FAILURE TO ACT

CLOSING THE INFRASTRUCTURE ★ INVESTMENT GAP ★ FOR AMERICA'S ECONOMIC FUTURE

UPDATE TO FAILURE TO ACT: THE IMPACT OF INFRASTRUCTURE INVESTMENT ON AMERICA'S ECONOMIC FUTURE ★★

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

This report was prepared for the
American Society of Civil Engineers by

Economic Development Research Group, Inc.
155 Federal St. Suite 600
Boston, MA 02110

www.edrgroup.com

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ASCE Foundation

ascefoundation@asce.org
www.ascefoundation.org

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4400
World Headquarters

101 Constitution Avenue, NW
Suite 375 East
Washington, DC 20001
Washington Office

reportcard@asce.org
www.asce.org/failuretoact

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THE FAILURE TO ACT SERIES ANALYZES TWO TYPES OF INFRASTRUCTURE NEEDS:

- Maintaining or rebuilding existing infrastructure that currently needs repair or replacement; and
- Building new infrastructure to service an increasing population that will reach 380 million by 2040,[3] and the expanded economic activity and infrastructure use resulting from this growth and added demands.

ABOUT FAILURE TO ACT

Every four years, the American Society of Civil Engineers (ASCE) publishes *The Report Card for America's Infrastructure*, which grades the current state of national infrastructure categories on a scale of A through F. Since 1998, America's infrastructure has earned persistent D averages, and the failure to close the investment gap with needed maintenance and improvements has continued. When the next *Report Card for America's Infrastructure* is released in 2017, it will provide an updated look at the state of our infrastructure conditions, but the larger question at stake is the implication of D+ infrastructure on America's economic future.

The *Failure to Act* report series answers this key question — how does the nation's failure to act to improve the condition of U.S. infrastructure systems affect the nation's economic performance? In 2011 and 2012, ASCE released four *Failure to Act* reports in a series covering 10 infrastructure sectors that are critical to the economic prosperity of the U.S.

These reports were followed by a fifth, comprehensive final report, *Failure to Act: The Impact of Infrastructure Investment on America's Economic Future*, which addressed the aggregate economic impact of failing to act in more than one sector. The purpose was to provide an aggregate analysis of the economic implications for the U.S. of continuing its current investment trends in multiple infrastructure categories.

Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future **is an update to the *Failure to Act* comprehensive report; it addresses the current infrastructure gaps between today's needs and investment and how they will affect the future productivity of industries, national competitiveness, and future costs to households.**

EXECUTIVE SUMMARY

Infrastructure is the backbone of the U.S. economy and a necessary input to every economic output. It is critical to every nation's prosperity and the public's health and welfare. Each *Failure to Act* study demonstrates that deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on our nation's economy, impacting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness.

The economic stakes of America's infrastructure systems are high because its condition can either help or hurt the productivity of the economy. Poor infrastructure affects business productivity as well as every sector and region of the U.S. because when one part of the infrastructure system fails, the impact can spread throughout the system and economy. The U.S. economy relies on low transportation costs and the reliable delivery of clean water and electricity to businesses and households to offset higher wage levels and costs.

Failure to Act shows that business costs and, therefore, prices will increase if surface transportation systems worsen, ports, airports and inland waterways become outdated or congested, and if water, wastewater and electricity infrastructure systems deteriorate or fail to keep up with changing demand. Greater costs to transport the wide array of imported goods that supply domestic manufacturers and rising costs for exports will affect our ability to compete in global markets for goods produced in the U.S. Irregular delivery of water and

The cost of deteriorating infrastructure takes a toll on families' disposable household income and impacts the quality and quantity of jobs in the U.S. economy.... From 2016 to 2025, each household will lose $3,400 each year in disposable income due to infrastructure deficiencies

wastewater services and electricity will make production processes more expensive and divert household disposable income to these basic necessities. Increased reliance on electricity to support modern data-driven systems and industries is particularly important when the cost of service outages and interruptions is considered.

The cost of deteriorating infrastructure takes a toll on families' disposable household income and impacts the quality and quantity of jobs in the U.S. economy. With deteriorating infrastructure, higher business costs will be incurred in terms of charges for services and efficiency, which will lead to higher costs incurred by households for goods and services due to the rising prices passed on by businesses. For example, travel times will lengthen with inefficient roadways and congested airports and airspace, and out-of-pocket expenditures to households and business costs will rise if the electricity grid or water delivery systems fail to keep up with demand. Goods will be more expensive to produce and more expensive to transport to retail shelves for households or to business customers. Business-related travel, as well as commuting and personal travel, will also become more expensive and less reliable. **As a consequence, U.S. businesses will be more inefficient. As costs rise, business productivity falls, causing GDP to drop, cutting employment, and ultimately reducing personal income.** The result of these effects will be a reduction of disposable income and reduced spending for consumer goods and services, which will further exacerbate business impacts. **From 2016 to 2025, each household will lose $3,400 each year in disposable income due to infrastructure deficiencies**; and if not addressed, the loss will grow to an average of $5,100 annually from 2026 to 2040, resulting in cumulative losses up to almost $34,000 per household from 2016 to 2025 and almost $111,000 from 2016 to 2040 (all dollars in 2015 value).

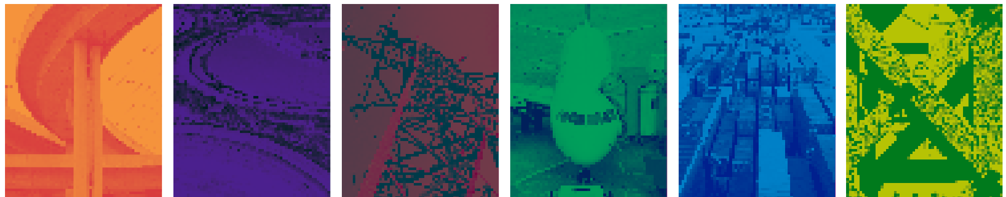
Over time, these impacts will also affect businesses' ability to provide well-paying jobs, further reducing incomes. **If this investment gap is not addressed throughout the nation's infrastructure sectors by 2025, the economy is expected to lose almost $4 trillion in GDP, resulting in a loss of 2.5 million jobs in 2025.**

Moreover, workers who are employed will earn lower wages, and in the long term, many higher paying jobs in technology and other leading sectors will be replaced by jobs that fulfill needs brought on by the inefficiencies of deteriorating infrastructure.

Closing each infrastructure investment gap is possible, and the economic consequences caused by these gaps are avoidable with investment. The economic analysis of this report indicates that our nation's inland waterways and marine ports, electricity infrastructure, airports, as well as water and wastewater infrastructure have all shown some modest improvement or been stable since the previous reports. However, this is not the case with for the surface transportation investment gap which has increased since the prior studies. While the physical condition of America's road pavement and bridge structures has improved, roadway congestion continues to increase over time, and the condition of America's public transportation facilities and equipment continues to decline. While some of the infrastructure investment gap are showing modest signs of improvement, and the overall U.S. investment funding gap is still quite substantial, and the negative economic consequences of insufficient investment continue to be a significant drag on economic productivity. With the failure to close the infrastructure investment gap, the economic consequences will grow as well.

TABLE 1 ★ Losses to the National Economy Due to Infrastructure Investment Gaps

(All values are in billions of constant 2015 dollars)[4,5,6,7]



	Surface Transportation	Water / Wastewater	Electricity	Airports	Inland Waterways & Marine Ports	Aggregate Economic Impact of All Sectors
Business Sales						
2016–2025	$2,212	$896	$1,399	$625	$1,252	$7,038
2026–2040	$8,152	$5,907	$2,024	$2,397	$4,239	$29,292
GDP						
2016–2025	$1,167	$508	$819	$337	$784	$3,955
2026–2040	$1,981	$3,215	$1,071	$1,073	$2,003	$14,201
Jobs						
2025	1,052,000	489,000	102,000	257,000	440,000	2,546,000
2040	473,000	956,000	242,000	494,000	1,153,000	5,809,000
Investment Funding Gap—2016 through 2025						
Total Needs	$2,042	$150	$934	$157	$37	$3,320
Funded	$941	$45	$757	$115	$22	$1,880
Funding Gap	$1,101	$105	$177	$42	$15	$1,440
Investment Funding Gap—2016 through 2040						
Total Needs	$7,646	$204	$2,458	$376	$112	$10,796
Funded	$3,312	$52	$1,893	$288	$69	$5,614
Funding Gap	$4,334	$152	$565	$88	$43	$5,182

NOTE The total economic impacts caused by the gap are listed by sector. Note that the economic impacts are based on each specific sector and the research and modeling by sector developed in the initial *Failure To Act* reports and adjusted based on the gap from 2016–2040. As these impacts do not related to the investment gaps across infrastructure systems is not totaled. However, projected cumulative economic effects of the gaps in all sectors are presented in the aggregate section. All year totals in constant 2015 value. However, job totals are a single year impacts for 2025, not cumulative totals.

1 METHODOLOGY

The *Failure to Act* reports prepared in 2011 and 2012, compare the current and projected needs for infrastructure investment against the national funding trends in: surface transportation (highways, bridges, commuter rail, transit), water and wastewater, electricity, airport and waterborne transportation, as well as a summary of failing to invest in all of these areas. This new report is an update to the final summary aggregate report and shows the category funding shortfalls and subsequent costs attributable to all the infrastructure sectors together.

Developing each initial *Failure to Act* sector report consisted of: (1) researching needs for future infrastructure investment and the cost of those needs; (2) estimating funding available to address these needs; (3) projecting both needs and available funding to 2040; (4) determining funding gaps, if any, by subtracting estimated funding from costs of needs; (5) calculating costs to households and businesses as a consequence of deteriorated infrastructure implied by the sizes of the gaps; and (6) modeling how these higher costs would affect national employment, exports, gross domestic product and gross output.[8]

Both infrastructure investment needs and funding were estimated by looking at past trends and future projections when available.[9] The *Failure to Act* reports, published in 2011 and 2012, list the multiple sources and approaches of projections for each infrastructure sector profiled. Sources were primarily government agencies, publicly mandated nonprofit corporations, and/or industry consortia. The projected needs and investment of infrastructure systems, as well as the consequential costs to industries and households of not making investments, are documented by models used by federal infrastructure agencies, databases and reports published by federal agencies, and by industry groups that represent local, regional and private sector infrastructure providers.

The 2016 *Failure to Act* analysis indicates that the overall infrastructure gap has grown relative to the initial reports. However, recent federal, state and local investments are stabilizing the gap and moderating the potential economic losses from growing more significantly.

These were complemented by literature reviews as needed. In addition, for each type of infrastructure, the impacts of projected deterioration of infrastructure were analyzed in terms of direct costs to households and businesses.

The broader consequences for the national economy and international competitiveness were then assessed using the INFORUM—LIFT model (Long-term Interindustry Forecasting Tool) of the Interindustry Forecasting Project at the University of Maryland.[10] Research was built on states, multi-state regions and specific facilities, depending on the category of infrastructure being addressed and documentation of needs and investment that are available. Results were reported in national, or multi-state regional contexts, for the years 2020 and 2040. Cutting across multiple infrastructure classifications, the fifth report was presented in a national perspective.

Given that the initial *Failure to Act* series was completed only four years ago, a comprehensive new study has not been undertaken. Previous research that identified needs, likely levels of expenditures and gaps if expenditures do not match needs were reexamined. This report is an update of findings from the initial *Failure to Act* aggregate report and presents a national perspective and highlights in terms of future impacts by the years 2025 and 2040 of failing to act now. New economic impact modeling was not undertaken for this update to document infrastructure investment needs, changes in the cost of infrastructure services to businesses or households due to the investment gap, and resulting economic impacts.

The steps that were undertaken for this report included:

1. Starting with the initial *Failure to Act* series, the most recently issued versions of data sources used to identify future needs and expenditures were reviewed; new legislation and trends that have adjusted funding and illustrated needs over the past six years and that will affect future funding and performance were analyzed.
2. Translate findings from Step 1 into how the gaps documented in 2011 and 2012 are projected to be changing for years out to 2040, given newer data available for estimating needs and expenditures;
3. Economic impacts documented in the initial *Failure to Act* series for each type of infrastructure were adjusted based on the changed size of the gap in Step 2. For example, if the investment gap for one type of infrastructure is found to change by 20%, then the economic impacts associated with that type of infrastructure would be adjusted by 20%. Widening gaps are associated with worsening economic outlooks and narrowing or eliminated gaps are associated with improved outlooks.

The initial *Failure to Act* reports and this update report do not assume catastrophic occurrences, such as the Minnesota bridge collapse or a natural event like Hurricane Katrina. These studies also do not consider the stimulus effect of construction jobs or purchases of goods and services related to the investments required to build or rebuild our nation's infrastructure.[11] The studies do not presume new technologies beyond extension of existing trends in infrastructure utilization rates, and enhanced technologies that are already scheduled for implementation. Examples of such technologies not considered in these reports are high speed rail or maglev systems in surface transportation or radical expansion of renewable energy for electricity generation. In the water study, the cost of funding or developing new water supply resources was not considered. The electricity study assumed that technologies in place or planned for power generation by region would be in place through 2040. For aviation, the cost of NextGen air traffic control technologies was considered as part of the gap, and likely air congestion without NextGen was part of the basis of estimating future economic impacts. NextGen is a system long promised to improve the efficiency and safety of aviation and to enhance the capacity of existing airport infrastructure; its implementation can mitigate the need for new airports or the expansion of airfields to accommodate forecasted growth of passengers and aircraft operations.

The 2016 *Failure to Act* analysis indicates that the overall infrastructure gap has grown relative to the initial reports. However, recent federal, state and local investments are stabilizing the gap and moderating the potential economic losses from growing more significantly. Even with these new initiatives, surface transportation, the infrastructure category with the largest investment gap, is falling further behind, and economic consequences continue to be significant out to 2025 and 2040.

TABLE 2 ★ Estimated Changes in U.S. Infrastructure Sector Investment Gaps and Aggregate Investment Gap

	CUMULATIVE GAP ESTIMATE IN 2016 *FAILURE TO ACT* ANALYSIS *(Billion 2015$)*		CUMULATIVE GAP ESTIMATE CALCULATED FOR 2011–12 *FAILURE TO ACT* ANALYSIS *(Adjusted from Billions 2010$ to Billions 2015$)*	
	2016–2025	2016–2040	2016–2025	2016–2040
Surface Transportation	$1,101	$4,334	$908	$3,931
Water & Wastewater	$105	$152	$113	$163
Electricity	$177	$565	$212	$743
Aviation	$42	$88	$46	$82
Ports & Inland Waterways	$15	$43	$18	$42
Total	**$1,440**	**$5,182**	**$1,297**	**$4,961**

NOTE Numbers may not add due to rounding.

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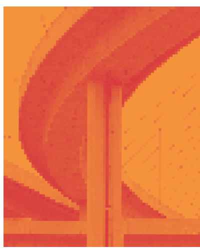
2 REVIEW OF INFRASTRUCTURE SECTORS



Surface Transportation

The average annual investment gap for surface transportation through 2025 is now expected to increase from $91 billion to $110 billion. Moreover, by 2040, the investment gap is expected to increase from a per year average of $157 billion to $173 billion (2015 dollars) over the 25 years spanning 2016–2040. The total investment gap through 2040 in now expected to be $1.1 trillion through 2025, and an additional $3.2 trillion from 2026 through 2040.

The nation's surface transportation infrastructure includes the critical highways, bridges, commuter rail, and transit systems that enable people and goods to access markets, services, and inputs of production essential to America's economic vitality. For many years, the nation's surface transportation infrastructure has been deteriorating. Yet, because this deterioration has been diffused throughout the nation and has occurred gradually over time, true costs and economic impacts were not always immediately apparent. In practice, the transportation funding that is appropriated is spent on a mixture of system expansion and preservation projects. **Although recent funding efforts have been sufficient to avoid the imminent failure of key facilities, continued deterioration leaves a significant and mounting burden on the U.S. economy.** Across the U.S., regions are affected differently by deficient and deteriorating infrastructure. The most affected regions are those with the largest concentrations of urban areas, because urban highways, bridges and transit systems are generally in worse condition today due to more congestion and, therefore, faster rates of deterioration.

The latest federal funding authorization for surface transportation — Fixing America's Surface Transportation (FAST) Act — authorizes an average of $56.2 billion per year of federal funds for highway and transit programs from 2016-2020. That compares to an average of $52.5 billion per year that the prior federal program, MAP-21, had authorized for highway and transit programs over 2013–2015. While this represents a 7% increase, the FAST Act barely keeps up with inflation over this period of time. Essentially, the overall federal transportation funding level is close to flat.

Other recent changes in federal funding include a mixture of program expansions and reductions. The TIFIA credit subsidy program, which provides loans, loan guarantees, and standby lines of credit for states to accelerate major projects has been cut over 70%. However, the FAST Act did provide new funding for competitive grant programs, including the new Fastlane grants for "nationally significant freight and highway projects" as well a formula program targeting the "National Highway Freight Network." It also maintained the popular Transportation Investment Generating Economic Recovery (TIGER) grant program, but with variable levels of funding through its life as well.

To a certain degree, states have been stepping in to address the investment shortfalls. From 2010 to 2016, twenty-three states have increased state gas tax rates, or have state legislation in place that allows for indexing the gas tax. **State action, combined with current levels of federal funding, have stabilized the downward trend in highway investment, but it remains at a level lower than required for effective functioning of the national highway system.**

Roads and Highways. At the federal level, highway spending has now stabilized, though it remains at a level that is still 23% less (in inflation adjusted terms) than it was in 2002. At the state and local level, road maintenance funding has remained stable (in inflation-adjusted terms) in recent years, though spending on capital investment is 30% less than it was in 2002.[12]

As highway spending has focused more on maintenance, the overall condition of U.S. highways has been slowly improving. The total miles of U.S. pavement rated mediocre or poor (pavement roughness index 170 or higher) has been reduced by 17% in six years.[13] The number of bridges considered structurally deficient has been reduced to 10% in 2014, showing a 14% decrease over six years.[14] However, while maintenance has improved, there is a flip side which is the reduction in capital spending. The consequences are readily apparent — the total hours of highway congestion delay in the top 50 metro areas has grown 36%.[15]

Congestion, especially in urban areas, is projected to continue worsening over time as population and economic activity continue to grow, though the growth in VMT (vehicle miles of travel) will be at a slightly lower rate than previously forecasted, because car VMT per capita is now stabilized at a lower rate than it was a decade ago. It is important to note that truck VMT has continued to expand at a faster rate, reflecting increased productivity. Overall, population growth over the next 30 years is forecast to be 0.7% per year, while net overall VMT growth is forecast to grow over time 0.6% per year.[16]

Public Bus and Rail Transportation. Both federal and state/local funding for public bus and rail transportation recently increased slightly. Small increases are expected to continue. However, the federal increase in transit capital funds has merely offset a reduction in local funding for capital investment. Local transit spending growth has nearly all been directed to pay for the increasingly expensive maintenance of aging fleet of vehicles.

The consequence of this spending pattern is that the average age of a transit bus in America has also increased from 18.5 to 18.7 years.[17] Today, over 40% of buses and 25% of rail transit assets are in marginal or poor condition. Estimates from the *National State of Good Repair Assessment* indicate that there is an $86 billion backlog of deferred maintenance and replacement needs — a backlog that continues to grow.[18]

Congestion. Congestion affects buses, freight trucks and cars. Across 470 urban areas, there was a total of 6.9 billion vehicle-hours of delay (compared to free flow speed) on roads due to congestion in 2014. While some peak delay is to be reasonably expected, the increase in this projected number — rising 20% to 8.3 billion hours by 2020 — indicates a problem of increasing delay for travelers that is attributable to a failure to significantly invest in capacity growth across all modes of transportation.[19]

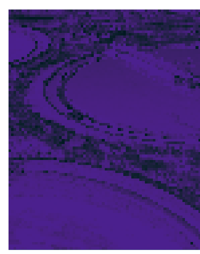
Economic Costs. Deteriorating conditions and performance impose costs on American households and businesses in a number of ways. Facilities in poor condition lead to increases in operating costs for trucks, cars, and rail vehicles. Additional costs include damage to vehicles from deteriorated roadway surfaces, imposition of both additional miles traveled, time expended to avoid unusable or heavily congested roadways or due to the breakdown of transit vehicles, and the added cost of repairing facilities after they have deteriorated as opposed to preserving them in good condition.

In addition, increased congestion decreases the reliability of transportation facilities, meaning that travelers are forced to allot more time for trips to assure on-time arrivals (and for freight vehicles, on-time delivery). Moreover, it increases environmental and safety costs by exposing more travelers to substandard travel conditions and requiring vehicles to operate at less efficient levels as conditions continue to deteriorate.

Current Economic Impact. Surface transportation costs are imposed primarily by pavement and bridge conditions, highway congestion, and transit and train vehicle conditions that are operating well below minimum tolerable levels for the level of traffic they carry. As of 2015, estimated deficiencies in America's surface transportation systems cost households and businesses nearly $147 billion. This included approximately $109 billion in vehicle operating costs, $36 billion in travel time delays, $1.4 billion in safety costs and $0.7 billion in environmental costs.

Future Economic Impacts. Extending current transportation spending and performance trends into the future would lead to cumulative economic impacts on multiple levels. By 2025, the annual costs imposed on the U.S. economy from deteriorating transportation infrastructure will increase to $238 billion (increasing by $91 billion over 2015 costs) and by 2040, the costs will have increased to $575 billion ($428 billion above 2015 and $337 billion above 2025 costs), with cumulative costs mounting to $1 trillion by 2025, and $3.2 trillion by 2040. In addition, as a consequence of those costs, America's projected surface transportation deficiencies would be expected to cost the national economy cumulatively almost $1 trillion in GDP by 2025, rising to $3.05 trillion through 2040. In 2025, about 1 million jobs are expected to be lost. By 2040, these gross job losses will be mitigated to slightly more than 470,000 jobs, but a greater proportion of this apparent job rebound will be due to the need to expand industries associated with automotive repairs.

Moreover, as productivity deteriorates with infrastructure degradation, more resources are wasted in each sector. In other words, it may take two jobs to complete the tasks that one job could handle without delays due to worsening surface transportation. By 2040, approximately 1.4 million more jobs that could exist in key knowledge-based and technology-related economic sectors will be lost to the U.S. economy if sufficient transportation infrastructure is maintained. These losses are balanced against almost 1 million additional jobs projected in traditionally lower paying service sectors of the economy that would benefit by deficient transportation (such as auto repair services) or by declining productivity in domestic service related sectors (such as truck driving and retail trade).



Water and Wastewater

The average annual investment gap for water and wastewater through 2025 is expected to decrease from $11.3 billion to $10.5 billion in constant 2015 dollars, in large measure due to projects funded through the American Recovery and Reinvestment Act. By 2040, the cumulative gap is expected to decrease from an annual average of $6.5 billion per year to $6.1 billion per year in constant 2015 dollars. The total investment gap through 2025 is expected to be $105 billion, and $152 billion, by 2040 if left unaddressed.

Of all the infrastructure types, water is the most fundamental to life, and is irreplaceable for drinking, cooking, and bathing. Farms in many regions cannot grow crops without irrigation. Government offices, hospitals, restaurants, hotels, and other commercial establishments cannot operate without clean water. Moreover, many industries, including food and chemical manufacturing and power plants, for example could not operate without the clean water that is a component of finished products or that is used for industrial processes or cooling. Drinking water systems collect source water from rivers and lakes, remove pollutants, and distribute safe water. Wastewater systems collect used water and sewage, remove contaminants, and discharge clean water back into the nation's rivers and lakes for future use. Wet weather investments, such as sanitary sewer overflows, prevent various types of pollutants like sewage, heavy metals, or fertilizer from lawns from ever reaching the waterways.

Delivery of water and wastewater services in the U.S. is decentralized and strained. The U.S. hosts about 156,000 public water systems that each serve at least 25 people per day. Of these, more than 52,000 are community systems that serve the primary residences of 286 million people (an additional 15 million households rely on private wells for drinking water). The remaining systems are transient, non-community water systems such as campgrounds, or non-transient, non-community water systems such as schools. The critical role of urban and large water delivery systems is demonstrated in that about 8% of U.S. community water systems provide water to 82% of the U.S. population. As the U.S. population has increased, the percentage served by public water systems has also increased. Each year new water lines are constructed to connect more distant dwellers to centralized systems, continuing to add users to aging systems. However, much of the drinking water infrastructure in major cities was built rapidly in the 1950s through 1970s.

Data from the Congressional Budget Office shows that capital investment for both water and wastewater infrastructure has been increasing sign the mid-1950s, with the steepest increase seen from 1956 to 1975. A second growth spurt in federal spending is seen in the last decade.[20]

Although access to centralized treatment systems is widespread, the condition of many of these systems is also poor, with aging pipes and inadequate capacity leading to the discharge of an estimated 900 billion gallons of untreated sewage each year. Although new pipes are being added to expand service areas, drinking water systems degrade over time, with the useful life of component parts ranging from 15 to 95 years. Significant portions of many municipal systems are now approaching 40 to 50 years in age. Failures in drinking water infrastructure can result in water disruptions, impediments to emergency response, and damage to other types of essential infrastructure. In extreme situations caused by failing infrastructure or drought, water shortages may result in unsanitary conditions, increasing the likelihood of public health issues.

Wastewater and clean watershed infrastructure face other challenges. While existing infrastructure is also aging, current standards for public health, environmental safety, and conservation require significant amounts of new infrastructure to be built. Urban drinking water solutions were implemented much earlier than waste treatment, storm water, and agricultural runoff management facilities. Urban publicly-owned treatment works pose even greater risks to cities if they are not maintained at adequate levels than much of the nation's aging drinking water systems.

In its gap analysis, USEPA (2002) accounted for underreporting by increasing its total point estimate of capital needs from the *1997 Clean Watersheds Need Survey* from \$157.2 to \$274 billion (in 2001 \$). Unfortunately, EPA has not repeated this study to determine the extent of underreporting. In subsequent *Drinking Water Infrastructure Needs Survey and Assessment* (DWNS), EPA has reported on its efforts to increase reporting. This study assumes a persistence of underreported conditions due to the

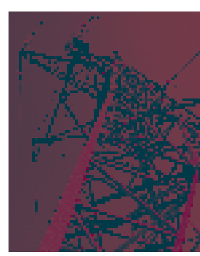
Water and wastewater systems in the U.S. are clearly aging, and investment is not able to keep up with the need. Spending jumped in 2009 and 2010 and then settled back to a rate similar to what was seen before ARRA.

extent of non-reported conditions remaining unknown. Therefore the significant underreporting in potable water infrastructure reported in the aforementioned 2002 EPA study has been retained for the purpose of estimating potential economic consequences of failing to meet needed capital investments and efficiently addressing operational and maintenance costs of systems.

In light of the recent events regarding lead water pipes, some have called for replacement of the more than 7.3 million lead service lines around the country.[23,24] This study does not take into account the replacement cost of this infrastructure, and this would add an additional $30 to $40 billion to the unfunded gap in water infrastructure.[25]

Water and wastewater systems in the U.S. are clearly aging, and investment is not able to keep up with the need. Spending jumped in 2009 and 2010 and then settled back to a rate similar to what was seen before ARRA. At the currently projected rate of investment, assuming capital investment required will amount to $150 billion by 2025 (in 2015 dollar value), and the anticipated capital funding gap will be $105 billion. Moreover, by 2040, the needs for capital investment is expected to amount to $204 billion and the funding gap will have escalated to $152 billion, unless strategies to address the gap are implemented in the intervening years to alter these needs. In addition to new capital investments, operation and maintenance costs are also expected to escalate from $93 billion needed in 2016, to $108 billion in 2025, and $134 billion in 2040.

Future Economic Impacts. These shortfalls in funding will cause the U.S. to lose nearly 500,000 jobs by 2025. Unless the infrastructure deficit is addressed by 2040, 956,000 jobs will be at risk relative to what is otherwise anticipated for that year. By 2025, the nation will have lost over $508 billion in GDP, while the cumulative impact through 2040 is expected to be $3.2 trillion of GDP.



Electricity

The average annual investment gap for electric generation, transmission and distribution through 2025 is expected to decrease from $21 billion to $18 billion. The average annual investment gap through 2040 is expected to show an overall average annual decrease from $30 billion to $23 billion in 2015 dollars. The total investment gap through 2040 in now expected to be $565 billion, with a cumulative investment gap of $177 billion through 2025 and $388 billion from 2026 through 2040.

Electricity, including that owned privately and publically, relies on an interconnected system that is composed of three distinct elements:

1. Generation facilities—including approximately 5,800 major power plants and numerous other smaller generation facilities and renewable energy systems;
2. High-voltage transmission lines—a network of over 450,000 miles that connects generation facilities with major population centers; and
3. Local distribution systems that bring electric power from transmission systems at lower voltages into homes and businesses via overhead or underground power lines.

The first two elements are usually referred to as the bulk power system.

The U.S. system of generation, transmission and distribution facilities was built over the course of a century. Centralized electric generating plants with local distribution networks were started in the 1880s and the grid of interconnected transmission lines was started in the 1920s. Today, the U.S. system is a complex, patchwork system of regional and local power plants, lines and transformers that have widely varying ages, conditions, and capacities. Regulations and policy are complicated and inefficient, leading to uncertainty from infrastructure owners in where and when to invest. As electricity is a subset of the broader reaching energy systems of the U.S., investment in the larger energy network is more significant than reported here but vitally needed.

Nationally, extending current trends leads to funding gaps in electric generation, transmission, and distribution that are projected to accumulate over time to a total of $177 billion by 2025, with about $21 billion that year. The gap is 22% due to generation, 24% for transmission and 54% for distribution infrastructure. By 2040, the cumulative gap will reach $565 billion. The annual gap is predicted to exceed $25 billion that year and is mostly due to projected shortfalls in generating capacity (57%).

FUTURE OF U.S. POWER

The initial *Failure to Act* study was based on the mix of then current generation technologies, and observable trends toward more "green technologies". Fundamental shifts in generation technologies were not assumed. In 2015, the Clean Power Plan was announced. Implementation of the Plan has been deferred due to court action, and it is currently assumed that final decisions on the degree of implementation, or if it will be implemented at all, will not be made until 2017. Therefore, this discussion uses the same framework as the 2012 *Failure to Act* electricity analysis.

Relative to the gap estimate made for the initial Failure to Act series, the cumulative shortfall in funding for generating facilities is expected to be much smaller, $189 billion compared to $401 billion, and only 34% of the cumulative total rather than 55%. This is due to improvements in the availability of generating capacity in the short-term and decreases in the rate of demand growth predicted by the North American Electric Reliability Corporation.

Transmission and distribution on the other hand are expected to have slightly larger cumulative gaps over 25 years than the original reports predicted over a 30-year period. This is due to an increasingly decentralized generation network, which requires additional transmission capacity for load balancing and resiliency. In some cases, generation is moving closer to consumers as smaller capacity utility-operated plans, in other cases power now travels much larger distances

The most significant economic threat concerning aviation is air and ground congestion at major airports and regions.

from renewable sources. Distribution investments are also essential to maintain or replace aging infrastructure, but also to providing utilities with the necessary information to balance loads, identify failures, and optimize power flows to use resources more efficiently instead of making expensive new generation investments.

The projected investment gap will lead to a greater incidence of electricity interruptions if aging equipment is not addressed, capacity bottlenecks are not resolved, and increased demands are not accounted for. The periods of time can be unpredictable in terms of frequency and length, but the end result is a loss of reliability in electricity supply, which imposes direct costs to households and businesses. Without significant investments, isolated failure of a transformer past its useful lifetime could lead to longer lasting, more widespread losses of power.

Future Economic Impacts. If future investment needs are not addressed to upgrade our nation's electric generation, transmission, and distribution systems, the economy will suffer. Costs may incur in the form of higher costs for electric power, costs incurred because of power unreliability, or costs associated with adopting more expensive industrial processes. As costs to households and businesses associated with service interruptions rise, GDP will fall by a total of $819 billion by 2025 and $1.9 trillion by 2040. The U.S. economy will end up with an average of 102,000 fewer jobs than it would otherwise have by 2025 and 242,000 fewer jobs in 2040.

Airports

The average annual investment gap for airports through 2025 is expected to decrease from $4.6 billion to $4.2 billion. However, by 2040, the cumulative gap is expected to slightly increase from a per year average of $3.3 billion to $3.5 billion in 2015 dollars. The total investment gap through 2040 in now expected to be $88 billion, $42 billion through 2025, and an additional $46 billion from 2026 through 2040, including the cost of NextGen.

Among the 3,300 airports in the U.S. that are designated by the Federal Aviation Administration (FAA) as important to the national aviation system, 30 "core" airports serve approximately 70% of commercial passengers.[26] Among commercial airports, FAA forecasts that domestic enplanements will grow at an average annual rate of 2.2% through 2036.[27] Similar to passenger travel, freight shipments are concentrated in major metro areas. Taken together, the 30 core airports handled 79% of all domestic and international air freight (by weight) in 2015.[28]

The most significant economic threat concerning aviation is air and ground congestion at major airports and regions. Extending the trends of needs and spending documented by FAA and Airports Council International North America shows an annual capital gap of about $2.1 billion through 2025 in constant 2015 dollars (roughly $13.6 billion in need and $11.5 billion in expenditures per year) and $1.6 billion annually from 2026 to 2040 ($13.2 billion in need to $11.6 billion in expenditures, assuming spending through 2025 does not fall lower than recent trends). In addition to construction needs, congestion relief is being proposed through implementation of the Next Generation Air Transportation System (NextGen). NextGen is expected to transform the management and operation of the air transportation system in the U.S., moving from the current ground-based radar system to a satellite-based system. FAA estimates that NextGen will require $19.9 billion in investment through 2025, and $38.2 billion through 2040.[29]

Future Economic Impacts. These projected airport infrastructure investment shortfalls will lead the U.S. to lose nearly 257,000 jobs in 2025. Unless the infrastructure investment deficit is addressed by 2040, 494,000 jobs will be at risk relative to what is otherwise anticipated for that year. By 2025, the nation will have lost over $337 billion in GDP, while the cumulative impact through 2040 is expected to be $1.4 trillion of GDP.

Inland Waterways and Marine Ports Infrastructure

The investment gap for waterborne infrastructure is roughly equivalent to the initial *Failure to Act* assessment. In the 2016–2025 short term, the average annual gap is expected to decrease from $1.8 billion to $1.5 billion. From 2026 through 2040, the average annual gap is expected to increase to $1.9 billion, compared with $1.6 billion in the initial study. As a result, the 25 year gap is expected to be $43 billion, compared to $42 billion in 2015 dollars in the earlier study. This gap applies for waterside improvements, including dredging, and lock and dam repair, and not privately owned land-side infrastructure and equipment.

The U.S. inland waterway system consists of over 12,000 miles of inland and intra-coastal waterways, with over 240 lock chambers, along with over 300 commercial harbors. Domestically, 5% of all tonnage moved in the U.S. and almost 4% of the total value of all freight transported over the entire U.S. transportation system is moved by water. This includes approximately 20% of all crude petroleum, 6% of all coal and 14% of other fuel oils, which alone affect the efficiency of all economic sectors that rely on energy. In addition, 63% of U.S. imports arrive to the U.S. by water, including 62% of this nation's crude petroleum imports, approximately 76% of U.S. exports (by tonnage), accounting for approximately 42% of total exports by value, are transported by water for foreign markets.

Since 2012, shifts in economic conditions have influenced the characteristics of unmet port and associated transportation system needs and the capacity required to address them. Changes in the U.S. and global economies are affecting demand for transportation, including port demand. Shifting economic conditions include the consequences of the recent sharp drop in world crude oil prices and declines in other commodity prices, declines in global equity markets, revised outlooks for developing country trade partner economic growth. The past four years have witnessed shifts in trade-related industries, the strength of commodity-producing areas within the U.S., and shifts in use of corridors connecting to internal and external markets of customers and suppliers.

The nation's port infrastructure is now challenged by a significant but short provision in the 2015 surface transportation funding authorization bill from Congress, the FAST Act. This is the removal on the general prohibition on exporting U.S. crude oil. The transportation need of the nation for both crude oil and refined petroleum products had been affected by the ban which extended back to the 1970s. The freeing of crude oil exports will place new demands on U.S. seaports for facilities and operations to receive, store and load crude oil onto oil tankers. In contrast, now that crude oil is not 'shut in' to the U.S. it no longer must be refined in the U.S. which means some of the new crude oil exporting may substitute for previous demand for handling of refined petroleum product exports. Except for the federal navigation channels, transportation infrastructure for handling crude oil and petroleum product exports are typically privately funded. They do require permitting and planning by public agencies. As initial crude oil export shipments have already begun, the need is immediate.

The strengthening of the U.S. dollar exchange rate versus foreign currencies in recent years is also affecting transportation system demand. The increased value of the dollar versus major trade partner country currencies has reduced U.S. export price competitiveness, resulting in reduced export demand and it has increased the price competitiveness of U.S. imports beyond what was anticipated in the macroeconomic forecast inputs used for the original study. Trade volumes have been affected by these changes including contributing to an uptick in offshoring and outsourcing of domestic production while the "onshoring" trend has slowed. The ports are directly affected as increases in trade volume challenge the existing capacity as well as expansion plans.

Updated Investment Gap. The gap analysis for the ports and waterways section of the ASCE has been updated to reflect new sources of funding for the periods 2016–2025 and 2016–2040. Three new sources were considered:

- ★ The U.S. Army Corps of Engineers (USACE) has updated the President's Budgets for Navigation through FY17
- ★ The Harbor Maintenance Trust Fund as designated under the Water Resources Reform Development Act of 2014 (WRRDA 2014) and
- ★ FASTLANE Grants as scheduled under the Fast Act of 2015.

USACE has revised their estimated needs for both deep draft and inland waterways navigational dredging (construction) and operations and maintenance. These changes are attributable to the need for deep draft navigational channels necessary to support new classes of container vessels that will call on U.S. East and Gulf coast ports through both the Panama and Suez Canals, and even larger vessels that are currently calling on U.S. West Coast ports.

The Water Resources Reform and Development Act (WRRDA) provides a schedule of proposed allocation of HMTF receipts for the period from FY2015 through FY2025. By 2025, 100% of all HMTF revenues collected each year are to be allocated to port and waterways projects. FASTLANE Grants are scheduled to last for the 5-year authorization period of the Fast Act. They range from $800 million in FY2016 to $1 billion in FY2020. These are funds designated for freight projects throughout the U.S. that are nationally significant. These freight-related projects are designed as competitive grants, similar in structure to the TIGER grant program that has been in place for about 10 years. Ports and related projects have typically received between 20% to 25% of the TIGER grants awarded in the past. The revised gap analysis assumes that this share of port-oriented grants will be awarded in the future.

It should be noted that substantial funding gaps continue to exist, even with the levels of funding anticipated under the FAST Act though 2020 and the WRRDA reforms though 2025. Under current authorized funding levels, over $11 billion in unmet needs (36% of the total as of 2012) will continue to exist. Even with an extension of the surface transportation funding through 2025 with levels of funding and grants similar to the FAST Act, the current 36% gap between needs and funding levels will only be cut in half.

Future Economic Impacts. The projected investment gap will potentially lead to 440,000 fewer jobs in 2025 and almost 1.2 million fewer jobs in 2040 than would otherwise be expected with modernized waterborne transportation systems in place. By 2025, the nation will have lost almost $800 billion in GDP, while the cumulative impact through 2040 is expected to be almost $2.8 trillion of GDP. These impacts include ground congestion at ports, so it slightly overlaps with the effects of surface transportation.

3 | CUMULATIVE ECONOMIC IMPACTS OF FAILING TO INVEST

The Failure to Act studies have found that the fundamental impacts of under investing in infrastructure will be higher costs to businesses and households as a consequence of less efficient and more costly infrastructure services. For example, travel times will lengthen with inefficient roadways and congested airports and airspace, and out-of-pocket expenditures to households and business costs will rise if the electricity grid or water delivery systems fail to keep up with demand. Goods will be more expensive to produce and more expensive to transport to retail shelves for households or to business customers. Business-related travel, as well as commuting and personal travel, will also become more expensive and less reliable. As a consequence, U.S. businesses will be more inefficient. **As costs rise, business productivity falls, causing GDP to drop, cutting employment, and ultimately reducing personal income.** Higher costs will also render U.S. goods and services less competitive internationally, reducing exports and decreasing dollars earned and brought into the U.S. from sales to international customers. Impacts will be spread throughout the economy, but will fall disproportionately on technology and knowledge-based industries that drive innovation and economic development.

Businesses and households face higher costs due to several factors, including unreliable transportation services, less reliable water and electricity services, as well as unmet maintenance needs and outdated facilities of airports, marine ports and on inland waterways, and the freight network as a whole. These costs absorb funds from businesses that would otherwise be directed to investment or research and development and from households that would go towards discretionary consumer purchases. Thus, not only will business and personal income be lower, but more of that income will need to be diverted to infrastructure-related costs. This dynamic creates lower demand in key economic sectors associated with business investments for expansion and research and development, and in consumer sectors. Economic impacts from failing to address the U.S.'s deteriorating infrastructure stems from the following general affects:

With the cumulative gaps in these profiled infrastructure sectors, the U.S. economy will still be producing goods and services. However, it will do so at a reduced scale, and the lower wages will lead to less consumer spending. Impacts will fall hardest on households that will pay more for services, including transportation, water and wastewater, and electricity, and absorb the brunt of fewer jobs, lower incomes and higher prices for both domestically produced and imported goods. Ultimately, the fall in business sales due to the drop in exports, personal income and consumer spending will reduce national GDP, a primary indicator of national economic productivity.

Each type of infrastructure will affect the national economy in different ways. For example, declining efficiency in surface transportation will affect business costs incurred outside company doors in terms of time of travel for people and freight, and out-of-pocket costs to repair

IMPACTS ON BUSINESSES

- ★ Increased cost of production (costs of electricity, water/wastewater, intermediate goods for production from surface transportation as well as costs associated with electricity, water and wastewater for these purchased products, and cost of imports)
- ★ Declining exports (cost of production, increased surface transportation costs to reach seaports and airports, and inefficiencies at airports and marine ports)
- ★ Increased cost of business travel (poor surface transportation, inefficiencies at airports)
- ★ Declining consumer spending (see impacts on households, below)

IMPACTS ON HOUSEHOLDS

- ★ Fewer jobs
- ★ Lower income due to restructuring of economy from technology/export sectors to lower paying, less productive services needed to address problems caused by poor infrastructure (in addition to lower income due to less employment)
- ★ More income diverted to transportation, electricity, water/wastewater, leaving less available for "lifestyle" purposes (entertainment, restaurants, and retail — including high-end consumer products)

vehicles. In terms of manufacturing, surface transportation affects the cost of moving goods to markets, and of bringing commodities that are integral inputs of production process to factory gates. More expense diverted to water supply and wastewater services, and electricity will result in higher production costs. Inefficient port operations will result in business costs that directly impede U.S. company sales through exports and impede import of low-cost goods for consumer sales and for intermediate steps in production processes. All on the impacts will lower business income, lead to layoffs and lower wages. Moreover, more household expenses being devoted to higher costs of transportation, water services and electricity will mean that households have less dollars available for other discretionary spending. If, for example, households purchase fewer electronics, such a loss of sales will contribute to the downward spiral of electronics firms that would already be hurt from less reliable infrastructure and higher costs.

BUSINESS EFFECTS

Surface Transportation

Travel time will increase due to poor roadway conditions, bridges that are not usable or are partially restricted, and transit services out of good repair. Repair and maintenance costs will also increase due to deteriorating roadway conditions. Higher costs (time and out-of-pocket costs) for shipping and receiving, drives up the cost of products. Increased travel time for service providers will lead to increased costs of services (and increased costs of products increases business supplies purchased by service providers). Products and services will be more expensive, reducing sales and rendering U.S. products less competitive with foreign imports (imports will also be more expensive due to U.S. transportation costs, but less expensive in the framework of overseas production). The higher costs are expected to reduce business demand, which in turn will lead to reductions in business income, profits and layoffs, and lower personal income for people who remain working.

Water/Wastewater

Major U.S. industries depend on a reliable and clean water supply as a core component for production. These include chemicals, biotech/pharmaceuticals, automobile assembly, electronics and other technologies, food processing, apparel, beverages, forest products, mining, refining and utilities. Less reliable service caused by aged infrastructure will force businesses into a series of unpalatable choices, including do nothing and endure the reduced service, which will increase costs of production; move to a location with better infrastructure, incurring moving costs; shift to self-supply for water (wells) and wastewater disposal, which will incur significant capital and annual maintenance costs; or adopt further sustainable practices, if possible, which will require the purchase and installation of new equipment. In all scenarios, business costs will rise making products either more expensive or reducing business profits.

Electricity

Unreliable electricity service carries significant costs associated with power outages, which vary by the duration of the outage and the sector being affected. The average frequency,[30] length[31] and corresponding costs of power outages was reported in the initial *Failure to Act series*. Updating the business cost values (from the 2002 dollars reported in those original studies to 2015 dollars today) yields a conclusion that the average outage cost for industrial firms is in the range of $2,600 to $6,600 per average short-duration power interruption and $900 to $1,700 for commercial firms. The nation's most energy intensive industries are primary metals, non-metal mineral manufacturing, paper manufacturing, and accommodation and food services. In manufacturing sectors, impacts of power outages cause higher production costs which, as in water and transportation, affect the competitiveness of U.S. industries, including basic manufacturing on global markets. To adjust to more frequent outages, manufacturers will need to adopt more expensive industrial processes, and/or all businesses will pay more for small and costly locally-based sources of generation and distribution will be needed to fill gaps. Extended outages, caused by severe grid-related incidents, have even a greater impact on the economy.

Airports, Inland Waterways and Marine Ports

A historic competitive advantage of U.S. industry has been relatively inexpensive transportation costs both internally and for international shipments. If airport and water port infrastructure is poorly maintained or allowed to become outdated, the affects will lead to increased cost of goods moved to domestic and international destinations because of increased time it takes to move goods along inland waterways and to load and unload cargo at airports and marine ports, as well as inland ports, and the cost of long distance business travel. There is an overlap with surface transportation in the sense that landside congestion at the ports delays cargo shipment, as well as passenger travel at airports. Unlike inadequate surface transportation, water and electricity infrastructure, which affect international competiveness indirectly by adding costs to goods, deficient airports and marine ports could not only raise costs but are very visible demonstrations that erode our national competitiveness. Overall, higher costs of exports will further erode the U.S. trade position and higher costs of imports will increase costs of materials for businesses, thereby, increasing production costs and lowering domestic sales.

HOUSEHOLD EFFECTS

Surface Transportation

Increased costs of goods in stores will lead to a decline in retail demand, and further layoffs. The decline in personal income will also affect industries that attract households' discretionary income, such as restaurants, entertainment and the purchase of high-end retail goods, as fewer purchases are made, and those that are made are for lower-value goods than would otherwise be bought. The spiral is that the domestic markets for electronics, medical devices and (perhaps) pharmaceuticals will decline, and with it the employment base of these industries.

Water/Wastewater

Due to the rise of business costs, households will pay more money from products derived from water reliant or water intensive industries. However, the most profound effect will in the tap of each household. More money will be paid for water, reducing discretionary household incomes, which will affect retail, restaurants and entertainment sectors (entertainment and retail sectors are not particularly water intensive). Most importantly, poor water infrastructure can result in failure to meet water quality standards which can lead to unsafe drinking water and public health hazards, water disruptions to households, and impediments to emergency response. Households will be faced with similar choices as businesses endure higher per-unit pricing, move, seek out opportunities to self-supply or invest in conservation technologies.

Electricity

Households will also be affected by outages, but at a far lower scale; the average household cost is minimal per interruption, which mostly is due to spoilage of refrigerated foods. Higher utility costs, however, will decrease discretionary spending, as will layoffs due to declining business sales due to higher electricity costs as an international competitive disadvantage.

Airports, Inland Waterways and Marine Ports

Households will be affected in three important ways. First, jobs will be lost due to increased cost of exports and imports, declining domestic and international sales and resulting loss of business revenues. The layoffs will produce a loss of household income. Second, domestic products will cost more, lowering the amount of goods sold, which will lead to additional layoffs both in primary industries and in retail sectors, further reducing household income. Third, the cost of air travel will rise, curtailing demand for air service

People will work more hours at lower pay. Industries that will be most affected are those that produce and sell high-end goods (e.g., electronics and medical devices) to domestic customers, who increasingly will be unable to afford them, and in international markets due to a price disadvantage with foreign competitors.

for business travel and especially for discretionary personal travel, leading to job losses in air transportation services.

OUTCOMES

Surface Transportation

People will work more hours at lower pay. Industries that will be most affected are those that produce and sell high-end goods (e.g., electronics and medical devices) to domestic customers, who increasingly will be unable to afford them, and in international markets due to a price disadvantage with foreign competitors. Jobs in auto and truck repair sectors will significantly increase due to poorly maintained roadways and increased demand for repairs, but overall business income and wages will be suppressed. With high-end industries not competitive to international competition, the U.S. economy will evolve away from sectors rooted in research and development and an expanding knowledge sector.

Water/Wastewater

Across the national economy, leading sectors that could be affected as a consequence of deteriorating water/wastewater infrastructure include knowledge sector services (excluding medical services), manufacturing construction, retail, and restaurants and other entertainment. Impacts on restaurants and other entertainment are as a consequence of households paying more money for water and therefore having less to spend elsewhere. The declines in other sectors mentioned are due to production cost increases and less demand from households and other businesses. The production cost increases will also lead to a decline in exports because U.S. made products will be less competitive on the world market. Medical services is expected to increase due to water-borne illnesses expected to incur due to faulty infrastructure.

Electricity

Higher costs of manufacturing associated with rising and unreliable energy delivery will (1) affect sales by U.S. companies in global markets by driving up production costs and sales prices; and (2) exacerbate the national trade deficit by seeing lower volume of sales to U.S. businesses if more efficiently foreign-made products can be imported and sold at cheaper prices. These two dynamics will affect employment and decrease household and income and the ability to use that income for discretionary spending. In addition, households will pay more for electricity or endure extended brownouts. The result is that impacts will fall heaviest on sectors that benefit from consumer spending.

Airports, Inland Waterways and Marine Ports

While specific outcomes vary for the three types of ports (inland-water, marine and air) that are profiled, a deficient gateway network will negatively affect the nation's ability to export essential commodities and high-value manufactured goods and services (using airports) at competitive costs, and will jeopardize the low cost of imports and the advantages that these imports bring for low-cost production by U.S. businesses and low cost of goods by U.S. consumers.

TABLE 3 ★ Cumulative Impacts to the National Economy *(Dollars are in $2015 Billions)*

				ANNUAL AVERAGES		
CUMULATIVE EFFECT	2016–2025	2026–2040	2016–2040	2016–2025	2026–2040	2016–2040
Business Sales	$7,038	$29,292	$36,331	$704	$1,953	$1,453
GDP	$3,955	$14,201	$18,156	$395	$947	$726

TABLE 4 ★ Cumulative Jobs Lost in the Economy in the Years of 2025 and 2040

Jobs Lost in 2025	2,546,000
Jobs Lost in 2040	5,809,000

NOTE Jobs lost are in the year noted.

TABLE 5 ★ Loss of Disposable Income per Household due to Infrastructure Investment Gap *(All values are in billions of constant 2015 dollars)*

	2016–2025	2026–2040	2016–2040
Average Annual Disposal Income Per Household	$3,400	$5,100	$4,400
Total Disposal Income Per Household	**$33,500**	**$76,200**	**$110,900**

NOTE Losses to households will vary by size, location and needs of each household. Dollars rounded to nearest $100. Totals may not multiply due to rounding. 2016–2025 and 2026–2040 totals do not add to 2016–2040 totals because the total number of households projected in the U.S. change annually, growing from 126.1 million in 2016 to 157.3 million in 2040.

SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

AGGREGATE ECONOMIC IMPACTS

If none of these infrastructure gaps are addressed, the U.S. is expected to lose nearly $4 trillion in GDP by 2025 and $18 trillion in GDP over the 25 year period of 2016 to 2040, averaging over $700 billion per year.

From 2016 to 2025, each household will lose almost $3,400 each year in disposable income due to infrastructure deficiencies; and if not addressed, the loss will grow to an average of $5,100 annually from 2026 to 2040. From 2016 to 2025, households will average a cumulative loss $34,000 in disposable income; and if infrastructure deficiencies are not addressed, households will average an additional cumulative loss of $76,000 in discretionary income from the years 2026 to 2040. Even though net job impacts are counted in millions of jobs lost from the U.S. due to insufficient infrastructure investment, overall economic impacts in dollars lost in the economy, measured by business sales and GDP will be even more dramatic than impacts on overall number of jobs. Job losses in part will be mitigated by more people working for less money. Many of these jobs will be in replacement for technology-based and education-driven industries that are the basis of long-term economic development.

4 CONCLUSION

The condition, capacity and performance of America's infrastructure is constantly evolving, and efforts to address those needs are also ongoing. In this update, modeling results from the national economic model used in the initial series were adjusted to reflect findings from the new analysis of infrastructure needs and gaps. **The results of this update study underscore the findings of the preceding reports in the *Failure to Act* series, showing that the economic benefits of infrastructure investment reverberate through every sector of the economy while economic losses that come from deferred investment also become worse over time.**

Deteriorating infrastructure affects businesses and households in various ways leading to reductions in business efficiencies, increasing business costs and increase costs of goods and services to households. The upshot of these impacts is a fall in business sales, national GDP, personal income, consumer spending and jobs compared to what would otherwise be expected to occur.

Results discussed in previous studies showed that deteriorating infrastructure affects businesses and households in various ways leading to reductions in business efficiencies, increasing business costs and increase costs of goods and services to households. The upshot of these impacts is a fall in business sales, national GDP, personal income, consumer spending and jobs compared to what would otherwise be expected to occur. This new study confirms that those same findings still apply.

Findings of the final report in the initial Failure To Act series demonstrated that weakening of multiple infrastructure systems will have a greater effect overall than simply adding the impacts for the individual infrastructure studies. Several core reasons explain this. First, if one transportation system fails, another system can be used in some cases. For example, if airports are too congested passengers can drive or use trains, and cargo can be shipped by truck or inland waterways. However, this substitution is not possible if multiple systems deteriorate. Moreover, part of every trip to and from an airport, marine port and inland port is comes by way of some form of surface transportation. Secondly, the efficient operations of different infrastructure systems depend on each other. For example, power plants use water to generate electricity (for boiling water to create steam and for cooling).[32] Thus, electricity and water are needed to manufacture parts for transportation vehicle repairs and materials for road repairs. Transportation of all modes is required to deliver parts and equipment to all types of infrastructure systems, including transportation facilities. In addition, railway electrification is a systems alternative to diesel powered locomotives for commuter rail, as well as local transit guided bus ways.

Sustainable policies and personal choices will not fix infrastructure, but they can reduce wear and tear, and thereby, extend useful lives of infrastructure systems. In turn, this could extend the timeframe for the full levels of investments suggested in these studies and may mitigate some of the economic consequences of not funding investment. More research on tying sustainable practices to infrastructure investment would be a valuable contribution for understanding tradeoffs faced nationally and regionally.

As discussed in the original *Failure to Act* series, these findings are analytical and do not offer policy or funding prescriptions. It is important to note that funding for infrastructure traditionally comes from multiple sources including business investors and rate payers on the private side, to federal, state, and local governments on the public side. Each report suggests more research is needed to document demand-response, how businesses and households will adjust demand based on changes in efficiencies and costs of infrastructure services, which may affect the level of investment funding from each of these traditional sources.

ENDNOTES

1. While the *Report Card* covers the category of energy overall, *Failure to Act* covers electricity specifically.

2. While the *Report Card* covers the category of rail infrastructure overall, *Failure to Act* covers commuter rail specifically.

3. U.S. Census, 2014 National Population Projections.

4. Note that all tables show impacts in absolute value. These impacts and all other impacts in this report are negative, unless noted otherwise. For example, as shown in, a failure to invest in surface transportation is expected to result in a loss of two trillion dollars in business sales through 2025 that otherwise would occur in the years 2016–2025.

5. Business sales may be more properly referred to as "output", which includes business sales, spoilage/breakage and unsold inventory, as well as budget expenditures by public and non-profit agencies. In this report, "output" is referred to as "business sales" to minimize the use of economic jargon.

6. Airport gaps include anticipated cost of NextGen.

7. Business sales may be more properly referred to as "output", which includes business sales, spoilage/breakage and unsold inventory, as well as budget expenditures by public and non-profit agencies. In this report, "output" is referred to as "business sales" to minimize the use of economic jargon.

8. The exact approached for each of these steps varied by type of infrastructure system, and are explained in the 2011–2012 *Failure to Act* reports.

9. The surface transportation analysis incorporated a series of transportation models to project needs, including HERS ST (highways), TERM (transit), NBIAS (bridges) and CUBE (network connections and effects) and others. This modeling was not replicated for the update.

10. Interindustry Forecasting Project at the University of Maryland—Long-term Interindustry Forecasting Tool.

11. Often, estimates of economic activity and job creation focus on the design and construction period for infrastructure projects, such as a project to rebuild an aging bridge. However, this study focuses exclusively on the incremental and gradual decline of infrastructure systems under current investment scenarios, impacts to our nation's productivity and economy get worse over time, as needed investments are deferred.

12. Congressional Budget Office based on data from the Office of Management and Budget, the Census Bureau, and the Bureau of Economic Analysis.

13. U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2009, HM-63 and HM-64, available at www.fhwa.dot.gov/policyinformation/statistics.cfm as of March 8, 2012.

14. U.S. Department of Transportation, Federal Highway Administration, Office of Bridge Technology, National Bridge Inventory, Functional Classification of Bridges by Highway System, available at www.fhwa.dot.gov/bridge/nbi.cfm as of June 2015.

15. Texas A&M University, Texas Transportation Institute, Urban Mobility Report 2015 and 2010.

16. FHWA Forecasts of Vehicle Miles Traveled (VMT): May 2015, *Office of Highway Policy Information, Federal Highway Administration*. June 5, 2015.

17. U.S. Department of Transportation, Federal Transit Administration, National Transit Database (Annual reports) as of 2015; and 1992–2012: Ibid., National Transit Summaries and Trends.

18. Federal Transit Administration—State of Good Repair and Asset Management. www.fta.dot.gov/13248.html

19. Texas A&M University, Texas Transportation Institute, Urban Mobility Report 2015.

20. Congressional Budget Office's 2015 report *Public Spending on Transportation and Water Infrastructure, 1956 to 2014*.

21. EDR Group analysis of U.S. EPA's 2011 Drinking Water Infrastructure Needs Survey and Assessment—Fifth Report to Congress (EPA 816-R-13-006, released by the Office of Water in April 2013) and 2008 Clean Watershed Needs Survey and Assessment—Report to Congress (EPA 832-R-10-002), as well as preceding needs surveys.

22. EDR Group analysis of the Congressional Budget Office's March 2015 report titled "Public Spending on Transportation and Water Infrastructure, 1956 to 2014." Specifically, Supplemental Table W-1, available at www.cbo.gov/publication/49910 and the U.S. Census Bureau's Annual Census of Government's estimates, available at www.census.gov/govs/estimate/.

23. See Government Accountability Office (2006) EPA Should Strengthen Ongoing Efforts to Ensure That Consumers Are Protected from Lead Contamination, GAO-06-148, Washington, D.C. [Online] Available: www.gao.gov/products/GAO-06-148.

24. See EPA. 2015. Report of the Lead and Copper Working Group to the National Drinking Water Advisory Council—Final, page 16. [Online] Available: www.epa.gov/sites/production/files/2016-01/documents/ndwaclcrwgfinalreportaug2015.pdf.

25. Cornwell, David A., Richard A. Brown, And Steve H. Via, "National Survey of Lead Service Line Occurrence." Environmental Engineering and Technology Inc., Newport News, Va., 2AWWA, Washington, D.C.

26. See page 36 of the following report for a chart showing the Core 30 airports, defined by the FAA as those having the most passenger activity (with the exception of Memphis, a major freight hub): www.faa.gov/data_research/aviation/aerospace_forecasts/media/2015_National_Forecast_Report_Final.pdf.

27. www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf

28. Source: www.wisertrade.org, data from U.S. Census Bureau Foreign, Trade Division; includes imports and exports.

29. See www.faa.gov/nextgen/media/BusinessCaseForNextGen-2014.pdf.

30. LaCommare and Eto, 2004.

31. The mean average time associated with "sustained outages" are 106 minutes.

32. See P. Torcellini, et al., Consumptive Water Use for U.S. Power Production, National Renewable Energy Laboratory, U.S. Department of Energy, December 2003.

ABOUT EDR GROUP

Economic Development Research Group, Inc. (EDR Group) focuses specifically on applying state-of the-art tools and techniques for evaluating economic development performance, impacts and opportunities. The firm was started in 1996 by a core group of economists and planners who are specialists in evaluating impacts of infrastructure services and technology on economic development opportunities. The firm provides consulting and analysis services to private and public-sector clients across the U.S., Canada and overseas. This includes benefit-cost, economic impact, and cost-effectiveness studies for projects, programs and policies. These efforts support economic development strategies, planning processes and public investment decision-making. In addition, EDR Group provides software tools to assist others in conducting economic analysis, including tools for assessing transportation, energy and economic development investments. EDR Group provides a large collection of its economic impact analysis studies and information on analysis tools, on the web at **www.edrgroup.com**.

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