



U.S. Department of Commerce  
National Institute of Standards and Technology

Office of Applied Economics  
Building and Fire Research Laboratory  
Gaithersburg, MD 20899

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# Methodology for Calculating Construction Industry Supply Chain Statistics

Douglas S. Thomas

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Sponsored by:  
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## **Abstract**

Data from the Economic Census provides detailed statistics on the construction industry; however, the data is only gathered every five years. The Bureau of Labor Statistics provides statistics on the construction industry on an annual basis, but these statistics do not contain the same detail as the Economic Census data. Both sources together, along with several additional data sources, can be used to generate estimates of annual detailed statistics on the construction industry. The purpose of this report is to provide a documented methodology for calculating annual detailed statistics on components of the construction industry supply chain. These estimates include values for facility design; facility construction; operation and use; renovation; demolition; contents and furnishings; materials, components, supplies, and fuels; maintenance and repair; water and energy use; and losses. The estimates presented in this report have greater accuracy than a naïve model and can be used by policy makers and stakeholders to improve efficiency and competitiveness in the construction industry.

## **Keywords**

Construction; facility construction; facility design; maintenance and repair; renovation; statistics



## **Preface**

This study was conducted by the Office of Applied Economics in the Building and Fire Research Laboratory at the National Institute of Standards and Technology. The study provides a methodology for calculating statistics on components of the construction industry supply chain.

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# 1 Introduction

## 1.1 Background

The construction industry is a significant element of the U.S. economy. It represents approximately 4 % of GDP and 7 % of U.S. employment. The industry facilitates all types of activity, both business and personal activities. The construction of factories, offices, infrastructure, and other professional facilities has provided the backbone of economic activity while the construction of housing, educational facilities, religious facilities, and facilities for other private activities have provided havens for personal consumption and development. Without the construction industry, many business and personal activities would not be possible.

The construction industry is complex. For example, small firms with nine or fewer employees constitute 90 % of the residential construction industry, but represent only 61 % of residential construction business.<sup>1</sup> The dominance of small firms can make it difficult to communicate with the industry. Nonresidential construction does not have the same small firm dominance that residential construction has, but has other complicating factors. Another complexity of the construction industry is that most construction occurs on site away from factories and offices, which makes it different from most other industries. In 2008, the value of construction put in place was 14 % down from its peak in 2006. In the period from 2007 to 2008, the industry lost 882 000 jobs, the most severe among all industries in terms of percent lost in an industry and number of jobs lost. During the 2008 to 2009 period, the industry lost an additional 1 272 000 jobs representing 23 % of the 5 485 000 jobs lost in the U.S. economy. Construction has had a significant effect on the U.S. economy, both in terms of the economic activity it represents and the functions which it enables. The significance of the construction industry makes it important to understand its complexities in order for policy makers and stakeholders to improve efficiency and competitiveness.

The construction industry is comprised of many components as illustrated in the construction industry supply chain in Figure 1.1-1. Beginning with facility design, the life cycle of a constructed facility moves through six stages: facility design, facility construction, commissioning, operation and use, renovation, and eventually demolition. These can also be considered the six primary components of the construction industry. A number of other secondary components support the primary components. Raw materials such as lumber, metal, and petroleum, are manufactured into component systems as illustrated by the line connecting raw materials and component systems in Figure 1.1-1. Some of the materials from component systems, facility construction, maintenance and repair, and renovations are disposed or recycled as illustrated by the green lines in Figure 1.1-1. Constructed facilities are occasionally damaged as illustrated by the red lines to the loss box; some of the materials from these losses can also be recycled while others are

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<sup>1</sup> U.S. Department of Housing and Urban Development, “Overcoming Barriers to Innovation in the Home Building Industry.” April 2005 < <http://www.pathnet.org/si.asp?id=1452> > (January 27, 2006), 9.





total values of construction put in place. Between the Economic Census and the C30 report, dollar values for five components of the construction industry can be estimated on an annual basis: facility design; facility construction; renovation; maintenance and repair; and a value for materials, components, supplies, and fuels (MCSF). This paper provides a method for calculating these and other components of the construction industry supply chain on an annual basis. The significance of the construction industry makes it important to understand the complexities of the industry in order for policy makers and stakeholders to improve efficiency and competitiveness. The estimates developed in this report provide an enhanced understanding of construction industry complexities. Federal and state agencies can use the estimates in assessing the effect of regulations, tax policy, finance policy, land development, and job retention efforts. It can provide insights into the extent that new structures are being erected as opposed to old structures being renovated and maintained. It also provides insight into industry growth for investors, economic development groups, and other construction industry stakeholders.

## **1.2 Purpose**

Data from the Economic Census provides detailed statistics on the construction industry; however, the data is only gathered every five years. The Bureau of Labor Statistics provides statistics on the construction industry on an annual basis, but these statistics do not contain the same detail as the Economic Census data. Both sources together, along with several additional data sources, can be used to generate estimates of annual detailed statistics on the construction industry. The purpose of this report is to provide a documented methodology for calculating annual detailed statistics on components of the construction industry supply chain. These estimates include values for facility design; facility construction; operation and use; renovation; demolition; contents and furnishings; materials, components, supplies, and fuels; maintenance and repair; water and energy use; and losses. The estimates presented in this report have greater accuracy than a naïve model and can be used by policy makers and stakeholders to improve efficiency and competitiveness in the construction industry.

## **1.3 Scope and Approach**

The six primary components of the construction industry along with supporting components have a significant effect on business and personal activities and they are a major driver of the U.S. economy. Therefore, it is essential that this industry be efficient and competitive, which points to the need to measure and track the magnitude of each component of the industry.

This report has five chapters with the introduction being chapter one. Chapter two discusses the data available on the construction industry. It begins with a discussion on the Census Bureau's C30 report on construction put in place followed by discussions on the Economic Census, Bureau of Economic Analysis GDP data, employment data, energy data, manufacturing data, services data, and loss estimation data. Trends and patterns of these datasets are discussed and used to measure and track the components of the construction industry. Chapter three provides a method to estimate three major

components of the construction industry that are not available on an annual basis: new construction; additions, alterations, and reconstruction; and maintenance and repair. The fourth chapter uses values from chapter 3 to calculate additional components of the industry supply chain. These components include values for facility design; materials, components, supplies, and fuels; demolition; facility construction; commissioning; renovation; maintenance and repair; contents and furnishings, services to buildings and dwellings; and water and energy use. A few of these components can simply be adjusted using the Consumer Price Index while others can be scaled using other annually available data sets. Chapter five provides an implementation of the methods in chapters three and four and a comparison to a naïve model estimate. The final chapter provides a summary discussion and recommendations for further research.

## 2 Construction Industry Data

This chapter lays out the principal data available on the construction industry. It then discusses the definitions used in the data and trends in the data. It begins with a discussion on the Census Bureau's C30 report on construction put in place followed by discussions on the Economic Census, Bureau of Economic Analysis GDP data, employment data, energy data, manufacturing data, services data, and loss estimation data related to the construction industry. When applicable, values have been adjusted to constant 2009 dollars using the consumer price index for all consumers for all products, unless specified otherwise.

### 2.1 C30 Report

The C30 report is published near the beginning of every month. It includes detailed data on public and private values of construction put in place.<sup>2</sup> These include values (see Table 2.1-1 and Table 2.1-2) for residential construction and nonresidential construction. Nonresidential data is broken out into sixteen subsectors: lodging, office, commercial, health care, educational, religious, public safety, amusement and recreation, transportation, communication, power, highway and street, sewage and waste disposal, water supply, conservation and development, and manufacturing construction. Public construction data is more detailed in 2002 and beyond. Private residential data is broken out into new single family, new multi-family, and improvements. Construction put in place includes costs for materials installed or erected, labor and proportionate share of construction rental, contractor's profit, architectural and engineering work, overhead and office costs, and interest and taxes paid during construction.<sup>3</sup>

For the purpose of the C30 report, the term construction includes the following items:

- New buildings and structures
- Additions, alterations, conversions, expansions, reconstruction, renovations, rehabilitations, and major replacements
- Mechanical and electrical installations
- Site preparation and outside construction of fixed structures or facilities
- Installation of the following types of equipment: boilers, overhead hoists and cranes, and blast furnaces.
- Fixed, largely site-fabricated, equipment not housed in a building, primarily for petroleum refineries and chemical plants
- Cost and installation of construction materials placed inside a building and used to support production machinery

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<sup>2</sup> Census Bureau. "Construction Spending." <<http://www.census.gov/const/www/c30index.html>>

<sup>3</sup> Census Bureau. "Definitions of Construction. C30." <<http://www.census.gov/const/C30/definitions.pdf>>

Construction excludes maintenance and repairs to existing structures or service facilities, the cost and installation of production machinery and equipment items, the drilling of gas and oil wells, and land acquisition.

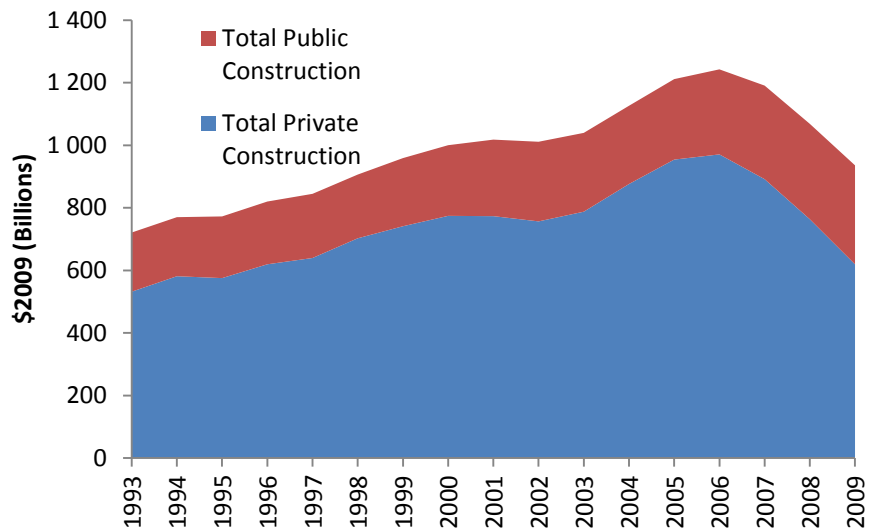
**Table 2.1-1: Construction Put in Place (\$2009 million) 1993-2001**

Type of Construction	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total Private Nonresidential	222,712	232,253	254,142	267,348	285,675	312,453	320,862	342,976	331,826
Lodging	6,815	6,742	10,038	14,923	17,240	19,503	20,546	20,312	17,588
Office	29,692	29,594	32,372	36,276	43,860	53,166	58,015	65,292	60,261
Commercial	51,067	57,347	62,075	67,521	70,962	73,286	76,461	79,804	77,052
Health care	22,180	22,361	21,480	21,085	23,245	23,345	23,679	24,238	23,629
Educational	7,147	7,251	8,023	9,551	11,765	12,937	12,563	14,555	15,562
Religious	5,781	5,604	6,121	6,204	7,729	8,692	9,492	10,004	10,167
Public safety	319	473	260	439	761	771	599	527	332
Amusement and recreation	6,831	7,394	8,286	9,593	11,411	11,305	12,298	10,924	9,483
Transportation	6,948	6,810	6,699	7,958	8,298	9,595	8,402	8,570	8,550
Communication	14,477	14,692	15,643	16,168	16,644	16,417	23,701	23,421	23,738
Power	34,970	30,462	30,978	23,810	21,871	28,548	28,382	36,559	38,158
Sewage and waste disposal	554	433	811	871	626	446	664	633	487
Water supply	632	821	943	640	599	715	532	890	682
Manufacturing	34,699	41,757	49,783	52,097	50,291	53,285	45,233	46,823	45,809
Total Private Residential	309,082	348,924	321,131	352,085	353,814	390,040	420,191	431,239	441,447
New single family	208,039	234,961	216,107	233,529	234,158	262,458	288,243	295,005	301,740
New multi-family	16,017	20,384	25,183	27,790	30,587	32,344	35,328	35,207	36,711
Improvements	85,026	93,578	79,842	90,766	89,068	95,239	96,620	101,028	102,996
Total Public	189,092	188,800	197,097	200,556	205,096	203,715	217,733	225,905	244,594
TOTAL	720,886	769,976	772,370	819,989	844,585	906,208	958,786	1,000,121	1,017,867

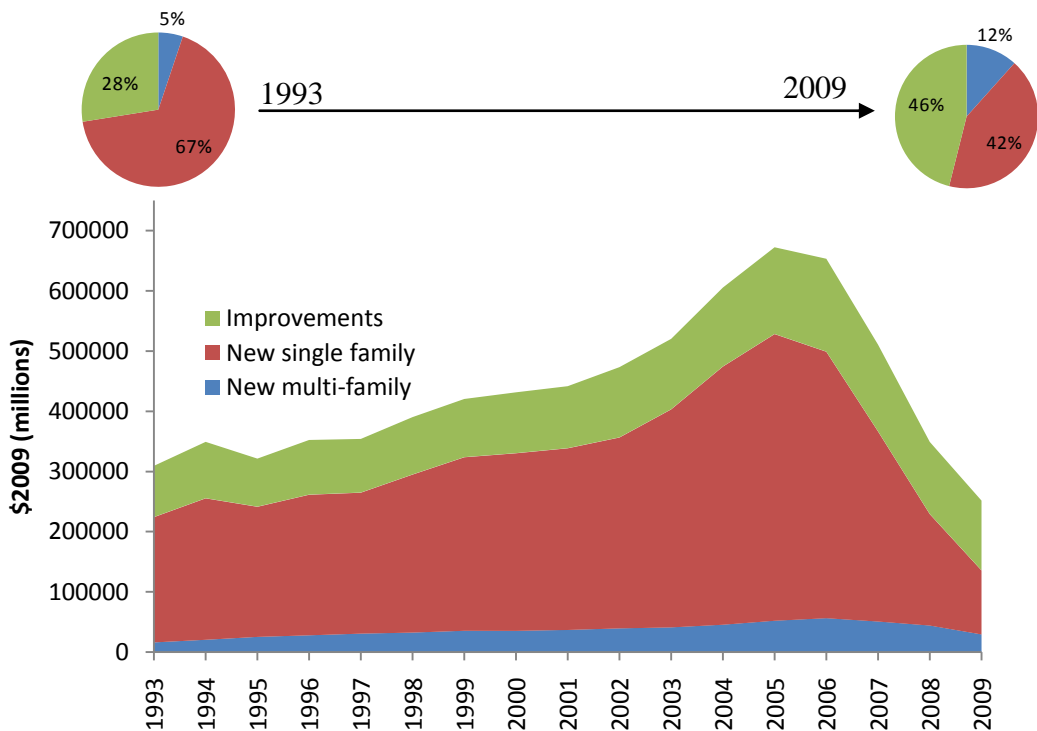
As illustrated in Figure 2.1-1, public construction put in place represented 26 % of total construction put in place in 1993. Between 1993 and 2007, it varied between 21 % and 26 % of total construction put in place, but in 2008 and 2009 it rose to 29 % and 34 % respectively. Private Construction put in place trended upward from 1993 through 2006. In 2007, it began to decline significantly. This decrease was primarily driven by residential construction which declined 22 % as illustrated in Figure 2.1-2. Private residential construction at its peak in 2005 represented 70 % of all private construction put in place. By 2009, it was down 63 % from its peak and now represented only 41 % of private construction. The decline in private residential construction was primarily driven by new-single family construction, which declined by 78 % between 2005 and 2009. Nonresidential construction trended upwards from 1993 through 2000, but declined slightly between 2001 and 2004 as seen in Figure 2.1-3. From 2004 to 2008, it increased while residential construction was decreasing. All subsectors of private nonresidential construction, except manufacturing construction, decreased from 2008 to 2009. Several subsectors are too small to be seen in the figure; these include public safety, sewage and waste disposal, and water supply.

**Table 2.1-2: Construction Put in Place (\$2009 million) 2002-2009**

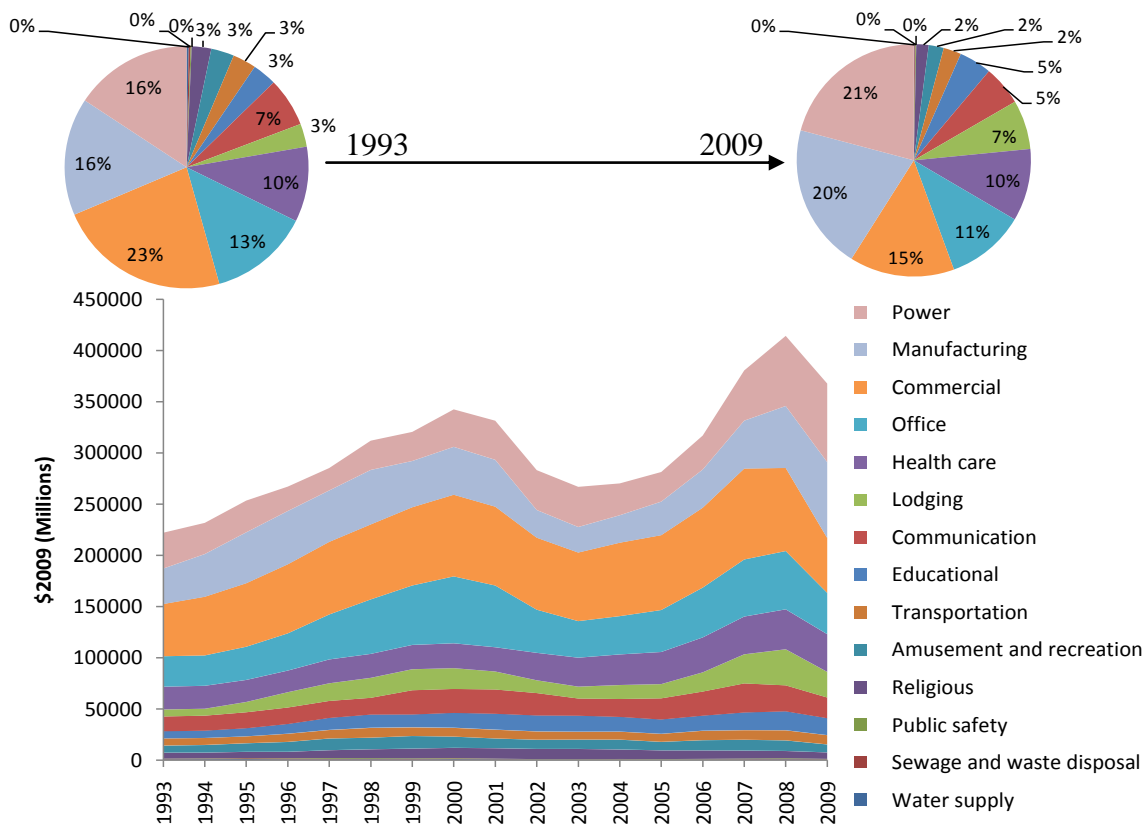
Type of Construction	2002	2003	2004	2005	2006	2007	2008	2009
Total Private Nonresidential	283,512	267,396	270,844	281,923	317,589	381,152	414,612	367,913
Lodging	12,482	11,578	13,608	13,914	18,755	28,435	35,253	25,033
Office	42,092	35,654	37,341	40,948	48,611	55,682	56,881	40,286
Commercial	70,369	67,049	71,772	73,143	78,076	88,837	81,205	53,654
Health care	26,758	28,236	29,838	31,302	34,071	36,823	38,962	36,760
Educational	15,633	15,652	14,425	14,048	14,727	17,270	18,519	16,619
Religious	9,940	9,979	9,260	8,475	8,237	7,783	7,072	6,287
Public safety	259	216	328	448	446	616	648	463
Amusement and recreation	8,918	9,072	9,576	8,246	9,924	10,547	10,279	7,718
Transportation	8,077	7,658	7,769	7,826	9,209	9,322	9,861	9,066
Communication	21,924	16,855	17,567	20,702	23,611	28,442	25,405	20,229
Power	38,886	39,198	31,073	28,895	33,164	49,009	68,458	76,699
Sewage and waste disposal	293	324	376	264	325	422	546	458
Water supply	473	458	460	358	508	534	694	345
Manufacturing	27,123	24,991	26,879	32,830	37,338	46,875	60,568	74,135
Total Private Residential	473,074	520,060	605,224	672,171	653,115	510,362	348,833	251,365
New single family	317,082	362,119	428,798	476,211	442,692	315,774	185,115	106,288
New multi-family	39,296	40,944	45,365	51,956	56,191	50,658	44,001	29,264
Improvements	116,695	116,997	131,061	144,005	154,231	143,930	119,717	115,813
Total Public Residential	6,278	6,082	6,256	6,160	6,473	7,473	7,304	8,093
Total Public Nonresidential	248,255	245,914	243,810	251,064	265,301	291,633	297,570	308,252
Office	10,711	10,306	10,818	9,323	9,053	11,842	13,175	14,919
Commercial	4,188	4,692	4,386	4,018	3,560	3,960	3,435	3,807
Health care	5,606	5,960	6,714	6,520	6,870	8,463	8,567	9,835
Educational	72,450	70,998	69,902	73,489	75,651	82,846	85,192	86,065
Public safety	9,075	8,134	7,643	7,586	7,822	9,939	12,242	13,727
Amusement and recreation	11,748	10,571	9,384	8,489	10,330	11,401	11,132	10,953
Transportation	22,667	21,153	20,692	19,694	20,549	23,662	23,971	26,206
Power	5,004	9,131	9,125	10,063	9,141	12,354	11,416	11,995
Highway and street	68,392	66,430	66,206	70,073	76,160	78,894	81,302	84,430
Sewage and waste disposal	19,070	19,010	19,986	21,560	24,349	25,313	24,508	24,392
Water supply	14,364	14,108	13,873	15,053	15,412	15,812	16,197	15,438
Conservation and development	4,193	4,307	4,394	4,748	5,371	5,334	5,331	5,767
Other	787	1,116	686	448	1,033	1,812	1,100	718
TOTAL	1,011,118	1,039,452	1,126,133	1,211,319	1,242,478	1,190,618	1,068,318	935,623



**Figure 2.1-1: Construction Put in Place**



**Figure 2.1-2: Components of Private Residential Construction Put in Place**



**Figure 2.1-3: Components of Private Nonresidential Construction Put in Place**

## 2.2 Economic Census

The Economic Census provides detailed data on most of the U.S. economy and is developed using establishment survey statistics. This census is provided once every five years for national and local economies.<sup>4</sup> The data is classified by the North American Industry Classification System (NAICS), which is a system of grouping establishments into similar production processes. There are 20 sectors and 1175 industries for the U.S. in the 2007 NAICS. The construction sector, NAICS 23, is listed in Table 2.2-1 and Table 2.2-2. The 2002 and 2007 construction data is based on receipts, billings, or sales. The Economic Census is more detailed than the C30 report, but the data is not annually collected and published. Variables shown in Table 2.2-1 and Table 2.2-2 include the following: values for construction work; values for new construction work; values for additions, alterations, and reconstruction; values for maintenance and repair; cost of

<sup>4</sup> Census Bureau. "2007 Economic Census." <<http://www.census.gov/econ/census07/>>

**Table 2.2-1: Construction Work from the Economic Census (\$2009 million)**

2007 NAICS code	Meaning of 2007 NAICS code	Value of const work	Construction work: new construction	Const work: additions, alterations, or reconstruction	Value of construction work: maintenance and repair
236115	New single-family general contractors	97,111	85,189	9,739	2,183
236116	New multifamily housing construction (except operative builders)	35,081	32,579	2,266	236
236117	New housing operative builders	176,352	173,598	2,276	478
236118	Residential remodelers	56,695	4,789	38,903	13,000
236210	Industrial building construction	17,475	9,401	4,770	3,304
236220	Commercial and institutional building construction	340,180	216,724	102,619	20,836
237110	Water and sewer line and related structures construction	47,620	32,248	9,058	6,314
237120	Oil and gas pipeline and related structures construction	31,346	17,486	4,293	9,566
237130	Power and communication line and related structures construction	34,289	20,482	5,537	8,270
237210	Land subdivision	64,314	50,649	11,345	2,320
237310	Highway, street, and bridge construction	105,753	59,052	29,830	16,870
237990	Other heavy and civil engineering construction	18,478	11,220	3,537	3,721
238110	Poured concrete foundation and structure contractors	48,778	38,333	6,274	4,171
238120	Structural steel and precast concrete contractors	15,091	12,042	2,093	956
238130	Framing contractors	18,322	15,188	2,456	679
238140	Masonry contractors	27,523	19,805	4,269	3,449
238150	Glass and glazing contractors	10,299	5,877	2,411	2,011
238160	Roofing contractors	29,465	10,136	10,847	8,483
238170	Siding contractors	7,540	3,827	2,314	1,398
238190	Other foundation, structure, and building exterior contractors	7,598	4,435	1,464	1,700
238210	Electrical contractors and other wiring installation contractors	130,242	66,046	38,328	25,868
238220	Plumbing, heating, and air-conditioning contractors	163,524	74,918	40,312	48,294
238290	Other building equipment contractors	24,461	9,446	5,498	9,517
238310	Drywall and insulation contractors	44,586	31,928	9,677	2,981
238320	Painting and wall covering contractors	22,673	8,859	4,418	9,396
238330	Flooring contractors	16,104	7,485	5,800	2,819
238340	Tile and terrazzo contractors	10,366	6,141	3,252	973
238350	Finish carpentry contractors	27,545	12,609	10,872	4,064
238390	Other building finishing contractors	8,821	4,646	1,999	2,176
238910	Site preparation contractors	86,367	61,695	13,987	10,685
238990	All other specialty trade contractors	40,169	23,833	7,211	9,126
<b>TOTAL</b>		<b>1,764,168</b>	<b>1,130,666</b>	<b>397,656</b>	<b>235,843</b>



**Table 2.2-2: Construction Costs and Value Added from the Economic Census (\$2009 million)**

2007 NAICS code	Meaning of 2007 NAICS code	Cost of materials, components, and supplies	Cost of construction work sub- contracted out to others	Total cost of selected power, fuels, and lubricants	Other business receipts	Value business done	Value added
236115	New single-family general contractors	41,744	23,868	1,421	1,018	98,129	31,095
236116	New multifamily housing construction (except operative builders)	7,630	17,501	247	164	35,246	9,867
236117	New housing operative builders	63,421	38,682	1,413	1,300	177,652	74,136
236118	Residential remodelers	18,369	14,061	1,140	470	57,166	23,595
236210	Industrial building construction	3,545	5,291	214	315	17,790	8,740
236220	Commercial and institutional building construction	76,721	163,352	2,261	1,677	341,857	99,522
237110	Water and sewer line and related structures construction	16,120	7,996	1,415	290	47,910	22,379
237120	Oil and gas pipeline and related structures construction	4,996	3,066	1,278	564	31,910	22,570
237130	Power and communication line and related structures construction	8,462	4,245	782	359	34,649	21,159
237210	Land subdivision	10,986	27,523	563	768	65,082	26,010
237310	Highway, street, and bridge construction	37,569	19,056	3,900	2,433	108,186	47,661
237990	Other heavy and civil engineering construction	5,920	2,087	558	280	18,758	10,193
238110	Poured concrete foundation and structure contractors	18,358	4,814	1,046	139	48,917	24,698
238120	Structural steel and precast concrete contractors	4,737	1,020	265	246	15,338	9,316
238130	Framing contractors	5,695	2,184	385	67	18,390	10,125
238140	Masonry contractors	8,781	2,111	600	136	27,659	16,167
238150	Glass and glazing contractors	4,259	349	160	86	10,386	5,618
238160	Roofing contractors	11,435	1,960	686	115	29,580	15,498
238170	Siding contractors	2,724	919	164	117	7,657	3,850
238190	Other foundation, structure, and building exterior contractors	2,352	513	159	153	7,751	4,727
238210	Electrical contractors and other wiring installation contractors	47,402	6,412	2,232	1,311	131,554	75,508
238220	Plumbing, heating, and air-conditioning contractors	61,072	14,120	3,208	1,300	164,824	86,423
238290	Other building equipment contractors	7,362	1,268	428	315	24,776	15,718
238310	Drywall and insulation contractors	14,454	4,497	709	203	44,789	25,129
238320	Painting and wall covering contractors	5,095	1,782	676	363	23,036	15,483
238330	Flooring contractors	7,297	1,714	278	167	16,271	6,982
238340	Tile and terrazzo contractors	3,636	710	210	89	10,455	5,899
238350	Finish carpentry contractors	8,880	3,647	704	395	27,940	14,709
238390	Other building finishing contractors	2,683	628	190	101	8,922	5,421
238910	Site preparation contractors	23,256	10,649	4,856	2,125	88,492	49,732
238990	All other specialty trade contractors	13,747	3,641	1,339	1,013	41,182	22,455
TOTAL		548,709	389,667	33,488	18,081	1,782,250	810,386

materials, components, and supplies; cost of construction work subcontracted out to others; costs of selected power, fuels, and lubricants; other business receipts; value added; and value of business done. Definitions from the Economic Census are quoted below:

*Value of Construction Work:* “In the 1987-1997 censuses, the value of construction work was collected to measure actual construction activity done during the year. Studies have shown that respondents were not able to accurately report these data. In 2002 and 2007, receipts, billings, or sales for construction work was collected... [Value of construction work] includes the receipts, billings, or sales for construction work done by building contractors, heavy and civil engineering construction contractors, and specialty trade contractors. Included are new construction, additions, alterations or reconstruction, and maintenance and repair construction work. Establishments engaged in the sale and installation of construction components such as plumbing, heating, and central air-conditioning supplies and equipment; lumber and building materials; paint, glass, and wallpaper; and electrical and wiring supplies, elevators or escalators were instructed to include both the value for the installation and receipts covering the price of the items installed. Excluded are the cost of industrial and other special machinery and equipment that are not an integral part of a structure, and receipts from business operations in foreign countries.”<sup>5</sup>

*Value of New Construction Work:* “This includes the original construction work done on a project including all finishing work on the original building or structure. Land development work on the site and demolition of existing structures are also included.”<sup>6</sup>

*Value of Additions, alterations, or reconstruction:* “Includes the construction work which adds to the value or useful life of an existing building or structure or which adapts a building or structure to a new or different use. Included are “major replacements” of building systems such as the installation of a new roof or heating system and the resurfacing of streets or highways. This contrasts to the repair of a hole in a roof or the routine patching of highways and streets, which would be classified as maintenance and repair.”<sup>7</sup>

*Value of maintenance and repair:* “Includes the incidental construction work which keeps a property in ordinary working condition. Excluded are trash and snow removal, lawn maintenance and landscaping, cleaning, and janitorial services.”<sup>8</sup>

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<sup>5</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>6</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>7</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>8</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

*Cost of materials, components, and supplies:* “Includes the costs for materials, components, and supplies used by establishments in the construction or reconstruction of buildings, structures, or other facilities plus costs for materials bought and resold to others. Also included are costs made for direct purchases of materials, components, and supplies although the purchases were subsequently provided to subcontractors for their use. Supplies include expendable tools which are charged to current accounts. Freight and other direct charges representing only that amount paid after discounts and the value of materials, components, and supplies obtained from other establishments of the respondent's company are also included. Excluded from this item are the cost of fuels, lubricants, electric energy, and industrial and other specialized machinery and equipment such as printing presses; computer systems that are not an integral part of a structure; and materials furnished to contractors by the owners of projects.”<sup>9</sup>

*Cost of construction work subcontracted out to others:* “Includes all costs for construction work subcontracted out to other construction contractors during the reporting year. Excluded from this item are costs to the reporting establishment for its purchases of materials, components, and supplies provided to a subcontractor for use. These costs are reported under costs for materials, components, and supplies. Also excluded are costs for the rental of machinery or equipment.”<sup>10</sup>

*Cost of selected power, fuels, and lubricants:* “Includes costs for fuels including gasoline, diesel fuel, and lubricants, and electric energy purchased during the year from other companies or received from other establishments of the company. Also included are costs for natural gas, manufactured gas, fuel oil, and coal and coke products.”<sup>11</sup>

*Other business receipts:* “Includes the receipts for all other business activities done by an establishment in the current year. Includes business receipts not reported as value of construction work. This includes business receipts from retail and wholesale trade, rental of equipment without operator, manufacturing, transportation, legal services, insurance, finance, rental of property and other real estate operations, and other nonconstruction activities. Receipts for separately definable architectural and engineering work for others are also included here. Excluded are nonoperating income such as interest, dividends, the sale of fixed assets, or receipts from other business operations in foreign countries.”<sup>12</sup>

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<sup>9</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>10</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>11</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>12</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

*Value added:* “This measure of construction activity is equal to value of business done, less costs for construction work subcontracted out to others and costs for materials, components, supplies, and fuels.”<sup>13</sup>

*Value of business done:* “Includes the sum of value of construction work and other business receipts. Value of business done is the sum of receipts, billings, or sales from establishments of construction business activities plus receipts from other business activities.”<sup>14</sup>

Value added is a common measure used in economics; therefore, it is important to understand how it is calculated. In general, it can be described as the total sales of a firm minus purchases of inputs from other firms.<sup>15</sup> It is calculated in the Economic Census as the value of construction work plus other business receipts minus the cost of materials, components, and supplies minus cost of selected power, fuels, and lubricants minus cost of construction work subcontracted out to others. It can be represented as the following:

$$VA_t = VC_t - MCS_t - F_t - SC_t + BR_t$$

Where:

$VA_t$  = Value added for time t

$VC_t$  = Value of construction work for time t (see Table 2.2-1)

$MCS_t$  = Cost of materials, components, and supplies for time t (see Table 2.2-2)

$F_t$  = Cost of selected power, fuels, and lubricants for time t (see Table 2.2-2)

$SC_t$  = Cost of construction work subcontracted out to others for time t (see Table 2.2-2)

$BR_t$  = Other business receipts for time t (see Table 2.2-2)

Since the Economic Census is only conducted every five years and the structure of the census changes occasionally, chronological trends in the census are not analyzed here. However, the Economic Census does provide a more detailed breakdown of the construction industry than the C30 report. The largest subsector of the construction industry is commercial and institutional building construction followed by new housing operative builders as seen in the bar graph of Figure 2.2-1. New construction work comprises the largest portion of each of these subsectors with additions, alterations, and reconstruction being a distant second. New construction comprises 64 % of all construction with additions, alterations, and reconstruction representing 23 % as seen in the pie chart of Figure 2.2-1.

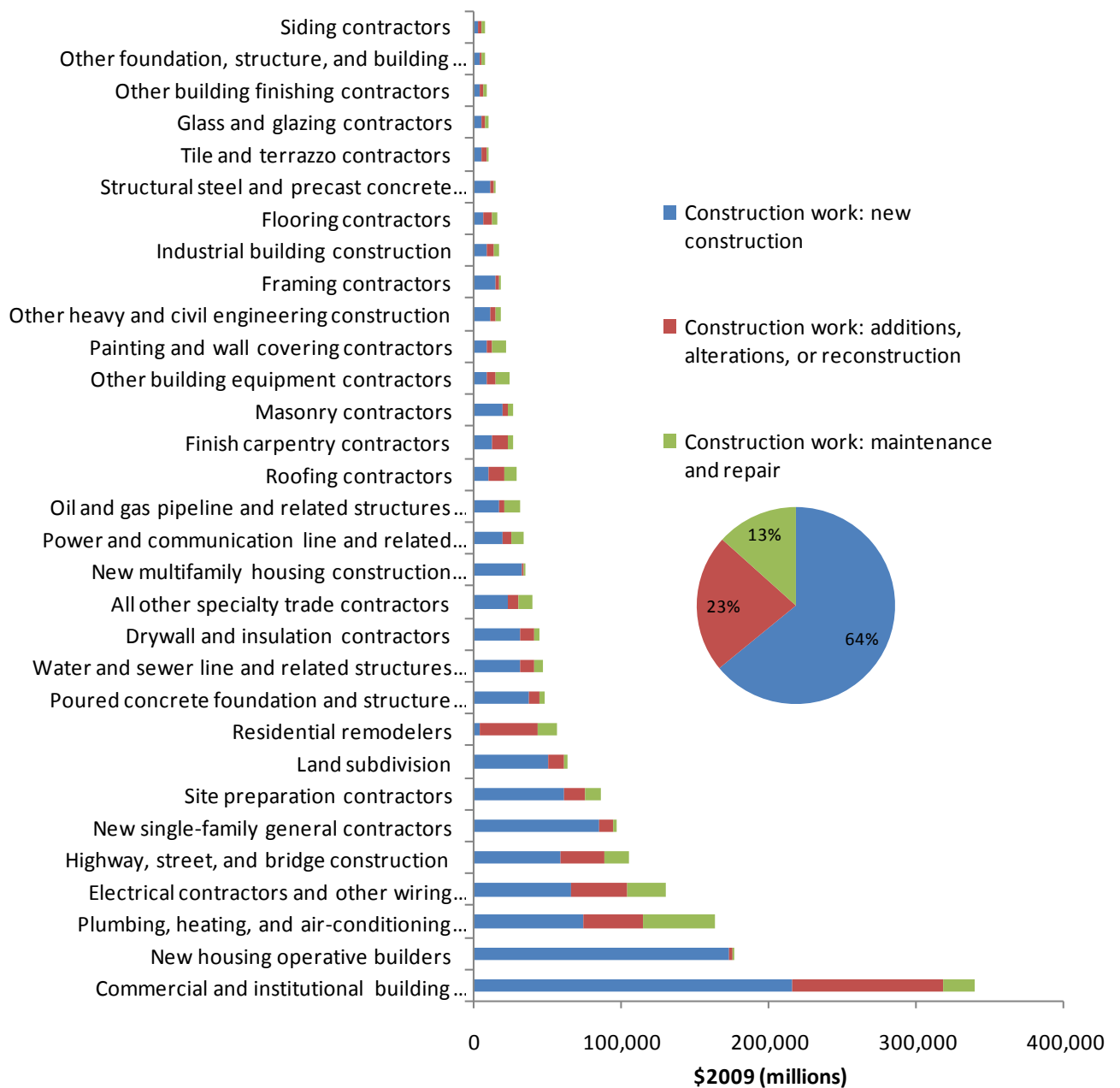
Unlike the C30 report, the Economic Census has values for other industries. The construction industry represents 6 % of the total economy and employs 7 % of the work force as seen in Figure 2.2-2 and Figure 2.2-3, substantially more than many of the other industries.

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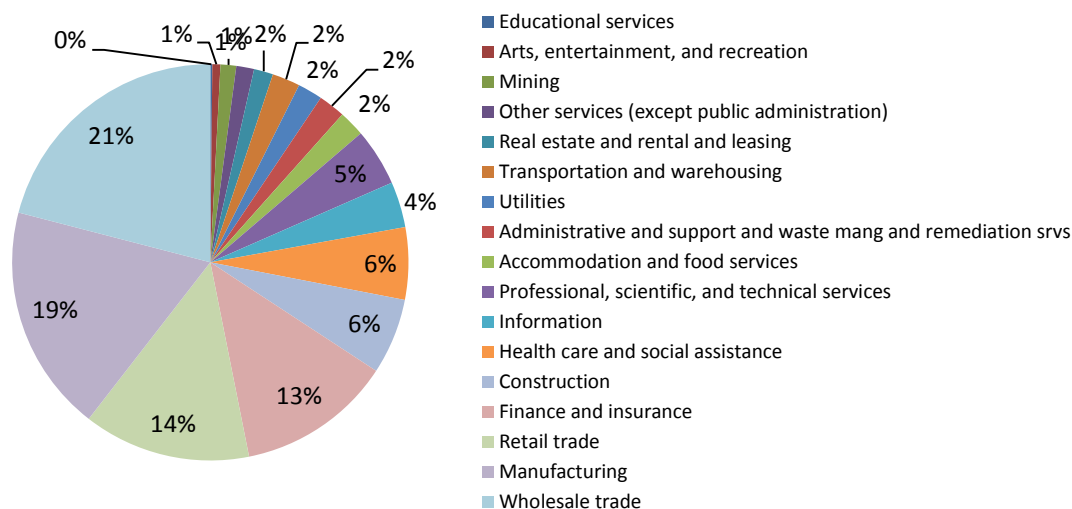
<sup>13</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>14</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

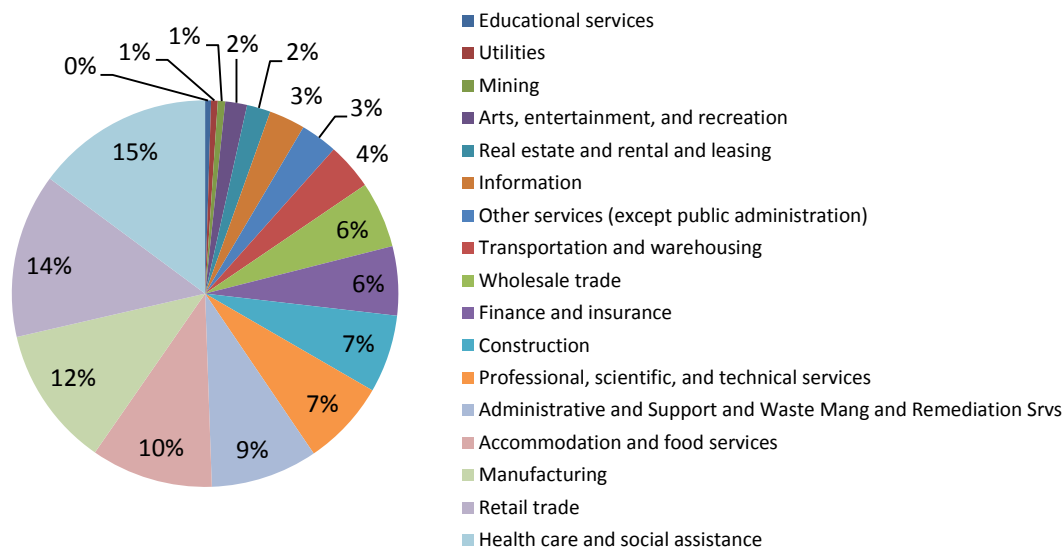
<sup>15</sup> Black, John. Oxford Dictionary of Economics. Oxford University Press; New York, 2002.



**Figure 2.2-1: Construction work from the Economic Census 2007**



**Figure 2.2-2: Percent of Total Sales, Shipments, Receipts, Revenue, or Business Done by Industry, Economic Census 2007**



**Figure 2.2-3: Percent of Paid Employees by Industry, Economic Census 2007**

The Economic Census also provides values for elements of facility design and other construction components. It includes architectural services, engineering services, building inspection services, and surveying and mapping services. Values from the 2007 Economic Census are displayed in Table 2.2-3 and they are defined as the following:

*Architectural Services:* “This industry comprises establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures by applying knowledge of design, construction procedures, zoning regulations, building codes, and building materials.”<sup>16</sup>

<sup>16</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

*Engineering Services:* “This industry comprises establishments primarily engaged in applying physical laws and principles of engineering in the design, development, and utilization of machines, materials, instruments, structures, processes, and systems. The assignments undertaken by these establishments may involve any of the following activities: provision of advice, preparation of feasibility studies, preparation of preliminary and final plans and designs, provision of technical services during the construction or installation phase, inspection and evaluation of engineering projects, and related services.”<sup>17</sup>

*Building Inspection Services:* “This industry comprises establishments primarily engaged in providing building inspection services. These establishments typically evaluate all aspects of the building structure and component systems and prepare a report on the physical condition of the property, generally for buyers or others involved in real estate transactions. Building inspection bureaus and establishments providing home inspection services are included in this industry.”<sup>18</sup>

*Surveying and Mapping Services:* “This industry comprises establishments primarily engaged in performing surveying and mapping services of the surface of the earth, including the sea floor. These services may include surveying and mapping of areas above or below the surface of the earth, such as the creation of view easements or segregating rights in parcels of land by creating underground utility easements.”<sup>19</sup>

**Table 2.2-3: Professional, Scientific, and Technical Services from the Economic Census (\$2009 thousands)**

2007 NAICS code	Meaning of 2007 NAICS code	Receipts/ Revenue
541310	Architectural services	38,544,839
541330	Engineering services	120,568,874
541350	Building inspection services	2,201,445
541370	Surveying and mapping (except geophysical) services	6,670,517

One additional value from the 2002 Economic Census is utilized to estimate demolition. It is identified using the 1997 NAICS code 23594000: Wrecking and Demolition Contractors and is part of the 2002 NAICS code 238910: Site Preparation Contractors. It is defined as the following:

*Wrecking and Demolition:* This U.S. industry comprises establishments primarily engaged in site preparation activities, such as excavating and grading, demolition of buildings and other structures, septic system

<sup>17</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>18</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

<sup>19</sup> Census Bureau. “2007 Economic Census.” <<http://www.census.gov/econ/census07/>>

installation, and house moving. Earth moving and land clearing for all types of sites (e.g., building, nonbuilding, mining) is included in this industry. Establishments primarily engaged in construction equipment rental with operator (except cranes) are also included.

## 2.3 Bureau of Economic Analysis GDP Data

The Bureau of Economic Analysis (BEA) develops estimates of value added by industry, which is an industry's contribution to the nation's output, or gross domestic product (GDP). As mentioned previously, value added is the total sales of a firm minus purchases of inputs from other firms.<sup>20</sup> Value added, as defined by the BEA, is equal to its gross output minus intermediate inputs such as energy, raw materials, and semi-finished goods. Gross output includes sales or receipts plus other operating income and inventory change. Intermediate inputs include goods and services that are purchased for use in production.<sup>21</sup> Value added can be broken into three major components: return to domestic labor (employee compensation), net return to government (taxes), and domestic capital return (surplus).<sup>22</sup>

As seen in Table 2.3-1, there are a number of sources for the data that the BEA uses to develop value added by industry. This table, however, is not an exhaustive list. There are various other sources from trade associations, businesses, international organizations, and other sources used by the BEA.

As seen in the pie graph in Figure 2.3-1, construction value added represented 4 % of total value added in 1950. In 2008, this value was also approximately 4 %. Meanwhile, other industries changed dramatically. For example, manufacturing changed from 27 % in 1950 to 11 % in 2008 and professional services went from 6 % to 20 %.

It is important to note that, at this point, we have discussed two entities that provide an estimate of value added for the construction industry. The first source discussed was the Economic Census and the second is the BEA. They each have similar definitions; however, due to different sources, methods, and definitions their estimates of value added differ.

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<sup>20</sup> Black, John. Oxford Dictionary of Economics. Oxford University Press; New York, 2002.

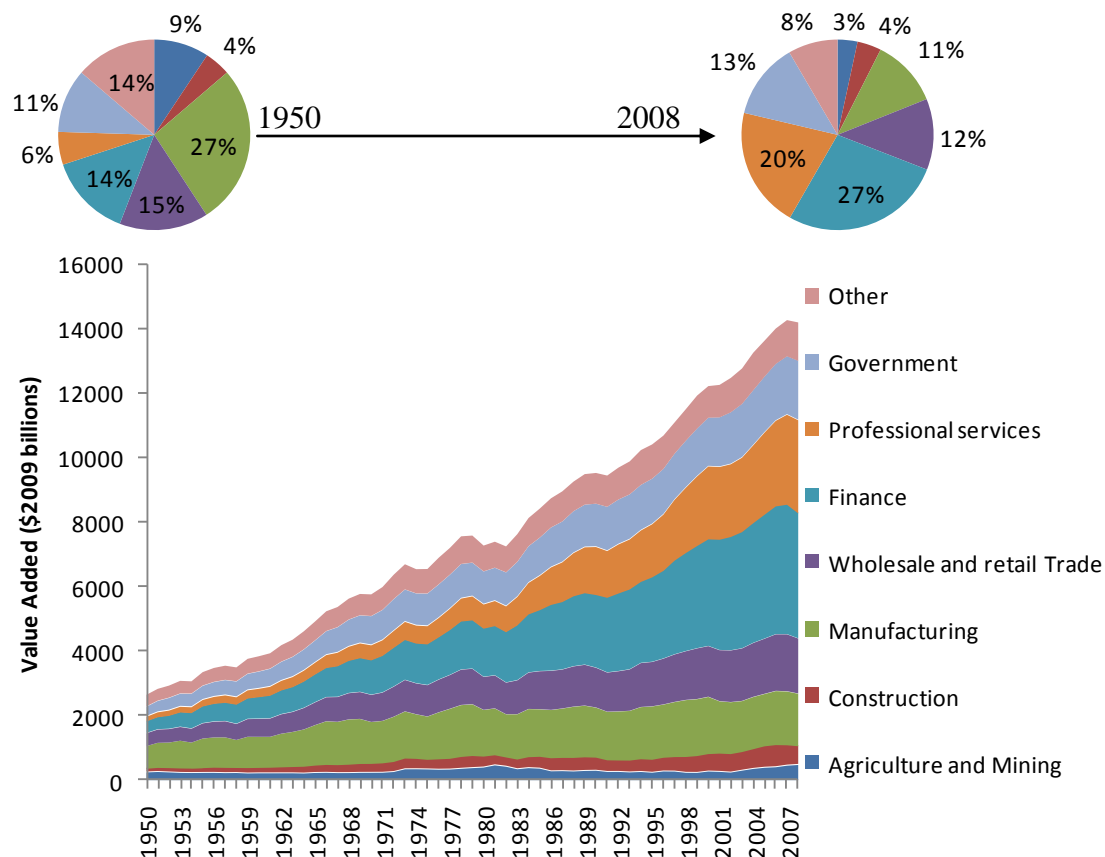
<sup>21</sup> Bureau of Economic Analysis. "Concepts and Methods of the U.S. National Income and Product Accounts." October 2009. Page 22. <<http://www.bea.gov/national/pdf/NIPAhandbookch1-4.pdf>>

<sup>22</sup> Bureau of Economic Analysis. Guide to the Interactive GDP-by-Industry Accounts. <<http://www.bea.gov/industry/gpotables/Guide.cfm?anon=507899>>



**Table 2.3-1: Primary Sources used to Calculate Quarterly and Annual Estimates of Industry Value Added**

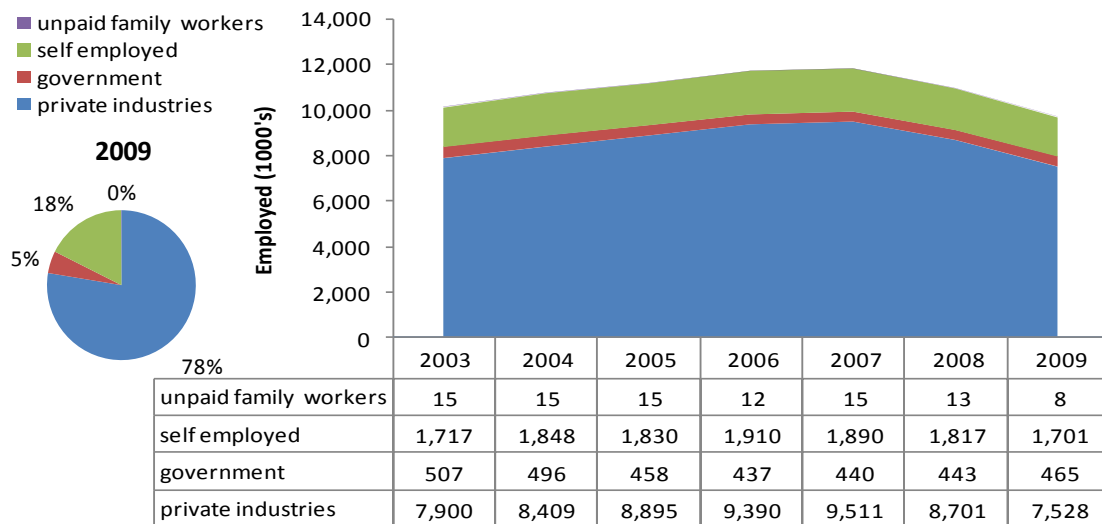
Source	Agency
Monthly survey of manufacturers' shipments, inventories, and orders	Census Bureau
Monthly wholesale trade survey	Census Bureau
Monthly retail trade and food services survey	Census Bureau
Quarterly services survey	Census Bureau
Monthly construction spending (value put in place)	Census Bureau
Monthly U.S. international trade in goods and services	Census Bureau and Bureau of Economic Analysis
U.S. international transactions accounts	Bureau of Economic Analysis
Annual projections and quarterly farm data	Agriculture Department
Monthly current employment statistics	Bureau of Labor Statistics
Quarterly financial report	Census Bureau
Monthly treasury statement	Treasury Department
Consumer price index	Bureau of Labor Statistics
Producer price index	Bureau of Labor Statistics
International price indexes	Bureau of Labor Statistics
Annual survey of manufactures	Census Bureau
Annual wholesale trade survey	Census Bureau
Annual retail trade survey	Census Bureau
Service annual survey	Census Bureau
Annual surveys of state and local government finances	Census Bureau
Annual revision of the international transactions accounts	Bureau of Economic Analysis
Annual farm statistics	Agriculture Department
Quarterly census of employment and wages	Bureau of Labor Statistics
Tabulations of tax returns	Internal Revenue Service
Federal government annual budget	Office of Management and Budget



**Figure 2.3-1: Value Added by Industry 1950-2008**

## 2.4 Employment Data

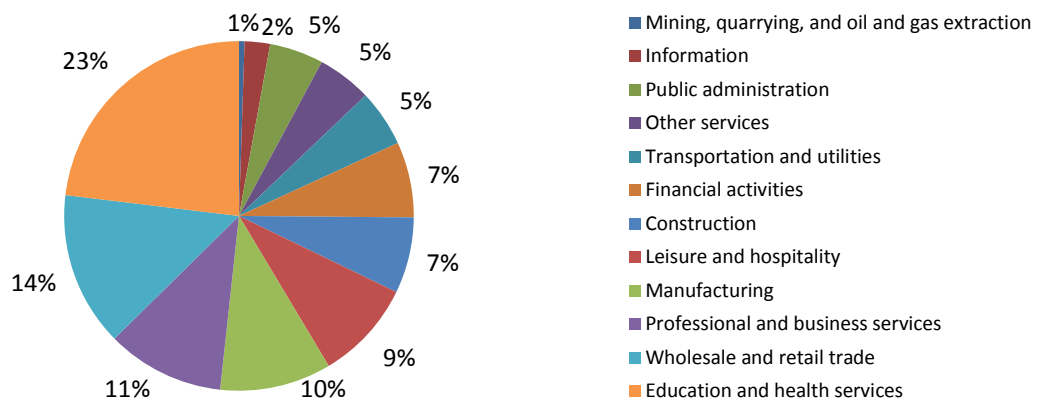
There are two major sources for employment data on the construction industry: the Current Population Survey and the Current Employment Statistics.<sup>23</sup> Both of these are available through the Bureau of Labor Statistics. The Current Population Survey is a monthly household survey of a sample of the population conducted by the Census Bureau for the Bureau of Labor Statistics. It is designed to represent the civilian noninstitutional population 16 years of age and older in the U.S. For this survey, employed persons are those who “(1) did any work at all as paid employees, worked in their own business or profession or on their own farm, or worked 15 hours or more as unpaid workers in a family-operated enterprise; and (2) all those who did not work but had jobs or businesses from which they were temporarily absent.”<sup>24</sup> Due to changes in data collection, only construction data from 2003 to the present can be compared. As seen in the pie chart in Figure 2.4-1, private industries represented 78 % of construction industry employment in 2009. Government employees represented 5 % and self-employed workers are 18 % of construction industry employment. Unpaid family workers, which were less than 1 %, were too small to be seen in the figure. Employment trended upwards from 2003 to 2007, but declined in 2008 and 2009 as seen in the stacked area graph in Figure 2.4-1. Total construction employment represents 7 % of all industries as seen in Figure 2.4-2. This figure is consistent with the values from the Economic Census.



**Figure 2.4-1: Construction Employment (1000's), Current Population Survey**

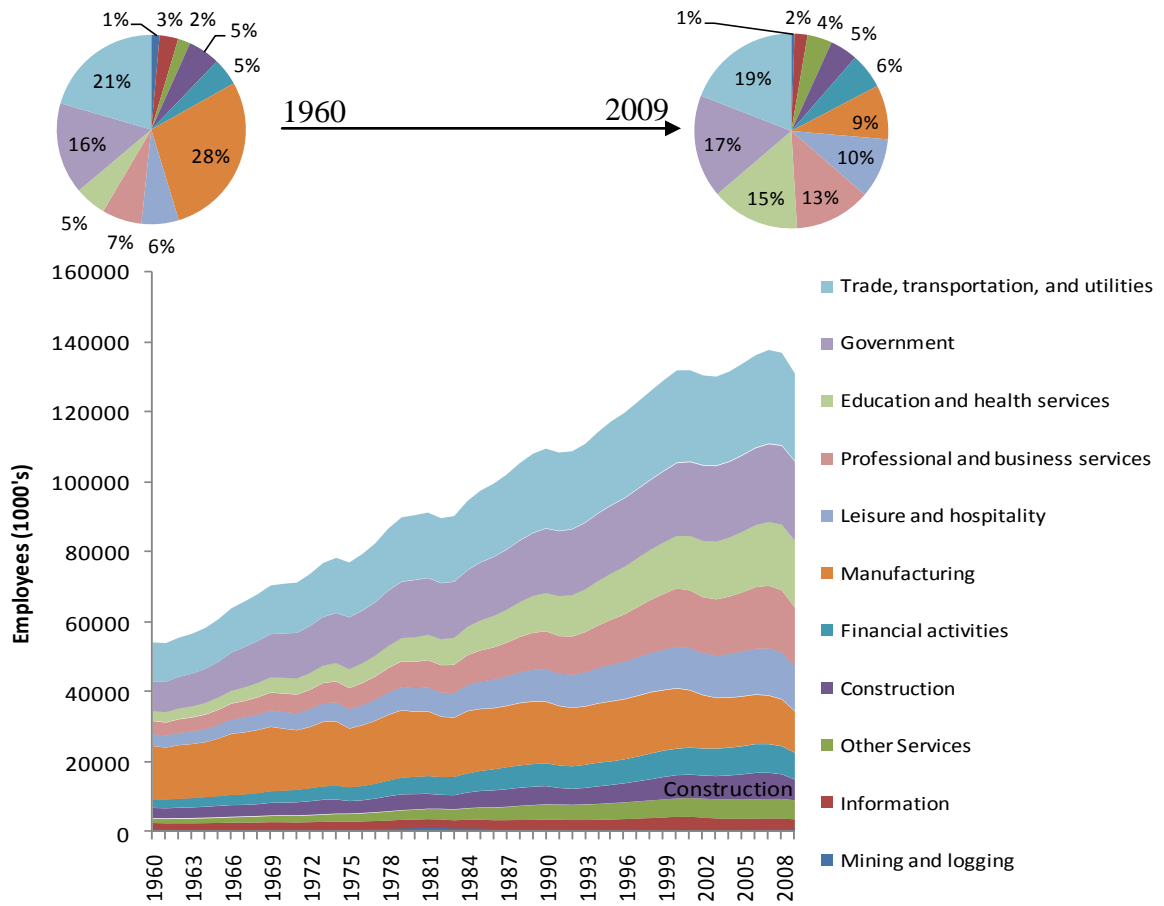
<sup>23</sup> Bureau of Labor Statistics. <[www.bls.gov](http://www.bls.gov)>

<sup>24</sup> Bureau of Labor Statistics. “Labor Force Statistics from the Current Population Survey.” <[http://www.bls.gov/cps/cps\\_over.htm#methodology](http://www.bls.gov/cps/cps_over.htm#methodology)>



**Figure 2.4-2: 2009 Employment by Industry, Current Population Survey**

The other major source for employment data, the Current Employment Statistics (CES), is based on a survey of 140 000 businesses and government agencies in the U.S. The CES is also known as the establishment survey or payroll survey. Since this data is an estimate of nonfarm wage and salary jobs and not an estimate of employed persons, an individual that holds two jobs would be represented twice in this survey. Agriculture employees, private households, and self-employed individuals are excluded. In contrast to the Current Population Survey, construction data available from the Current Employment Statistics spans from 1960 to the present. In 1960, the earliest data available, almost 3 million of the 54 million nonfarm wage and salary jobs in the U.S. were construction jobs. This equates to approximately 5 %, as seen in the 1960 pie graph in Figure 2.4-3. In 2009, 6 million of the 131 million jobs are construction jobs and remains to be approximately 5 % of all jobs as seen in the 2009 pie graph in the same figure. Meanwhile, other industries shifted dramatically. For example, manufacturing went from 28 % of all jobs in 1960 to 9 % in 2009 and education and health services went from 5 % in 1960 to 15 % in 2009. Most of the job data used to create Figure 2.4-3 can be examined in Table 2.4-1.



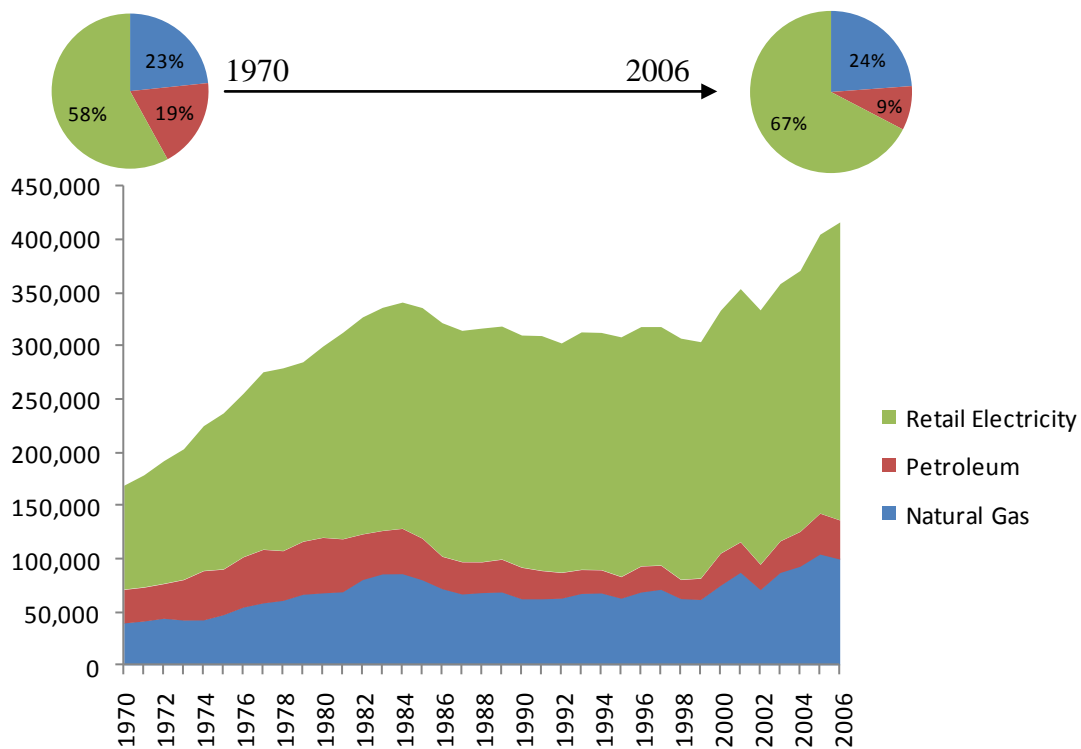
**Figure 2.4-3: Nonfarm Wage and Salary Jobs by Industry 1960-2009, Current Employment Statistics**

**Table 2.4-1: Employment, Current Employment Statistics (1000's)**

Year	Total	Mining and logging	Information	Other Services	Construction	Financial activities	Manufacturing	Leisure and hospitality	Professional and business services	Education and health services	Government	Trade, transportation, and utilities
1979	89,932	1,008	2,375	2,637	4,562	4,843	19,426	6,631	7,312	6,767	16,068	18,303
1980	90,528	1,077	2,361	2,755	4,454	5,025	18,733	6,721	7,544	7,072	16,375	18,413
1981	91,289	1,180	2,382	2,865	4,304	5,163	18,634	6,840	7,782	7,357	16,180	18,604
1982	89,677	1,163	2,317	2,924	4,024	5,209	17,363	6,874	7,848	7,515	15,982	18,457
1983	90,280	997	2,253	3,021	4,065	5,334	17,048	7,078	8,039	7,766	16,011	18,668
1984	94,530	1,014	2,398	3,186	4,501	5,553	17,920	7,489	8,464	8,193	16,159	19,653
1985	97,511	974	2,437	3,366	4,793	5,815	17,819	7,869	8,871	8,657	16,533	20,379
1986	99,474	829	2,445	3,523	4,937	6,128	17,552	8,156	9,211	9,061	16,838	20,795
1987	102,088	771	2,507	3,699	5,090	6,385	17,609	8,446	9,608	9,515	17,156	21,302
1988	105,345	770	2,585	3,907	5,233	6,500	17,906	8,778	10,090	10,063	17,540	21,974
1989	108,014	750	2,622	4,116	5,309	6,562	17,985	9,062	10,555	10,616	17,927	22,510
1990	109,487	765	2,688	4,261	5,263	6,614	17,695	9,288	10,848	10,984	18,415	22,666
1991	108,375	739	2,677	4,249	4,780	6,558	17,068	9,256	10,714	11,506	18,545	22,281
1992	108,726	689	2,641	4,240	4,608	6,540	16,799	9,437	10,970	11,891	18,787	22,125
1993	110,844	666	2,668	4,350	4,779	6,709	16,774	9,732	11,495	12,303	18,989	22,378
1994	114,291	659	2,738	4,428	5,095	6,867	17,020	10,100	12,174	12,807	19,275	23,128
1995	117,298	641	2,843	4,572	5,274	6,827	17,241	10,501	12,844	13,289	19,432	23,834
1996	119,708	637	2,940	4,690	5,536	6,969	17,237	10,777	13,462	13,683	19,539	24,239
1997	122,776	654	3,084	4,825	5,813	7,178	17,419	11,018	14,335	14,087	19,664	24,700
1998	125,930	645	3,218	4,976	6,149	7,462	17,560	11,232	15,147	14,446	19,909	25,186
1999	128,993	598	3,419	5,087	6,545	7,648	17,322	11,543	15,957	14,798	20,307	25,771
2000	131,785	599	3,630	5,168	6,787	7,687	17,263	11,862	16,666	15,109	20,790	26,225
2001	131,826	606	3,629	5,258	6,826	7,808	16,441	12,036	16,476	15,645	21,118	25,983
2002	130,341	583	3,395	5,372	6,716	7,847	15,259	11,986	15,976	16,199	21,513	25,497
2003	129,999	572	3,188	5,401	6,735	7,977	14,510	12,173	15,987	16,588	21,583	25,287
2004	131,435	591	3,118	5,409	6,976	8,031	14,315	12,493	16,394	16,953	21,621	25,533
2005	133,703	628	3,061	5,395	7,336	8,153	14,226	12,816	16,954	17,372	21,804	25,959
2006	136,086	684	3,038	5,438	7,691	8,328	14,155	13,110	17,566	17,826	21,974	26,276
2007	137,598	724	3,032	5,494	7,630	8,301	13,879	13,427	17,942	18,322	22,218	26,630
2008	136,790	767	2,984	5,515	7,162	8,145	13,406	13,436	17,735	18,838	22,509	26,293
2009	130,920	700	2,807	5,364	6,037	7,758	11,883	13,102	16,580	19,191	22,549	24,949

## 2.5 Annual Energy Review

The Annual Energy Review from the Energy Information Administration is a report that provides over 400 pages of energy statistics. Publication of the report is required under the Department of Energy Organization Act. In this report, the data will be used to calculate residential and commercial energy expenditures. The data is collected from the State Energy Data System (SEDS),<sup>25</sup> which originates from a number of sources. Some data is collected from other federal agencies such as the Department of Transportation while other data is collected from state and local agencies. The energy statistics from the Annual Energy Review go as far back as 1970. As seen in Figure 2.5-1, energy expenditures trended upwards from 1970 into the early 1980's and then hit a plateau somewhat until the late 1990's. Much of the increase in expenditure is due to increases in retail electricity expenditure, which was 58 % of energy expenditures in 1970 and increased to 67 % of energy expenditures in 2009. The source data for Figure 2.5-1 can be seen in Table 2.5-1. Using data from this table, energy expenditures expressed in \$2009 have increased 145 % between 1970 and 2006.



**Figure 2.5-1: Energy Expenditures by Energy Source and Energy use (\$2009 million)**

<sup>25</sup> Energy Information Administration. "Technical Notes and Documentation."  
<[http://www.eia.doe.gov/emeu/states/\\_seds\\_tech\\_notes.html](http://www.eia.doe.gov/emeu/states/_seds_tech_notes.html)>

**Table 2.5-1: Consumer Expenditure Estimates (\$2009 million)**

Year	Residential				Commercial				TOTAL
	Natural Gas	Petroleum	Retail Electricity	Total	Natural Gas	Petroleum	Retail Electricity	Total	
1970	29,150	23,699	57,239	111,764	10,196	7,691	40,469	58,765	170,529
1971	30,205	23,657	61,389	116,713	10,912	8,068	43,972	63,408	180,121
1972	31,939	24,282	66,897	124,221	11,748	8,207	48,466	68,826	193,047
1973	30,354	28,784	71,087	131,124	11,698	9,089	51,735	72,933	204,057
1974	30,240	32,167	77,999	141,703	11,928	13,947	58,195	84,831	226,535
1975	33,536	30,235	82,322	147,273	13,498	12,493	64,429	91,194	238,467
1976	37,674	33,395	85,291	157,547	16,511	13,717	68,426	99,332	256,879
1977	40,089	34,949	92,513	168,847	18,034	15,212	74,426	108,370	277,216
1978	41,344	32,661	95,650	170,935	19,124	13,919	76,226	110,042	280,978
1979	43,652	33,321	93,625	172,182	22,526	16,353	75,156	114,712	286,894
1980	44,826	33,053	100,129	180,008	22,709	18,920	79,699	121,838	301,846
1981	45,168	31,612	105,687	184,717	23,377	18,003	88,468	130,476	315,192
1982	52,494	27,848	111,259	193,959	27,514	14,909	92,838	135,959	329,918
1983	56,409	24,741	116,139	199,399	28,911	15,922	93,761	139,249	338,648
1984	56,921	25,672	115,171	200,009	28,592	16,769	97,675	143,717	343,726
1985	53,469	25,709	116,982	198,293	26,293	13,301	99,875	140,005	338,299
1986	48,698	20,774	118,966	190,038	22,742	9,531	100,709	133,475	323,512
1987	44,796	20,538	119,578	186,294	21,675	9,590	98,015	129,697	315,991
1988	45,568	20,318	121,129	188,419	22,217	8,442	98,674	129,752	318,171
1989	46,248	22,040	119,800	189,537	22,103	8,647	99,414	130,596	320,132
1990	41,373	20,203	118,805	181,976	20,577	9,305	99,516	129,909	311,885
1991	41,411	18,770	121,017	182,711	20,542	7,673	99,876	128,549	311,260
1992	41,852	17,224	117,511	177,994	20,711	6,834	98,221	126,214	304,208
1993	44,967	16,628	122,953	185,740	22,002	5,795	100,403	128,636	314,376
1994	44,594	16,053	122,399	184,096	22,856	5,569	100,808	129,643	313,739
1995	41,042	15,084	123,331	180,443	21,473	5,121	102,033	129,029	309,472
1996	45,117	18,156	123,749	188,147	23,197	6,178	101,349	131,145	319,292
1997	45,938	17,009	121,242	185,083	24,888	5,571	103,129	134,015	319,099
1998	40,374	13,625	122,878	177,555	21,783	4,241	103,977	130,331	307,886
1999	40,401	15,368	120,380	176,866	20,905	4,559	101,913	127,709	304,574
2000	48,248	22,457	122,355	194,141	26,406	7,626	106,059	140,440	334,581
2001	55,638	21,708	124,964	203,190	31,153	6,864	113,146	151,507	354,697
2002	45,705	18,085	127,403	191,991	24,825	5,654	111,816	142,638	334,629
2003	56,034	22,065	129,712	208,788	30,630	7,537	112,239	150,779	359,566
2004	59,123	24,195	131,263	215,687	33,363	8,452	114,192	156,459	372,146
2005	66,945	27,627	141,040	237,143	36,978	10,682	121,408	169,597	406,740
2006	63,475	26,168	149,603	240,792	35,730	10,477	130,802	177,459	418,251

Source: Energy Information Administration. "Annual Energy Review 2008." Pg 79 Table 3.6.  
<http://www.eia.doe.gov/aer/pdf/aer.pdf>

## 2.6 Annual Survey of Manufactures

The Annual Survey of Manufactures provides statistics on employment, payroll, worker hours, cost of materials, operating expenses, value added, capital expenditures, inventories, and energy use for manufacturing. For this report, it is used solely for the purpose of estimating the value of contents and furnishings within structures. The data from the survey includes estimates for value added, total value of shipments, and value of product shipments.<sup>26</sup> For the purposes of this report, total value of shipments is used since it includes the net selling values of all products shipped as well as all miscellaneous receipts for contract work, installation, and repair. This variable best represents the value of building contents and furnishings. Total value of shipments is defined by the Census Bureau as the following:

<sup>26</sup> Census Bureau. "Annual Survey of Manufactures."  
<http://www.census.gov/manufacturing/asm/index.html>

Total value of shipments – “Includes the received or receivable net selling values, “Free on Board” (FOB) plant (exclusive of freight and taxes), of all products shipped, both primary and secondary, as well as all miscellaneous receipts, such as receipts for contract work performed for others, installation and repair, sales of scrap, and sales of products bought and sold without further processing. Included are all items made by or for the establishments from material owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. The net selling value of products made in one plant on a contract basis from materials owned by another was reported by the plant providing the materials. In the case of multiunit companies, the manufacturer was requested to report the value of products transferred to other establishments of the same company at full economic or commercial value, including not only the direct cost of production but also a reasonable proportion of “all other costs” (including company overhead) and profit (interplant transfers). In addition to the value for the North American Industry Classification System (NAICS) defined products, aggregates of the following categories of miscellaneous receipts are reported as part of a total establishment’s value of product shipments:

1. value of resales — sales of products bought and sold without further manufacture, processing, or assembly;
2. contract receipts — receipts for work or services that a plant performed for others on their materials; and
3. other miscellaneous receipts — includes repair work, installation, sales of scrap, etc.

Total value of shipments is comprised of three components. These components are:

1. primary product value of shipments
2. secondary product value of shipments; and
3. total miscellaneous receipts.”<sup>27</sup>

Relevant subsectors of manufacturing have been selected to represent building contents and furnishings for 2007 and 2008 as seen in Table 2.6-1.

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<sup>27</sup> Census Bureau. “Annual Survey of Manufactures.” Definitions.  
<<http://www.census.gov/manufacturing/asm/definitions/index.html>>



**Table 2.6-1: Annual Survey of manufactures (\$2009)**

NAICS-based code	Meaning of NAICS-based code	Year	Number of employees	Total value of shipments (\$1,000)
334310	Audio and video equipment manufacturing	2007	16,213	7,832,216
314110	Carpet and rug mills	2007	38,114	13,677,694
31412	Curtain and linen mills	2007	37,238	5,735,187
337	Furniture & related product mfg	2007	515,764	88,501,968
335224	Household laundry equipment manufacturing	2007	11,087	4,604,955
335222	Household refrigerator and home freezer manufacturing	2007	13,971	5,955,856
33512	Lighting fixture manufacturing	2007	49,079	12,146,416
335221	Household cooking appliance manufacturing	2007	11,516	4,952,874
33521	Small electrical appliance manufacturing	2007	13,502	4,205,663
<b>TOTAL</b>		<b>2007</b>	<b>706,484</b>	<b>147,612,829</b>
334310	Audio and video equipment manufacturing	2008	14,476	5,817,238
314110	Carpet and rug mills	2008	39,622	11,709,553
31412	Curtain and linen mills	2008	31,230	4,594,306
337	Furniture & related product mfg	2008	459,835	80,179,802
335224	Household laundry equipment manufacturing	2008	9,579	4,046,080
335222	Household refrigerator and home freezer manufacturing	2008	12,310	4,550,990
33512	Lighting fixture manufacturing	2008	46,026	11,651,712
335221	Household cooking appliance manufacturing	2008	11,113	4,441,951
33521	Small electrical appliance manufacturing	2008	12,809	4,115,161
<b>TOTAL</b>		<b>2008</b>	<b>637,000</b>	<b>131,106,792</b>

## 2.7 Service Annual Survey

The Service Annual Survey provides annual revenues and expenses of selected service sector establishments. The data includes nine industries. For the purpose of this report, we use selected subsectors of the “administrative and support and waste management and remediation services” industry (NAICS 56) for estimates on building services. The selected subsectors to represent building services are listed in Table 2.7-1.<sup>28, 29</sup>

**Table 2.7-1: Service Annual Survey, Revenue (\$2009 million)**

NAICS	Kind of Business	2001	2002	2003	2004	2005	2006	2007	2008
561621	Security systems services (except locksmiths)	11,829	12,631	11,644	11,911	12,175	11,664	12,196	12,657
56171	Exterminating and pest control services	7,349	7,867	8,402	8,714	8,946	9,083	9,088	8,985
56172	Janitorial services	31,763	32,209	34,166	34,399	34,870	34,885	37,768	38,400
56174	Carpet and upholstery cleaning services	3,078	3,243	3,274	3,366	3,732	3,850	4,026	4,065
56179	Other services to buildings and dwellings	4,046	4,554	5,107	5,341	5,949	6,694	7,451	7,858
<b>TOTAL</b>		<b>58,066</b>	<b>60,504</b>	<b>62,594</b>	<b>63,732</b>	<b>65,672</b>	<b>66,176</b>	<b>70,528</b>	<b>71,965</b>

<sup>28</sup> Census Bureau. “Annual and Quarterly Services.” <<http://www.census.gov/services/index.html>>

<sup>29</sup> Census Bureau. “Service Annual Survey 2008.” Current Business Reports. January 2010.  
<<http://www2.census.gov/services/sas/data/Historical/sas-08.pdf>>

## 2.8 Loss Estimation

Annual estimates of constructed facility losses due to natural and manmade hazards are limited; however, some data does exist. In regards to losses related to weather, NOAA Storm Data provides annual loss summaries of general property for a number of weather phenomena for 1998 through 2005.<sup>30</sup> NOAA receives this data from the National Weather Service who gathers it from various sources, which include but are not limited to the following: federal, state, and local emergency management officials; law enforcement; SKYWARN spotters; damage surveys; newspapers; insurance companies; and the general public. Since some weather events generally do not affect constructed facilities (e.g., dust storm, fog, and rip currents), we have selected the relevant events and adjusted the values to 2009 as shown in Table 2.8-1.

**Table 2.8-1: 2005 Storm Data (\$2009 million)**

Weather Event	2005	2004	2003	2002	2001	2000	1999	1998	AVERAGE
Tornado	463.3	610.0	1,475.6	955.6	763.3	527.7	2,562.5	2,256.2	1,201.8
Tstm Wind	438.0	190.0	414.8	345.6	385.0	305.5	403.7	1,889.6	546.5
Hail	527.8	525.8	609.2	387.8	2,868.9	555.7	570.5	1,774.7	977.6
Flash Flood	322.1	973.0	2,476.4	393.1	1,037.8	978.9	1,547.6	1,196.5	1,115.7
River Flood	1,367.1	953.4	488.2	385.0	1,044.2	582.4	276.5	1,843.8	867.6
Coastal Storm	2.4	0.6	13.3	0.4	21.4	0.5	0.9	154.4	24.2
Tropical Storm/Hurricane	102,231.2	21,467.1	2,191.4	1,317.0	6,284.4	10.1	5,395.7	4,668.0	17,945.6
Winter Storm	322.7	208.4	582.3	896.8	125.5	1,289.8	79.7	692.2	524.7
High Wind	64.3	3,762.4	193.8	98.9	77.3	60.9	111.6	83.8	556.6
TOTAL	105,738.9	28,690.7	8,445.1	4,780.0	12,607.9	4,311.5	10,948.7	14,559.3	23,760.3

Fire loss estimates are available from the NFPA on an annual basis starting in 1977 as seen in Table 2.8-2. In 2008, there was approximately \$ 12.361 billion in losses in structure fires with \$ 8.550 billion being residential properties.<sup>31</sup> These estimates are calculated using data from the National Fire Incident Reporting System (NFIRS), a voluntary reporting system for fire departments. The NFIRS data is combined with an NFPA survey to produce national estimates. Earthquake damage to the built environment has been extensively researched by FEMA. Their latest research, from 2008, estimates that \$ 5.3 billion of damage is caused to the national building stock annually.<sup>32</sup> After adjusting all data to 2009 dollars, averaging the last five years of NFPA fire losses (\$ 10.6 billion), averaging the last five years of storm data (\$ 32.1 billion), and adding the FEMA earthquake estimates (\$ 5.3 billion), the average losses are \$ 47.9 billion. This estimate includes direct property damage. Losses due to lives lost, disruption of

<sup>30</sup> National Oceanic and Atmospheric Administration. Storm Data.

<<http://www.ncdc.noaa.gov/oa/climate/sd/>>

<sup>31</sup> Karter, Michael J. Fire Loss in the United States 2008. August 2009. National Fire Protection Association. <<http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf>>

<sup>32</sup> FEMA. HAZUS MH, Estimated Annualized Earthquake Losses for the United States. FEMA 366. April 2008. <<http://www.fema.gov/library/viewRecord.do?id=3265>>

commerce, and the cost of mobilizing emergency equipment is not included. The National Science and Technology Council has estimated that annual losses due to lives lost, disruption of commerce, mobilizing emergency equipment, and properties destroyed is \$ 57 billion after adjusting to 2009 dollars.<sup>33, 34</sup>

**Table 2.8-2: Structure Fire Losses**

<b>Year</b>	<b>Fires</b>	<b>Civilian Deaths</b>	<b>Civilian Injuries</b>	<b>Damage (\$2009 billion)</b>
1977	1,098,000	6,505	26,310	14.5
1978	1,062,000	6,350	24,985	13.2
1979	1,036,500	5,970	24,850	14.8
1980	1,065,000	5,675	24,725	14.3
1981	1,027,500	5,760	25,700	14.2
1982	946,500	5,200	25,575	12.7
1983	868,500	5,090	26,150	12.5
1984	848,000	4,525	23,025	12.2
1985	859,500	5,265	23,350	12.8
1986	800,000	4,985	22,750	11.4
1987	758,000	4,880	23,815	11.7
1988	745,000	5,280	26,275	13.1
1989	688,000	4,655	24,025	13.0
1990	624,000	4,400	24,075	11.0
1991	640,500	3,765	24,975	13.1
1992	637,500	3,940	24,325	10.7
1993	621,500	3,980	26,550	11.0
1994	614,000	3,590	23,125	10.0
1995	573,500	3,985	21,725	10.7
1996	578,500	4,220	21,875	10.8
1997	552,000	3,510	20,375	9.5
1998	517,500	3,420	19,425	8.8
1999	523,000	3,040	18,525	10.9
2000	505,500	3,535	19,600	10.6
2001	521,500	3,220	17,225	10.8
2002	519,000	2,775	15,600	10.4
2003	519,500	3,385	15,600	10.1
2004	526,000	3,305	15,525	9.4
2005	511,000	3,105	15,325	10.1
2006	524,000	2,705	14,350	10.2
2007	530,500	3,000	15,350	11.0
2008	515,000	2,900	14,960	12.4
<b>AVERAGE</b>	<b>847,500</b>	<b>3,103</b>	<b>20,084</b>	<b>11.6</b>

<sup>33</sup> Damages were originally quoted as \$ 52 billion in 2005 dollars.

<sup>34</sup> National Science and Technology Council. June 2005. "Grand Challenges for Disaster Reduction." <<http://www.sdr.gov/SDRGrandChallengesforDisasterReduction.pdf>>



### 3 Construction Statistics Methodology: Subsectors of Construction

This chapter provides a method for estimating annual values of construction industry components. These components represent significant sub sectors of the industry and are important in understanding the industry as a whole. New construction is discussed first, followed by additions, alterations, and reconstruction and then maintenance and repair. Other components are discussed in Chapter 4.

#### 3.1 New Construction

As described in Section 2.2, new construction includes original construction work done on a project. It includes all finishing work on the original structure, land development, and demolition of existing structures. The value for new construction will be used in the calculation of facility construction in the construction industry supply chain as well as other construction industry components. Construction can be broken into four categories: residential, commercial/institutional, manufacturing, and public works. In order to estimate the value of construction being done in each of these categories, the construction data from the C30 report can be allocated to each of the four categories. Table 3.1-1 shows the four categories and their corresponding values from the C30 report. The sum of public and private values listed for each category is the total construction put in place for that category. Residential construction includes private values of new single family construction, new multi-family construction, and improvements along with total public residential construction from the C30 Report.

**Table 3.1-1: Construction Put in Place by Category**

Category	Private Values	Public Values
Residential	New single family	Total Public Residential
	New multi-family	
	Improvements	
Commercial/Institutional	Lodging	Office Commercial Health care Educational Religious Public safety
	Office	
	Commercial	
	Health care	
	Educational	
	Religious	
	Public safety	
Manufacturing	Amusement and recreation	Amusement and recreation
	Manufacturing	
	Transportation	
Public Works	Communication	Power Sew age and waste disposal Water supply Highway and street Conservation and development
	Power	
	Sew age and waste disposal	
	Water supply	

Conveniently, new construction is easily categorized for residential construction as new single family, new multi-family, and public residential construction. New construction for commercial/institutional, manufacturing, and public works construction must be

broken out using another method. For the purpose of this paper, NAICS codes from the Economic Census included in residential, commercial/institutional, manufacturing, and public works construction include the total of the subsectors marked for each category in Table 3.1-2. These will be used to calculate scaling ratios. Value of construction work from the Economic Census is closely related to construction put in place from the C30 report, except, that value of construction work includes maintenance and repair while construction put in place does not. Using the Economic Census, a scaling ratio can be calculated to apply to the C30 data providing an estimate of new construction.

**Table 3.1-2: NAICS Codes from the Economic Census for Each Construction Category**

	Residential	Commercial/ Institutional	Manufacturing	Public Works
236115 new single fam	✓			
236116 new multifam	✓			
236117 new housing operative	✓			
236118 residential remodelers	✓			
236210 industrial building construction			✓	
236220 commercial/institute		✓		
237110 water/sewer				✓
237120 oil and gas				✓
237130 power and communication				✓
237210 land subdivision				✓
237310 highway, street, bridge				✓
237990 other heavy and civil				✓
238110 poured concrete foundation	✓	✓	✓	✓
238120 structural steel and precast concrete	✓	✓	✓	✓
238130 framing	✓	✓	✓	
238140 masonry	✓	✓	✓	✓
238150 glass and glazing	✓	✓	✓	
238160 roofing	✓	✓	✓	
238170 siding	✓	✓	✓	
238190 other foundation structure, and building	✓	✓	✓	
238210 electrical	✓	✓	✓	
238220 plumbing, heating, and air cond	✓	✓	✓	
238290 other building equipment	✓	✓	✓	
238310 drywall and insulation	✓	✓	✓	
238320 painting and wall covering	✓	✓	✓	
238330 flooring	✓	✓	✓	
238340 tile and terrazzo	✓	✓	✓	
238350 finish carpentry	✓	✓	✓	
238390 other building finishing	✓	✓	✓	
238910 site preparation	✓	✓	✓	✓
238990 all other specialty trade	✓	✓	✓	✓

The scaling ratio can be calculated with the total of new construction from the Economic Census in the numerator and the value of construction work less total maintenance and repair in the denominator. This calculation can be made for each category of nonresidential construction (i.e., commercial/institutional, manufacturing, and public works) using a separate ratio. The scaling ratio is represented in the following equation:

**Equation 3.1-1: Scaling Ratio for New Nonresidential Construction**

$$SR_{NC,x,t} = \frac{NC_{x,t}}{VC_{x,t} - MR_{x,t}}$$

Where:

$SR_{NC,x,t}$  = Scaling ratio for construction category x, where x is either commercial/institutional, manufacturing, or public works construction at time t

$NC_{x,t}$  = The sum of new construction for construction category x, where x is either commercial/institutional, manufacturing, or public works construction from the Economic Census at time t

$VC_{x,t}$  = The sum of the value of construction work for construction category x, where x is either commercial/institutional, manufacturing, or public works construction from the Economic Census at time t

$MR_{x,t}$  = The sum of maintenance and repair for construction category x, where x is either commercial/institutional, manufacturing, or public works construction from the Economic Census at time t

The scaling ratio ( $SR_{NC, x, t}$ ) can then be multiplied by each of the categories from the C30 report to get values for new construction for commercial/institutional, manufacturing, and public works construction. This can be represented as the following:

**Equation 3.1-2: New Nonresidential Construction**

$$NC_{x,t+n} = SR_{NC,x,t} * CP_{x,t+n}$$

Where:

$NC_{x,t+n}$  = New construction for time t plus n for category x, where x is either commercial/institutional, manufacturing, or public works construction

$SR_{NC, x, t}$  = Scaling ratio for time t for new construction in Equation 3.1-1

$CP_{x,t+n}$  = Construction put in place for time t plus n for category x, where x is either commercial/institutional, manufacturing, or public works construction

The sum of new construction for commercial/institutional, manufacturing, and public works construction added to residential new construction is total new construction. It is represented as the following:

**Equation 3.1-3: Total New Construction**

$$NC_{Tot,t+n} = NC_{CI,t+n} + NC_{M,t+n} + NC_{PW,t+n} + NC_{R,t+n}$$

Where:

$NC_{Tot, t+n}$  = Total new construction for time t plus n

$NC_{x,t+n}$  = New construction for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction from Equation 3.1-2 or residential new construction (R) described in Section 3.1

## 3.2 Additions, Alterations, and Reconstruction

Additions, alterations, and reconstruction include construction work that adds to the value or useful life of an existing building or structure or which adapts a building or structure to a new or different use. The replacement of a heating and cooling system, roof, or the resurfacing of a road would be included. Additions, alterations, and reconstruction can be calculated in a similar fashion to that of new construction from the previous section. The value of residential additions, alterations, and reconstruction is equal to the value for residential improvements from Table 3.1-1. The remaining three categories are calculated using a scaling ratio similar to the one in Equation 3.1-1, except, instead of nonresidential new construction being in the numerator, nonresidential additions, alterations, and reconstruction is in the numerator:

**Equation 3.2-1: AAR Scaling Ratio**

$$SR_{AAR,x,t} = \frac{AAR_{x,t}}{VC_{x,t} - MR_{x,t}}$$

Where:

$SR_{AAR, x, t}$  = Scaling ratio for additions, alterations, and repair for construction category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction for time t

$AAR_{x, t}$  = The sum of additions, alterations, and repair for construction category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction from the Economic Census at time t

$VC_{x, t}$  = The sum of the value of construction work for construction category x, where x is either commercial/institutional, manufacturing, or public works construction from the Economic Census at time t

$MR_{x, t}$  = The sum of maintenance and repair for construction category x, where x is either commercial/institutional, manufacturing, or public works construction from the Economic Census at time t

The scaling ratio ( $SR_{AAR}$ ) can then be multiplied by each of the nonresidential categories of construction put in place from the C30 report. This will provide values for additions, alterations, and reconstruction for commercial/institutional, manufacturing, and public works construction. This can be represented as the following:

**Equation 3.2-2: Nonresidential Additions, Alterations, and Reconstruction**

$$AAR_{x,t+n} = SR_{AAR,x,t} * CP_{x,t+n}$$



Where:

$AAR_{x,t+n}$  = Additions, alterations, and reconstruction for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction

$SR_{AAR,x,t}$  = Scaling ratio for additions, alterations, and repair for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction for time t in Equation 3.2-1

$CP_{x,t+n}$  = Construction put in place from the C30 report for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction

The sum of additions, alterations, and reconstruction for commercial/institutional, manufacturing, and public works construction added to residential additions, alterations, and reconstruction equals the total. It is represented as the following:

**Equation 3.2-3: Total AAR**

$$AAR_{Tot,t+n} = AAR_{CI,t+n} + AAR_{M,t+n} + AAR_{PW,t+n} + AAR_{R,t+n}$$

Where:

$AAR_{Tot,t+n}$  = Total additions, alterations, and reconstruction for time t plus n

$AAR_{x,t+n}$  = Additions, alterations, and reconstruction for year t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction from Equation 3.2-2, or additions, alterations, and reconstruction for residential (R) construction described above

### 3.3 Maintenance and Repair

Maintenance and repair is the incidental construction work that is done to maintain a property. It does not include snow and trash removal or lawn maintenance, landscaping, cleaning, or janitorial services. The Economic Census provides an estimate of maintenance and repair that can be scaled using new construction from the Economic Census. It is important to remember that maintenance and repair is not part of construction put in place from the C30 report; that is, maintenance and repair is excluded. Maintenance and repair is calculated similarly to that of new construction. A scaling ratio can be calculated with maintenance and repair from the Economic Census in the numerator and new construction in the denominator. This ratio can be used to estimate maintenance and repair. Four ratios are calculated, one for each category of construction. The sum of the calculations is the total maintenance and repair. It can be represented as the following:

**Equation 3.3-1: Total Maintenance and Repair**

$$MR_{t+n} = \sum \left( \frac{MR_{x,t}}{NC_{x,t}} * NC_{x,t+n} \right)$$

Where:

$MR_{t+n}$  = Total maintenance and repair for time t plus n

$NC_{x,t}$  = The sum of new construction for time t for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction or residential (R) new construction described in Section 3.1

$NC_{x,t+n}$  = New construction for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction from Equation 3.1-2 or residential (R) new construction described in Section 3.1

$MR_{x,t}$  = The sum of maintenance and repair for time t for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW) or residential (R) construction from the Economic Census

## 4 Construction Statistics Methodology: Industry Supply Chain

This chapter provides values for the construction industry supply chain. First it develops estimates for facility design followed by materials, components, supplies, and fuels; demolition; facility construction; commissioning; maintenance and repair; renovation; contents and furnishings; services to buildings; and water and energy. Some estimates differ from those in Section 3 in that they separate facility design and materials, components, supplies, and fuels from other types of construction work. For example, the value for maintenance and repair in Chapter 3 includes materials, components, supplies, and fuels whereas in Chapter 4 materials, components, supplies, and fuels is excluded from maintenance and repair to avoid double counting.

### 4.1 Facility Design

Facility design is the value of services rendered to design construction projects. Unfortunately, there is no annual data available on the design of construction projects. However, there are values for architectural services, engineering services, and surveying services in the Economic Census. It has been estimated that one half of engineering services is dedicated to construction. Annual values for facility design can be estimated by using a ratio to construction put in place. Facility design can be represented as the following:

**Equation 4.1-1: Facility Design**

$$FD_{t+n} = \frac{AS_t + SS_t + \frac{1}{2} * ES_t}{CP_t} * CP_{Tot,t+n}$$

Where:

$FD_{t+n}$  = Facility design for time t plus n

$AS_t$  = Architectural services at time t from the Economic Census

$SS_t$  = Surveying and mapping services from the Economic Census at time t

$ES_t$  = Engineering services from the Economic Census at time t

$CP_{Tot, t+n}$  = Total construction put in place from the C30 report for time t plus n

$CP_{t, t+n}$  = Total construction put in place from the C30 report for time t

The value for facility design includes materials, components, supplies, and fuels. Unfortunately, data does not exist on materials, components, supplies, and fuels for facility design but it is assumed that it is approximately 2 % of the total.<sup>35</sup> Thus, facility design for the supply chain is 98% of  $FD_{t+n}$ .

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<sup>35</sup> This assumption is based on consultation with construction industry experts.

## 4.2 Materials, Components, Supplies, and Fuels

Materials, components, supplies, and fuels (MCSF) include the costs for items used by establishments in the construction or reconstruction of buildings, structures, or other facilities. It is the sum of the cost of materials, components, and supplies from Table 2.2-2 and the total cost of selected power, fuels, and lubricants from Table 2.2-2. In the construction industry supply chain, materials, components, supplies, and fuels needs to be broken out for new construction; additions, alterations, and reconstruction; maintenance and repair; and facility design. Unfortunately, data does not exist on materials, components, supplies, and fuels for facility design but industry experts estimate that it is approximately 2 % of the total. This is the best estimate available. Using data from the Economic Census, a scaling ratio can be used to estimate values for the years that the Economic Census is not published. A scaling ratio for materials, components, supplies, and fuels can be computed for residential and nonresidential construction and then applied to the value of construction. The ratios can be represented in the following equation:

**Equation 4.2-1: Scaling Ratio for Materials, Components, Supplies, and Fuels**

$$SR_{M,x,t} = \frac{M_{x,t} + F_{x,t}}{VC_{x,t}}$$

Where:

$SR_{M,x,t}$  = Scaling ratio for materials, components, supplies, and fuels for time t for construction category x, where x is either commercial/institutional (CI), Manufacturing (M), public works (PW) or residential (R) construction

$M_{x,t}$  = Materials, components, and supplies at time t for construction category x, where x is either commercial/institutional (CI), Manufacturing (M), public works (PW) or residential (R) construction

$F_{x,t}$  = Cost of selected power, fuels, and lubricants at time t for construction category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW) or residential (R) construction

$VC_{x,t}$  = Value of construction for time t for construction category x, where x is either commercial/institutional (CI), Manufacturing (M), public works (PW) or residential (R) construction

The ratios calculated above can then be used to estimate materials, components, supplies and fuels for residential and nonresidential construction. Each construction category is multiplied by its corresponding ratio. The sum of these is the total materials, components, supplies, and fuels for both construction put in place and maintenance and repair. These calculations can be represented as the following:

**Equation 4.2-2: Total Materials, Components, Supplies, and Fuels**

$$M_{t+n} = \sum \left( SR_{M,x,t} * (CP_{x,t+n} + MR_{x,t+n}) \right)$$

Where:

$M_{t+n}$  = Total materials, components, supplies, and fuels for time t plus n

$SR_{M, x, t}$  = Scaling ratio for materials, components, supplies, and fuels for time t for construction category x, where x is either commercial/institutional (CI), Manufacturing (M), public works (PW), or residential (R) construction

$CP_{x, t+n}$  = Construction put in place for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R)

$MR_{x, t+n}$  = Maintenance and repair for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R)

### 4.3 Demolition

Demolition is the wrecking and demolition of buildings and other structures. Demolition is found in the Economic Census; however, it is only broken out in earlier editions. The 2007 Economic Census does not break demolition into its own category; however, the 2002 version does have it broken out. A scaling ratio can be generated using the 2002 value. This ratio should exclude materials, components, supplies, and fuels since these are included in the total calculation of materials, components, supplies, and fuels. The ratio can be multiplied by construction put in place excluding materials, components, supplies, and fuels to get an estimate for demolition in other years. Demolition can be represented as the following:

**Equation 4.3-1: Total Demolition**

$$D_{t+n} = \frac{D_t - MC_{D,t} - F_{D,t}}{VC_t - MC_t - F_t} * (NC_{Tot,t+n} + AAR_{Tot,t+n} + MR_{t+n} - M_{t+n})$$

$D_{t+n}$  = Demolition at time t plus n

$D_t$  = Demolition at time t from the Economic Census

$VC_t$  = Total value of construction work from the Economic Census at time t

$MC_{D,t}$  = Total materials, components, and supplies for demolition from the Economic Census at time t

$F_{D,t}$  = Selected power, fuels, and lubricants for demolition from the Economic Census at time t

$MC_t$  = Total materials, components, and supplies from the Economic Census at time t

$F_t$  = Selected power, fuels, and lubricants from the Economic Census at time t

$NC_{Tot, t+n}$  = Total new construction for time t plus n from Equation 3.1-3

$AAR_{Tot, t+n}$  = Total AAR for time t plus n from Equation 3.2-3

$MR_{t+n}$  = Maintenance and repair for time t+n from Equation 3.3-1

$M_{t+n}$  = Total materials, components, supplies, and fuels for time t plus n from Equation 4.2-2

## 4.4 Facility Construction

Values for facility construction capture new construction work done but exclude design costs and materials, components, supplies, and fuels. The values can be calculated as new construction minus facility design for new construction; minus materials, components, supplies, and fuels for new construction; and minus demolition. Materials, components, supplies, and fuels for each category of construction for new construction is represented in the first set of brackets in Equation 4.4-1. The second set of brackets is materials, components, supplies, and fuels used for the facility design of new construction. This value is subtracted because it is included in facility design for new construction in Equation 4.4-2. It is estimated that 2 % of facility design is materials, components, supplies, and fuels; therefore, facility design is multiplied by 0.02 in order to calculate the materials, components, supplies, and fuels used in the facility design of new construction. Materials, components, supplies, and fuels for new construction can be represented as the following:

**Equation 4.4-1: Materials, Components, Supplies, and Fuels for New Construction**

$$MN_{t+n} = \sum (SR_{M,x,t} * NC_{x,t+n}) - (SR_{NC,tot,t} * (0.02 * FD_{t+n}))$$

Where:

$MN_{t+n}$  = Materials, components, supplies, and fuels for new construction for time t plus n

$SR_{M,x,t}$  = Scaling ratio for materials, components, supplies, and fuels for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R) from Equation 4.2-1

$NC_{x,t+n}$  = Construction put in place for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) construction from Equation 3.1-2, or residential construction (R) from Section 3.1

$SR_{NC,tot,t}$  = Scaling ratio for total new construction from Equation 3.1-1

$FD_{t+n}$  = Facility design for time t plus n from Equation 4.1-1

Facility design for new construction can be calculated as a ratio for new construction from the Economic Census multiplied by facility design for time t plus n. It is assumed that facility design applies to new construction and additions, alterations, and reconstruction while maintenance and repair does not include values of facility design. The calculation for facility design for new construction can be represented as the following:

**Equation 4.4-2: Facility Design for New Construction**

$$FNC_{t+n} = \frac{NC_t}{VC_t - MR_t} * FD_{t+n}$$

Where:

$FNC_{t+n}$  = Facility design for new construction at time t plus n

$NC_t$  = Total new construction from the Economic Census for time  $t$   
 $VC_t$  = Total value of construction work from the Economic Census at time  $t$   
 $MR_t$  = Total maintenance and repair from the Economic Census at time  $t$   
 $FD_{t+n}$  = Facility design for time  $t$  plus  $n$  from Equation 4.1-1

Facility construction for time  $t$  plus  $n$ , therefore, can be calculated as new construction minus facility design for new construction minus materials, components, supplies, and fuels for new construction minus demolition. It is assumed that demolition occurs only for new construction and it must be subtracted from new construction since it is part of NAICS code 238910: Site Preparation. Construction put in place also states that site preparation is included. Facility construction is represented as the following:

**Equation 4.4-3: Facility Construction**

$$FC_{t+n} = NC_{Tot,t+n} - FNC_{t+n} - MN_{t+n} - D_{t+n}$$

Where:

$FC_{t+n}$  = Facility construction for time  $t$  plus  $n$   
 $NC_{Tot, t+n}$  = Total new construction for time  $t$  plus  $n$  in Equation 3.1-3  
 $FNC_{t+n}$  = Facility design for new construction at time  $t$  plus  $n$  from Equation 4.4-2  
 $MN_{t+n}$  = Materials, components, supplies, and fuels for new construction in Equation 4.4-1  
 $D_{t+n}$  = Demolition at time  $t$  plus  $n$  from Equation 4.3-1

## 4.5 Commissioning

According to ASHRAE Guideline 0, building commissioning is “a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”<sup>36</sup> There is no estimate in the Economic Census or the C30 report for commissioning; however, building inspection services has a slightly narrower definition as being establishments that evaluate all aspects of the building structure and component systems of new and existing facilities and prepare a report on the physical condition of property for buyers and others involved in real estate transactions. It does not include conducting inspections for enforcing public building codes and standards, inspection for pests, or inspections for hazardous materials. Commissioning is often referred to as inspection and servicing;<sup>37</sup> therefore, inspection services, quite arguably, has significant overlap with commissioning, re-commissioning, and retro-commissioning.<sup>38</sup> An estimate of inspection services conducted is included in

<sup>36</sup> National Institute of Building Sciences. Whole Building Design Guide. <<http://www.wbdg.org/project/buildingcomm.php>>

<sup>37</sup> Mills, Evan. “Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions.” Prepared for the California Energy Commission, Public Interest Energy Research. July 21, 2009. Pg 3. <<http://cx.lbl.gov/2009-assessment.html>>

<sup>38</sup> National Institute of Building Sciences. Commissioning Definitions. ASHRAE Guideline 0-2005. <[http://www.wbdg.org/pdfs/comm\\_def.pdf](http://www.wbdg.org/pdfs/comm_def.pdf)>

the Economic Census. An annual value can be estimated using the ratio estimated for new construction. Inspection services can be estimated as the following:

**Equation 4.5-1: Commissioning**

$$CM_{t+n} = \frac{BI_t}{NC_t} * NC_{Tot,t+n}$$

Where:

$CM_{t+n}$  = Commissioning for time t+n

$BI_t$  = Building inspection services from the Economic Census at time t

$NC_t$  = New construction from the Economic Census at time t

$NC_{Tot, t+n}$  = Total new construction for time t plus n from Equation 3.1-3

## 4.6 Maintenance and Repair

Maintenance and repair is not included in values for construction put in place from the C30 report. The value of maintenance and repair for the construction industry supply chain does not include materials, components, supplies, and fuels; therefore, it must be subtracted. Maintenance and repair for the supply chain can be calculated by taking the value of maintenance and repair from Section 3.3 and subtracting materials, components, supplies, and fuels. The value for maintenance and repair is represented as the following:

**Equation 4.6-1: Maintenance and Repair**

$$MM_{t+n} = \sum (MR_{x,t+n} * SR_{M,x,t})$$

$$MR_{Sup,t+n} = MR_{t+n} - MM_{t+n}$$

Where:

$MM_{t+n}$  = Materials, components, supplies, and fuels for maintenance and repair for time t plus n

$MR_{x, t+n}$  = Maintenance and repair for time t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R) from Equation 3.3-1

$SR_{M, x, t}$  = Scaling ratio for materials, components, supplies, and fuels for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R) for time t from Equation 4.2-1

$MR_{Sup, t+n}$  = Total maintenance and repair for the supply chain for time t plus n

$MR_{t+n}$  = Total maintenance and repair for time t plus n from Equation 3.3-1

## 4.7 Renovation

Renovation includes construction work that adds to the value of useful life of an existing building or structure. It does not include materials, components, supplies, and fuels or



facility design. It can be calculated by taking the value for additions, alterations, and reconstruction from Section 3.2 and subtracting materials, components, supplies and fuels and facility design used in additions, alterations, and reconstruction. The two values being subtracted can be calculated using ratios from the Economic Census. Residential and nonresidential materials, components, supplies, and fuels used for additions, alterations, and reconstruction is represented in the first set of brackets in Equation 4.7-1. The second set of brackets subtracts materials, components, supplies, and fuels used in the facility design of additions, alterations, and reconstruction. This value is subtracted because it is included in total facility design for additions, alterations, and reconstruction represented in Equation 4.7-2. It is estimated that 2 % of facility design is materials, components, supplies, and fuels; therefore, facility design is multiplied by 0.02 in order to calculate the materials, components, supplies, and fuels used in the facility design of additions, alterations, and reconstruction. Materials, components, supplies, and fuels for additions, alterations, and reconstruction can be represented as the following:

**Equation 4.7-1: Materials, Components, Supplies, and Fuels for Additions, Alterations, and Reconstruction**

$$MA_{t+n} = \sum (AAR_{x,t+n} * SR_{M,x,t}) - (SR_{AAR,tot,t} * (0.02 * FD_{t+n}))$$

Where:

$MA_{t+n}$  = Materials, components, supplies, and fuels for additions, alterations, and reconstruction for time t plus n

$AAR_{x,t+n}$  = Additions, alterations, and reconstruction for year t plus n for category x, where x is either commercial/institutional (CI), manufacturing (M), or public works (PW) from Equation 3.2-2 or residential construction (R) described in Section 3.1

$SR_{M,x,t}$  = Scaling ratio for materials, components, supplies, and fuels for time t for category x, where x is either commercial/institutional (CI), manufacturing (M), public works (PW), or residential construction (R) from Equation 4.2-1

$SR_{AAR,tot,t}$  = Scaling ratio additions, alterations, and repair from Equation 3.2-1 for all construction

$FD_{t+n}$  = Facility design for time t plus n in Equation 4.1-1

Facility design for additions, alterations, and reconstruction can be calculated by taking facility design from Section 4.1 and multiplying it by the ratio of additions, alterations, and reconstruction. It can be represented as the following:

**Equation 4.7-2: Facility Design for Additions, Alterations, and Reconstruction**

$$FDA_{t+n} = FD_{t+n} * \frac{AAR_t}{VC_t - MR_t}$$

Where:

$FDA_{t+n}$  = Facility design for additions, alterations, and reconstruction

$FD_{t+n}$  = Facility design for time t plus n in Equation 4.1-1

$AAR_t$  = Additions, alterations, and reconstruction for time t from the Economic Census

$VC_t$  = Total value of construction work from the Economic Census at time t

$MR_t$  = Total maintenance and repair from the Economic Census at time t

Renovation can then be calculated by taking additions, alterations, and reconstruction from Section 3.2 and subtracting the previously mentioned variables. It can be represented as the following:

**Equation 4.7-3: Renovations**

$$R_{t+n} = AAR_{Tot,t+n} - MA_{t+n} - FDA_{t+n}$$

Where:

$R_{t+n}$  = Renovations for time t plus n

$AAR_{Tot,t+n}$  = Total additions, alterations, and reconstruction for time t plus n from Equation 3.2-3

$MA_{t+n}$  = Materials, components, supplies, and fuels for additions, alterations, and reconstruction for time t plus n from Equation 4.7-1

$FDA_{t+n}$  = Facility design for additions, alterations, and reconstruction from Equation 4.7-2

## 4.8 Contents and Furnishings

Contents and furnishings includes nine values from the Annual Survey of Manufactures listed in Table 2.6-1. It includes audio/video equipment, carpets, rugs, curtains, furniture, laundry equipment, refrigerators, lighting fixtures, major household appliances, and small electrical appliances. To get the most recent values for these items we simply adjust them using the consumer price index. The values in Table 2.6-1 have already been adjusted to 2009 values.

## 4.9 Services to Buildings and Dwellings

Services to buildings and dwellings includes five values from the Service Annual Survey. These items are listed in Table 2.7-1: security systems services, exterminating and pest control, janitorial services, cleaning, and other services. Similar to contents and furnishings, these values are simply adjusted using the consumer price index to get current estimates. The values in Table 2.7-1 have already been adjusted to 2009 values.

## 4.10 Water and Energy

Energy includes all residential and commercial energy expenditures as seen in Table 2.5-1. For the purposes of this report, the latest value available is used and adjusted to current dollars. The values in the table have already been converted to 2009 dollars. Water use for commercial and residential purposes is provided by U.S. Geological

Survey for 1995.<sup>39</sup> More recent data does not break water data into residential and commercial. In 1995, 402 billion gallons of water were used per day and water cost approximately \$ 3 per 1000 gallons of water. Approximately 9.59 billion gallons were used for residential purposes and 26.1 billion gallons were used for commercial purposes. In 2005, a total of 410 billion gallons of water were used daily, an increase of 1.99 % from 1995. To calculate water use in the current year, we assume that commercial and residential water use has increased at the same rate as total water use from 1995 to 2005 and adjust the cost to current dollars using the consumer price index for all goods for all consumers.

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<sup>39</sup> U.S. Geological Survey. "Estimated Use of Water in the United States in 1995."  
<<http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf>>



## 5 Implementation of Methodology and Results

### 5.1 Construction Statistics Methodology: Accuracy

The accuracy of the estimate for nonresidential new construction in Section 3.1 relies on two notions. The first notion is that the ratio of new construction to the value of construction is the same for both the Economic Census and the C30 report.

Unfortunately, there is no way to test this hypothesis empirically for nonresidential construction. The second is that the ratio of new construction to the value of construction (excluding maintenance and repair) remains relatively constant from the most recent Economic Census until the time being assessed. This ratio does in fact change only slightly from one Economic Census to the next. The ratios from the 2002 and 2007 Economic Census can be compared in Table 5.1-1. The ratio of commercial/institutional new construction (NC) to the value of construction (NC+AAR) in 2002 was 0.707 and 0.697 in 2007; a change of 1.5 %. The other ratios changed at similar rates. In Table 5.1-2 new construction put in place in 2007 is calculated using the 2002 Economic Census and compared to values estimated using the 2007 Economic Census. The mean absolute percent error (MAPE) is 0 % for residential construction since this is provided directly from the C30 report on an annual basis. New nonresidential construction (commercial/institutional, manufacturing, and public works) has a MAPE between 0 % and 2 %.

The accuracy of the estimates for nonresidential additions, alterations, and reconstruction depend on similar notions as those for new construction. The first notion is that the ratio of additions, alterations, and reconstruction to the value of construction (excluding maintenance and repair) in the Economic Census is similar to that of construction put in place. Unfortunately, there is no way to test this hypothesis empirically. The second notion that accuracy relies on is that the ratio of additions, alterations, and reconstruction to the value of construction (excluding maintenance and repair) remains relatively constant from the most recent Economic Census until the time being assessed. The ratios between 2002 and 2007 vary only slightly as seen in Table 5.1-1. In Table 5.1-2, additions, alterations, and reconstruction put in place in 2007 is calculated using the 2002 Economic Census and compared to values estimated using the 2007 Economic Census. The mean absolute percent error (MAPE) is 0 % for residential construction since this is provided directly from the C30 report on an annual basis. Nonresidential construction (commercial/institutional, manufacturing, and public works) has a MAPE between 1 % and 4 %.

**Table 5.1-1: Ratios from the 2002 and 2007 Economic Census**

Category	2002	2007	2002	2007
	NC/(NC+AAR)	NC/(NC+AAR)	AAR/(NC+AAR)	AAR/(NC+AAR)
Residential	0.767	0.759	0.233	0.241
Commercial/Institutional	0.707	0.697	0.293	0.303
Manufacturing	0.709	0.705	0.291	0.295
Public Works	0.779	0.781	0.221	0.219

**Table 5.1-2: Construction Estimates**

	2002 Economic Census (\$Billions 2007)	2007 Economic Census (\$Billions 2007)	MAPE
<b>a. Value of Construction Put in Place by Sector</b> (Including Facility Design)	<b>\$1,150.69</b>	<b>\$1,150.69</b>	<b>0.0%</b>
Total Private Construction	\$861.62	\$861.62	0.0%
Total Public Construction	\$289.07	\$289.07	0.0%
<b>b. Value of Construction Put in Place by Type of Construction</b>	<b>\$1,150.69</b>	<b>\$1,150.69</b>	<b>0.0%</b>
<b>i. Residential</b>	<b>\$500.47</b>	<b>\$500.47</b>	<b>0.0%</b>
New Construction	\$361.37	\$361.37	0.0%
Renovation (Additions, Alterations, and Reconstruction (AAR))	\$139.10	\$139.10	0.0%
<b>ii. Commercial/Institutional</b>	<b>\$363.13</b>	<b>\$363.13</b>	<b>0.0%</b>
New Construction	\$256.81	\$252.96	1.5%
Renovation (AAR)[2]	\$106.31	\$110.17	3.5%
<b>iii. Manufacturing</b>	<b>\$45.72</b>	<b>\$45.72</b>	<b>0.0%</b>
New Construction	\$32.43	\$32.25	0.6%
Renovation (AAR)	\$13.29	\$13.47	1.4%
<b>iv. Public Works</b>	<b>\$241.37</b>	<b>\$241.37</b>	<b>0.0%</b>
New Construction	\$188.09	\$188.44	0.2%
Renovation (AAR)	\$53.28	\$52.94	0.7%
<b>c. Value of Construction Put in Place by Projecture</b>	<b>\$1,150.69</b>	<b>\$1,150.69</b>	<b>0.0%</b>
New Construction	\$838.70	\$835.01	0.4%
Renovation (AAR)	\$311.99	\$315.68	1.2%
<b>d. Expenditures for Maintenance and Repair</b>	<b>\$175.86</b>	<b>\$203.54</b>	<b>13.6%</b>

The accuracy of the estimates for maintenance and repair relies on the notion that the ratio of maintenance and repair to new construction does not change significantly from one Economic Census to the next. Accuracy also relies on the ratio of maintenance and repair to new construction being similar to that of maintenance and repair to construction put in place from the C30 report. These two cannot be compared as the C30 report does not actually include maintenance and repair. In Table 5.1-2, maintenance and repair put in place in 2007 is calculated using the 2002 Economic Census and compared to values estimated using the 2007 Economic Census. The mean absolute percent error (MAPE) is 13.6 % for all maintenance and repair construction.

Accuracy of estimates of the construction supply chain components rely on several additional notions. The accuracy of facility design estimates relies on the notion that architectural, surveying, and engineering services increase at a similar rate as construction put in place. Accuracy of facility construction and renovations relies on the notion that facility design is proportionally distributed between the two. Facility

construction, renovation, and maintenance and repair rely on three notions: first, that materials, components, supplies, and fuels is distributed proportionally between all three; second, that the ratio of materials, components, supplies, and fuels to total construction in the Economic Census is the same for the C30 report; and third, that the ratio of materials, components, supplies, and fuels to total construction in the Economic Census does not change significantly from the year of the census to the year being estimated. The first two cannot be tested; however, the third can be examined more closely. The maintenance and repair ratio and the materials, components, supplies, and fuels ratio for 2002 and 2007 are compared in Table 5.1-3. The percent change from 2002 to 2007 ranges from 9 % to 22 %. In Table 5.1-4, each of the construction supply chain components is calculated for 2007 using the 2002 Economic Census and also using the 2007 Economic Census. The values are compared to generate a mean absolute percent error (MAPE). The MAPE ranges from 10 % to 17 % for the supply chain components shown in bold.

**Table 5.1-3: Ratios from the 2002 and 2007 Economic Census**

Category	2002	2007	2002	2007
	MR/NC	MR/NC	MCSF/TC	MCSF/TC
Residential	0.199	0.231	0.305	0.368
Commercial/Institutional	0.224	0.267	0.267	0.325
Manufacturing	0.312	0.356	0.317	0.364
Public Works	0.194	0.218	0.298	0.326

**Table 5.1-4: Estimates of Construction Supply Chain Components**

	2002 Economic Census (\$Billions 2007)	2007 Economic Census (\$Billions 2007)	MAPE
a. Facility Design (FD)			
Architectural Services (NAICS 541310)	\$34.4	\$37.3	7.7%
Surveying Services (NAICS 54137)	\$5.8	\$6.4	9.4%
Engineering Services (NAICS 54133)	\$79.1	\$94.7	16.5%
<b>Total Facility Design</b>	<b>\$119.3</b>	<b>\$138.4</b>	<b>13.8%</b>
Less Materials, Components, Supplies, and Fuels for FD	-\$2.4	-\$2.8	13.8%
<b>Facility Design</b>	<b>\$116.9</b>	<b>\$135.7</b>	<b>13.8%</b>
b. Facility Construction			
New Construction Put in Place (NC)	\$838.7	\$835.0	0.4%
Less NC Facility Design (FD)	-\$89.3	-\$102.4	12.8%
Less Materials, Components., Supplies, and Fuels for NC	-\$246.0	-\$288.4	14.7%
<b>Facility Construction</b>	<b>\$503.4</b>	<b>\$444.1</b>	<b>13.3%</b>
c. Commissioning			
<b>Inspection Services</b>	<b>\$1.4</b>	<b>\$1.6</b>	<b>14.9%</b>
d. Renovation (Additions, Alterations, and Reconstruction (AAR))			
Value of AAR	\$312.0	\$315.7	1.2%
Less AAR Facility Design (FD)	-\$30.0	-\$36.0	16.6%
Less Materials, Components, Supplies, and Fuels for AAR	-\$90.2	-\$108.4	16.8%
<b>Renovation</b>	<b>\$191.7</b>	<b>\$171.2</b>	<b>12.0%</b>
e. Maintenance and Repair (M&R)			
Value M&R	\$175.9	\$203.5	13.6%
Less Materials, Components, Supplies, and Fuels for M&I	-\$37.4	-\$50.4	25.8%
<b>Maintenance and Repair</b>	<b>\$138.5</b>	<b>\$153.2</b>	<b>9.6%</b>
f. Materials, Components, Supplies, and Fuels (MCSF)			
Facility Design	\$2.4	\$2.8	13.8%
Facility Construction	\$243.2	\$286.4	15.1%
Renovation	\$90.2	\$108.4	16.8%
Maintenance and Repair	\$37.4	\$50.4	25.8%
<b>MCSF</b>	<b>\$373.2</b>	<b>\$447.9</b>	<b>16.7%</b>

To evaluate the accuracy of the methodology, some of the MAPE values found in Table 5.1-2 and Table 5.1-4 can be compared to a naïve model. In Table 5.1-5, MAPE values for a naïve model have been calculated for new construction; additions, alterations, and reconstruction; maintenance and repair; and materials, components, supplies, and fuels. The naïve model simply assumes that values of construction from the 2002 Economic Census increase at the rate of inflation. Estimates for 2007 are generated and compared with the 2007 Economic Census. The MAPE values under the “Estimates” column are from Table 5.1-2 and Table 5.1-4. The methodology presented in this report has a lower MAPE than the naïve model for all five estimates.



**Table 5.1-5: Estimates Compared to Naive Model**

	Naïve	Estimates
New Construction	16.2%	0.4%
Additions, Alterations, and Reconstruction	19.8%	1.2%
Maintenance and Repair	28.4%	13.6%
Materials, Components, Supplies, and Fuels	29.1%	16.7%

## 5.2 2009 Calculations

Calculations for the year with the most recently available data, 2009, have been calculated below. Some data from the previous year has also been included for comparison along with data concerning value added from the Bureau of Economic Analysis and employment data. Examining section I, private construction put in place declined 22 % from 2008 to 2009 while public construction increased by 2 %. The decline was due to new residential construction, which declined by 29 %, and commercial/institutional construction, which declined by 17 %. Manufacturing and public works construction grew at 10 % and 1 % respectively. Overall, new construction decreased by 18 % and renovations decreased by 8 %. The volume of construction work, which is the sum of construction put in place and maintenance and repair, decreased 15 %. The value of materials, components, supplies and fuels decreased by 16 %. Employment in the construction industry has dropped by 12 % to 16 % depending on the source data. Construction value added, from the Bureau of Economic Analysis, decreased 10 % and represents 4 % of the total value added for all industries. Facility design for the construction industry supply chain is \$ 107 billion; facility construction is estimated at \$ 331 billion; commissioning is \$ 1 billion; renovation is \$ 160 billion; maintenance and repair is \$ 115 billion; materials, components, supplies, and fuels is \$ 347 billion; contents and furnishings is \$ 157 billion; operations and use is \$ 552 billion; demolition is \$ 2 billion; and losses are \$ 48 billion.

**Table 5.2-1: 2009 Construction Estimates**  
**I. Value of Construction Put in Place**

	2008 (\$Billions 2008)	2009 (\$Billions 2009)	Percent Change
<b>a. Construction Put in Place by Sector</b> (Including Facility Design)	<b>\$1,067.56</b>	<b>\$907.78</b>	<b>-15.0%</b>
Total Private Construction	\$758.83	\$592.33	-21.9%
Total Public Construction	\$308.74	\$315.46	2.2%
 <b>b. Construction Put in Place by Type of Construction</b>	 <b>\$1,067.56</b>	 <b>\$907.78</b>	 <b>-15.0%</b>
 <b>i. Residential</b>	 <b>\$357.75</b>	 <b>\$253.58</b>	 <b>-29.1%</b>
New Construction	\$237.60	\$141.54	-40.4%
Renovation (Additions, Alterations, and Reconstruction (AAR))	\$120.14	\$112.04	-6.7%

<b>ii. Commercial/Institutional</b>	<b>\$384.51</b>	<b>\$320.46</b>	<b>-16.7%</b>
New Construction	\$267.86	\$223.24	-16.7%
Renovation (AAR)	\$116.65	\$97.22	-16.7%
<b>iii. Manufacturing</b>	<b>\$53.23</b>	<b>\$58.51</b>	<b>9.9%</b>
New Construction	\$37.55	\$41.27	9.9%
Renovation (AAR)	\$15.69	\$17.24	9.9%
<b>iv. Public Works</b>	<b>\$272.08</b>	<b>\$275.24</b>	<b>1.2%</b>
New Construction	\$212.41	\$214.88	1.2%
Renovation (AAR)	\$59.67	\$60.36	1.2%
	2008	2009	Percent
	(\$Billions 2008)	(\$Billions 2009)	Change
<b>c. Construction Put in Place by Projecture Nature</b>	<b>\$1,067.56</b>	<b>\$907.78</b>	<b>-15.0%</b>
New Construction	\$755.41	\$620.92	-17.8%
Renovation (AAR)	\$312.15	\$286.86	-8.1%
<b>II. Expenditures for Maintenance and Repair</b>			
(Based on C30 and 2007 Census Data)			
	2008	2009	Percent
	(\$Billions 2008)	(\$Billions 2009)	Change
a. New Construction Put in Place	\$755.41	\$620.92	-17.8%
<b>b. Maintenance and Repair (M&amp;R)</b>	<b>\$186.07</b>	<b>\$153.83</b>	<b>-17.3%</b>
<b>III. Volume of Construction Work</b>			
(Based on C30 and 2007 Census Data)			
	2008	2009	Percent
	(\$Billions 2008)	(\$Billions 2009)	Change
a. New Construction	\$755.41	\$620.92	-17.8%
b. Renovation (AAR)	\$312.15	\$286.86	-8.1%
c. Maintenance and Repair (M&R)	\$186.07	\$153.83	-17.3%
<b>d. Volume of Construction Work</b>	<b>\$1,253.63</b>	<b>\$1,061.61</b>	<b>-15.3%</b>
<b>IV. Cost of Materials, Components, Supplies, and Fuels</b>			
(Calculated from ratios based on C30 and 2007 Census Data)			
	2008	2009	Percent
	(\$Billions 2008)	(\$Billions 2009)	Change
a. Facility Design MCSF	\$2.21	\$2.18	-1.5%
b. New Construction MCSF	\$255.78	\$208.09	-18.6%
c. Renovation (AAR) MCSF	\$106.56	\$98.22	-7.8%
d. Maintenance and Repair (M&R) MCSF	\$46.64	\$38.92	-16.6%
<b>e. Cost of Materials, Components, Supplies, and Fuels</b>	<b>\$411.19</b>	<b>\$347.42</b>	<b>-15.5%</b>
<b>V. Construction Value Added</b>			
(Based on BEA Data)			
	2008	2009	Percent
	(\$Billions 2008)	(\$Billions 2009)	Change
<b>a. Construction Value Added</b>	<b>\$639.3</b>	<b>\$578.3</b>	<b>-9.5%</b>

## VI. Employment in Construction

**a. Data from Current Population Survey, Bureau of Labor Statistics (Based on household surveys; includes government workers (2009: 465,000) proprietors and self-employed workers (2009: 1,701,000) and unpaid family workers (2009: 8,000)).**

	2008	2009	Percent Change
i. Employment in Construction	10,974,000	9,702,000	-11.6%
ii. Total U.S. Employment	143,194,000	137,775,000	-3.8%
<b>iii. Construction Employment as Share of Total Employment</b>	<b>7.66%</b>	<b>7.04%</b>	<b>-8.1%</b>

**b. Data from Current Employment Statistics, Bureau of Labor Statistics (Based on establishment surveys; includes civilian government workers but not non-civilian government workers, proprietors and self-employed workers or unpaid family workers).**

	2008	2009	Percent Change
i. Employment in Construction	7,162,000	6,037,000	-15.7%
ii. Total Non-farm US Employment	136,790,000	130,912,000	-4.3%
<b>iii. Construction Employment as Share of Total Non-farm Employment</b>	<b>5.24%</b>	<b>4.61%</b>	<b>-11.9%</b>

	2008 (\$Billions 2008)	2009 (\$Billions 2009)	Percent Change
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## VII. Construction Share of GDP

**a. Ratio of Value of Construction Put in Place to GDP:**

i. Value of Construction Put in Place	\$1,067.56	\$907.78	-15.0%
ii. GDP	\$14,441.40	\$14,258.20	-1.3%
<b>iii. Value of Construction Put in Place as Share of GDP</b>	<b>7.39%</b>	<b>6.37%</b>	<b>-13.9%</b>

**b. Ratio of Value of Construction Put in Place less Materials, Components, Supplies & Fuels (MCSF) to GDP:**

i. Value of Construction Put in Place			
Less MCSF	\$656.37	\$560.37	-14.6%
ii. GDP	\$14,441.40	\$14,258.20	-1.3%

<b>iii. Value of Construction Put in Place</b>			
Less MCSF as Share of GDP	4.55%	3.93%	-13.5%
<b>c. Ratio of New Construction</b>			
<b>Put in Place to GDP</b>			
i. New Construction Put in Place	\$755.41	\$620.92	-17.8%
ii. GDP	\$14,441.40	\$14,258.20	-1.3%
<b>iii. New Construction Put in Place</b>			
<b>as Share of GDP</b>	5.23%	4.35%	-16.7%
<b>d. Ratio of Construction Value Added to GDP</b>			
i. Construction Value Added	\$639.30	\$578.30	-9.5%
ii. GDP	\$14,441.40	\$14,258.20	-1.3%
<b>iii. Value Added as Share of GDP</b>	4.43%	4.06%	-8.4%

## VIII. Estimation of 2009 Construction Industry Supply Chain Components

2009  
(\$Billions 2009)

<b>a. Facility Design (FD)</b>	
(From the Architectural, Engineering, and Related Services section of the 2002 Census)	
Architectural Services (NAICS 541310)	\$29.3 B
Surveying Services (NAICS 54137)	\$5.1 B
Engineering Services (NAICS 54133)	\$74.6 B
<b>Total Facility Design</b>	<b>\$109.1 B</b>
Less Materials, Components, Supplies, and Fuels for FD	-\$2.2 B
<b>Facility Design</b>	<b>\$106.9 B</b>
<b>b. Facility Construction</b>	
New Construction Put in Place (NC)	\$620.9 B
Less NC Facility Design (FD)	-\$80.7 B
Less Demolition and Materials, Components., Supplies, and Fuels for NC	-\$209.7 B
<b>Facility Construction</b>	<b>\$330.5 B</b>
<b>c. Commissioning</b>	
<b>Inspection Services</b>	<b>\$1.2 B</b>
<b>d. Renovation (Additions, Alterations, and Reconstruction (AAR))</b>	
Value of AAR	\$286.9 B
Less AAR Facility Design (FD)	-\$28.4 B
Less Materials, Components, Supplies, and Fuels for AAR	-\$98.2 B
<b>Renovation</b>	<b>\$160.3 B</b>
<b>e. Maintenance and Repair (M&amp;R)</b>	
Value M&R	\$153.8 B
Less Materials, Components, Supplies, and Fuels for M&R	-\$38.9 B
<b>Maintenance and Repair</b>	<b>\$114.9 B</b>

f. Materials, Components, Supplies, and Fuels (MCSF)		
Facility Design		\$2.2 B
Facility Construction		\$208.1 B
Renovation		\$98.2 B
Maintenance and Repair		\$38.9 B
	<b>MCSF</b>	<b>\$347.4 B</b>
g. Contents and Furnishings		
From Annual Survey of Manufactures 2006		
Audio and Video Equip.Mfg. 334310		\$9.6 B
Carpets and Rug Mills 314110		\$15.2 B
Curtains and Linen Mills 31412		\$6.7 B
Furniture and Related Prod. Mfg. 337		\$85.6 B
Hh. Laundry Equipment 335224		\$4.9 B
Hh. Refrig. and Home Freezer 335222		\$6.2 B
Lighting Fixture Mfg. 33512		\$10.9 B
Household Cooking Appl.Mfg. 335221		\$4.9 B
Small Elec. Appl. Mfg. 33521		\$3.7 B
Total		\$147.7 B
	<b>Contents and Furnishings</b> <b>(adjusted to 2009)</b>	<b>\$157.1 B</b>
h. Operation and Use		
Energy		
(Based on the 2005 values from the 2007 Annual Energy Review)		
Commercial		\$179.9 B
Residential		\$251.5 B
	<b>Energy</b>	<b>\$431.4 B</b>
Water		
Commercial		\$40.2 B
Residential		\$14.8 B
Commercial and Residential		\$55.0 B
Services to Buildings and Dwellings		
(From the Service Annual Survey: NAICS 561621, 56171, 56172, 56174, 56179)		
		\$65.9 B
	<b>Operation and Use (total of energy, water, and services)</b>	<b>\$552.4 B</b>
i. Demolition		
	<b>Value of Construction Less MCSF times 2002 ratio</b>	<b>\$1.6 B</b>
j. Loss		
Fire		\$10.6 B
Wind (tornado, tstm wind, high wind)		\$2.0 B
Earthquakes		\$5.3 B
Floods (flash flood, river flood)		\$1.9 B
Other (hail, coastal storm, tropical storm/hurricane, winter storm)		\$28.1 B
	<b>Loss</b>	<b>\$47.9 B</b>



## 6 Summary and Recommendations for Further Research

### 6.1 Summary

Beginning with the owners' needs, the life cycle of a constructed facility moves through six primary stages, which are the primary components of the construction industry: facility design, facility construction, commissioning, operation and use, renovation, and eventually demolition. A number of other components support them; these include maintenance and repair; materials, components, supplies, and fuels; contents and furnishings; and standards, codes, and regulatory approvals. The methods discussed in this report provide annual estimates for the six primary components along with the supporting components and losses. Without the methodology presented in this report, some values are only available every five years and others are not available at all. Having a method to estimate these components of the construction industry provides a better understanding of the construction industry. The accuracy of the methods discussed relied on several notions, primarily that the ratios in the Economic Census do not change significantly from one year to the next and that ratios found in the Economic Census are similar to those of construction put in place from the C30 reports. The 2009 estimates for the construction industry supply chain values, as described in the report, are illustrated in Figure 6.1-1. Federal and state agencies can use the estimates in assessing the effect of

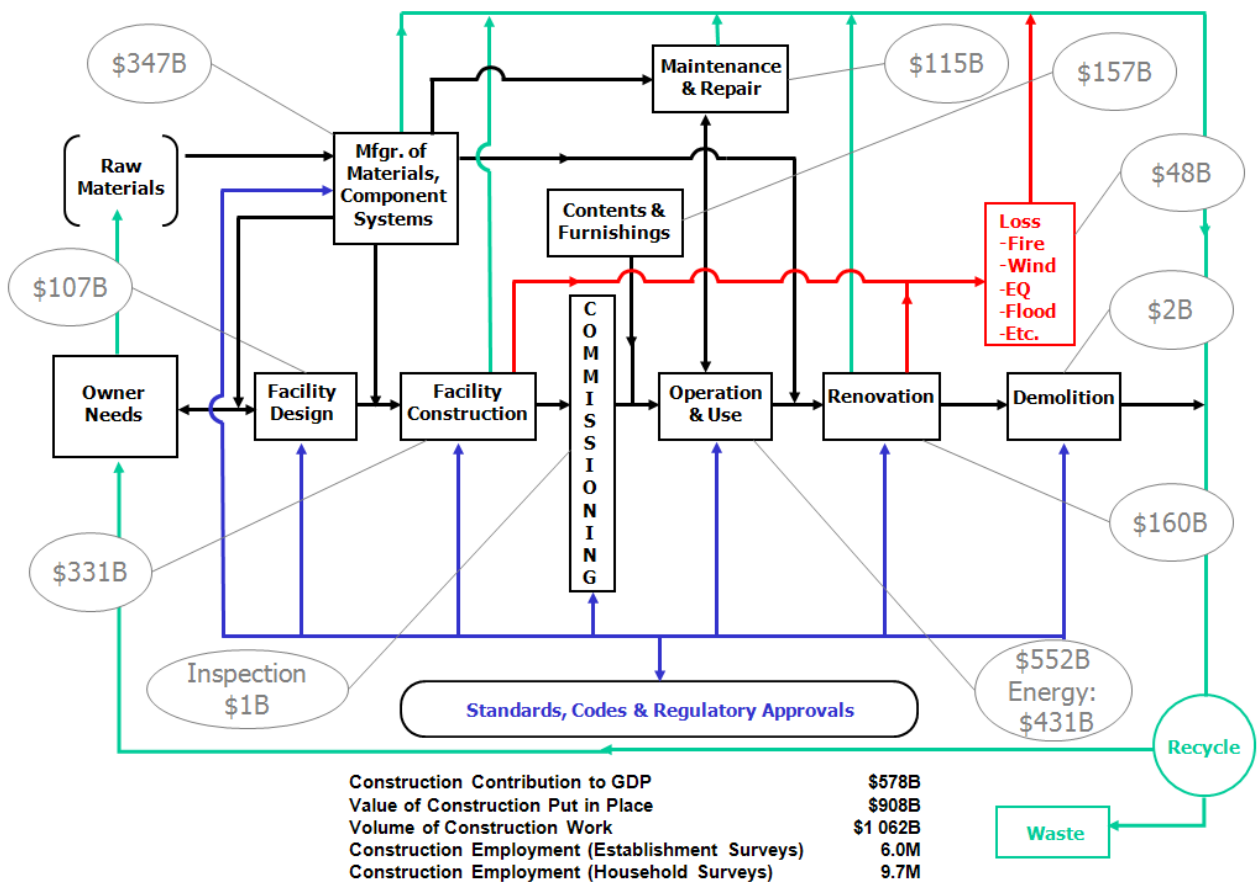


Figure 6.1-1: Construction Industry Supply Chain

regulations, tax policy, finance policy, land development, and job retention efforts. They can provide insights into the extent that new structures are being erected as opposed to old structures being renovated and maintained while also providing insight into industry growth for investors, economic development groups, and other construction industry stakeholders.

## **6.2 Recommendations for Further Research**

There are a number of opportunities for further research and improvement on the estimation of the construction industry supply chain statistics. Among them is the estimate for commissioning, which now only includes values for inspection. According to ASHRAE Guideline 0, Building commissioning is “a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”<sup>40</sup> The estimate for commissioning, therefore, needs to also include additional expenditures on design, servicing, and other steps in the process. Commissioning is a review of a building to identify suboptimal situations or malfunctions that has been shown to provide median whole-building energy savings between 13 % and 16 %.<sup>41</sup> Inspection is arguably one part of the commissioning process which begins in the pre-design phase of construction and continues through the operation of the structure.

Further research is needed on expenditures for developing and implementing building standards and codes along with expenditures on regulatory approval of structures. The development of standards for the built environment is critical to the health and safety of those who occupy or use structures. It includes fire codes, disaster resistance standards, electrical codes, plumbing codes, and other standards for structural components. Although current building codes and standards, which are primarily prescriptive in nature, increase construction expenditures and lengthen the delivery time of construction projects, the use of performance-based codes and standards is seen as a mechanism for reducing regulatory burdens. Currently, there is not a complete understanding of the expenditures on developing and implementing building standards.

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<sup>40</sup> National Institute of Building Sciences. Whole Building Design Guide.  
<<http://www.wbdg.org/project/buildingcomm.php>>

<sup>41</sup> Mills, Evan. 2009 “Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions.” < <http://ex.lbl.gov/2009-assessment.html>>



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