Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs

Joseph Kane and Robert Puentes

"By limiting infrastructure employment to construction alone, and viewing it largely in terms of stimulus spending, policymakers have not considered the breadth of infrastructure jobs found across the U.S. economy."

Findings

An analysis of occupational employment data for the nation reveals that:

- **In 2012, 14.2 million workers were employed in infrastructure jobs across the country, accounting for 11 percent of national employment.** Truck drivers, electricians, and civil engineers are among the occupations employing the most workers overall, the broad majority of whom (77 percent) focus on operating infrastructure rather than its construction (15 percent), design (6 percent), or governance (2 percent). At the same time, 9.1 million of these jobs are found in the nation's 100 largest metropolitan areas, with logistics hubs like Memphis and Louisville having the highest share of workers involved in infrastructure-related activities.

- **Infrastructure occupations tend to offer more equitable wages compared to all occupations nationally, paying over 30 percent more to workers at lower ends of the income scale.** Workers in infrastructure occupations earn significantly higher wages at the 10th and 25th percentile ($24,750 and $30,190) relative to all workers in the U.S. ($18,090 and $22,480). These not only include specialized occupations that pay above-average wages such as nuclear engineers and hydrologists, but also other sizable occupations such as telecommunication line installers and water treatment plant operators found in nearly every metropolitan area throughout the country.

- **More than 80 percent of workers employed in infrastructure occupations typically have short- to long-term on-the-job training, but only 12 percent hold a bachelor's degree or higher and generally need less education to qualify for these jobs.** Many infrastructure jobs have low barriers of entry in terms of formal education, including cargo agents, rail car repairers, and other trade occupations, which frequently rely on skills developed on the job. However, these workers still earn competitive wages across a variety of occupations, ranging from gas compressor operators to septic tank servicers.

- **Infrastructure occupations are projected to increase 9.1 percent during the next decade, including the need to replace more than 2.7 million workers.** From 2012 to 2022, many infrastructure jobs are projected to grow by thousands of additional workers, led by fast-growing occupations such as wind turbine service technicians and solar photovoltaic installers. Critically, though, there will be a need to replace almost one quarter of this infrastructure workforce due to retirements and other employment shifts.

This report sheds new light on the widespread contributions that infrastructure jobs make to the nation's economy, including their importance at the metropolitan level. Since many of these jobs offer more equitable wages, require less formal education for entry, and are projected to grow over the next decade, they represent a key area of consideration for policymakers aiming to address the country's ongoing infrastructure and jobs deficit.

I. Introduction

For decades, policymakers have called for more spending on America's infrastructure to stimulate job growth. In 1982, President Ronald Reagan wanted to raise the federal gasoline tax by a nickel to generate "real, worthwhile work."[1] President George H. W. Bush was widely quoted in 1991 after signing a federal transportation law that, he said, "could be summed up in three words: jobs, jobs, jobs."[2] Similarly, the American Recovery and Reinvestment Act of 2009 focused on job preservation by pumping billions of dollars into "shovel-ready" transportation, energy, and water projects.[3] In his latest State of the Union address, President Barack Obama noted how "first-class jobs gravitate to first-class infrastructure" through new ladders of opportunity into the middle class.[4]

In many ways, this focus is understandable in Washington and beyond given the recent economic struggles facing the country. Construction jobs, after all, accounted for one-third of the jobs lost since the start of the Great Recession, and they are still 1.5 million below their pre-recession level despite three years of steady increases.[5] Spending on infrastructure also attracts attention from policymakers owing to the large multiplier effects these projects can often have on the overall economy, which can lead to gains in productivity and employment.[6]

Yet, as policymakers continue to direct attention to infrastructure, they do not always identify the exact types of jobs supported by these investments. By limiting infrastructure employment to construction alone, and viewing it largely in terms of stimulus spending, policymakers have not considered the breadth of infrastructure jobs found across the U.S. economy.

For example, investing in systems essential to providing clean water, efficient energy, and safe transportation are key priorities in preparation for extreme weather events, but the particular jobs responsible for managing these systems are often left undefined.[7] Such ambiguity makes it difficult to develop targeted solutions in a time of political gridlock and constrained budgets. Beyond investing in physical structures, then, policymakers need to ask whether the nation has the workforce necessary to tackle these pressing challenges.

This report aims to define a more precise range of jobs in occupations and industries that play a distinct role in the design, construction, operation, and governance of the nation's infrastructure assets. It explores where this employment is concentrated nationally and provides insight into the wages, projections, and skills required for these jobs. Through this comprehensive approach, the report finds that infrastructure employment spans across a variety of public and private sectors—from pipelines and railroads to warehouses and utilities—containing an array of jobs that pay competitive wages, have low barriers of entry, and are expected to grow in years to come.

II. Background and Approach

Attempts to measure infrastructure employment are complicated by the ever-expanding and evolving definition of infrastructure itself. Depending on the individual or organization involved in a given project infrastructure can take on many different meanings and lead to an uneven assessment of its true extent, economically or otherwise.[8] On the one hand, infrastructure serves as an essential foundation for public services such as water, electricity, and waste removal, which allow communities to function on a daily basis.[9] It also represents an important form of physical capital for investors interested in managing risk, facilitating commerce, and building wealth.[10] Still, to others, infrastructure includes social institutions such as schools, hospitals, and prisons that are vital to the nation's education, health, and security.

At the same time, determining which jobs fall under each of these categories can lead to a confounding number of possibilities. Unlike workers in construction, manufacturing, or even STEM-related fields (science, technology, engineering, and math), little precedent exists for identifying the knowledge required and activities carried out by infrastructure workers.[11] Since infrastructure spans numerous types of establishments, these workers vary considerably in the products they handle and services they provide as well. Infrastructure jobs share many of the same complexities of those jobs in the "clean" economy—the sector that produces goods and services with an environmental benefit—which lack standard guidelines, definitions, and data to isolate their employment.[12]

Our initial goal in this analysis is to develop a consistent definition for infrastructure, building on previous reports to help capture a clear range of employment opportunities. Among prior studies, Statistics Canada (StatCan) offers a detailed approach to measure infrastructure's economic scope at a national level. By classifying these assets into industry sectors on the basis of their physical functions and characteristics, StatCan was able to compare infrastructure investments over time.[13] Rather than relying on an ad hoc definition as many reports do, we follow StatCan's lead and focus on a set of tangible assets that support the nation's larger infrastructure network.

In turn, we establish the following definition of infrastructure:

In general, infrastructure encompasses a broad range of systems and facilities designed, constructed, operated, and governed across the public and private sector. Foundational in nature, these physical assets are either manmade or natural, often operate as part of larger networks, support a variety of economic activities, and provide a host of other services with a clear public benefit over the course of many years.

As a first step, we use the seven infrastructure sectors described below. Each sector's distinct specialty—from transportation to water and energy—helps isolate the services provided within this expansive space. Although the separation between these sectors is not absolute, each typically depends on different frameworks to get projects done, contains assets overseen by unique groups of public and private actors, and supports infrastructure in a highly individualized manner.[14] In this way, the sectors offer a useful guide to home in on specific jobs of interest.

Seven Infrastructure Sectors

Intra-Metro Transportation includes local roads and bridges; public transit such as subways and buses; taxis and limousines; sightseeing transportation; and bicycle/pedestrian infrastructure.

Inter-Metro Transportation includes passenger rail, airports, and highways, and inter-urban and rural bus transportation.

Trade and Logistics includes freight rail, air cargo operations, trucking, seaports/inland waterways, transportation support, and warehousing and express/local delivery services.

Energy includes the generation, transmission, and distribution of energy from natural gas (pipelines), facilities responsible for electricity (nuclear, hydroelectric, and solar/wind), and other utilities.

Water includes clean/drinking water, stormwater, wastewater, sewage/water treatment facilities, and "green" infrastructure critical to conserving related natural resources.

Telecommunications include broadband and transmission infrastructure (wired, wireless, and satellite), concentrated in facilities outside radio and television broadcasting.

Public Works include streetscapes, land redevelopment, and waste/landfills (solid waste, hazardous materials, and remediation).[15]

Based on our definition, we consequently classified infrastructure jobs in terms of occupations and industries engaged in these activities, regardless of the ownership or output associated with individual establishments.[16] Although this approach follows the green jobs methodology used by the U.S. Bureau of Labor Statistics (BLS) to some degree, our analysis focuses more on the services provided by workers in relevant activities rather than the type of products created. Workers who help forge metals,

extract raw energy resources, or assemble vehicles, for instance, are among those employed in jobs that fall outside the scope of this definition.

As a result, workers may frequently carry out different responsibilities depending on their specific line of work, but they directly support the long-term performance of the nation's infrastructure across several clearly delineated sectors.[17] For example, although some engineers specialize in the design of bridges, dams, and large-scale utility projects, other technicians concentrate on the operation of these facilities. Meanwhile, pipe layers and electricians physically install needed components, and certain managers, analysts, and planners contribute to oversight and governance.

Key Terms

Infrastructure Jobs: Employment opportunities based on the total number of workers in occupations and industries in the seven infrastructure sectors.

Occupations: The activities that employees regularly carry out for pay, which are grouped into distinct categories on the basis of similar job duties as outlined in the 2010 Standard Occupation Classification (SOC) system.[18] In total, there are more than 800 detailed occupations found across all industries. "Infrastructure occupations," in particular, are often concentrated in infrastructure activities and perform duties central to infrastructure design, construction, operation, and governance.

Industries: Groups of establishments that provide similar goods or services, as determined by the 2012 North American Industry Classification System (NAICS). Private and government-owned establishments are included, while agricultural establishments and private households are excluded. "Infrastructure industries," in particular, provide services closely linked to at least one of the seven infrastructure sectors.

Employment: The total number of full-time and part-time workers paid a wage or salary, excluding household and self-employed workers, as defined in the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) survey.[19]

Wages: Based on straight-time, gross pay over a standard work period, as defined in the OES survey. These include tips, production bonuses, cost-of-living allowances, and over-the-road pay based on mileage. However, overtime pay, back pay, and holiday bonuses are among the types of compensation excluded.[20] Wages include mean hourly and annual pay, but also percentile wages (10th, 25th, 50th, 75th, and 90th). The latter are based on the percentage of workers who earn wages below a certain value. For instance, if $9.00 represents the 10th percentile wage for a given occupation, this means that 10 percent of workers employed in the occupation earn less than this amount.

Skills: Levels of education and training typically needed to perform the duties in a particular line of work. Similar to BLS, we use three categories to classify skills across different occupations: education required for entry, related work experience, and on-the-job training to demonstrate competency.[21]

Through this approach, we identify 95 *occupations* whose employment is often linked to specific infrastructure assets and other relevant work activities.[22] This report examines a variety of occupations, including telecommunication line installers, power plant operators, and aircraft mechanics, many of whom perform specialized tasks and use specialized knowledge and tools to support infrastructure assets.[23] Some occupations, such as railroad conductors and cargo agents, have especially

high concentrations of employment dealing with particular types of infrastructure. In other words, infrastructure jobs are found in an assortment of occupations that are essential to the long-term operation of various infrastructure assets. Public-sector workers at the federal, state, and local levels play a large role as well.[24]

Although several additional occupations could conceivably be considered—including those involved in the postal service—the 95 occupations represent a discrete collection of jobs that design, construct, operate, and govern the nation's infrastructure in a well-defined capacity. Their employment, as such, is counted across all industries at the national and metropolitan level.

To complement these 95 occupations, the analysis also includes workers employed in 42 *industries* closely aligned with the seven infrastructure sectors. In addition to energy and transportation, many industries have a clear focus in trade and logistics, as evident in the enormous employment totals for freight trucking, warehousing, and delivery services. However, the notable lack of workers counted in several interrelated sectors, such as water, illustrates how these industries do not necessarily capture a full range of infrastructure employment on their own, pointing to the importance of the occupations defined above.[25]

For more information on the report's methodology, see Appendix B.

III. Findings

A. In 2012, 14.2 million workers were employed in infrastructure jobs across the country, accounting for 11 percent of national employment.

Nationally, infrastructure jobs touch every corner of the economy, supporting the movement of people and goods, the distribution of energy and water, and the deployment of technologies and related services.

Of the 14.2 million workers involved in these infrastructure activities—making up 11 percent of the nation's total employment—11.4 million are employed in the 95 infrastructure occupations and 2.8 million are employed in the 42 infrastructure industries.[26] *Occupations* with the most workers include material movers, truck drivers, and electricians, accounting for nearly 30 percent of all infrastructure jobs, while nuclear engineers, hydrologists, and logisticians are among the smaller, more specialized infrastructure occupations. Combined, the 20 largest occupations make up nearly two-thirds (63 percent) of all infrastructure employment throughout the nation.

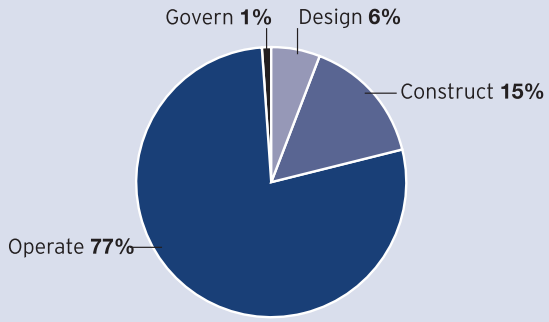
The 2.8 million workers in the 42 infrastructure *industries* are led by freight trucking, warehousing, and wired telecommunications carriers. For the most part, these workers carry out generalized tasks in support of larger infrastructure operations by fulfilling essential administrative duties, managing daily finances, and providing a range of other services in different establishments. As a result, they can vary widely in their occupational focus, despite their significant concentration in infrastructure industries. Office clerks, accountants, customer service representatives, operating engineers, and construction laborers rank among the largest occupations in this respect.

Table 1. Twenty Largest Occupations by Infrastructure Employment and Activity, 2012

Rank	Occupation	Employment	Infrastructure Activity
1	Laborers and Freight, Stock, and Material Movers, Hand	2,143,940	Operate
2	Heavy and Tractor-Trailer Truck Drivers	1,556,510	Operate
3	Light Truck or Delivery Services Drivers	769,010	Operate
4	Packers and Packagers, Hand	660,670	Operate
5	Electricians	519,850	Construct
6	Industrial Truck and Tractor Operators	496,570	Operate
7	Bus Drivers, School or Special Client	489,750	Operate
8	Plumbers, Pipefitters, and Steamfitters	340,370	Construct
9	Civil Engineers	258,100	Design
10	Bus and Truck Mechanics and Diesel Engine Specialists	230,030	Operate
11	Telecommunications Equipment Installers and Repairers, Except Line Installers	208,220	Construct
12	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	197,300	Operate
13	Dispatchers, Except Police, Fire, and Ambulance	184,890	Operate
14	First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand	168,910	Operate
15	Taxi Drivers and Chauffeurs	167,360	Operate
16	Bus Drivers, Transit and Intercity	162,840	Operate
17	Highway Maintenance Workers	141,180	Construct
18	Reservation and Transportation Ticket Agents and Travel Clerks	135,930	Operate
19	Telecommunications Line Installers and Repairers	133,040	Construct
20	Logisticians	119,560	Design
	20 Occupation Total	***9,084,030***	

Source: Brookings analysis of BLS Occupational Employment Statistics.

Figure 1. 95 Infrastructure Occupations by Infrastructure Activity, 2012

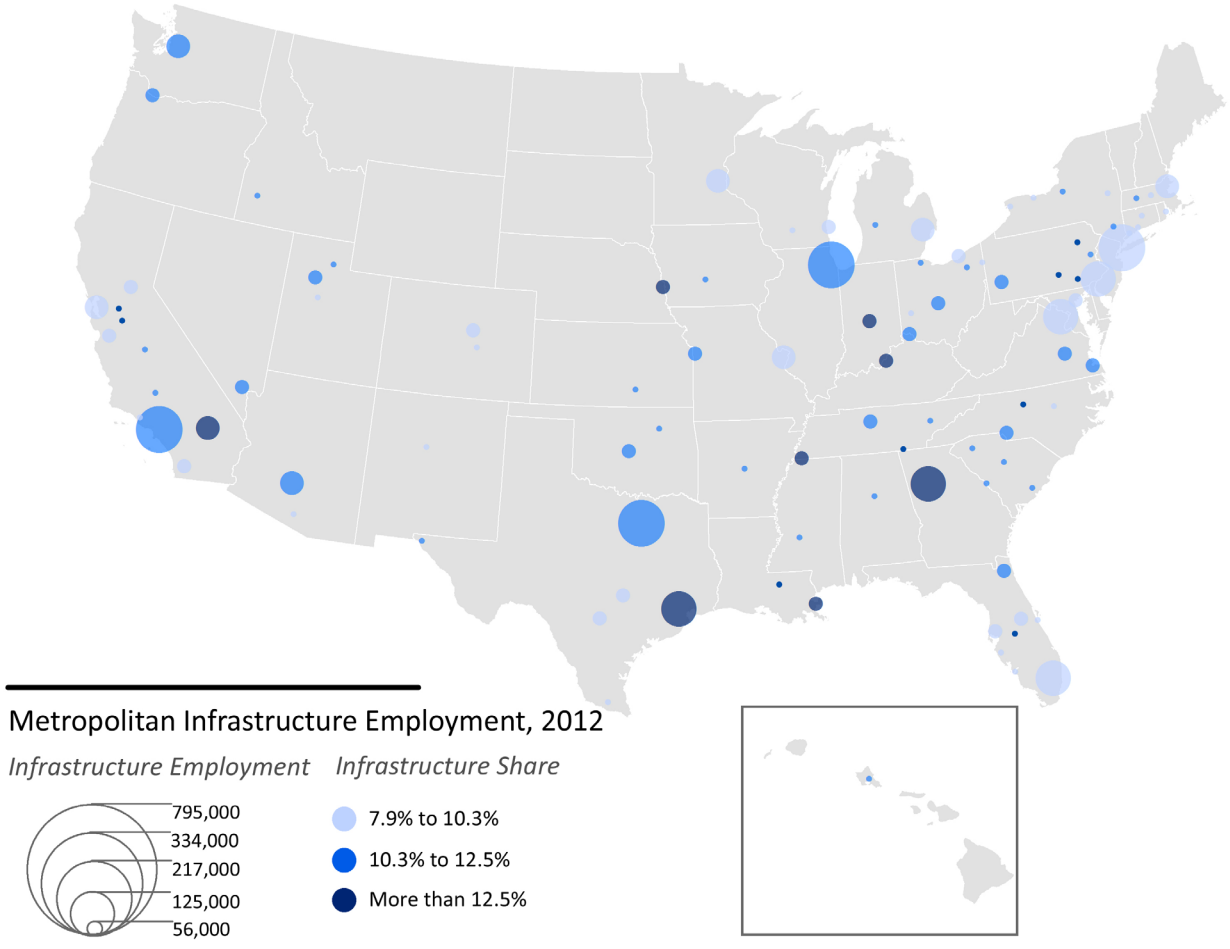


Source: Brookings analysis of BLS Occupational Employment Statistics.

Contrary to popular belief, most workers employed in infrastructure jobs tend to operate physical assets, rather than constructing or installing them.[27] Across all infrastructure occupations, 77 percent of workers are primarily concerned with operation versus 15 percent with construction, 6 percent with design, and fewer than than 2 percent with governance. This focus is also apparent among workers in the 20 largest infrastructure occupations in Table 1, where 7.4 million work in operations (81 percent) compared to only 1.3 million in construction (15 percent). These shares help to not only clarify the type of duties in infrastructure occupations, but also underscore the variety of tasks—and skills needed—to maintain infrastructure assets in the long term.

Infrastructure workers also play a key role in driving metropolitan economic growth. Combined, 9.1 million workers are employed in infrastructure jobs in the 100 largest metropolitan areas, and they make up 64 percent of U.S. infrastructure employment, on par with their 66 percent share of the country's population.[28] Trade and logistics jobs are particularly widespread and represent four of the five largest infrastructure occupations; material movers, heavy truck drivers, light truck drivers, and packers and packagers alone account for 36 percent of all metropolitan infrastructure employment.

Figure 2. Infrastructure Jobs in the 100 Largest Metropolitan Areas by Total Employment and Share of Employment, 2012



Source: Brookings analysis of BLS Occupational Employment Statistics.

Not surprisingly, the largest labor markets have the most infrastructure employment overall. For example, New York, Los Angeles, and Chicago are the nation's three largest labor markets and alone contain more than 1.8 million infrastructure workers. This total exceeds the number of infrastructure workers employed in the smallest 55 metropolitan areas combined. Poughkeepsie, Palm Bay, and Colorado Springs, for example, are among the nation's smallest markets and have fewer than 60,000 workers employed in infrastructure jobs.

As a share of total employment, however, infrastructure jobs stand out in several metropolitan areas and reveal distinct patterns in labor specialization. In total, 46 metropolitan areas have shares of infrastructure employment above the national average (11 percent). These include warehousing and logistics hubs such as Memphis (17.8 percent) and Louisville (13.6 percent) as well as energy and utility centers such as New Orleans (12.8 percent) and Houston (12.5 percent).[29] Seattle has the most avionics technicians, Richmond has the most nuclear engineers, and Chicago has the most septic tank servicers. In contrast metropolitan areas that are not major logistics hubs but have other economic specialties have lower shares of infrastructure employment, such as Washington, D.C. (8.4 percent), Austin, TX (8.8 percent), and Tucson, AZ (8.9 percent).

Beyond Infrastructure: Examining Out-of-Scope Occupations and Industries

Infrastructure jobs cut across a number of occupations and industries, but millions of closely related jobs appear in several additional areas of the economy.[30] Although these jobs involve similar skills and responsibilities, they do not connect as directly to the infrastructure sectors outlined in this report. Instead, they are frequently found in residential and other building construction, mining and energy extraction, and the postal service. In many cases, workers in these jobs focus on projects over a shorter timeframe and carry out a wider range of tasks that fall outside the scope of infrastructure design, construction, operation, and governance.

For example, residential and other building construction employs more than 4 million workers, who concentrate on the installation of windows, flooring, and site-specific improvements. Roofers and brick masons, in turn, are among the many trade occupations in these industries and have duties that differ markedly depending on the contractor involved, unlike workers employed in heavy and civil engineering construction.[31] On the other hand, electricians and pipelayers in residential and other building projects help maintain the energy and water systems crucial to long-term infrastructure performance, so they are included in this report.[32]

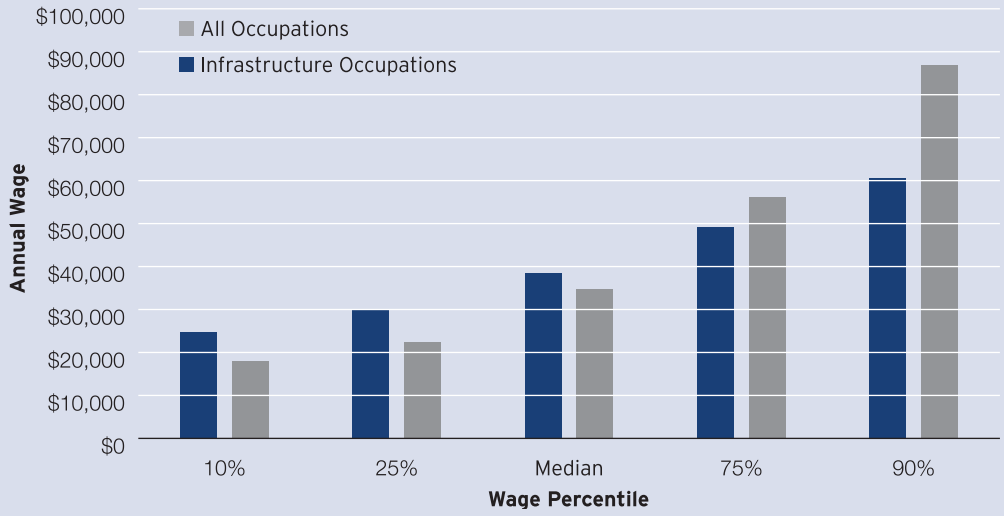
In the same way, only certain jobs in mining and extraction are counted, rather than the industry as a whole.[33] The generation, transmission, and distribution of energy rely on numerous infrastructure assets, ranging from hydroelectric plants and wind turbines to power lines and pipes. These jobs require more than 1 million workers.[34] The mining sector alone, however, employs nearly 800,000 workers and focuses on extracting the raw materials needed to fuel this network. Similar to manufacturing, jobs in mining are primarily concerned with achieving higher levels of physical output, using inputs to drive productivity in oilfields, natural gas platforms, and refineries.[35] Although certain pump operators are critical in the larger infrastructure network, several occupations such as derrick operators and roustabouts are limited to extraction activities and are not included in this report.

Despite its enormous role linking national communications and commerce, the U.S. Postal Service has jobs that do not always clearly relate to trade and logistics infrastructure.[36] Employing more than 600,000 workers, the Postal Service depends on an extensive assortment of mail processing facilities, distribution centers, and retail outlets, each of which requires different types of labor and has different efficiency concerns.[37] Although these individual establishments can have operations that closely parallel those in express delivery services and local messengers, both of which are included in this report, it is harder to distinguish the types of services postal workers offer in some cases. Clerks, mail carriers, and machine operators, for instance, may be responsible for a variety of tasks during the delivery process, as opposed to the truck drivers and cargo agents in warehousing and other well-defined freight activities.

B. Infrastructure occupations tend to offer more equitable wages than all occupations nationally, paying over 30 percent more to workers at lower ends of the income scale.

Infrastructure wages can vary widely depending on the specific occupation. As shown in Figure 3, though, infrastructure jobs tend to pay higher wages to workers at the 10th and 25th percentile ($24,750 and $30,190 annually) compared with all occupations nationally ($18,090 and $22,480), signaling their importance to workers at lower ends of the income spectrum. More than 7 million workers—across 86 different infrastructure occupations—earn more at these percentiles, including truck drivers, civil engineers, and water treatment plant operators.[38] Infrastructure occupations also frequently pay higher median wages ($38,480) than the national median ($34,750); traffic technicians and sailors are among the infrastructure occupations earning median wages around $38,000.

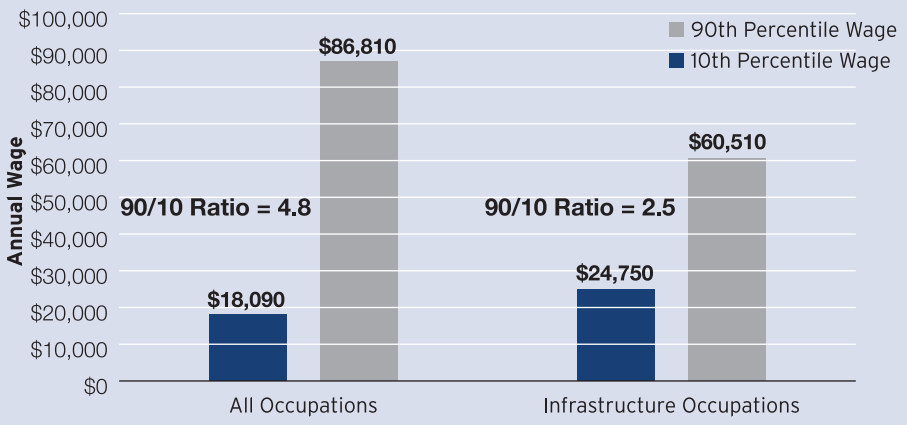
Figure 3. U.S. Annual Wage Comparison: Infrastructure Occupations across All Industries, 2012



Source: Brookings analysis of BLS Occupational Employment Statistics

While many infrastructure occupations pay lower wages to workers at the 75th and 90th percentile, their wages are more evenly distributed relative to all occupations in the United States. This lower wage dispersion, in turn, may indicate the potential for less wage growth in the long run, but may also lead to greater certainty for workers employed in these jobs, which benefit from structured wage practices as a result of unionization or other industry norms.[39] For example, the ratio of wages earned by workers at the 90th and 10th percentile is significantly less for infrastructure jobs (2.5) than all others nationally (4.8) (Figure 4). From ship captains (4.0) and nuclear technicians (2.3) to subway and streetcar operators (1.9), this 90/10 ratio is lower for workers in every infrastructure occupation compared with the nation as a whole, illustrating a more equitable distribution of incomes overall.[40]

Figure 4. Distribution of Wages in Infrastructure Occupations, 2012

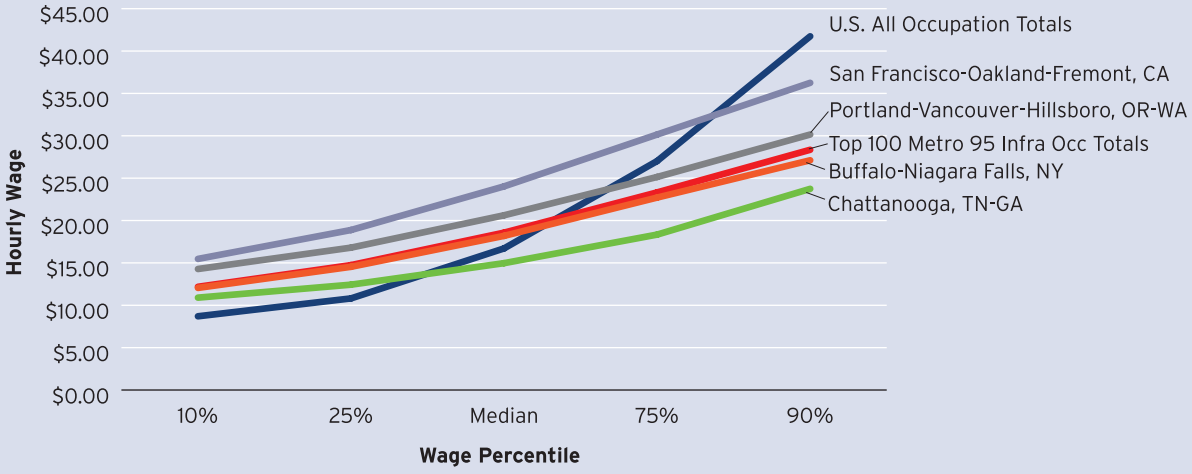


Source: Brookings analysis of BLS Occupational Employment Statistics

Although workers in infrastructure occupations earn more equitable wages as a whole, they earn slightly less on average ($19.39 per hour or $40,970 annually) than workers in all occupations nationally ($22.01 and $45,790). Packers and packagers ($10.80), bus drivers ($14.01), and highway maintenance workers ($17.43) are among the largest occupations paying the least. Nonetheless, 59 of the infrastructure occupations pay above-average wages, with air traffic controllers ($56.94 per hour), nuclear engineers ($51.51), and marine engineers and naval architects ($46.22) leading the way.[41]

These national wage patterns are also evident in the 100 largest metropolitan areas, often reflecting distinctive types of local infrastructure jobs. For example, as a hub for several passenger and cargo airlines, Atlanta employs many high-paying pilots, aircraft mechanics, and freight agents. Likewise, Baton Rouge has hundreds of well-paid petroleum pump operators and pipefitters, drawing from the strength of its energy sector. Cost-of-living, of course, is an important factor determining the relative wages in these areas, but infrastructure jobs continue to offer competitive wages for lower-income workers in particular, regardless of location.[42]

Figure 5. Hourly Wage Comparison, Infrastructure Occupations in Select Metropolitan Areas, 2012



Source: Brookings analysis of BLS Occupational Employment Statistics

Indeed, infrastructure occupations in every metropolitan area except McAllen, TX, and El Paso, TX—which have outsized concentrations of lower-paying material movers—pay higher wages to workers at the 10th and 25th percentile relative to all occupations nationally. The differences are notable across the country, even in metropolitan areas with persistently high unemployment rates such as Stockton, CA, and Detroit. Together, these two areas have more than 100,000 workers employed in infrastructure occupations paying higher wages at the 10th percentile than the nation as a whole.[43]

C. More than 80 percent of workers employed in infrastructure occupations typically have short- to long-term on-the-job training, but only 12 percent hold a bachelor's degree or higher and generally need less education to qualify for these jobs.

Infrastructure jobs typically require less formal education and thus have lower barriers to entry. For example, the highest level of education for 57 percent of infrastructure workers is a high school diploma or less. This compares with 34 percent of workers employed in all occupations nationally.[44] Moreover, with a combined employment of 9 million workers, 67 of the 95 infrastructure occupations only require a high school diploma or less for entry. Wages for these jobs, though, remain competitive: 59 of the 67 occupations pay higher wages to workers at the 10th percentile than nationally. Paving equipment operators, solar photovoltaic installers, and septic tank servicers are among the many occupations that fall into this category (Table 2).

Table 2. Top 20 Infrastructure Occupations Ranked by Share of Workers with High School Diploma or Less, 2012

Occupation	Employment	Percent With High School Diploma or Less	10th Percentile Wage	25th Percentile Wage
Paving, Surfacing, and Tamping Equipment Operators	54,700	82.4%	$11.51	$13.67
Packers and Packagers, Hand	666,900	79.4%	$8.04	$8.66
Helpers—Electricians	60,800	78.9%	$9.14	$10.85
Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	47,400	78.9%	$8.66	$10.20
Refuse and Recyclable Material Collectors	133,200	77.5%	$9.03	$11.48
Dredge Operators	2,000	76.4%	$11.27	$13.71
Industrial Truck and Tractor Operators	508,600	75.5%	$9.80	$11.78
Pile-Driver Operators	3,800	74.6%	$13.85	$17.91
Highway Maintenance Workers	147,600	69.9%	$10.68	$13.37
Laborers and Freight, Stock, and Material Movers, Hand	2,197,300	68.4%	$8.32	$9.27
Light Truck or Delivery Services Drivers	841,600	67.7%	$8.75	$10.54
Heavy and Tractor-Trailer Truck Drivers	1,701,500	67.7%	$12.07	$14.86
Tank Car, Truck, and Ship Loaders	12,500	66.1%	$11.49	$15.25
Material Moving Workers, All Other	28,700	66.1%	$9.40	$11.60
Solar Photovoltaic Installers	4,800	63.2%	$12.62	$14.98
Septic Tank Servicers and Sewer Pipe Cleaners	25,400	63.2%	$10.23	$12.83
Plumbers, Pipefitters, and Steamfitters	386,900	63.0%	$13.95	$17.72
Pipelayers	48,500	63.0%	$11.22	$13.46
Hazardous Materials Removal Workers	37,500	58.2%	$12.02	$14.30
Forest and Conservation Workers	10,500	55.5%	$8.03	$9.31
20 Occupation Total	**6,920,200**	**69.8%**	**$9.85**	**$11.68**
All U.S. Occupations*	**145,355,800**	**34.3%**	**$8.70**	**$10.81**
***Occupation totals from the Employment Projections Program may deviate from OES estimates.**				

Source: Brookings analysis of BLS Employment Projections data and Occupational Employment Statistics wage data.

Nevertheless, several higher-paying infrastructure occupations require additional postsecondary education for entry, with many of these workers holding a bachelor's degree or higher (Table 3). For example, seven of the ten infrastructure occupations paying the highest average wages overall require a bachelor's degree or higher. Civil engineers are among the largest of these occupations, followed by logisticians and environmental engineers. Many of these jobs are concentrated in infrastructure design and governance, with six of the ten highest-paying occupations primarily focused on one of these two activities. In contrast, all of the ten lowest-paying occupations focus on infrastructure construction or operation.

Table 3. Top 20 Infrastructure Occupations Ranked by Share of Workers with Bachelor's Degree or Higher, 2012

Occupation	Employment	Percent With Bachelor's Degree or Higher	75th Percentile Wage	90th Percentile Wage
Hydrologists	7,400	94.0%	$45.18	$54.25
Urban and Regional Planners	38,700	93.4%	$39.25	$46.94
Landscape Architects	20,100	89.6%	$40.08	$48.97
Environmental Engineers	53,200	87.9%	$49.49	$58.79
Conservation Scientists	22,100	86.6%	$36.02	$43.69
Foresters	12,000	86.6%	$32.72	$37.74
Civil Engineers	272,900	85.3%	$48.24	$58.66
Nuclear Engineers	20,400	82.0%	$59.02	$72.09
Airline Pilots, Copilots, and Flight Engineers	66,400	72.0%	*	*
Commercial Pilots	37,600	72.0%	*	*
Marine Engineers and Naval Architects	7,300	69.1%	$54.53	$72.38
Forest and Conservation Technicians	34,000	46.0%	$21.30	$25.85
Logisticians	125,900	41.7%	$43.85	$53.90
Air Traffic Controllers	25,000	41.0%	$72.65	$82.37
Airfield Operations Specialists	7,100	41.0%	$29.04	$37.98
Flight Attendants	84,800	37.6%	*	*
Nuclear Technicians	8,100	33.7%	$39.57	$46.78
Transit and Railroad Police	4,300	33.5%	$34.76	$42.01
Transportation, Storage, and Distribution Managers	105,200	28.9%	$51.70	$66.66
Reservation and Transportation Ticket Agents and Travel Clerks	139,100	27.6%	$20.79	$22.91
20 Occupation Total	**1,091,600**	**59.8%**	**$35.10**	**$42.61**
All U.S. Occupations**	**145,355,800**	**34.7%**	**$27.02**	**$41.74**

***Hourly wages are not reported for airline pilots, commercial pilots, and flight attendants.**

****Occupation totals from the Employment Projections Program may deviate from OES estimates**

Source: Brookings analysis of BLS Employment Projections data and Occupational Employment Statistics wage data.

However, regardless of education, most workers employed in infrastructure occupations rely on skills developed through on-the-job training. In total, 73 of the 95 infrastructure occupations, covering 10 million workers, call for short or long-term on-the-job training, or an apprenticeship, as general requirements for competency. Electricians, plumbers, and other traditional trade occupations are the most common in this respect.

In addition, infrastructure jobs requiring hands-on experience often pay well. Nearly 6 million workers employed in 64 of these 73 occupations earn higher wages at the 10th and 25th percentile, illustrating the breadth of higher-paying infrastructure opportunities available to those who may lack an advanced degree but demonstrate the ability to perform tasks on the job. Indeed, in the same 73 infrastructure occupations calling for on-the-job training, only 10 require some form of postsecondary education beyond a high school diploma.

D. Infrastructure occupations are projected to increase 9.1 percent during the next decade, including the need to replace more than 2.7 million workers.

From 2012 to 2022, infrastructure occupations are projected to grow by 1.1 million workers, led by an additional 242,000 material movers, 193,000 truck drivers, and 115,000 electricians. Fast-growing occupations include wind turbine service technicians, solar photovoltaic installers, and logisticians, each of which is expected to see employment increase by more than 20 percent. Moreover, many workers in these occupations hold a high school diploma or less (Table 4). Overall, 74 of the 95 infrastructure occupations are projected to grow, with declines in only a few occupations, such as ticketing agents, meter readers, and locomotive firers.

Table 4. Top 10 Infrastructure Occupations by Projected Growth Rate and Replacement Rate, 2012-2022

Rank	Occupation	2012 Employment	Growth Rate	Percent with High School Diploma or Less
1	Helpers--Electricians	60,800	36.9%	78.9%
2	Commercial Divers	3,600	29.4%	52.7%
3	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	47,400	27.9%	78.9%
4	Pile-Driver Operators	3,800	27.5%	74.6%
5	Septic Tank Servicers and Sewer Pipe Cleaners	25,400	25.8%	63.2%
6	Solar Photovoltaic Installers	4,800	24.5%	63.2%
6	Wind Turbine Service Technicians	3,200	24.5%	52.7%
8	Logisticians	125,900	21.9%	15.4%
9	Plumbers, Pipefitters, and Steamfitters	386,900	21.3%	63.0%
10	Pipelayers	48,500	20.8%	63.0%

continued

Table 4. Top 10 Infrastructure Occupations by Projected Growth Rate and Replacement Rate, 2012-2022 (continued)

Rank	Occupation	2012 Employment	Replacement Rate	Percent with High School Diploma or Less
1	Captains, Mates, and Pilots of Water Vessels	35,400	46.4%	48.9%
2	Motorboat Operators	3,400	46.4%	48.9%
3	Urban and Regional Planners	38,700	45.0%	0.3%
4	Sailors and Marine Oilers	31,900	44.9%	56.1%
5	Ship Engineers	10,800	44.9%	56.1%
6	Air Traffic Controllers	25,000	44.1%	10.6%
7	Airfield Operations Specialists	7,100	44.1%	10.6%
8	Transportation Workers, All Other	37,100	39.5%	43.1%
9	Traffic Technicians	6,600	39.5%	43.1%
10	Bridge and Lock Tenders	3,600	39.5%	43.1%

Source: Brookings analysis of BLS Employment Projections data

Although infrastructure occupations have a projected rate of employment growth (9.1 percent) slightly lower than all occupations nationally (10.8 percent), their replacement rate is quite high. Due to retirements and other employment shifts, 57 infrastructure occupations are projected to exceed the national replacement rate. This means that these occupations will need to replace more than 23.4 percent of their workforce during the next decade.

As shown in Table 4, some occupations are projected to replace at least 40 percent of their workers, including ship engineers, air traffic controllers, and bridge and lock tenders. Significantly, these jobs are also often more specialized than the many lower-skilled service occupations that experience high turnover, such as waiters, cashiers, or tellers, making them more indispensible and costlier to replace in the long run for individual establishments.[45] In this way, there is a clear need to fill the employment gap resulting from these projected replacements during the next several years, even as new job openings emerge elsewhere to help fuel additional employment growth.[46]

IV. Implications

As the nation continues to pull out of the Great Recession, policymakers must consider a broader range of development strategies and employment opportunities to drive future economic growth. Although metropolitan areas are leading this charge—creating a variety of innovative partnerships, programs, and policies across the public and private sectors—millions of workers still sit on the sidelines struggling to find and fill the jobs that support all this activity.[47] Stubbornly high unemployment not only wastes an enormous pool of talent, but also acts as a continual drag on spending and output, holding back new projects and investments in the country.[48]

Given its widespread economic impact, however, infrastructure is uniquely positioned to address these challenges in both the short and long term. Employing more than 14 million workers across 95 different occupations and 42 industries, infrastructure jobs are numerous and diverse, engaged in activities crucial to the nation's economic competiveness.

At the same time, because many of these jobs tend to focus on operating rather than constructing infrastructure assets, they should figure prominently in discussions concerning infrastructure investment over many years. Too often, calls for infrastructure investment only focus on the jobs involved at the beginning of a project's lifecycle. Policymakers need to view the costs and benefits of designing, constructing, operating, and governing infrastructure over several decades, which necessarily involves millions of workers. The large number of workers involved in trade and logistics, for instance, is a key factor to consider as policymakers develop national freight plans and export strategies.[49]

In addition, infrastructure jobs are prominent in metropolitan areas, underscoring their importance to local industries, utilities, and other government bodies. From Atlanta and Indianapolis to Riverside and Oklahoma City, metropolitan areas vary widely in their economic base—whether oriented toward energy, trade, or another sector—but regardless of the base, their infrastructure workforce can account for up to 18 percent of total employment. As metropolitan leaders explore ways to create more and better jobs, they should note infrastructure's contribution to their labor market.

Since infrastructure jobs often pay higher wages to workers at lower ends of the income ladder, they can also be accessible to many potential jobseekers, offering a clearer path to better employment opportunities. The need to identify well-paying jobs poses a serious challenge during the economic recovery, as workers settle for positions below their abilities and issues of income inequality dominate national headlines.[50] The growing wedge between high-income earners and others, in particular, continues to raise awareness of these economic issues and lead to questions over possible long-term strategies across the public and private sectors.

In the past, policymakers have focused on infrastructure jobs with stimulus spending, but by considering a new range of infrastructure industries and occupations, they can begin to direct more attention to long-term employment opportunities supported by these investments. A full assessment of infrastructure wages, of course, involves many factors beyond the scope of this report, including the number of hours worked, cost of living, whether the jobs are temporary or permanent, and the location of jobs within metropolitan areas. However, these factors should not diminish infrastructure's sizable impact on workers at all income levels.[51]

Finally, with their emphasis on training rather than formal education, infrastructure jobs may appeal to a broad class of workers who lack advanced degrees. Because many of these jobs are projected to grow over the next decade and have high replacement rates, a new generation of workers will need to fill this void and manage the nation's most valuable infrastructure assets. In the federal workforce alone, air traffic controllers are expected to see a wave of retirements in the coming years, with the Federal Aviation Administration having hired more than 7,500 controllers from 2007 to 2012 to accommodate these changes.[52] Moreover, the physical demands required in certain infrastructure occupations may be attractive to the disproportionate number of male workers unemployed following the Great Recession.[53] Policymakers would be well advised to monitor these types of labor needs and skill requirements in light of relevant training programs and career pathways.

V. Conclusion

As the American economy continues to recover and make gains in the labor market, it has a long way to go to repair the damage wrought by the Great Recession, particularly in the construction sector.[54] Policymakers have often framed stimulus spending on infrastructure as a way to address these kinds of losses by promoting short-term job creation, assisting state and local governments, and providing much-needed investments in a range of projects.

Although construction workers play a pivotal role building and maintaining infrastructure, this report shows they only compose a fraction of the entire workforce responsible for managing the nation's physical assets. To help promote additional trade, move more passengers, ensure the efficient use of energy and water, and carry out other infrastructure-related activities, it is essential to gain a firmer understanding of the employment opportunities behind these investments. This report is a first step in that task.

Appendix A. Infrastructure Occupations, National Totals, 2012

Occupation	Employment		Infrastructure Activity	Mean Wage		Educational Attainment		2012 to 2022 Projections	
	Total	Rank		Hourly	Annual	Share with High School Diploma or Less	Share with Bachelor's Degree or Higher	Growth Rate	Replacement Rate
Air Traffic Controllers	23,260	57	Operate	$56.94	$118,430	10.6%	41.0%	1.4%	44.1%
Aircraft Cargo Handling Supervisors	6,720	82	Operate	$24.44	$50,830	44.0%	17.0%	0.7%	27.5%
Aircraft Mechanics and Service Technicians	119,160	21	Operate	$26.78	$55,690	30.0%	10.5%	2.4%	26.8%
Airfield Operations Specialists	6,990	79	Operate	$24.17	$50,270	10.6%	41.0%	5.1%	44.1%
Airline Pilots, Copilots, and Flight Engineers	66,270	31	Operate	*	$128,760	5.3%	72.0%	-6.6%	28.9%
Architectural and Civil Drafters	83,410	27	Design	$24.30	$50,550	13.1%	27.5%	0.8%	13.3%
Avionics Technicians	16,810	63	Operate	$26.65	$55,440	27.9%	13.4%	2.9%	20.2%
Bridge and Lock Tenders	3,460	90	Operate	$20.82	$43,300	43.1%	11.5%	-2.0%	39.5%
Bus and Truck Mechanics and Diesel Engine Specialists	230,030	10	Operate	$20.99	$43,660	63.4%	3.2%	8.6%	21.3%
Bus Drivers, School or Special Client	489,750	7	Operate	$14.01	$29,150	56.0%	7.9%	8.5%	18.3%
Bus Drivers, Transit and Intercity	162,840	16	Operate	$18.50	$38,470	56.0%	7.9%	9.8%	18.3%
Captains, Mates, and Pilots of Water Vessels	30,860	50	Operate	$35.46	$73,760	48.9%	22.9%	13.8%	46.4%
Cargo and Freight Agents	78,750	28	Operate	$20.34	$42,310	42.9%	17.2%	14.5%	27.0%
Civil Engineering Technicians	70,790	30	Design	$23.66	$49,220	26.8%	17.4%	0.6%	20.7%
Civil Engineers	258,100	9	Design	$40.45	$84,140	2.9%	85.3%	19.7%	24.3%
Commercial Divers	3,480	89	Construct	$26.32	$54,750	52.7%	10.3%	29.4%	24.3%
Commercial Pilots	34,990	47	Operate	*	$80,140	5.3%	72.0%	9.4%	28.9%
Conservation Scientists	18,460	61	Govern	$30.57	$63,590	0.0%	86.6%	0.5%	29.1%
Control and Valve Installers and Repairers, Except Mechanical Door	40,310	41	Construct	$24.97	$51,930	52.8%	5.4%	-0.5%	33.7%
Couriers and Messengers	76,830	29	Operate	$12.99	$27,020	43.5%	13.4%	-11.1%	12.8%
Dispatchers, Except Police, Fire, and Ambulance	184,890	13	Operate	$18.49	$38,450	39.4%	13.5%	11.2%	28.8%
Dredge Operators	1,740	94	Operate	$20.73	$43,120	76.4%	4.3%	13.3%	8.0%
Electrical and Electronics Installers and Repairers, Transportation Equipment	15,530	66	Construct	$25.41	$52,850	29.2%	11.4%	2.3%	20.2%
Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	23,920	55	Operate	$32.40	$67,380	29.2%	11.4%	-0.2%	20.2%
Electrical Power-Line Installers and Repairers	112,450	23	Construct	$29.94	$62,280	50.6%	5.9%	8.9%	34.7%
Electricians	519,850	5	Construct	$25.50	$53,030	46.7%	7.2%	19.7%	18.8%
Environmental Engineering Technicians	18,590	60	Operate	$23.74	$49,380	26.8%	17.4%	18.4%	20.7%
Environmental Engineers	50,850	34	Design	$40.93	$85,140	4.1%	87.9%	15.3%	24.4%
First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand	168,910	14	Operate	$22.69	$47,180	44.0%	17.0%	8.5%	27.5%
First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	197,300	12	Operate	$26.65	$55,430	44.0%	17.0%	8.6%	27.5%
Flight Attendants	84,960	26	Operate	*	$42,340	16.4%	37.6%	-6.5%	16.5%
Foresters	9,470	73	Govern	$27.47	$57,140	0.0%	86.6%	6.1%	29.1%
Forest and Conservation Technicians	31,720	48	Govern	$17.80	$37,030	17.0%	46.0%	-3.5%	39.3%
Forest and Conservation Workers	7,910	77	Govern	$13.75	$28,600	55.5%	17.1%	4.5%	17.1%

Appendix A. Infrastructure Occupations, National Totals, 2012 (continued)

Occupation	Employment		Infrastructure Activity	Mean Wage		Educational Attainment		2012 to 2022 Projections	
	Total	Rank		Hourly	Annual	Share with High School Diploma or Less	Share with Bachelor's Degree or Higher	Growth Rate	Replacement Rate
Gas Compressor and Gas Pumping Station Operators	4,350	86	Operate	$24.92	$51,840	56.3%	7.3%	-3.1%	34.7%
Gas Plant Operators	12,380	68	Operate	$29.37	$61,090	49.1%	8.6%	-8.8%	37.1%
Hazardous Materials Removal Workers	37,440	44	Operate	$20.03	$41,660	58.2%	13.4%	14.2%	21.6%
Heavy and Tractor-Trailer Truck Drivers	1,556,510	2	Operate	$19.40	$40,360	67.7%	5.0%	11.3%	16.0%
Helpers--Electricians	59,610	32	Construct	$13.86	$28,840	78.9%	3.3%	36.9%	15.7%
Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	46,510	36	Construct	$13.65	$28,380	78.9%	3.3%	27.9%	15.7%
Highway Maintenance Workers	141,180	17	Construct	$17.43	$36,240	69.9%	2.9%	5.7%	14.9%
Hydrologists	6,880	80	Govern	$37.94	$78,920	0.3%	94.0%	10.4%	29.5%
Industrial Truck and Tractor Operators	496,570	6	Operate	$15.43	$32,090	75.5%	2.4%	-2.7%	23.0%
Laborers and Freight, Stock, and Material Movers, Hand	2,143,940	1	Operate	$12.70	$26,410	68.4%	5.4%	11.0%	31.0%
Landscape Architects	15,750	65	Design	$32.71	$68,030	1.6%	89.6%	14.3%	23.7%
Light Truck or Delivery Services Drivers	769,010	3	Operate	$16.32	$33,940	67.7%	5.0%	3.8%	16.0%
Locomotive Engineers	37,060	45	Operate	$26.36	$54,830	43.1%	10.6%	-3.9%	30.0%
Locomotive Firers	1,580	95	Operate	$23.34	$48,550	43.1%	10.6%	-42.0%	30.0%
Logisticians	119,560	20	Design	$36.38	$75,670	15.4%	41.7%	21.9%	11.6%
Marine Engineers and Naval Architects	6,880	80	Design	$46.22	$96,140	9.9%	69.1%	10.3%	25.5%
Material Moving Workers, All Other	27,260	51	Operate	$19.73	$41,040	66.1%	5.1%	5.3%	27.5%
Meter Readers, Utilities	39,530	42	Operate	$18.52	$38,510	47.4%	9.8%	-19.2%	25.2%
Motorboat Operators	3,040	92	Operate	$18.54	$38,560	48.9%	22.9%	5.7%	46.4%
Nuclear Engineers	19,930	58	Design	$51.51	$107,140	3.4%	82.0%	9.3%	25.5%
Nuclear Power Reactor Operators	7,140	78	Operate	$36.55	$76,020	33.1%	16.0%	0.5%	31.0%
Nuclear Technicians	8,040	76	Operate	$33.52	$69,720	25.6%	33.7%	14.9%	35.9%
Packers and Packagers, Hand	660,670	4	Operate	$10.80	$22,470	79.4%	4.7%	6.0%	26.2%
Paving, Surfacing, and Tamping Equipment Operators	54,460	33	Construct	$19.31	$40,170	82.4%	1.4%	19.7%	14.5%
Petroleum Pump System Operators, Refinery Operators, and Gaugers	41,020	40	Operate	$29.20	$60,730	49.1%	8.6%	-5.1%	37.1%
Pile-Driver Operators	3,800	88	Construct	$26.67	$55,480	74.6%	3.5%	27.5%	17.0%
Pipelayers	43,590	37	Construct	$19.22	$39,970	63.0%	4.3%	20.8%	12.4%
Plant and System Operators, All Other	11,710	70	Operate	$25.32	$52,660	49.1%	8.6%	0.7%	37.1%
Plumbers, Pipefitters, and Steamfitters	340,370	8	Construct	$25.46	$52,950	63.0%	4.3%	21.3%	12.4%
Power Distributors and Dispatchers	11,590	71	Operate	$35.44	$73,710	33.1%	16.0%	-0.9%	31.0%
Power Plant Operators	41,350	39	Operate	$31.29	$65,080	33.1%	16.0%	-10.8%	31.0%
Pump Operators, Except Wellhead Pumpers	11,870	69	Operate	$22.88	$47,590	56.3%	7.3%	10.8%	34.7%
Radio, Cellular, and Tower Equipment Installers and Repairers	15,780	64	Construct	$22.24	$46,260	34.7%	13.3%	6.6%	13.7%
Rail Car Repairers	19,140	59	Operate	$22.80	$47,430	62.5%	3.7%	2.5%	28.9%
Rail Transportation Workers, All Other	3,040	92	Operate	$26.41	$54,930	47.7%	9.3%	2.2%	30.3%

Appendix A. Infrastructure Occupations, National Totals, 2012 (continued)

Occupation	Employment		Infrastructure Activity	Mean Wage		Educational Attainment		2012 to 2022 Projections	
	Total	Rank		Hourly	Annual	Share with High School Diploma or Less	Share with Bachelor's Degree or Higher	Growth Rate	Replacement Rate
Rail Yard Engineers, Dinkey Operators, and Hostlers	5,170	84	Operate	$20.89	$43,450	43.1%	10.6%	2.4%	30.0%
Railroad Brake, Signal, and Switch Operators	24,380	52	Operate	$24.16	$50,260	50.9%	11.9%	-2.6%	30.3%
Railroad Conductors and Yardmasters	42,740	38	Operate	$27.30	$56,770	42.4%	11.6%	-2.9%	30.3%
Rail-Track Laying and Maintenance Equipment Operators	16,870	62	Construct	$22.21	$46,200	63.8%	6.3%	5.2%	21.0%
Refuse and Recyclable Material Collectors	117,670	22	Operate	$16.94	$35,230	77.5%	3.7%	16.2%	20.7%
Reservation and Transportation Ticket Agents and Travel Clerks	135,930	18	Operate	$16.14	$33,580	27.6%	27.6%	-14.0%	13.3%
Sailors and Marine Oilers	31,500	49	Operate	$19.11	$39,760	56.1%	15.7%	15.5%	44.9%
Septic Tank Servicers and Sewer Pipe Cleaners	24,020	54	Operate	$17.29	$35,970	63.2%	8.7%	25.8%	21.0%
Ship Engineers	10,760	72	Operate	$36.29	$75,480	56.1%	15.7%	7.8%	44.9%
Signal and Track Switch Repairers	8,600	75	Operate	$26.63	$55,390	52.7%	10.3%	-1.2%	24.3%
Solar Photovoltaic Installers	4,710	85	Construct	$19.53	$40,620	63.2%	8.7%	24.5%	17.0%
Subway and Streetcar Operators	8,750	74	Operate	$27.99	$58,220	47.7%	9.3%	6.5%	30.3%
Tank Car, Truck, and Ship Loaders	12,390	67	Operate	$22.31	$46,400	66.1%	5.1%	2.7%	28.2%
Taxi Drivers and Chauffeurs	167,360	15	Operate	$12.09	$25,140	52.1%	17.0%	15.5%	11.8%
Telecommunications Equipment Installers and Repairers, Except Line Installers	208,220	11	Construct	$25.82	$53,710	34.7%	13.3%	3.9%	13.7%
Telecommunications Line Installers and Repairers	133,040	19	Construct	$24.96	$51,920	43.8%	10.1%	6.0%	24.5%
Traffic Technicians	6,340	83	Design	$20.42	$42,480	43.1%	11.5%	11.7%	39.5%
Transit and Railroad Police	4,140	87	Govern	$27.83	$57,880	13.9%	33.5%	3.4%	28.8%
Transportation Attendants, Except Flight Attendants	23,790	56	Operate	$11.52	$23,960	55.6%	13.1%	11.0%	16.5%
Transportation Inspectors	24,310	53	Govern	$31.96	$66,470	41.4%	17.2%	11.2%	33.3%
Transportation Security Screeners	47,200	35	Govern	$17.85	$37,130	28.7%	20.6%	5.9%	23.0%
Transportation Workers, All Other	36,190	46	Operate	$16.50	$34,330	43.1%	11.5%	5.1%	39.5%
Transportation, Storage, and Distribution Managers	98,600	25	Operate	$42.75	$88,920	33.9%	28.9%	4.9%	22.8%
Urban and Regional Planners	37,620	43	Design	$32.67	$67,950	0.3%	93.4%	10.3%	45.0%
Water and Wastewater Treatment Plant and System Operators	108,440	24	Operate	$21.46	$44,630	43.4%	9.4%	7.7%	35.1%
Wind Turbine Service Technicians	3,200	91	Operate	$23.23	$48,320	52.7%	10.3%	24.5%	16.8%
95 Infrastructure Occupations	11,409,840			$19.39	$40,970	56.6%	12.0%	9.1%	22.5%
All Occupations	130,287,700			$22.01	$45,790	34.3%	34.7%	10.8%	23.4%

*Note that hourly wages are not reported for airline pilots, commercial pilots, and flight attendants

Source: Brookings analysis of BLS Occupational Employment Statistics data and Employment Projections data.

Appendix B. Methodology

1. Employment Data

This report uses 2012 employment data publicly available from the U.S. Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) program and Employment Projections (EP) program. Supplemental information has also been gathered from the Occupational Information Network (O*NET), an online resource center and database sponsored by the Department of Labor's Employment and Training Administration.

We draw infrastructure employment and wage totals primarily from the OES program, which releases estimates annually. The OES program bases these estimates on a semi-annual mail survey in May and November in partnership with State Workforce Agencies. The survey measures employment for workers in non-farm establishments. Estimates for 2012 were drawn from 1.2 million establishments across six panels of data collected over three years (May 2012, November 2011, May 2011, November 2010, May 2010, and November 2009).[55] The sample is developed from state unemployment insurance files.

OES employment and wage data are defined in terms of specific occupations and industries, as established under the 2010 Standard Occupational Classification (SOC) system and 2012 North American Industry Classification System (NAICS).[56] This report focuses on detailed SOC occupations and 4-digit NAICS industries. OES cross-industry occupational employment and wage estimates are available across national, state, metropolitan statistical area, metropolitan division, and nonmetropolitan geographies, while industry-specific estimates are available for the nation only.

In contrast, infrastructure employment totals used to analyze skills and projections in this report are drawn from the EP program, which relies on a National Employment Matrix that combines employment data from several different sources, including the OES program, the Current Employment Statistics (CES) program, and the Current Population Survey (CPS). Detailed information on EP skill and projection estimates is described later in this appendix.

2. Criteria Used to Define Infrastructure Jobs

This report defines infrastructure jobs based on a particular set of industries and occupations tied to seven infrastructure sectors. Workers in infrastructure jobs, as such, must meet at least one of the following two criteria:

- Employed in industries that provide services closely linked to infrastructure assets classified under seven key sectors.

- Employed in occupations that perform duties central to the design, construction, operation, and governance of these infrastructure assets.

Given the variety of assets—and range of activities covered—in the nation's infrastructure network, this analysis aims to move beyond abstract discussions to consistently define, quantify, and measure infrastructure-related employment.[57] The two criteria above are structured in a way to classify infrastructure jobs in terms of a clear list of related industries and occupations, offering a useful guide to home in on specific work activities.

3. Using Infrastructure Sectors to Classify Related Industries

In this way, the report classifies infrastructure industries according to seven key infrastructure sectors: intra-metro transport, inter-metro transport, trade and logistics, energy, water, telecommunications, and public works. Workers in these industries typically initiate the development and oversee the maintenance of the nation's major infrastructure assets.

Excluded are industries in manufacturing (NAICS 31-33), mining (NAICS 21), residential or other building construction (NAICS 236 and 238), retail or wholesale trade (NAICS 42 and 44-45), and various service activities such as finance (NAICS 52), health care (NAICS 62), and education (NAICS 61).[58]

Several agencies and organizations adopt a similar "sector" approach to classify infrastructure in the past. From the Department of Homeland Security to the Department of Energy, dividing infrastructure in this way can help direct strategic resources and clarify programmatic responsibilities.[59]

Likewise, the World Bank, European Investment Bank, and Organisation for Economic Co-operation and Development all categorize these assets to establish long-term priorities, steer global engagements, and prioritize investments.[60] In its semi-annual report card on infrastructure, the American Society of Engineers conducts a comprehensive assessment across several areas as well, including water, transport, public works, and energy.[61]

With this context in mind, the report uses seven discrete infrastructure sectors to determine a list of closely related NAICS industries. Relevant information from the U.S. Census Bureau Industry Statistics Portal has aided in the identification of these industries. In turn, this analysis classified 42 four-digit NAICS industries, which have a combined employment of nearly 7 million workers across all occupations according 2012 OES estimates shown in the table below.[62] To avoid duplication, only 2.8 million of these workers are counted in national infrastructure totals given that 4.1 million workers are employed in infrastructure occupations, which are counted across all industries.

Table B1. 42 Infrastructure Industries by Infrastructure Activity and Total Employment, 2012

NAICS	Industry	Infrastructure Sector	Employment
484100	General Freight Trucking	Trade and Logistics	914,790
493100	Warehousing and Storage	Trade and Logistics	673,800
517100	Wired Telecommunications Carriers	Telecommunications	576,280
492100	Couriers and Express Delivery Services	Trade and Logistics	463,190
237100	Utility System Construction	Energy	416,180
481100	Scheduled Air Transportation	Transport	415,260
484200	Specialized Freight Trucking	Trade and Logistics	412,060
221100	Electric Power Generation, Transmission and Distribution	Energy	395,130
237300	Highway, Street, and Bridge Construction	Transport	301,630
482100	Rail Transportation	Transport	222,930
485400	School and Employee Bus Transportation	Transport	198,760
488500	Freight Transportation Arrangement	Trade and Logistics	180,150
517200	Wireless Telecommunications Carriers (except Satellite)	Telecommunications	159,390
488100	Support Activities for Air Transportation	Trade and Logistics	157,260
562100	Waste Collection	Public Works/Waste	147,100
562900	Remediation and Other Waste Management Services	Public Works/Waste	123,360
221200	Natural Gas Distribution	Energy	105,160
237900	Other Heavy and Civil Engineering Construction	Public Works	95,010
562200	Waste Treatment and Disposal	Public Works/Waste	94,600
517900	Other Telecommunications	Telecommunications	92,190
485900	Other Transit and Ground Passenger Transportation	Transport	86,410
488300	Support Activities for Water Transportation	Trade and Logistics	84,790
488400	Support Activities for Road Transportation	Trade and Logistics	78,930
485300	Taxi and Limousine Service	Transport	73,950
492200	Local Messengers and Local Delivery	Trade and Logistics	46,140
221300	Water, Sewage and Other Systems	Water*	46,060
485100	Urban Transit Systems	Transport	40,430
237200	Land Subdivision	Public Works	39,330
483100	Deep Sea, Coastal, and Great Lakes Water Transportation	Transport	38,390
481200	Nonscheduled Air Transportation	Transport	35,200

Table B1. 42 Infrastructure Industries by Infrastructure Activity and Total Employment, 2012 (continued)

NAICS	Industry	Infrastructure Sector	Employment
485500	Charter Bus Industry	Transport	29,550
486200	Pipeline Transportation of Natural Gas	Energy	26,230
488900	Other Support Activities for Transportation	Transport	25,680
488200	Support Activities for Rail Transportation	Trade and Logistics	24,200
483200	Inland Water Transportation	Trade and Logistics	22,960
485200	Interurban and Rural Bus Transportation	Transport	17,550
487200	Scenic and Sightseeing Transportation, Water	Transport	12,750
487100	Scenic and Sightseeing Transportation, Land	Transport	10,050
517400	Satellite Telecommunications	Telecommunications	7,590
486100	Pipeline Transportation of Crude Oil	Energy	5,930
486900	Other Pipeline Transportation	Energy	5,800
487900	Scenic and Sightseeing Transportation, Other	Transport	1,550
42 Industry Total			6,903,700

Note: Most water-related employment is captured under federal, state, and local government (NAICS 99)

There are several excluded industries, such as oil and gas extraction (NAICS 2111) and the postal service (NAICS 4911), that could meet alternative infrastructure definitions and add hundreds of thousands of additional workers to this national total. However, the report did not classify these industries under the seven outlined sectors, primarily owing to services better captured under other industrial activities, as previously described.[63]

4. Examining Occupation Concentrations and Classifications

Beyond these 42 infrastructure industries, the report classifies a specific set of infrastructure occupations separately based on a three-step process: (1) their share of national employment in the infrastructure industries; (2) their share of national employment in related government activities (NAICS 99 OES designation); and (3) other relevant job duties as defined by O*NET. Ultimately, these occupations, similar to the industries that employ them, have a particular role to play in designing, constructing, operating, and governing the nation's infrastructure assets.

On the basis of these three measures, the report identified 95 infrastructure occupations, with a total cross-industry employment of 11.4 million workers. Approximately 36 percent of employment in these occupations (4.1 million workers) is in the 42 infrastructure industries compared with only 2 percent for all occupations nationally. Many excluded occupations are concentrated in out-of-scope retail services as well as administrative, health, and education activities. Retail salespersons, janitors, registered nurses, and teachers are among the largest occupations falling outside infrastructure, and their employment is only partially included if they are found in an infrastructure industry.

Under the first criterion, occupations with more than 25 percent of their national employment concentrated in the 42 infrastructure industries are included, which captures 64 of the 95 infrastructure occupations.[64] Nuclear power operators, locomotive firers, and ship engineers, for instance, are among the nearly 20 occupations that have more than 75 percent of their employment in the 42 infrastructure industries, while aircraft mechanics, septic tank servicers, and recyclable collectors are among those occupations with more than 50 percent. Table B2 lists the 15 occupations with the highest concentration of employment in the 42 infrastructure industries nationally.

Table B2. Fifteen Infrastructure Occupations Ranked by Highest Concentration of National Employment in Infrastructure Industries, 2012

Occupation	Cross Industry Employment	Infrastructure Industry Employment	Infrastructure Share of Employment
Flight Attendants	84,960	84,030	98.9%
Railroad Brake, Signal, and Switch Operators	24,380	24,000	98.4%
Locomotive Firers	1,580	1,550	98.1%
Locomotive Engineers	37,060	36,290	97.9%
Cargo and Freight Agents	78,750	73,490	93.3%
Railroad Conductors and Yardmasters	42,740	39,200	91.7%
Airline Pilots, Copilots, and Flight Engineers	66,270	58,530	88.3%
Rail Car Repairers	19,140	16,580	86.6%
Rail Yard Engineers, Dinkey Operators, and Hostlers	5,170	4,350	84.1%
Nuclear Power Reactor Operators	7,140	5,950	83.3%
Signal and Track Switch Repairers	8,600	6,930	80.6%
Aircraft Cargo Handling Supervisors	6,720	5,310	79.0%
Electrical Power-Line Installers and Repairers	112,450	88,810	79.0%
Hazardous Materials Removal Workers	37,440	29,250	78.1%
Captains, Mates, and Pilots of Water Vessels	30,860	23,980	77.7%
15 Occupation Total	**563,260**	**498,250**	**88.5%**

The second criterion considers occupations concentrated in government activities closely related to the seven infrastructure sectors, including highways, water facilities, and public transportation systems, which account for an additional 17 of the 95 infrastructure occupations.[65] Due to the public and private nature of many infrastructure projects, occupations involved in design and governance, in particular, are heavily concentrated in federal, state, and local government (NAICS 99 OES designation). For example, air traffic controllers, transportation security screeners, and highway maintenance workers have more than 90 percent of their employment concentrated in relevant government activities. Many of these occupations are showcased in Table B3.

Table B3. Fifteen Infrastructure Occupations Ranked by Highest Concentration of National Employment in Related Government Activities, 2012

Occupation	Cross Industry Employment	Government Employment	Government Share of Employment
Transportation Security Screeners	47,200	45,950	97.4%
Highway Maintenance Workers	141,180	135,850	96.2%
Forest and Conservation Technicians	31,720	30,220	95.3%
Air Traffic Controllers	23,260	21,900	94.2%
Subway and Streetcar Operators	8,750	8,150	93.1%
Bridge and Lock Tenders	3,460	2,900	83.8%
Traffic Technicians	6,340	5,150	81.2%
Water and Wastewater Treatment Plant and System Operators	108,440	86,310	79.6%
Conservation Scientists	18,460	14,490	78.5%
Urban and Regional Planners	37,620	28,800	76.6%
Forest and Conservation Workers	7,910	5,900	74.6%
Foresters	9,470	6,160	65.0%
Transit and Railroad Police	4,140	2,650	64.0%
Hydrologists	6,880	3,710	53.9%
Bus Drivers, Transit and Intercity	162,840	81,150	49.8%
15 Occupation Total	**617,670**	**479,290**	**77.6%**

Excluded in this report are the numerous service and administrative occupations that frequently perform generalized tasks in government agencies, lacking a clear relation to at least one of the seven infrastructure sectors. Also excluded are most public safety workers, including police and firefighters, many of whom are employed in government. Only those protective safety workers linked to a particular infrastructure sector, such as transit and railroad police, are included.

The third criterion examines the remaining 14 occupations with particular tasks, knowledge, and work activities linked to the design, construction, operation, and governance of the seven infrastructure sectors. In other words, rather than looking exclusively at industry shares of occupational employment, we consider whether job duties for these occupations are linked to specific infrastructure activities. Depending on the scope of these different tasks, O*NET offers useful background to consider individual occupations. In particular, we classify each occupation under one of four distinct categories, outlined in the following box.

Infrastructure Job Activities

Design involves knowledge of design techniques and tools for developing plans, drawings, maps, and models. Engineering principles and processes are often used, as well as other technology and analytics to determine project feasibility, develop reports, and communicate findings, among other activities. In total, 670,000 workers across 10 occupations are classified under this category, including civil engineers, urban planners, and landscape architects.

Construction involves knowledge of building and construction techniques, related equipment and tools, and maintenance and repair. With an understanding of different system designs, components, and materials, workers physically build or install roadways, railroads, wiring, and piping among numerous other types of infrastructure. In total, 1.8 million workers across 17 occupations are classified under this category, including electricians, pipe layers, and telecommunication line installers.

Operation involves knowledge of different physical and mechanical operations that vary depending on the specific processes, equipment, instruments, controls, and labor entailed. Monitoring the movement of people and goods, the generation and distribution of energy, and the treatment of water and waste are among the frequent activities carried out by these workers. In total, 8.8 million workers across 60 occupations are classified under this category, including material movers, truck drivers, railroad conductors, power plant operators, meter readers, water treatment plant operators, and hazardous material removal workers.

Governance involves knowledge of law and government, public safety and security, and environmental conservation. Assessing different transportation activities, recording potential violations, and overseeing environmental conditions are among the central tasks performed by these workers. In total, 150,000 workers across eight occupations are classified under this category, including transportation security screeners and transportation inspectors.

In this way, regardless of their industry concentrations, some infrastructure occupations have job duties tightly linked to the design, construction, operation, and governance of specific infrastructure assets; in turn, their total cross-industry employment is included here.

O*NET provides a helpful rubric to determine the relative importance of core tasks performed by individual occupations. At the detailed occupation level, for instance, O*NET allows users to see how foresters are essential in establishing land management plans and enforcing regulations to protect critical natural resources, both of which are tied to governing green infrastructure. Electricians and pipelayers are similar in this respect; while most of their employment falls outside infrastructure industries, they still have job duties vital to the operation of various energy and water assets. As described earlier, occupations heavily concentrated in residential and commercial construction, such as carpenters, possess many relevant skills, but are only partially included on the basis of their share of employment in the 42 infrastructure industries.

Although many engineering and design occupations also play an enormous role in the nation's infrastructure, it is hard to distinguish their work in professional, scientific, and technical services (NAICS 54). Therefore, we have counted only those occupations directly connected to a specific infrastructure sector, such as landscape architects (public works). We also only partially include employment in other related occupations, such as management analysts, cartographers, and surveying and mapping technicians, on the basis of their share of employment in the 42 infrastructure industries.

5. Measuring Infrastructure Employment at the National and Metropolitan Level

Workers employed in the 95 infrastructure occupations and 42 infrastructure industries serve as the basis for measuring infrastructure employment across the nation and metropolitan areas.

At the national level, the report counts the number of workers employed in infrastructure occupations regardless of their industry (11.4 million), and adds this total to the number of workers employed in infrastructure industries regardless of their occupation. To avoid double-counting, we subtract employment from infrastructure industries for those workers who are also employed in any of the infrastructure occupations, resulting in 2.8 million employed. For example, because airline pilots are an infrastructure occupation, we count their cross-industry employment (66,270), but not their employment in infrastructure industries.

At the metropolitan level, the report follows a similar methodology. It includes all workers employed in infrastructure occupations, and adds this total to the number of workers employed in infrastructure industries. However, since OES does not release industry data for individual metropolitan areas, the report uses a national share of employment to estimate infrastructure employment at this geographic scale.[66] In Youngstown, for instance, 320 construction managers are employed across all industries; 14 percent of workers in this occupation are employed in infrastructure industries nationally, which means that approximately 45 construction managers are included for Youngstown in this analysis. Table B4 illustrates how this method works for other occupations in this area.

Table B4. Example of Infrastructure Occupational Employment in the Youngstown Metropolitan Area, 2012

Metro	SOC Title	Infrastructure Weight	Total Employment	Infrastructure Employment
Youngstown-Warren-Boardman, OH-PA	Telecommunications Equipment Installers and Repairers, Except Line Installers	1.000	100	100
Youngstown-Warren-Boardman, OH-PA	Electrical and Electronics Repairers, Commercial and Industrial Equipment	0.052	90	5
Youngstown-Warren-Boardman, OH-PA	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	1.000	90	90
Youngstown-Warren-Boardman, OH-PA	Electronic Home Entertainment Equipment Installers and Repairers	0.060	60	4
Youngstown-Warren-Boardman, OH-PA	Security and Fire Alarm Systems Installers	0.001	170	0
Youngstown-Warren-Boardman, OH-PA	Aircraft Mechanics and Service Technicians	1.000	100	100
Youngstown-Warren-Boardman, OH-PA	Automotive Body and Related Repairers	0.010	350	3
Youngstown-Warren-Boardman, OH-PA	Automotive Service Technicians and Mechanics	0.030	1,130	34
Youngstown-Warren-Boardman, OH-PA	Bus and Truck Mechanics and Diesel Engine Specialists	1.000	510	510
Youngstown-Warren-Boardman, OH-PA	Farm Equipment Mechanics and Service Technicians	0.004	50	0

When calculating the infrastructure employment for each metropolitan area, then, cross-industry occupation totals are weighed by national infrastructure shares. These "infrastructure weights" are based on (1) the share of employment for a given occupation in the 42 infrastructure industries, and (2) whether an occupation is classified separately as infrastructure-related regardless of its industry employment. For example, 25.1 percent of all construction laborers are employed across the 42 infrastructure industries, so this share (.251) is used to weigh their cross-industry employment at the metropolitan scale. Similarly, because civil engineers are identified as always being infrastructure-related, their share (1.00) is used to include all of their employment in every metropolitan area.

Notably, cross-industry occupational employment for individual metropolitan areas in this report is based on detailed occupation totals. In short, this means only employment in occupations that were not suppressed at the detailed level is included.[67] Likewise, wages are only counted for those occupations without suppressions. Typically, OES cross-industry totals for metropolitan areas, in particular, are higher than totals seen here because OES totals include suppressed and nonsuppressed data.

6. Comparing Wages at the National and Metropolitan Levels

Throughout the report, OES wages are based on straight-time, gross pay, which includes forms of compensation such as cost-of-living allowances and over-the-road pay, but excludes overtime pay and holiday bonuses. Mean hourly and annual wages are highlighted in this report, in addition to percentile wages (10th, 25th, 50th, 75th, and 90th). By definition, workers at the 10th and 25th percentiles earn wages at the lower end of each occupation and industry, while workers at the 75th and 90th percentiles earn wages at the higher end.

Nationally, we look exclusively at cross-industry wages for the 95 infrastructure occupations. Although wages for individual occupations can vary by industry, this cross-industry perspective follows the same approach used to count national infrastructure employment, consistently viewing these occupations in a larger national context. However, we exclude wages for workers employed in other occupations within the 42 infrastructure industries.

As such, mean and percentile wages for individual occupations like truck drivers and civil engineers are a main focus of this report. When viewed together, though, we average wages for all 95 infrastructure occupations based on employment. Without the full OES survey sample, this approach is intended to approximate a distribution of earnings across all infrastructure occupations, reflecting the large number of workers earning competitive wages at lower percentiles compared to the small number of workers earning competitive wages at higher percentiles. Indeed, almost 8 million workers across 87 different infrastructure occupations earn higher wages at the 10th percentile compared to the nation as a whole, while only 1 million workers across 25 different infrastructure occupations earn higher wages at the 90th percentile.

At the metropolitan level, we also consider cross-industry wages for these 95 infrastructure occupations. Because most areas do not employ workers across all of these occupations—and some records may be suppressed—we examine wages only for occupations with reported employment. We calculate overall infrastructure wages for each metropolitan area on the basis of the relative weight for each infrastructure occupation. All hourly and annual wages—mean and percentile—are averaged for each area using levels of occupational employment.

7. Measuring Skills in Terms of Education and Training

This report examines skills in terms of education and training typically needed for the 95 infrastructure occupations. BLS tracks levels of education, related work experience, and on-the-job training required for different occupations. While some occupations can potentially have multiple paths of entry, BLS only tracks one typical path in its classification system. Gathering information from O*NET, the National Center for Education Statistics, and the U.S. Census Bureau's American Community Survey (ACS), BLS uses a combination of quantitative and qualitative measures to evaluate skills across detailed occupations.

Typical levels of education attained—and needed for entry—are based on the following education levels for workers ages 25 years and older: doctoral or professional degree; master's degree; bachelor's degree; associate's degree; postsecondary non-degree award; some college, no degree; high school diploma or equivalent; and less than high school.[68] EP educational attainment by detailed occupation, in particular, is based on 2010 to 2011 totals.

While not common for infrastructure occupations, related work experience is considered necessary for many other jobs nationally and defined in three categories: 5 years or more, less than 5 years, and none.

Based on competency requirements, typical on-the-job training needed falls into six categories: internship/residency; apprenticeship; long-term on-the-job training (more than 12 months); moderate-term on the job training (more than 1 month and up to 12 months); short-term on-the-job training (1 month or less); and no training.

8. Projecting Employment Growth and Replacement Rates

Since OES estimates are not designed for comparisons across time—due to changing NAICS and SOC classifications, among other factors—the report instead uses the projected employment growth and replacement needs calculated by BLS from 2012 to 2022. Similar to the skills data, however, occupational employment in these projections does not precisely match those reported by the OES program. Projections are released every other year by BLS, with the next release covering 2014 to 2024.

BLS industry and occupation projections are developed in six steps that are based on several different assumptions, relating to the labor force, aggregate economy, industry output, and numerous other economic indicators.[69] Future changes in population and industry demand, for instance, are two measures used to estimate and allocate occupational employment. The projections in this report are calculated using a base year of 2012.

Replacement needs are calculated based on historical replacement rates and other factors related to projected job growth, retirements, and new entrants to the labor force. As illustrated in this report, occupations projected to grow or decline in overall employment often require workers to replace those retiring or otherwise leaving a particular line of work.

Endnotes

1. Ronald Reagan. "Radio Address to the Nation on Proposed Legislation for a Highway and Bridge Repair Program." November 27, 1982. Available online at: **http://www.reagan.utexas.edu/archives/speeches/1982/112782a.htm**. (Accessed April 17, 2014).

2. Michael Wines. "Bush Signs Transit Bill In Texas And Touts Jobs." *The New York Times*. December 19, 1991.

3. For more information on ARRA and public investment in water and transportation infrastructure, see: Congressional Budget Office. "Public Spending on Transportation and Water Infrastructure." (2010).

4. Another example is the Federal Highway Administration's oft-cited estimation that nearly 35,000 jobs are supported by every $1 billion in federal highway spending. For more information, see: U.S. Department of Transportation, Federal Highway Administration. "Employment Impacts of Highway Infrastructure Investment." Direct and indirect jobs refer to workers employed in construction and other supporting industries that are closely associated with these activities. Induced jobs—jobs formed as a result of spending by this construction workers—are also counted in the FHWA's employment total.

5. Gary Burtless, "Private Sector Payrolls Finally Top Pre-Recession Peak," Brookings. April 4, 2014; and Christopher J. Goodman and Steven M. Mance, "Employment loss and the 2007-09 recession: an overview," *Monthly Labor Review*, April 2011, p. 4.

6. Barry P. Bosworth and Sveta Milusheva, "Innovations in U.S. Infrastructure Financing: An Evaluation," (Washington, Brookings, 2011).

7. American Society of Civil Engineers. "Guiding Principles for the Nation's Critical Infrastructure." (2009).

8. Larry Beeferman et al. "Infrastructure – Defining Matters." Harvard Law School. Available online at: **http://www.law.harvard.edu/programs/lwp/pensions/publications/INFRASTRUCTURE%20DEFINING%20MATTERS%20FINAL.pdf**. (Accessed March 6, 2014).

9. The National Academy of Sciences. *Infrastructure for the 21st Century: Framework for a Research Agenda.* (Washington: National Academy Press, 1987). Available online at: **http://www.nap.edu/catalog.php?record_id=798#toc** (Accessed March 6, 2014).

10. Mark Weisdorf. "Infrastructure: A Growing, Real Return Asset Class." (New York: CFA Institute, 2007).

11. For more information on STEM jobs, including measures of employment, see: Jonathan Rothwell. "The Hidden STEM Economy." (Washington, Brookings, 2013).

12. Mark Muro et al. "Sizing the Clean Economy: A National and Regional Green Jobs Assessment." (Washington: Brookings, 2011).

13. For more information on the specific taxonomy behind these infrastructure assets, see: John Baldwin and Jay Dixon. "Infrastructure Capital: What is It? Where is It? How Much of It Is There?" (Ottawa: Statistics Canada, 2008).

14. Note that these sectors are intended to provide a clear and consistent way to group different infrastructure activities, but they are not necessarily absolute in their separation. In many cases, more than one sector can apply to certain NAICS industries, particularly those involved in transport or trade and logistics. It is more critical here, then, that a NAICS industry can be classified under at least one of these sectors.

15. Given the out-of-scope service activities concentrated in schools, hospitals, and other social institutions, these industries—and their related occupations—are excluded in the "public works" sector.

16. The criteria used here follow the precedent established by the Bureau of Labor Statistics (BLS) in measuring green jobs. However, rather than using an output and process approach, these criteria relate more directly to the services offered by particular industries and performed by certain occupations. In other words, workers in these establishments must carry out at least one of four activities—designing, constructing, operating, or governing—that support infrastructure, often with a clear public benefit over the course of many years. Additional information on this approach can be found at the BLS Green Jobs homepage: **http://www.bls.gov/green/**.

17. This analysis concentrates on direct jobs as opposed to indirect jobs tied to infrastructure. Several reports that focus on stimulus spending consider employment multipliers to approximate the number of infrastructure jobs found in the U.S. and elsewhere. More information on the importance of infrastructure investment for economic productivity, employment, and other measures is described at length in: Richard Dobbs et al. "Infrastructure Productivity: How to Save $1 trillion a Year." (McKinsey Global Institute, 2013).

18. For more information on the 2010 SOC, see: **http://www.bls.gov/soc/home.htm**.

19. Note that employment totals for skills and projections are drawn from the BLS Employment Projections (EP) Program, which relies on different methods than those used in the OES data. As a result, these figures may vary slightly. For more information on EP methods, see: **http://www.bls.gov/emp/ep_projections_methods.htm**.

20. For more information on OES pay terms, see: **http://www.bls.gov/respondents/oes/payterms.htm**.

21. Specific descriptions for these categories can be found at: **http://www.bls.gov/emp/ep_education_tech.htm**.

22. As described in the detailed methodology in Appendix B, occupations are identified based on a three-step process: (1) their concentration in 42 infrastructure industries; (2) their concentration in related government activities (NAICS 99); and (3) their particular tasks, knowledge, and work activities linked to the design, construction, operation, and governance of the seven infrastructure sectors.

23. Specialized tasks, knowledge, and tools are among the job characteristics described in the Occupational Information Network (O*NET), which is used as a guide throughout this report to examine occupations linked to specific infrastructure assets. Similarly, BLS's Occupational Outlook Handbook provides a wealth of information when considering particular occupations. For more information, see: **http://www.bls.gov/ooh/**.

24. Transportation infrastructure is especially notable in this respect, as exemplified by highway maintenance workers, air traffic controllers, and subway and streetcar operators, among numerous other occupations.

25. The financing and operation of water infrastructure often entails widespread public sector involvement, including several federal bodies such as the Environmental Protection Agency. For more information on drinking water and wastewater infrastructure, in particular, see: U.S. Government Accountability Office. "Water Infrastructure: Comprehensive Asset Management Has Potential to Help Utilities Better Identify Needs and Plan Future Investments." (2004).

26. As described in Appendix B, these infrastructure occupations and industries are not mutually exclusive; in many cases, workers in the 95 infrastructure occupations are also employed in the 42 infrastructure industries. However, the report employs a specific method to avoid double-counting these employment totals.

27. Construction workers, to be sure, play an enormous role in infrastructure projects, as captured across the 42 NAICS industries. However, many of these occupations are concentrated in residential and other building construction, including specialized contractors, as opposed to heavy construction involving highways or utilities. For more information on these jobs, see: Kristina Costa and Adam Hersh. "Infrastructure Spending Builds American Jobs: Public Investments Help Private Businesses Create Jobs." (Washington: Center for American Progress, 2011).

28. Based on Brookings analysis of U.S. Census data.

29. Since cross-industry totals are included for infrastructure occupations, it is possible some temporary workers are included in these metropolitan areas. For example, many workers can be employed in employment services (NAICS 5613), including material movers in particular. However, this is still a small share of their total employment.

30. Depending on the infrastructure definition used, employment in construction projects can be traced to specific economic activities. For more information, see: Linda Levine. "Job Loss and Infrastructure Job Creation During the Recession." (Washington: Congressional Research Service, 2009).

31. Establishments in the construction sector (NAICS 23) can vary significantly in terms of the equipment used and activities performed, as specified in the U.S. Census Bureau Industry Statistics Portal.

32. For more information on electricity infrastructure, in particular, see: American Society of Civil Engineers. "Failure to Act: The Economic Impact of Current Investment Trends in Electricity Infrastructure." (2011).

33. The mining activities described here are captured under NAICS 21.

34. Brookings analysis of Occupational Employment Statistics data.

35. While extraction facilities are outside the scope of this report, more information on these structures and their relationship to infrastructure more broadly can be found in: Government Accountability Office. "Climate Change: Energy Infrastructure Risks and Adaptation Efforts." (2014).

36. For more background on the postal service's infrastructure connections, see: U.S. Postal Service Office of Inspector General. "Postal Service Contributions to National Infrastructure." (2012)

37. Government Accountability Office. "U.S. Postal Service: The Service's Strategy for Realigning Its Mail Processing Infrastructure Lacks Clarity, Criteria, and Accountability." (2005).

38. Truck drivers are currently facing new regulations from the Federal Motor Carrier Safety Administration (FMCSA) to improve safety and address fatigue, which will affect the number of hours many of these drivers can work consecutively and weekly. While the issue continues to stir considerable debate, more than 85 percent of these drivers will not be affected according to FMCSA. For more information on these regulations, see: Federal Motor Carrier Safety Administration. "New Hours-of-Service Safety Regulations to Reduce Truck Driver Fatigue Begin Today." (2013). Online at: **http://www.fmcsa.dot.gov/new-hours-service-safety-regulations-reduce-truck-driver-fatigue-begin-today** (Accessed April 3, 2014).

39. Whether it is high or low, wage dispersion can be the result of many different industry factors and consequently entail many different meanings. For a brief description of this topic in light of occupational employment data, see: John Jones. "An Investigation of Industry and Size Effects on Wage Dispersion." (Washington: Bureau of Labor Statistics, 2003).

40. Rising levels of income inequality are a particular topic of interest in recent years. Statistical measures, such as the 90/10 ratio used here, offer one way to measure inequality. For more information on these inequality measures at the metropolitan scale, see: Alan Berube. "All Cities Are Not Created Unequal." (Washington: Brookings, 2014).

41. Note that only annual wages are reported for flight attendants, airline pilots, and commercial pilots, which are included the 95 infrastructure occupations. Their annual wages, however, exceed the national average.

42. Livable wages are an ongoing topic of interest given cost of living considerations and numerous other economic factors not examined in this report, which are prevalent throughout different metropolitan areas.

43. Unemployment rates for metropolitan areas in this report are based on annualized 2012 averages released by the Local Area Unemployment Statistics (LAUS) program at BLS.

44. Note that the high school diploma category includes other educational equivalencies as included in data from the BLS Employment Projection Program.

45. Beyond skills, unionization can also frequently be a contributing factor to the cost of replacing workers, several of whom are included in infrastructure occupations. For additional background, see: Howard Kimeldorf. "Worker Replacement Costs and Unionization: Origins of the U.S. Labor Movement." (*American Sociological Review,* Vol. 78, 2013, 1033-1062).

46. The Employment Projections Program considers replacement needs as a contributing factor in its employment

growth projections, as well as new opportunities calculated in total job openings over the next decade.

47. Bruce Katz and Jennifer Bradley. *The Metropolitan Revolution: How Cities and Metros are Fixing our Broken Politics and Fragile Economy.* (Washington: Brookings Institution Press, 2013).

48. For more information on unemployment effects following the Great Recession, see: Congressional Budget Office. "Understanding and Responding to Persistently High Unemployment." (2012).

49. As specified under the Moving Ahead for Progress in 21st Century Act (MAP-21), a national freight plan is currently being developed by the United States Department of Transportation in concert with other public- and private-sector partners. Beyond the National Export Initiative, efforts to promote export growth in metropolitan areas are being facilitated by the Brookings Metropolitan Export Initiative (MEI): **http://www.brookings.edu/about/projects/state-metro-innovation/mei** (Accessed March 31, 2014).

50. Eduardo Porter. "Income Equality: A Search for Consequences." *The New York Times.* March 25, 2014.

51. Similarly, the wages described here do not necessarily capture all forms of compensation, including training opportunities, health insurance, or retirement benefits.

52. The Federal Aviation Administration has examined these replacement needs in greater depth. Needs for air traffic controllers are highlighted in the following report: Federal Aviation Administration. "A Plan for the Future: 10-Year Strategy for the Air Traffic Control Workforce, 2012–2021." (2012).

53. Labeled a "mancession" by some economists, the Great Recession frequently had a disproportionate effect on male workers. For more background, see: Catherine Rampell. "The Mancession." *The New York Times.* August 10, 2009. Additional demographic data by Census occupation is available through the BLS Current Population Survey (CPS). Notably, several infrastructure occupations have a high concentration of male workers, including electricians (98.2 percent) and pipelayers (98.9 percent). In contrast, some infrastructure occupations like bus drivers and logisticians are more than 40 percent female.

54. Lawrence Summers. "Now Is the Time to Rebuild Our National Infrastructure." *The Huffington Post*. Available online at: **http://www.huffingtonpost.com/lawrence-h-summers/national-infrastructure-rebuild_b_5144081.html?utm_hp_ref=politics** (Accessed April 14, 2014).

55. The 2012 OES technical notes indicate there was a 76.6 percent response rate for the survey based on establishments. The remaining 23.3 percent are based on imputation methods.

56. OES includes local, state, and federal government employment in these industry estimates; however, federal employment only covers workers employed in the U.S. Postal Service and the federal executive branch.

57. The term "shovel-ready" was popularized in late 2008 by President Obama to describe construction projects that could benefit from increased stimulus spending. For more information, see: Manuel Roig-Franzia. "Obama Brings 'Shovel-Ready' Talk Into Mainstream." *The Washington Post.* January 9, 2009.

58. Although the report excludes most workers in these industries, several occupations, including electricians and plumbers, may be concentrated in these activities, particularly in specialty trade contractors (NAICS 238).

59. The Department of Homeland Security (DHS) defines critical infrastructure sectors as part of an overarching strategy to "strengthen and maintain" the security of these assets. More information can be found online at: **https://www.dhs.gov/critical-infrastructure-sectors**. The Department of Energy (DOE), primarily through the Energy Information Administration (EIA), tracks different types of energy infrastructure nationally.

60. As part of its "Infrastructure to 2030" program, OECD considers telecom, land transport, water, and electricity.

61. For more information, see the American Society of Civil Engineers "Report Card for America's Infrastructure 2013" available online at **http://www.infrastructurereportcard.org/a/#p/home**. (Accessed March 7, 2014).

62. Note that total industry employment shown in this table is based on non-suppressed occupation totals.

63. While others include oilfields, natural gas platforms, refineries, and extraction facilities as energy infrastructure, this report considers these to be better captured under separate mining activities, as defined under NAICS 22. Likewise, while the postal service carries out many similar activities as express delivery services and local

messengers, they transport an enormous amount of unrelated parcels and have a significant number of retail establishments.

64. Given their concentration in other industries, their loose connection to specific infrastructure assets, and unrelated work activities according to O*NET, employment in the following occupations is only partially included here, despite having more than 25 percent of their employment in infrastructure industries: telephone operators, earth drillers, operating engineers, conveyor operators, baggage porters, and construction laborers.

65. Several occupations already classified as infrastructure-related based on criterion 1 also have a sizable share of employment concentrated in federal, state, and local government.

66. Many metropolitan areas, of course, have higher concentrations of certain industries that can influence the number of workers employed in related occupations, making it difficult to precisely weigh these estimates.

67. OES data may not be disclosed for a number of reasons, including survey respondent confidentiality.

68. For more information on these education categories, see: **http://www.bls.gov/emp/ep_definitions_edtrain.pdf** (Accessed April 4, 2014).

69. Information on these methods can be found at: **http://www.bls.gov/emp/ep_projections_methods.htm#labor** (Accessed April 18, 2014).

Acknowledgments

For their valuable insights on the data, methods, and/or earlier iterations of this report we wish to thank Alan Berube, Mary Clagett, Anita Harrison, Siddharth Kulkarni, Nick Marchio, Jonathan Rothwell, Patrick Sabol, and Adie Tomer, and Xinge Wang. Alec Friedhoff, David Jackson, and Stephen Russ provided help with editing and final production.

The Metropolitan Policy Program at Brookings would like to thank the Surdna Foundation and the Ford Foundation for their support of the Program's Metropolitan Infrastructure Initiative. We also thank the Metropolitan Leadership Council, a network of individual, corporate, and philanthropic investors that provide the Metro Program with financial support and true intellectual partnership.

For More Information:

Joseph Kane
Policy/Research Assistant
jkane@brookings.edu
@jwkane1

Robert Puentes
Director, Metropolitan Infrastructure Initiative and Senior Fellow
rpuentes@brookings.edu
@rpuentes

For General Information:

Metropolitan Policy Program at Brookings
202.797.6139
www.brookings.edu/metro

1775 Massachusetts Avenue NW
Washington D.C. 20036-2188
telephone 202.797.6139
fax 202.797.2965

Also In the Series

- *Getting Smarter About Smart Cities*
- *Metro-to-Metro: Global and Domestic Goods Trade in Metropolitan America*
- *Metro Freight: The Global Goods Trade that Moves Metro Economies*
- *A New Alignment: Strengthening America's Commitment to Passenger Rail*
- *Global Gateways: International Aviation in Metro America*
- *Expect Delays: An Analysis of Air Travel Trends in the United States*
- *Banking on Infrastructure: Enhancing State Revolving Funds for Transportation*
- *Moving Forward on Public Private Partnerships: U.S. and International Experience With PPP Units*
- *Missed Opportunity: Transit and Jobs in Metropolitan America*
- *Access for Value: Financing Transportation Through Land Value Capture*

About the Metropolitan Policy Program at Brookings

Created in 1996, the Brookings Institution's Metropolitan Policy Program provides decision makers with cutting-edge research and policy ideas for improving the health and prosperity of cities and metropolitan areas including their component cities, suburbs, and rural areas. To learn more visit: **www.brookings.edu/metro**

About the Metropolitan Infrastructure Initiative

Launched in 2008, the goal of the Metropolitan Infrastructure Initiative is to develop timely, independent analysis, frame key debates, and offer policy recommendations to help leaders in the United States and abroad address key infrastructure challenges. This and other publications, speeches, presentations, and commentary on infrastructure are available at: **www.brookings.edu/about/programs/metro/infrastructure-initiative**

BROOKINGS