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ANDERSON ECONOMIC GROUP

The Economic Impact of Argonne National Laboratory

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I. Executive Summary

REPORT PURPOSE

Argonne National Laboratory is a basic and applied science and engineering research facility situated on1,500 acres, 25 miles southwest of the city of Chicago. The laboratory receives most of its funding from the federal government, through the U.S. Department of Energy, and is administered by the University of Chicago. The purpose of this report is to produce a credible and conservative estimate of the economic impact of Argonne National Laboratory on the Chicago region and the state of Illinois as a whole.

OVERVIEW OF APPROACH

In this report we estimate the local economic impact of Argonne's operations and its contributions to scientific research nationally. We discuss key features of our methodology below.

Economic Impact Defined. Economic impact is the measure of *net new* economic activity that occurs in a defined geographic region as a result of an investment, event, project, industry, or institution. A direct economic impact stems from the initial spending or investment, while an indirect economic impact stems from the recirculation of dollars within the defined region. In this report, we measure economic impact in terms of 1) total new economic activity, 2) earnings to workers, and 3) number of jobs created or supported.

Approach to Estimating Argonne's Economic Impact. We estimated the impact of Argonne National Laboratory on two geographic regions: 1) the Chicago metropolitan region, which includes an eight-county area in Illinois,[1] and 2) the entire state of Illinois. We were careful to count *only* the portion of federally-funded expenditures that occurred in these geographic regions, and would not have occurred in the region without Argonne's presence. We also considered alternative uses of the land that Argonne currently occupies. The land surrounding Argonne is the DuPage County Forest Preserve. We assumed that in Argonne's absence the land would either be preserved or developed for residential uses. Either of these alternative uses would not have contributed to new jobs in the region. This produces a more conservative measure than gross-related expenditures. See "Appendix A. Data and Methodology" on page A-1 for a complete description of our economic impact analysis.

National Impact of Argonne's Role in Developing Science and Technology. In addition to estimating the jobs and earnings that Argonne generates in the Chicago region and the state of Illinois, we reviewed its contributions to basic science, applied science and engineering, creating science infrastructure, and contributing to the pipeline of new scientists and engineers in the U.S. We quantified the value of these contributions whenever possible. For example, we

1. The Chicago region includes the counties of Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall.

report the lab's technology transfer agreements with outside organizations and the number of peer reviewed research papers its scientists produce.

ABOUT ARGONNE NATIONAL LABORATORY

Argonne traces its roots to the 1940s and the Second World War when America's top scientists were commissioned to join the Manhattan Project and develop the world's first atomic bomb. In 1942 a group led by physicist Enrico Fermi at the University of Chicago helped found what would officially become Argonne National Laboratory in 1946. Argonne is one of 17 national laboratories in the U.S. Its research focus is broad, covering fields throughout science, technology, engineering, and mathematics. See "Argonne's Operations" on page 5.

OVERVIEW OF FINDINGS

Argonne makes significant economic contributions. We report the findings of our analysis below.

1. Argonne is Responsible for Almost 5,000 New Jobs in Illinois.

We estimate that Argonne's operations contributed almost 5,000 jobs in the state of Illinois in FY 2010. Argonne directly employed 4,031 workers in 2010. This included 2,725 full-time equivalent employees. These jobs were due to the lab's direct expenditures on payroll for its employees and purchases of supplies and materials from businesses in the state of Illinois. It also includes the jobs created due to the re-spending of these dollars in the state. We estimate that 92% of these jobs were in the Chicago region. See Table 1 below and "Economic Impact From Argonne Related Expenditures" on page 13.

2. Argonne Generated Almost $700 Million in Net New Earnings for Households and Businesses in 2010.

After accounting for the share of Argonne's direct expenditures that go to businesses and workers in Illinois (55% or $360 million in FY 2010), we estimate that the total impact of Argonne's operations was almost $700 million in FY 2010. We estimate that 94% of these earnings go to households and businesses in the Chicago region. See Table 1 below.

TABLE 1. Argonne Economic Impacts in Illinois

	Economic Output	Household Earnings	Employment
Contractor and Visitor Economic Impacts	$7,671,239	$2,217,214	77
Argonne Expenditure Economic Impacts	$689,213,735	$211,521,121	4,875
Total Economic Impacts	$696,884,974	$213,738,336	4,952

Source: Anderson Economic Group, LLC

3. Argonne Helps the Nation Through Basic and Applied Science and Engineering.

American science is an important contributor to improvements in our standard of living and our ability to address national priorities such as energy, transportation, and security concerns. Argonne's scientists and engineers make important contributions to the stock of scientific knowledge available to solve future problems, producing over 11,000 scientific publications in many scientific disciplines over the past 10 years.

Argonne's role as a national laboratory brings with it a focus on applied science and engineering, where private companies and government agencies need cutting-edge science and engineering to solve difficult problems. Argonne works with others on hundreds of projects annually, contributing to product designs, and techniques for analysis, testing, and manufacturing. For example, in 2010, Argonne had 156 "work for other" agreements that allowed Argonne to assist federal agencies, local governmental entities, and businesses with technical problems in the lab's area of expertise. Such work also regularly leads to the licensing of technologies to companies that then commercialize new technologies. In the past five years, Argonne has licensed or patented between 30 and 50 technologies each year. See "How Argonne Contributes to Applied Science and Engineering" on page 21.

4. Argonne Supports U.S. Science by Hosting Important Science Infrastructure and Contributing to the Pipeline of Future Scientists and Engineers.

Argonne hosts five U.S. Department of Energy designated "user facilities" which provide unique equipment, technologies, and clusters of experts that help outside researchers and companies pursue research they could not do on their own. These facilities include the Advanced Photon Source (which has the highest x-ray in the Western Hemisphere), a heavy ion particle accelerator, supercomputers, and facilities for electron microscopy, nanotechnology research, and transportation-related engineering and analysis. These facilities have over 5,000 users each year from around the country and the world, each advancing their own research ideas using equipment and know-how they may not have had access to without Argonne.

Argonne also contributes to the pipeline of new scientists and engineers produced in the U.S. at all levels of education. Argonne contributes to the training and early research careers of hundreds of visiting scholars, post-doctoral researchers, and graduate students. This increases the amount of researcher positions available to scientists and engineers in the U.S. The lab also provides training and support for many high-school science teachers seeking to develop high-quality science curricula, hosts hundreds of paid, competitively-awarded internships for high school, community college, and undergraduate students. Thousands of K-12 students throughout the country are touched by Argonne and its scientists each year through tours, science fairs and competitions, and

science events such as open houses. "Argonne Contributions to Science Infrastructure" on page 24.

ABOUT ANDERSON ECONOMIC GROUP

Anderson Economic Group, LLC offers research and consulting in economics, finance, market analysis, and public policy. Since AEG's founding in 1996, the company has helped clients including universities, state and local governments, non-profit organizations, and private and public companies. AEG has completed economic impact studies for universities located throughout the United States. For more information on the report's authors, please see "Appendix B. About the Authors" on page B-1.

II. Argonne's Operations

BRIEF HISTORY

Argonne traces its roots to the 1940s and the Second World War, when America's top scientists were commissioned to join the Manhattan Project and develop the world's first atomic bomb. In 1942, a group led by physicist Enrico Fermi at the University of Chicago's Metallurgical Laboratory (Met Lab) made a key breakthrough when they achieved the world's first controlled, self-sustaining nuclear chain reaction. This group, along with some others from the university, moved their research to a site in the Argonne Forest, southwest of Chicago. Fermi would act as director for this lab until 1945.

On July 1, 1946, this site officially became Argonne National Laboratory. The first official director of Argonne was Walter Zinn, and the lab remained under the oversight of the University of Chicago, as it does to this day.[2] Within a few years, Argonne National Laboratory moved to its current location on 1,500 acres in DuPage County, Illinois, 25 miles southwest of Chicago.

Since its inception, Argonne has been part of a network of national laboratories owned by the federal government, at which the world's top scientists and engineers can use the most technologically-advanced equipment and facilities in order to carry out research. In total, the U.S. Department of Energy (DOE) owns 17 national laboratories throughout the country. Of these, ten labs, including Argonne, are overseen by the DOE Office of Science. Most of these labs, like Argonne, got their start as part of the Manhattan Project. The national laboratories cooperate with each other in order to encourage collaboration in the scientific community and to design and construct new science and technical research facilities.

Argonne's research focus is broad, covering fields throughout science, technology, and engineering. In brief, the main fields of research at Argonne are particle and nuclear physics; molecular, chemical, and materials science and engineering; transportation, energy storage, applied mathematics; advanced computer science; and systems engineering. The sprawling nature of Argonne's focus is not unique among the national laboratories. Four others—Brookhaven, Lawrence Berkeley, Oak Ridge, and Pacific Northwest—all have similarly broad research programs.

OVERVIEW OF OPERATIONS

In 2010, Argonne National Laboratory had 4,031 employees working at the lab. This included 2,725 full-time equivalent employees (FTEs), as well as 1,147 visiting scholars and researchers with long-term appointments. There were also 159 graduate and other students with special appointments working on site.

2. UChicago Argonne LLC is the legal entity that operates the lab.

KEY TERMS

- **Catalyst.** A substance that can influence the speed of a chemical reaction, but is not itself consumed in the reaction.
- **Linear accelerator (or, linac).** A particle accelerator that uses electromagnetic fields to bring subatomic particles to very high speeds, in order to observe high-energy collisions or produce particle or light beams of a specific energy.
- **Nanoscale.** Refers to the field of research dealing with objects that are so small that they are best measured in nanometers. A nanometer is 10^{-9} meters, or one billionth of a meter, which is the size of a single large molecule.
- **Rare isotopes.** Isotopes are atoms that contain the same number of protons, and therefore are the same element, but have a different number of neutrons. Rare isotopes are usually heavier and less stable than their more common counterparts.
- **Spectroscopy.** The study of interactions between matter and radiated energy. This often involves measuring the frequencies of emitted and absorbed light.
- **Supercomputer.** A custom-built computer that is at the forefront of the computing field in terms of processing power and speed.
- **Superconductor.** A material that exhibits no resistance to the flow of electricity. Superconductivity occurs in certain metals at very low temperatures.

The Argonne National Laboratory site, in order to accommodate its 4,500 employees, users, and guests, includes 99 buildings with 4.7 million total square feet of floor space. The facilities and other structures at Argonne are worth an estimated $2.1 billion. Argonne spends around $100 million a year in order to maintain its facilities and infrastructure. The largest and most distinct user facilities housed at Argonne National Laboratory are listed below:

- **Advanced Photon Source (APS).** A source of high-energy x-rays for scattering, spectroscopy, and imaging studies. The APS is able to accommodate experiments at high speeds and extreme pressure and temperature. Argonne just received approval for an upgrade to the APS projected to take 6-7 years.
- **Advanced Protein Crystallization Facility (APCF).** A new project that the State of Illinois is funding. The APCF would accommodate experiments that determine the structure of proteins and how they are formed.
- **Argonne Leadership Computing Facility (ALCF).** Home of some of the most powerful supercomputers in the world and a "computational ecosystem" used by every major research initiative carried out at the laboratory. In addition, the Department of Energy and researchers from around the world use the equipment at this facility to accomplish tasks requiring state-of-the-art computational and imaging capabilities.
- **Argonne Tandem-Linac Accelerator System (ATLAS).** A superconducting linear accelerator, providing observations of heavy-ion collisions. The energy at which ATLAS is tuned is ideal for studying properties of the nucleus of the atom and the fuel of stars (hydrogen). The Californium Rare Ion Breeder Upgrade (CARIBU) is currently taking place at this facility, allowing the production of beams of rare isotopes. In addition, American Recovery and Reinvestment Act funding (also known as the federal stimulus package) has recently allowed an upgrade to this accelerator's efficiency and intensity.
- **Center for Nanoscale Materials (CNM).** Center that provides advanced microscopes and an x-ray nanoprobe, allowing imaging and other measure-

ments on nanomaterials. This center also provides capabilities in synthesis and fabrication of nanomaterials.

- **Electron Microscopy Center (EMC).** The equipment at this center gives users the ability to observe elements in three dimensions at high resolution, with applications in observing the dynamics of catalysts and nanoscale reactions as they occur.
- **Transportation Research and Analysis Computing Center (TRACC).** TRACC is funded by the U.S. Department of Transportation to provide researchers and developers in transportation more powerful imaging and computational capabilities.

ARGONNE FUNDING

Argonne National Laboratory received $667 million in total funding in FY 2010 (October 1, 2009 to September 30, 2010). The overwhelming majority of these funds (90%) were from the federal government. The Department of Energy is the primary source of funds, but Argonne also performs research for other federal departments including the Departments of Defense, Homeland Security, Health and Human Services, and Transportation, among others. Of the money that went to Argonne directly from federal agencies or departments, $47.9 million was allocated due to the American Recovery and Reinvestment Act.

Beside the federal government, Argonne National Laboratory has two other main sources of funding—universities, and other national laboratories. Of universities, which contributed $27.2 million (or 4% of total funding) in 2010, the University of Chicago is by far the largest contributor, with about $20 million of Argonne funding coming from its parent organization. Michigan State University and Purdue University are a distant second and third in terms of funding contributed by universities. Other Department of Energy-owned national laboratories and technology centers contributed a total of $23.6 million to Argonne funding in 2010. The breakdown of funding provided to the Lab in fiscal year 2010 is shown in Table 2 on page 8.

Some small businesses, corporations, and Department of Energy national laboratories received stimulus funds in order to perform research at Argonne. In addition to the $47.9 million in stimulus funds that Argonne received directly from federal entities in FY 2010, Argonne received another $3.8 million in rev-

enues backed by stimulus funds from small businesses, corporations, and other national laboratories.

TABLE 2. Argonne National Laboratory Revenues, FY 2010

Source of Revenue	Amount (millions of $)	% of Total Revenue
Federal Government (not ARRA)	$551.8	*82.7%*
Federal Government (ARRA)	$47.9	*7.2%*
State & Local Governments	$1.0	*0.2%*
Foreign Governments	$1.8	*0.3%*
Universities	$27.2	*4.1%*
Other National Laboratories	$23.6	*3.5%*
Non-Profit Organizations	$3.7	*0.6%*
Corporations	$6.5	*1.0%*
Small Businesses	$3.3	*0.5%*
TOTAL REVENUE	**$666.8**	***100%***

Source: Argonne National Laboratory
Analysis: Anderson Economic Group, LLC

III. Employment and Earnings Impact

ECONOMIC IMPACT DEFINED

Economic impact is the measure of net new economic activity that occurs in a defined geographic region as a result of an investment, event, project, or industry. A direct economic impact stems from the initial spending or investment, while an indirect economic impact stems from the recirculation of dollars within the defined region. Economic impact is measured in terms of 1) total new economic activity, 2) earnings to workers, and 3) number of jobs created or supported.

We specifically measure the *net new* economic impact of Argonne National Laboratory. We emphasize *net* and *new* as we were careful to exclude expenditures that would have been realized in the area regardless of Argonne's operations, and we were careful to consider costs associated with generating an expenditure. For example, the opening of an additional fast food restaurant along a busy commercial corridor will not create significant new economic activity. Instead it will likely just shift activity within the market as consumers spread their spending amongst all of the fast food outlets. However, Argonne, with its unique types of expenditures and operating revenue from the federal government, does have a significant economic impact. We also considered the alternative use of the land currently occupied by Argonne. See "Economic Impact Methodology" on page A-9 for a complete description of our methodology.

Impact Areas. In this analysis we specifically assess Argonne's economic impact on the state of Illinois as a whole, and on just the Chicago region. A map of these areas and the relative location of Argonne is shown on page 10. The Chicago region includes the counties of Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall.

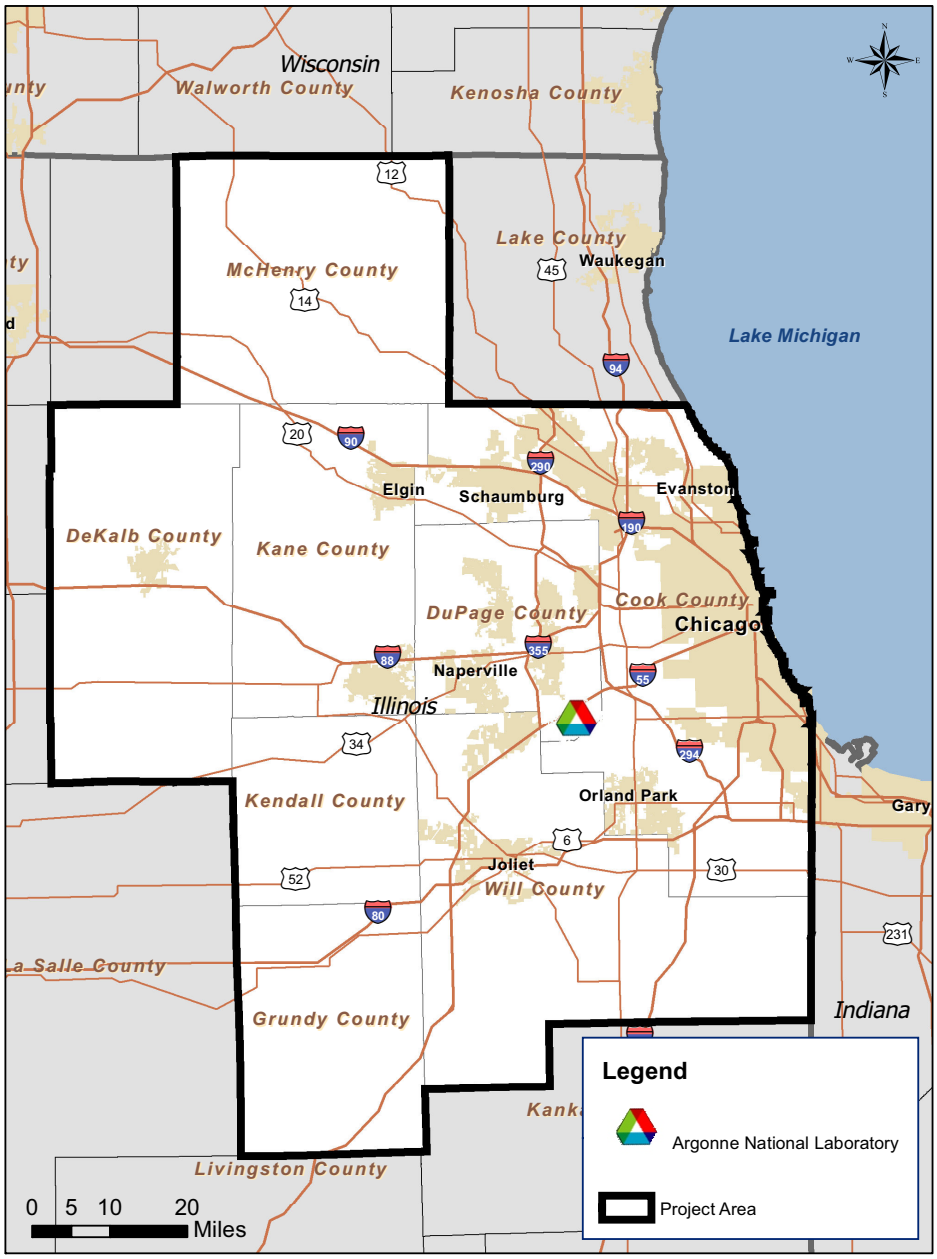
ARGONNE EXPENDITURES

To understand the economic impact that Argonne has on the Chicago region and the state of Illinois requires first understanding the expenditure patterns of the lab and people from outside the area who visit the lab. Argonne provided data on each of these areas of expenditure for fiscal year 2010.

Argonne Expenditures

In fiscal year 2010, Argonne had total expenditures of $641.5 million. This represents the total cash outflows of the lab during the year, covering operating expenses, capital expenditures, and payroll for employees. Each payment recorded was analyzed based on vendor name, vendor location data, payment amount and account category. From this we were able to allocate the expenses into categories, and assess whether the payment was directed within the Chicago region, within the state, or to a location outside Illinois.

FIGURE 1. Eight-County Chicago Region



Source: Anderson Economic Group, LLC, 2011; ESRI Inc., 2011, Argonne National Laboratory, 2011.

Expenditures by Category. Table 3 summarizes the total fiscal year 2010 expenditures made by Argonne. The expense categories align with the industry sector to which the payment was directed. We determined this based on the payment category (e.g. materials and supplies indicates a wholesale industry transaction, while legal services indicates a professional service industry transaction) and the name of the vendor. The "Household" industry sector includes all salary and wages paid to Argonne employees. This, not surprisingly, was the largest expense category, followed by professional, scientific, and technical services.

Expenditures by Geographic Area. To assess where the expenditures were directed required the use of our Geographic Information System (GIS). We used the GIS to assess the location data given for each payment entry and to identify whether the payment was made to a vendor within the Illinois, within the Chicago region, or elsewhere. As shown in Table 3, almost 56 percent of Argonne's total expenditures were made in the Chicago region ($357 million). These expenditures account for 99% of Argonne's expenditures in Illinois.

TABLE 3. Argonne Expenditures in FY 2010

Receiving Industry	Total Expenditure	Share of Total in Chicago Region	Expenditure in Chicago Region
Accommodations	$8,060,890	3.7%	$299,133
Construction	$34,139,823	55.7%	$19,00,518
Educational Services	$8,997,445	91.0%	$8,187,957
Banks	$31,440	0.0%	$-
Food Services	$259,072	62.3%	$161,523
Insurance Carriers	$73,022,267	18.8%	$13,725,026
Management	$249,635	100.0%	$249,635
General Manufacturing	$39,816,273	21.7%	$8,635,308
Other Services	$5,384,375	47.8%	$2,571,881
Transportation	$8,387,257	23.8%	$1,997,806
Prof, Sci, Tech Services	$172,084,166	49.9%	$85,945,708
Publishing Industries	$12,947,025	14.1%	$1,822,169
Real Estate	$4,090,834	4.7%	$193,973
Rental and Leasing	$10,958,901	14.2%	$1,556,453
Social Assistance	$971,315	85.1%	$826,751
Utilities	$22,649,847	88.4%	$20,026,083
Waste Mngt	$2,944,554	11.4%	$334,473
Wholesale Trade	$58,460,146	47.2%	$27,591,089
Households	$178,008,935	92.5%	$164,575,791
Grand Total	**$641,464,199**	**55.8%**[a]	**$357,701,259**

Source: Argonne National Laboratory, Finance Department
Analysis: Anderson Economic Group, LLC

a. 99% of Argonne's expenditures in the state of Illinois take place in the Chicago region.

Argonne Visitors

Researchers, business people, students, and many others visit Argonne each year. Many of these visitors come from outside the region and the state, and with each visit they bring new expenditures to the area. Many of these visitors will stay on site at Argonne's Guest House, which includes a hotel and restaurant, while others stay at nearby hotels. Below we present the expenditures associated with these visitors. We do so using actual operating expenditure data from the contracted operator of the Guest House and by estimating off-site expenditures that over-night visitors bring to the region.

Guest House. Argonne, like many large organizations, contracts out certain operations that others can more effectively operate. To operate the Guest House, the contractor service provider spent nearly $3.1 million in FY 2010.[3] This amount, which included $2.1 million for operating expenses and just under $1 million for payroll expenses, is representative of the economic activity brought to the region by over-night visitors who stay at the Guest House.[4] The Guest House had 23,050 visitor nights in the last fiscal year.

Off-Site Visitor Expenditures. While most visitors to Argonne do stay on site, it is estimated that about 15 percent of all visitors stay off site at nearby hotels. This results in 3,458 off-site visitor nights for which accommodation, meal, and incidental expenditures are incurred. Federal *per diem* expense guidelines suggest an average daily expenditure of $161 per person for these categories. This totals to $556,658 for FY 2010.

Visitors who stay on site are also likely to make some expenditures off site, whether for a meal on the drive in, gasoline, or a forgotten toiletry item. We conservatively estimate this expenditure level by assuming a daily off-site expenditure of $10 for visitors staying on site. With 23,050 annual visitor nights for the Guest House, this yields an expenditure estimate of $230,500 in 2010.

Geographic Distribution of Visitor Expenditures. Of the total $3.9 million in visitor related expenditures, we conservatively estimate that nearly $3.6 million of these expenditures stays in the region, and $3.7 million stays in the state, with the remainder directed out of state, mainly in fees passed along to the out-of-state headquarters that oversee many of the national hotel and food chain operators.

3. The on-site childcare center and cafeteria operations are also contracted out, but are mainly supported by Argonne employee expenditures. As such we do not include their operating expenditures here, as their revenue comes from an expenditure source (Argonne payroll) already accounted for.
4. This expenditure level excludes rents and other facility usage fees received as revenue by Argonne from the contractor, thus avoiding any double counting of expenditures.

A Note on Argonne Revenue Sources

When analyzing economic impacts it is important to count expenditures as being net new to an area only if the funds that supported the expenditure would not have been spent in that area if not for the event or institution being studied. To think of this another way, we can ask ourselves if the funding that Argonne uses to support its expenditures would have gone to another source in the region if Argonne were not in operation. Given the very specialized nature of operations at Argonne, it is very unlikely that any of the funds provided to the lab would have come to the region if the lab were closed, or located elsewhere. As such, we have assumed that 100% of Argonne's expenditures are net new to the region and the state.

ECONOMIC IMPACT FROM ARGONNE RELATED EXPENDITURES

Economic Impact Multipliers

As each dollar spent by Argonne enters the state and regional economy it supports additional business activity, jobs, and payroll. The magnitude of this additional activity varies by industry and region, and these variances are reflected in the economic impact multipliers used in our analysis.[5] Larger multipliers indicate that spending by an industry in a region is likely to produce greater levels of indirect economic impacts as the dollars continue to circulate in the area. Lower multiples suggest that the spending is likely to produce smaller levels in indirect economic impacts. Spending that supports significant reinvestment in an area produces a high multiplier, while spending that quickly leaves the region and is reinvested elsewhere yields a low multiplier.

Please see table Table A-1, "State of Illinois Economic Impact Multipliers," on page A-2 and Table A-2, "Chicago Region Economic Impact Multipliers," on page A-3 for the economic impact multipliers used in this analysis.

Argonne Economic Impacts in Illinois

Based on our analysis of FY 2010 expenditures related to Argonne, we estimate that the lab contributed to the creation of $696.9 million of total economic output in the State of Illinois.[6] This includes earnings going both to households and to businesses in Illinois. This includes creating 4,952 jobs and earnings of $214 million. These impacts come from the lab's direct expenditures and the expenditures attributable to those visiting the lab from outside of the area, as broken out below in Table 4 on page 14.

5. Economic multipliers used in this analysis are from the United States Bureau of Economic Analysis (BEA), Regional Input-Output Modeling System (RIMS).

6. This is inclusive of the Chicago region.

TABLE 4. Argonne Economic Impacts in Illinois

	Economic Output	Earnings	Employment
Contractor and Visitor Economic Impacts	$7,671,239	$2,217,214	77
Argonne Expenditure Economic Impacts	$689,213,735	$211,521,121	4,875
Total Economic Impacts	**$696,884,974**	**$213,738,336**	**4,952**

Source: Anderson Economic Group, LLC

Argonne Expenditures. As noted earlier, Argonne had total expenditures of $361 million directed to vendors and employees within the state of Illinois. These expenditures went to 19 different industry groups, including households, generating total economic output of $689 million dollars, creating 4,875 jobs, and earnings of $211.5 million for Illinois residents. This is summarized in Table 4 above and presented in more detail in Table A-4, "Economic Impacts from Argonne Expenditures, State of Illinois," on page A-5.

Argonne Visitors. The $3.7 million of expenditures in Illinois attributable to Argonne visitors also stimulates additional economic activity. As this money is reinvested in the state it is estimated to generate total economic output of $7.6 million dollars, create 77 jobs, and produce earnings of $2.2 million. Please see Table A-5, "Economic Impacts from Argonne Visitors, State of Illinois," on page A-6 for details on the impacts.

Argonne Economic Impacts in the Chicago Region

Argonne expenditures in FY 2010 are estimated to have contributed to the creation of $655.9 million of total economic output in the Chicago region while creating 4,575 and earnings of $195 million. These impacts come from the lab's direct expenditures and the expenditures attributable to those visiting the lab from outside of the area, as broken out in Table 5 below.

TABLE 5. Argonne Economic Impacts in the Chicago Region

	Economic Output	Earnings	Employment
Contractor and Visitor Economic Impacts	$7,007,887	$1,991,308	70
Argonne Expenditure Economic Impacts	$648,889,205	$193,492,954	4,505
Total Economic Impacts	**$655,897,092**	**$195,484,262**	**4,575**

Source: Anderson Economic Group, LLC

Argonne Expenditures. The nearly $358 million of Argonne expenditures directed to vendors and employees in the Chicago region were spread across 19 different industry groups, including households. As these groups received and reinvested the funds they contributed to an estimated economic output of $649

million dollars, 4,505 jobs, and $193.5 million of earnings for Illinois residents. This is presented in more detail in Table A-6, “Economic Impacts from Argonne Expenditures, Chicago Region,” on page A-7, and also summarized in Table 5, “Argonne Economic Impacts in the Chicago Region,” on page 14.

Argonne Visitors. Economic impacts from the nearly $3.7 million of expenditures in the Chicago region by Argonne visitors is estimated to generate total economic output of $7.0 million dollars, create 70 jobs, and produce earnings of $1.9 million. This is presented in more detail in Table A-7, “Economic Impacts from Argonne Visitors, Chicago Region,” on page A-8.

IV. The National Impact of Research Activities

Argonne National Laboratory makes a substantial contribution to nearly every aspect of American science and engineering. To understand the breadth and depth of Argonne's contributions, one must first understand the role of science and engineering in America. This section defines our use of key terms to describe the work of scientists and engineers. It then briefly outlines what we gain from technological progress and the resources provided by our nation's system of scientific knowledge production. Finally, the section describes the contributions that Argonne National Laboratory makes to these resources, providing specific examples to illustrate.

SCIENCE, ENGINEERING, AND TECHNOLOGY

To set the stage for the remainder of this section, we must first define what we mean by "science," "engineering," and "technology."

Argonne National Laboratory's staff includes highly trained scientists and engineers. Broadly speaking, scientists are trained in methods and techniques of basic science, preparing them for a career advancing the frontiers of human knowledge. Engineers, by contrast, are armed with extensive knowledge of science but focus on tools and techniques that allow the application of science to practical problems such as creating products that incorporate advanced science in their function but are usable by non-experts and can be produced at a reasonable price. The lines between scientists and engineers can be extremely blurry, however, as scientists often work on "applied science" and engineers often work on research that advances scientific knowledge.

As discussed above, Argonne's scientists and engineers work on basic science, applied science, and engineering. When the result of this work is an increase in the stock of scientific knowledge available to other researchers (often in the form of scientific publications) we refer to these results as "**science**." When the result is a new application of existing (or new) science to products or tools, we refer to these results as "**technology**."[7] We refer to the steady accumulation of advances in science and technology as "technological progress."

CONTRIBUTIONS OF AMERICA'S SCIENCE SYSTEM

Technological progress contributes to our nation in countless ways. At one end of the spectrum are intangible contributions, including improving national prestige, or advancing knowledge out of a drive and curiosity to push out from the frontiers of human achievement. Other contributions are more concrete, where

7. As with the distinction between the activities of "science" and "engineering," these results ("science" and "technology") can often defy easy classification, as when advanced engineering allows basic science research, or when new scientific ground is broken in the development of a new technology.

scientists and engineers work on solutions to specific problems our nation is facing in areas such as energy or national security. These "fruits" of science make a difference in our lives by helping to address national strategic priorities and by improving our standard of living.

Contributions to National Strategic Priorities

One important set of contributions that science and technology makes to our nation is the ability to address national strategic priorities that arise. Science contributes to the solution of countless technical problems in areas such as defense, which requires the ability to safely maintain our nation's nuclear arsenal; homeland security, where the ability to effectively scan cargo for weapons is crucial; and energy and transportation, where developing and producing a high-efficiency vehicle fleet and large scale renewable generation capacity will require many scientific and engineering breakthroughs.

Contributions of Science to our Standard of Living

Science makes contributions to our standard of living by improving both how much we can produce and what advanced products and services we can design.

Products and Services. Americans have grown used to steady improvements in their day-to-day lives stemming from scientific advancements in the technologies they use, including improved medical, transportation, and energy technologies.

Production Capacity. The productivity of our economy (that is, how much value in goods and services we can produce with an hour of a person's time) has been steadily improving as well, which gives us more income. Production is improved by science in several ways. First, scientific progress can make our plant and equipment (our capital stock) more efficient, less expensive, or both. Having access to more or better capital makes workers more productive. Additionally, better education, including science education, tends to make workers more productive above what can be accomplished by simply improving their tools. Improved technology can also allow new, more effective forms of organization in firms—think of the logistics revolution that has accompanied the ubiquitous use of computers in American companies.

ARGONNE'S ROLE IN DEVELOPING AMERICAN SCIENCE AND TECHNOLOGY

It is sometimes difficult for newcomers to Argonne to get a handle on the breadth of topics touched on by the laboratory's scientists. Indeed, simply listing the areas of research pursued by teams of researchers at Argonne, as in Table 6 below, shows the remarkable breadth and depth of scientific and engineering research taking place at Argonne National Laboratory. This section puts Argonne's role in American science and engineering into perspective by describing the types of research pursued by Argonne. It also provides perspective on how this research is used, describing Argonne National Laboratory's

contributions to both scientific knowledge and the nation's capacity to produce the new science needed to address our needs.

TABLE 6. Argonne National Laboratory Research Groups

Divisions	Research Groups
Nanoscale materials	Six research groups focusing on nanophotonics (how light interacts with very small materials), theory and modeling, and other topics.
Chemical Sciences and Engineering	Work on fundamental chemical interactions, catalysts, batteries, and other topics.
High Energy Physics	Work on particle accelerator research, astrophysics, theoretical physics, and other topics.
Material Science	Ten research groups focused on superconductivity, magnetic films, electron microscopy, and other topics.
Physics	Research groups focused on accelerator research, theory, and other topics.
Decision and Information Sciences	Work on simulation of the electricity market, weapons system procurement simulations, emergency preparedness, and other topics.
Energy systems	Research centers focused on distributed energy, process technology (such as materials recycling and metals research), ceramic membranes, and other topics.
Nuclear Engineering	Research on nuclear systems engineering, non-proliferation, system diagnostics, and other topics.
Transportation Research Analysis and Computing Center user facility	Research on traffic modeling, alternative fuel systems, fluid dynamics, and other topics.
Mathematics and Computer Science	Research focuses on optimization, parallel algorithm and software development, scalable systems software, applied mathematics, advanced simulations, distributed computing, bioinformatics, and other topics.
Biosciences	Work on structural biology, computational biology, and other topics.
Environmental Science	Work on climate research, environmental policy, integrated environmental assessments, and other topics.
Photon Sciences	X-ray research on structural biology, advanced materials, and other topics.

Source: Argonne National Laboratory

Argonne's role is closely linked to its role as one of 17 national laboratories. It is one of 10 labs currently overseen by the U.S. Department of Energy's Office of Science.[8] Its mission is "... to apply a unique mix of world-class science, engineering and user facilities to deliver innovative research and technologies," and to "... create new knowledge that addresses the most important scientific and societal needs of our nation."[9] In short, Argonne provides resources not found in university or corporate research settings and is a valuable resource for addressing national priorities.

8. Seven other national laboratories are overseen by Department of Energy divisions other than the Office of Science.
9. Source: Argonne National Laboratory website accessed January 2011 at http://www.anl.gov/Administration/mission.html

Argonne's contributions are in the following areas:

1. *Basic Science*
   Research is often called "basic" research if it advances the frontiers of human knowledge and increases fundamental understanding of the world, but doesn't necessarily have a clear, immediate application. While much basic research ends up being widely applied, the applications sometimes come much later and are not a major focus of the scientists engaging in the research.
2. *Applied Science and Engineering*
   Scientists and engineers often try to solve particular problems by putting existing scientific knowledge into practice, or by working through particular scientific puzzles that are acting as barriers to a solution. Though such work can lead to new knowledge of basic science, work undertaken with a particular practical problem in mind is broadly referred to as "applied science."
3. *Hosting and Creating Science Infrastructure*
   The work of scientists sometimes relies on access to particular pieces of equipment, technologies, communities, or institutions. We might think of these tools that support scientific advancement as the "infrastructure" of the scientific community.
4. *Contributing to the Pipeline of Scientists and Engineers*
   Scientific research is undertaken by scientists, engineers, technicians, and others with an interest and education in science. The "pipeline" of scientists in this context is the system of education and training that produces the people that perform and support this work.

The remainder of this section provides explanations and examples of how each of these types of contributions improve our standard of living and enhances our ability to address national priorities.

ARGONNE CONTRIBUTIONS TO BASIC SCIENCE

The most straight forward contribution of Argonne National Laboratory to American science and engineering is through its work on basic science. "Basic science" is a term commonly used for research meant to advance human knowledge without a specific, immediate application in mind. Such research adds to the body of scientific knowledge available to later scientists, engineers, entrepreneurs, and policymakers as they work to address national priorities, improve their company's productivity, or invent a new product.

Such advancements are often completed without the original scientists having considered such an application of their work. Imagine the surprise it would give early researchers of electromagnetism and quantum mechanics to see the computers, wireless internet connections, and mobile phones in wide use today that have come from steady advancements built on their original work. Indeed, it is rare that a particular product, efficiency improvement, or technical solution can be easily traced back to an individual scientific paper advancing a field. Never-

theless, one way that scientists measure their own progress in contributing to basic science is by simply counting the number of publications they have produced and the number of times that work has been cited. By these measures, Argonne scientists continually make significant contributions to basic science. Scientists at Argonne have published over 11,000 peer-reviewed papers from 2000-2010. These papers fall into eight categories of science, as shown below in Table 7.

TABLE 7. Published Papers by Argonne Scientists, 2000-2010

Field	Number of Papers	Rank in Field (Based on Number of Papers)[a]
Physics	5,004	31
Chemistry	1,992	152
Engineering	1,391	149
Materials Science	862	118
Biology & Biochemistry	403	484
Geosciences	397	291
Computer Science	259	280
Environment/Ecology	158	494
Other Fields[b]	543	n/a
Total	**11,009**	**313**[c]

Source: Essential Science Indicators, accessed November 2010

a. Rank among thousands of research institutions worldwide tracked by Essential Science Indicators.

b. Published papers not falling into one of the eight major categories.

c. This rank is based on number of publications. Argonne is ranked 246 in terms of number of citations. Having a higher rank in citations than in number of publications is a rough indicator that publications produced by Argonne Scientists have more impact than the average scientific publication.

As shown in Table 7, Argonne makes the most significant contribution to basic science in physics, where it has contributed over 5,000 publications in the past decade and ranks 31st out of thousands of research institutions worldwide tracked by Thompson-Reuters, the publishers of Essential Science Indicators. Argonne also ranks between 118 and 152 (out of thousands) in chemistry, engineering, and materials science, producing hundreds of papers in each of these broad categories of science. Argonne scientists also have produced hundreds of papers in several other broad fields of science, including computer science, biology and biochemistry, and others.

HOW ARGONNE CONTRIBUTES TO APPLIED SCIENCE AND ENGINEERING

In addition to basic science, Argonne scientists and engineers produce a tremendous amount of applied science, producing scientific know-how that others can apply to specific problems of national or industrial importance. There are two main ways that Argonne science is applied outside the laboratory. First is research done at Argonne addressing a need for an outside entity (such as a private company or a federal government agency), including research on grants provided by the government or companies. As discussed below, Argonne partners with outside entities in hundreds of such agreements each year.

Second, research and technology development at Argonne can be transferred to private sector use through patents and other technology transfer licensing, whereby a private company pays for permission to use a technology developed by Argonne scientists.

Contracts and agreements with federal agencies such as the U.S. Department of Energy are among the clearest examples of Argonne National Laboratory contributing to our nation's capacity to address national priorities as they arise. Below we outline the main types of applied research partnerships Argonne uses; provide some basic data on the number of partnerships; and provide several illustrative examples of recent successes in areas of science that are currently national priorities.

Research at Argonne for outside entities falls into four main categories:

- *Cooperative Research and Development Agreements (CRADA)*
  These agreements facilitate the transfer of technology from Argonne and other government laboratories to the broader research community, the private sector, and state and federal governments.
- *Work for Others (WFO)*
  WFO is a Department of Energy program that allows Argonne and other government laboratories to assist organizations outside the DOE, such as private companies and other federal agencies, with technical problems drawing on the labs' unique areas of expertise.
- *Technology Services Agreements (TSA)*
  TSAs allow outside organizations such as a universities or a private companies to take advantage of specialized equipment and expertise at Argonne and other laboratories. These agreements typically do not involve extensive research participation by Argonne scientists and engineers and involve a much smaller budget and shorter timeline than other agreements such as WFOs.
- *"Other DOE Contractor" Funding Agreements*
  Other federal laboratories that are operated by Department of Energy contractors sometimes wish to make use of Argonne's technology, equipment, and expertise to work through specific problems. This section refers to the funding associated with these arrangements as "Other DOE Contractor" funding agreements.

As shown in Table 8 below, Argonne engages in hundreds of agreements each year with outside organizations such as universities, federal agencies, and private companies. We discuss patents and licensing agreements further in "Argonne Contributions to Science Infrastructure" on page 24.

TABLE 8. R&D Sponsor and Technology Transfer Agreements at Argonne, 2006-2010

Fiscal Year	CRADAs	Nonfederal WFO	Federal WFO	Nonfederal TSAs	Federal TSAs	Other DOE Contractors	Licensing Agreements /Options	Total Tech Transfer Agreements
2006	15	108	72	25	0	272	50	542
2007	12	120	65	25	3	222	44	491
2008	13	101	74	13	4	235	50	490
2009	13	86	69	20	3	285	40	516
2010	19	76	80	24	1	275	28	503

Source: Argonne National Laboratory

To amplify the impact of Argonne's core science mission, the laboratory works with outside companies to commercialize and license technologies developed there. As shown in Table 9 below, for the past several years Argonne has licensed or patented between 30 and 50 technologies each year, including the licensing of software developed at the lab.

TABLE 9. Patent and Licensing Activity at Argonne, 2006-2010

Fiscal Year	Number of New Patent Licenses	Number of New Software Licenses	*Memo: Total Number of Licenses*	Gross License Revenue
2006	10	30	*40*	$2,100,000
2007	10	26	*36*	$6,100,000
2008	9	41	*50*	$1,318,000
2009	4	34	*38*	$3,270,000
2010	3	30	*33*	$2,480,000

Source: Argonne National Laboratory

EXAMPLES OF APPLIED SCIENCE AT ARGONNE

As an organization that has hundreds of tech-transfer agreements and produces thousands of basic science papers, Argonne's work on applied science touches a very large set of topics. To narrow the examples to a manageable scope, we provide examples focused on three areas that are currently national priorities

for policy makers and industry: national security, energy and transportation, and public health.

Argonne Science Applied to Energy and Transportation

NMC Technology for Advanced Batteries. Argonne scientists and engineers have developed Nickel-Manganese-Cobalt (NMC) technology, which increases by at least 50% the amount of energy that can be stored in a lithium-ion battery of a given size. Starting from basic science research in the 1980s, DOE-supported R&D in the 1990s, and early patents in 2000, Argonne-developed NMC technology is now licensed to several companies for applications in electronics and automotive applications. Companies licensing NMC include BASF and LG Chem Power Inc., which manufactures the batteries for the Chevy Volt, the first mass-market plug-in hybrid-electric vehicle in the country. Advanced-battery manufacturers Panasonic, Samsung and Sanyo also use the technology extensively in markets abroad.

EnerDel/Argonne High-Power Battery for Hybrid Electric Vehicles. Argonne National Laboratory and EnerDel corporation[10] have jointly developed a lithium-ion battery for hybrid electric vehicles (HEVs) that is reliable, safe, lightweight, more compact, more powerful and longer lasting than the batteries in today's HEVs, which use nickel-metal hydride (Ni-MH) technology. One important advance in this battery's development is the replacement of graphite anode material in previous lithium-ion batteries with nano-phase lithium titanate (LTO), which improves safety.

The battery is expected to meet the U.S. Advanced Battery Consortium's $500 manufacturing price criterion for a 25-kilowatt battery representing a significant cost advantage over available Lithium ion and NI-MH batteries currently in use.

Advanced Fuel Cycle Initiative. Argonne scientists are working with the research community in the U.S. and internationally to develop technologies that improve the safety, proliferation risk, and cost of disposing of spent nuclear fuel from nuclear power plants. Argonne researchers from 3 departments are engaged in research on systems with advanced fuel cycles, new chemical separation technologies, new fuels, materials, and applied physics.

Vehicle Technologies Program. Argonne's Electrochemical Energy Storage department participates in the Department of Energy's Vehicle Technology Program by leading its applied battery R&D program. Working in conjunction with five other DOE-administered laboratories to develop new materials that will allow the capacity, safety, and energy densities required to achieve a 40-mile range on electric power only.

10. EnerDel is owned by Ener1, Inc. and Delphi Corp.

Integrated Fuel Technologies Using Licensed Technology. Washington-based Integrated Fuel Technologies has licensed from Argonne a catalyst for removing 95 to 100 percent of nitrogen oxide emissions from diesel engine emissions. Compared to existing technologies, the Argonne-developed technology is relatively inexpensive and performs well in high water vapor environments and with newly-required low-sulfur diesel fuel. The technology will be used in new products and could be retrofitted into existing applications.

Argonne Science Applied to National Security

Trace Explosives Detection Capability at Argonne. Argonne is working in collaboration with other researchers in the private sector, other national laboratories, and university researchers to develop a detection method for quickly screening people for trace explosives. The technology relies on detecting the specific spectral signals of molecules common in explosives while ignoring harmless molecules in nearby materials and the air. The Department of Defense-funded team's work will provide the basis for detection equipment produced by Sarnoff Corporation.

Nuclear Forensics Capability at Argonne. The Chemical Science and Engineering division at Argonne works with law enforcement and other government agencies providing work on nuclear forensics. This is the ability to identify unique chemical "fingerprints" in radioactive materials available in the private sector, which helps track down the source of the material.

Argonne Science Applied Public Health

Protein Crystallography at Argonne's APS used to Develop Kaletra. The hard x-ray capabilities of Argonne's Advanced Photon Source played a crucial role in Abbot Labs' development of Kaletra. The drug, approved by the FDA in late 2000, is an antiretroviral drug that is an important component of one approach to treating HIV using a combination of drugs. The drug had sales of over $2.3 billion from 2003 to 2009, making it one of the most important treatment options available.

Akonni Biosystems Using Licensed Technology. Maryland-based Akonni Biosystems has licensed 26 patents from Argonne (and filed many of their own) to provide products based on gel-drop array technology in medical applications. The company's products test for industrial contaminants, food pathogens, disease indicators, and bioterror agents.

ARGONNE CONTRIBUTIONS TO SCIENCE INFRASTRUCTURE

Argonne makes a significant contribution to our nation's (and the world's) science infrastructure by hosting five widely-used national user facilities on-site and other equipment and facilities. These facilities are widely-used by researchers throughout the country and the world to engage in cutting-edge research in many fields. The facilities include unique equipment, such as unique x-ray and

imaging equipment and supercomputers, and unique teams of expert scientists and engineers that can help users address specific research problems.

User Facilities

Each Argonne user facility is used by hundreds, or in some cases thousands, of scientists and others each year. The users come from other research institutions. such as universities and private industry, and use the facilities for their own research, supported by Argonne's professional staff of experts on operating the facilities. As such, Argonne's user facilities represent a significant asset for researchers in the university, research, and private sectors, who are able to benefit from, for example, the use of an advanced x-ray source that they do not have the scale or expertise to maintain on their own.

As shown in Table 10 below, thousands of users visited Argonne's campus in 2010 to use these facilities, and over a thousand more were able to use facilities remotely.

TABLE 10. Users of Argonne User Facilities, 2010

Facility	Unique Visitors	Remote Users	Total Users	*Memo: Foreign Users*
Argonne Leadership Computing Facility (ALCF)	n/a	928	928	*104*
Advanced Photon Source (APS)	3,642	154	3,796	*459*
Argonne Tandem Linear Accelerator System (ATLAS)	170	n/a	170	*63*
Center for Nanoscale Materials (CNM)	382	88	470	*24*
Electron Microscopy Center at Argonne National Laboratory (EMC)	190	n/a	190	*17*
Totals	**4,384**	**1,170**	**5,554**	***667***

Note: Argonne's Transportation Research Analysis and Computing Center (TRACC) user facility works differently than the facilities listed in this table. They work with outside groups, but the analysis is performed by TRACC's staff rather than by the "users" themselves.
Source: Argonne National Laboratory

Advanced Photon Source. The Advanced Photon Source (APS) is one of the most important pieces of scientific infrastructure at Argonne. It provides the brightest x-ray beams available outside Europe, and is used by thousands of researchers each year to investigate the structures of molecules such as proteins. It is a very important resource for biologists, chemists, materials scientists, physicists, and others.

Scientists from private companies make up 3-4% of users of the APS, including companies that use the x-ray beams from the APS to probe the structure of candidate molecules for pharmaceutical applications. As discussed above in "How Argonne Contributes to Applied Science and Engineering" on page 21, Abbot Labs used the APS as part of its process to develop an important component of a

drug combination treatment for HIV that is widely-used in both the developed and developing worlds.

Manufacturers of automotive fuel injectors have made extensive use of the APS to analyze the effect of design choices on fuel spray, which affects the efficiency and emissions of engines. These companies use the APS to investigate using x-rays properties of fuel sprays that they cannot see with visual light. Companies that have used the APS in this way include General Motors, Chrysler, and Daimler, and the major automotive parts suppliers Visteon, Delphi, Bosch, Continental, and Denso. This work has also lead to several high-impact publications in top science journals.

Argonne Tandem-Linac Accelerator System. The Argonne Tandem-Linac Accelerator System (ATLAS) is a superconducting linear particle accelerator. It is particularly useful for researchers studying the properties of the nucleus of atoms. In 2010 researchers from 14 U.S. states and 63 foreign countries used ATLAS.

Center for Nanoscale Materials. The Center for Nanoscale Materials (CNM) at Argonne provides instruments and expertise for interdisciplinary research on nanoscience and nanotechnology, the study manipulating matter on the molecular and atomic scale. CNM supports the development of advanced instrumentation and assists researchers doing basic nanoscience research. Over 380 users from 28 states and territories and 24 foreign countries used CNM in 2010.

Electron Microscopy Center. Argonne's Electron Microscopy Center (EMC) allows scientists to research advanced materials and works to develop advanced instrumentation and techniques for doing research with electron microscopes. In 2010 EMC had 190 unique users from 16 U.S. states and 17 foreign countries.

Leadership Computing Facility. The Argonne Leadership Computing Facility (ALCF) provides its users access to one of the world's fastest supercomputers. Over 900 users annually use this facility remotely to help with especially computationally-intensive research such as climate science. Past users that have achieved product advancements through their use of the ALCF include Proctor and Gamble and Pratt and Whitney. Proctor and Gamble used the ALCF to improve the efficiency of their product development process by simulating bubble formation. Pratt and Whitney used the ALCF to simulate combustion and other processes in improving their jet engine designs.

Transportation Research and Analysis Computing Center. Argonne's Transportation Research and Analysis Computing Center (TRACC) provides supercomputing capability for its users. The simulation and visualization capabilities it provides has contributed to advances in crashworthiness of airplanes, aerodynamics, combustion, structural analysis of bridges, and traffic simulation.

Open-Source Contributions

In addition to having widely-used equipment and facilities, Argonne contributes to the nation's science infrastructure by creating open-source tools available to scientists and others. These include dozens of software packages and tool kits created by Argonne scientists that are widely used by researchers and high-tech industry in fields such as parallel computing, cryptography, optimization, numerical algorithms, and grid technology.

One important and widely-used software tool created by Argonne scientists is GREET, the Greenhouse gases, Regulated Emissions, and Energy use in Transportation model that simulates emissions output and energy consumption of vehicles with different designs and fuel uses. This software is used by government agencies, researchers, and the energy and automotive industries. It currently has over 14,000 users worldwide.

ARGONNE CONTRIBUTION TO THE SCIENCE PIPELINE

Argonne also contributes to the world of American science by supporting the "pipeline" of new scientists produced by our nation's K-12 schools, colleges, and universities. While educating future scientists is not a primary mission of Argonne National Laboratory, the programs and opportunities provided by this national resource directly touch the lives of and inspire hundreds of students each year. The remainder of this section describes many of the educational programs Argonne operates.

Argonne's Engagement with The Local Community

Argonne contributes to the local community's awareness of scientific research and science careers with many types of engagement. The laboratory also periodically hosts an open house that attracts around 25,000 people and hosted 325 organized tours in 2010. The most important contributions may be from the scientists and other workers simply being part of their community. Argonne scientists regularly participate in school events such as science fairs and talking with students and community groups about science. Many Argonne employees are members of community service organizations and affinity groups that focus on getting underrepresented minorities interested and involved in science.

Argonne Contributes to K-12 Science Education

Argonne contributes to the pipeline of American scientists and engineers at the K-12 level in several ways. At the most basic level, the laboratory hosts between 3,000 and 5,000 students each year in field trips, mostly from Chicago-region schools. These field trips reinforce students' interest in science by providing hands-on experiences with science concepts. The laboratory also gets students directly involved with science by providing competitively-awarded internships to 20 high school students each year that get students involved in real research at Argonne. Argonne also participates in several science programs and competitions for students, including:

- Rube Goldberg Machine Competition
- Introduce a Girl to Engineering Day
- Science Careers in Search of Women
- Energy Challenge competition for students on Indian reservations
- Middle School Science Bowl

Argonne also contributes to K-12 science education. They operate the Newton Ask a Scientist website where students can submit science questions that are answered by volunteer scientists from Argonne and elsewhere, providing a resource for students and teachers. Argonne is also involved directly with high school science teachers, hosting 10-week programs for 20 teachers who make a 3-year commitment to science curriculum development.

Opportunities for Community College and Undergraduate Students

Argonne contributes directly to the training of community college and undergraduate students by giving hands-on experience in conducting scientific research. The lab offers 300-400 competitively-awarded paid internships annually for these students, who work directly with scientists and technicians at Argonne on tasks like setting up experiments and collecting data.

Training for Graduate Students and Post-Doctoral Scientists

The most direct way that Argonne contributes to the pipeline of scientists is by providing positions that allow graduate students, post-doctoral researchers, and visiting faculty to pursue research that furthers their education and career opportunities. Argonne typically hosts 70 visiting faculty, 300 post-doctoral researchers, and 350 graduate students pursuing research at any given time. As a result of this continuing engagement with the early careers of scientists, there are thousands of scientists with Argonne connections and experience in top research institutions throughout the country and the world.

Appendix A. Data and Methodology

This appendix includes methodological discussions, as well as data tables.

ECONOMIC IMPACT ANALYSIS TABLES

This appendix includes the following tables:

TABLE A-1. State of Illinois Economic Impact Multipliers

	Economic Output	Earnings	Employment
Accommodations	2.14	0.63	17.98
Construction	2.45	0.78	18.30
Educational Services	2.38	0.77	23.69
Fed Reserve Banks	2.05	0.55	10.92
Food Services	2.35	0.68	29.34
Insurance Carriers	2.43	0.71	14.29
Management of Companies	2.35	0.79	13.53
Misc Manufacturing	2.34	0.67	12.94
Other Services	2.41	0.71	21.01
Other Transportation	2.35	0.86	19.75
Prof, Sci, Tech Services	2.30	0.83	16.55
Publishing Industries	2.29	0.62	13.41
Real Estate	1.59	0.22	6.65
Rental and Leasing Services	1.97	0.48	10.87
Social Assistance	2.37	0.76	34.74
Utilities	1.80	0.43	7.50
Waste Mngt	2.17	0.57	12.61
Wholesale Trade	2.09	0.63	12.73
Households	1.51	0.42	11.40

Source: United States Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II).

Note: Output and Earnings multipliers represent the total dollar change in output or earnings that occurs across all industries for each additional dollar delivered to final demand in the listed industry. Employment multiplier represents the total change in jobs that occurs in all industries for each additional $1 million dollars delivered to final demand in the listed industry

TABLE A-2. Chicago Region Economic Impact Multipliers

	Economic Output	Earnings	Employment
Accommodations	2.07	0.60	17.18
Construction	2.31	0.71	16.82
Educational Services	2.30	0.73	22.57
Fed Reserve Banks	1.99	0.51	10.22
Food Services	2.23	0.64	28.28
Insurance Carriers	2.35	0.65	13.12
Management of Companies	2.26	0.73	12.44
Misc Manufacturing	2.24	0.62	12.00
Other Services	2.34	0.67	20.00
Other Transportation	2.28	0.82	18.96
Prof, Sci, Tech Services	2.22	0.78	15.54
Publishing Industries	2.24	0.58	12.70
Real Estate	1.55	0.21	6.61
Rental and Leasing Services	1.96	0.46	10.61
Social Assistance	2.28	0.72	33.82
Utilities	1.64	0.36	6.29
Waste Mngt	2.11	0.54	11.98
Wholesale Trade	2.02	0.59	11.84
Households	1.42	0.38	10.66

Source: United States Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II).

Note: Chicago Region defined to include the counties of Cook, DeKalb, DuPage, Grundy, Kane, Kendall, McHenry, and Will. Output and Earnings multipliers represent the total dollar change in output or earnings that occurs across all industries for each additional dollar delivered to final demand in the listed industry. Employment multiplier represents the total change in jobs that occurs in all industries for each additional $1 millio dollars delivered to final demand in the listed industry.

TABLE A-3. Argonne Visitor Expenditures by Category and Geography

	Total Expenditure	Amount Assumed In-State	Amount Assumed Regional
Guest House Operations (hotel and restaurant)			
Operations (less payments to ANL)	$ 2,101,600	$ 1,996,520	$ 1,891,440
Payroll	$ 993,841	$ 993,841	$ 993,841
Subtotal: Onsite Contractor Expenditures	*$ 3,095,441*	*$ 2,990,361*	*$ 2,885,281*
Over-Night Visitors			
Staying Off-site, accommodations	$ 345,750	$ 328,463	$ 311,175
Staying Off-site, meals and incidentals	$ 210,908	$ 200,362	$ 189,817
Staying On-site, off-site incidentals	$ 230,500	$ 218,975	$ 207,450
Subtotal: Over-Night Visitor Expenditures	*$ 787,158*	*$ 747,800*	*$ 708,442*
Total Expenditures	$ 3,882,599	$ 3,738,161	$ 3,593,723

Source: Anderson Economic Group, LLC.

TABLE A-4. Economic Impacts from Argonne Expenditures, State of Illinois

	Economic Output	Earnings	Employment
Accommodations	768,566	226,785	6
Construction	46,562,670	14,757,703	348
Educational Services	19,516,814	6,326,834	194
Fed Reserve Banks	-	-	-
Food Services	378,772	109,868	5
Insurance Carriers	33,413,576	9,751,631	196
Management of Companies	585,819	197,911	3
Misc Manufacturing	20,229,074	5,791,701	112
Other Services	6,187,175	1,821,921	54
Other Transportation	4,704,233	1,718,512	39
Prof, Sci, Tech Services	200,995,027	72,575,964	1,444
Publishing Industries	4,167,665	1,121,181	24
Real Estate	373,607	52,090	2
Rental and Leasing Services	3,071,659	744,451	17
Social Assistance	1,958,326	628,744	29
Utilities	36,093,009	8,543,127	150
Waste Mngt	779,617	205,823	5
Wholesale Trade	57,790,007	17,468,061	351
Households	251,638,118	69,478,814	1,896
Total Economic Impact	$ 689,213,735	$ 211,521,121	4,875

Source: Anderson Economic Group, LLC.

** Includes Chicago Region*

Note: Each industry line represents the economic impact that is created across all industries by the total ANL expenditures directed to the named industry

TABLE A-5. Economic Impacts from Argonne Visitors, State of Illinois

	Economic Output	Earnings	Employment
Guest House Operations (accommodations and food service multipliers)	$ 4,482,187	$ 1,307,721	47
Guest House Payroll (household multiplier)	$ 1,500,700	$ 417,413	11
Subtotal: Onsite Contractor Impact	*$ 5,982,887*	*$ 1,725,134*	*59*
Over-Night Visitors			
Staying Off-site, accommodations (accommodations multiplier)	$ 702,910	$ 206,931	6
Staying Off-site, meals and incidentals (food service multiplier)	$ 470,851	$ 136,246	6
Staying On-site, off-site incidentals (food service multiplier)	$ 514,591	$ 148,903	6
Subtotal: Over-Night Visitor Impact	*$ 1,688,352*	*$ 492,081*	*18*
Contractor and Visitor Economic Impacts	$ 7,671,239	$ 2,217,214	$ 77

Source: Anderson Economic Group, LLC.

TABLE A-6. Economic Impacts from Argonne Expenditures, Chicago Region

	Economic Output	Earnings	Employment
Accommodations	618,896	178,242	5
Construction	43,801,895	13,513,169	320
Educational Services	18,791,361	5,965,746	185
Fed Reserve Banks	-	-	-
Food Services	359,583	103,181	5
Insurance Carriers	32,204,402	8,899,307	180
Management of Companies	563,776	181,335	3
Misc Manufacturing	19,340,500	5,366,844	104
Other Services	6,008,429	1,714,930	51
Other Transportation	4,550,202	1,641,597	38
Prof, Sci, Tech Services	190,704,932	66,917,328	1,335
Publishing Industries	4,072,730	1,054,854	23
Real Estate	301,279	41,200	1
Rental and Leasing Services	3,047,846	721,416	17
Social Assistance	1,887,391	598,981	28
Utilities	32,746,651	7,199,377	126
Waste Mngt	704,768	180,649	4
Wholesale Trade	55,700,891	16,198,728	327
Households	233,483,675	63,016,070	1,754
Total Economic Impact	$ 648,889,205	$ 193,492,954	4,505

Source: Anderson Economic Group, LLC.

Note: Each industry line represents the economic impact that is created across all industries by the total ANL expenditures directed to the named industry

TABLE A-7. Economic Impacts from Argonne Visitors, Chicago Region

	Economic Output	Earnings	Employment
Guest House Operations (accommodations and food service multipliers)	$ 4,066,596	$ 1,172,693	43
Guest House Payroll (household multiplier)	$ 1,411,254	$ 377,660	11
Subtotal: Onsite Contractor Impact	*$ 5,477,850*	*$ 1,550,352*	*54*
Over-Night Visitors			
Staying Off-site, accommodations (accommodations multiplier)	$ 644,132	$ 186,705	5
Staying Off-site, meals and incidentals (food service multiplier)	$ 423,291	$ 121,483	5
Staying On-site, off-site incidentals (food service multiplier)	$ 462,614	$ 132,768	6
Subtotal: Over-Night Visitor Impact	*$ 1,530,037*	*$ 440,956*	*17*
Contractor and Visitor Economic Impacts	$ 7,007,887	$ 1,991,308	$ 70

Source: Anderson Economic Group, LLC.

ECONOMIC IMPACT METHODOLOGY

In order to estimate the economic impact of Argonne National Laboratory we used an economic model that translates an increase in demand (e.g. spending) into total economic impact, which can be expressed in output, earnings and employment. The specific model we used is the U.S. Department of Commerce Regional Input-Output Modeling System (RIMS II), which uses multipliers to estimate final demand. We identify our assumptions for inputs, substitution effects, and multipliers in the preceding tables. This avoids the common problems of "black box" models for which some of the methodology and assumptions are hidden.

ESTIMATING EMPLOYMENT, OUTPUT AND EARNINGS

We estimated the net economic impact of Argonne National Laboratory in the State of Illinois and in the eight-county Chicago-Naperville-Joliet Metropolitan Division, which we call the "Chicago Region" in our analysis. We define net economic impact as the difference in employment, output, and earnings in two scenarios: (1) the current scenario, where Argonne operates in the Chicago Region, and (2) a counter factual scenario, in which we assume the lab was not in the area. We used the following methodology when estimating net economic impact.

1. Identified the impact region for the analysis.
   The first step in estimating the economic impact of a new project is to select the region for the analysis where additional earnings and employment occurs. In this analysis we looked at two regions: The State of Illinois and the Chicago Region of Illinois (Cook, DeKalb, DuPage, Grundy, McHenry, Will, Kane, and Kendall Counties).
2. Assessed the expenditure base.
   Next we assessed the expenditures that occurred in the impact regions in FY 2010 as a result of the lab being in operation. Payroll, operating, and capital expenditure data was obtained from the lab, and analyzed to measure where the expenditures were being directed. This was done using vendor and employee address data (city, state, and zip code information). We also used information on visitors to the laboratory to estimate spending by out-of-region visitors who make expenditures while in the market.
3. Determined substitution.
   We determined substitution for the lab using revenue source information and professional judgement based on the availability of the labs functions elsewhere in the market. Revenue data showed that more than 95 percent of all of the labs revenue came from out-of-state sources, and that the majority of in-state revenue came from University of Chicago, which administers the lab and forwards on revenues from federal sources. This, along with the fact that there is no ready substitute in the state, and in many cases the country, for Argonne's services, led us to assume that none of the expenditures would be substituted for if the lab were not in the region.
4. Considered alternative uses of the land.
   Argonne is situated 25 miles southwest of the City of Chicago. We considered what the area would be like if Argonne had not been started in its current location. We believe the area would be mostly residential, with some parks and light

commercial areas. We do not believe the alternative uses would have contributed to new employment or increased demand for goods and services in the region. Most of the development that would have taken place has already occurred around the lab.

5. Estimated economic impact.
To estimate Argonne's impact (in terms of total earnings, employment and output), we multiplied the net new demand (expenditures) by RIMS multipliers. These multipliers are industry specific, estimated by the U.S. Department of Commerce and are customized to the region. We then chose the RIMS industry category that most closely corresponded to the industries that the expenditures were being directed to. See Table A-1, "State of Illinois Economic Impact Multipliers," on page A-2.

Appendix B. About the Authors

Anderson Economic Group, LLC is research and consulting firm specializing in economics, finance and business valuation, and market and industry analysis. The firm has offices in Chicago, Illinois and East Lansing, Michigan. AEG has conducted economic and fiscal impact studies for universities across the United States. For more information please visit www.AndersonEconomicGroup.com.

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Ms. Sallee is a Senior Consultant and Director of the Public Policy, Fiscal, and Economic Analysis practice area.

Ms. Sallee's recent work includes preparing the report *Dollars and Sense*, a 2011 citizen's guide to Michigan's financial health released by Governor Rick Snyder. Ms. Sallee also completes an annual economic impact assessment for Michigan's University Research Corridor (Michigan State University, University of Michigan, and Wayne State University), and has done work for a number of other universities including the University of Chicago. She is also the lead author of the firm's annual 50-state business tax burden study.

Prior to joining Anderson Economic Group, Ms. Sallee worked for the U.S. Government Accountability Office (GAO) as a member of the Education, Workforce and Income Security team. She has also worked as a market analyst for Hábitus, a market research firm in Quito, Ecuador and as a legislative assistant for two U.S. Representatives.

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SCOTT D. WATKINS

Mr. Watkins is a Senior Consultant with Anderson Economic Group, LLC, with expertise in economic, industry, and market analyses, as well as public policy. He manages the firm's market and industry analysis practice area, working with public and private sector clients to deepen understandings of their market and place in the economy, and to develop strategies to strengthen their positions.

Among the clients for whom he has worked are more than 85 automobile dealerships; the Project Management Institute; City of Hamtramck, Michigan; City of Lansing, Michigan; Oakland County, Michigan; Collier County, Florida;

Northern Michigan University; Michigan State University; Ferris State University; Michigan Retailers Association; and the West Virginia High Technology Consortium Foundation. Recent publications by Mr. Watkins include: "Land Use and Infrastructure Investments by Olympic Host Cities: Legacy Projects for Long-term Economic Benefits," and The State Economic Handbook, as published by Palgrave Macmillan in 2008, 2009, and 2010. Mr. Watkins has made presentations to a number of audiences and media outlets on topics concerning the automotive industry, economics, education finance, and industry trends. He has also provided expert testimony in legislative and legal hearings, including automobile dealership arbitrations.

Prior to joining Anderson Economic Group in 2001, Mr. Watkins was an analyst in the automotive market and planning group at J.D. Power and Associates, and a marketing assistant with Foster, Swift, Collins, and Smith P.C.

Mr. Watkins holds an M.B.A. from the Eli Broad College of Business at Michigan State University. He also has a B.A. in marketing from Eli Broad College of Business and a B.A. in international relations from the James Madison College, both at Michigan State University.

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Mr. Rosaen is a Consultant at Anderson Economic Group, working in the Public Policy, Fiscal, and Economic Analysis practice areas. Mr. Rosaen's background is in applied economics and public finance.

Mr. Rosaen's recent work includes several economic and fiscal impact analyses, including of proposed real estate developments, power plants, and infrastructure projects; analysis of tax incentives; an analysis of the impact of federal tax incentives on the freight rail industry; and an analysis of the economic contribution that research universities make in the State of Michigan.

Prior to joining Anderson Economic Group, Mr. Rosaen worked for the Office of Retirement Services (part of the Michigan Department of Management and Budget) for the Benefit Plan Design group. He has also worked as a mechanical engineer for Williams International in Walled Lake, Michigan.

Mr. Rosaen holds a Masters in Public Policy from the Gerald R. Ford School of Public Policy at the University of Michigan. He also has a Masters of Science and a Bachelors of Science in mechanical engineering from the University of Michigan.