# Calculating the Economic Benefits of U.S. LNG Exports

Prepared for LNG Allies

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# Calculating the Economic Benefits of U.S. LNG Exports

At the request of LNG Allies, ICF has prepared tables and charts that present some of the benefits to the U.S. economy and energy markets of LNG exports from the United States. ICF prepared this information based on three EIA cases from the 2018 Annual Energy Outlook. Those three cases are the 2018 Reference Case, the High Oil & Gas Resources and Technology Case, and the High Oil Price Case.

For the calculation of impacts, ICF used methodologies we employed for the American Petroleum Institute (API) in two recent reports: Benefits and Opportunities of Natural Gas Use, Transportation, and Production (June 2017) and Impact of LNG Exports on the U.S. Economy: A Brief Update (Sept. 2017). Although the methodology used here to estimate GDP and job impacts is similar to that of the prior API reports, the results differ for two primary reasons: First, the underlying energy market projections are different. This report starts from the most recent AEO published in Feb. 2018, while the prior API reports used older and different cases from the 2016 and 2017 AEOs. Second, the current study uses more recent base year economic data (e.g., revenues and employment by industrial sector) and input/output coefficients among industrial sectors.

The first two economic impact measures we examine here are direct, indirect, and induced value added[1] and jobs related to LNG liquefaction plants. These impact measures are defined to include only the economic activity related to the construction and operation of the liquefaction plants and ports themselves and do not include the economic activity related to producing and transporting the natural gas used for liquefaction plant fuel and feedstock. Thus, to provide a full picture of the economic impacts, we also estimate the value added and jobs related to supplying natural gas to the liquefaction plants.

As shown in Figure 1, the cumulative direct, indirect, and induced value added from the LNG plants from 2013 to 2050 will range from $716 billion to $1.267 trillion for the three AEO cases. In that same period, the LNG plants would support 2.0 million to 3.9 million job-years of direct, indirect, and induced labor.

As shown in Figure 2, the cumulative direct, indirect, and induced value added from supplying natural gas to the liquefaction plants would range from $948 billion to $1.988 trillion for the three AEO cases from 2016 to 2050. The labor impacts of supplying natural gas in the three AEO cases would range from 5.3 to 11.6 million job-years through 2050.

**Thus, considering the whole value chain (LNG Plants + Natural Gas Supply): (1) the cumulative direct, indirect, and induced value added from U.S. LNG exports would range from $1.664 trillion to $3.255 trillion for the three selected AEO-2018 cases over the 2013 to 2050 time frame; and (2) the direct, indirect, and induced employment benefits from U.S. LNG exports would range from 7.346 to 15.459 million job-years over that same period (an average of 205,403 to 432,897 direct, indirect, and induced jobs per year).**

1. "Value added" can also be thought of as the contribution to Gross National Product (GDP) from one or more industrial sectors or geographic regions.

### Exhibit 1. Economic Impacts from U.S. LNG Export Terminals

| | Reference Case | High Oil & Gas Case | High Oil Price Case |
|---|---|---|---|
| Highest Annual LNG Exports Billion cubic feet per day (Bcf/d) | 14.7 | 22.9 | 32.2 |
| Highest Annual Value Added from LNG Terminals (Billion 2017$) | 23.0 | 32.4 | 45.7 |
| Cumulative Value Added from LNG Terminals (2013-2050, Billion 2017$) | 716 | 976 | 1,267 |
| Highest Annual Direct, Indirect, Induced Jobs from LNG Terminals (jobs) | 142,534 | 142,534 | 160,807 |
| Average Annual Direct, Indirect, Induced Jobs from LNG Terminals (jobs) | 52,441 | 76,134 | 102,809 |
| Cumulative Direct, Indirect, Induced Jobs from LNG Terminals (job-years) | 1,992,770 | 2,893,087 | 3,906, 756 |

### Exhibit 2. Economic Impacts from U.S. Natural Gas Supplied for LNG Fuel and Feedstock

| | Reference Case | High Oil & Gas Case | High Oil Price Case |
|---|---|---|---|
| Highest Annual Value Added from Natural Gas for LNG Terminals (billion 2017$) | 36.8 | 34.9 | 95.5 |
| Cumulative Value Added from Natural Gas for LNG Terminals (2016-2050, billion 2017$) | 948 | 909 | 1,988 |
| Highest Annual Direct, Indirect, Induced Jobs from Natural Gas for LNG Terminals | 182,844 | 259,908 | 476,543 |
| Average Annual Direct, Indirect, Induced Jobs from Natural Gas for LNG Terminals | 152,962 | 193,940 | 330,088 |
| Cumulative Direct, Indirect, Induced Jobs from Natural Gas for LNG (job-years) | 5,353,659 | 6,787,913 | 11,553,067 |

Note: Value added and jobs include direct, indirect, and induced impacts. LNG export plant construction began in 2013, so that is the first year for estimating economic impacts from the plants. U.S. LNG exports began in 2016, so that is the first year for estimating the impacts related to natural gas supply.

## AEO Cases for 2018

EIA's Reference Case for the Annual Energy Outlook generally assumes that current laws and regulations affecting the energy sector are unchanged throughout the projection period. The potential impacts of any proposed legislation, regulations, and standards are not included. The underlying Reference Case demographic and economic assumptions reflect the current views of leading economic forecasters and demographers. For both the supply-side and demand-side, the Reference Case projection assumes gradual improvements in known technologies that increase the efficiency of energy production and utilization.

EIA addresses the uncertainty inherent in energy projections by developing alternative cases with different assumptions of macroeconomic growth, world oil prices, technological progress, and energy policies. For example in the High Oil and Gas Resource and Technology Case, assumptions of (a) faster upstream technology progress that lowers oil and gas production costs and (b) higher oil and gas resource availability than in the Reference Case allow for higher oil and gas production at lower prices. The Low Oil and Gas Resource and Technology Case is created by moving those same assumptions in the opposite direction. The High Oil Price Case is driven by both supply-side and demand-side assumptions that lead to much tighter global market balances and higher crude oil prices. The Low Oil Price Case is created from assumptions that increase oil supplies (at a given price), reduce petroleum demand (at a given price), and lead to lower prices than seen in the Reference Case.

## Oil and Gas Prices for the AEO Cases

Exhibit 3 shows Brent Crude oil prices in 2017 dollars per barrel for the three selected AEO cases that ICF examined here. Natural gas prices at Henry Hub are shown in Exhibit 4 in 2017 dollars per million Btu. As would be expected, the High Oil Price Case generally has the highest oil and gas prices. The High Oil & Resources & Technology Case generally has the lowest oil and gas prices, reflecting the impacts of an assumed larger undiscovered oil and gas resource base and lower finding and developing cost per unit of production.

## LNG Exports in the AEO Cases

The forecasted U.S. LNG exports are shown in Exhibit 5 for the three AEO cases and the estimated export capacity is shown in Exhibit 5. Since the AEO does not report LNG terminal capacity, ICF estimated the export capacity values shown here based on plants now under construction and an assumption that long-run capacity utilization rates will be 85%. Additions of new capacity contribute to value added through construction expenditures.

Exhibit 3.

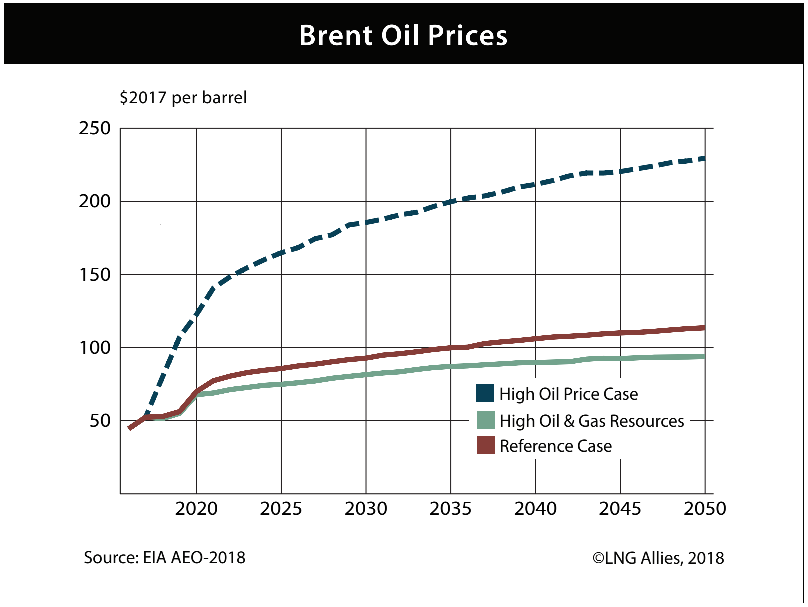
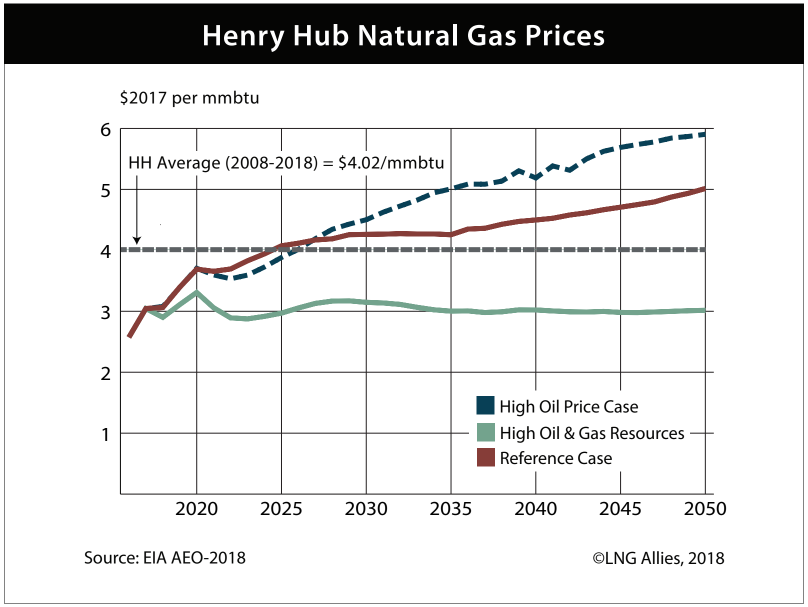
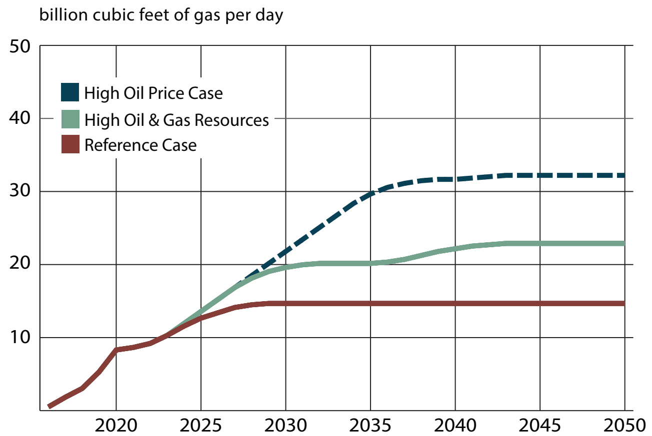



Exhibit 4.



### Exhibit 5.

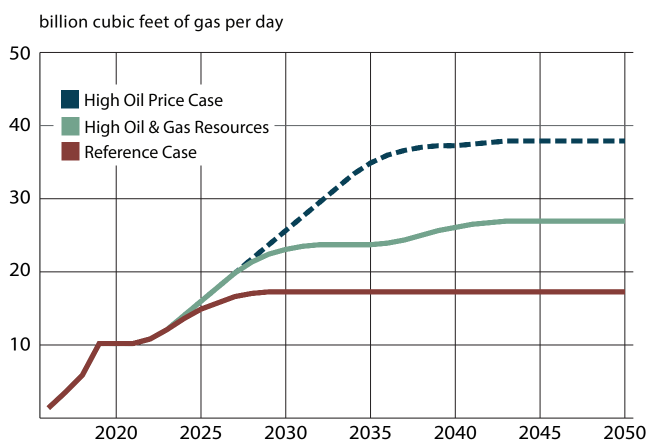
**U.S. LNG Exports**




Source: EIA AEO-2018 ©LNG Allies, 2018

### Exhibit 6.

**U.S. LNG Export Terminal Capacity (Year End)**




Source: ICF Estimates Based on AEO-2018 Selected Cases. ©LNG Allies, 2018

## Value Added and Employment for Liquefaction Plants

Exhibits 7 and 8 show direct, indirect, and induced value added and jobs related to liquefaction plants and associated port facilities for the three selected AEO cases. These charts do not include production and transportation of natural gas used as fuel and feedstock for plants.

Exhibit 7 shows value added by construction expenditures in the year the construction expenditures are incurred. Likewise, the associated jobs appear in Exhibit 8 during the years the plants are being constructed. The up and down patterns for value added and jobs occur as new plant capacity is added.

There is very little difference among the three AEO cases in terms of value added or associated jobs per unit of LNG exports. The small differences are due to the fact that more liquefaction plants are added in the High Oil & Gas Resources & Technology Case and the High Oil Price Case compared to the Reference Case. This means that the Reference Case has the highest number of operating years per plant and so the dollars and jobs associated with plant construction are spread over more units of LNG export by the year 2050.

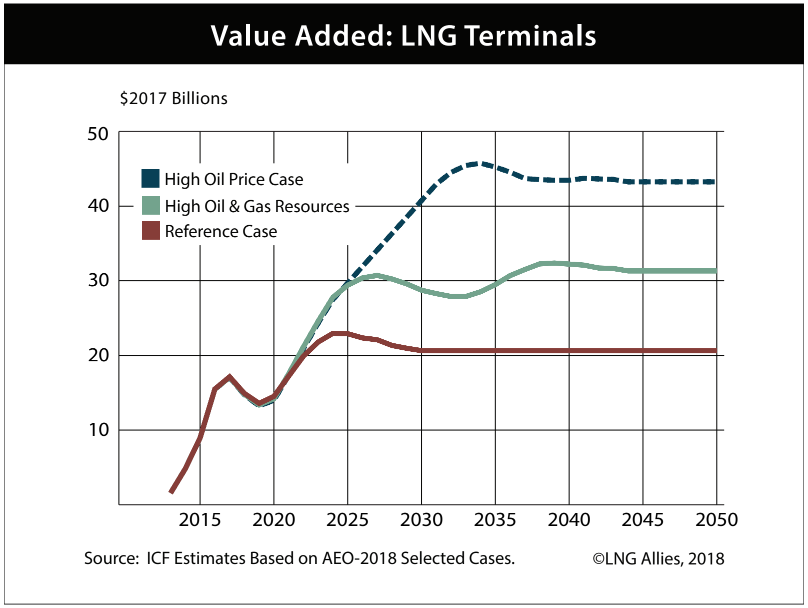
## Value Added and Employment for Natural Gas Supply for LNG Exports

Exhibits 9 and 10 show the direct, indirect, and induced valued added and jobs associated with producing, gathering, processing, and transporting natural gas that will be used as liquefaction plant fuel and feedstock. The AEO assumes that a volume of natural gas equivalent to 10% of LNG exports will be used as fuel at the liquefaction plants or to generate electricity for those U.S. liquefaction plants that will run their electric-drive refrigeration compressors using purchased electricity. Therefore, total natural gas needs are 110% of LNG export volumes.

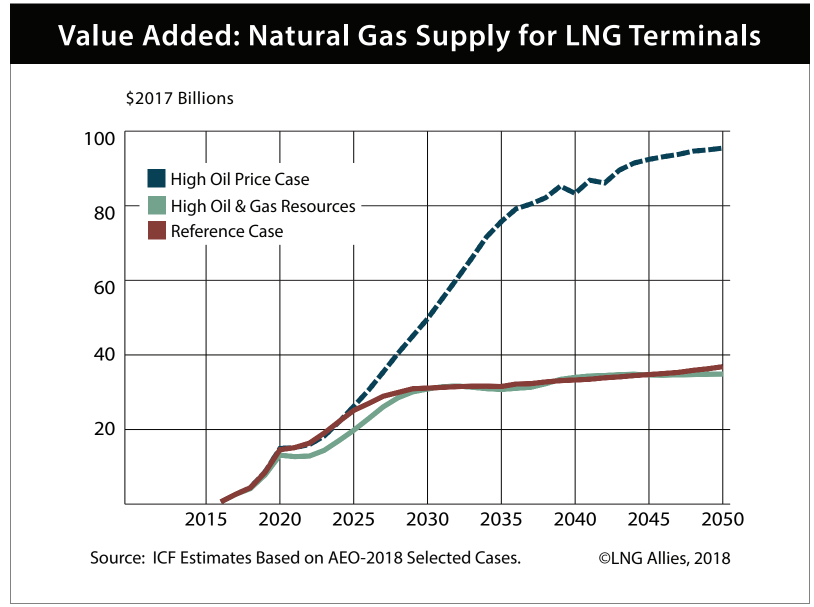
The estimated value added in supplying natural gas is influenced mostly by the AEO's projected natural gas prices. Because the High Oil & Gas Resources & Technology Case has lower natural gas prices than the Reference Case, it has a long-run value added trend that is very close to that of the Reference Case, despite its larger LNG export volumes. The High Oil Price Case has both the highest natural gas prices and highest LNG export volumes among the three cases and so its supply-related value added is much larger than the other two cases.

The effort needed (measured as dollars expended or job-years) to produce a given amount of natural gas vary among the AEO cases. For example, in the High Oil & Gas Resources & Technology Case, wherein resources are larger and technologies are more advanced, less labor and dollars will be need compared to the Reference Case for each unit of gas produced. This is why the supply-related jobs in the High Oil & Gas Resources & Technology Case do not go up as much as the volume of gas required. On the other hand, in the High Oil Price Case, more expenditures and labor are needed per unit of production compared to the Reference Case and the number of jobs supported goes up by a larger percent than does the volume of gas needed.

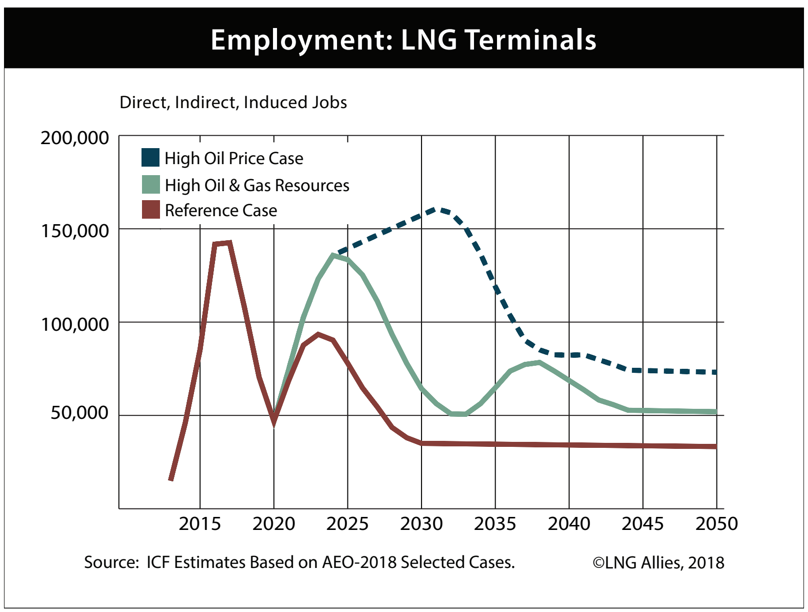
## Exhibit 7.



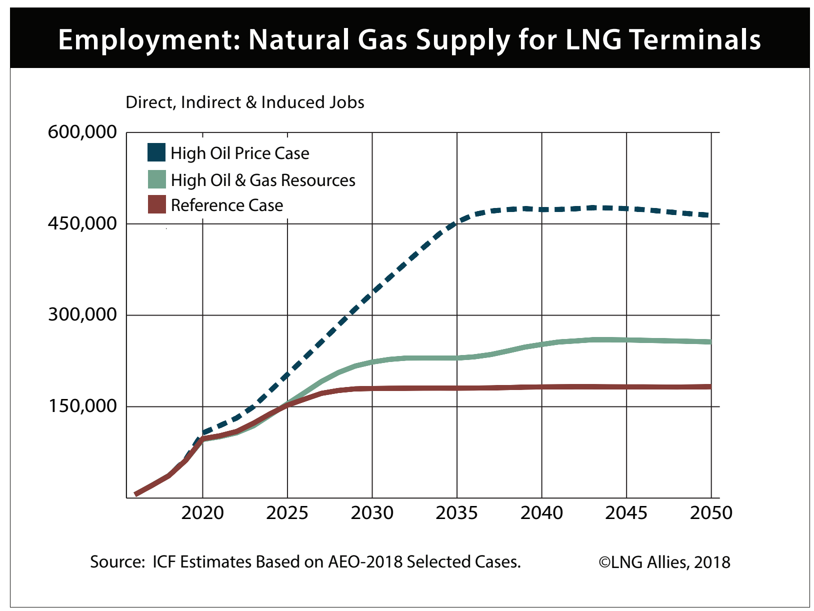

## Exhibit 9.



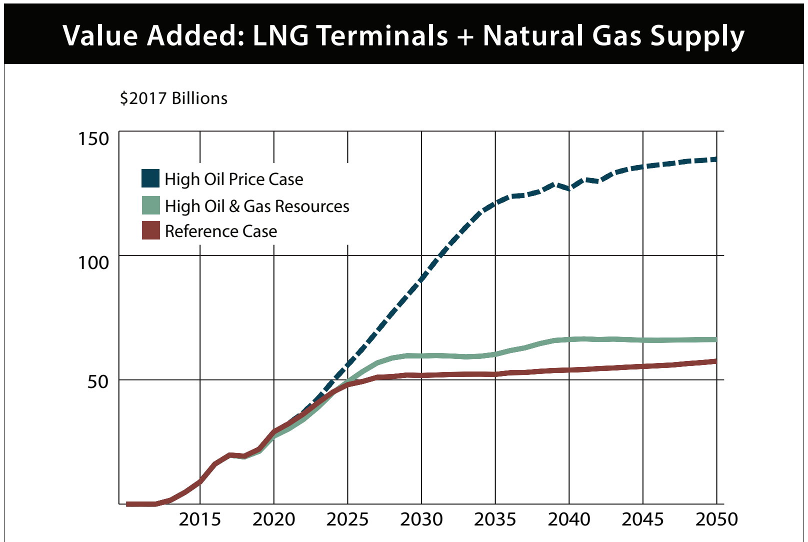

## Exhibit 8.




## Exhibit 10.

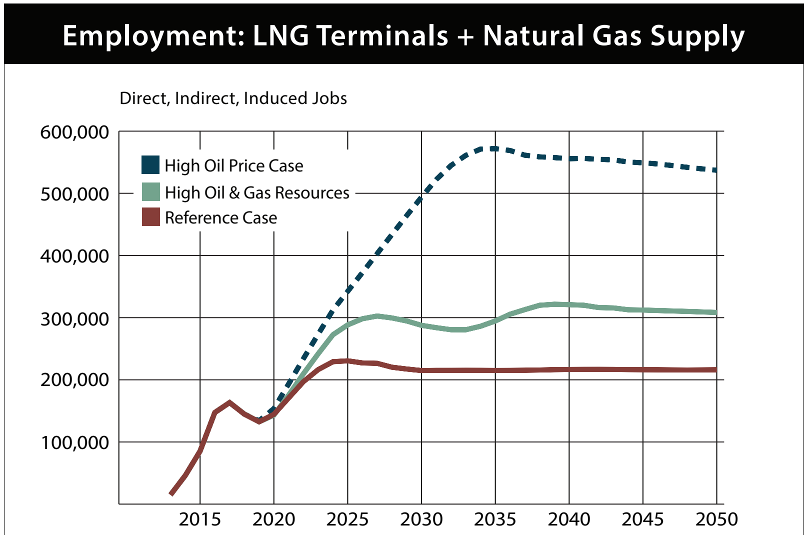


## Exhibit 11.




Source: ICF Estimates Based on AEO-2018 Selected Cases. ©LNG Allies, 2018

## Exhibit 12.




Source: ICF Estimates Based on AEO-2018 Selected Cases. ©LNG Allies, 2018

## Methodology for Impact Estimates

ICF estimated value added and jobs related to LNG exports using the 2018 Annual Energy Outlook, data from the Bureau of Labor Statistics and other public sources, and input-output relationships developed with the Impact Analysis for Planning (IMPLAN) model of the U.S. economy. This input-output (I-O) model is based on a social accounting matrix that incorporates all flows within the U.S. economy and is used to assess the aggregate economic impacts associated with a given level of an industry's output. For example, natural gas production requires oil and gas drilling and support services, equipment, and materials. Those direct impacts will lead to indirect impacts as intermediate inputs for those items (e.g., steel production to make casing and iron mining to make steel) also will see higher demand. The IMPLAN model also estimates induced impacts due to consumers' expenditures rising due to higher household incomes that are generated by the direct and indirect effects flowing through to the general economy. The term "induced impacts" is used in industry-level input-output modeling and applies to similar scenarios as does calculation of the Multiplier Effect used in macroeconomics.

These I-O relationships can be extracted into matrices that indicate the number of direct and indirect jobs in sector X per million dollars of output in sector Y. A matrix can also be defined as the number of direct and indirect jobs in sector X per physical unit of output in sector Y. Similar matrices can be constructed showing the value added in sector X per million dollars or per unit of production in sector Y. By multiplying these matrices by a base year or forecast year level of output in sector X (that is to say a given level of capital or O&M expenditures that lead to that sector X output) direct, indirect, and induced jobs and wages can be estimated. See Exhibit 13.

## Exhibit 13.

**Direct Impacts** represent the immediate impacts (e.g., employment or output changes) in Sector X due to greater demand for and output from Sector X.

**Indirect Impacts** represent the impacts outside of Sector X in those industries that supply or contribute to the production of intermediate goods and services used by Sector X.

**Induced or "Multiplier Effect" Impacts** represent the cumulative impacts of the spending of income earned in the direct and indirect sectors and subsequent spending of income in each successive round. Examples include a restaurant worker who takes a vacation to Florida, or a store owner who sends children to college, based on higher income that arises from the initial activity in Sector X.

The level of output in an industry is often measured in terms of "value of shipments" and "value added." Value of shipments is the total value (price x quantity) of what an industry produces in terms of goods or services. Value added can be computed as value of shipment minus the value of imported intermediate goods and services (all along the supply chain) and is a measure of contribution to Gross Domestic Product (GDP). Calculating the value added to the U.S. economy in this way differs from calculating value added of just one specific industry whereby the costs of the intermediate goods and services are deducted whether imported or domestic. On the other hand, the value added for the aggregate GDP includes domestic intermediate goods and services (all along the supply chain) because they also are part of U.S. GDP, and so, only imported intermediate goods are subtracted.

The convention used by ICF is to estimate the value added associated with capital stock such as liquefaction plants in the year in which the capital expenditures are made. In this way the value added (GDP contribution) occurs in the same years as are the jobs associated with the construction of the capital stock and the mining and manufacturing of materials and equipment used in the capital stock. To avoid double counting of the GDP contribution from the capital stock, depreciation of the capital stock is subtracted when production occurs. More specifically, the equation used to estimate value added in given year is:

$\text{Value Added}_{i,t} = \text{Value of Shipments}_{i,t} - \text{Imported Intermediate Goods}_{i,t} - \text{Depreciation}_{i,t} + \text{Capital Expenditures}_{i,t} - \text{Imported Capital Goods}_{i,t}$

Where:

$\text{Value Added}_{i,t}$ = the contribution of industry i to the U.S. GDP in year t.

$\text{Value of Shipments}_{i,t}$ = the total revenue received for goods and service produced by industry i in year t.

$\text{Imported Intermediate Goods}_{i,t}$ = the value of goods and services imported to U.S. for foreign countries for materials, feedstocks, operations and maintenance in year t.

$\text{Depreciation}_{i,t}$ = the cost of prior year's capital investments (which were counted in prior year's GDP) that must be subtracted to avoid double counting.

$\text{Capital Expenditures}_{i,t}$ = new capital investment made in year t.

$\text{Imported Capital Goods}_{i,t}$ = foreign purchases of goods and services used in new capital investment made in year t.

This method of calculating value added is different from what might be done by the Department of Commerce or other sources for a given industry in that we are adding in the value added by domestic intermediate goods (other than fuels and feedstocks). Our method is also different in that we count capital expenditures in the year in which they are made (so that they will align year-by-year with related construction and capital good jobs) and (to avoid double counting) remove annual depreciation. Conceptually, the method used by ICF should over time yield the same total value added as the Department of Commerce method, but might differ either in terms of which industry for which the value added is counted or in terms of the annual pattern.

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