REPOWERING AMERICA: Transmission investment for economic stimulus and climate change

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Prepared for: WIRES

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Disclaimer

The analysis London Economics International LLC ("LEI") provides in this study is intended to illustrate the potential economic benefit of transmission investment in terms of GDP and employment for the American economy (to support economic recovery), and as a potential public policy tool (to support longer term environmental goals to reduce carbon emissions, which will itself create positive economic benefits). While LEI has taken all reasonable care to ensure that its analysis is complete, the interplay of electric infrastructure investment and dynamics of local economies are highly complex, and thus this illustrative analysis does not quantify all tradeoffs and substitution effects, nor attempt to quantify various positive effects from reduced carbon emissions and containment of damages from Climate Change. Furthermore, certain recent developments in the US economy and transmission investment plans of various regions of the US may or may not be included in LEI's illustrative analysis. This report is not intended to be an evaluation of any specific transmission investment or a definitive assessment of future economic conditions in the US. The opinions expressed in this report as well as any errors or omissions, are solely those of the authors and do not represent the opinions of other clients of London Economics International LLC.

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Acronyms

Acronym	Description
AAA	Agricultural Adjustment Act
ARRA	American Recovery and Reinvestment Act
BEA	Bureau of Economic Analysis
CAISO	California ISO
CBO	Congressional Budget Office
CLCPA	Climate Leadership and Community Protection Act
CPI	Consumer Price Index
CREZ	Competitive Renewable Energy Zone
D.C.	District of Columbia
DERs	Distributed energy resources
DOE	US Department of Energy
EIA	US Energy Information Administration
EPA	US Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
EU	European Union
EVs	Electric vehicles
FDR	Franklin D. Roosevelt
FERC	Federal Energy Regulatory Commission
FTE	Full-time employment
GDP	Gross Domestic Product
GHG	Greenhouse gas
GNP	Gross National Product
IIP	Index of Industrial Production
I-O	Input-Output
IOU	Investor-owned utility
IRPs	Integrated Resource Plans
ISD	In-service date
ISO	Independent system operator
ISO-NE	ISO New England
ITC	Investment Tax Credit
LEI	London Economics International
LT	Long-term investments
NIRA	National Industrial Recovery Act
NOPR	Notice of Proposed Rulemaking
NYISO	New York ISO
NYPA	New York Power Authority
O&M	Operation and maintenance
OOS	Out-of-state
PCIs	Projects of Common Interest
PJM	Pennsylvania, Jersey, Maryland Interconnection

Acronym	Description
$PM_{2.5}$	Fine particulate matter
PSC	Public Service Commission
PTC	Production Tax Credit
PV	Photovoltaic
PWA	Public Works Administration
REA	Rural Electrification Administration
RIMS II	Regional Input-Output Modeling System
ROE	Return on Equity
RTO	Regional transmission organization
$SC\text{-}CO_2$	Social cost of carbon
SDG&E	San Diego Gas & Electric
SERC	SERC Reliability Corporation
SGDP	Smart Grid Demonstration Program
SGIG	Smart Grid Investment Grant
SPP	Southwest Power Pool
ST	Short-term investments
TEN-E	Trans-European Networks – Energy
TFP	Total Factor Productivity
UC	Under construction
WAPA	Western Area Power Administration
WECC	Western Electricity Coordinating Council
WWI	World War I

1 Executive Summary

Federal support for already planned transmission investment can yield substantial economic stimulus effects in the shorter term, while also advancing longer term decarbonization objectives

The Covid-19 pandemic has caused one of the greatest shocks to the United States economy in living memory. US real Gross Domestic Product ("GDP")[1] fell by $668.3 billion or 3.5% in 2020 from 2019 levels, the sharpest yearly drop since 1946.[2] As of April 2021, total unemployment in the US hovers at 3.9 million.[3] More than one year after states first implemented public health restrictions, unemployment levels remain nearly twice as high as pre-pandemic levels.

Even as the US faces optimistic prospects for reigning in the public health crisis with a universal vaccination program, the US economy is still in need of additional economic stimulus programs in order to progress with economic recovery. In the words of Treasury Secretary Janet Yellen, the United States has to "continue to take significant fiscal and financial policy actions and avoid withdrawing support too early. If there was ever a time to go big, this is the moment."[4]

Economic stimulus is a policymaking tool commonly employed during recessions to support economic activity in a region. Economic stimulus programs can include increased government spending (through new legislation or automatic stabilizers like unemployment insurance), as well as indirect measures such as tax cuts to individuals or businesses and other reforms that can motivate increased private sector spending. Monetary policy can also be used as stimulus – for example, the Federal Reserve can reduce interest rate or acquire large quantities of financial assets. Economic stimulus involving infrastructure investment has a long history in US economic policymaking.

Source: Center on Budget and Policy Priorities. *Policy Basics: Fiscal Stimulus*. May 21, 2020; International Monetary Fund. *Monetary Policy: Stabilizing Prices and Output*. February 24, 2020.

The electric industry is primarily a private sector enterprise in the US. Current plans for transmission investment across the US amount to tens of billions of dollars, and the private sector is poised to fund most of this new infrastructure. However, there are many other challenges to getting new transmission built in the US. Federal policy reforms that support investment could go a long way to ameliorating these challenges and realizing construction of new transmission. Such construction will amount to increased construction-related spending and creation of new

[1] According to the Bureau of Economic Analysis, GDP can be defined as "a comprehensive measure of U.S. economic activity. GDP measures the value of the final goods and services produced in the United States (without double counting the intermediate goods and services used up to produce them). Changes in GDP are the most popular indicator of the nation's overall economic health."

[2] Based on US real Gross Domestic Product data from the Bureau of Economic Analysis as of February 2021.

[3] The unemployment differential has been calculated using unemployment data from the Bureau of Labor Statistics between March 2021 and December 2019.

[4] US Department of the Treasury. *Letter from Treasury Secretary Janet L. Yellen to G20 Colleagues*. February 25, 2021.

construction and technical jobs, as we discuss further below. There would also be major positive spillover effects to other areas of the economy through expansion of the domestic manufacturing and increased spending by the construction workers on other goods and services.

The Covid-19 pandemic also highlighted the importance of electricity to the everyday lives of Americans. During the second quarter of 2020, when many Americans were either working from home or out of work, while commercial and industrial electricity demand declined, residential electricity consumption in fact rose by 10% on average, leading to nearly $6 billion in additional purchases of electricity by households.[5] Looking towards the future, electricity will become even more important as an energy source for the United States. Demand for electricity will increase as sectors such as transportation and heating, which now rely largely on carbon-emitting fuels like gasoline and natural gas, begin to switch over to electricity as an energy source. Some studies are predicting double digit growth in electricity demand in the coming decades due to these electrification trends.[6] The Biden Administration's focus on managing the devastating effects of climate change will require a variety of new electricity infrastructure, including strategic transmission investment to bolster electrification efforts and tap into various zero-carbon natural resources and deliver carbon-free supply to customers. Successfully addressing climate change will also yield benefits for the economy, in the form of avoided damages and socio-environmental costs. Stimulus measures that foster new transmission construction will bolster decarbonization efforts and yield another layer of socio-economic benefits for the US over the longer term.

In summary, Federal policies and economic stimulus measures aimed at supporting planned transmission investment and encouraging timely construction of beneficial transmission system expansion over time can contribute significantly to economic recovery and assist with the achievement of critical environmental policy goals.

Infrastructure development has been a critical element of past economic recovery programs

Stimulus programs that underwrite and encourage infrastructure development have proved highly beneficial in past economic downturns, including in the Great Depression of the 1930s and the Great Recession of the late 2000s. Case studies of the New Deal and the 2009 American Recovery and Reinvestment Act demonstrate the importance of programs that focus on new infrastructure and advancement of energy projects. Analysis of economic stimulus programs from those two prior events provide two "lessons" for the design of economic stimulus measures around transmission infrastructure for the current crisis:

1. Encourage private sector spending: policies that support planned (and already approved or recommended) transmission investment by the private sector should be on the critical path for Federal government support. The Federal government can support transmission

[5] Cicala, Steve. "Powering Work from Home." *National Bureau of Economic Research Working Paper 27937.* October 2020.

[6] For example, in Massachusetts, attainment of legislated decarbonization goals is predicted to increase the share of final energy delivered by electricity by 3.5x by 2050. See Massachusetts Executive Office of Energy and Environmental Affairs. *Energy Pathways to Deep Decarbonization*. December 2020. p. 2.

investment through regulatory policies, which would remove siting and permitting obstacles that can delay realization of beneficial transmission investment and create a supportive planning and financing environment. Indirect financial support, such as stable return on equity ("ROE") policies and incentives for qualified investments, can also be useful. More generally, policies and measures should focus on these other regulatory and indirect pathways for promoting and ensuring that beneficial transmission investment is realized. Prior experience in other sectors has shown how direct Federal government funding[7] is most useful when there is a vacuum of private investment. Experience has also shown that economic policies and stimulus measures that support private investment typically result in a higher payout or benefit. In addition, such programs should have a smaller impact on the federal deficit nor directly compete with budgetary dollars (therefore, not deter other critical programs that are more likely to necessitate direct federal funding).

2. Design policies and stimulus measures that lead to long-lasting impacts: experience from the 1930's under the New Deal shows the magnitude of foregone economic benefits when stimulus measures ended prematurely. Local spending on construction of transmission can yield relatively immediate increase in (direct) jobs across a large geographical area and perpetuate benefits for other sectors of the economy (known as indirect and induced effects) quickly once construction begins. However, moving from the planning and design stage to the construction phase is a much lengthier process. And frequently, there are delays in the initiation of construction even after transmission projects are evaluated and approved, due to regulatory uncertainties and siting challenges. Regulatory improvements to the permitting and siting process would alleviate delays. Because of the amount of capital investment typically involved and the inherent economic life of transmission assets, invested dollars are recouped over many years. Private investors therefore need assurance of a stable regulatory environment.

The payoff for policies and measures should continue well past the period of construction.[8] Transmission investment can reduce the costs of electricity that would bring about additional round of macroeconomics benefits.[9] Furthermore, given the need for additional transmission infrastructure to bring to market various remotely-located clean energy generation resources,

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[7] Similar to the direct investment under the New Deal in the nation's transportation infrastructure (roads and railroads), direct Federal government funding of transmission would hypothetically involve the Federal construction and ownership of transmission. The Federal government, through its agencies and corporations, already owns some transmission infrastructure in the U.S., but such investment is typically limited to the service territory of the federal agencies and power marketing authorities (and investment is typically financed through revenues received by those entities, rather than taxpayer funds). In our use of the terminology "direct Federal investment", we are not referring to situations in which the private and public sector might combine efforts to develop major transmission projects under a public-private partnership.

[8] For other WIRES studies on the benefits of transmission expansion and development, please see https://wiresgroup.com/category/wires-report/

[9] In a January 2018 paper prepared for WIRES entitled, *How Does Electric Transmission Benefit You?*, LEI estimated ratepayer impacts for two hypothetical transmission projects, and the resulting macroeconomic benefits from lower electricity costs.

transmission investment can lead to other electricity infrastructure investment, and realization of decarbonization benefits.[10] Therefore, stimulus measures related to transmission investment should consider the longer-term nature of the investment cycle, the inherent need for stability to bring such investments to fruition, and the longevity of the indirect and induced economic benefits from follow-up investments and beneficial impacts. As such, stimulus measures should contemplate policies that provide both immediate economic impact, and long-lasting support.[11]

Construction of transmission infrastructure can have an immediate and far-reaching impact on the US economy

Analysis of past stimulus packages has also shown that the implementation of new programs could delay the realization of economic benefits. For example, the American Recovery and Reinvestment Act ("ARRA") funds assigned to newly created programs took longer to distribute than ARRA funds disbursed through existing programs. In parallel to this finding, this White Paper presents estimates of the economic stimulus effects of already planned transmission projects. Based on known transmission plans and status reports of Independent System Operators ("ISOs")/Regional Transmission Organizations ("RTOs") and utilities across the US, over $83 billion of transmission investment has been approved and/or recommended for approval (see location of these investments in Figure 1).[12] This figure is a conservative estimate of transmission investment plans in the US, as it excludes proposed transmission projects that have not been Board-approved or selected (recommended) as part of a utility planning process. This study also excludes merchant transmission project proposals outside the ISO/RTO and utility planning processes. There are billions of dollars of such merchant-based transmission investment in various stages of development.

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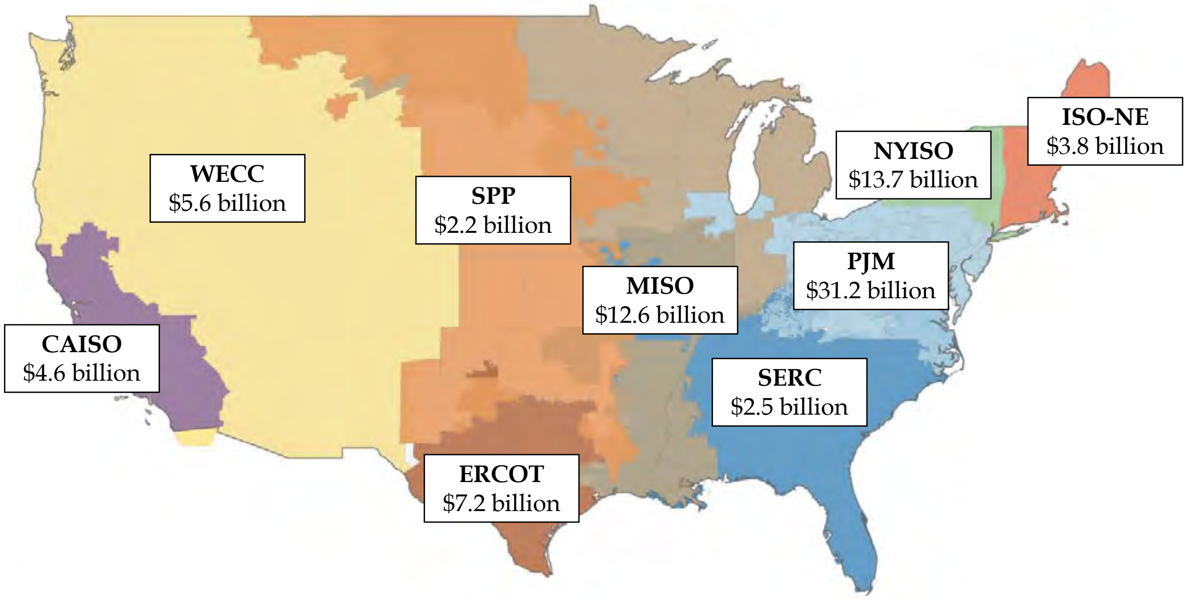
[10] The January 2018 paper described in the footnote above examined some of these effects as well, specifically in the form of local benefits stemming from the wind generation construction in Wyoming catalyzed by the "Resource Delivery" transmission project in the Western Interconnect. The illustrative knock-on effects associated with the construction of the wind generation in sparsely populated, rural areas of Wyoming demonstrate how transmission infrastructure can be used to further economic justice goals. By supporting local economic development opportunities in areas that might otherwise have fewer economic opportunities, transmission investment offers a pathway for improving the economic condition of underprivileged segments of the US population.

[11] Examples of long-lasting support schemes as part of economic stimulus programs include the rural electrification initiative deployed during the New Deal and ARRA´s funding for innovation in the energy sector.

[12] Transmission planning process vary across ISOs/RTOs and utilities. Some ISOs/RTOs have approved and budgeted transmission projects for only the next six years, while others have official transmission investment plans over a much longer period. LEI collected and aggregated available data for each region and ISO/RTO. On average, the transmission investments covered in this $83 billion figure cover a time span of 6 to 10 years (except, for NYISO and WECC, where approved and/or recommended transmission investments cover a longer period). See Section 4.2 for more detailed information on how transmission investment data was compiled based on the regions identified and the time period covered.

Figure 1. Approved or recommended transmission investments by region as of 2020



Source: S&P Global Market Intelligence (map only); LEI (transmission survey data).

There are a number of obstacles in realizing these investment plans, as acknowledged by policymakers and industry experts.[13] The main challenges have been institutional barriers around securing customer commitments and/or allocation of costs, regulatory approval for siting, and conflicting and unclear planning frameworks. In addition, the financial environment for investors specifically in relation to ROE policies, has also been in flux. Notwithstanding such obstacles, if these approved and/or recommended $83 billion of transmission investments proceed as planned, significant economic benefits will be realized across regions and diverse sectors of the US economy. As shown in Figure 2 below, the construction of this magnitude of planned transmission infrastructure would increase direct local spending (in the U.S.) by nearly $39 billion, boost US GDP by $42 billion and create an additional approximate 442,000 jobs. To put these numbers into context, such impacts are the equivalent of a 14% increase in the contribution to GDP currently made by the utilities sector,[14] and equivalent to more than a doubling of current employment in the utilities sector. However, these positive economic impacts are not limited to just the utilities sector. Construction involves many different industries and will improve the take-home income of various workers directly and indirectly involved in the installation of the transmission infrastructure. For example, as a result of increased demand for its service, a

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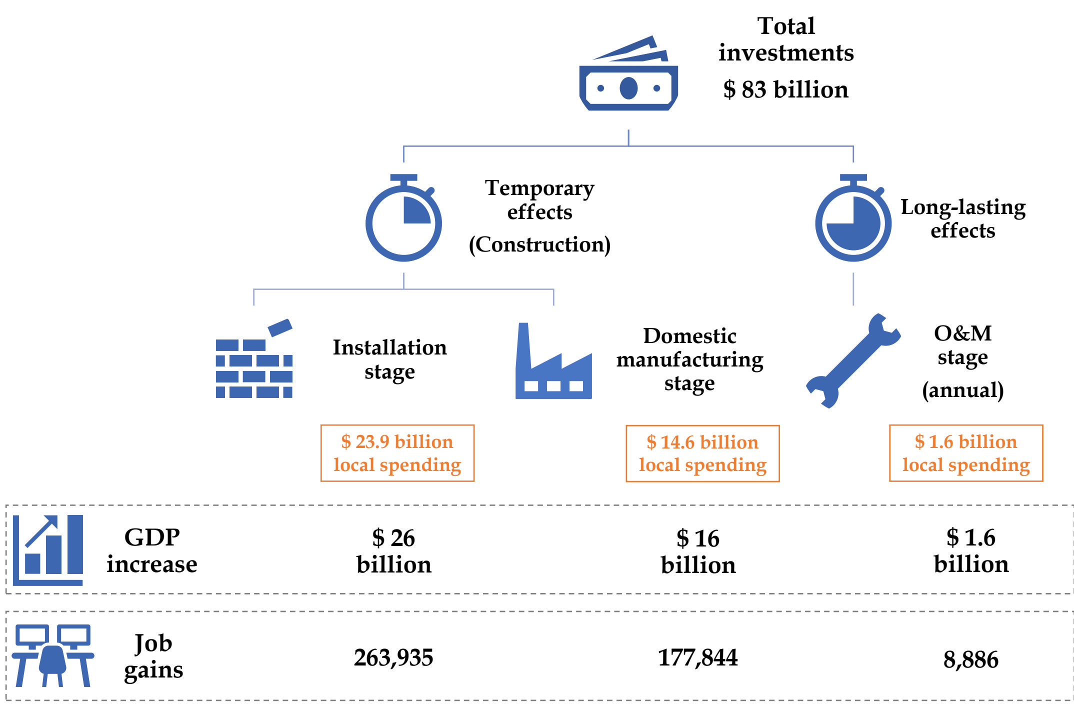
[13] See for example: Joskow, Paul L. *Transmission Capacity Expansion Is Needed to Decarbonize the Electricity Sector Efficiently*. *Joule* 4.1 (January 2020): 1-3. Digital; Staff of the Federal Energy Regulatory Commission. *Report on Barriers and Opportunities for High Voltage Transmission*. June 2020. pp. 21-34.

[14] Per the US Bureau of Economic Analysis ("BEA") classification, the "Utilities" sector comprises not only electric power generation, transmission, and distribution, but also natural gas distribution, and water and sewage system operations.

construction company may hire additional support staff. Although such employees are not directly working at the construction site, their jobs are created as a consequence of the transmission investment. The wages paid to the direct and indirect workers will be used by them to spend on a variety of household expenses, and thereby the money spent during construction is re-invested into the broader economy, impacting almost every other sector of the economy in what is known as the "multiplier" or "ripple" effect.

Once the transmission construction is complete and the asset is operating, the owners of the asset will need to hire additional workers to operate and maintain the assets. Such operational and maintenance spending could generate another $1.6 billion in GDP per year and almost 9,000 jobs per year (also shown in Figure 2).

Figure 2. Transmission investments contribution to GDP increase and job gains



Transmission investment has many other benefits as well, including reducing energy prices for customers, increasing electricity generation from renewables, and advancing decarbonization efforts. Each of these benefits will have their own longer-term impact on GDP and employment, however estimating the precise GDP and employment effects of each is beyond the scope of this White Paper.

President Biden and his policy team acknowledge that transmission investment is an integral part of the commitment to rebuild America´s infrastructure, while getting to a net-zero carbon economy by 2035.[15] Transforming the grid to utilize zero carbon natural resources effectively is already a cornerstone of many utility and ISO/RTO transmission plans. For example, over $1.2 billion of planned transmission investments in NYISO in the next few years is related to the integration of renewable sources to achieve the state´s energy goals.[16] Without the necessary transmission infrastructure, some renewable and clean energy generation investment will simply not happen. As such, transmission investment also serves as a catalyst for additional generation investment by the private sector, which creates its own set of direct, indirect, and induced benefits.

Federal policies and economic stimulus-related measures for encouraging and supporting transmission investment would be beneficial to US the economy

The $83 billion of planned transmission investments discussed in the White Paper are being pursued by the private sector. Therefore, unlike some of the infrastructure-related stimulus programs from the Great Depression, there is no need for the government to step in and completely fund construction of such infrastructure with taxpayer funds. However, federal government involvement through policy support could be invaluable in ensuring that the construction of these planned transmission investments not get unnecessarily delayed, so that the positive impacts on GDP and employment contribute to longer term recovery of the US economy. A variety of Federal policies and economic stimulus measures could accomplish this overarching goal. Regulatory-focused policies that improve siting and permitting would ensure beneficial transmission investment is realized. This area of policy development should also consider better coordination of inter-regional transmission planning, including scenario-based planning to build transmission in preparation for meeting state renewable targets and decarbonization goals (to the extent it is not being done already) and more pragmatic framework for cost allocation. In addition to regulatory reforms, economic stimulus measures that encourage continued private sector investment are desirable (including measures that deliver stable and commercially reasonable frameworks for transmission rate design and ROEs).

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[15] The White House - Briefing Room. *Fact Sheet: The American Jobs Plan*. March 31, 2021.

[16] NYISO. *NYISO Board of Directors' decision on approval of AC transmission public policy, transmission planning report and selection of public policy transmission projects*. April 8, 2019.

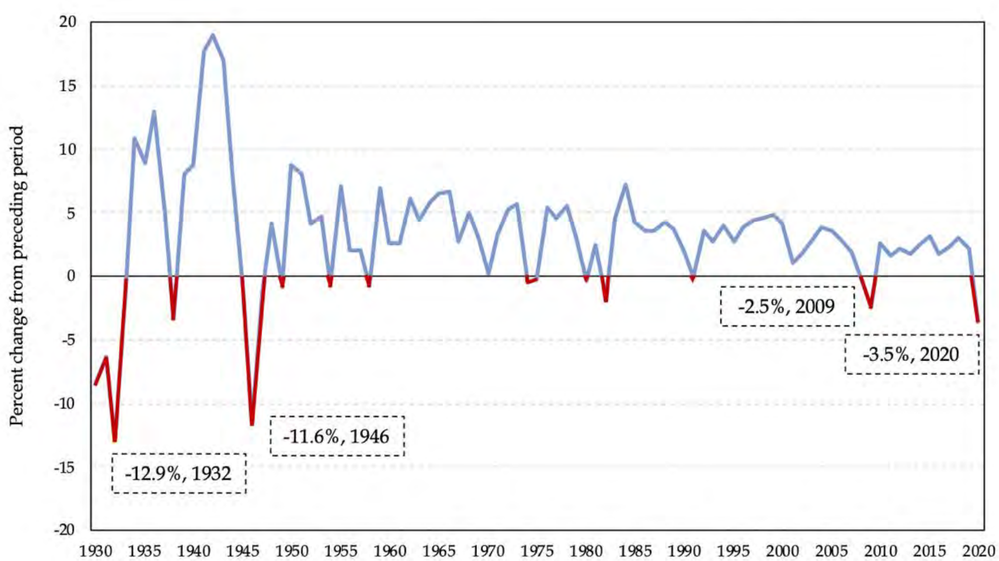
2 What are the critical needs of the US economy in the near term and longer term that transmission investment can fulfill?

Following the onset of a worldwide pandemic caused by the Covid-19 virus in early 2020, the United States experienced a significant downturn to its economy from which it is only starting to recover. Measures of national output (GDP) and employment remain below pre-pandemic levels, and employment in particular may take several years to fully recover. At the same time, combatting climate change and decarbonizing the United States economy have emerged as high legislative and policy priorities. At this critical juncture, infrastructure investment that supports decarbonization and continues to further the economic recovery is essential. Supporting private investment in transmission can achieve both these goals.

2.1 Recovery from the Covid-19 pandemic will require direct and indirect stimulus

The United States is currently recovering from a period of severe economic disruption due to the ongoing Covid-19 pandemic. As seen in Figure 3 below, the pandemic has resulted in the most significant economic contraction since the 1940s.

Figure 3. Annual precent change in US GDP



Note: Data is seasonally adjusted.

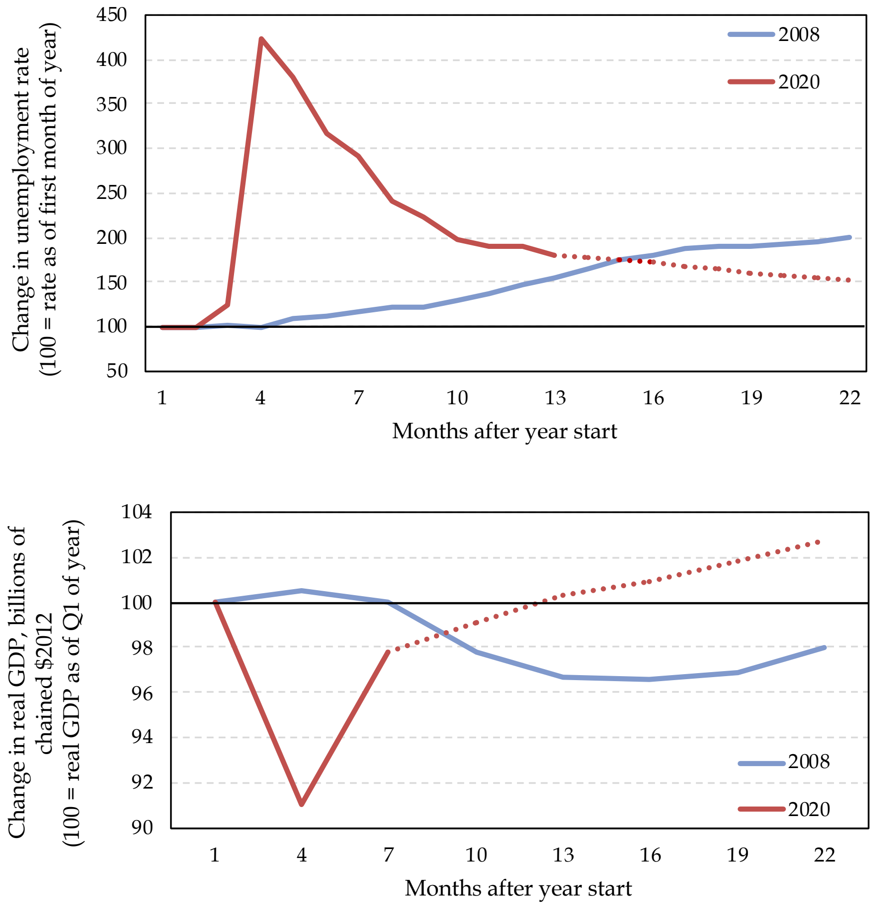
Source: Bureau of Economic Analysis.

Compared to the Great Recession of 2008, the decline in output and employment caused by Covid-19 has been much larger and has occurred much faster as shown in comparisons of unemployment and real GDP changes during the two crises (see Figure 4).[17] In the top-most chart,

[17] Boskin, Michael J. "How does the Covid recession compare?" *World Economic Forum.* August 28, 2020.

the steep rise in the red line displays a quadrupling in the unemployment rate by April 2020, compared to a much smaller slope in the blue line representing 2008. In the second chart, the sharp drop in the red line depicts the sharp drop in real GDP, also by April 2020, compared to a more gradual decline in 2008.

Figure 4. Changes in unemployment rate and real GDP in 2008 and 2020



Note: Dotted line indicates projections of real GDP and unemployment rate from the Congressional Budget Office, which estimates each per quarter. Certain data points for mid-quarter months have been extrapolated assuming linear change.

Source: Congressional Budget Office; Federal Reserve Bank of St. Louis.

Following a strong reboot to activity in the second half of 2020, economic recovery stalled amid a resurgence in Covid-19 cases: the December 2020 jobs report from the Bureau of Labor Statistics showed the first net decline in nonfarm payrolls since April 2020.[18] The most significant job losses

[18] International Monetary Fund. *World Economic Outlook Update*. January 2021.

were seen in the leisure and hospitality industry sector and the private education sector (part of the education and health services industry sector).[19]

As illustrated in Figure 5, various forecasters predict that US GDP will rise in 2021, between 3.2% and 5.1%, following the sharp 3.5% decline in 2020. The most recent outlook from the Congressional Budget Office ("CBO") predicts that real GDP will return to its pre-pandemic level by 2021. However, employment will not see a similar recovery until 2024.[20]

Figure 5. Projected percent change in US GDP

Forecaster	Year-on-year % change in GDP	
	2021	2022
International Monetary Fund	5.1	2.5
Consensus Forecasts	4.7	3.6
Congressional Budget Office	4.6	2.9
Organization for Economic Co-operation and Development	3.2	3.5

Source: Consensus Forecasts.

Since the start of the pandemic, US policymakers have legislated nearly $5.4 trillion in aid packages: $2.4 trillion in Spring 2020 through various legislation that established among other things the Paycheck Protection Program and direct payments to households, $920 billion in December 2020[21] and a $1.9 trillion package passed in early March 2021.[22] Fiscal policy response so far has mainly focused on direct relief (e.g., augmented unemployment insurance benefits and small business loans),[23] with the most recent package continuing to emphasize relief to individuals and state governments.[24] These measures have contributed to a sharp upward trend in US federal debt (as seen in Figure 6). Rising federal debt may create longer term consequences for the economy, such as depressed private investment.[25] Therefore, to balance the direct relief

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[19] Bureau of Labor Statistics. *The Employment Situation – December 2020*. January 8, 2021.

[20] Congressional Budget Office. *An overview of the economic outlook: 2021 to 2031*. February 2021. p. 1.

[21] Gale, William G. and Grace Enda. "Economic relief and stimulus: Good progress but more work to do." *Brookings*. December 16, 2020.

[22] The Brookings Institution. *The Current: What's in the latest Covid-19 relief bill?* March 9, 2021.

[23] Gale, William G. and Grace Enda. "Economic relief and stimulus: Good progress but more work to do." *Brookings*. December 16, 2020.

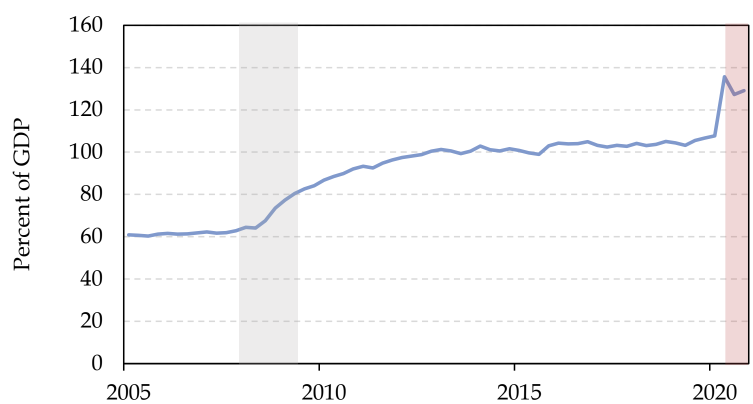
[24] The Brookings Institution. *The Current: What's in the latest Covid-19 relief bill?* March 9, 2021.

[25] The CBO estimates that every dollar of deficit increase would reduce private investment by 33 cents. (Source: Congressional Budget Office. *The Macroeconomic and Budgetary Effects of Federal Investment*. June 2016. p. 9)

that has been the mainstay of recent economic stimulus legislation, it is also vital for the federal government to look at ways to promote and encourage the private sector to increase spending.

Direct spending by the Federal government, for example construction of new infrastructure, as was done under the New Deal in the 1930s, is one of several tools that policymakers can wield to stimulate the economy; other levers include tax credits, grants, and other measures to promote private investment. Such indirect financial measures work by reducing the cost of doing business and stimulating investment and spending by the private sector, instead of the federal government. Stimulus measures chosen by policymakers often have two aims: to provide relief for individuals and businesses (e.g. expanded unemployment benefits or forgivable loans for businesses as in the Paycheck Protection Program) and to increase demand and employment in the economy.[26] Stimulus measures can also lay the groundwork for longer-term, sustainable economic growth, if the improved infrastructure enhances productivity and reduces costs for other profitable economic activities.[27] In addition, Federal policies that encourage continued private investment, by reducing or eliminating regulatory risks and obstacles, can be helpful in the longer term. As described further in the case studies in Section 3, economic stimulus in the United States has frequently included measures to spur activity in the infrastructure and energy sectors, precisely because of the material indirect and induced benefits that such measures have on the broader economy and positive implications for the US labor force.

Figure 6. Total public debt as percent of GDP



Note: Most recent data available represents Q4 2020. Grey shading indicates Great Recession; red shading indicates beginning of current recession caused by Covid-19 pandemic. Data is seasonally adjusted.

Source: Federal Reserve Bank of St. Louis.

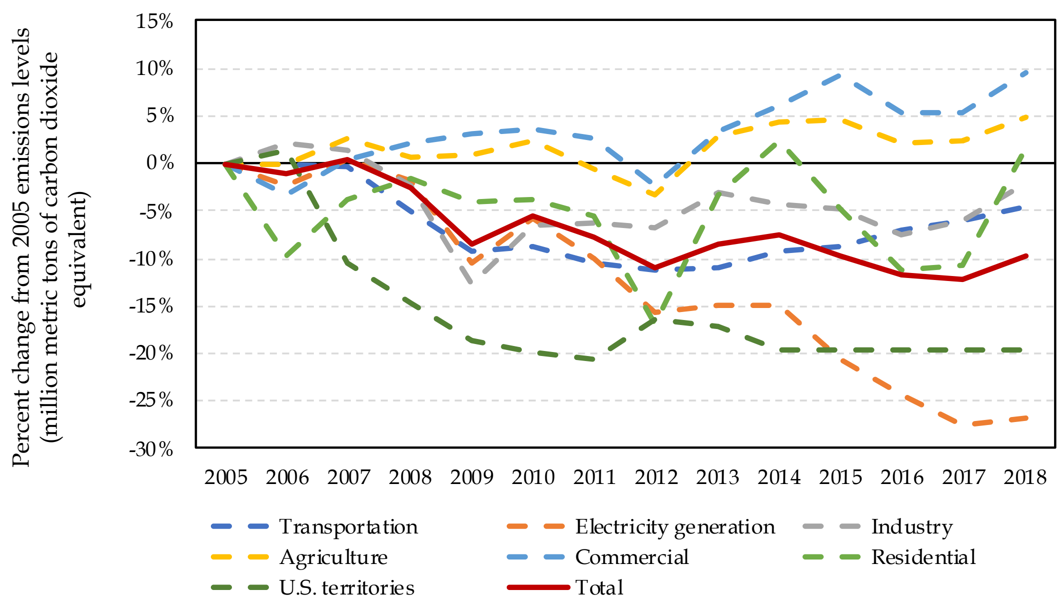
[26] Some measures, such as expanded unemployment benefits, may in fact tackle both aims. (Source: Congressional Research Service. *Fiscal Policy and Recovery from the Covid-19 Recession*. February 1, 2021.)

[27] Horton, Mark and Asmaa El-Ganainy. "Fiscal Policy: Taking and Giving Away." *International Monetary Fund.* February 24, 2020.

2.2 Additional greenhouse gas emissions reductions are necessary in the longer term to avert a Climate Change crisis

As shown below in Figure 7, greenhouse gas ("GHG") emissions in the United States were nearly 10% lower in 2018 compared to their 2005 levels. This reduction has been driven by a 27% drop in GHG emissions from electricity generation, as shown by the orange dotted line. However, GHG emissions remain at an estimated 6.6 billion metric tons of carbon dioxide equivalent as of 2019.[28] To meet the Paris Climate Accords goal of limiting global warming to 1.5ºC above preindustrial levels, US emissions must be 3.5 billion metric tons lower by 2030 compared to their 2019 level.[29] Under an executive order signed in January 2021, President Joe Biden announced the goal of a "carbon-pollution free power sector by 2035" and "a net-zero economy by 2050."[30]

Figure 7. Percent change in US emissions since 2005 by source



Note: 2018 is the most recent year for which the US Environmental Protection Agency ("EPA") has finalized national emissions data.

Source: United States Environmental Protection Agency. *Greenhouse Gas Inventory Data Explorer*. Accessed March 11, 2021.

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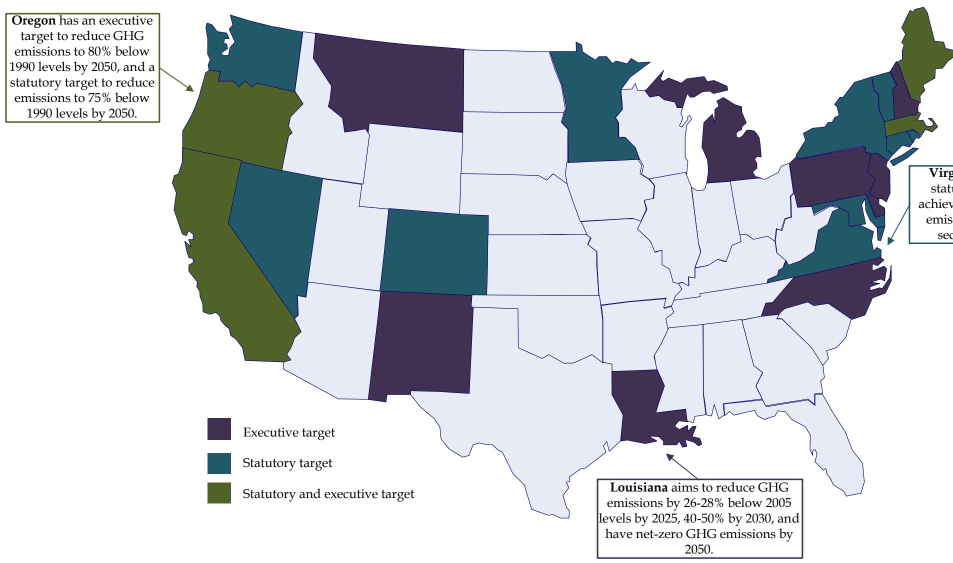
[28] United States Environmental Protection Agency. *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*. p. ES-4.

[29] Climate Action Tracker. *To show climate leadership, US 2030 target should be at least 57-63%.* March 2021.

[30] The White House - Briefing Room. *Fact Sheet: President Biden takes executive actions to tackle the climate crisis at home and abroad, create jobs and restore scientific integrity across federal government*. January 27, 2021.

In recent years, states and local governments have been a major driver of climate action in the United States.[31] Twenty-four states and the District of Columbia ("D.C.") have emissions reduction targets,[32] and thirty-eight states have some level of requirement for renewable/clean energy in their electricity (in addition to four US territories and D.C.).[33] Figure 8 below shows states that have implemented GHG reduction targets, with certain examples highlighted. At the same time, ISOs and RTOs have started to evolve their system planning and organized market rules to align with state policies to change energy supply mix toward clean energy, reduce GHG emissions, and grow distributed energy resources ("DERs").[34]

Figure 8. State-level emissions reduction targets



Note: Map excludes Hawaii, which enacted a statutory target in 2018 to reach net-zero GHG emissions by 2050. Net-zero emissions means that the jurisdiction removes any remaining human-caused GHG emission from the atmosphere, through either natural or technological means.

Source: Center for Climate and Energy Solutions. *State Climate Policy Maps*. Accessed March 11, 2021; Levin, Kelly and Chantal Davis. "What Does 'Net-Zero Emissions' Mean? 6 Common Questions, Answered." *World Resources Institute*. September 17, 2019.

[31] Bloomberg Philanthropies. *Accelerating America's Pledge*. 2019. p. 7.

[32] Center for Climate and Energy Solutions. *State Climate Policy Maps*. Accessed March 11, 2021.

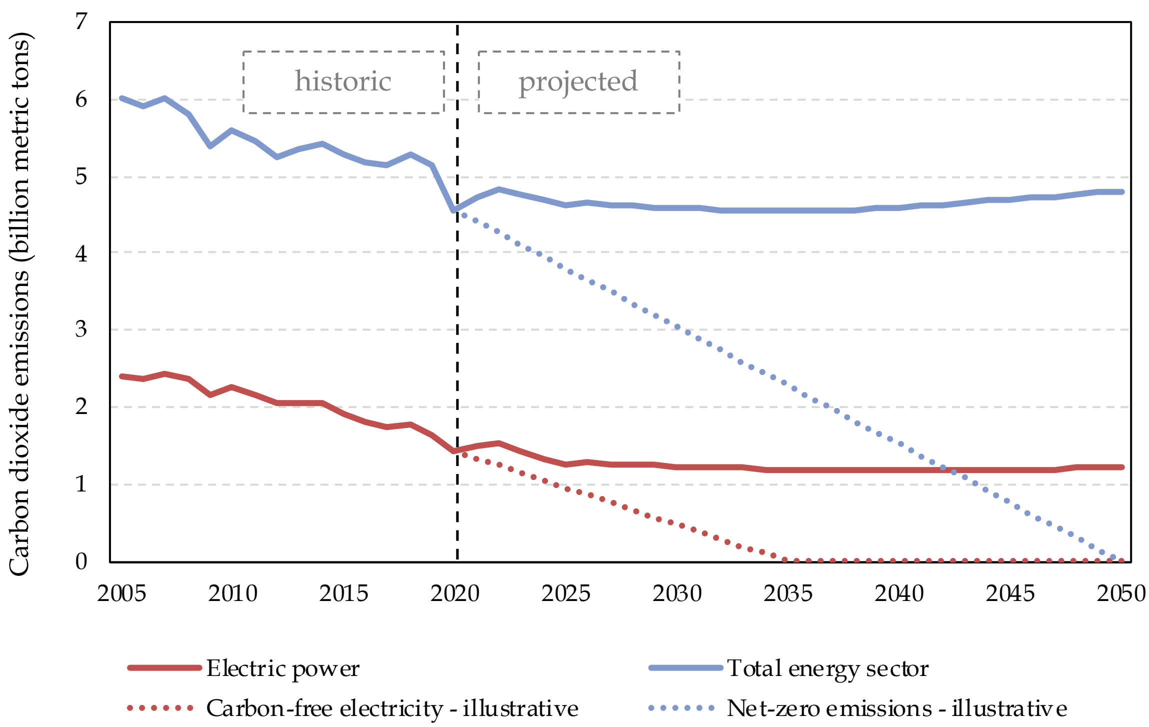
[33] S&P Global Platts. *Analysis: States' renewable mandates continue to grow; nine set 100% clean energy goals.* August 14, 2020.

[34] See for example: California ISO. *2019-2020 Transmission Plan*. March 25, 2020.; PJM. *Regional Transmission Expansion Planning: Planning the Future of the Grid, Today*. 2019.; ISO New England. *2019 Regional System Plan*. October 31, 2019.

Based on the Reference Case projections in the Annual Energy Outlook released by the US Energy Information Administration ("EIA") in February 2021, illustrated in Figure 9 below, GHG emissions from electric power sector are predicted to decrease by 49% by 2050 compared to 2005 levels; total emissions from the energy sector are predicted to fall by 20% by the same year.[35] EIA's reference case is based on laws and regulations in force as of 2020, when EIA was developing its assumptions. Due to the lack of a national policy, GHG emissions reductions are expected to plateau past 2025, as demonstrated by the slope of the solid red and blue lines. Economic stimulus measures that promote transmission investment that facilitate decarbonization in the power sector can be a pivotal component for achieving GHG emissions reductions to be helpful in meeting the Paris Climate Accord commitments previously made by the US.

Figure 9 shows what GHG emissions reductions might need to resemble in order to meet these goals, relative to projected business-as-usual conditions, illustrated by the dotted lines.

Figure 9. Carbon dioxide emissions from electric power and energy sector



Note: electric power is a subset of total energy sector emissions. Illustrative dotted lines assume no carbon removal to reach goals, and a linear rate of reduction based on the targets from President Biden detailed above.

Source: U.S. Energy Information Administration.

[35] US Energy Information Administration. *Annual Energy Outlook 2021 – Emissions*. February 3, 2021.

Transmission investment is crucial to decarbonizing the United States.[36] In the power sector, decarbonization will likely mean integrating more renewable energy sources so that they can meet a greater share of electricity demand. Transmission lines are crucial to connecting areas of high-quality renewable resources and major population centers, which are often located far apart. Even beyond the power sector, cost-effective GHG emissions reductions in transportation, buildings and industry will likely involve electrification, which will raise demand for electricity. Higher demand, in turn, will require increasing amounts of transmission system infrastructure and power generation resources.

[36] See National Academies of Sciences, Engineering and Medicine. *Accelerating Decarbonization of the U.S. Energy System.* Washington, D.C., National Academies Press, 2021. p. 55; Larson, Eric et al. "Net-Zero America: Potential Pathways, Infrastructure and Impacts." *Princeton University.* December 15, 2020.

3 Historical experience from two prior economic downturns: infrastructure investment and economic recovery

The New Deal and the 2009 American Recovery and Reinvestment Act are useful case studies of federal response to past economic depressions/recessions. Both programs/legislative actions involved infrastructure construction and promotion of investment in the electricity sector to drive economic recovery. While the precise measures in these two landmark stimulus programs are unlikely to be directly applicable to the situation today, the New Deal and ARRA demonstrate that the payoff from new infrastructure construction can be significant, and that such investments can also help achieve other policy goals (for example, labor productivity improvements, which were a major driver of the New Deal). Relative to today's dual priorities – economic recovery and decarbonization of the economy – these two case studies suggest two important considerations for policymakers.

First, federal programs that aim to stimulate the economy should strive to **encourage private sector spending.** The CBO has estimated that private-sector investment yields a return that is twice as large as the same amount of federal direct investment. This is particularly relevant when it comes to infrastructure. While the New Deal saw significant direct funding of transportation sector infrastructure, this would not be necessary today for electric transmission, since transmission investment is already well-established in the private sector. Indeed, most of the approved transmission projects across RTO/ISOs and utilities are financed by the private sector, namely investor-owned utilities and other for-profit transmission developers.[37,38] Furthermore, while stimulus measures carry a direct cost in terms of increase federal spending, they may create additional (unintended) costs if Federally-funded investments displace opportunities for the private sector. Empirical analysis has shown that the benefit of private sector spending outweighs direct Federal government spending, as we discuss further below. However, federal support, in the form of stable and effective regulatory policies and incentives is valuable for overcoming the various challenges in realizing large infrastructure projects.

Second, federal policymakers should **design policies and stimulus measures that lead to long-lasting impacts**. The New Deal illustrates the potential impacts if stimulus measures end prematurely: following an initial period of stimulus, President Roosevelt attempted to balance his budget in 1936, which led to a further recession in 1937-1938. On the other hand, both the New Deal and ARRA provide examples of forward-looking stimulus directed towards infrastructure, energy, and innovation that provided benefits for many years after formal stimulus spending ended—even providing, in many cases, benefits to this very day. Transmission investment shares

[37] Non-profit consumer-owned or government-owned utilities (municipalities, state power authorities, and cooperatives) can be found across the US. Some of these entities also own and continue to invest in transmission infrastructure within their respective service territories. In addition, transmission assets are owned by the Tennessee Valley Authority, a US power agency that is funded through its self-administered tariff, as well as other federal power marketing authorities (such as the Bonneville Power Administration and Western Area Power Administration).

[38] US Department of Energy, *Electricity 101*.

these characteristics, and can boost employment, GDP and efforts to fight climate change in both the short- and long-term. However, moving a project from planning and design to construction and completion is a lengthy, years-long process fraught with challenges. Construction, itself, can take a number of years, depending on the complexity of the project. Moreover, the capital investment costs associated with construction represents the majority of the total costs of such investments (operations and maintenance expenses are a very small percentage of the total). Once constructed, transmission assets can operate for many years. Given these various timeframe considerations, effective stimulus policies and measures need to consider the longer-term nature of the investment cycle, the need for stability in project completion, and the longevity of the assets and possibility of beneficial knock-on effects[39] in other segments of the economy. A transmission stimulus package should focus on policies that provide long-lasting support and stability in the regulatory environment.

3.1 The New Deal and 1933 National Industrial Recovery Act

The suite of economic and policy reforms instituted by President Franklin D. Roosevelt in response to the Great Depression, known collectively as The New Deal, illustrate the effectiveness of economic stimulus focused on expanding employment opportunities, bringing affordable electricity to the under-served, and developing new infrastructure. Similar to the current situation, the Great Depression-era saw a sharp decline in economic activity and employment. Under the New Deal, economic stimulus through federal spending and loans to support infrastructure was a key driver of recovery - creating jobs, improving labor productivity, and expanding industries critical to commercial activity. Empirical evidence from ex-post analysis of New Deal programs suggests that government programs were successful and exemplifies the significant value that transmission infrastructure investment could bring to the economic recovery today.

3.1.1 Triggering events for the Great Depression

The Great Depression was a consequence of multiple economic factors working in parallel that displaced a vulnerable US economy after the World War I ("WWI"). The growing cost of wartime debts, declining growth in labor workforce, varoius international economic factors, and collapse of financial markets contributed to the economy´s contraction:[40]

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[39] In a January 2018 paper prepared for WIRES entitled, *How Does Electric Transmission Benefit You?*, LEI examined some of these effects as well, specifically in the form of local benefits stemming from the wind generation construction in Wyoming catalyzed by the "Resource Delivery" transmission project in the Western Interconnect. The illustrative knock-on effects associated with the construction of the wind generation in sparsely populated, rural areas of Wyoming demonstrate how transmission infrastructure can be used to further economic justice goals. By supporting local economic development opportunities in areas that might otherwise have fewer economic opportunities, transmission investment offers a pathway for improving the economic condition of underprivileged segments of the US population.

[40] Romer, Christina D. *The Great Crash and The Onset of The Great Depression*. NBER. Working Paper 2639. June 1998.

- ***growing cost of wartime debts***: total cost of WWI to the US economy was approximately $32 billion (roughly $478 billion in 2020 dollars), representing around 50% of the GDP at that time;[41]

- ***declining growth of labor workforce***: due to below-par economic activity, the production volumes dropped leading to excessive labor supply in the market causing high unemployment rates, and leading to further depression of economic activity;

- ***international economic factors***: disruption in patterns of international trade due to trend of increasing specialization, and restoration of the international gold standard had a compound effect on the weakening of economic fundamentals; and

- ***collapse of financial markets***: stock market crash of October 1929 caused consumers and producers to become uncertain about the course of future income, leading to a delay in current spending on durable and semi-durable goods, thereby driving down aggregate income level. Finally, a decline in money supply caused by the banking panics of mid-1931, further depressed the economy.

Consequently, between 1929 and 1933, real gross private investment fell by over 90% and real Gross National Product ("GNP") fell by 30% (real GDP contracted by 26%). Further, the European monetary collapse and the Kreditanstalt Crash in July 1931, caused the Bank of England to move away from the gold standard, setting a new wave of liquidation that accentuated the period of economic downturn in the US, stalling all possible monetary policy measures.[42]

The 2020 recession commenced with a sharp decline across indicators including contracting Index of Industrial Production ("IIP"), a measure of economic activity, rising unemployment rates, and declining Consumer Price Index ("CPI"), a measure of inflation. These trends had similarities in severity to the initial declines of the Great Depression but not in duration.[43]

3.1.2 The New Deal had a dual focus: economy recovery as well as a longer term to reinvigorate America's farmers and overall labor force

Franklin D. Roosevelt ("FDR") won the election in 1932 and launched 'The New Deal' in three waves from 1933 to 1939.

- ***first New Deal (1933-35)***: to restore banking stability, FDR recommended that the US abandon the gold standard and devalue the US dollar. These measures intended the

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[41] Rockoff, Hugh. *Until it's Over, Over There: The U.S. Economy in the World War I*. NBER. Working Paper 10580. June 2004.

[42] Barber, Clarence L. *On the Origins of the Great Depression*. Southern Economic Journal. January 1978, pp. 432-456.

[43] Federal Reserve Bank of St. Louis. *How Does the Pandemic Recession Stack Up against the Great Depression?* October 19, 2020. <https://www.stlouisfed.org/on-the-economy/2020/october/pandemic-recession-stack-great-depression>

Federal Reserve to renounce deflationary policies that had not yielded results in the past 13 years.[44] To provide an economic stimulus that would drive expansion of monetary supply, two key programs were launched – Agricultural Adjustment Act ("AAA") that focused on providing subsidies to farmers, and the National Industrial Recovery Act ("NIRA") that focused on fair trade codes and guaranteed laborers a right to collective bargaining;[45]

- ***second New Deal (1935-36)***: according to FDR, "the major cause of the Depression was the small amount of purchasing power in the hands of farmers and workers." To address this, the New Deal now focused on increasing purchasing power through redistribution of income. This led to the National Labor Relations Act (Wagner Act) of 1935 that gave labor unions support in pressing for higher wages;[46] and

- ***third New Deal (1937-38)***: to respond to another recession that hit the US economy, FDR administration launched an expansionary fiscal policy. Specifically, a large stimulus package, emphasizing work relief and public works, was launched by the federal government.[47]

As a part of the infrastructure stimulus, the New Deal established two key organizations that were given federal dollars to be spent on infrastructure – the Public Works Administration ("PWA"), under the NIRA of 1933 to prepare a comprehensive program of public works, and the Rural Electrification Administration ("REA") in May 1935 to electrify rural areas of the US.[48] Under REA, the construction of electricity lines created jobs not only in the fields, but also in maintenance and operation of the utility infrastructure, wiring materials and electricity appliances for newly served farm homes. This contributed to elevating the real purchasing power and agricultural income of the farmers; a proof of how economic justice was enhanced during the New Deal.

3.1.3 A snapshot of the program's economic results

As the New Deal matured, the US economy was able to soften the blow from ongoing deflation. Budget deficits widen when expansionary measures are announced to boost economic productivity. As shown in Figure 10, these deficits increased due to various stimulus packages announced under the New Deal. In response, the Total Factor Productivity ("TFP"), which is the

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44 Crafts, Fearon. *Lessons from the 1930s Great Depression*. Oxford Review of Economic Policy. 2010. pp. 296-298.

45 Lee, Bradford A. *The New Deal Reconsidered*. The Wilson Quarterly (1976-), Spring, 1982, Vol. 6, No. 2 (Spring, 1982). pp. 62, 66.

46 Ibid, pp. 63, 71.

47 Jeffries, John W. *The "New" New Deal: FDR and American Liberalism, 1937-1945*. Political Science Quarterly, Vol. 105, No. 3 (Autumn, 1990). p. 400.

48 Originally, the PWA was called Federal Emergency Administration of Public Works.

ratio of real GDP to the weighted average of labor and capital inputs and considered as a proxy for long-term economic growth, rebounded to pre-crisis levels by 1937.[49]

Figure 10. Economic Indicators – 1929 to 1941

Macroeconomic Indicators		*Unit*	1929	1931	1933	1935	1937	1939	1941	
Real Gross Domestic Product		$ bn	1,109.4	950.0	817.3	986.2	1,170.3	1,222.4	1,565.8	Period of very high deflation
Nominal Gross Domestic Product		$ bn	104.6	77.4	57.2	74.2	93.0	93.4	129.3	
Expenditure	*(i)*	$ bn	4.0	3.6	4.4	6.3	7.8	9.0	14.0	
Receipts	*(ii)*	$ bn	3.0	3.5	2.0	4.6	4.9	5.1	9.1	
Budget Deficit	*(i) – (ii)*	$ bn	1.0	0.1	2.4	1.7	2.9	3.9	4.9	Period of very high budget deficit
Total Factor Productivity (TFP)		Indexed: 1929=100	100.0	96.0	92.6	96.6	100.5	103.1	109.0	TFP recovery achieved in 1937

Source: Gross Domestic Product: Federal Reserve Economic Data – Federal Reserve Bank of St. Louis; Economic Expenditure and Receipts: Lee. Bradford A. The New Deal Reconsidered. The Wilson Quarterly (1976-), Spring, 1982, Vol. 6, No. 2 (Spring, 1982). pp. 62- 76.; Total Factor Productivity: Cole, Ohanian. New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis. August 2004. pp. 779 - 816.

The New Deal employed direct government spending to boost consumer demand that in turn accelerated TFP and eventually decreased unemployment.[50] The positive impact on employment can be seen in Figure 11 (on the next page). Employment improved as a result of the GDP rebound in early 1933.

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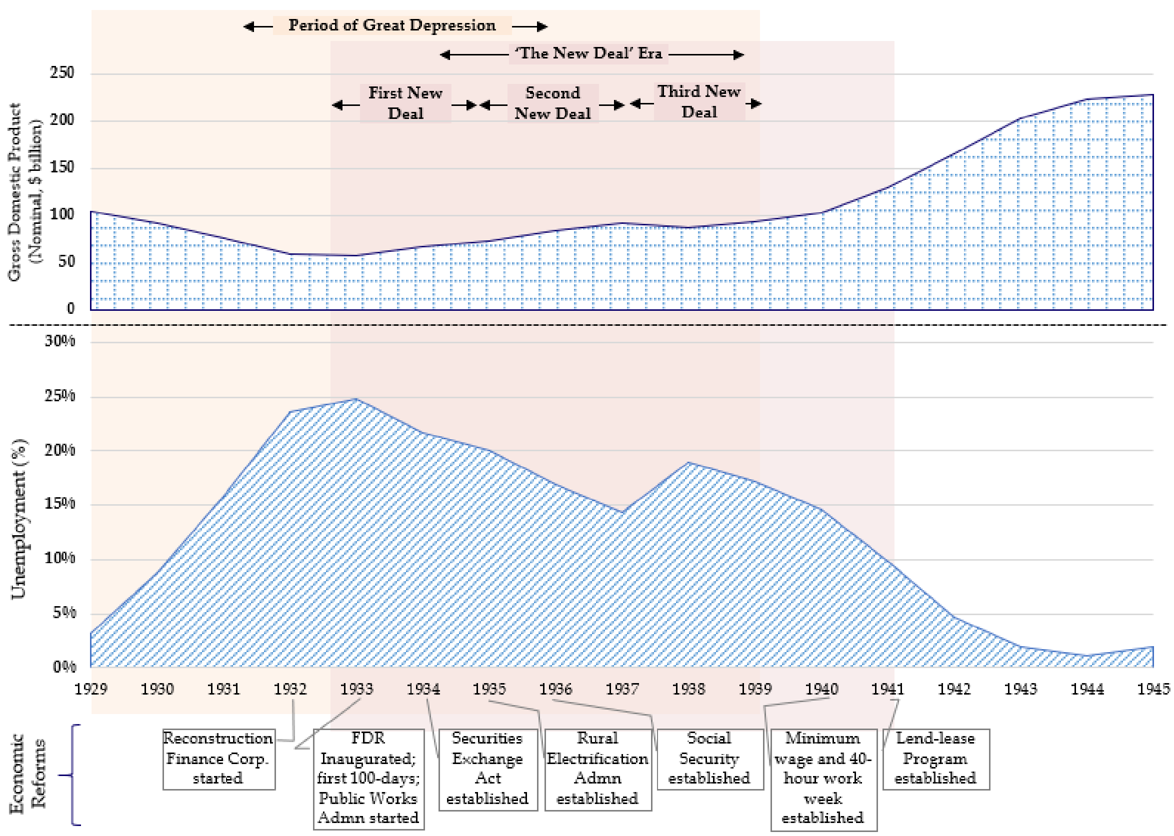
[49] Ohanian, Lee E. Why Did Productivity Fall So Much during the Great Depression? The American Economic Review. Vol. 91, No. 2. May 2001. pp. 34-38.

[50] Edwards, Sebastian. Keynes on the Sequencing of Economic Policy: Recovery and Reform in 1933. NBER. Working Paper 24367. March 2018.

Figure 11. Snapshot of the U.S. Economy – 1929 to 1945



Source: Unemployment Rate: Bureau of Labor Statistics, Bureau of Economic Analysis, Balance.com; Gross Domestic Product: Federal Reserve Economic Data – Federal Reserve Bank of St. Louis; Economic Reforms: Lee. Bradford A. The New Deal Reconsidered. The Wilson Quarterly (1976-), Spring, 1982, Vol. 6, No. 2 (Spring, 1982). pp. 62- 76.

3.1.4 The infrastructure agenda of the New Deal

One of the key drivers of the GDP recovery was the infrastructure stimulus that contributed to job creation, labor productivity improvements, and expansion of critical industries for commercial activity, such as transportation (through building of roads and railroads), communication, and energy (oil and gas, and power). The New Deal program promulgated many grants and loan programs, that were distributed between 1934 and 1940, including the following:

- grants totaling $34.5 billion (roughly $651.7 billion in 2020 dollars): among these, approximately 18% were in the form of 'public sector grants' that were directed towards financing of projects including public-works, housing, federal buildings, and roads;[51]

- loans totaling $13.1 billion (roughly $247.5 billion in 2020 dollars): in addition to homeowner loans and reconstruction loans to local governments and industry, the PWA and REA activities supported construction of local public works and electrification to rural sections of the US, respectively. [52]

Figure 12 shows that $3.7 billion spent on the PWA and REA programs during the New Deal in 1935 increased personal income by $116.8 billion (in 2020 dollar terms).[53,54]

Figure 12. Economic outcomes of the selected infrastructure programs under the New Deal

Selected Program	Outlay per New Deal, 1935 dollars *($ billion, nominal)* *(a)*	Personal Income Multiplier *(b)*	Multiplier Impact New Deal, 1935 dollars *($ billion, nominal)* *(a)*(b)*	Outlay per 2020 dollars *($ billion, nominal)*
Public Works Administration (PWA)	3.3	1.67	5.51	104.1
Rural Electrification Administration (REA)	0.4	1.67	0.67	12.7
Total Personal Income Impact	***3.7***		***6.18***	***116.8***

Source:
PWA Outlay per New Deal: Transcript of National Industrial Recovery Act (1933). Accessed Jan 28, 2021.; REA Outlay per New Deal: Rural Electrification Act of 1936 [U.S. Code, Title 7, Chap. 31]. Chapter 432 of the 74th Congress, Approved May 20, 1936, 49 Stat. 1363.; Personal Income Multiplier: NBER. Fishback, Price. *U.S. Monetary and Fiscal Policy in the 1930s.*Working Paper 16477. October 2010.

3.2 The American Recovery and Reinvestment Act of 2009

Observations of the outcomes generated by American Recovery and Reinvestment Act of 2009 highlights the benefit of considering long-term aims when crafting economic stimulus. President Obama signed ARRA into law in response to an economic crisis that began in the US financial

[51] Fishback, Price. "How Successful Was the New Deal? The Microeconomic Impact of New Deal Spending and Lending Policies in the 1930s." *Journal of Economic Literature*, Vol. 55, No. 4. December 2017. pp. 1451-1453.

[52] Ibid.

[53] The total outlay for the PWA and REA programs under the New Deal in 1935 was $3.3 billion and $0.4 billion, respectively. When this outlay is multiplied by the personal income multiplier of 1.67, as published across relevant empirical studies, the multiplier impact of New Deal on personal income is ascertained as $5.51 billion for PWA and $0.67 billion for REA, collectively coming to $6.18 billion. When converted to 2020 dollar terms, the overall impact has a value of $116.8 billion.

[54] GDP and employment multipliers are different from personal income multiplier. Indeed, personal income might be considered as an estimate for earnings (plus transfers), which is just one component of the value-added measure (in addition to earnings, GDP also includes gross operating surplus, and taxes on production and imports less subsidies).

system, and spread into all sectors of the economy and around the world. Similar to the current day, the Great Recession caused deep declines in GDP and employment. ARRA provided economic relief to households and businesses through increased federal benefits and tax breaks, but also focused on driving investment to sectors that could deliver long-lasting benefits, such as technology innovation, clean energy and infrastructure. In particular, evidence from ARRA electricity- and energy- related programs indicate that stimulus investments in these sectors can provide robust increases to employment and GDP. ARRA's economic relief measures also contributed significantly to averting and reducing the severity of poverty for nearly 40 million Americans.

3.2.1 The Great Recession was triggered by financial sector issues

The Great Recession[55] began due to a series of negative events in the US banking system related to housing assets. In the summer of 2007, US housing prices began to fall. This decline caused serious damage to household wealth and impacted the banking system, which was heavily invested in housing assets. Business investment also fell as banks restricted credit issuance. As a result, households slashed spending, reducing demand in the economy, and firms cut back on investment and hiring. These reactions reinforced each other to create a downward economic spiral.[56] The effects of the crisis spread globally, through links that foreign banks had with their American counterparts, leading to a slowdown in international trade and investment, and weakened global financial markets.[57] The Great Recession had deep and lasting impacts on the US economy. The decline in US GDP caused by the Great Recession was reversed only in 2011, more than three years following the recession's start. Even as of 2016, the US economy's output was estimated to be $400 billion below its hypothetical potential if the Great Recession had not occurred.[58]

In response to the financial sector problems and the resulting recession, the Federal Reserve gradually lowered the federal funds rate starting in August 2007, eventually reaching then-historic lows (between 0.25 and 0.5) by December 2008.[59] There were also three legislative efforts to combat the recession over the course of 2008, but these initiatives had relatively limited reach,

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[55] A recession is characterized by a severe, economy-wide decline in economic activity which lasts more than a few months. It is usually reflected in real GDP, employment, real income, industrial production, and wholesale-retail sales. There is no standard way to define an economic depression, although it is usually considered a more severe form of a recession. (Source: Federal Reserve Bank of San Francisco. *What is the difference between a recession and a depression?* February 2007.)

[56] Christiano, Lawrence J. "The Great Recession: A Macroeconomic Earthquake." *Federal Reserve Bank of Minneapolis.* February 7, 2017.

[57] Boivin, Jean. "The 'Great' Recession in Canada: Perception vs. Reality." *Bank of Canada.* March 28, 2011, Montréal CFA Society, Montréal, Quebec. Remarks.

[58] The Hamilton Project - Brookings. *Nine facts about the Great Recession and tools for fighting the next downturn.* May 2016.

[59] The federal funds rate is the interest rate at which banks and other institutions lend deposits at the Federal Reserve overnight to other institutions. (Source: Federal Reserve Bank of St. Louis. *Effective Federal Funds Rate [FEDFUNDS].* Accessed March 19, 2021.)

as they aimed to stabilize the mortgage market, or were narrowly focused on helping specific industries (such as the banking sector and the automotive industry).[60]

3.2.2 ARRA's overview: A bold stimulus during recession

In February 2009, President Barack Obama signed ARRA into law.[61] This act initially proposed spending and tax provisions worth $787 billion, or roughly 5.5% of US GDP at that time.[62] In absolute terms, ARRA was the largest stimulus package passed by any nation at the time in response to the Great Recession.[63] ARRA aimed to provide both short-term relief to mitigate the effects of the recession on households, businesses and state and local governments, and to trigger long-term economic benefits by investing in sectors of the economy that can create such long-lasting effects, as shown in Figure 13 below.

Figure 13. Snapshot of ARRA

Source: American Recovery and Reinvestment Act of 2009; Congressional Budget Office.

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[60] Kus, Basak. "Relief, Recovery, Reform: A Retrospective on the US Policy Responses to the Great Recession." *Intereconomics* 55.4 (July/August 2020): 257-265. Digital.

[61] ARRA passed the US House of Representatives with only Democrats voting in favor, and passed the Senate with Democrats, Independents and three Republicans voting in favor. (Sources: Clerk – United States House of Representatives. *Roll Call 70 – Bill Number: H. R. 1.* February 13, 2009.; United States Senate. *Roll Call Vote 111th Congress – 1st Session*. February 13, 2009.)

[62] More recent estimates place the total value of ARRA's spending and tax provisions at nearly $840 billion. (Source: Congressional Budget Office. *Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output in 2014.* February 2015.)

[63] ARRA was only the fourth largest in relative terms (as a percent of national GDP), after China, Saudi Arabia and Malaysia. (Source: Ahrens, Steffen. "Fiscal Responses to the Financial Crisis." *Kiel Institute for the World Economy.* October 2009.)

ARRA employed both direct and indirect stimulus measures. Direct federal government spending represented roughly 73.1% of ARRA's total cost. This direct spending went to fund contracts, grants and loans allocated to various agencies, programs and activities,[64] and entitlement programs such as Medicare, unemployment and social security. The remaining 26.9% of cost was in the form of tax provisions, a type of indirect stimulus program.

3.2.3 Outcomes of ARRA: effective economic aid through spending

ARRA has been estimated to have increased US real GDP by $265 billion (low-end estimate) to as much as $1,467 billion (high-end estimate) between 2009 and 2014.[65] Total cost of ARRA has been estimated to be around $840 billion. Without ARRA's stimulus, 2011 GDP would have been roughly $500 billion less, and it would have taken one year longer for US GDP to reach pre-recession levels.[66] Direct federal government spending, particularly through purchases of goods and services (e.g., energy- and electricity-related programs) and transfers to state and local governments for infrastructure, had the largest impact on output relative to amounts spent. Tax cuts were less stimulative, based on CBO estimates.[67] ARRA also had significant impacts on poverty in 2009: seven ARRA provisions granting support to individuals kept more than 6 million people out of poverty and reduced poverty's severity for another 33 million people.[68] Figure 14 shows estimates of ARRA's annual estimated impact on GDP and employment. The blue and red bars represent the high and low estimates of percent change in real GDP attributable to ARRA, whereas the orange and green lines depict the high and low estimates of employment years supported by ARRA. As Figure 14 shows, while ARRA's effect peaked in 2010 and then slowly diminished, it continued to stimulate the economy four to five years after enactment.

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[64] ARRA provided funds for new and existing programs in the 15 Cabinet-level departments and 11 independent agencies of the US federal government. Funds were also disbursed to states, localities, individuals and other entities through direct assistance, formula-based grants, and grants through competitive application. (Source: Congressional Research Service. *American Recovery and Reinvestment Act of 2009 (P.L. 111-5): Summary and Legislative History*. April 20, 2009.)

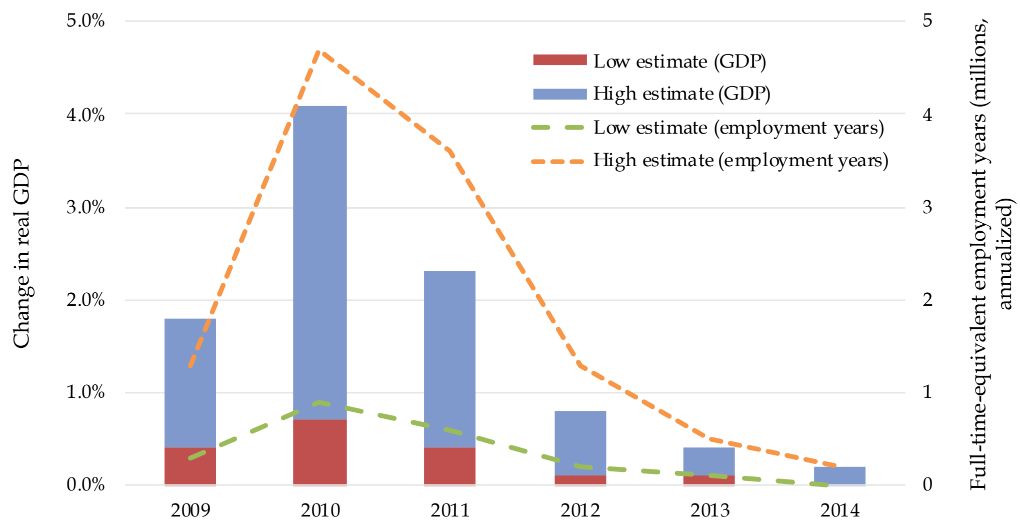
[65] LEI calculation based on change in real GDP attributable to ARRA per year from 2009 to 2014, and real GDP in those years. (Source: Congressional Budget Office. *Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output in 2014*. February 2015.; Federal Reserve Bank of St. Louis. *Real Gross Domestic Product [GDPC1].* February 25, 2021.)

[66] The Hamilton Project - Brookings. *Nine facts about the Great Recession and tools for fighting the next downturn.* May 2016. p. 3.

[67] Based on high-estimate output multipliers. (Source: Congressional Budget Office. *Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output in 2014*. February 2015. p. 6).

[68] Sherman, Arloc. "State-level data show recovery act protecting millions from poverty." *Center on Budget and Policy Priorities.* December 17, 2009.

Figure 14. Estimated impact of ARRA on US GDP and total employment



Source: [Congressional Budget Office.]

Certain ARRA components that used direct Federal funding may have displaced other sources of funding for the same investments. As a result of this substitution, the programs might not have achieved the full set of benefits that were originally expected. For example, in the area of highway improvements, ARRA funding likely did not raise investments beyond what would have occurred without it.[69] Displacement of private investments is of particular concern with transmission infrastructure as well, given that the private-sector is already engaged in funding such investments, once regulatory approvals, siting, and permitting have been addressed. The CBO has previously estimated that private-sector investment is twice as productive as federal spending on average.[70] Moreover, the transportation funds allocated to programs created under ARRA took longer to distribute than ARRA funds disbursed through existing programs, which may have also contributed to the dulled impact. The delay was largely attributable to the need to design the new programs, receive and evaluate applications, and then clear logistical barriers before breaking ground on construction.[71]

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[69] The Act provided $27.5 billion for improvements, or 44% of all highway capital improvements made by states in 2008. However, data indicates that the highway system did not see significant improvement in the following years, potentially due to federal funds simply replacing state funds. States receiving highway grants were not required to commit to maintaining pre-ARRA spending levels, and many states cut highway spending. (Source: Dupor, Bill. "Why the 2009 Recovery Act didn't improve the nation's highways." *Economic Synopses* 14 (2017). Digital.)

[70] Congressional Budget Office. *The Macroeconomic and Budgetary Effects of Federal Investment*. June 2016. p. 4.

[71] Congressional Research Service. *Transportation infrastructure investment as economic stimulus: lessons from the American Recovery and Reinvestment Act of 2009*. May 5, 2020.

3.2.4 Electricity and clean energy initiatives under ARRA

Figure 15 shows an overview of ARRA's major electricity sector-related measures. While some of these past measures under ARRA would not be directly applicable to transmission investment, the principal ideas behind such stimulus programs are transferable to the promotion of transmission investment and would be expected to produce similar economic benefits.

Figure 15. Key measures for electricity investment under ARRA

Program	Brief Description	Relation to ARRA
Federal Production Tax Credit ("PTC")	A 10-year, inflation-adjusted production tax credit for ceratin types of renewable energy generation, including wind, geothermal, landfill gas and others. PTC calculated at dollar rate per megawatt hour, differing based on renewable type.	Modified under ARRA.
Federal Investment Tax Credit ("ITC")	A tax credit worth 30% of qualifying costs for solar, fuel cell, and small wind projects, and 10% of qualifying costs for geothermal, microturbines, and combined heat and power projects.	Modified under ARRA.
Payments for Specified Energy Property in Lieu of Tax Credits ("Section 1603") Program	Eligible participants received payments instead of investment tax credits from the Department of Treasury. Reimbursed a portion of the cost of installing cetain types of renewable energy. In most cases, the award was worth 30% of a project's eligible cost basis.	Established under ARRA.
Section 1705 Loan Program	Allowed developers to gain access to low-cost financing by authorizing loan guarantees for US-based projects. Involved certain renewable energy technologies, transmission systems, and certain biofuels.	Established under ARRA.
Smart Grid Investment Grant	Aimed to accelerate modernization of transmission and distribution system. Recipients were electric providers across the nation with plans to upgrade their systems. Selected through merit-based competitive solicitation.	Established under ARRA.
Smart Grid Demonstration Program	Grants related to innovation in tools, technologies, techniques and system configurations such as automated metering, intelligent universal transformers, and integration of electric vehicles.	Established under ARRA.

Source: Department of Energy; Department of Treasury; National Renewable Energy Laboratory; China Energy Group; SmartGrid.gov.

According to studies completed after the ARRA programs were finished, both short- and long-term benefits to the economy were achieved:

- For example, $90 billion allocated for clean energy under ARRA supported around 900,000 job-years from 2009 and 2015 and contributed to dramatic cost reductions in clean energy technologies. These cost reductions had long-lasting effects on the energy sector. ARRA programs are credited as partially responsible for driving cost reductions in utility-scale solar photovoltaic ("PV") systems, whose overnight capital cost fell by 50% from 2008 to 2014.[72]

- The 1603 Cash Grant program was highly successful in spurring deployment of relatively nascent renewable technologies, by providing a less costly (more efficient and speedy process) for developers to finance their projects, in lieu of the more conventional tax credit policy. The cash grants narrowed the gap on the "above market" economics of solar PV resources as compared to other technologies. Through

[72] Council of Economic Advisers. *A retrospective assessment of clean energy investments in the recovery act*. February 2016.

this program, over 27,000MW of new generating capacity was brought online, and is also credited with associated job creation in the tens of thousands. The 1705 Loan Guarantee program also affected the cost of certain renewable generation technologies, albeit on a smaller scale than the 1603 Cash Grant program, as summarized in the figure below.[73]

Figure 16. Outcomes of 1705 and 1603 programs under ARRA

Selected Outcomes	Program	
	1705 Loan Guarantee	1603 Cash Grant
Spending (USD)	$18 billion ($2 billion in credit subisidies, $16 billion in guaranteed loans)	$20 billion
Installed capacity supported (GW)	6.1	27.1
Jobs created (construction)	13,733	52,000 - 75,000
Jobs created (long-term)	1,518	5,100-5,500

Note: 1705 Loan Guarantee program spending does not represent actual government outlays, except in the case of recipient default.

Source: Mundaca, Luis and Jessika Luth Richter. "Assessing 'green energy economy' stimulus packages: evidence from the U.S. programs targeting renewable energy." *Renewable and Sustainable Energy Reviews* 42 (2015): 1174-1186. Digital.

- Furthermore, for every $1 million of direct spending under the Smart Grid Investment Grant ("SGIG") and Smart Grid Demonstration Program ("SGDP"), GDP increased by $2.5 to $2.6 million.[74] These programs provided $4 billion in federal spending (accompanied by $8.9 billion in industry cost-share) for deployment and innovation in electric grid technologies, including transmission equipment. It is believed that the SGDP and SGIG together were the "largest-ever one-time investment in upgrading" electric infrastructure in the US.[75] The economics benefits from these two programs as estimated by the US Department of Energy ("DOE") are summarized in Figure 17.

[73] Mundaca, Luis and Jessika Luth Richter. "Assessing 'green energy economy' stimulus packages: evidence from the U.S. programs targeting renewable energy." *Renewable and Sustainable Energy Reviews* 42 (2015): 1174-1186. Digital. pp. 1182.

[74] Typically, direct federal government spending (purchases of goods and services or transfers to state and local governments for infrastructure) has multipliers ranging from 1.0 to 2.5. (Source: US Department of Energy – Electricity Delivery and Energy Reliability. *Economic Impact of Recovery Act Investments in the Smart Grid.* April 2013.)

[75] Lawrence Berkeley National Laboratory - China Energy Group. *A Review of the American Recovery and Reinvestment Act Smart Grid Projects and Their Implications for China*. January 2017.

Figure 17. Outcomes of Smart Grid grants

Selected Outcome	Smart Grid vendors only	All vendors
Jobs created	33,000	47,000
GDP impact (2010$)	2.91 billion	4.18 billion
State and local tax revenue generated (2010$)	260 million	360 million
Federal tax revenue generated (2010$)	490 million	660 million

Source: U.S. Department of Energy.

Note: DOE derived these using estimates from the IMPLAN model. All vendors scenario includes vendors not considered core to Smart Grid industries, such as legal, accounting, freight, employment services, etc.

4 Transmission investment can create significant benefits for the American economy

A survey of transmission plans across the US has revealed over $83 billion of approved and/or recommended transmission investment projects from independent system operators, regional transmission organization, and utilities, with nearly $17 billion of those slated to begin construction in the near term.[76] This $83 billion total is a very conservative estimate of transmission investment potential for the next decade, as it does not include merchant transmission projects under development, nor proposed transmission projects that have not progressed through their RTO's/ISO's e planning and approval stage, or recommended to a regulatory body.[77]

Using a well-established technique of regional economic impact assessment, LEI estimates that construction of this transmission infrastructure would increase direct local spending (in the U.S.) by nearly $39 billion, raise national GDP by $42 billion and create around 442,000 new jobs (see Figure 18 on the next page). The increased economic activity and jobs would not be limited to just the construction and utility sectors – other sectors of the economy, including the "arts, entertainment, recreation, accommodation, and food services" and "transportation and warehousing" industries hit hard by the Covid-19 pandemic would also benefit.[78] Once this new transmission infrastructure is installed and operating, the direct spending to operate and maintain these new infrastructure assets will continue to stimulate the economy, with estimated increase in GDP of $1.6 billion annually and a permanent increase of 9,000 jobs.

Such transmission investment would also unleash additional social and environmental benefits that will improve the economic outlook for the US population by reducing electricity prices, fostering renewable generation, and advancing decarbonization efforts. Indeed, new transmission will facilitate the adoption of electrification initiatives (such as electric vehicles). The resulting reduction of fossil fuel generation and carbon emissions is expected to have its own wave of socioeconomic benefits and employment opportunities in the longer term. Transmission investment has the potential to support the location of renewable generation in less densely populated and underprivileged areas contributing to a more equitable distribution of economic wealth. For example, transmission investment provides local communities with the possibility of construction-related jobs opportunities, as well as permanent jobs operating the infrastructure assets and local property tax revenues that support various programs for the local population. Although estimating these follow-on investments and economic impacts is beyond the scope of this paper, based on what we know about the general level of investment required to evolve the

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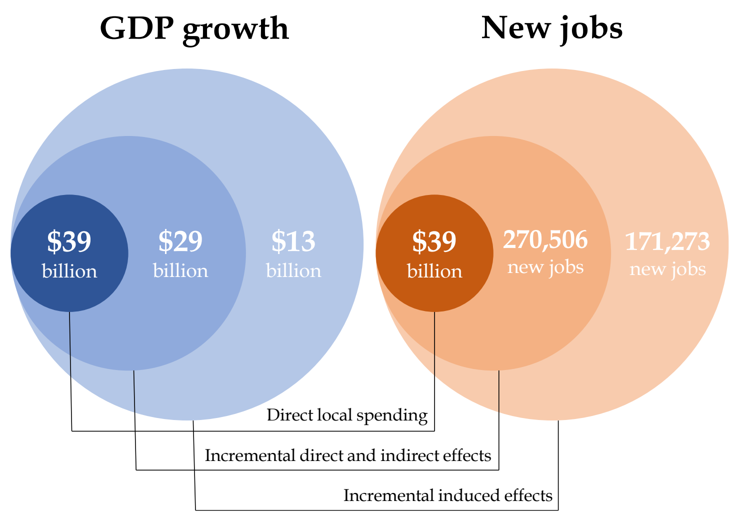
[76] Near term has been defined as planned and/or recommended transmission projects with in-service data less than or equal to 2021. For further information, see the definition of short-term investment in Figure 21 below.

[77] In 2019 alone, U.S. investor-owned electric utilities reported spending $23.5 billion associated with new transmission investments (Source: US Energy Information Administration. *Utilities continue to increase spending on the electric transmission system*. March 26, 2021.)

[78] Based on the comparison of GDP by industry data between Q3 2019 and Q3 2020 from Bureau of Economic Analysis.

electricity system to net zero and move the broader economy toward a carbon-free footprint (for example, with purchases of durable goods like electric vehicles), the long-term economic effects are likely to be multiples times larger than the benefits created by construction of planned transmission investment projects that have been approved and/or recommended.

Figure 18. Projected economic benefits from construction of approved and/or recommended transmission investment projects in the US



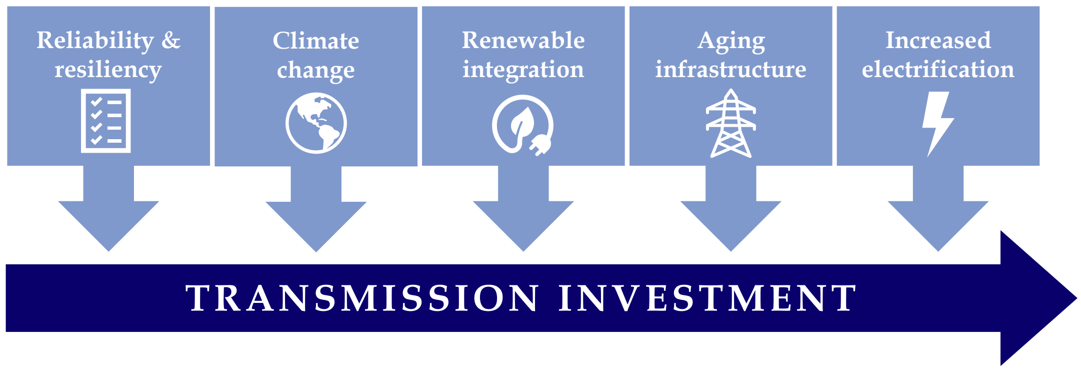
Note: The incremental direct and indirect effects and incremental induced effects should be added together to get the total economic benefits for the installation stage and domestic manufacturing stage. Direct local spending and economic benefits related to O&M stage are not included in this figure.

4.1 Transmission investment drivers

In order to understand the magnitude of spending associated with planned transmission investments, it is important to understand the drivers for such investment in the US. These drivers are not simply conceptual factors – these are the concrete considerations requiring transmission investment today. Moreover, these drivers will continue to influence transmission investment in the future. Exploring these drivers will also help provide prospective into the larger power ecosystem in the US and how transmission investment enables the expansion of electric generation and impacts other sectors of the economy.

There are five broad categories of drivers to investment in transmission: reliability (and resiliency), climate change, renewable integration, aging infrastructure, and increased electrification. Each of these drivers has a technical foundation, but also an economic or financial dimension. For example, reliability is often measured in the context of standardized engineering practices. Resilience is another dimension of reliability but is often paired with discussion of opportunity costs and damages arising from the lack of resilience. Though we discuss each driver separately, transmission investments are frequently a solution to issues that straddle multiple drivers. Transmission system planners commonly classify transmission projects into three types: reliability projects, economic projects, and public-policy projects. As is evident, these three types are heavily influenced by one or more of the five drivers. For example, reliability projects "ensure that the transmission system will be operated in compliance with reliability standards."[79] Therefore reliability projects address reliability and aging infrastructure drivers. Economic projects "relieve economic congestion and/or improve the overall economic efficiency of generation dispatch."[80] This type of project would primarily address renewable integration and electrification. Finally, public-policy projects "address transmission needs driven by federal, state, or local public-policy requirements."[81] This type of project could address climate change and renewable integration, but also the basic premise of reliability.

Figure 19. Summary of transmission investment drivers



4.1.1 Reliability and resiliency

The first transmission investment driver combines the historical primary driver behind transmission investment (reliability) with the newer concept of resilience, which has emerged in recent years as a consequence of the devastating effects of climate change. Reliability refers to "the degree to which the performance of the elements in a bulk system results in electricity being delivered to customers within accepted standards and in the amount desired."[82] Reliability continues to be one of the most significant drivers of planned transmission investments.[83] Reliability analyses are conducted to ensure the transmission system is adequately serving current customers as well as being able to serve projected future customers. Should reliability analyses determine that reliability standards are (or would be) violated, transmission projects are then proposed to remedy the violation.

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[79] Eto, Joseph H. "Planning Electric Transmission Lines: A Review of Recent Regional Transmission Plans." *Lawrence Berkeley National Laboratory*. September 2016.

[80] Ibid.

[81] Ibid.

[82] Kueck. John D. and Brendan J. Kirby. "Measurement Practices for Reliability and Power Quality." *Oak Ridge National Laboratory*. June 2004.

[83] National Association of Regulatory Utility Commissioners. "Transmission Planning Whitepaper." January 2014.

In contrast to the embedded requirement to prevent system disruptions inherent in the definition of reliability, resilience is generally understood in terms of being able to endure and survive disruptive events. More specifically, resilience has been defined by the Biden Administration to include the "ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions."[84] As such, resiliency-related investments in existing infrastructure can be attributed to damage prevention, system recovery, and survivability.[85] Damage prevention requires investments in vegetation management, selective underground transmission facilities, and reinforcement of overhead lines, among other considerations. System recovery includes investments in damage assessment of infrastructure and in damage clean-up. Survivability considers investments in a basic level of service for the end-user in the event of a transmission failure.

A resilient transmission system is particularly important to ensuring overall electric system reliability, since transmission lines are integral to the movement of power from generators to the final end-user/customer. Given the evolution of supply resources and emerging trends around severe weather events, the future power system will have to become more resilient than it has had to be in the past. Some experts have posited that emerging patterns of extreme weather will likely require more transmission investment to ensure this resiliency.[86]

4.1.2 Climate change

The second transmission investment driver is climate change, which is requiring a different transmission network due to a shift in the location of supply and demand and levels of uncertainty in operations. Climate change is not a 'stand-alone' investment driver. Climate change has significant connection to electrification and renewable integration. This connection is evident through governmental policies which respond to the effects of climate change by enacting regulations and climate goals. These regulations and climate goals facilitate a shift toward electrification and renewable integration. As a result of climate change, there are several considerations that are directly driving investments in transmission: increased air temperatures and increased occurrences of extreme weather events.

Increased air temperatures can cause a reduction in the carrying capacity of transmission lines, an acceleration in the aging of transmission assets, and an increase in demand for electricity related to cooling. Furthermore, the demand for electricity related to cooling is expected to be magnified by the effects of another transmission investment driver, electrification, as more people shift to electricity-based cooling systems. According to at least one study, by mid-century (2040-2060), increased air temperatures may reduce average summertime transmission capacity by 2%-

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[84] The White House. United States, Office of the Press Secretary. "Presidential Policy Directive – Critical Infrastructure Security." February 12, 2016.

[85] Electric Power Research Institute. "Electric Power System Resiliency: Challenges and Opportunities." February 2016.

[86] United States Government Accountability Office. "Electricity Grid Resilience: Climate Change is Expected to Have Far-reaching Effects and DOE and FERC Should Take Action." March 2021.

6% relative to a reference period of 1990-2010.[87] As a result of this reduction in average transmission capacity, more investment will be needed to compensate for the loss in capability. Rising temperatures also have an impact on the aging of transmission assets which could result in more frequent replacement of transmission power lines and transformers.[88] In addition, demand for electricity related to cooling by 2040-2060 may increase peak-per capita summertime loads by 4%-15% compared to 1990-2010.[89] Greater investment into transmission would be needed to meet this increased demand.

Extreme weather has been noted to be a leading cause of power outages in the US.[90] One prevalent extreme weather event is wildfires. Since 2000, the United States has experienced an average of 70,685 wildfires per year which have burnt an average of 7.1 million acres per year. The severity of these wildfires has significantly increased from before 2000, as the average of acres burned after 2000 was almost double the average of acres burned before 2000.[91] The increased likelihood of wildfires, mostly in the western part of the US, has caused and will continue to cause damage to transmission lines. Over the 2000-2016 period, wildfires in California cost utilities more than $700 million in assets related to transmission and distribution.[92] Furthermore, in 2007 the California Independent System Operator Corporation ("CAISO") declared an emergency due to wildfires and over a two-week span more than 1,500 utility poles were burned, more than 35 miles of transmission lines were damaged, and almost 80,000 customers of San Diego Gas & Electric ("SDG&E") lost power.[93] Therefore, maintenance and repair of damaged transmission lines and installation of equipment needed to protect existing infrastructure are expected to increase.

4.1.3 Renewable integration

The third transmission investment driver is renewable integration. There is great need for increased investment in the grid to connect more renewable energy generation to places with increasing demand for such sources of energy. By its nature, renewable energy generation will be

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[87] Bartos, Matthew. "Impacts of rising air temperatures on electric transmission ampacity and peak electricity load in the United States." *Environmental Research letters*. 2016.

[88] Allen-Dumas, Melissa. "Extreme Weather and Climate Vulnerabilities of the Electric Grid: A Summary of Environmental Sensitivity Quantification Methods." *Oak Ridge National Laboratory*. August 16, 2019.

[89] Ibid.

[90] The White House. Executive Office of the President. "Economic Benefits of Increasing Electric Grid Resilience to Weather Outages." August 2013.

[91] Wildfire Statistics. Congressional Research Service. January 4, 2021.

[92] Dale, Larry et al. "Assessing the Impact of Wildfires on the California Electricity Grid." *State of California Energy Commission*. August 2018.

[93] Vine, Edward. "Adaptation of California's Electricity Sector to Climate Change." *Public Policy Institute of California*. November 2008.

located in very specific geographical areas of the US - areas with the longest and hottest exposure to the sun and strongest wind patterns. These natural resource-rich areas are usually not located near areas with high demand, such as cities, nor are they located near existing energy infrastructure, which was built around load centers, areas of rich fossil fuel supply, and transportation corridors (to support fossil fuel delivery to power plants).[94] Figure 20 illustrates areas where solar and wind energy can generate the most supply and the existing transmission infrastructure supporting the supply. To move the generated power from high wind and solar areas to high demand areas, additional transmission infrastructure will be needed. The textbox below outlines several transmission projects that seek to bring stranded renewable energy to high demand areas.[95]

Planned Transmission Projects to Address Renewable Integration

In 2019, NYISO approved the transmission Project T019, to address New York State's identified need to expand its AC transmission capacity to deliver power from renewable generating facilities in upstate New York to other parts for the state. Project T019 includes "a new double-circuit 345/115 kV line from a new Knickerbocker 345 kV switching station to the existing Pleasant Valley Substation, including a rebuild of the Churchtown 115 kV switching station, an upgrade of the existing Pleasant Valley 345/115 kV Substation, and 50% series compensation on Knickerbocker to Pleasant Valley 345 kV line." Project T019 is one of two approved AC transmission projects and together the two projects have an expected total cost of $1.23 billion.

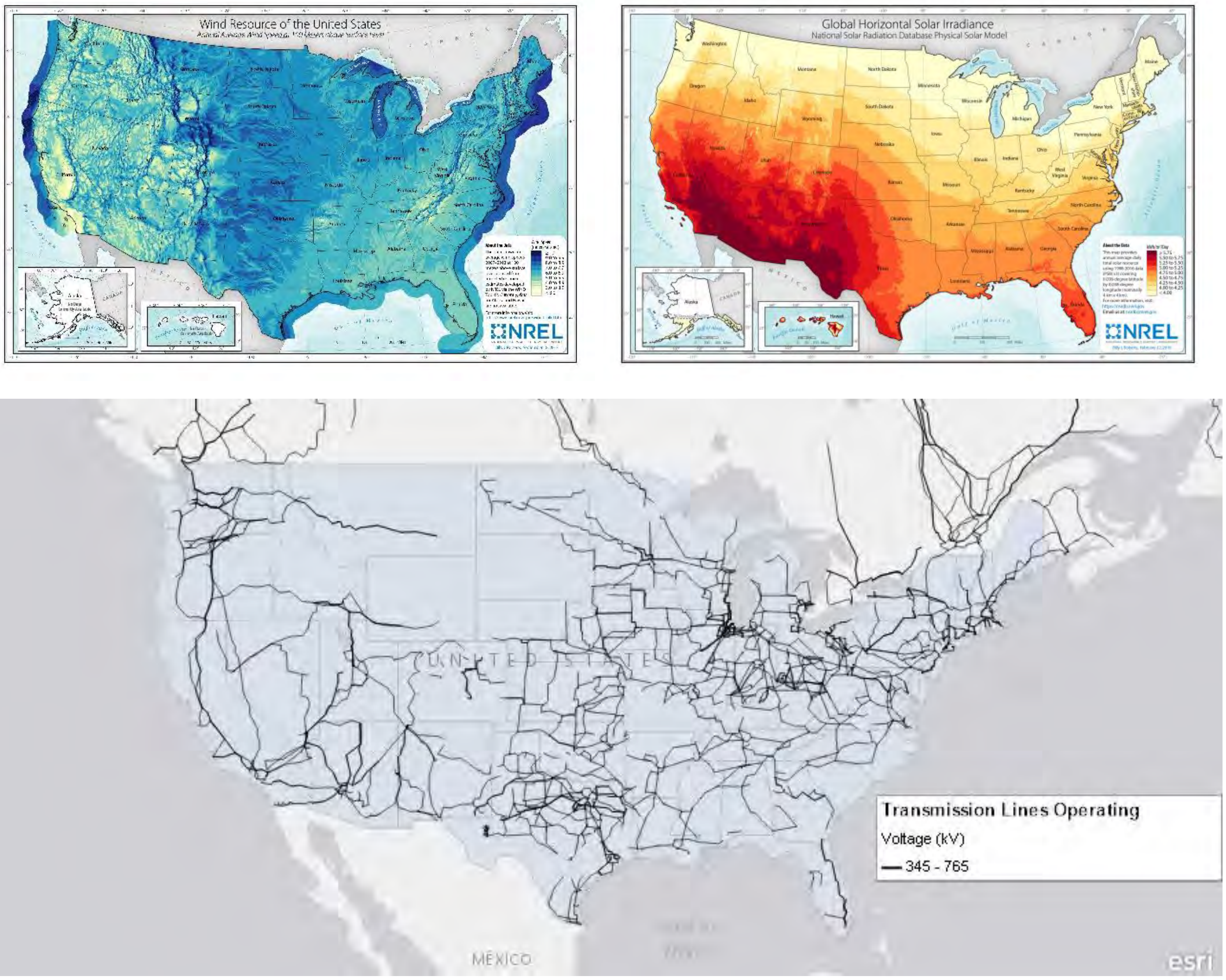
Xcel Energy is rebuilding the 17-mile 345 kV Helena-Scott Transmission Line through the Helena-Scott Transmission Rebuild Project. The purpose of the project is to "increase capacity to enable more renewable energy to enter the electric grid." Work on the project began in 2020 and is expected to be completed by the end of 2021. The cost of the project is expected to be $34 million.

Source: NYISO. *NYISO Board of Directors' decision on approval of AC transmission public policy, transmission planning report and selection of public policy transmission projects*. April 8, 2019., Xcel Energy. "Helena-Scott Transmission Line Rebuilding Project." Company Website., 2021 MISO Quarterly Appendix A Status Report.

[94] Gross, Samantha. "Renewables, Land Use, and Local Opposition in the United States." *Brookings Institution*. January 2020.

[95] The list of proposed transmission solutions for renewable integration is continuously growing. Transmission projects can include upgrades to existing infrastructure as well as new build. For example, in March 2021, GridLiance West LLC proposed a $1.5 billion electric transmission project that would provide California access to almost 6,000 MW of renewable energy capacity by expanding existing 230-kV transmission lines in southwestern Nevada and California. California ISO is expected to study the proposal during 2021 as part of its transmission planning cycle and is expected to make final recommendations in March 2022. This is just one example of many new proposals for transmission investment to facilitate more renewable generation.

Figure 20. Most abundant wind and solar areas in the US lack sufficient transmission infrastructure



Source: Sengupta, M., Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby. "The National Solar Radiation Data Base (NSRDB)." *National Renewable Energy Laboratory*. Renewable and Sustainable Energy Reviews 89 (June 2018): 51-60., S&P Global Market Intelligence.

4.1.4 Aging infrastructure

The fourth transmission investment driver is aging infrastructure. The majority of U.S. high voltage transmission lines were built in the 1950s and 1960s and have an expected lifespan of 50 to 75 years.[96] A Department of Energy study from 2015 found that 70% of power transformers are over 25 years old, 60% of circuit breakers are over 30 years old, and 70% of transmission lines are

[96] American Society of Civil Engineers. "Infrastructure Report Card." 2017.

over 25 years old.[97] Upgrading/replacing aging infrastructure is driving investment as newer transmission technology can enhance reliability, decrease impact of extreme weather events, increase capacity, and better handle variable renewable generation.

Smart Path Project: Replacing Aging Transmission Infrastructure

The New York Power Authority ("NYPA") began construction of its 86-miles-long Moses-Adirondack transmission line in 2020. The transmission line was over 70 years old and has exceeded its service life according to the NYPA. The project runs from the St. Lawrence-Franklin D. Roosevelt Power Project in Massena to the Adirondack Substation in Croghan. The rebuilt lines will be operated in the short-term at 230 kV but is capable of transmitting up to 345 kV. The project has an expected cost of $483.8 million and is expected to be completed in 2023.

Source: The Official Website of New York State. "NYPA Board Approves $294 Million Contract for Rebuild of Major North-South Transmission Artery that will Modernize New York State's Power Grid and Advance Governor's Clean Energy Goals." February 3, 2021., New York Power Authority. *Moses-Adirondack Smart Path Reliability Project.* January 2021.

4.1.5 Increased electrification

The fifth driver of transmission investment is increased electrification. Electrification is the "process of transitioning energy services from direct fossil fuel-based energy to electricity."[98] Electrification is not an isolated factor but advances in tandem with climate change and decarbonization goals. Decarbonization goals, resulting from the adverse effects of climate change, seek to shift energy consumption from fossil fuels to electricity. Recent reports suggest that electrification could lead to a 20% (932 TWh) increase in electricity consumption by 2050 on the low end, and a 38% (1,782 TWh) increase in electricity consumption by 2050 on the high end.[99] The majority of the increase in electricity demand is expected to be due to increased use of electric vehicles ("EVs").[100] This large increase in demand due to electrification is expected to impact grid operations and is already being considered as part of ongoing transmission planning efforts, with many ISOs/RTOs and utilities considering the impact of EVs on system demand, use of other distributed energy resources, and conversion of fossil fuel-based heating to electricity (e.g., air source heat pumps). As peak demand increases relative to average demand, transmission operations become more expensive and investment into transmission infrastructure is needed to

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[97] US Department of Energy. "Quadrennial Technology Review 2015: Enabling Modernization of the Electric Power System." 2015.

[98] Blonsky, Michael et al. "Potential Impacts of Transportation and Building Electrification on the Grid: A Review of Electrification Projections and Their Effects on Grid Infrastructure, Operation, and Planning." *Springer Nature Switzerland AG*. 2019.

[99] Mai, Trieu et al. "Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States." *National Renewable Energy Laboratory*. 2018.

[100] Ibid.

compensate. In addition, the increased demand due to electrification will require greater generation of electricity which will in turn result in greater need for transmission investment to connect generation to load centers. The textbox below provides an example of how transmission investment is being used to support the shift towards electrification.

Planned Transmission Project to Address Electrification

In early 2021, New York Public Service Commission approved **Project T027** which intends to help New York work towards the requirements of the Climate Leadership and Community Protection Act ("CLCPA"). According to PSC Chair, John Rhodes, meeting CLCPA milestones "will require investment in renewable generation, as well as storage, energy efficiency measures, electrification of the transportation and heating sectors, and electric transmission and distribution infrastructure." Project T027 includes "a new 86-mile double-circuit line between the Edic and New Scotland 345 kV substations and the addition of a new Princetown 345 kV switchyard to connect to Rotterdam." Project T027 is expected to cost $854 million. The project will provide greater power capacity which will help facilitate the electrification of New York.

Source: Walton, Robert. "New York approves $854M transmission line, outlines path to reach storage, renewables goals" *Utility Dive*. January 25, 2021.

4.2 Assessing the economic impact of transmission investment

To better understand how transmission investments could boost US economic activity, LEI performed a macroeconomic impact analysis using the anticipated dollar values for local and national spending on approved and/or recommended transmission investments across the US. LEI employed regional multipliers from the US BEA' Regional Input-Output Modeling System ("RIMS II") for this analysis.[101,102]

LEI began the study by compiling data from various public sources about planned (non-merchant) transmission investments across the US, and the magnitude (dollar value) of such transmission investments (see Figure 21 below).[103]

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101 RIMS II has been used to estimate the economic impact of geographically diverse transmission investments in the US – see for example: (1) a 2018 presentation to the Kansas Senate Utilities Committee, (2) a 2008 study to the New York City Economic Development Corporation, and (3) a 2013 transmission proposal in New Mexico.

102 These regions include seven independent system operators and regional transmission organizations, namely, California ISO, Electric Reliability Council of Texas ("ERCOT"), ISO New England ("ISO-NE"), New York ISO ("NYISO"), Pennsylvania, Jersey, Maryland Interconnection ("PJM") and Southwest Power Pool ("SPP"), and two US regions not covered by ISOs/RTOs represented by SERC Reliability Corporation ("SERC") and Western Electricity Coordinating Council ("WECC"). Alaska, Hawaii, and US territories are not considered in this analysis. Notably, the macroeconomic data from BEA was compiled on a county level. For counties that share more than one ISO/RTO area, the assignment was made to the ISO/RTO with the larger part of the county. To avoid any overlap, if a county was both in an ISO/RTO and in a non-ISO/RTO region (e.g., WECC and SERC), the county was allocated to an ISO/RTO region.

103 Proposed and under-development merchant transmission projects were excluded because of the difficulty in identifying and tallying merchant investments that are akin to "approved" regulated transmission

Figure 21. Approved transmission investment by category and by region (in current $ billion)

Region	Under construction projects	Short-term investments	Long-term investments	Total investments
CAISO	$1.01	$1.69	$1.94	**$4.63**
ERCOT	$1.66	$3.53	$2.03	**$7.22**
ISO-NE	$2.05	$0.26	$1.53	**$3.84**
MISO	$1.20	$3.06	$8.31	**$12.58**
NYISO	$0.48	$0.26	$12.99	**$13.73**
PJM	$7.18	$6.91	$17.08	**$31.17**
SERC	$0.03	$0.65	$1.85	**$2.53**
SPP	$0.07	$0.53	$1.56	**$2.17**
WECC (*)	$0.18	$0.00	$5.46	**$5.63**
US	**$13.87**	**$16.88**	**$52.75**	**$83.49**

Note: LEI has relied mainly on ISO/RTO transmission investment plans, and specifically Board-approved plans, in order to be confident that the selected projects have a high likelihood of advancing to construction. If Board-approved investment plans was not available directly, LEI used other ISO/RTO's transmission status reports and investor-owned utilities' ("IOUs") Integrated Resource Plans ("IRPs") to identify recommended transmission investments, as in the case of SERC and WECC. Transmission projects considered were not only new projects, but also rebuilds of existing transmission lines and various equipment upgrades to meet transmission planning requirements. Based on the reported in-service date ("ISD") and operation status of each project, LEI has classified transmission investments under three categories:

- Under construction ("UC"): all identified transmission projects that have begun construction;
- Short-term investments ("ST"): all projects that have a "planned or proposed" status and ISD less than or equal to 2021; and
- Long-term investments ("LT"): all projects that have a "planned or proposed" status and ISD greater than 2021 (or no specified ISD).

(*) IOU's IRPs do not have enough detailed information to sort the transmission investments by projected in-service date. Therefore, all investments have been considered under the long-term category.

Source: 2019-2020 CAISO Transmission Plan - Appendix E; 2020 ERCOT Transmission Project Information and Tracking; 2020 ISO-NE Regional System Plan - Project Lists and Asset Condition List Updates; 2021 MISO Quarterly Appendix A Status Report; New York Power Authority - Smart Path project; State of New York Public Service Commission ("PSC") - Utility Transmission and Distribution Investment Working Group Report under Case 20-E-0197 (which includes local transmission plans developed and filed with the state regulator to accommodate the state´s clean energy goals); NYISO report and documents; 2021 PJM Transmission Cost Information Center; 2020 SERTP - Input assumptions overview; SPP - Q1 2021 Quarterly Project Tracking Appendix 1; WECC - IOUs Integrated Resource Plan; third party data provider.

investments. Realization (construction) of merchant transmission projects becomes more certain once a project secures a customer to pay for transmission services. In some case, there may be multiple merchant transmission projects being developed simultaneously for the same customer. As a result, it is difficult to estimate which proposed merchant transmission project will eventually reach construction. Nonetheless, there has been billions of dollars of successful merchant transmission investment in the US to date, and such investment models are likely to continue.

Under construction, short-term, and long-term approved and/or recommended transmission investments range from $0.3 billion to $17.1 billion per region. These region-by-region figures total to over $83 billion nationally. This is a conservative figure, given that merchant transmission investments and projects in the initial development or design stage (and not yet recommended to regulatory or Board approvals) have not been included. [104] The forward-looking period for these investments ranges from 6 to 10 years, except for NYISO and WECC (in these two regions, approved and recommended investments cover a longer time horizon of 15 and 18 years, respectively).

4.2.1 Methodology

Once the primary data compilation was complete, LEI employed a two-step process for the analysis phase: (1) identification of direct local and national spending and (2) estimation of the economic impact. The objective of the analysis phase was to quantify the GDP and employment impacts from the construction of the approved and/or recommended transmission investments identified across regions.

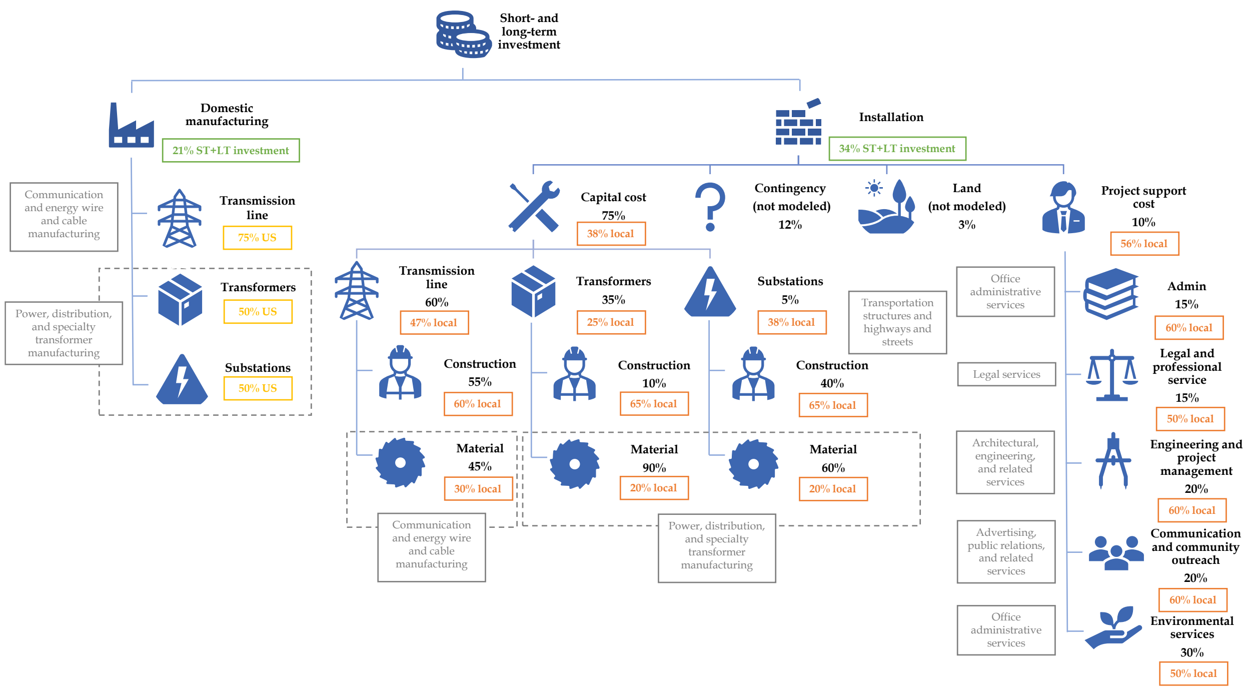
The first step involved the identification of industries/sectors that are recipients of construction budgets (and operations), as well as the determination of direct (local) spending in the region (i.e., the share of the capital investment that will be spent locally) and direct (national) domestic manufacturing spending within US.[105] A high-level summary of the construction cost breakdown, including itemized cost allocation, local share assumptions, and the affected BEA-RIMS II supply industries, is presented in Figure 22. Only a 55% of short- and long-term investment is spent within US during construction (34% local and 21% national)[106]; "transportation structures and highways and streets", "communication and energy wire and cable manufacturing", and "power, distribution, and specialty transformer manufacturing" industries are the directly affected sectors.

[104] According to a project list maintained by S&P Global Market Intelligence, active proposed merchant transmission projects in U.S. total well over $10 billion.

[105] To be consistent with previous WIRES reports, LEI has used the same cost breakdown for the installation as the one developed for a study of the transmission investments benefits of the Eastern Interconnect project, which was based on publicly-available studies along with LEI's project experience and professional judgement. For further details, see LEI for WIRES. *How Does Electric Transmission Benefit You? Identifying and Measuring the Life-cycle Benefits of Infrastructure Investment.* January 8, 2018.

[106] Contingency and land costs that account for 15% of overall investments expenses are not considered in the model.

Figure 22. Construction cost breakdown and allocation of a typical AC transmission project



Note: Grey boxes illustrate the industry assignment to the cost component based on BEA-RIMS II classification.

Source: LEI for WIRES. *How Does Electric Transmission Benefit You? Identifying and Measuring the Life-cycle Benefits of Infrastructure Investment.* January 8, 2018.

In the second step to the analysis, LEI applied BEA-RIMS II multipliers to the allocated dollars of direct local and national spending to calculate two major impacts that can arise from the construction of these approved and/or recommended transmission projects: the change in employment (in terms of number of jobs)[107] and GDP growth (on a regional and national level).[108]

The increase in GDP and employment occurs as a result of the direct spending associated with the transmission investments, as well as due to indirect and induced economic impacts (together known as the "multiplier effects", which are described in Figure 23).

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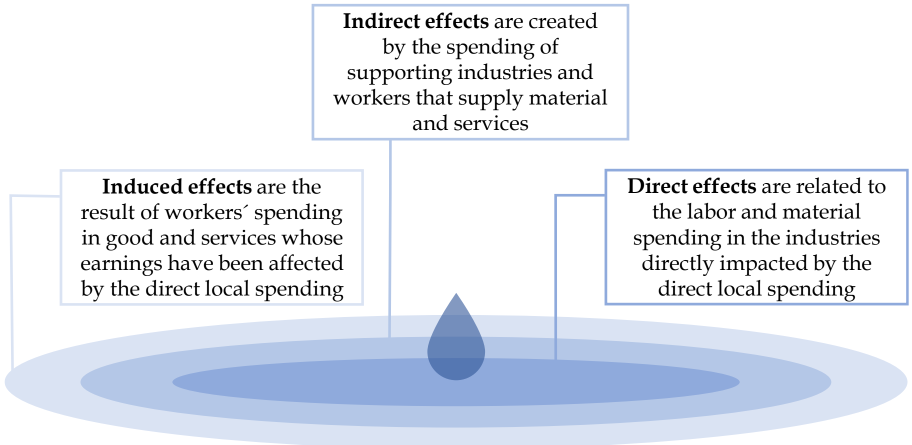
[107] Employment is the amount of full- and part-time jobs. It is not based on measures of full time equivalent ("FTE") employment.

[108] BEA calculates multipliers that estimate the total impact of four main economic variables, namely, output (sales), value added (GDP), earnings and employment. See BEA. RIMS II - *An essential tool for regional developers and planners*. May 2018.

Figure 23. Illustration of the "multiplier effect"



In addition to the effects of construction-related spending in each region where the transmission project is located (i.e., installation), LEI also assessed additional "supply-chain" benefits, arising from the manufacturing of electrical equipment and components inside the US, as well as provision of technical labor force.

Once the construction phase is completed and the transmission project comes online, there are also supplementary benefits linked to the operation and maintenance expenditures ("O&M" spending) needed during the useful life of the transmission project that should be considered. LEI followed a conservative approach for measuring the economic benefits during the operation phase of transmission investment project, focusing only on direct O&M spending. It was beyond the scope of this paper to quantify other possible long-lived benefits, such as lower electricity costs or the positive impact of knock-on effects (such as generation investments motivated by the new transmission resources).

In summary, LEI estimated the impact on employment and GDP in three stages:

- an installation stage that calculates the local (i.e., within each region) economic impact of construction; this is a temporary effect as it lasts only as long as the construction activity continues;[109]
- a domestic manufacturing stage that measures the temporary economic effects associated with equipment manufacturing to support construction; based on general

[109] The construction period varies significantly among different transmission projects. Construction of many transmission projects will last for a multi-year period. LEI has not attempted to consider the specific timeline of construction for each transmission project. Instead, LEI has estimated the economic impacts based on the aggregate level of spending. Therefore, the results present with respect to estimated GDP and employment impacts may be smaller once the spending amount is allocated across time and spread out over multiple years.

location of such manufacturing sites, LEI estimated these impacts using multipliers for select regions, but the results are reported for the US as a whole;[110,111] and

- an operating stage that captures the impact of local O&M-related spending once the asset is operational. This benefit is estimated to reoccur annually and last for the foreseeable life of the new assets.

The amount of direct spending considered as inputs for each stage is depicted in Figure 24.

Figure 24. Inputs used in each stage of analysis ($ billions)

Region	ST + LT investments	Local spending during construction from ST+LT investments	Domestic manufacturing spending during construction	Local spending (annually) after construction from ST+LT investments is completed (*)
Stage input		Installation	Domestic manufacturing	O&M
CAISO	$3.62	$1.24	$0.76	$0.09
ERCOT	$5.56	$1.91	$1.16	$0.14
ISO-NE	$1.79	$0.61	$0.37	$0.07
MISO	$11.38	$3.91	$2.38	$0.24
NYISO	$13.25	$4.55	$2.77	$0.26
PJM	$23.99	$8.23	$5.02	$0.58
SERC	$2.50	$0.86	$0.52	$0.05
SPP	$2.10	$0.72	$0.44	$0.04
WECC	$5.46	$1.87	$1.14	$0.11
US	**$69.63**	**$23.90**	**$14.57**	**$1.57**

Note: (*) Local spending for the O&M stage also considered projects designated under construction. The reason for excluding this category in the installation and domestic manufacturing stages is that these stages assess the economic impact of upcoming spending, not ongoing projects that have already created stimulus effects.

4.2.2 Results

At a national level, GDP is expected to increase by an average of $26 billion due to local installation spending and $16 billion resulting from the domestic manufacturing effects. That is an upsurge in GDP of approximately $42 billion from construction of the infrastructure. In the case of employment, jobs are forecasted to rise by 264,000 for local installation, and by another

[110] Based on the location of current domestic manufacturers of cables and large transformers, LEI determined that multipliers for the Southeast US are the most suitable to assess the domestic manufacturing effects of spending on equipment manufacturing.

[111] LEI assumed that the US would keep its domestic manufacturing competitive advantages during the period under analysis.

almost 178,000 due to the domestic manufacturing effects. Overall, this would mean the creation of approximately 442,000 new jobs over the period of construction.[112]

> BEA provides all its multipliers in two versions: **type I and II**. Type I multipliers allow to estimate the direct and indirect effects of a change in final demand. In addition to this *interindustry effect*, type II multipliers also account for the *household-spending effect*, which are the induced effects generated by workers spending their earnings' variation due to the final demand change.
>
> - BEA. *RIMS II - An essential tool for regional developers and planners*. May 2018.

The detailed results by region of the economic impact model using type II multipliers for the installation and domestic manufacturing stages associated with the construction phase, including both short- and long-term investments, are illustrated in Figure 25.

The installation and domestic manufacturing stages generate notable economic benefits, considering that LEI conservatively assumed only 34% of short- and long-term investments are directly spent in each region, and another 21% of their overall capital investment costs are spent on domestic manufacturing related initiatives within the US.

Figure 25. Regional economic impact of the installation and domestic manufacturing stages

Region	GDP increase	GDP Impact over 2019 Utilities´ GDP	Employment gains	Employment impact over 2019 Utilities´ employment
	(in $ billion)	(%)	(in number of jobs)	(%)
Installation stage				
CAISO	$1.24	2.9%	11,648	21.9%
ERCOT	$2.29	8.2%	23,713	52.4%
ISO-NE	$0.62	3.7%	6,145	27.7%
MISO	$4.32	11.6%	44,438	78.1%
NYISO	$4.06	20.0%	35,424	140.0%
PJM	$9.93	14.6%	102,972	110.8%
SERC	$1.00	2.2%	11,641	17.9%
SPP	$0.72	3.9%	7,503	26.3%
WECC	$2.02	8.6%	20,452	48.8%
US	**$26.20**	**8.7%**	**263,935**	**61.2%**
Domestic manufacturing stage				
US	**$15.54**	**5.2%**	**177,844**	**41.2%**

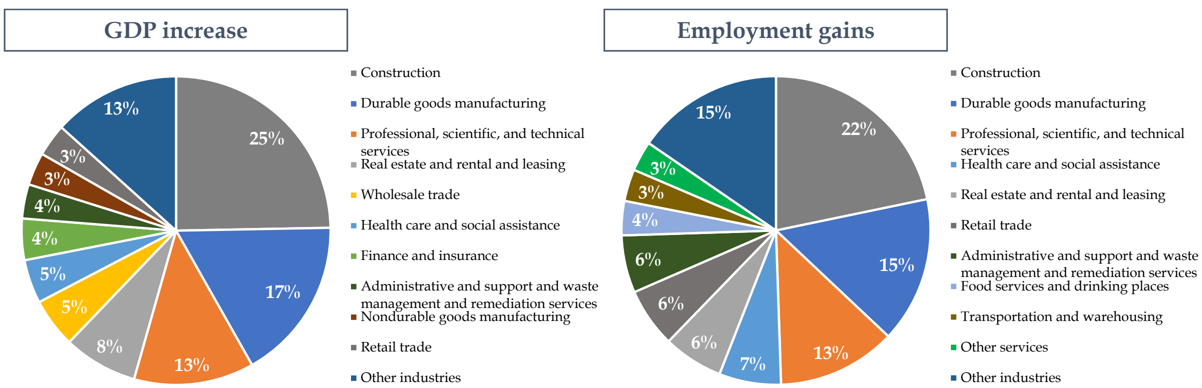
Note: These results have been calculated using type II multipliers to account for direct, indirect, and induced effects. See Appendix C for detailed results on GDP and employment using type I multipliers.

[112] As construction may span multiple years, the number of new jobs has not been calculated on an annual basis.

A simple comparison of the results with the same economic indicators for the Utilities[113] industry shows that the construction impact (including the installation and domestic manufacturing stages) can generate an increase of nearly 14% of Utilities' current value added (GDP contribution) and more than double Utilities' current regional employment (as of 2019 levels).[114] Although construction-related impacts are temporary in nature (i.e., coming to an end when construction is completed), this characteristics is well-aligned with the immediate needs of the US economy.

During the installation stage, economic activity improvements in the construction, durable goods manufacturing, and professional, scientific and technical services sectors account for approximately 50% of the total impact, not only in terms of GDP growth but also in terms of new jobs (see Figure 26). These sectors benefit the most during the construction period because they receive allocation of a large share of the direct spending dollars for material purchases and labor. Other sectors of the local economies benefit too, due to the indirect and induced effects, although these will naturally be smaller. For example, the "health care and social assistance" sector is expected to see its GDP increase by $1.2 billion nationally and its employment to rise by 17,125 new jobs.

Figure 26. Industry breakdown of the economic impact during the installation stage at a national level



Note: These results have been calculated using type II multipliers to account for direct, indirect, and induced effects. See Appendix C for detailed results on GDP and employment using type I multipliers.

The domestic manufacturing focuses on the positive benefits associated with skilled labor and manufacturing of necessary equipment and components to support transmission investment projects. Some of these services are provided by international companies and therefore would not benefit the US economy (except as a result of international "ripple" effects). However, for some

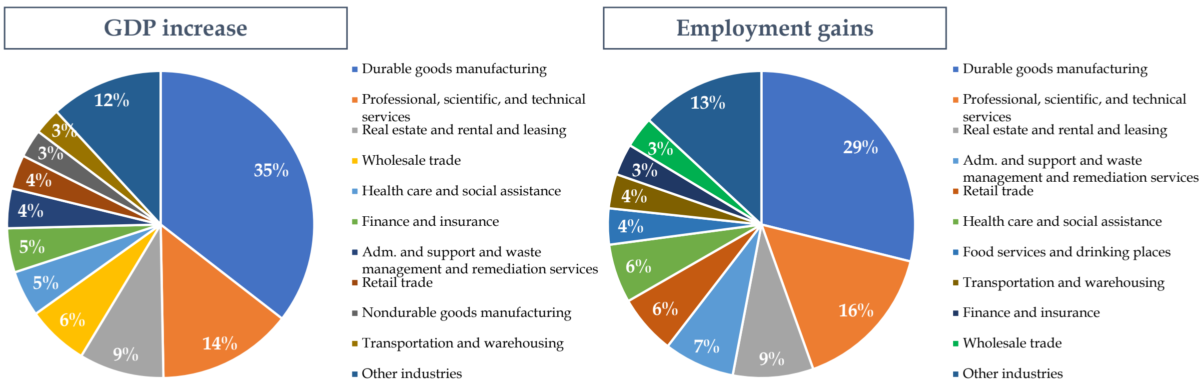
[113] Following BEA's industry classification, the Utilities industry includes not only electric power generation, transmission, and distribution, but also natural gas distribution, water, sewage and other systems.

[114] Utilities' GDP and employment at a national level in 2019 were $300 billion and 431,309 jobs, respectively.

components, such as transmission cable, there is expertise and capability in the US (domestic) manufacturing sector. Based on an informal survey of WIRES members, LEI assumed that 75% of the cable, and 50% of transformers and substations parts are manufactured domestically.[115] Additionally, LEI assigned a 100% local share to all manufacturing support costs.[116]

The domestic manufacturing analysis shows a similar breakdown of benefits by sector (see Figure 27). At least 45% of the increase in GDP and employment benefits are experienced in the durable goods manufacturing and the professional, scientific, and technical services industries.

Figure 27. Industry breakdown of the economic impact during the domestic manufacturing stage at a national level



Note: These results have been calculated using type II multipliers to account for direct, indirect, and induced effects. See Appendix C for detailed results on GDP and employment using type I multipliers.

LEI also estimated the annual economic impacts associated with O&M spending once the transmission projects come into service. The calculation was based on the share of capital costs for O&M expenses among US transmission providers. More specifically, based on historical financial data and industry benchmarks, LEI estimated that annual O&M spending would be equal to 2.5% of overall capital costs. Moreover, this direct spending would occur in the Utilities sector. LEI estimated the annual benefits for this stage based on the capital cost investments across all investment types, not just short- and long-term investments (i.e., "under construction" projects were considered as well).

The results of the O&M stage indicate that direct spending by the utilities on these new transmission assets is anticipated to grow national GDP by about $1.6 billion per year, while jobs are expected to increase by nearly 9,000 annually, as illustrated in Figure 28. Most of the new jobs are in the utilities sector, but there is also a small, induced effect in other sectors of the economy. While the O&M stage shows smaller scale improvements than the installation and domestic

[115] These local shares estimates were the result of a survey conducted by WIRES among its member in March 2021.

[116] This assignment excludes "engineering and project management" which was allotted with an 80% share as this service might be partially provided by non-US firms.

manufacturing stages, it is important to highlight that these are long-lasting effects. Hence, the O&M stage could have a distinct role in the expected benefits of an economic stimulus program, since these benefits are longer lasting and could help keep the pace of the economic recovery going.

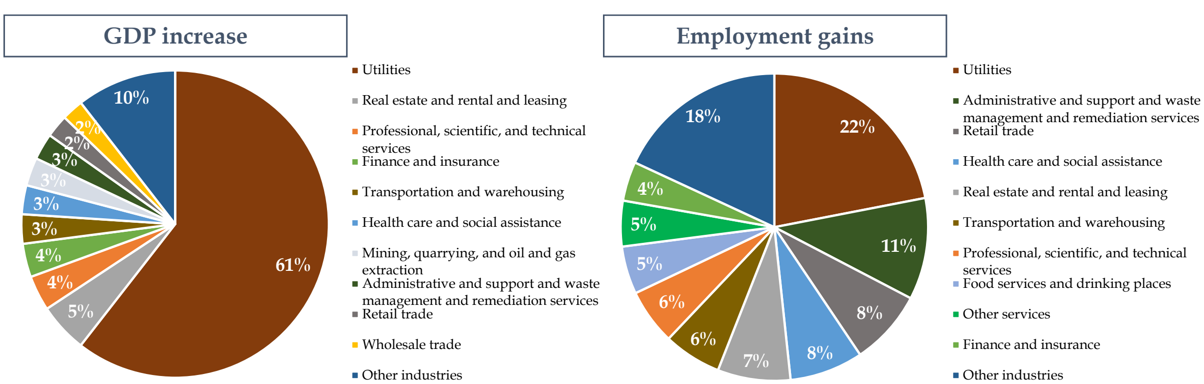
Figure 28. Regional economic impact of the O&M stage

Region	GDP increase	GDP Impact over 2019 Utilities´ GDP	Employment gains	Employment impact over 2019 Utilities´ employment
	(in $ billion)	(%)	(in number of jobs)	(%)
		O&M stage		
CAISO	$0.08	0.2%	417	0.8%
ERCOT	$0.15	0.6%	947	2.1%
ISO-NE	$0.06	0.4%	322	1.5%
MISO	$0.24	0.6%	1,364	2.4%
NYISO	$0.22	1.1%	915	3.6%
PJM	$0.62	0.9%	3,723	4.0%
SERC	$0.05	0.1%	307	0.5%
SPP	$0.04	0.2%	231	0.8%
WECC	$0.11	0.5%	661	1.6%
US	**$1.58**	**0.5%**	**8,886**	**2.1%**

Note: These results have been calculated using type II multipliers to account for direct, indirect, and induced effects. See Appendix C for detailed results on GDP and employment using type I multipliers.

The economic impact of the O&M stage shows a different industry pattern than the other two stages in terms of GDP growth. The reason behind this divergence in the industry breakdown is that the Utilities industry is the primary "spender" of O&M dollars, and also the sector to which the revenues accrue from customers to finance this spending. Consequently, the Utilities industry receives about 60% of value added (GDP) increase.

Figure 29. Industry breakdown of the annual economic impact associated with the O&M stage at a national level

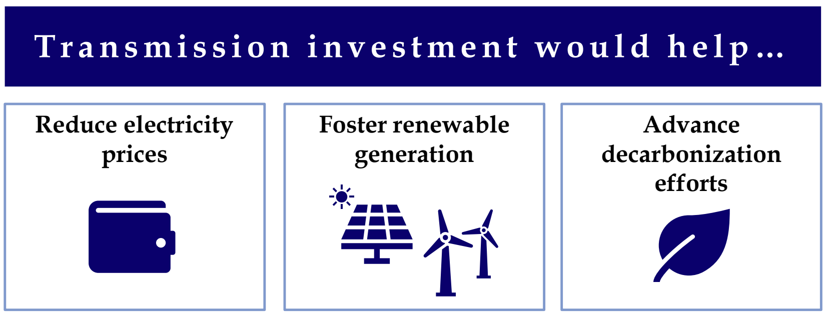


Note: These results have been calculated using type II multipliers to account for direct, indirect, and induced effects. See Appendix C for detailed results on GDP and employment using type I multipliers.

4.3 Additional economic benefits arising as a result of beneficial transmission investment

There are several additional benefits that are associated with investments in transmission that LEI did not quantify using the BEA-RIMS II multipliers. Nevertheless, these benefits are highly likely and significant. These other benefits will also take longer to emerge than the benefits associated with construction of approved and/or recommended transmission investment, but can also have a much longer positive effect. These other benefits include increased GDP and employment stemming from (i) reduced electricity prices, (ii) increased investment in renewable generation, and (iii) successful achievement of decarbonation goals. In this section of the report, LEI will discuss these three benefits qualitatively.

Figure 30. Summary of transmission investment benefits



4.3.1 Reduction in electricity prices

The first additional benefit related to transmission investment is the potential for reduced electricity prices. There are two major pathways for transmission investment to reduce electricity prices. The first pathway arises when transmission investment reduces transmission congestion and allows for lower cost electricity. Transmission congestion occurs when existing transmission capacity is not sufficient to deliver low-cost power to load areas. Figure 31 outlines the annual transmission congestion costs for six major US ISOs/RTOs.

Over $3.7 billion a year on average in the last four years, these costs are substantial and have an upwards impact on electricity prices paid by end-users. Furthermore, transmission congestion in the electric grid often leads to curtailment of certain generation, which is a "loss" for society because of the foregone effect of lower electricity prices and the loss of productivity for the generation.[117]

[117] See for example, California ISO. "Curtailment Fast Facts." 2017.

Figure 31. Annual transmission congestion costs by ISO/ RTO ($ billion)

ISO/RTO	2016	2017	2018	2019
CAISO	$0.30	$0.30	$0.40	$0.70
ERCOT	$0.41	$0.79	$1.10	$1.08
ISO-NE	$0.04	$0.04	$0.06	$0.03
MISO	$0.70	$0.67	$0.67	$0.51
NYISO	$0.44	$0.42	$0.50	$0.43
PJM	$1.02	$0.70	$1.31	$0.58
SPP	$0.28	$0.50	$0.45	$0.46
Total	**$3.19**	**$3.41**	**$4.50**	**$3.80**

Note: ERCOT and NYISO congestion costs based on day-ahead congestion costs; ISO-NE, MISO, PJM, SPP congestion costs based on total congestion costs (sum of day-ahead congestion costs and balancing congestion costs).

Source: State of the Market Report for the ERCOT Electricity Markets 2016, 2017, 2018, 2019; ISO-NE Annual Markets Report 2016, 2017, 2018,2019; State of the Market Report for the MISO Electricity Markets 2016, 2017, 2018, 2019; State of the Market Report for the New York ISO Electricity Markets 2016, 2017, 2018, 2019; State of the Market Report for PJM 2016, 2017, 2018, 2019; SPP State of the Market 2016, 2017, 2018, 2019. U.S. Department of Energy. "National Electric Transmission Congestion Study. September 2020.

There are several studies performed by ISOs/RTOs that indicate that there is currently substantial curtailment of renewable generation and that additional transmission investments would reduce curtailment. A NYISO study found that "the addition of significant amounts of renewable generation causes stresses and certain violations on the NY transmission system."[118] The study states further that a substantial amount of renewable generation may need to be curtailed to prevent overloading transmission facilities and that there is a need for transmission upgrades to transmit the full amount of renewable generation.[119] An ISO-NE study suggests that should off-shore wind generation additions exceed levels of 5,800 MW, there would be a need for major additional transmission investment to avoid overloading of the projected ISO-NE transmission system in 2030 and curtailment of offshore wind generation.[120] Transmission investment has been shown to substantially decrease curtailment, as seen through ERCOT's success with un-bottlenecking wind resources in western Texas (see textbox below).

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118 Lin, Yachi. "Public Policy Transmission Needs Study: Transmission Constrained Renewable Generation Pockets." *New York Independent System Operator*. July 27, 2018.

119 Ibid.

120 ISO New England. "2019 Economic Study Offshore Wind Transmission Interconnection Analysis." June 17, 2020.

CREZ transmission investment program in Texas: Impact on Wind generation Curtailments

Between 2007 and 2014, ERCOT experienced wind curtailment rates of around 8%. Data from December 2008 to July 2009 indicated that ERCOT was curtailing 500-1000 MW of wind capacity daily during peak hour. In 2009, wind curtailment spiked to 17%. The Competitive Renewable Energy Zone ("CREZ") initiative sought to expand the transmission system and allow for up to 18,500 MW of western wind to be delivered to key load centers in eastern and southern Texas. By 2014, 3,600 miles of transmission lines were built at an investment cost of approximately $6.8 billion. As a result of the investment into transmission lines, curtailment fell to 0.5% in 2014. More recently, as of 2018, curtailment rates were 2.5% which is still significantly below the 2007 to 2014 levels of 8%.

Source: Mormann, Felix et al. "A Tale of Three Markets: Comparing the Renewable Energy Experiences of California, Texas, and Germany." Stanford Environmental Law Journal Vol. 35, 55 (Mar 2016). Web., National Renewable Energy Laboratory. "Latest Grid Data Book Reveals Key Trends in Renewable Integration." March 2020.

The second impact leading to the reduction in electricity costs is that transmission capacity can encourage new generation investment and that in turn could bring low-cost power to market and through competition further lower electricity prices. Studies conducted by CAISO show the downward pressure on electricity prices that transmission investment could have by bringing low-cost power to market. A 2019 CAISO study suggested that "allowing a selection of interconnect out-of-state ("OOS") resources that may require new transmission appears to provide value over restricting resource selection to only those resources that can be built with existing transmission capacity."[121]

The economic benefits that electricity customers receive due to access to low-cost power and relief of transmission congestion through the investment in transmission extends beyond just the electricity market and the utility bills. Due to lower electricity costs, businesses can hire more workers and expand operations. A previous WIRES report explained the intuition and implications of lower electricity prices on local economies.[122]

4.3.2 Foster renewable generation

The second additional benefit related to transmission investment is that it encourages other infrastructure investment, which then releases its own series of local economic benefits. As of 2020, there was a significant backlog of proposed generation waiting in interconnection queues throughout the US according to a study by Lawrence Berkley National Laboratories and updated 2020 ISO/RTO interconnection queue numbers. Recent analysis suggests that the interconnection

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121 California Public Utilities Commission. "Proposed IRP Portfolios for the 2019-20 CAISO Transmission Planning Process." January 11, 2019.

122 *See* LEI. *How Does Electric Transmission Benefit You? Identifying and Measuring the Life-cycle Benefits of Infrastructure Investment.* January 8, 2018.

queues have only grown. Moreover, experts believe that current transmission infrastructure is insufficient to bring all this capacity online.[123, 124] Of the 567 GW of proposed generation by a sample of ISOs/RTOs in 2020, 72% was related to renewables – particularly, wind and solar (see Figure 32). The construction of such renewable resources would have the added benefit of not only stimulating the local economy but also supporting the decarbonization goals.

Figure 32. GW of capacity in queues at year-end for major ISOs/RTOs

RTO/ISO	2016	2017	2018	2019	2020	% of Renewable Generation 2020
CAISO	50.1	52.7	57.3	70.7	85.9	43.7%
ERCOT	59.9	68.3	69.3	88.0	119.9	76.6%
ISO-NE	13.2	14.4	23.5	19.2	35.5	68.8%
MISO	61.5	55.3	76.7	81.2	85.3	90.3%
NYISO	13.9	15.4	28.9	42.4	57.1	72.1%
PJM	71.6	65.8	88.4	108.7	99.4	65.6%
SPP	37.8	72.6	85.7	90.2	83.8	82.5%
Total	**308.1**	**344.4**	**429.7**	**500.4**	**567.1**	**71.7%**

Source: ISO/RTO interconnections queue database as of March 2021.

As illustrated in Figure 33 (on the next page), during the period of 2016 to 2020, renewable energy capacity backlog has increased dramatically (this is seen by the size of the bars for solar and wind relative to other conventional technologies). In summary, facilitating and fostering investment in transmission infrastructure will help bring some of proposed generation also online.

Furthermore, transmission investment can help address a major issue facing renewable energy – namely, that renewable energy, in the form of wind power and solar power, is subject to variable and intermittent supply. Wind power is dependent upon the strength of the wind on any given day. The uncertainties in wind strength can affect up to 100% of wind capacity on calm days.[125] Solar power is subject to the intermittent nature of day and night as well as overcast weather. During the day, solar produces power, while at night (in the absence of storage capacity) solar does not. Furthermore, passing clouds can reduce solar capacity by up to 70%.[126]

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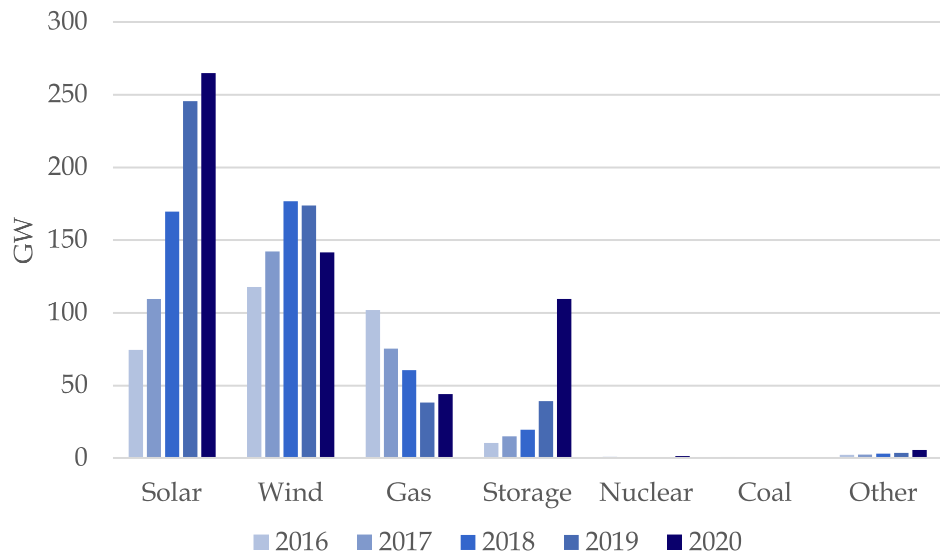
123 Americans for a Clean Energy Grid. *Disconnected: the Need for a New Generator Interconnection Policy.* January 2021.

124 And it would be unrealistic to assume all this capacity would be developed even if transmission capacity was ample.

125 Crabtree, George et al. "Integrating Renewable Electricity on the Grid." *Aronne National Laboratory, University of Illinois at Chicago*. November, 2011.

126 Crabtree, George et al. "Integrating Renewable Electricity on the Grid." *Aronne National Laboratory, University of Illinois at Chicago*. November, 2011.

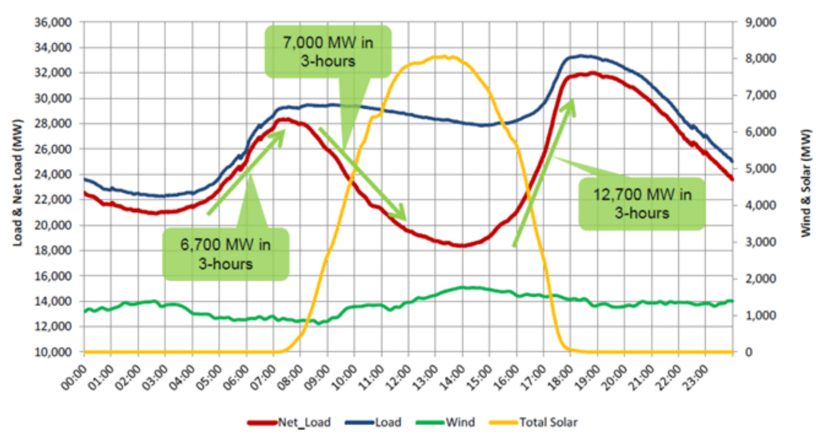
Figure 33. ISO/RTO backlog of capacity in the US by resource type



Source: Wiser, Ryan et al. "Wind Technology Data and Trends: Land-Based Focus, 2020 Update." *Lawrence Berkeley National Laboratory*. August 17, 2020; CAISO, ERCOT, ISO-NE, MISO, NYISO, PJM, SPP interconnection queue database.

Figure 34 illustrates the variability of wind power and intermittency of solar power on a given day. Solar power (yellow line) can be seen to substantially supply load demand (blue line) between 8:00 AM and 6:00 PM before quickly becoming irrelevant after 6:00 PM.

Figure 34. Variability and intermittency of wind and solar power



Source: National Conference of State Legislatures. *Integrating Renewable Energy*. May 2016. p. 4.

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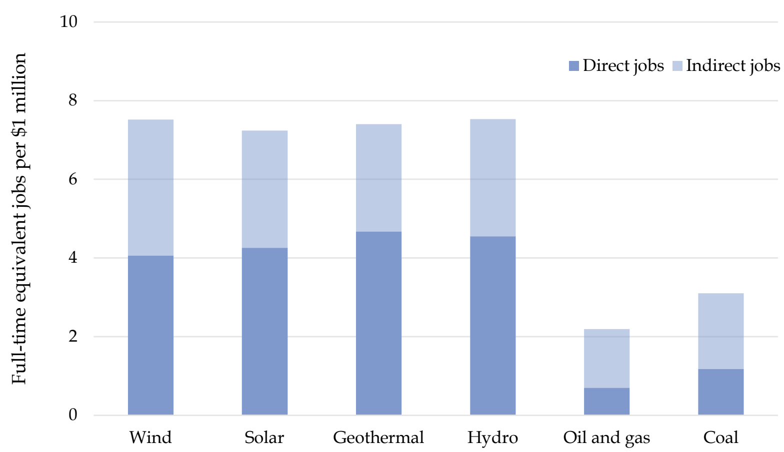
The benefit of transmission investment is that it enables more renewable power to reach a market (through transmission) in lieu of being curtailed. More renewable energy will also reduce the need for fossil fuel-based energy, complementing decarbonization goals.

Investments in renewable energy resources, propelled by transmission investment, should result in new jobs and economic activity as the installation work has to be done by local labor, even if the majority of equipment is manufactured abroad. According to a Yale Center for Business and the Environment study, investment into renewable energy project construction and the maintenance and operation of these generation facilities leads to approximately 0.76-0.98 jobs per MW for wind facilities and 2.45 jobs per MW for solar facilities.[127] In addition to direct jobs associated with renewable energy, the ability of the energy sector to increase employment in other industries would likely grow, as indicated by the indirect jobs multipliers summarized in the figure below.

Figure 35. Estimated multipliers for various energy sources



Source: Garrett-Peltier, Heidi. "Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy and fossil fuels using an input-output model." *Economic Modelling* 61 (2017): 439-447.

Furthermore, since some of the new renewable generation will be located in remote areas, transmission investment that unlocks the opportunity for new renewable generation facilities will help provide participating communities with additional local economic benefits - beyond the jobs created during the construction of these resources. Some potential economic benefits include property tax payments from the land used by the renewable generation facilities and in some cases, royalties paid to landowners. The revenue collected by the local communities could then be used to assist other programs within the local community such as education and healthcare and improvement of local transportation infrastructure.

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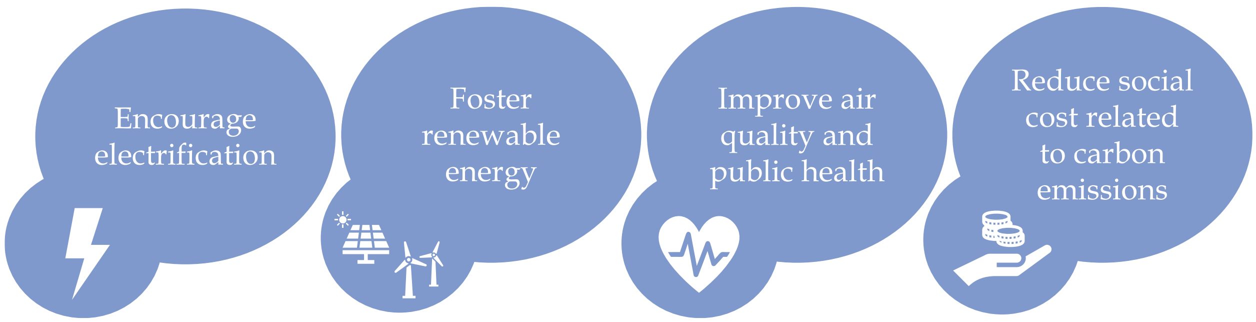
[127] Springer, Nikki. "Key Economic Benefits of Renewable Energy on Public Lands." *Yale Center for Business and the Environment*. May 2020.

4.3.3 Advancement of decarbonization efforts

Transmission investment offers a third additional benefit: support for decarbonization efforts (see Figure 36). Under executive orders signed by President Biden in January 2021, the US has targets of a "carbon-pollution free power sector by 2035" and a "net-zero [carbon] economy by 2050."[128] Transmission investment can advance these goals.

Figure 36. Summary of transmission investment benefits associated with decarbonization



Electrification is one cornerstone of economy-wide decarbonization. Electrification will likely lead to higher load (in certain periods) and a changing pattern of demand; transmission networks may need to evolve to accommodate such shifts in demand, especially in the transportation sector.[129] As noted in President Biden's proposed *American Jobs Plan*, affordability and accessibility to clean energy-based technology (such as electric vehicles ("EVs")) and energy efficient devices (and homes) is a priority condition for the decarbonization goal. Transmission investment can help increase the availability of carbon-free electricity to support electrification and energy efficiency efforts nationwide.

There are several other socio-economic benefits associated with advancing decarbonization efforts besides electrification and fostering renewable generation (which has been discussed earlier). Studies have noted that carbon emissions reduction (and other fossil fuel-fired related pollution abatement) can have substantial impacts air quality and on the health of the population.[130,131] Some segments of the population have been found to have been affected

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[128] The White House - Briefing Room. *Fact Sheet: President Biden takes executive actions to tackle the climate crisis at home and abroad, create jobs and restore scientific integrity across federal government*. January 27, 2021.

[129] Blonsky, Michael et al. "Potential Impacts of Transportation and Building Electrification on the Grid: A Review of Electrification Projections and Their Effects on Grid Infrastructure, Operation, and Planning." *Springer Nature Switzerland AG*. 2019.

[130] The White House. "United States Mid-Century Strategy for Deep Decarbonization." November 2016.

[131] United States Environmental Protection Agency. "Particulate Matter (PM) Basics." Web.

disproportionately.[132] Carbon emissions have also been shown to elevate property damage, escalate energy bills, and worsen agricultural productivity.[133] These various negative costs, including human health costs, associated with unmitigated and uncontrolled carbon emissions is captured in the social cost of carbon ("SC-CO_2"). US federal agencies projected that the net present value of carbon dioxide mitigation benefits using the SC-CO_2 metric over the span of the next 40 years to range from $78 billion to $1.2 trillion globally.[134,135] Transmission investment that provides uncongested access to clean energy, especially in underprivileged communities where residents may not be able to afford to purchase their own DERs, can help address environmental justice issues and equality of economic opportunity.

[132] Thind, Maninder P. S. et al. "Fine Particulate Air Pollution from Electricity Generation in the US: Health Impacts by Race, Income and Geography." *Environmental Science and Technology*, 53 (2019): 14010-14019.

[133] United States Environmental Protection Agency. "The Social Cost of Carbon: Estimating the Benefits of Reducing Greenhouse Gas Emissions." January 2017.

[134] Ibid.

[135] The social cost of carbon is calculated worldwide as it is a global rather a region-specific environmental problem.

5 Recommendations around supportive Federal policies and stimulus measures

Introducing regulatory policies and economic stimulus measures that promote transmission investment offers a golden opportunity for accomplishing economic stimulus objectives, re-vitalizing local economies, and moving the needle on transformative decarbonization goals. The private sector has proven willing to invest in such infrastructure, as indicated by recent track record (e.g., $23.5 billion of spending on new transmission by major utilities in 2019) and definitive plans for the next 6-10 years ($83 billion in under construction projects and either Board-approved projects or recommended projects to regulators). In spite of the strong interest from investors, electric transmission investment is fraught with challenges and uncertainty.

Most obstacles to transmission investment that occur during the planning and approval stages can be grouped into three broad categories of issues:

- occasionally conflicting and unclear planning frameworks (particularly for projects located in multiple jurisdictions and involving multiple ISOs/RTOs);
- uncertainty in the regulatory protocols on the allowed return on investment and how the investment costs will be recouped from beneficiaries (transmission pricing policy and cost allocation); and,
- siting and permitting challenges (that frequently delay construction of otherwise beneficial projects).

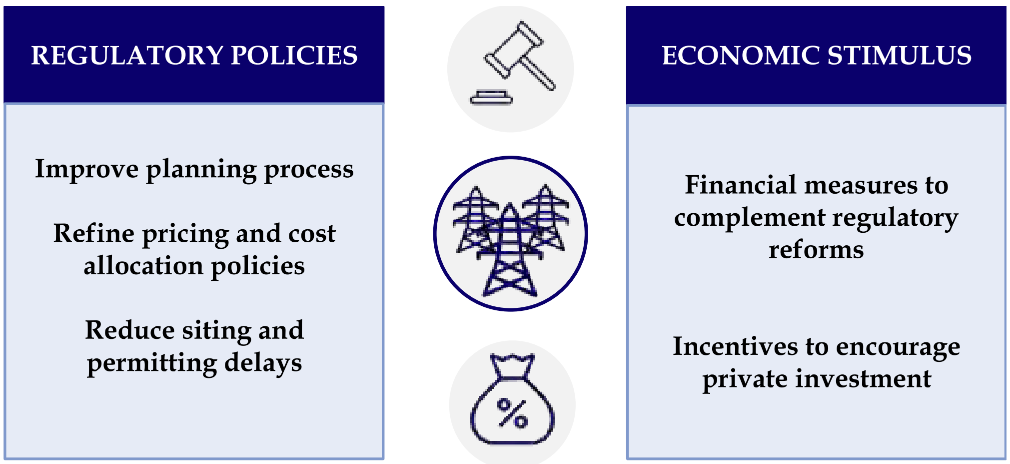
The economics and lifecycle of transmission investment contributes to those challenges due to (i) the large amounts of upfront capital required, (ii) the long period of time required to bring a proposed idea from the planning process through permitting and siting, and finally to construction, and (iii) the long lifetime of transmission assets (which means that recovery of the invested capital will also take a long time). These realities cannot be changed, but regulatory policy and economic stimulus measures could be adapted to mitigate these challenges and reduce the risk (and unnecessary cost) of undertaking such high upfront cost, but long-lived and beneficial, investment.

Public policy changes that streamline and stabilize regulatory frameworks for the development and construction of new transmission should seek to enhance investor confidence[136] and reduce the possibility of unnecessary risks (especially political and regulatory risks) and delay. Economic stimulus measures, for example, in the form of financial incentives and tax programs, would spur new technology applications and project designs. Incentives would also attract more investor

[136] *See* Zenghelis, Dimitri. *A strategy for restoring confidence and economic growth through green investment and innovation*. April 2012.

interest to the transmission sector, promoting innovation of various forms.[137] In the aggregate, such actions should lead to lower costs and greater benefits for consumers over time, but in the short-term, ensure that approved transmission projects move timely to construction, generating billions of dollars of economic activity and new jobs, as described in Section 4. Although a detailed proposal of regulatory and legislative programs is beyond the scope of this White Paper, LEI describes several recommendations for further consideration below (see Figure 37).

Figure 37. Policies and economic stimulus measures for promoting transmission investment



5.1 Regulatory policies

Improve planning process: The transmission sector faces significant obstacles in the regional and inter-regional planning processes, despite numerous state and local initiatives to move to a 'clean energy' power system. Given existing infrastructure age, condition, performance and local large customer interconnections, the majority of the investment dollars have been necessarily directed towards maintenance of the existing transmission network, and conventional local and reliability needs.[138] A recent study suggests that between 2010 and 2018, total investment in regionally-planned transmission actually *decreased* by 50%.[139] Despite Federal Energy Regulatory Commission´s ("FERC") Order 1000 mandating certain interregional planning requirements, to date no interregional transmission lines have been built pursuant to this order,[140] partially

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[137] *See* LEI. Economic Considerations in the Matter of Electric Transmission Incentives (FERC Docket No. RM20-10-000). July 1, 2020. pp. 26-27.

[138] Americans for a Clean Energy Grid. *Planning for the Future: FERC's Opportunity to Spur More Cost-Effective Transmission Infrastructure*. January 2021. pp. 25-26.

[139] Americans for a Clean Energy Grid. *Disconnected: the Need for a New Generator Interconnection Policy.* January 2021. p. 21.

[140] S&P Global Market Intelligence. *'The time has come' for FERC to act on interregional transmission, report argues*. January 27, 2021.

because existing generation interconnection processes address incremental transmission requirements to interconnect generation customers. This is especially concerning given the location of renewable resource potential and the dearth of transmission infrastructure to deliver the potential energy to market.[141] FERC must carefully consider policy decisions and their impact on advancing the administration's clean energy goals. Regulatory decisions can shift around risk and inadvertently disrupt the evolution of competitive markets. For example, the recently approved supplemental Notice of Proposed Rulemaking ("NOPR") would effectively eliminate the RTO/ISO participation adder.[142] Such a policy, if adopted, could inadvertently send a negative message to transmission owners about the benefits of remaining with an RTO/ISO, especially given the risks associated with relinquishment of control.

Congress could pass legislation that directs FERC to initiate a formal rulemaking on intra- and inter-regional planning.[143] FERC should consider regulatory reforms that target identification of beneficial transmission that aids in decarbonization of the economy, for example by incorporating dynamic generation queue data and trends into regional planning; incorporating local, state and corporate renewable energy targets and electrification assumptions into scenario planning; and considering the full range of net benefits that a transmission project provides, including the economic value of decarbonization, resiliency, and achievement of other public policies (such as economic and environmental justice). The textbox presented in the next page provides a brief case-study on the success of reforms undertaken in Europe that had a similar goal for bring about more investment in transmission across borders, especially with regards to streamlining permitting and accelerating construction, in order to achieve overarching policy goals like carbon emissions reduction.

Refine transmission pricing and cost allocation policies: In order to encourage efficient investment, Congress can urge Federal regulators to adopt economic and financial factors that reduce regulatory risks around transmission economics. For long-lived assets that produce services for customers over many years, stability in economic regulation is of paramount importance. In concert with inter-regional planning reforms, FERC should look for ways to clarify and upgrade cost allocation frameworks (with an aim to avoid negotiating stalemates when multiple regions and constituents are involved). Congress could also give guidance to FERC to pursue commercially-reasonable ROE incentives to promote transmission investment. ROE incentives would still not represent direct federal funding, as ROE-related cost factors would be paid by customers in rates.

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141 See Brown, Patrick R. and Audun Botterud. "The value of inter-regional coordination and transmission in decarbonizing the US electricity system." *Joule* 5.1 (January 2021): 115-134. Digital.

142 FERC. "Electric Transmission Incentives Policy Under Section 219 of the Federal Power Act". *Supplemental notice of proposed rulemaking*. April 15, 2021. Docket No. RM-10-000.

143 Legislation to similar effect was introduced in the House and Senate during the 116th Congress, and was referred to relevant committees in each body. Legislation introduced during the 117th Congress has also recommended planning reforms.

European experience with transmission regulatory reforms

In 2013, the European Union ("EU") adopted the Trans-European Networks – Energy ("TEN-E") Regulation to encourage cross-border energy projects in Europe (including electricity, gas, and oil). At the time, the EU was experiencing lagging levels of investment, with particular concern regarding large cross-border projects. Under the TEN-E regulation, twelve regional groups selected infrastructure projects that had pan-European benefits, called Projects of Common Interest ("PCIs"). PCIs are able to access accelerated planning and permit granting, streamlined bureaucratic processes, and increased visibility to investors. EU member states must designate a competent authority (also known as a "one-stop shop") to coordinate and facilitate the permitting process. The regulation also requires EU member states to provide dedicated investment incentives for PCIs facing higher project risks. The TEN-E Regulation has had a positive impact on the lead time of permitting for PCIs. In a 2018 evaluation of the TEN-E, 35% of project promoters surveyed indicated that their projects had seen accelerated progress as a result of the TEN-E Regulation. Furthermore, the TEN-E Regulation was found to have helped advance the EU's 2020 climate and energy targets by promoting renewable energy integration.

Source: Florence School of Regulation. *The TEN-E Regulation*. May 26, 2020.; Schittekatte, Tim et al. "Making the TEN-E Regulation Compatible with the Green Deal: Eligibility, Selection and Cost Allocation for PCIs." *European University Institute Robert Schuman Centre for Advanced Studies Policy Brief* – Issue 2020/27. July 2020.; Trinomics for the European Commission. *Evaluation of the TEN-E Regulation and Assessing the Impacts of Alternative Policy Scenarios.* February 27, 2018.

Reduce delays caused by siting and permitting: Congress should consider approaches for streamlining and de-risking the siting and permitting process for transmission. Differentiating and prioritizing challenges with comprehensive analysis of measurable and verifiable costs and benefits would go a long way toward a more efficient process. An example of beneficial efforts being undertaken recently include the US Department of Transportation's commitment "to facilitate the use of public highways and other transportation rights-of-way to speed the siting and permitting of transmission lines."[144] The Federal government can also contribute toward this goal by learning from economic theory and practices being implemented elsewhere for reaching settlement (see a short explanation of *Coase Theory* in the textbox below). In addition, formulating a framework for information disclosure could also facilitate and expedite siting and permitting.[145] Overall, any permitting and siting policy should recognize the legitimate concerns and opposition from project stakeholders, including state policymakers and regulators, but also ensure that beneficial investments are not held back. Tackling inefficient siting and permitting would also go a long way to meeting the directive that President Biden gave to his administration

[144] The White House - Briefing Room. *Fact Sheet: Biden Administration Advances Expansion & Modernization of the Electric Grid.* April 27, 2021.

[145] For example, New York state has recently taken measures to accelerate and streamline the permitting of major renewable energy generation facilities by adopting Uniform Standards and Conditions for siting permits. (Source: New York State Department of State – Division of Administrative Rules. *New York State Register – Vol. XLIII Issue 9*. March 3, 2021.)

in order to "accelerate clean energy and transmission projects under federal siting and permitting processes in an environmentally sustainable manner."[146]

Ronald Coase and Social Cost

Nobel prize-winning economist Ronald Coase is well-known for his discussion of social costs and externalities (i.e., negative outcomes of an activity that primarily affect other parties). Coase observed that an optimal allocation of social cost may be achievable through bargaining and payment between affected parties. The theory has been put into practice in various contentious settings involving landowner disputes and, in some cases, government intervention has been shown to be more effective to resolve disputes, for example, when property rights are weakly defined or transaction costs are high for some parties.

To address allegations of negative impact from proposed transmission projects, Federal regulators can use the basic elements of the Coast Theory to design a framework for settling disputes and addressing verifiable issues of negative impacts, while improving overall social welfare (economic well-being). Such a framework should include an identification of affected parties, a rigorous and independent expert review of the negative externalities that stakeholders may face, and an opportunity for negotiation and compensation between the developer and affected parties to resolve issues. Such a process could alleviate barriers to the siting and permitting of large-scale projects, while also improving outcomes for aggrieved parties.

Sources: Coase, R. H. "The Problem of Social Cost." *The Journal of Law & Economics* 3 (October 1960).

5.2 Economic stimulus measures

Various economic stimulus programs and financial measures can complement regulatory reforms to encourage transmission investment. For example, recognizing the success of the ITC and PTC in promoting deployment of renewable energy technologies, Congress could encourage transmission investment by passing tax programs that incentivize beneficial transmission investment. Federally-backed financial incentives could also be helpful for motivating the private sector to tackle regionally-significant but complex transmission projects, or projects delivering on targeted goals of decarbonization or other important drivers (e.g., resiliency). For instance, the DOE recently announced the availability of two loan programs totaling $8.25 billion to foster transmission investment. [147] In designing such incentives, policymakers should ensure that

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[146] The White House - Briefing Room. *Fact Sheet: President Biden takes executive actions to tackle the climate crisis at home and abroad, create jobs and restore scientific integrity across federal government*. January 27, 2021.

[147] The White House - Briefing Room. *Fact Sheet: Biden Administration Advances Expansion & Modernization of the Electric Grid.* April 27, 2021. This includes $3.5 billion allocated through the Western Area Power Administration ("WAPA") transmission infrastructure fund to transmission projects that release renewable energy in the West, and $5 billion directly assigned by DOE Loan Programs Office to support innovative transmission projects (i.e., high-voltage direct current systems), as well as transmission lines located along routes and rails and facilities that connect offshore wind.

benefits outweigh the costs, and that stimulus measures seek to promote the role of private-sector spending in the transmission sector.

5.3 Concluding remarks

LEI's recommendations are designed to address major obstacles to transmission investment, particularly as they relate to regulatory uncertainty and costly deferral of otherwise beneficial investment. Supporting transmission investment in this way can help stimulate the economy (both GDP and employment) while also positively affecting longer-term objectives, most notably carbon emissions reductions and other environmental goals, as well as economic justice considerations.

6 Appendix A: Background on London Economics International LLC

LEI is a global economic, financial, and strategic advisory professional services firm specializing in energy and infrastructure. The firm combines detailed understanding of specific network and commodity industries, such as electricity generation, transmission and distribution, with a suite of proprietary quantitative models to produce reliable and comprehensible results. LEI's areas of expertise are briefly described in Figure 38.

Figure 38. LEI's areas of expertise

The firm has its roots in advising on the initial round of privatization of electricity, gas, and water companies in the UK. Since then, LEI has advised private sector clients, market institutions, and governments on privatization, asset valuation, deregulation, tariff design, market power, strategy, and strategy development in virtually all deregulated markets worldwide, including the United States, Canada, Europe, Asia, Latin America, Africa, and the Middle East. LEI is active across the power sector value chain and has a comprehensive understanding of the issues faced by investors, utilities, and regulators.

The following attributes make LEI unique:

- *clear, readable deliverables that are* grounded in substantial topical and quantitative evidence;
- *internally developed proprietary models* for electricity price forecasting (energy, capacity, RECs, GHGs credits, etc.) that incorporate a detailed assessment of fundamentals, game theory, real options valuation, Monte Carlo simulation, and sophisticated statistical techniques;
- *a balance of private and public sector clients* enables LEI to effectively advise both regarding the impact of regulatory initiatives on private investment and the extent of possible regulatory responses to individual firm actions; and
- *worldwide experience* backed by a multilingual and multicultural staff.

7 Appendix B: Overview of RIMS II multipliers

According to BEA, RIMS-II multipliers are a type of Input-Output ("I-O") multipliers, used to estimate the cross-industry effects that an initial change in final demand has over the economy.[148] Like Keynesian (macroeconomic) multipliers[149], I-O multipliers consider how an initial shift in final demand impacts spending by firms and individuals. Macroeconomics multipliers rely on assumptions related to individuals' behaviors and wide economic activity measures, while I-O multipliers depend on a disaggregated set of industry accounts that estimate the production of each industry and its consumption among industries and final users.

Derived from national I-O tables, such as the make, use and import tables, RIMS II multipliers are adjusted to regional or local economic conditions and income and consumption household data to offer four kinds of final-demand multipliers,[150] namely, *output* (sales), *value-added* (GDP), *earnings*, and *employment* (full and part-time jobs).[151] Each of these four final-demand multipliers measures the total impact on the specific variable per dollar of change in final demand. For instance, the value-added multiplier represents the total dollar variation in the value added that arises in all industries due to an additional dollar shift in the final demand of the industry under consideration.

Furthermore, RIMS II multipliers cover both type I and II impacts. Type I multipliers account for the *inter-industry effects*, which is the cumulative effects resulting from the acquisition of intermediate inputs made by the industries directly affected (direct) and the subsequent purchase of intermediate inputs made by the supporting industries (indirect). Type II multipliers include direct and indirect effects, and the *household-spending effects*, also known as induced effects. These additional effects can be attributed to worker´s spending habits being affected by the final change in demand.

Using RIMS II multipliers requires identification of three main factors – the dollar amount of the final demand change, the industries through which this shift will be channeled, and the region where this change will be applied. The accuracy of the results of the impact analysis using RIMS II multipliers will depend on the breakdown of the initial dollar amount among identified industries, which in turn is limited by data availability and BEA industry classification.

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148 BEA. RIMS II - *An essential tool for regional developers and planners*. May 2018.

149 Keynesian multipliers have been used to describe how an initial increase in government spending contribute through multiple spending cycles to enhance economic activity.

150 RIMS II also provides two sorts of direct-effect multipliers - earnings and employment - that can be used to estimate the total impact of a change in final demand, if additional information on the linkage between those variables and final demand is available.

151 RIMS II employment multipliers are not expressed in terms of full-time equivalent employment.

8 Appendix C: Detailed results by region

The tables below have the purpose of illustrating the industry breakdown of the economic impact in terms of GDP increase and job gains of each of the stages calculated (installation, domestic manufacturing, and O&M) at a regional and national level.

8.1 Economic impact of the installation, domestic manufacturing, and O&M stages on GDP by multiplier type

Figure 39. Installation and domestic manufacturing effects on GDP using type I multipliers by industry and region

Industry	Region									Supply-chain	US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC		
Agriculture, forestry, fishing and hunting	$0.2	$0.5	$0.3	$6.6	$0.0	$5.1	$1.0	$1.0	$2.3	$7.0	**$23.9**
Mining, quarrying, and oil and gas extraction	$3.4	$27.6	$1.6	$45.8	$12.6	$63.6	$6.1	$11.8	$21.7	$26.4	**$220.7**
Utilities	$4.8	$14.6	$2.9	$31.9	$23.2	$65.2	$6.4	$5.2	$11.9	$142.7	**$308.8**
Construction	$333.2	$512.3	$164.3	$1,048.6	$1,216.8	$2,209.8	$230.4	$193.3	$502.4	$24.5	**$6,435.6**
Durable goods manufacturing	$199.9	$342.4	$106.4	$748.2	$713.8	$1,618.8	$163.1	$125.4	$313.2	$5,416.6	**$9,747.7**
Nondurable goods manufacturing	$17.8	$50.5	$7.5	$122.9	$25.3	$224.5	$18.0	$18.3	$31.1	$245.5	**$761.5**
Wholesale trade	$38.0	$85.5	$21.2	$171.8	$124.9	$360.5	$36.4	$27.3	$68.0	$736.7	**$1,670.2**
Retail trade	$5.0	$10.7	$3.0	$22.4	$14.3	$47.4	$4.9	$3.9	$10.2	$47.0	**$168.6**
Transportation and warehousing	$12.7	$34.7	$5.0	$73.1	$28.9	$158.0	$15.4	$11.1	$28.1	$281.8	**$648.8**
Information	$11.0	$16.0	$4.8	$24.1	$34.2	$67.4	$8.1	$4.1	$17.2	$127.8	**$314.7**
Finance and insurance	$12.9	$32.8	$8.4	$56.5	$63.7	$147.9	$13.7	$8.5	$23.0	$259.7	**$627.1**
Real estate and rental and leasing	$25.2	$44.1	$11.0	$62.4	$76.6	$169.9	$18.7	$9.7	$37.8	$262.6	**$718.1**
Professional, scientific, and technical services	$149.4	$236.4	$73.7	$455.7	$520.1	$1,031.6	$103.3	$79.8	$221.5	$1,942.9	**$4,814.2**
Management of companies and enterprises	$11.8	$21.9	$6.7	$50.1	$40.6	$106.7	$9.2	$7.7	$16.9	$170.6	**$442.1**
Adm. and support and waste management and remediation services	$34.3	$60.9	$16.0	$112.5	$119.7	$258.3	$27.2	$18.6	$54.6	$483.2	**$1,185.3**
Educational services	$0.4	$0.8	$0.2	$1.6	$1.5	$3.5	$0.3	$0.2	$0.7	$5.6	**$14.9**
Health care and social assistance	$0.2	$0.5	$0.1	$1.0	$0.8	$2.2	$0.2	$0.2	$0.4	$1.6	**$7.2**
Arts, entertainment, and recreation	$2.1	$1.6	$0.5	$2.5	$6.9	$7.2	$1.0	$0.3	$1.5	$18.3	**$42.0**
Accommodation	$1.4	$1.7	$0.6	$3.6	$4.2	$7.6	$1.1	$0.5	$2.1	$19.7	**$42.5**
Food services and drinking places	$2.4	$4.1	$1.1	$6.9	$7.5	$17.1	$1.8	$1.1	$3.7	$33.2	**$79.0**
Other services	$5.2	$11.1	$2.5	$20.1	$12.5	$47.7	$4.6	$3.6	$9.8	$66.6	**$183.6**
Households	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total Impact	**$871.2**	**$1,510.5**	**$437.9**	**$3,068.2**	**$3,048.0**	**$6,619.8**	**$671.0**	**$531.6**	**$1,378.0**	**$10,320.2**	**$28,456.4**
2019 Utilities GDP in current-dollar	$42,029.7	$27,826.9	$16,584.9	$37,346.6	$20,286.7	$67,943.4	$46,432.5	$18,615.5	$23,653.7	$300,719.8	**$300,719.8**
Total Impact / 2019 Utilities GDP in current-dollar	**2.1%**	**5.4%**	**2.6%**	**8.2%**	**15.0%**	**9.7%**	**1.4%**	**2.9%**	**5.8%**	**3.4%**	**9.5%**

Figure 40. Installation and domestic manufacturing effects on GDP using type II multipliers by industry and region

Industry	Region									Supply-chain	US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC		
Agriculture, forestry, fishing and hunting	$2.3	$4.0	$0.6	$23.3	$1.5	$23.1	$2.8	$3.6	$8.3	$35.2	**$104.6**
Mining, quarrying, and oil and gas extraction	$3.9	$38.1	$1.6	$54.7	$12.6	$73.3	$6.4	$15.0	$29.0	$31.4	**$266.2**
Utilities	$12.4	$36.6	$7.0	$69.5	$50.4	$153.2	$15.2	$11.7	$30.0	$281.6	**$667.6**
Construction	$336.2	$518.8	$165.6	$1,056.9	$1,223.9	$2,234.2	$232.9	$194.7	$508.1	$66.1	**$6,537.6**
Durable goods manufacturing	$205.0	$352.5	$108.9	$780.6	$721.2	$1,692.8	$169.5	$128.9	$322.4	$5,517.0	**$9,998.7**
Nondurable goods manufacturing	$33.4	$78.6	$13.5	$202.4	$54.7	$402.1	$31.6	$27.9	$53.1	$460.6	**$1,357.9**
Wholesale trade	$55.0	$128.5	$29.7	$249.7	$165.4	$537.0	$53.5	$39.3	$101.1	$1,006.8	**$2,366.0**
Retail trade	$40.3	$83.9	$21.0	$151.1	$103.1	$354.9	$37.3	$24.6	$75.9	$555.8	**$1,447.9**
Transportation and warehousing	$22.2	$58.3	$8.1	$113.3	$47.6	$261.7	$25.2	$16.4	$47.1	$436.3	**$1,036.5**
Information	$27.5	$45.6	$12.4	$62.9	$75.7	$186.7	$22.1	$10.5	$45.8	$347.9	**$837.1**
Finance and insurance	$40.9	$108.7	$26.8	$167.7	$182.6	$474.2	$43.1	$23.0	$71.6	$721.9	**$1,860.4**
Real estate and rental and leasing	$109.5	$210.3	$49.0	$244.5	$316.3	$799.3	$90.2	$36.0	$178.4	$1,387.8	**$3,421.3**
Professional, scientific, and technical services	$170.1	$278.9	$83.7	$509.0	$574.7	$1,219.8	$120.2	$87.1	$251.5	$2,209.4	**$5,504.4**
Management of companies and enterprises	$18.3	$35.5	$10.1	$76.5	$57.4	$171.6	$14.8	$11.4	$26.8	$258.7	**$681.2**
Adm. and support and waste management and remediation services	$45.1	$86.0	$20.7	$146.1	$147.3	$358.5	$37.9	$23.2	$74.3	$652.0	**$1,591.2**
Educational services	$9.2	$17.5	$4.7	$32.6	$27.6	$76.7	$7.2	$5.0	$15.2	$112.8	**$308.6**
Health care and social assistance	$47.8	$107.4	$29.6	$207.2	$149.8	$482.6	$48.0	$35.0	$93.5	$752.5	**$1,953.2**
Arts, entertainment, and recreation	$9.0	$9.8	$2.9	$18.6	$23.4	$53.0	$5.6	$2.7	$10.5	$90.6	**$226.1**
Accommodation	$6.9	$9.6	$3.1	$19.2	$18.7	$41.3	$5.8	$2.7	$11.5	$93.8	**$212.6**
Food services and drinking places	$17.0	$32.8	$7.6	$53.8	$44.8	$131.5	$14.1	$8.8	$28.5	$227.0	**$565.8**
Other services	$22.6	$45.6	$10.3	$76.0	$56.3	$198.4	$18.6	$13.1	$40.3	$286.9	**$768.0**
Households	$0.7	$1.5	$0.4	$2.7	$2.3	$6.5	$0.7	$0.5	$1.3	$10.0	**$26.5**
Total Impact	**$1,235.5**	**$2,288.5**	**$617.2**	**$4,318.0**	**$4,057.2**	**$9,932.4**	**$1,002.9**	**$721.4**	**$2,024.2**	**$15,542.1**	**$41,739.4**
2019 Utilities GDP in current-dollar	$42,029.7	$27,826.9	$16,584.9	$37,346.6	$20,286.7	$67,943.4	$46,432.5	$18,615.5	$23,653.7	$300,719.8	**$300,719.8**
Total Impact / 2019 Utilities GDP in current-dollar	**2.9%**	**8.2%**	**3.7%**	**11.6%**	**20.0%**	**14.6%**	**2.2%**	**3.9%**	**8.6%**	**5.2%**	**13.9%**

Figure 41. O&M effects on GDP using type I multipliers by industry and region

Industry	Region									US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC	
Agriculture, forestry, fishing and hunting	$0.0	$0.0	$0.0	$0.1	$0.0	$0.2	$0.0	$0.0	$0.0	**$0.4**
Mining, quarrying, and oil and gas extraction	$0.4	$7.6	$0.0	$9.4	$0.1	$17.8	$0.6	$2.8	$6.4	**$45.1**
Utilities	$51.9	$82.3	$43.2	$143.3	$155.3	$354.0	$28.7	$24.7	$64.1	**$947.5**
Construction	$0.8	$1.5	$0.6	$2.4	$2.0	$5.8	$0.5	$0.5	$1.2	**$15.3**
Durable goods manufacturing	$0.2	$0.7	$0.2	$1.4	$0.4	$3.2	$0.2	$0.2	$0.5	**$7.1**
Nondurable goods manufacturing	$0.7	$1.6	$0.2	$3.0	$0.3	$5.5	$0.2	$0.5	$0.9	**$12.8**
Wholesale trade	$0.8	$2.0	$0.7	$3.2	$2.0	$7.7	$0.6	$0.5	$1.4	**$18.8**
Retail trade	$0.3	$0.7	$0.3	$1.2	$0.6	$2.9	$0.2	$0.2	$0.6	**$6.9**
Transportation and warehousing	$1.5	$4.6	$0.9	$7.5	$2.6	$17.1	$1.1	$1.3	$3.0	**$39.4**
Information	$0.6	$0.9	$0.4	$1.1	$1.5	$3.6	$0.3	$0.2	$0.8	**$9.4**
Finance and insurance	$0.9	$2.5	$1.0	$3.5	$3.7	$10.2	$0.7	$0.6	$1.5	**$24.7**
Real estate and rental and leasing	$1.1	$2.0	$0.7	$2.1	$2.8	$7.2	$0.6	$0.3	$1.5	**$18.4**
Professional, scientific, and technical services	$2.1	$4.2	$1.7	$5.2	$6.1	$17.4	$1.1	$0.8	$2.8	**$41.5**
Management of companies and enterprises	$0.2	$0.7	$0.2	$1.1	$0.6	$2.6	$0.1	$0.2	$0.5	**$6.3**
Adm. and support and waste management and remediation services	$1.8	$3.6	$1.2	$4.9	$5.1	$13.5	$1.2	$0.7	$2.4	**$34.3**
Educational services	$0.1	$0.1	$0.1	$0.2	$0.2	$0.4	$0.0	$0.0	$0.1	**$1.1**
Health care and social assistance	$0.0	$0.0	$0.0	$0.0	$0.0	$0.1	$0.0	$0.0	$0.0	**$0.1**
Arts, entertainment, and recreation	$0.1	$0.1	$0.0	$0.1	$0.2	$0.4	$0.0	$0.0	$0.1	**$0.9**
Accommodation	$0.1	$0.1	$0.1	$0.2	$0.3	$0.6	$0.1	$0.0	$0.1	**$1.7**
Food services and drinking places	$0.2	$0.4	$0.2	$0.6	$0.7	$1.6	$0.1	$0.1	$0.3	**$4.3**
Other services	$1.3	$2.1	$0.6	$2.5	$2.5	$8.0	$0.5	$0.6	$1.6	**$19.8**
Households	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	**$0.0**
Total Impact	**$65.1**	**$117.8**	**$52.1**	**$193.1**	**$186.9**	**$479.7**	**$37.0**	**$34.3**	**$89.7**	**$1,255.7**
2019 Utilities GDP in current-dollar	$42,029.7	$27,826.9	$16,584.9	$37,346.6	$20,286.7	$67,943.4	$46,432.5	$18,615.5	$23,653.7	**$300,719.8**
Total Impact / 2019 Utilities GDP in current-dollar	**0.2%**	**0.4%**	**0.3%**	**0.5%**	**0.9%**	**0.7%**	**0.1%**	**0.2%**	**0.4%**	**0.4%**

Figure 42. O&M effects on GDP using type II multipliers by industry and region

Industry	Region									US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC	
Agriculture, forestry, fishing and hunting	$0.1	$0.2	$0.0	$0.7	$0.1	$0.9	$0.1	$0.1	$0.3	**$2.5**
Mining, quarrying, and oil and gas extraction	$0.4	$8.0	$0.0	$9.8	$0.1	$18.2	$0.6	$2.9	$6.7	**$46.7**
Utilities	$52.2	$83.3	$43.5	$144.7	$156.1	$357.8	$29.0	$25.0	$64.8	**$956.4**
Construction	$0.9	$1.8	$0.7	$2.7	$2.2	$6.8	$0.6	$0.5	$1.4	**$17.7**
Durable goods manufacturing	$0.5	$1.2	$0.4	$2.6	$0.6	$6.4	$0.4	$0.4	$0.8	**$13.2**
Nondurable goods manufacturing	$1.4	$2.9	$0.5	$5.9	$1.3	$13.0	$0.6	$0.9	$1.7	**$28.1**
Wholesale trade	$1.5	$4.0	$1.2	$6.1	$3.3	$15.1	$1.1	$1.0	$2.6	**$36.0**
Retail trade	$1.8	$4.1	$1.4	$5.9	$3.6	$15.8	$1.2	$1.0	$3.1	**$37.9**
Transportation and warehousing	$1.9	$5.7	$1.1	$8.9	$3.2	$21.4	$1.4	$1.5	$3.7	**$48.8**
Information	$1.3	$2.3	$0.9	$2.5	$2.9	$8.6	$0.8	$0.4	$1.9	**$21.5**
Finance and insurance	$2.1	$6.1	$2.1	$7.6	$7.6	$24.0	$1.6	$1.1	$3.4	**$55.7**
Real estate and rental and leasing	$4.6	$9.8	$3.2	$8.8	$10.8	$33.8	$2.8	$1.3	$6.8	**$81.9**
Professional, scientific, and technical services	$3.0	$6.2	$2.4	$7.1	$7.9	$25.3	$1.7	$1.1	$3.9	**$58.7**
Management of companies and enterprises	$0.5	$1.4	$0.4	$2.1	$1.2	$5.4	$0.3	$0.3	$0.8	**$12.4**
Adm. and support and waste management and remediation services	$2.3	$4.7	$1.5	$6.2	$6.0	$17.7	$1.5	$0.8	$3.2	**$43.9**
Educational services	$0.4	$0.9	$0.3	$1.3	$1.0	$3.5	$0.2	$0.2	$0.6	**$8.6**
Health care and social assistance	$2.0	$5.0	$1.9	$7.5	$4.9	$20.3	$1.5	$1.3	$3.6	**$48.1**
Arts, entertainment, and recreation	$0.4	$0.5	$0.2	$0.7	$0.7	$2.3	$0.2	$0.1	$0.4	**$5.4**
Accommodation	$0.3	$0.5	$0.2	$0.8	$0.8	$2.0	$0.2	$0.1	$0.5	**$5.5**
Food services and drinking places	$0.9	$1.8	$0.6	$2.3	$1.9	$6.4	$0.5	$0.4	$1.3	**$16.1**
Other services	$2.0	$3.7	$1.1	$4.5	$4.0	$14.4	$1.0	$1.0	$2.8	**$34.5**
Households	$0.0	$0.1	$0.0	$0.1	$0.1	$0.3	$0.0	$0.0	$0.1	**$0.7**
Total Impact	**$80.6**	**$154.2**	**$63.7**	**$238.8**	**$220.3**	**$619.4**	**$47.4**	**$41.4**	**$114.5**	**$1,580.2**
2019 Utilities GDP in current-dollar	$42,029.7	$27,826.9	$16,584.9	$37,346.6	$20,286.7	$67,943.4	$46,432.5	$18,615.5	$23,653.7	**$300,719.8**
Total Impact / 2019 Utilities GDP in current-dollar	**0.2%**	**0.6%**	**0.4%**	**0.6%**	**1.1%**	**0.9%**	**0.1%**	**0.2%**	**0.5%**	**0.5%**

8.2 Economic impact of the installation, domestic manufacturing and O&M stages on employment by multiplier type

Figure 43. Installation and domestic manufacturing effects on employment using type I multipliers by industry and region

Industry	Region									Supply-chain	US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC		
Agriculture, forestry, fishing and hunting	3	15	5	130	6	106	20	21	40	148	**495**
Mining, quarrying, and oil and gas extraction	23	143	13	253	73	367	35	58	111	152	**1,228**
Utilities	10	29	6	68	42	139	15	11	25	323	**667**
Construction	2,799	4,573	1,443	9,467	9,266	20,377	2,487	1,772	4,519	325	**57,027**
Durable goods manufacturing	1,518	3,157	955	6,651	7,063	14,362	1,538	1,117	2,658	50,358	**89,376**
Nondurable goods manufacturing	121	318	57	799	180	1,540	134	120	208	1,955	**5,432**
Wholesale trade	200	459	111	929	568	1,947	211	151	368	4,275	**9,220**
Retail trade	68	159	41	345	186	727	77	59	146	771	**2,579**
Transportation and warehousing	182	495	76	976	404	2,179	223	153	391	4,068	**9,148**
Information	51	89	25	141	131	372	48	25	82	776	**1,738**
Finance and insurance	75	241	48	369	275	970	97	55	147	1,942	**4,220**
Real estate and rental and leasing	161	316	91	443	428	1,275	174	75	267	2,522	**5,752**
Professional, scientific, and technical services	1,446	2,344	735	4,813	4,177	10,655	1,228	867	2,277	24,659	**53,201**
Management of companies and enterprises	73	180	40	339	207	670	70	56	118	1,294	**3,047**
Adm. and support and waste management and remediation services	498	1,050	232	1,853	1,522	4,269	525	297	865	9,243	**20,355**
Educational services	7	13	4	28	22	61	6	4	12	102	**260**
Health care and social assistance	2	6	2	11	9	25	3	2	5	14	**78**
Arts, entertainment, and recreation	31	40	10	63	96	174	28	9	31	502	**984**
Accommodation	17	27	8	56	48	110	15	8	29	277	**596**
Food services and drinking places	61	113	29	209	184	507	54	33	100	978	**2,269**
Other services	67	167	35	307	168	679	77	53	132	1,152	**2,837**
Households	0	0	0	0	0	0	0	0	0	0	**0**
Total Impact	**7,415**	**13,933**	**3,965**	**28,249**	**25,054**	**61,512**	**7,064**	**4,947**	**12,531**	**105,836**	**270,506**
2019 Utilities Employment in number of jobs	53,291	45,249	22,202	56,934	25,294	92,904	64,949	28,578	41,908	431,309	**431,309**
Total Impact / 2019 Utilities Employment in number of jobs	**13.9%**	**30.8%**	**17.9%**	**49.6%**	**99.1%**	**66.2%**	**10.9%**	**17.3%**	**29.9%**	**24.5%**	**62.7%**

Figure 44. Installation and domestic manufacturing effects on employment using type II multipliers by industry and region

Industry	Region									Supply-chain	US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC		
Agriculture, forestry, fishing and hunting	48	131	17	555	70	604	64	86	189	851	**2,617**
Mining, quarrying, and oil and gas extraction	26	181	13	290	73	421	37	70	140	181	**1,433**
Utilities	25	72	15	150	93	329	35	26	63	641	**1,447**
Construction	2,831	4,649	1,456	9,562	9,331	20,653	2,522	1,788	4,584	876	**58,251**
Durable goods manufacturing	1,559	3,249	976	6,943	7,124	15,031	1,601	1,153	2,742	51,341	**91,719**
Nondurable goods manufacturing	251	579	107	1,485	389	3,019	260	217	431	3,930	**10,669**
Wholesale trade	290	690	156	1,350	752	2,899	311	218	548	5,842	**13,055**
Retail trade	678	1,572	364	2,862	1,668	6,744	734	468	1,325	11,116	**27,531**
Transportation and warehousing	337	868	137	1,600	702	3,887	373	239	695	6,442	**15,279**
Information	129	246	63	359	294	1,012	130	62	220	2,064	**4,579**
Finance and insurance	296	937	165	1,156	880	3,499	348	156	522	5,891	**13,851**
Real estate and rental and leasing	783	1,719	473	2,045	1,991	6,830	972	337	1,417	15,075	**31,643**
Professional, scientific, and technical services	1,643	2,779	835	5,387	4,610	12,600	1,431	951	2,591	27,849	**60,674**
Management of companies and enterprises	113	292	61	519	292	1,079	112	84	187	1,961	**4,699**
Adm. and support and waste management and remediation services	700	1,599	318	2,556	1,989	6,327	779	393	1,257	13,232	**29,150**
Educational services	171	352	86	671	465	1,509	149	109	307	2,351	**6,169**
Health care and social assistance	679	1,546	400	3,022	1,978	6,948	703	511	1,339	11,029	**28,154**
Arts, entertainment, and recreation	154	255	60	429	380	1,186	156	67	211	2,508	**5,404**
Accommodation	86	150	41	292	216	594	82	44	157	1,336	**2,998**
Food services and drinking places	443	899	197	1,577	1,086	3,841	421	256	766	6,755	**16,241**
Other services	351	817	179	1,387	892	3,449	368	226	659	5,734	**14,063**
Households	56	130	28	240	151	512	53	42	101	840	**2,153**
Total Impact	**11,648**	**23,713**	**6,145**	**44,438**	**35,424**	**102,972**	**11,641**	**7,503**	**20,452**	**177,844**	**441,779**
2019 Utilities Employment in number of jobs	53,291	45,249	22,202	56,934	25,294	92,904	64,949	28,578	41,908	431,309	**431,309**
Total Impact / 2019 Utilities Employment in number of jobs	**21.9%**	**52.4%**	**27.7%**	**78.1%**	**140.0%**	**110.8%**	**17.9%**	**26.3%**	**48.8%**	**41.2%**	**102.4%**

Figure 45. O&M effects on employment using type I multipliers by industry and region

Industry	Region									US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC	
Agriculture, forestry, fishing and hunting	0	1	0	3	0	4	0	1	1	**9**
Mining, quarrying, and oil and gas extraction	3	29	0	42	1	88	3	11	26	**202**
Utilities	105	163	90	302	283	737	64	54	134	**1,932**
Construction	9	17	7	28	19	67	6	5	13	**171**
Durable goods manufacturing	2	6	2	13	3	29	2	2	4	**63**
Nondurable goods manufacturing	5	10	1	19	3	38	2	3	6	**87**
Wholesale trade	4	11	3	17	9	42	3	3	7	**100**
Retail trade	5	12	4	20	9	50	4	3	9	**116**
Transportation and warehousing	16	44	10	69	29	170	12	12	29	**390**
Information	3	5	2	6	6	20	2	1	4	**48**
Finance and insurance	5	17	5	20	14	60	4	3	9	**137**
Real estate and rental and leasing	7	15	7	16	17	59	6	3	11	**141**
Professional, scientific, and technical services	17	36	14	46	40	150	12	7	24	**347**
Management of companies and enterprises	1	6	1	7	3	16	1	1	3	**41**
Adm. and support and waste management and remediation services	37	83	24	115	92	308	30	15	53	**757**
Educational services	1	2	1	3	3	8	1	1	2	**21**
Health care and social assistance	0	0	0	0	0	0	0	0	0	**1**
Arts, entertainment, and recreation	1	2	1	2	3	8	1	0	1	**19**
Accommodation	1	2	1	4	3	8	1	1	2	**23**
Food services and drinking places	6	11	5	17	17	47	4	3	8	**118**
Other services	9	17	5	22	18	66	5	5	13	**159**
Households	0	0	0	0	0	0	0	0	0	**0**
Total Impact	**237**	**488**	**182**	**773**	**571**	**1,975**	**164**	**135**	**358**	**4,883**
2019 Utilities Employment in number of jobs	53,291	45,249	22,202	56,934	25,294	92,904	64,949	28,578	41,908	**431,309**
Total Impact / 2019 Utilities Employment in number of jobs	**0.4%**	**1.1%**	**0.8%**	**1.4%**	**2.3%**	**2.1%**	**0.3%**	**0.5%**	**0.9%**	**1.1%**

Figure 46. O&M effects on employment using type II multipliers by industry and region

Industry	Region									US
	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SERC	SPP	WECC	
Agriculture, forestry, fishing and hunting	2	6	1	18	2	25	2	3	6	**65**
Mining, quarrying, and oil and gas extraction	3	31	0	44	1	90	3	11	27	**209**
Utilities	105	165	90	305	285	745	65	54	135	**1,950**
Construction	10	21	7	31	21	79	7	6	16	**198**
Durable goods manufacturing	4	10	3	24	5	57	4	4	8	**118**
Nondurable goods manufacturing	10	22	5	44	10	101	5	7	14	**218**
Wholesale trade	8	22	6	33	15	82	6	5	14	**192**
Retail trade	30	78	25	112	59	303	25	19	54	**705**
Transportation and warehousing	23	61	14	92	39	242	17	15	40	**542**
Information	6	13	5	14	11	47	4	3	9	**111**
Finance and insurance	14	49	12	49	34	166	12	7	23	**368**
Real estate and rental and leasing	34	81	31	75	69	293	31	13	55	**681**
Professional, scientific, and technical services	26	56	21	67	54	232	18	11	36	**521**
Management of companies and enterprises	3	11	2	14	6	34	2	2	6	**81**
Adm. and support and waste management and remediation services	45	108	29	141	108	395	38	19	68	**951**
Educational services	8	18	6	27	18	69	5	4	13	**168**
Health care and social assistance	29	72	26	110	65	292	22	19	51	**687**
Arts, entertainment, and recreation	6	12	4	16	12	50	5	2	8	**116**
Accommodation	4	8	3	12	9	29	3	2	7	**77**
Food services and drinking places	22	48	16	67	47	188	15	11	34	**448**
Other services	21	48	14	61	42	182	14	12	33	**427**
Households	2	6	2	9	5	22	2	2	4	**53**
Total Impact	**417**	**947**	**322**	**1,364**	**915**	**3,723**	**307**	**231**	**661**	**8,886**
2019 Utilities Employment in number of jobs	53,291	45,249	22,202	56,934	25,294	92,904	64,949	28,578	41,908	**431,309**
Total Impact / 2019 Utilities Employment in number of jobs	**0.8%**	**2.1%**	**1.5%**	**2.4%**	**3.6%**	**4.0%**	**0.5%**	**0.8%**	**1.6%**	**2.1%**

9 Appendix D: Works Cited

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