FAILURE TO ACT

THE IMPACT OF CURRENT 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.

The report was funded by a generous
grant from the ASCE Foundation.

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

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

www.edrgroup.com

Copyright © 2013 by the American Society of Civil Engineers.
All Rights Reserved.

FAILURE TO ACT

THE IMPACT OF CURRENT INFRASTRUCTURE INVESTMENT ON AMERICA'S ECONOMIC FUTURE★★★★

★ CONTENTS

2 | List of Figures and Tables

2 | Preface

4 | Section 1 INTRODUCTION

6 | Section 2 ECONOMIC IMPACTS OF FAILING TO INVEST ACROSS INFRASTRUCTURE SYSTEMS

14 | Section 3 REVIEW OF INFRASTRUCTURE SECTORS

16 | Summary of Findings from Previous Studies

16 | Surface Transportation

18 | Airports

19 | Inland Waterways & Marine Ports

19 | Electricity

20 | Water and Wastewater

22 | Section 4 CONCLUSIONS

24 | Endnotes

25 | Acknowledgments

25 | About EDR Group

★ FIGURES AND TABLES

Figure

1 Investment Gap by Infrastructure Category as a Percentage of Total Needs in the Years 2020 and 2040

Tables

1 Comparison of 2009 Report Card and Failure to Act Series

2 Cumulative Infrastructure Needs by System based on Current Trends Extended to 2020 and 2040

3 Costs to Businesses and Households of Degrading Infrastructure

4 Impacts of Infrastructure Investment Gap Per Household

5 The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Business Sales in 2020 and 2040

6 The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Jobs in the Years 2020 and 2040

7 The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Value of Exports in 2020 and 2040

8 Cumulative Impacts to the National Economy by Category

★ PREFACE

Every four years, the American Society of Civil Engineers (ASCE) publishes *The Report Card for America's Infrastructure*, which grades the current state of the nation's infrastructure categories on a scale of A through F. In 2009, the U.S. infrastructure earned just a D average. When the next Report Card is released in 2013, it will provide an updated look at the state of U.S. infrastructure conditions, but there is also a larger question at stake: **How does a D for infrastructure affect America's economic future?**

This *Failure to Act* report answers the key question of how the conditions of the United States' infrastructure systems affect the nation's economic performance. The *Failure to Act* report provides this economic analysis by addressing 9 of ASCE's 16 infrastructure categories that are addressed in the 2013 *Report Card* (see table 1). Today, perhaps more than ever, economic performance is critical to the nation's future.

The purpose of the *Failure to Act* report series is to provide an analysis of the economic implications for the United States of continuing its current investment trends in infrastructure. The *Failure to Act* series analyzes two types of infrastructure needs:

- ★ Building new infrastructure to service increasing populations and expanded economic activity; and
- ★ Maintaining or rebuilding existing infrastructure that needs repair or replacement.

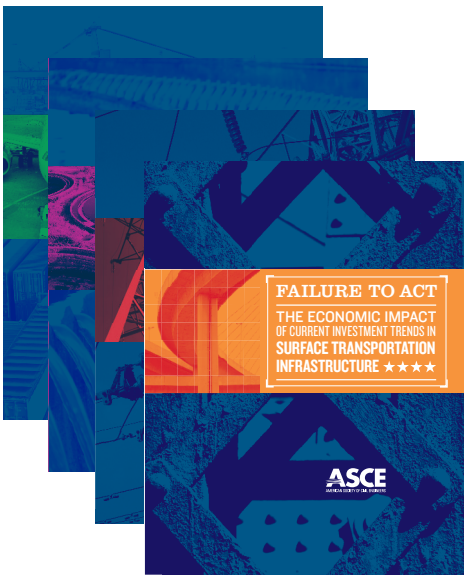
The four preceding reports in this series assess the implications of present trends in infrastructure investment for the productivity of industries, for national competitiveness, and for costs to households.

TABLE 1 ★ Comparison of 2009 Report Card and Failure to Act Series

2009 REPORT CARD	INCLUDED IN FAILURE TO ACT SERIES
Dams	
Drinking Water	★
Hazardous Waste	
Levees	
Solid Waste	
Wastewater	★
Aviation	★
Bridges	★
Inland Waterways	★
Rail	★
Roads	★
Transit	★
Parks and Recreation	
Schools	
Energy	★
Marine Ports	★

NOTE Marine ports were not evaluated in the 2009 *Report Card*, but were part of the *Failure to Act* series and will be included in the 2013 *Report Card*.

2009 REPORT CARD



FAILURE TO ACT SERIES

1 INTRODUCTION

Infrastructure is the physical framework upon which the U.S. economy operates and the nation's standard of living depends. Everything depends on this framework, including transporting goods, powering factories, heating and cooling office buildings, and enjoying a glass of clean water.

The preceding four *Failure to Act* reports compared current and projected needs for infrastructure investment against the current funding trends in surface transportation; water and wastewater; electricity; and airports, inland waterways, and marine ports. Our projections included both the cost of building new infrastructure to service increasing populations and the cost of expanded economic activity; and for maintaining or rebuilding existing infrastructure that needs repair or replacement. The total documented cumulative gap between projected needs and likely investment in these critical systems will be $1.1 trillion by 2020. The subsequent analyses focused on the long-term effects associated with infrastructure investments and did not consider the immediate benefits associated with the construction process. The results show that deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on the nation's economy, negatively affecting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness.

The results show that deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on the nation's economy, negatively affecting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness.

The categories of infrastructure systems analyzed in the preceding *Failure to Act* reports were reviewed in isolation by each study.[1] However, it is clear that there is an interactive effect between different infrastructure sectors and a cumulative impact of an ongoing investment gap in multiple infrastructure systems. For example, regardless of how quickly goods can be offloaded at the nation's ports, if highway and rail infrastructure needed to transport these goods to market is congested, traffic will slow and costs to business will rise, creating a drag on the U.S. economy that is ultimately reflected in a lower GDP.

This fifth and final report analyzes the interactive effect between investment gaps in the infrastructure sectors addressed in each of the preceding studies. It presents an overall picture of the national economic opportunity associated with infrastructure investment and the consequences of failing to fill the investment gap.

The overall impact of deficient infrastructure associated with a general failure to invest cannot be estimated by simply adding the impacts found in each report because the degradation of surface transportation, water delivery and wastewater treatment, electricity, inland waterways, and marine ports each affect business productivity differently. Shifts to other production methods or modes of infrastructure may be possible given a decline in one system, which could mitigate the economic impacts of failing to invest in that system. For example, rail, inland waterways, and trucks are used to get goods to retail shelves—deteriorating conditions in one sector tend to make the other sectors more competitive. However, a general decline in infrastructure conditions across multiple sectors would preclude such strategies.

In addition, the consequences of infrastructure shortfalls differ by each system. With degrading surface transportation, trips can still be made, but they would take longer and be less reliable, and travel could be less safe. Declining airport and marine port infrastructure directly impacts the nation's ability to import and export goods efficiently, driving up costs to U.S. consumers.

Overall, if the investment gap is not addressed throughout the nation's infrastructure sectors, by 2020, the economy is expected to lose almost $1 trillion in business sales, resulting in a loss of 3.5 million jobs. Moreover, if current trends are not reversed, the cumulative cost to the U.S. economy from 2012–2020 will be more than $3.1 trillion in GDP and $1.1 trillion in total trade.[2]

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 on the incremental and gradual decline of infrastructure systems under current investment scenarios, and it shows that the negative impacts on the nation's economy are exacerbated over time as needed investments are deferred. Conversely, this study demonstrates that the economic benefits of infrastructure investment reverberate through every sector of the economy over time.

2 ECONOMIC IMPACTS OF FAILING TO INVEST ACROSS INFRASTRUCTURE SYSTEMS

In combination with current investment trends, cumulative infrastructure investment needs will be approximately $2.7 trillion by 2020 and will rise to $10 trillion by 2040. It is expected that funding will be available to cover only 60% (approximately $1.7 trillion) of these needs through 2020, and that will drop to 53% by 2040. Thus, the investment gaps will total $1.1 trillion by 2020, and will grow to $4.7 trillion by 2040.

As shown in table 2, the bulk of the gap is due to surface transportation needs, including roads, bridges, and transit systems. In addition, figure 1 shows the percentage of needs for each infrastructure type and the remaining unfunded investment gap.

The previous studies in the *Failure to Act* series found that underinvesting in infrastructure will result in 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 air service, 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. As a consequence, U.S. businesses will become less efficient. 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 the technology and knowledge-based industries that drive innovation and economic development.

Although the U.S. economy will still be producing goods and services, it will do so at a reduced scale, and the lower wages will lead to less consumer spending. Impacts ultimately will fall hardest on households that will pay more for services—including transportation, water and wastewater, and electricity—and absorb the brunt of fewer

TABLE 2 ★ Cumulative Infrastructure Needs by System Based on Current Trends Extended to 2020 and 2040 *(Dollars in $2010 billions)*

INFRASTRUCTURE SYSTEMS	2020 TOTAL NEEDS	2020 EXPECTED FUNDING	2020 FUNDING GAP	2040 TOTAL NEEDS	2040 EXPECTED FUNDING	2040 FUNDING GAP
Surface Transportation	$1,723	$877	$846	$6,751	$3,087	$3,664
Water/Wastewater	$126	$42	$84	$195	$52	$144
Electricity	$736	$629	$107	$2,619	$1,887	$732
Airports*	$134	$95	$39	$404	$309	$95
Inland Waterways & Marine Ports	$30	$14	$16	$92	$46	$46
TOTALS	**$2,749**	**$1,657**	**$1,092**	**$10,061**	**$5,381**	**$4,681**

*Airport needs and gaps include anticipated cost of NextGen: $20 billion by 2020 and $40 billion by 2040.

jobs, lower incomes, and higher prices for both domestically produced and imported goods.

The reduction in business sales due to the drop in exports, personal income and consumer spending will eventually reduce national GDP, which a primary indicator of national economic productivity.

Aggregate Economic Impacts

Businesses and households face higher costs due to several factors, including unreliable transportation services, less reliable water and electricity services, and unmet maintenance needs and outdated facilities for airports, marine ports, and inland waterways. These costs absorb funds from businesses that would otherwise be directed to investment or research and development, and funds from households that would go toward discretionary consumer purchases. The costs are expected to total over $1.8 trillion by 2020, as shown in table 3. 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.

Compared with baseline forecasts for the years 2012–20, the cumulative impact of deficient infrastructure due to continued underinvestment in the transportation, water, energy, and port sectors is predicted to result in an aggregated loss of $3.1 trillion in GDP from the U.S. economy. Losses are expected to include $484 billion in exports and almost $1.1 trillion in total trade. As a result of this underperformance, job losses will mount annually, and by 2020 it is predicted that there will be 3.5 million fewer jobs throughout the country.

The expected impact for every household in the U.S. will be an average loss of more than $3,000 per year through 2020 in disposable personal income, amounting to $28,000 per household over nine years, as shown in table 4. These losses will be due to job cutbacks and declining business productivity (which includes less sales and lower GDP), which will result in lower household incomes. By 2040, these effects will be more pronounced. Based on extending identified needs and finding trends, by the year 2040, the impacts of a cumulative $4.7 trillion gap in transportation, water, energy, and ports (including the investments through 2020)

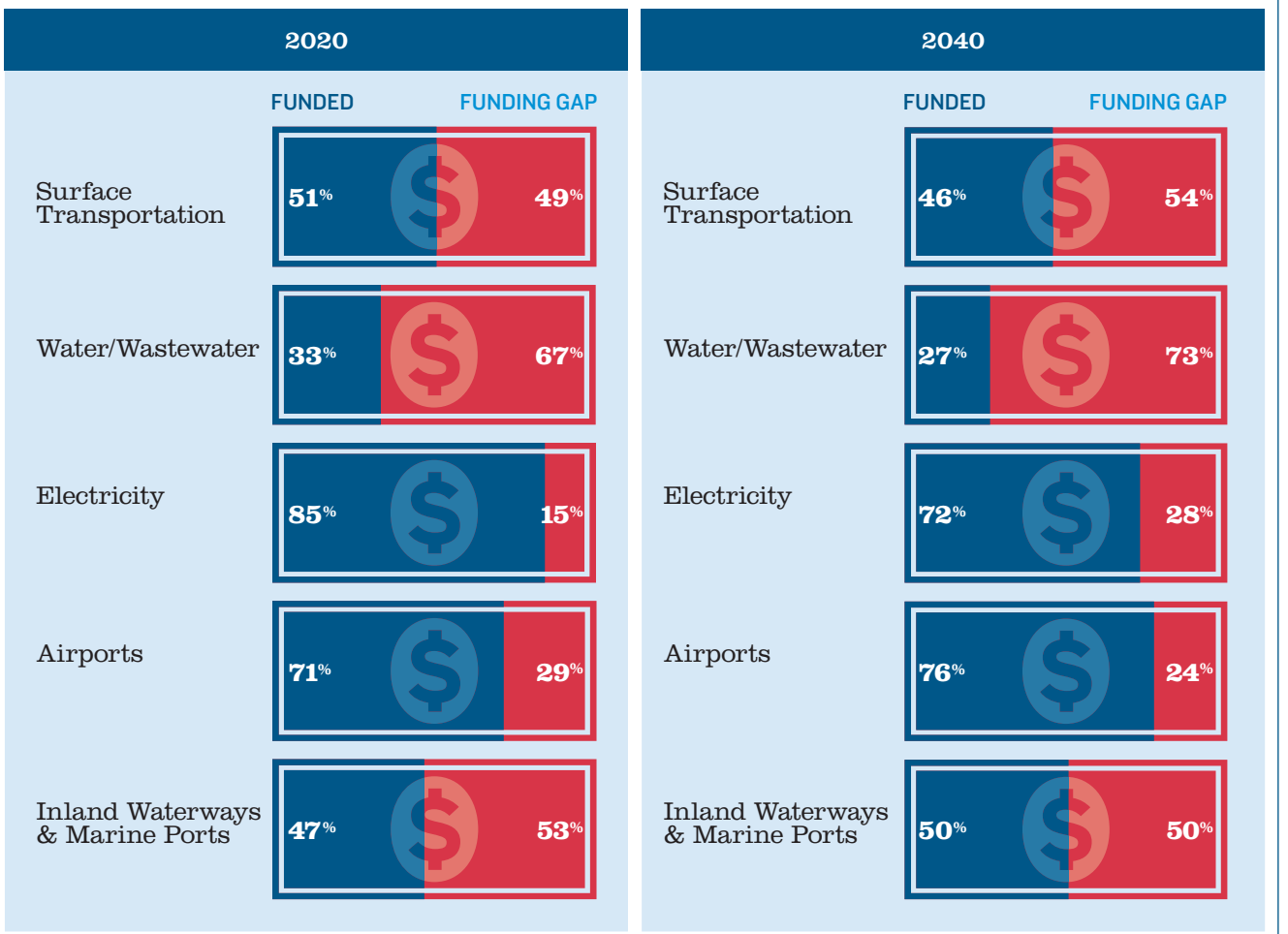
includes losses of almost 7 million jobs from the national economy. In terms of dollar losses from expected levels in 2040 are $2.5 trillion in business sales, including $473 billion in exports ($712 billion in total trade), $1.3 trillion in national GDP, and $1.2 trillion in disposable personal income that would be lost to U.S. households.

Per household, the expected loss of disposable personal income is estimated to exceed $6,000 annually from 2021 to 2040, which adds to $126,000 over the 20-year time frame. On average, the cost of deficient infrastructure is expected to reach $5,400 per year for each household in the nation from 2012 to 2040, as shown in table 4.

From 2012 until 2020, consumer spending will drop by almost $2.4 trillion as a consequence of the declines in disposable income. Although consumer spending is calculated to decline in each of the preceding *Failure to Act* studies, the effect is particularly pronounced when examining impacts on all the infrastructure systems together.

Nationally, the cumulative loss in national business sales[3] will be almost $6 trillion over the years 2012-2020. Nearly $34 trillion more

FIGURE 1 ★ Investment Gap by Infrastructure Category as a Percentage of Total Needs in the Years 2020 and 2040



SOURCE Data taken from previous *Failure to Act* studies.

TABLE 3 ★ Costs to Businesses and Households of Degrading Infrastructure

CUMULATIVE TO 2020

INFRASTRUCTURE SYSTEMS	HOUSEHOLDS	BUSINESSES	TOTAL
Surface Transportation	$481	$430	$911
Water/Wastewater	$59	$147	$206
Electricity	$71	$126	$197
Airports	N/A	$258	$258
Inland Waterways & Marine Ports	N/A	$258	$258
TOTALS	**$611**	**$1,219**	**$1,830**

NOTE Dollars in $2010 Billions. Costs do not include personal income or value of time other than business travel.

CUMULATIVE TO 2040

INFRASTRUCTURE SYSTEMS	HOUSEHOLDS	BUSINESSES	TOTAL
Surface Transportation	$1,880	$1,092	$2,972
Water/Wastewater	$616	$1,634	$2,250
Electricity	$354	$640	$994
Airports	N/A	$1,212	$1,212
Inland Waterways & Marine Ports	N/A	$1,233	$1,233
TOTALS	**$2,850**	**$5,811**	**$8,661**

NOTE Dollars in $2010 Billions. Costs do not include personal income or value of time other than business travel.

TABLE 4 ★ Impacts of Infrastructure Investment Gap Per Household

	2012-2020	2021-2040	2012-2040
Average Annual Disposal Income Per Household	–$3,100	–$6,300	–$5,400
Total Disposal Income Per Household	**–$28,300**	**–$126,300**	**–$157,200**

NOTE Dollars rounded to nearest $100. Totals may not multiply due to rounding.

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

TABLE 5 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Business Sales in the Years 2020 and 2040

(Dollars in $2010 billions)

2020		2040	
SECTOR	BUSINESS SALES/OUTPUT	SECTOR	BUSINESS SALES/OUTPUT
Retail trade	–$95	Finance & insurance	–$204
Water and sanitary services	–$76	Retail trade	–$172
Restaurants and bars	–$55	Real estate and royalties	–$159
Finance & insurance	–$51	Wholesale trade	–$132
Electric utilities	–$46	Owner-occupied housing	–$115
Hotels	–$36	Professional services	–$100
Medical Services	–$35	Other business services	–$94
Advertising	–$34	Medical Services	–$94
Personal & repair services*	–$25	Computer & data processing	–$82
Gas utilities	–$23	Air transport	–$62
Computer & data processing	–$21	Restaurants and bars	–$59
Wholesale trade	–$21	Maintenance & repair	–$59
Other instruments	–$19	Aerospace	–$58
Other business services	–$18	Agriculture, forestry, fisheries	–$54
Agriculture, forestry, fisheries	–$17	Movies and amusements	–$50
Other Sectors	–$386	Other Sectors	–$1,037
Total	**–$958**	**Total**	**–$2,529**

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

*Excludes auto repair services.

TABLE 6 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Jobs in the Years 2020 and 2040

(Dollars in $2010 billions)

2020		2040	
SECTOR	JOBS	SECTOR	JOBS
Retail trade	–786,000	Retail trade	–1,198,000
New construction	–394,000	New construction	–753,000
Medical Services	–298,000	Medical Services	–638,000
Other business services	–294,000	Wholesale trade	–601,000
Restaurants and bars	–272,000	Restaurants and bars	–558,000
Finance & insurance	–245,000	Other business services	–549,000
Wholesale trade	–228,000	Education, social services, NPO	–437,000
Education, social services, NPO	–213,000	Finance & insurance	–358,000
Professional services	–154,000	Professional services	–298,000
Movies and amusements	–102,000	Movies and amusements	–249,000
Printing & publishing	–67,000	Air transport	–191,000
Air transport	–63,000	Printing & publishing	–126,000
Automobile services	–58,000	Computer & data processing	–109,000
Real estate and royalties	–57,000	Real estate and royalties	–107,000
Computer & data processing	–54,000	Personal & repair services, ex. auto	–89,000
Other Sectors	–178,000	Other Sectors	–598,000
Total	**–3,463,000**	**Total**	**–6,859,000**

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

in sales are predicted to be lost from 2021-2040. The aggregate loss of GDP from the U.S. economy is expected to be $3.1 trillion cumulatively over the years 2012-2020, and an additional $18 trillion from 2021 through 2040.

By 2020, the economy is expected to lose almost 3.5 million jobs, and mounting impacts from underinvestment in infrastructure will result in nearly 7 million jobs lost by 2040.[4] Tables 5 and 6 show that the economic benefits of infrastructure investment reverberate through every sector of the economy and are exacerbated over time as needed investments are deferred.[5]

Tables 5 and 6 show that the impacts by sector will shift by 2040, as the gaps between infrastructure needs and investment widens and the economy has time to adjust to lower levels of services. Large, labor-intensive industries such as retail, medical services, and restaurants will be particularly hard hit by 2040. This is the long-term result of households earning less disposable income and reducing purchases (restaurant meals, home improvements, consumer electronics, new furniture for examples), deferring services (medical care), and the long-term reduction in business sales that will particularly affect construction spending.

By 2040, the key sectors related to America's innovation and knowledge base—including aerospace, air transportation, business services, professional services, and finance—will all be among the hardest-hit in terms of sales and industry sales.

Primarily, these impacts are due to: (1) fewer purchases for higher priced goods and services by both households and businesses in adjusting to declining business sales and lower disposable personal income; (2) higher production costs, transportation costs and a less efficient supply chain reduces the competitiveness of U.S. produced exports; (3) supply-chain impediments, including the costs of transportation, inefficiencies at ports that increase the costs of products; and (4) a redistribution of business revenues from R&D, major purchases and higher priced business services in order to pay for higher costs of transportation, water and energy.

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 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 replace technology-based and education industry jobs that are the basis of long-term economic development.

In 2020, the United States population is predicted to exceed 340 million people and the national population is expected to grow to more than 400 million by 2040. Workers will still be needed to provide basic and a reduced level of luxury products and services to this population.

The impact of declining business productivity due to inefficient infrastructure may add some jobs to the economy even as income is declining. As an example, in 2020 and 2040, deficient infrastructure is expected to negatively affect the value of agriculture sales and exports as shipping costs rise. However, even though this sector's sales and exports will fall, more workers will be needed in 2020 to produce and supply its products, as shown in table 7. Other sectors that will increase job shares by 2020 are automobile repair services, truck driving, and highway passenger services. These findings are consistent with those of the previous *Failure to Act* study on surface transportation, because poor pavement conditions and deficient roads will cause more damage to vehicles, slower travel times will require more drivers and crews, and a degrading inland waterway system and congested air space will lead more people to travel by car and more goods to be shipped by truck.

Table 7 presents data on those industries that will be most affected by a decline in exports in 2020 and 2040. These industries include a cross-section of critical sectors of the national economy, including finance, aerospace, instruments, and communications. These industries also represent basic manufacturing and services, including wholesale trading, equipment, and agricultural products.

TABLE 7 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Value of Exports in 2020 and 2040

(Dollars in $2010 billions)

2020		2040	
SECTOR	VALUE	SECTOR	VALUE
Finance & insurance	–$9	Finance & insurance	–$50
Wholesale trade	–$7	Aerospace	–$47
Aerospace	–$6	Wholesale trade	–$35
Agriculture, forestry & fisheries	–$5	Air transport	–$31
Air transport	–$4	Agriculture, forestry & fisheries	–$18
Other chemicals	–$3	Communications equipment	–$15
Professional services	–$2	Professional services	–$13
Other instruments	–$2	Other instruments	–$13
Petroleum refining	–$2	Other chemicals	–$13
Ag., const. & material handling equipment	–$2	Meat products	–$10
Drugs	–$2	Electronic components	–$9
Meat products	–$2	Ag., const. & material handling equipment	–$8
General & misc. industrial equipment	–$2	Computer & data processing	–$7
Communications equipment	–$2	Plastics & synthetics	–$7
Motor vehicle parts	–$2	Medical instruments & supplies	–$7
Other Sectors	–$41	Other Sectors	–$188
Total	**–$106**	**Total**	**–$517**

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

3 REVIEW OF INFRASTRUCTURE SECTORS

Each of the specific infrastructure studies that were conducted in the *Failure to Act* series was based on assuming extending current needs through 2040, recent funding trends, and trends in how infrastructure is being used.

The projected needs for investments in infrastructure systems, and the consequent costs to industries and households of not making these investments, are documented by models used by federal infrastructure agencies; databases; reports published by federal agencies and by industry groups that represent local, regional, and private sector infrastructure providers; academic and professional literature; and interviews with industry experts. Economic impacts were calculated using the LIFT model (Long-Term Interindustry Forecasting Tool) of the Inforum Interindustry Forecasting Project at the University of Maryland.

TABLE 8 ★ Cumulative Impacts to the National Economy by Category

(Dollars are in $2010 billions)

	Surface Transportation	Airports	Inland Waterways & Marine Ports	Electricity	Water / Wastewater
Business Sales					
Through 2020	$1,700	$580	$1,335	$847	$734
2021–2040	$7,062	$2,682	$6,496	$3,590	$6,791
GDP					
Through 2020	$897	$313	$697	$496	$416
2021–2040	$1,765	$1,209	$3,278	$1,954	$3,702
Jobs					
2020	877,000	350,000	738,000	529,000	669,000
2040	410,000	358,000	1,384,000	366,000	1,377,000
Disposable Income					
Through 2020	$930	$361	$872	$656	$541
2021–2040	$2,205	$1,128	$3,662	$2,294	$4,440
Value of Exports					
Through 2020	$114	$54	$270	$51	$20
2021–2040	$1,093	$708	$1,712	$630	$807

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

NOTE This Table reflects the research conducted in 2011 and 2012 and findings of the four infrastructure sector studies that preceded this report. Jobs rounded to the nearest thousand.

Summary of Findings from Previous Studies

The projected annual impacts of the infrastructure systems reviewed are shown for 2020 and 2040 in table 8. It is important to note that in some cases the national economy is expected to adjust from the degradation of infrastructure. In particular, annual losses in GDP and income will be similar in 2020 and 2040 because inadequate investment in surface transportation and job impacts are expected to be cut in half between these two years. These numbers, however, mask the dynamic that job increases will be in those industries that address poor roadway conditions and that job losses will continue to be seen in the U.S. knowledge-based and innovation industries that drive economic development.

The studies did not presume new technologies, or expanded technologies not currently scheduled for implementation. Examples of such technologies not considered in these reports are high-speed rail or maglev systems in surface transportation and a radical expansion of renewable energy for electricity generation. The electricity study assumed that technologies in place or planned for power generation by region would be in place through 2040. For aviation, the costs of the Next Generation Air Transportation System's (NextGen's) technologies were considered as part of the gap, and likely air congestion without NextGen was part of the basis for estimating future economic impacts.

The nation's surface transportation infrastructure includes the critical highways, bridges, railroads, and transit systems that enable people and goods to access the markets, services, and inputs of production that are essential to America's economic vitality. For many years, the nation's surface transportation infrastructure has been deteriorating. However, because this deterioration has been diffused throughout the nation, and has occurred gradually over time, its true costs and economic impacts have not always been immediately apparent. In practice, the transportation funding that is appropriated is spent on a mixture of system expansion and preservation projects. Although these allocations have often been sufficient to avoid the imminent failure of key facilities, the 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 than rural facilities. Peak commuting patterns also place larger burdens on the capacities of urban areas. However, because the nation is so dependent on the Interstate Highway System, impacts on interstate performance in some regions or areas are felt throughout the nation.

Nationally, for highways and transit, 630 million vehicle hours traveled were lost due to congestion in 2010. This total is expected to triple to 1.8 billion hours by 2020 and further increase to 6.2 billion hours in 2040. These vehicle hours understate person hours and underscore the severity of the loss in productivity.

Deteriorating conditions and performance impose costs on American households and

By 2020, America's projected surface transportation infrastructure deficiencies are expected to cost the national economy cumulatively almost $900 billion in GDP, rising to $2.7 billion through 2040.

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, the 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, congestion increases environmental and safety costs by exposing more travelers to substandard conditions and requiring vehicles to operate at less efficient levels as conditions continue to deteriorate.

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. In 2010, it was estimated that deficiencies in America's surface transportation systems cost households and businesses nearly $130 billion. This included approximately $97 billion in vehicle operating costs, $32 billion in travel time delays, $1.2 billion in safety costs, and $590 million in environmental costs. If present trends continue, by 2020 the annual costs imposed on the U.S. economy from deteriorating surface transportation infrastructure will increase to $210 billion, and by 2040 to $520 billion—with cumulative costs mounting to $912 billion and $2.9 trillion by 2020 and 2040, respectively.

By 2020, America's projected surface transportation infrastructure deficiencies—in a scenario of extended trends—are expected to cost the national economy cumulatively almost $900 billion in GDP, rising to $2.7 trillion through 2040. In 2020, nearly 900,000 jobs are expected to be lost. By 2040, these gross job losses will be mitigated to slightly more than 400,000 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 along with infrastructure degradation, more resources will be 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 1.3 million more jobs could exist in key knowledge-based and technology-related economic sectors if sufficient transportation infrastructure were maintained. These losses would be balanced against almost 900,000 additional jobs projected in traditionally lower-paying service sectors of the economy that would benefit from deficient transportation (such as auto repair services) or from declining productivity in domestic service-related sectors (such as truck driving and retail trade).

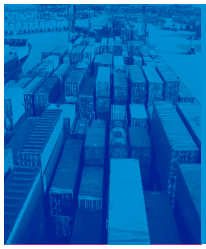
The most significant economic threat concerning aviation is air and ground congestion at major airports and regions.

Airports

Among the 3,300 airports in the United States that are designated by the Federal Aviation Administration (FAA) as important to the national aviation system, 35 airports with the nation's top 15 markets account for 80 percent of U.S. passenger origin and destination movements, totaling 343 million trips. The FAA forecasts that enplanements in these 15 markets will increase 30% by 2020 and 121% by 2040.[6] These projections exceed enplanements forecasted at other commercial airports, which are predicted to increase 25% by 2020 and 93% by 2040. More important from the perspective of air traffic projections, commercial aircraft operations are projected to grow by 17% through 2020 and 62% by 2040, including increases in the 15 major markets of 23% by 2020 and 86% by 2040. Similar to passenger travel, freight shipments are concentrated in major metro areas. By tonnage, 92% of international air freight tonnage is imported or exported through the 15 leading U.S. customs districts, and 70% of domestic air tonnage originates at key metro markets.

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 the FAA and Airports Council International shows an annual capital gap of about $2 billion through 2020 (roughly $13 billion in need and $11 billion in expenditures per year) and $1 billion annually from 2021 to 2040 ($12 billion in need and $11 billion in expenditures, assuming that spending through 2020 does not fall lower than recent trends). In addition to construction needs, congestion relief is being proposed through NextGen, which is expected to transform the management and operation of the air transportation system in the United States, moving from the current ground-based radar system to a satellite-based system. At present the most widely accepted cost of NextGen is $31 billion, in addition to approximately $9 billion that has already been invested between 2003 and 2011.

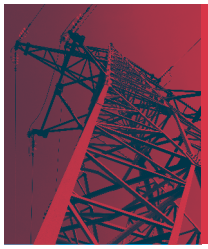
The implications of these investment needs are expected to result in a cumulative impact on the U.S. economy. Anticipated growth of aircraft operations and passengers at major airports will lead to delays for cargo movement and business travel, assuming that capital spending remains consistent through 2040 as it has been from 2001 (about $10 billion annually in 2010 value). The broad impacts on the U.S. economy would represent a cumulative loss of GDP amounting to $313 billion by 2020 and $1.52 trillion by 2040. Overall, the U.S. economy will end up with an average of 350,000 fewer jobs than it would otherwise have by 2020 and 358,000 fewer jobs in 2040.



Inland Waterways & Marine Ports

The U.S. inland waterway system consists of over 12,000 miles of inland and intracoastal waterways, with over 240 lock chambers, along with over 300 commercial harbors. Domestically, this system accounts for 10% of all tonnage moved in the United States and almost 20 percent of the total value of all freight transported over the entire U.S. transportation system. This includes approximately 56% of all crude petroleum, 15% of all coal, and 24% of other fuel oils, which alone affect the efficiency of all economic sectors that rely on energy. In addition, 70% of U.S. imports arrive by water, including 86% of crude petroleum imports, as well as approximately 76% of U.S. exports (by tonnage), accounting for approximately 35% of total exports by value.

If America's current level of investment in its inland waterways and marine ports continues, the losses to its economy will increase shipping costs. The toll of these impacts will be seen in GDP losses that will accumulate every year—from a loss of almost $95 billion in 2020 to over $255 billion by 2040. The cumulative loss in national GDP through 2040 will be over $4.0 trillion—driven by the rising costs to import and export goods and declining competitiveness. In turn, these effects will result in over 738,000 fewer jobs in 2020. By 2040, the job losses will grow to over 1.3 million—jobs that will be lost by the nation's lack of competitiveness in global trade and because households and businesses will be spending more for commodities that move within the U.S. on inland waterways and for goods that are imported.



Electricity

Electricity relies on an interconnected system that is composed of three distinct elements:[7]

1. Generation facilities—including approximately 5,800 major power plants and numerous other smaller generation facilities;
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 into homes and businesses via overhead lines or underground cables.

The United States' 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, power lines, and transformers that have widely varying ages, conditions, and capacities.

Nationally, extending current trends leads to funding gaps in electric generation, transmission, and distribution that are projected to grow over time to a level of $107 billion by 2020, about $11 billion per year, and almost $732 billion by 2040. By 2020, distribution and transmission infrastructure are expected to account for more than 88% of the investment gap and generation infrastructure to represent roughly 11.5%. By 2040, however, generation infrastructure will potentially be the most costly element of the gap, accounting for 55% of the total, with transmission accounting for 15%, and distribution accounting for 30%. This would be a reversal from 2020, when generation is seen as the best-funded element of electricity infrastructure

due to investments made during the preceding decade. The projected investment gap will be due to some combination of aging equipment and capacity bottlenecks that lead to the same general outcome—a greater incidence of electricity interruptions. The interruptions may occur in the form of equipment failures, intermittent voltage surges, power quality irregularities due to equipment insufficiency, and blackouts or brownouts as demand exceeds capacity for periods of time. These periods could be unpredictable in frequency and length, but the end result would be a loss of reliability in electricity supply that imposes direct costs to households and businesses. A failure to meet the projected gap would cost households $6 billion in 2012, $71 billion by 2020, and $354 billion by 2040. It would cost businesses $10 billion in 2012, $126 billion by 2020, and $641 billion by 2040.

If future investment needs are not addressed to upgrade the nation's electric generation, transmission, and distribution systems, the economy will suffer. Costs may occur in the form of higher costs for electric power, costs incurred because of power unreliability, or costs associated with adopting more expensive industrial processes. Ultimately, these costs all lead to the same economic impact: the diversion of household income from other planned expenditures to cover these increased costs. As costs to household and businesses associated with service interruptions rise, GDP will fall by a total of $496 billion by 2020. The U.S. economy will end up with an average of 529,000 fewer jobs than it would otherwise have by 2020. Even with economic adjustments occurring later on, with catch-up investments, the result would still be 366,000 fewer jobs in 2040.

Water/Wastewater

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—for example, food and chemical manufacturing and power plants—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, and fertilizer from lawns from ever reaching the waterways.

Delivery of water and wastewater services in the United States is decentralized and strained. Approximately 54,000 drinking water systems collectively serve more than 264 million people (more than half the nation's public drinking-water systems serve fewer than 500 people). In addition, almost 15,000 wastewater treatment facilities and 20,000 wastewater pipe systems are spread across the U.S. as of 2008.

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. 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

Water-related infrastructure in the United States is clearly aging, and investment is not able to keep up with the need. If current trends continue, the investment required will amount to $126 billion by 2020, and the anticipated capital funding gap will be $84 billion.

dwellers to centralized systems, continuing to add users to aging systems. 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. 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.

The U.S. Environmental Protection Agency estimated the cost of the capital investment that is required to maintain and upgrade drinking-water and wastewater treatment systems across the U.S. in 2010 as $91 billion. However, only $36 billion of this $91 billion was funded, leaving a capital funding gap of nearly $55 billion. Water-related infrastructure in the United States is clearly aging, and investment is not able to keep up with the need. If current trends continue, the investment required will amount to $126 billion by 2020, and the anticipated capital funding gap will be $84 billion. Moreover, by 2040, the needs for capital investment will amount to $195 billion and the funding gap will have escalated to $144 billion, unless strategies to address the gap are implemented in the intervening years to alter these needs.

By 2020, the predicted deficit for sustaining water delivery and wastewater treatment infrastructure will be $84 billion. This may lead to $206 billion in increased costs for businesses and households between now and 2020. In a worst case scenario, the U.S. will lose nearly 700,000 jobs by 2020. Unless the infrastructure deficit is addressed by 2040, 1.4 million jobs will be at risk in addition to what is otherwise anticipated for that year.

The impacts on jobs are a result of costs to businesses and households managing unreliable water delivery and wastewater treatment services, and will be spread throughout the economy. Moreover, the situation is expected to worsen as the gap between needs and investment continues to grow over time. In 2020, almost 700,000 jobs will be threatened, which will grow to 1.4 million jobs by 2040. By 2020, the nation will have lost over $400 billion in GDP, while the cumulative impact through 2040 is expected to be almost $4 trillion.

4 CONCLUSIONS

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 of production when compared with many of America's competitors. However, this report series shows that business costs and therefore prices will increase if surface transportation systems worsen; ports 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 U.S. domestic manufacturers and rising costs for exports will affect the nation's ability to compete in global markets for goods produced in the U.S., while irregular delivery of water and wastewater services and electricity will make production processes more expensive and divert household disposable income to these basic necessities.

Higher business costs will be incurred due to deteriorating infrastructure 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. The result of these effects will be a reduction in disposable income and reduced spending for consumer goods and services, which will further exacerbate business impacts. Moreover, over time, these impacts will affect the means for businesses to provide well-paying jobs, further reducing incomes.

The results of this final study underscore the findings of the preceding reports in the *Failure to Act* series. Often, estimates of economic activity and job creation focus on the design and construction period for infrastructure projects. Generally, in these type of analyses, the construction impacts rise with the magnitude of infrastructure investment. However, these studies demonstrate that the economic benefits of infrastructure investment reverberate through every sector of the economy and are exacerbated over time as needed investments are deferred, in addition to the economic "shock value" of construction spending.

The analyses presented in the previous studies show that deteriorating infrastructure affects businesses and households in various ways, leading to reductions in business efficiencies, increasing business costs, and increasing costs of goods and services to households. The findings of this final report show that the weakening of multiple infrastructure systems will have a greater effect overall than a simple adding up of the impacts for the individual infrastructure studies.

Several core reasons explain this effect. 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, rail, or inland waterways. However, this substitution is not possible if multiple systems deteriorate. Moreover, every trip to and from an airport, marine port, and an inland port is by some form of surface transportation. Second, 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).[8] 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.

Sustainable policies and personal choices will not fix America's infrastructure, but they can reduce wear and tear, and thereby extend the useful lives of the nation's infrastructure systems. In turn, this could extend the time frame 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 the trade-offs that must be faced both nationally and regionally.

The five reports in the *Failure to Act* series are analytical and do not offer policy or funding prescriptions. Each report suggests that more research is needed to document the demand response—that is, how businesses and households will adjust demand based on changes in the efficiencies and costs of infrastructure services, which may affect the level of investment funding from each of these traditional sources. Regardless of the policy solutions, the *Failure to Act* series demonstrates that maintaining and modernizing out nation's infrastructure has long-term economic implications.

ENDNOTES

1. The single exception is that the logic of the airports, inland waterways, and marine ports study is that ports require ground access to and from these facilities.

2. Note that these are single-year impacts for 2020 and 2040, not cumulative totals.

3. Output is primarily business sales but also includes spoilage/breakage and unsold inventory.

4. Note that these are single-year impacts for 2020 and 2040, not cumulative totals.

5. Although the data shown in table 5 are net impacts to the economy, it should be noted that economic sectors will gain jobs and/or business sales above projected levels in order to serve needs caused by declining infrastructure performance.

6. An "enplanement is a passenger boarding. The FAA uses revenue passenger boardings (enplanements) and cargo data to calculate the apportionments that determine apportionment formula for the Airport Improvement Program.

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

8. See P. Torcellini et al., *Consumptive Water Use for U.S. Power Production* (Washington: National Renewable Energy Laboratory, U.S. Department of Energy, 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, which can be found at www.edrgroup.com.

ACKNOWLEDGMENTS

EDR Group wishes to thank Brian Pallasch, Emily Fishkin, Jane Howell and Brittney Kohler of ASCE staff for their ongoing support as these studies were conducted. We also want to thank the members of ASCE's Committee on America's Infrastructure, for the opportunity to conduct this research. We gratefully acknowledge the assistance of Jeffrey Werling, Ron Horst, and Doug Mead of the University of Maryland Economics Department. We gratefully acknowledge the firms of LaCapra Associates and Downstream Technologies for their collaboration in developing the electricity and water/wastewater analyses. In addition, we are indebted to the staff of federal agencies, subject matter experts and industry organizations that shared their data and insights with us, were sounding boards for initial analyses and reviewed draft reports.

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

World Headquarters
1801 Alexander Bell Drive
Reston, Virginia 20191

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

202/789-7850
202/789-7859 FAX

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