Metropolitan Policy Program at BROOKINGS

Methodological Appendix—Infrastructure Skills

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Note: Methods used to classify infrastructure jobs, including specific occupations and industries, are described at greater length in "Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs" available at:

http://www.brookings.edu/~/media/research/files/reports/2014/05/09-infrastructure-jobs/beyond-shovel-ready.pdf

Occupational data

This report primarily uses occupational data from O*NET, an online resource center and database sponsored by the Department of Labor's Employment and Training Administration. Beyond providing career exploration tools, O*NET surveys workers across a wide range of occupations to describe the characteristics of their jobs and the specific requirements they face. Using the 20.2 version of the O*NET database updated in February 2016, we have examined several different fields at a detailed occupation level, including the knowledge required, tools/technology used, and education frequently needed. Each of these data elements are described in the following sections of this appendix.

In addition, the report uses 2014 employment data publicly available from the U.S. Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) program. Additional data on skills and educational attainment comes from the BLS Employment Projections (EP) program.

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 2014 were drawn from 1.2 million establishments across six panels of data collected over three years (May 2014, November 2013, May 2013, November 2012, May 2012, and November 2011). The sample is developed from state unemployment insurance files.

2014 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). 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.

Since O*NET uses a slightly different occupational classification system compared to the 2010 SOC system, we used a crosswalk to consistently relate the two systems. In total, O*NET codes more than 900 occupations, which have been related to 772 detailed SOC occupations. Infrastructure-specific occupations are described in more depth below.

Defining infrastructure occupations

Similar to previous analyses, this report defines infrastructure jobs based on a particular set of occupations and industries tied to seven infrastructure sectors.

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).

Based on these sectors, the report has determined a list of closely related NAICS industries. Relevant information from the U.S. Census Bureau Industry Statistics Portal has aided in this process as well, resulting in the classification of 42 four-digit NAICS industries, which range from warehousing and storage (NAICS 4931) to utility system construction (NAICS 2371) and waste collection (NAICS 5621). 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).

Using 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. On the basis of these three measures, the report has identified 95 infrastructure occupations. 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.

Collectively, 92 of the 95 SOC infrastructure occupations can be linked to O*NET classifications, which form the basis of all data concerning knowledge, tools, and training. Rail transportation workers, all other (53-4099); transportation workers, all other (53-6099); and material moving workers, all other (53-7199) are the excluded SOC infrastructure occupations.

Determining levels of infrastructure knowledge

O*NET surveys workers to rate the level of knowledge needed in specific occupations. On a scale from 0 (minimum) to 7 (maximum), workers rate their required knowledge across 33 distinct categories, ranging from biology and chemistry to communications and media. Higher levels of knowledge in a given category, in turn, typically mean that workers possess an advanced understanding of how to perform certain tasks in that category. For instance, nuclear engineers rated their level of knowledge in physics at 5.95 according to O*NET, meaning they required fairly extensive familiarity with this particular discipline to perform their jobs. In contrast, recyclable material collectors only rated their level of knowledge in this same category at 1.57, showing how they tend to rely less on physics to carry out their jobs.

To determine which categories of knowledge are required at higher levels among infrastructure occupations, we first calculated the average score in each category among all occupations nationally. We then did the same for the 92 detailed SOC infrastructure occupations that had available data in O*NET, comparing the differences. In total, infrastructure occupations had higher average scores in 11 different categories of knowledge, particularly in transportation, mechanical, and public safety knowledge.

Table A1. Knowledge categories where infrastructure occupations score higher than the national average

Knowledge Category	Average Knowledge Score, All Occupations (0-7)	Average Knowledge Score, Infrastructure Occupations (0-7)	Infrastructure Advantage
Transportation	1.76	3.21	1.45
Mechanical	2.37	3.54	1.17
Public Safety and Security	2.48	3.48	1.00
Building and Construction	1.43	2.25	0.82
Physics	1.71	2.34	0.63
Engineering and Technology	2.24	2.84	0.60
Geography	1.65	2.19	0.53
Telecommunications	1.46	1.90	0.45
Design	2.03	2.40	0.37
Chemistry	1.94	2.11	0.17
Law and Government	2.29	2.43	0.14

Detailed O*NET descriptions for each of these 11 “infrastructure knowledge categories” further reveals the specific types of principles and processes typically required in individual occupations.

Eleven infrastructure knowledge categories

Transportation — Knowledge of principles and methods for moving people or goods by air, rail, sea, or road, including the relative costs and benefits.

Mechanical — Knowledge of machines and tools, including their designs, uses, repair, and maintenance.

Public Safety and Security — Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions.

Building and Construction — Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.

Physics — Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub- atomic structures and processes.

Engineering and Technology — Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

Geography — Knowledge of principles and methods for describing the features of land, sea, and air masses, including their physical characteristics, locations, interrelationships, and distribution of plant, animal, and human life.

Telecommunications — Knowledge of transmission, broadcasting, switching, control, and operation of telecommunications systems.

Design — Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.

Chemistry — Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.

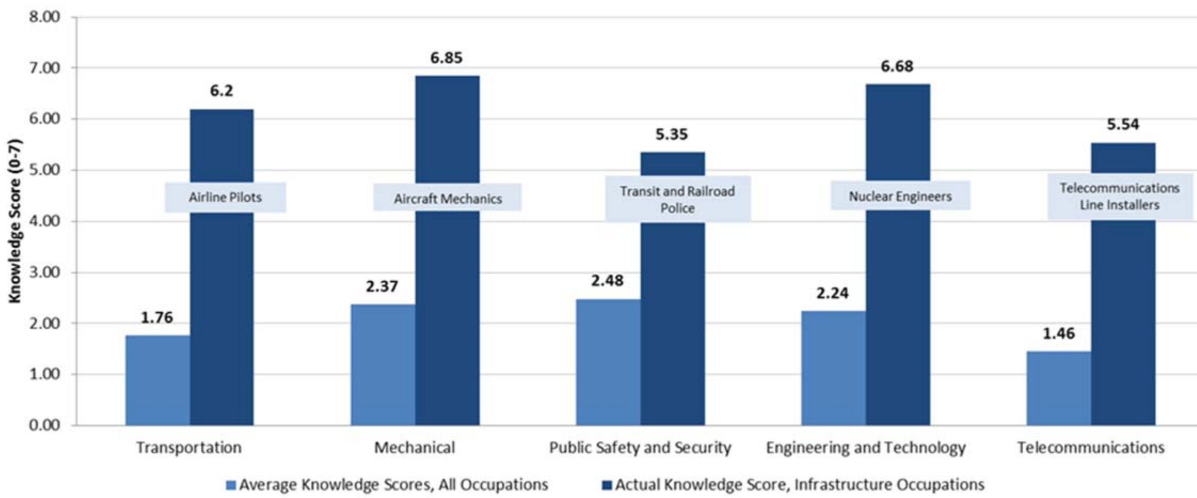
Law and Government — Knowledge of laws, legal codes, court procedures, precedents, government regulations, executive orders, agency rules, and the democratic political process.

*** Note that all knowledge categories shown in this box are drawn directly from O*NET definitions, available at:**

https://www.onetonline.org/find/descriptor/browse/Knowledge/

Based on these 11 categories, we further investigated differences among individual occupations, looking at whether the actual knowledge scores in a given discipline exceeded (or lagged behind) the national average. For example, airline pilots rated their actual level of knowledge in transportation at 6.20, surpassing the national average (1.76) by 4.44 points. Likewise, aircraft mechanics, transit and railroad police, nuclear engineers, and telecommunication line installers had above-average knowledge scores across a variety of other infrastructure knowledge categories. However, several infrastructure occupations scored below average in these 11 categories and relied more extensively on other disciplines, such as customer and personal service.

Figure A1. Average knowledge scores vs. actual knowledge scores for selected infrastructure occupations, by knowledge category



*Source: Brookings analysis of O*NET data*

By aggregating these differences across all 11 categories, we computed a cumulative "infrastructure knowledge score" for each occupation. Among the 92 infrastructure occupations, environmental engineers had the highest infrastructure knowledge score (26.79), with above-average knowledge in all 11 categories. Several other engineering occupations – including civil engineers and marine engineers – had similarly high levels of infrastructure knowledge, meaning they scored nearly 2 points higher (on average) compared to the national mean in each of the 11 infrastructure knowledge categories. In total, 73 of the 92 infrastructure occupations had a positive infrastructure knowledge score; the remaining 19 occupations, on the other hand, tended to score lower in these categories despite being employed in industries tightly linked to infrastructure activities.

Quantifying the number of tools and technologies used in infrastructure occupations

O*NET also compiles extensive information on the tools and software technologies used in individual occupations. While O*NET provides specific examples – such as Adobe Systems software or Microsoft Word – used by each occupation, the focus of this analysis is on more generalized commodities – like personal computers, forklifts, and two-way radios – as defined in the United Nations Standard Products and Services Code (UNSPSC). In total, 4,300 individual commodities are classified, including 4,174 tools and 126 software technologies.

In this report, we analyzed the number and type of commodities associated with each detailed SOC occupation nationally. An aggregation of these commodities revealed distinct concentrations of tools and technologies in the 92 infrastructure occupations. Plumbers and electricians, for instance, use more than 100 different tools and technologies to perform their jobs. Associated levels of employment and infrastructure knowledge scores were also compared alongside these commodity totals.

Defining levels of education, training, and experience required in infrastructure occupations

While previous analyses have focused more on levels of *educational attainment* – relying on BLS data through the EP program – this particular report examines the *education required* in individual occupations, according to O*NET worker surveys. Additional information on the levels of on-the-job-training and related experience needed for infrastructure occupations was also compiled from O*NET.

In these surveys, incumbent workers select one of several possible categories to describe the education, training, and experience typically needed for their occupation. In turn, each category reveals a specific share of these responses; for example, 82.4 percent of landscape architects indicated that a bachelor's degree was commonly required to enter their occupation. Meanwhile, 29.63 percent of landscape architects indicated that they needed 1 to 2 years of on-the-job training. To determine the most relevant categories of education, training, and experience frequently required for infrastructure occupations, we have focused our attention on those categories that received the greatest share of responses from incumbent workers (the mode).

O*NET includes a total of 12 different education categories: less than a high school diploma; high school diploma or GED; post-secondary certificate; some college courses; Associate's Degree; Bachelor's Degree; post-baccalaureate certificate; Master's Degree; post-master's certificate; first professional degree; Doctoral Degree; and post-doctoral training.

For on-the-job training, O*NET includes 9 different categories based on duration: none or short demonstration; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 10 years; and over 10 years.

Finally, for related work experience, O*NET includes 11 different categories, also based on duration: none; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 6 years; 6 to 8 years; 8 to 10 years; and over 10 years.

Measuring infrastructure employment at the national level

Workers employed in infrastructure occupations represent the major focus of this report, amounting to nearly 11.9 million workers in 2014.

However, when considering total national employment in this space (14.5 million workers), infrastructure occupations and industries are both considered, as in previous analyses. The 14.5 million worker total counts the number of workers employed in infrastructure occupations regardless of their industry, 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.

Comparing wages at the national level

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.