0	$1,006	$1,006
	Indirect Business Tax: S/L Non Taxes	$0	$0	$0	$0	$111	$111
	Indirect Business Tax: Sales Tax	$0	$0	$0	$0	$1,136	$1,136
	Indirect Business Tax: Severance Tax	$0	$0	$0	$0	$29	$29
	Personal Tax: Income Tax	$0	$0	$336	$0	$0	$336
	Personal Tax: Motor Vehicle License	$0	$0	$18	$0	$0	$18
	Personal Tax: Non Taxes (Fines-Fees)	$0	$0	$78	$0	$0	$78
	Personal Tax: Other Tax (Fish/Hunt)	$0	$0	$6	$0	$0	$6
	Personal Tax: Property Tax	$0	$0	$8	$0	$0	$8
	Social Insurance Tax-Employee Contribution	$10	$0	$0	$0	$0	$10
	Social Insurance Tax-Employer Contribution	$40	$0	$0	$0	$0	$40
	Total	$50	$0	$446	$514	$2,487	$3,496
Total		$1,701	$77	$1,732	$1,728	$2,846	$8,084

*Results are not displayed for tax categories that experience no impact. Totals still reflect all tax categories.

9.2.12 Region 6 (U.S. Lower 48) – Scenario Analysis.

Three scenario analyses for the U.S.-Lower 48 Region were performed and all are reported. All three of these analyses are evaluated as opportunity costs of the S.2191 legislation. Tables 73–75 give a summary report of the data inputs and the total impacts from import substitution and construction for the U.S.-Lower 48.

Table 73. Input Data and Summary Results for U.S. – Lower 48, 2010

Input Data Summary for US - Lower 48		
	Natural Gas	Oil
Production Increases	95973 MMcf/yr	60 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	3,750-4,999 ft/well
Well Construction Cost	843 th$/well	911 th$/well
Average Producer Price	6.56 $/tcf	59.05 $/bbl
Industry Output	672 Million $	4 Million $
Reduced Import Payments	580 Million $	4 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for US - Lower 48			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$988	2,905	$145
Construction Impacts	$4,187	14,522	$447

Table 74. Input Data and Summary Results for U.S. – Lower 48, 2020

Input Data Summary for US - Lower 48		
	Natural Gas	Oil
Production Increases	573692 MMcf/yr	3056 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	3,750-4,999 ft/well
Well Construction Cost	843 th$/well	911 th$/well
Average Producer Price	6.56 $/tcf	59.05 $/bbl
Industry Output	4018 Million $	180 Million $
Reduced Import Payments	3465 Million $	181 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for US - Lower 48			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$6,122	17,987	$896
Construction Impacts	$27,261	96,366	$2,916

Table 75. Input Data and Summary Results for U.S. – Lower 48, 2030

Input Data Summary for US - Lower 48		
	Natural Gas	Oil
Production Increases	84802 MMcf/yr	2686 thbbl/yr
Estimated Average Well Depth	5,000-7,499 ft/well	3,750-4,999 ft/well
Well Construction Cost	843 th$/well	911 th$/well
Average Producer Price	6.56 $/tcf	59.05 $/bbl
Industry Output	594 Million $	159 Million $
Reduced Import Payments	512 Million $	159 Million $
International Trade Feedback Share	10%	10%
Year Dollars	2006	2006

Summary Results for US - Lower 48			
(Millions of US Dollars)	Output	FTEs	Taxes
Import Substitution Impacts	$1,071	3,078	$157
Construction Impacts	$5,563	19,939	$596

9.3 Comparison to Other Studies

In anticipation of technological data for new technologies, the original intent was to provide a comparison of the results of these impacts analyses to those reported elsewhere. However, because other technological data remain undeveloped to date, there are no other reports that are directly comparable. Hence, the data reported here result from the necessity of generating alternate scenarios for analysis. Therefore, no model comparisons beyond those already presented in Section 2.0 of this document are reported.

Appendix A: The Input-Output Model

Input-output (IO) analysis is based on the inter-industry sales and purchases relationships that exist in every economy. IO analysis characterizes an economy by describing these flows of goods and services between industries, institutions and the final market.

François Quesnay (1694–1774), a French physician turned economist, was the first to use this type of system to describe the economy. One of his main works, *Le Tableau Économique* (1758), contained an early, much less sophisticated version of a multi-sector IO system. He aimed to show diagrammatically the flow of money in a primarily agrarian economy. Later, forms of this technique would be expounded upon by such great economic minds as David Ricardo, Karl Marx, and Léon Walras.

It wasn't until the late 1930s that Wassily Leontief (1906–1999), a Russian-born American economist, developed the analytical framework that would become modern IO analysis. For this substantial contribution to the field, he was awarded the Nobel Prize in Economic Science in 1973. In more recent years, IO analysis has been extended to cover items such as energy consumption, environmental factors, and employment impacts. It can now also be extended to consider interregional and multiregional analyses.

Methodological Basis

The statistical foundation of IO analysis is essentially an accounting framework. The basis of any type of IO system is the transactions matrix. The transactions matrix is a means of ordering all inter-industry sales (outputs) and purchases (inputs)—the economic transactions that occur in the economy—during a given time period. Each column of this matrix consists of the values of the inputs required by a given industry to produce its output. Each row consists of the values of the industry's outputs distributed throughout the economy. This transactions matrix only reports the intermediate goods and services being exchanged among industries.

Additionally, a full IO table also includes a few additional rows (value added) and additional columns (final demand). The value added rows include information about the non-industrial inputs of production, such as labor. The final demand columns show the sales by each industry to a final market, such as consumption, investment, government purchases and net exports. An example of an IO table is produced below in Figure A1.

Transactions Table

				Final Demand						
		I1	I2	C	G	I	E	M	X	Gross Product
	I1	0.3	0.5	0.6	0.4	0.1	0.5	-0.2	2.2	1.4
	I2	0.7	0.2	0.3	0.1	0.8	0.4	-0.5	2	1.1
Value Added	P	0.8	0.7							
	W	0.4	0.6							
	X	2.2	2							
	Gross Income	1.2	1.3							2.5

Figure A1: *Accounting Foundations of IO Analysis*

Notation:
Z : transactions matrix
$\mathbf{z_{ij}} \in \mathbf{Z}$: dollar flow of commodities from industry i to industry j on current account
$\mathbf{P_j}$: profits for industry j
$\mathbf{W_j}$: wages and salaries for industry j
$\mathbf{v_j}$: value added for industry j
$\mathbf{C_i}$: value of flows of commodities from industry i to consumption
$\mathbf{G_i}$: value of flows of commodities from industry i to government expenditures
$\mathbf{I_i}$: value of flows of commodities from industry i to investment
$\mathbf{E_i}$: value of flows of commodities from industry i to export sales
$\mathbf{M_i}$: value of imports of commodities for industry i
$\mathbf{f_i}$: value of flows of commodities from industry i to category k of final demand (consumption, government expenditures, investment and export sales)
$\mathbf{X_i}$: output of industry i
$v_j = P_j + W_j$

$f_i = C_i + G_i + I_i + E_i$

Balance Equation for Output:

$$\left(\sum_j z_{ij} \right) + C_i + G_i + I_i + E_i = X_i \forall\, i, i = 1,..., n$$

Balance Equation for Input:

$$\left(\sum_i z_{ij} \right) + P_j + W_j + M_j = X_j \forall\, j,\ j = 1,..., n$$

Total Output:

$$\sum_i \sum_j z_{ij} + \sum_i (C_i + G_i + I_i + E_i) = \sum_i X_i$$

Total Input:

$$\sum_j \sum_i z_{ij} + \sum_j (P_j + W_j + M_j) = \sum_j X_j$$

To make economic sense, total outputs must equal total inputs. Then we can see that:

$$\sum_i \sum_j z_{ij} + \sum_i (C_i + G_i + I_i + E_i) = \sum_j \sum_i z_{ij} + \sum_j (P_j + W_j + M_j)$$

$$\sum_i (C_i + G_i + I_i + E_i) = \sum_j (P_j + W_j + M_j)$$

C + I + G + E = P + W + M

C + I + G + E – M = P + W

The left hand side of this final equation is gross national product and the right hand side is gross national income.

Technical Coefficients (a_{ij})

Assumptions

1. Inter-industry flows from *i* to *j* in a given time period depend solely on the total output for sector j in that same time period.
2. The technical coefficients are constant and measure fixed relationships between an industry's output and its inputs.
3. Production operates under constant returns to scale.
4. IO analysis requires that an industry uses inputs in fixed proportions.

$$a_{ij} = \frac{z_{ij}}{X_j}$$

The technical coefficient, a_{ij}, can be interpreted as the dollar's worth of input from industry i per dollar's worth of output of industry j. We can now define the technical coefficients matrix for an n-industry economy, A:

$$A = \begin{bmatrix} a_{11} & a_{12} & . & . & . & a_{1n} \\ a_{21} & a_{22} & . & . & . & a_{2n} \\ . & . & . & & & . \\ . & . & & . & & . \\ . & . & & & . & . \\ a_{n1} & a_{n2} & . & . & . & a_{nn} \end{bmatrix}$$

Using the numbers above in Figure 1, the technical coefficients matrix is defined as:

$$A = \begin{bmatrix} .1364 & .25 \\ .3182 & .1 \end{bmatrix}$$

Now, if Y_i is designated as industry i's sales to final demand:

$$Y_i = C_i + G_i + I_i + E_i$$

Then we can write that:

$$X_i = z_{i1} + z_{i2} + \ldots + z_{in} + Y_i$$

Using the equation for technical coefficients above:

$$X_i = a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{in}X_n + Y_i$$

By manipulating this equation in matrix form we can define the complete system as:

$$(I-A)X = Y \qquad \text{or} \qquad X = (I-A)^{-1}Y$$

where I corresponds to the (nxn) identity matrix and $(I-A)^{-1}$ is called the Leontief inverse.

The Leontief inverse referencing Figure 1 is:

$$(I-A)^{-1} = L = \begin{bmatrix} 1.28997 & .3583 \\ .45608 & 1.2378 \end{bmatrix}$$

To show the dependence of the gross outputs on the values of the final demands we can define the elements of the Leontief inverse as l_{ij} and write the equation:

$$X_i = l_{i1}Y_1 + l_{i2}Y_2 + \ldots + l_{in}Y_n$$

Open or Closed Model

The IO model can either be open or closed with respect to households. If our project goal is to model the direct, indirect and induced impacts of domestic oil and natural gas consumption, then we are necessarily considering a model that is closed with respect to households.

The difference between an open model and a closed model is that households are exogenous in the open model and endogenous in the closed model. In a closed model, households are treated as part of the production sector and are therefore economically connected with all other parts of the transactions matrix. This addition adds one extra row and column to the transactions matrix, the matrix of technical coefficients, and the Leontief inverse. The household sector can be thought of as buying consumer goods from and selling labor to all other industries.

Strengths

- IO models provide a large amount of information in a concise and easy to understand form. They present a comprehensive picture of the economy and its inter-industry relations.
- IO analysis is transparent; it does not rest on as many assumptions and parameters as some of the models that are discussed later in this document.
- IO models are extremely useful in analyzing the impact of a change in any sector on the output of others.

- One main attribute of IO analysis is its descriptive analytical power. It has predictive capabilities in that it can estimate both direct and indirect impacts as they are tracked through the economy.
- IO analysis analyzes changes and impacts on an industry-by-industry level, tracing the flow of dollars between industries; thus, making it possible to have a very precise calculation of the economic impacts to the economy.
- The extension of an IO model to an interregional or multiregional framework is straightforward.

Weaknesses

- Constructing transactions matrices can be costly and time-consuming. These data, however, are often collected by government agencies and are available for use but with some significant time lag.
- An IO matrix gives a static view of the economy and can make structural projection difficult. Even so, with a significant level of complication, IO models can be transformed into dynamic models. With required data and economic assumptions, it is also possible to make changes to the initial IO model in order to model different time periods by assuming that technical coefficients are stable over time.
- IO analysis does not allow for interaction between supply and demand. Prices are fixed in both goods and labor.
- IO models are not set up for any supply or capacity constraints; however, these could be handled with the external processing of data.
- The linear relationships assumed in IO analysis do not allow for externalities or increasing/decreasing returns to scale.
- There is no statistical test to check the model specification.

Geographical Scale

Most available IO data are collected and published on a national scale. These national data can be used to estimate regional data using one of several regionalization techniques. The regionalization technique of greatest relevance to this project is the regional purchase coefficient (RPC) technique used in Impact Analysis for Planning (IMPLAN), from whom project data have been obtained.

RPC Method

The regional purchase coefficient is the proportion of the regional demand for a good or service that is fulfilled by production within the region, as opposed to being fulfilled by imports from other regions.

Notation:
$\boldsymbol{R^M}$: regional purchase coefficient for region M
$\boldsymbol{S^{MM}}$: amount of good produced locally in region M (amount shipped from region M to itself)
$\boldsymbol{S^{LM}}$: amount of the same good produced in region L and shipped to region M. (If this were a multi-region setup, L corresponds to the rest of the "world," not just one other region.)
A general equation of an RPC for a region *M* can then be defined as:

$$R^M = \frac{S^{MM}}{S^{MM} + S^{LM}}$$

IMPLAN uses a more sophisticated form of this equation that estimates the RPC as a function of the wage ratio, the ratio of "other costs," the output ratio, the weight/value ratio of the good, the ratio of the number of users of a good, the ratio of the number of producers of a good and the land area ratio of each region.

Data Requirements

- Sales and purchases data, disaggregated by industry and region
- Final demand data by industry and region
- Household consumption data by industry and region
- Household compensation data by industry and region
- Data on the impact scenario

Applications

There is voluminous literature available on the uses and applications of IO analysis. The literature ranges from many different policy implications to environmental applications (Duchin 1992, Hubacek et al. 2002) with general studies on many different countries (e.g., Haddad and Hewings 2000, Cho et al. 2000). Studies have even been conducted predicting the effects of sudden changes to the economy (Okuyama et al. 1997, Lahr et al. forthcoming). There is also literature in which IO analysis techniques are advanced and changes in regional structure are further explored (Rey and Jackson 1999, Jackson et al. 1989).

Appendix B: Assessment of Tax Impact Estimation

The following assessment of the tax impact estimates in this project is provided by Dr. Brian Cushing, Associate Professor in West Virginia University's Department of Economics.

As it is with most impact analyses, estimation of tax impacts is an important component of the DOE/NETL project, "Valuing Domestically Produced Natural Gas and Oil." This note explains how tax impacts come out of the IMPLAN model. It then evaluates this method of estimating tax impacts, discussing advantages and disadvantages. The bottom line is simple: while tax impact estimates from IMPLAN may not be perfect, they are likely to be reasonable. Given the normal limitations in knowledge and data, it is unlikely that one could find a better (and feasible) method to handle tax impacts.

For this project, tax impacts are developed as they normally come out of an IMPLAN impact model:

(1) For each of the six models (five regions and the national model), the research team begins with social accounts for the base year, which show the distribution of receipts and disbursements for all the different industries, institutional sectors (households, Federal Government, ...), etc.

(2) Given a shock to the system (in this case, increased domestic production of oil and natural gas), IMPLAN's impact analysis generates changes in the four components of value added (employee compensation, proprietor's income, indirect business taxes, and other property income), as well as for enterprises;

(3) These changes are applied to the (normalized) social accounts, which yields estimated tax impacts;

(4) The researchers assume that any marginal changes (impacts) flow through the system according to the base year distribution discussed above;

(5) The researchers also assume that the detailed distribution of expenditures by employment compensation, proprietor's income, other property income, indirect business taxes, and enterprise holds, no matter what the mix of affected industries.

For the first step, a typical IMPLAN model begins by developing a set of social accounts for each state that will be part of the analysis. If impacts are desired at the county level, the each state model is used as the basis for developing models for its counties. The DOE/NETL model does not need county-level detail.

The key data used to develop tax impacts for IMPLAN models come from four primary sources: 1) the *National Income and Product Accounts (NIPA)* [U.S. Bureau of Economic Analysis]; 2) the *Consumer Expenditure Survey (CES)* [U.S. Bureau of the Census]; 3) the *Annual Survey of State and Local Government Finances (SLGF)* [U.S. Bureau of the Census]; and 4) the *Regional Economic Information System (REIS)* [U.S. Bureau of Economic Analysis]. Most of the tax

information for states comes directly from these sources. For example, personal income taxes paid to the Federal Government come directly from the *REIS* data, with *NIPA* used as a control for the total. Some tax information must be estimated even at the state level of analysis. For example, corporate profit taxes paid to the Federal Government are based on the national total from NIPA, which is allocated to states based on each state's proportion of US Other Property Income.

Rather than a collection of individual states, the DOE/NETL model was developed to separately analyze six regions. These six regions include two large (in terms of magnitude of the data) individual states (California and Texas), one four state region (New York, Ohio, Pennsylvania, and West Virginia) that includes three large states, one three-state region (Colorado, Utah, and Wyoming) that includes two moderate-sized states, one region with two small states (Montana and North Dakota), and one region that encompasses the lower 48 states. For the multi-state regions, the individual state models are integrated into a single regional model, with imports and exports adjusted accordingly. As will be discussed later, integrating states into regions has some favorable implications for tax impact estimation.

Once the social accounts are developed for the region or regions used in an impact analysis, actually generating the estimated impacts is straightforward, following the procedure briefly described in (2) and (3) above. The assumptions listed in (4) and (5) assure that estimating impacts will be easy. (4) is the same assumption used to generate predictive multipliers in any input-output analysis – that the current structure of the local economy does not change during the impact period. It is this assumption that allows the modelers to generate all of the detailed tax impacts based on estimated impacts for just the value added and enterprise components of the model, which can then be applied to the unchanged normalized social accounts matrix. Without the assumption, the information requirements to generate detailed tax impacts or just about any other impacts would be prohibitive. The second assumption reveals an aggregation issue implicit in IMPLAN's impact estimations. For impact estimation, it does not matter whether the initial impact takes place in the extraction industries (as in the DOE/NETL model), manufacturing, various service industries, or some other industry. The model initially estimates impacts on the four value-added components and on enterprises for each of the impacted industries. Once the model gets these initial impacts, however, each component is distributed based on the normalized social accounts, regardless of the initial source of the impacts. For example, the model does not differentiate the distribution of initial tax impacts originating in the retail industry from those originating in the oil and gas industry, even though the former would likely yield a relatively greater sales tax impact while the latter would yield a relatively greater severance tax impact. In IMPLAN, these two taxes are both treated generically as "indirect business taxes" and distributed accordingly. This simplifying assumption is necessary in order to keep the impact analysis manageable.

Ultimately, we want to know how accurate the tax impact estimates are likely to be. The answer is that, in general, the impact estimates are likely to be good. First, while the researchers do not have ready access to accurate primary-source data, the IMPLAN model generates the social accounts matrix using comprehensive secondary-source data gathered by the Federal Government that is widely accepted as high quality data. Whether one uses the type of model

employed for the DOE/NETL project or some other method, such as an econometric forecast model, this is the most accurate and comprehensive data available.

Second, the social accounts matrix that is the basis for generating impacts in the DOE/NETL model provides a highly-detailed structure for each region's economy. Thus, the initial impacts on value added, including the initial indirect business taxes, account for hundreds or even thousands of relationships. Even though the tax impacts of these initial value-added (and enterprise) changes are distributed based on region-wide coefficients, these coefficients are also built in a bottom-up fashion that accounts for hundreds or thousands of relationships. No other method could provide such rich and precise detail in tracing the initial oil and natural gas impacts through the regional economies. One outcome of this detailed structure should be highly robust impact estimates. A small error or a peculiarity in the base-year data is unlikely to have much impact on the overall impact estimates by the time it makes its way through the detailed relationships of the model. In methods that have less detail and thus far fewer data points, an outlier in the data has a much greater chance of significantly affecting model outcomes.

Third, the regional structure of the model makes it more likely that the model's coefficients and predictions are representative for each region. Two of the regions are two of the largest individual states (California and Texas). Data for both states are based on a very large number of household, government, and business transactions, which should average out any outlier data. Together, the four states of the Marcellus Shale Region are much larger than either California or Texas. The states in Region 4 (Colorado, Utah, and Wyoming) are not so large, but with three different states, including two moderate-sized states, this region can still benefit from averaging out any oddities. The Bakken Shale Region, with two less populous states (North Dakota and Montana), is the most susceptible to any peculiarities in the base year, but still benefits from having two states to diminish the impact of any atypical data.

The only other issue with predicting tax impacts is the assumption that the base-year structure and coefficients hold throughout the impact period. This issue has been addressed at length in many forums. There may indeed be ways to account better for system dynamics over time, but they would come at a cost, primarily a cost of sacrificing much of the rich detail regarding the structure of the regional economy that is the strength of Input-Output models. Especially since much of the impact of shocks occurs relatively early in the impact period, assuming that the system's structure does not change is generally a good approximation. This assumption might be more problematic if the regions were single counties or even single small states. However, given the current structure, with two regions being large states and the rest being multi-state regions, small changes in the structure of one or a few relationships are not likely to have much of an effect on predicted tax impacts. If structural changes are major, but anticipated, then the modified structure can be built into the impact model. Major structural changes that are not anticipated could cause significant errors in the projected impact, but such changes would also be problematic for any other way of projecting tax impacts.

No tax impact estimation will be perfect. The rich, detailed structure of the Input-Output model used for the DOE/NETL project should provide reasonable tax impact estimates in the absence of unanticipated major structural changes that would significantly change the coefficients used to generate tax impacts. These tax impact estimates should be as good as, and likely better than,

estimates that alternative methodologies could provide. If unanticipated major structural changes related to tax impacts did occur, the methodology used here might not work so well, but then neither would other methodologies since a model can never predict well without adequate information. The detailed structure of an Input-Output model and the deeper understanding it enables of a regional economy make these large unanticipated changes less likely. All-in-all, while not perfect, the methodology used for the DOE/NETL model is likely the best available for providing tax impact estimates.

Bibliography

Hewings, Geoffrey. 1986. *Regional Input-Output Analysis.* Sage Publications: Scientific Geography Series, Vol. 6.

King, B.B. 1985. "What is a SAM?" In Pyatt, G., & Round, J. I. (eds.), *Social Accounting Matrices: A Basis for Planning*. Washington, D.C.: The World Bank.

Loveridge, Scott, "A Typology and Assessment of Multi-sector Regional Economic Impact Model," *Regional Studies*, 83, 305-317.

Miller, Ronald E. and Peter D. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, NJ: Prentice-Hall.

Minnesota IMPLAN Group, "Elements of the Social Accounting Matrix (Elements of the IMPLAN SAM)" MIG IMPLAN Technical Report TR-98002, Stillwater, MN: Minnesota IMPLAN Group, Inc., url: http://implan.com/index2.php?option=com_docman&task=doc_view&gid=91&Itemid=65

Olson, Douglas, "Using Social Accounts to Estimate Tax Impacts," Stillwater, MN: Minnesota IMPLAN Group, Inc., url: http://implan.com/index2.php?option=com_docman&task=doc_view&gid=97&Itemid=65

Schaffer, William. 1999. "Regional Impact Models." In Scott Loveridge (ed.), *The Web Book of Regional Science* (www.rri.wvu.edu/regscweb.htm). Morgantown, WV: Regional Research Institute, West Virginia University.

Biographical Sketch

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Brian Cushing is Associate Professor of Economics and Faculty Research Associate of the Regional Research Institute at West Virginia University. He obtained a B.A. in economics from University of Notre Dame (1975) and an M.A. (1979) and Ph.D. (1981) in economics from University of Maryland – College Park. His primary research and teaching interests include population migration, poverty, and regional policy, but also touch on a variety of other urban/regional issues. Cushing's most recent work has focused on analysis of Appalachian poverty, consideration of appropriate methods to measure the true extent of poverty, the effects of poverty, and of public policy - especially social welfare programs - on migration decisions of low-income households, the role of race relations in population migration, the relationship between amenities and migration, and technical aspects of migration modeling. He has taught urban economics and regional economics at both the undergraduate and graduate level. Cushing developed the initial version of the West Virginia State Economic Forecast Model – an expanded version of the model is still used today, 20 years after its initial development. He has published on a range of economics and regional science journals such as the *Annals of Regional Science, Journal of Econometrics, Journal of Regional Science, Journal of Urban Economics, Papers in Regional Science, Socio-Economic Planning Sciences*, *Southern Economic Journal*, and *Urban Studies,* among others.

Appendix C: Industry Aggregation Schema

Project Model Sector #	*Sector Name*	*IMPLAN Sector Code*	*Related BEA Sectors*
1	Agriculture, Forestry, Fishing and Hunting	1-18	11
2	Oil and Gas Extraction	19	2110
3	Coal, Metal Ores and Non-Metallic Mineral Mining, Quarrying and Support Activities	20-26, 29	212X
4	Drilling Oil and Gas Wells	27	213111
5	Support Activities for Oil and Gas Operations	28	213112
6	Power Generation and Supply, and Water, Sewage and Other Systems	30, 32	221X
7	Natural Gas Distribution	31	2212
8	Manufacturing and Industrial Buildings	37	23621
9	Water-, Sewer- and Pipeline Construction	40	23711, 23712
10	Other New Construction, including Maintenance and Repair Construction	33-36, 38-39, 41-45	23X
11	Construction and Mining Machinery Manufacturing	259-260	3331X
12	Oil and Gas Field Machinery and Equipment Manufacturing	261	333132
13	Motor Vehicle Manufacturing	344-345	3361
14	Other Manufacturing	46-258, 262-343, 346-389	3X
15	Wholesale Trade	390	42
16	Retail Trade	401-412	4A
17	Air, Rail and Water Transportation	391-393	481-483
18	Truck Transportation	394	484
19	Pipeline Transportation	396	486
20	Transit and Sightseeing Transportation and Transportation Support Services	395, 397	485, 487
21	Postal Services, Couriers, and Messengers and Warehousing and Storage	398-400	49
22	Information	413-424	51
23	FIRE and Rental and Leasing Services, excluding Commercial and Industrial Machinery and Equipment Rental and Leasing	425-433, 435-436	52_3X
24	Commercial and Industrial Machinery and Equipment Rental and Leasing	434	5324
25	Architectural, Engineering and Related Services	439	5413
26	Environmental and Other Technical Consulting	445	5416X
27	Other Professional, Scientific and Technical Services	440-444, 446-450	541X
28	Management of Companies and Enterprises	451	55
29	Administrative and Support and Waste Management and Remediation Services	452-460	56
30	Educational Services, Health Care and Social Assistance	461-470	6
31	Arts, Entertainment, Recreation, Accommodation and Food Services	471-481	7
32	Other Services, except Government	482-493	8

33	Government and Non-NAICS	494-509	92

Appendix D: Acronyms

AEO	Annual Energy Outlook
AMIGA	All-Modular Industry Growth Assessment Model
BEA	Bureau of Economic Analysis
CBM	Coal Bed Methane
DOE	Department of Energy
EIA	Energy Information Administration
EPAct	Energy Policy Act
FERC	Federal Energy Regulatory Commission
IMPLAN	Impact Analysis for Planning
IO	Input-Output
IOGCC	Interstate Oil and Gas Compact Commission
IPAA	Independent Petroleum Association of America
JAS	Joint Association Survey
JEDI	Job and Economic Development Impact
LNG	Liquefied Natural Gas
NAICS	North American Industry Classification System
NEMS	National Energy Modeling System
NETL	National Energy Technology Laboratory
NGPL	Natural Gas Plant Liquids
O&M	Operation and Maintenance
OSAP	Office of Systems, Analyses and Planning (NETL)
RPC	Regional Purchase Coefficient

Appendix E: Glossary

Absorption Table – A coefficient form of the Use table derived by dividing each element of the Use table by total industry output.

Byproducts Table – A coefficient form of the Make table derived by dividing each element by the Make table row totals.

Crude Oil – Unprocessed oil that has come out of the ground.

Direct Impact – The initial change in the industries to which a final demand change was made.

Final Demand – The purchases of goods and services for final consumption.

Import Substitution – The process of replacing imports with domestic production.

Indirect Business Taxes – These taxes include sales, excise, fees, licenses and other taxes that are paid during the normal operation of a business. This includes all payments to the government except for income taxes.

Indirect Impact – The changes in inter-industry purchases that occur as they respond to the new demands of the industries that were directly affected.

Induced Impact – The changes that typically reflect the changes in spending from households as income changes due to the changes in production.

Input-Output Analysis – The manner in which an input-output model is used to perform an economy-wide analysis for a given time period. The model is capable of examining inter-industry relationships as well as relationships between industries and final consumption.

Liquefied Natural Gas – Natural gas that has been converted to liquid form for ease of storage or transport.

Make Table – The matrix that contains the dollar value of each commodity or service that is produced by each industry. In this matrix, the rows are the industries and the columns are commodities.

Marginal Wells – Marginal wells can be either oil or gas wells. Marginal oil wells are those producing 10 or fewer barrels of oil per day. Marginal gas wells are those producing 60,000 or fewer cubic feet of gas per day.

Margins – The difference between producer and purchaser prices.

Producer Prices – The selling price received by a producer for goods and/or services produced.

Purchaser Prices – The price paid by the purchaser for a good or service. This price reflects the producer's price plus all applicable retail, wholesale and transportation costs.

Regional Purchase Coefficient – A coefficient representing the proportion of local demand that is purchased from local producers.

Social Accounting Matrix – A set of economic accounts which describe inter-industry relationships and transfers between institutions, as well as value added components for a given time period.

Use Table – The matrix that contains the dollar value of commodities and services purchased by each industry for use in the production process. In this matrix, the rows are the commodities and the columns are industries.

Value Added – Payments made by industries to workers, interest, profits and indirect business taxes.

References

Cho, Byung-Do, Jungyul Sohn, and Geoffrey J.D. Hewings. (2000). "Industrial Structural Change in the Korean Economy between 1975 and 1995: Input-Output Analysis," *Economic Papers (Bank of Korea)* 3: 109–136. [Korean version in *Quarterly Economic Analysis*, 5: 136–162. (1999)].

Duchin, Faye. (1992). "Industrial Input-Output Analysis: Implications for Industrial Ecology," *Proc. Natl. Acad. Sci*. USA. 89(3): 851–855.

Driscoll, Daniel, George Richards, and Brad Tomer. (2007). "LNG Interchangeability/Gas Quality: Results of the National Energy Technology Laboratory's Research for the FERC on Natural Gas Quality and Interchangeability." DOE/NETL-2007/1290.

Haddad, Eduardo A., and Geoffrey J.D. Hewings. (2000). "Linkages and Interdependence in the Brazilian Economy: An Evaluation of the Inter-Regional Input-Output System, 1985," *Revista Econômia do Nordeste,* 31:330–367.

Hewings, Geoffrey J.D. (1985). *Regional Input-Output Analysis*. Beverly Hills: Sage Publications.

Hubacek, Klaus, Jon D. Erickson, and Faye Duchin. (2002). "Input-Output Modeling of Protected Landscapes: The Adirondack Park," *The Review of Regional Studies,* 32(2): 207–222.

Isard, Walter, et al. (1998). *Methods of Interregional and Regional Analysis*. Brookfield, VT: Ashgate.

Jackson R.W., G.J.D. Hewings, and M. Sonis. (1989). "Decomposition Approaches to the Identification of Change in Regional Economies," *Economic Geography*, 65: 216–231.

Kidnay and Parrish. (2006). *Fundamentals of Natural Gas Processing.*

Lahr, Michael, Michael Greenberg, and Nancy Mantell. "Understanding the Economic Costs and Benefits of Catastrophes and Their Aftermath: A Review and Suggestions for the U.S. Federal Government," forthcoming in *Risk Analysis*.

Miller, Ronald E., and Peter D. Blair. (1985). *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, NJ: Prentice Hall.

NETL. (2007). *2007 Annual Plan for the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research and Development Program*. DOE/NETL-2007/1294.

Okuyama, Yasuhide, Geoffrey J.D. Hewings, and Michael Sonis. (1997). "Economic Impacts of an Unscheduled Event: Interregional Input-Output Approach," *Journal of Applied Regional Science,* 2: 79–93.

Rey, S., and R.W. Jackson. (1999). “Interindustry Employment Demand and Labor Productivity in Regional Econometric+Input-Output Models,” *Environment and Planning, A*, 31: 1583–1599.

Stevens, Benjamin H., et al. (1983). “A New Technique for the Construction of Non-Survey Regional Input-Output Models,” *International Regional Science Review*. 8(3): 271–86.