

PNNL-25883



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ECONOMIC IMPACT OF
Pacific Northwest
National Laboratory on
the State of Washington
in Fiscal Year 2015

OCTOBER 2016

U.S. DEPARTMENT OF
ENERGY

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Economic Impact of Pacific Northwest National Laboratory on the State of Washington in Fiscal Year 2015

JM Niemeyer

October 2016

Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Highlights



\$302M

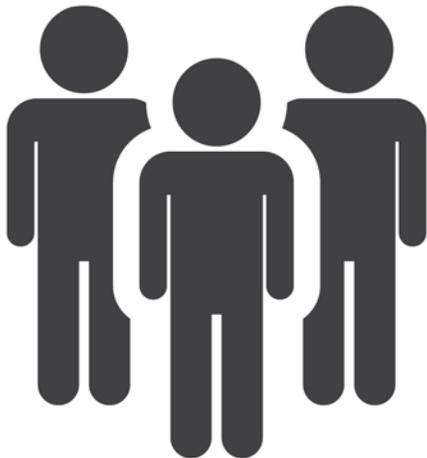
Domestic purchased goods and services

\$76M in Washington State



\$955M

Annual Spending



4,377

Employees

94% (4,107) living in Washington State in 2015

24% growth in employment 2000-2015



\$412M

Total payroll

\$384M in Washington State



\$24.2M

Estimated taxes paid by PNNL and its employees to Washington State and local governments

Impacts



\$1.38B

Total economic output supported by PNNL payroll and domestic purchased goods and services

\$519M in Washington State wage income

6,786 total jobs generated in Washington State

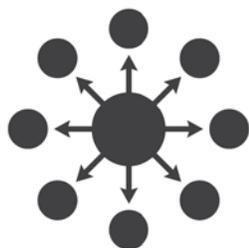


\$1.14B

Total economic output supported by PNNL-related health care, companies with PNNL roots, visitors, and retirees in Washington State

\$422M in Washington State wage income

5,687 total jobs generated in Washington State



99

Companies with PNNL roots

71 in Washington State

\$567M estimated revenue in Washington State

3,701 total employees

2,293 employees in Washington State



\$824K

Value of Battelle, PNNL, and PNNL employee cash contributions to philanthropic and civic organizations, including **\$269K** corporate support for STEM education

Acknowledgments

Pacific Northwest National Laboratory's (PNNL's) fiscal year (FY) 2015 Economic Impact Analysis report was prepared by PNNL Economist Michelle Niemeyer and Energy Analyst Eric Poehlman, with editorial support from Jennifer Blake and Julie Fisher and key contributions throughout the report by Christopher Larmey.

Other PNNL and Battelle staff members who provided the data used in this report include Jennifer Anaya, Lori Avery, Kerry Bass, Jonathan Bates, Mark Bayless, Jim Blount, Andrea Brown, Steve Cassidy, Peter Christensen, Robin Conger, Tracie Cowen, Danielle Deichman, Jeff Estes, Mindy Frankenfield, Spencer Garrett, Mark Hatstrup, Brenda Herrington, Pamela Hughes, Kelly Kraft, Terry Law, Vanessa Moore, Charlotte Morgan, Marc Podratz, Bruce Simanton, Gary Spanner, Christie Sylvester, Annette Schutzenhofer, Janel Tingey, Lori Williams, and Jimmy Voyles.

Executive Summary



PNNL is a large economic entity with a total of 4,377 employees, \$919 million (M) in total funding, and \$955M in total spending during FY 2015.¹ The number of employees that live in Washington State is 4,107, which is 94 percent of the Laboratory staff.

The Laboratory directly and indirectly supported \$1.38 billion (B) in economic output, 6,786 jobs, and \$519M in Washington State wage income from current operations. The state also gained more than \$1.14B in output, over 5,500 jobs, and \$422M in income through closely related economic activities such as visitors, health care spending, spending by resident retirees, and companies with PNNL roots.²

PNNL affects Washington's economy through commonly recognized economic channels, including spending on payrolls and other goods and services that support Laboratory operations. Less commonly recognized channels also have their own impacts and include company-supported spending on health care for its staff members and retirees, spending of its resident retirees, Laboratory visitor spending, and the economic activities in a growing constellation of companies founded on PNNL research, technology, and managerial expertise.

PNNL also has a significant impact on science and technology (S&T) education and community not-for-profit organizations. PNNL is an active participant in the future scientific enterprise in Washington with the state's K-12 schools, colleges, and universities. The Laboratory sends staff members to the classroom and brings hundreds of students to the PNNL campus to help train the next generation of scientists, technicians, engineers, and mathematicians. This investment in human capital, though difficult to measure in terms of current dollars of economic output, is among the important lasting legacies of the Laboratory. Finally, PNNL contributes to the local community with millions of dollars' worth of cash and in-kind corporate and staff contributions, all of which strengthen the economy.

The purpose of this report is to quantify these effects, providing detailed information on PNNL's revenues and expenditures, as well as the impacts of its activities on the rest of the Washington State economy.

¹The latest PNNL data available was for FY 2015, spanning Oct. 1, 2014 through Sept. 30, 2015.

² Economic impact of PNNL's operations on Washington State varies annually, as federal research programs are dynamic and affected by levels of federal funding. For a comparison with selected other major technology entities in Washington State and with other Department of Energy national laboratories, see Appendix B.

Acronyms

ANL	Argonne National Laboratory	M	million
ARM	Atmospheric Radiation Measurement	MESA	Mathematics, Engineering, and Science Achievement
B	billion	NAICS	North American Industry Classification System
BNL	Brookhaven National Laboratory	NREL	National Renewable Energy Laboratory
DOE	U.S. Department of Energy	OASI	Social Security Old Age and Survivors' Insurance
EMSL	Environmental Molecular Sciences Laboratory	ORNL	Oak Ridge National Laboratory
FY	fiscal year	PNNL	Pacific Northwest National Laboratory
gsf	gross square feet	R&D	research and development
GSP	gross state product	S&T	science and technology
INL	Idaho National Laboratory	STEM	science, technology, engineering, and mathematics
IP	intellectual property	TAP	Technology Assistance Program
K	thousand	U.S.	United States
LASER	Leadership and Assistance for Science Education Reform	WBL	Work-Based Learning
LBNL	Lawrence Berkeley National Laboratory		

Contents

Highlights.....	ii
Impacts.....	iii
Acknowledgments.....	iv
Executive Summary.....	v
Acronyms.....	vi
Introduction.....	1
PNNL as an Economic Entity.....	2
PNNL Revenues and Expenses.....	2
PNNL Employment.....	2
PNNL’s Payroll and Benefits.....	3
Purchased Goods and Services and Investments.....	3
Expenditures for New Construction and Renovations.....	4
PNNL State and Local Taxes Paid.....	5
Economic Impact of PNNL Operations.....	6
Other Economic Influences.....	7
Health Care Expenditures.....	7
PNNL Retirees.....	7
Technology Transfer.....	8
Technology Commercialization: New Products and Companies with PNNL Roots.....	8
Intellectual Property.....	9
Honors and Awards.....	10
STEM Education and Work-Based Learning.....	10
PNNL Visitors.....	13
Community Investments and Assistance.....	13
EMSL and ARM Climate Research Facility Users.....	14
Economic Impact of Closely Related Activity.....	15
Conclusion.....	16
Appendix A The IMPLAN Model.....	17
Appendix B Benchmarking the Results.....	19

Figures

Figure 1. PNNL’s Total Funding in FY 2015 Was \$919M	2
Figure 2. PNNL’s Spending in FY 2015 Was \$955M.....	2
Figure 3. Location of PNNL Employees	2
Figure 4. PNNL Life Sciences Laboratory at the Richland, Washington Campus	4
Figure 5. FY 2015 Economic Impact of Washington Payroll and Purchased Goods and Services Expenditures by PNNL	6
Figure 6. Estimated Spending for Washington State PNNL Employee and Retiree Health Care in FY 2015	7
Figure 7. Total Impact of Health Care Spending, Companies with PNNL Roots, Visitor Spending, and Retirees on the Washington State Economy in FY 2015	15

Tables

Table 1. FY 2015 PNNL Purchased Goods and Services Spending (Total U.S. Domestic and in Washington State)	3
Table 2. PNNL Construction Spending in FY 2015	5
Table 3. FY 2015 Washington State and Local Taxes Paid by PNNL and its Employees	5
Table 4. Estimated Washington State PNNL Retiree Income in FY 2015	8
Table 5. Companies with Ties to PNNL—Number, Estimated FY 2015 Funding, and Number of Employees	8
Table 6. Technology Assistance Program Statistics	8
Table 7. PNNL Statistics on Inventions, Patents, Technology Transfers, and License Income	9
Table 8. Statistics on the PNNL STEM Education Programs in FY 2015	12
Table 9. Number of Out-of-Town Visitors and Visitor Days to PNNL Facilities	13
Table 10. PNNL and Battelle Community Assistance Statistics for FY 2015.....	14
Table 11. FY 2015 EMSL Users.....	15

Introduction

PNNL is a multidisciplinary national laboratory celebrating over 50 years of innovation and advancing the frontiers of S&T in areas that inspire and enable the world to live prosperously, safely, and securely. Located in Richland, Washington, PNNL is one of 10 United States (U.S.) Department of Energy (DOE) Office of Science national laboratories.

Since 1965, PNNL has made significant S&T discoveries that have benefitted the nation. These include major advances in our scientific understanding of changes in frequency and intensity of climate events, which help us prepare for droughts, floods, and other extreme conditions. In the area of energy, PNNL has developed advanced computing tools that analyze grid congestion faster and more accurately, saving utilities millions of dollars. The Laboratory has also developed a new organic aqueous flow battery that uses water-based liquid electrolytes and is 60 percent less expensive than current flow batteries. Research in national security has resulted in the development of low-cost attachments to a mobile platform, enabling detection of infectious pathogens in the field.

PNNL delivers world-leading S&T to understand, predict, and control the behavior of complex adaptive systems through a strong foundation of nationally and internationally recognized scientific capabilities. Major initiatives focus on answering critical scientific questions in complex biological, climate, subsurface, chemical, materials, and computing systems. PNNL's research strengthens the nation's foundation for innovation as staff members develop solutions for DOE and the National Nuclear Security Administration, U.S. Department of Homeland Security, and other federal agencies.

Operated by Battelle Memorial Institute, PNNL has 4,377 staff members with total spending of \$955M during FY 2015. PNNL operates the Environmental Molecular Sciences Laboratory (EMSL) and provides technical and operational leadership to the Atmospheric Radiation Measurement (ARM) Climate Research Facility. PNNL also operates a marine research facility in Sequim, Washington, and has satellite offices in Seattle, Washington; Portland, Oregon; and College Park, Maryland.

PNNL as an Economic Entity

PNNL Revenues and Expenses

► In FY 2015, PNNL’s funding totaled \$919M and spending totaled \$955M.

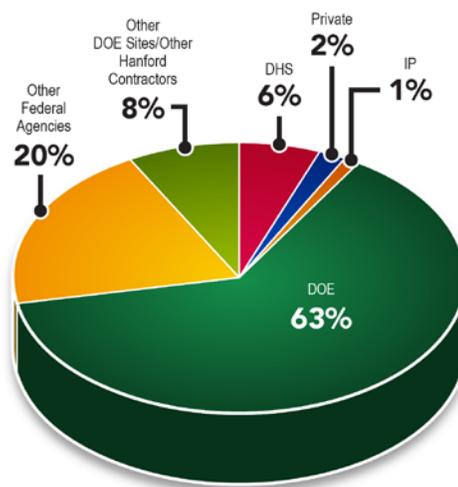
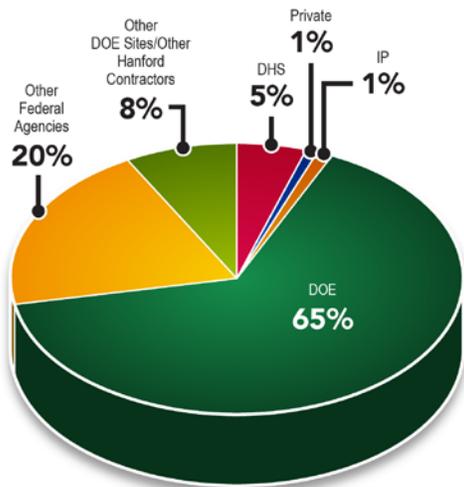


Figure 1. PNNL’s Total Funding in FY 2015 Was \$919M **Figure 2.** PNNL’s Spending in FY 2015 Was \$955M

During FY 2015, PNNL’s total funding was \$919M and total spending was \$955M (Figure 1 and Figure 2, respectively). The majority of the work that PNNL performs is for DOE (63 percent during FY 2015). Work that is conducted for other federal agencies includes the U.S. Department of Defense, the Nuclear Regulatory Commission, the U.S. Department of Health and Human Services, and other federal agencies that collectively represent 20 percent of PNNL’s funding. The U.S. Department of Homeland Security also plays a major role.

PNNL Employment

- Employment at PNNL grew 24% between FY 2000 and FY 2015.
- As of September 30, 2015, PNNL employed 4,377 staff members, with 94% (4,107) employed and residing in Washington State.

PNNL employed 4,377 people in FY 2015, 4,107 of who were residents of Washington State and worked mainly in Richland, Seattle, and Sequim (Figure 3).

In addition, there were 91 staff members in the Washington, D.C. area; 33 staff members assigned to work in Corvallis and Portland, Oregon (and are assumed to live in Oregon); and 146 staff members employed at other offices in the United States or in foreign countries.

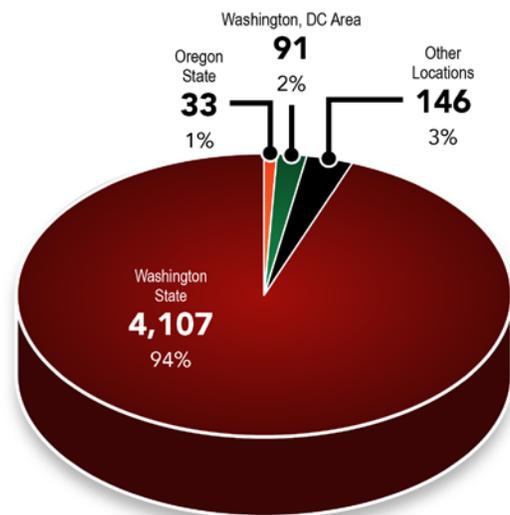


Figure 3. Location of PNNL Employees

PNNL's Payroll and Benefits

- ▶ PNNL spent a total of \$412M on payrolls, with \$384M going to Washington State residents.
- ▶ PNNL provides \$102M for employer-provided benefits to support Laboratory operations.

PNNL's total payroll during FY 2015 was \$412M, of which \$384M went to Washington State residents. Because the Lab is a research and development (R&D) organization, PNNL has a large percentage of high-wage professions (see the average wages of other selected Washington R&D organizations and other DOE national laboratories in Appendix B).

The average annual wage for all Washington State PNNL employees at the end of FY 2015 was \$93,401.¹ In 2015, the state average occupational wage was about \$52,000.² As such, the average PNNL worker likely spends at a higher level and, therefore, has an above-average impact on the state economy compared with the average worker in the state.

While not directly part of wages, benefits outlays contribute to PNNL's economic impact. PNNL provides a benefit package that costs \$102M per year. Included are an employer-provided health insurance package, employer matching of a portion of employee 401K contributions, a defined benefit pension plan, and other items (e.g., disability, tuition refunds, and group life insurance).

Purchased Goods and Services and Investments

- ▶ \$76M was spent on purchases made from Washington State firms.

During FY 2015, PNNL placed domestic procurements³ for \$302M in goods and services to support operations of the Laboratory. Table 1 shows that a wide variety of goods and services were purchased, from small scientific equipment to subcontracts with universities, consultants, and research firms. Of the total, 26 percent (or \$76M) of the purchases were made from Washington State firms.

Table 1. FY 2015 PNNL Purchased Goods and Services Spending (Total U.S. Domestic and in Washington State)

Type of Expenditure	Total (\$M)	In WA (\$M)
Construction	\$24	\$22
Finance, Insurance, Real Estate	\$26	\$16
Computers, Lab Equipment, Software, Services, Retail Trade	\$74	\$7
Wholesale Trade	\$13	\$10
Utilities, Transportation, Publishing, Management, and Business Services	\$114	\$12
Technical and Scientific Subcontractors	\$23	\$3
Medical and Health Services	\$3	\$3
All Other	\$24	\$4
Total*	\$302	\$76

*Detail may not add to total due to rounding.

¹ \$93,401 includes student employees, which reduce the PNNL average. For comparable data on other Washington State R&D organizations and other DOE national laboratories, see Appendix B.

² The weighted average for all occupations for which the average annual wage and the number of workers both were published was \$52,021.

³ Excludes purchases outside of the United States.

Expenditures for New Construction and Renovations

- ▶ One hundred and two (102) construction jobs were supported by the \$18.5M in in-state subcontractor construction spending.



Figure 4. PNNL Life Sciences Laboratory at the Richland, Washington Campus

PNNL is located in southeastern Washington State, with several off-site locations. The main campus (shown in Figure 4), located at the north end of Richland, consists of land owned by DOE, Battelle, and third parties. In FY 2015, PNNL's facility profile comprised a total of 78 buildings and 41 other structures, including the following:

- 21 DOE-owned buildings and 18 other DOE structures and facilities (861,547 gross square feet [gsf]) on 379 acres
- 31 Battelle-owned facilities (486,260 gsf) and 23 other structures and facilities on 203 acres, including 39 acres in Sequim, Washington
- 26 buildings from third-party leases and agreements (956,713 gsf).

Large scientific enterprises like PNNL periodically must renovate their research facilities and procure major scientific equipment as their scope of work, scientific knowledge base, and responsibilities change. PNNL makes these investments through its capital budgets.

Fiscal year 2015 was an active year for making capital investments, with major renovations worth \$29M (see Table 2). All PNNL major renovations were performed on buildings located in Washington State. Of this total, 71 percent (\$20M) included reimbursements to subcontractors working on PNNL buildings, including out-of-state contractors working on in-state projects.¹ Washington State resident subcontractors earned \$18.5M of this \$20M, or 91 percent. Total costs other than PNNL labor related to these renovations are included in the \$302M non-payroll purchases listed in Table 1. An estimated

¹ Renovations of PNNL building space or other construction activities conducted in other states (Oregon; the Washington, D.C. area; and other places where PNNL may be conducting research or other activities) are assumed not to affect the Washington State economy.

102 construction jobs were supported by the \$18.5M in in-state subcontractor construction spending. These are included in the total impacts detailed in Table 2 and Figure 5 (located in the Economic Impact of PNNL Operations section below).

Table 2. PNNL Construction Spending in FY 2015

FY 2015 Renovations	Total Spending (\$M)
PNNL Labor Costs	\$6
Miscellaneous Procurements	\$3
Disbursements to Subcontractors	\$20
<i>Item: Disbursements to Washington State Subcontractors = \$18.5M</i>	
Total Renovation Spending	\$29

PNNL State and Local Taxes Paid

► **PNNL and its employees paid a total of approximately \$24.2M in local and Washington State taxes.**

PNNL and its employees paid a total of approximately \$24.2M in local and Washington State taxes, which includes sales and use taxes, property taxes, and a few others (e.g., motor fuel taxes).¹ Employee taxes were based on the total \$384M in wages of PNNL employees who are residents of Washington and the 2014 state and local governments' collection rates (for every dollar of personal income): an estimated \$0.028 in sales, use, and other production-related taxes by individuals; \$0.029 in state and local property tax collections; and \$0.003 in other taxes per dollar of personal income. The estimated tax payments by employees are shown in Table 3.

In total, PNNL paid \$1.6M in state and local taxes, and employees paid \$22.6M. In addition, the Laboratory paid \$4M into the state's unemployment and workers' compensation insurance systems during the fiscal year. This payment is not considered a tax and, therefore, is not included in the total.

Table 3. FY 2015 Washington State and Local Taxes Paid by PNNL and its Employees

Washington Tax Category	Paid by PNNL in FY 2015 (\$K)	Estimated Paid by PNNL Employees in FY 2015 (\$K) ^(*)
Sales and Use Taxes	\$289	\$10,574
Business and Occupation Taxes	\$322	\$0
Leasehold Taxes	\$14	\$0
Property Taxes	\$1,005	\$10,995
Other State and Local Taxes	Negligible	\$1,021
Total	\$1,630	\$22,591

**Detail does not sum to total because of rounding.*

¹ Washington State does not have a personal or corporate income tax.

Economic Impact of PNNL Operations

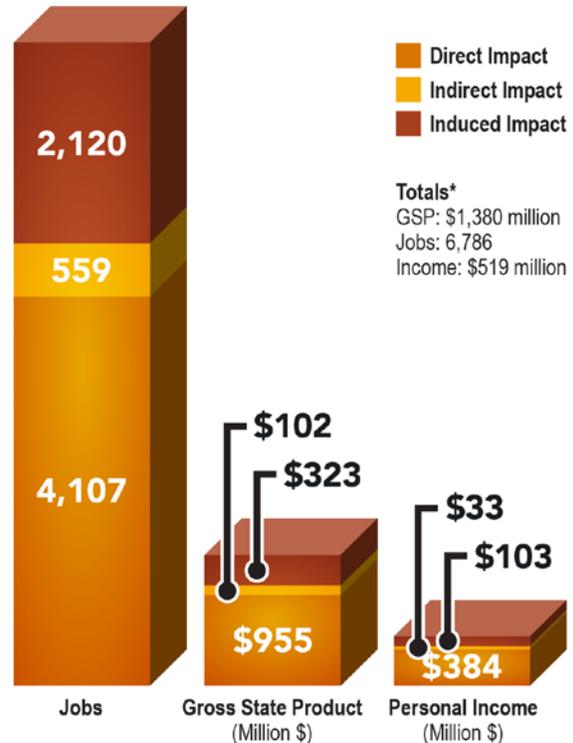
- Total impacts of FY 2015 PNNL payroll and non-payroll purchases are \$1.38B in gross state product, 6,786 jobs, and \$519M in total wages in Washington State.

PNNL’s expenditures on operations (payrolls and non-payroll purchases) generate additional economic activity in Washington State. The dollar value of PNNL’s output, its employment, and its wages are measurements of PNNL’s *direct* economic activity. In turn, companies that supply the goods and services demanded by PNNL and its employees also buy goods and services. This is called *indirect* economic activity. Since many of the indirect purchases are made in Washington, much of the indirect economic activity also occurs in Washington State.

Finally, when workers in the direct and indirect supplying firms spend their wages for goods and services, they *induce* additional output, employment, and wages in retail and services firms and their suppliers. The sum of direct, indirect, and induced impacts is usually called the *total impact* on output, employment, or income. The total value of output (value of goods and services) produced in the state is also called *gross state product* (GSP). Finally, the ratio of total to direct impact is called the *multiplier effect*.¹

Figure 5 shows estimates of direct, indirect, induced, and total impacts of PNNL payroll and non-payroll procurement spending in Washington State. The direct PNNL activity is shown as the lower bars: \$955M contribution to GSP in Washington, 4,107 Washington jobs, and \$384M in Washington wages. Together, with the indirect (middle bars) and induced (upper bars) impacts, the total impacts are \$1.38B in GSP, 6,786 jobs, and \$519M in total wages in Washington State.

Total Impacts of FY 2015 PNNL Payroll and Non-Payroll Purchases



*Details may not add to total due to rounding

Figure 5. FY 2015 Economic Impact of Washington Payroll and Purchased Goods and Services Expenditures by PNNL

¹This study uses the IMPLAN economic model (discussed in Appendix A) to estimate the indirect and induced impacts and total impact of PNNL direct payroll, benefits, in-state non-payroll purchases, and investment-related expenditures on Washington State GSP, employment, and personal income.

Other Economic Influences

This section of the report provides estimates of the total impact of economic activity that, while not strictly PNNL activity, would not exist in Washington State without the presence of the Laboratory. These activities include health care insurance expenditures on behalf of PNNL employee and retiree households, spending by PNNL retirees, spending by companies that have their “roots” in PNNL and likely would not be located in Washington State except for the presence of the Laboratory, and spending by visitors to the Laboratory who are paid by other institutions.

Health Care Expenditures

- ▶ **PNNL employees and their households spent approximately \$43M in health-related services funded by PNNL health insurance (not personal income).**
- ▶ **Retired employees’ health insurance (e.g., Medicare) spent over \$18M.**
- ▶ **These two sources together spent an estimated \$62M in FY 2015 in Washington State.**

Health insurance expenditures for PNNL’s 4,107 Washington State employees, 1,644 retirees, and their households in the state of Washington totaled an estimated \$62M in FY 2015. PNNL’s direct medical and dental insurance expenditures on behalf of employee households in Washington were estimated at \$43M (see Figure 6).

Total costs of over \$18M for retired households were based on Kaiser Family Foundation estimates of per capita expenditures by type for health care in Washington State in 2009, adjusted to 2015 dollars. While not directly related to current Laboratory activity because they are insurance payments, health care expenditures depend on the presence of Laboratory employees and have a substantial additional economic impact.

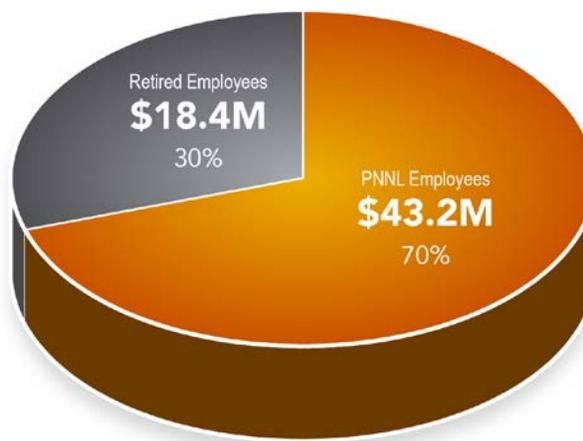


Figure 6. Estimated Spending for Washington State PNNL Employee and Retiree Health Care in FY 2015

PNNL Retirees

Although they are no longer paid by PNNL, many former employees have retired in Washington State and represent a significant additional source of consumer spending in the state’s economy. There are three principal sources of income that support this spending: pension benefits, federal Social Security Old Age and Survivors’ Insurance (OASI) benefits, and accumulated personal savings.

In FY 2015, the Battelle defined benefit pension plan for PNNL employees paid out \$70M to 2,187 retirees and other beneficiaries; however, because this included an abnormally large number of

lump sum payments, an annual growth rate from FY 2012 through FY 2014 was derived to estimate the FY 2015 amount. The PNNL pension benefit was an average of \$2,097 per month, per person, in Washington. For purposes of this report, 1,644 (75 percent) of all PNNL retirees were reported to live in Washington State.¹

The estimated average monthly payment per OASI retired beneficiary in FY 2015 was \$1,371 in Washington. Because PNNL retirees have had salaries about 1.8 times the state average salary, Social Security calculator software shows that their average OASI payment would be 1.514 times the Washington State average. Information in Table 4 assumes that the 1,644 Washington PNNL retirees receive 1.514 times the OASI payment of the average retiree in the state, or about \$2,077 per month, for a total estimated \$41M. Pensions and Social Security together total \$110M, of which about \$82M is estimated to be spent in the state on goods and services. No estimate is available for spending of personal savings by PNNL retirees.

Table 4. Estimated Washington State PNNL Retiree Income in FY 2015

	Estimated Average Retiree Monthly Income in FY 2015	Total Retiree Annual Income in FY 2015 Income (\$M)
Pension	\$2,097	\$41
OASI (Social Security)	\$2,077	\$41
Total	\$4,173	\$82

Technology Transfer

Technology Commercialization: New Products and Companies with PNNL Roots

Many of PNNL’s research activities generate ideas and inventions (intellectual property [IP]) that have commercial value. PNNL prides itself on rapidly deploying this IP into the marketplace in cooperation with new or existing firms. In the case of new start-up firms, PNNL also takes an active role in helping new businesses succeed.

Table 5 shows that 99 companies operating in FY 2015 had their technological or managerial roots in PNNL. They had estimated sales of \$746M and 3,701 employees. The 71 companies located in Washington State have an estimated sales of \$567M and 2,293 employees in Washington State.

Table 5. Companies with Ties to PNNL—Number, Estimated FY 2015 Funding, and Number of Employees

	Total	In Washington State
Number of Firms	99	71
Estimated Sales (\$M)	\$746	\$567
Employment	3,701	2,293

Table 6. Technology Assistance Program Statistics

	Total	In Washington State
Number of Projects in FY 2015	57	51%
Cumulative Projects Since 1994	1,257	69%

¹ Direct data from the pension administrator were available on PNNL retiree locations for FY 2015. Of 2,187 retirees, 1,644 had Washington addresses.

PNNL's Economic Development Office's Technology Assistance Program (TAP) provides funding for researchers to work with a small business for up to a staff-week per project. Small businesses that use PNNL's free TAP are eligible to receive a royalty-free license for IP generated in the course of the project. Table 6 shows that PNNL conducted 57 TAP projects during FY 2015. Fifty-one (51) percent of these were conducted for Washington-State-based companies.

These projects involved 2,057 hours of assistance at no cost to the small business. Since 1994, PNNL has completed 1,257 assistance projects—69 percent of them for Washington-State-based companies. Many fledgling companies in Washington State either directly receive in-kind assistance from PNNL or become partners with PNNL in identifying potential start-up funding or markets for their products and services. In many cases, the funding that they receive from others likely would not occur if PNNL was not providing this assistance.

Intellectual Property

While undoubtedly valuable as investments in the future or in Washington's current quality of life, there are other aspects of PNNL's presence in Washington State that are much more difficult to calculate in terms of the state's GSP or employment. The first of these is IP created by PNNL R&D activities.

The discoveries and outcomes resulting from the research enterprise are the Laboratory's most important product. Table 7 shows results that are easily countable, but it is much harder to put a dollar value on a newly discovered fundamental principle in proteomics or calculate the future economic value associated with a new energy-saving approach, securing U.S. border crossings, or reducing greenhouse gases, let alone developing new ways to process terabytes of data or the discovery of a new organism. PNNL is transferring technologies—primarily through IP options and licenses—nearly once every 10 days, including 26 new license agreements during FY 2015.

PNNL leads all other DOE laboratories in implementation of Agreements for Commercializing Technology, with 65 agreements with 56 different sponsors. In FY 2015, PNNL had 21 active Cooperative Research and Development Agreements and 222 non-federal Strategic Partnership Project agreements. Table 7 provides additional highlights of these efforts, including invention disclosures, patent applications, patents issued, commercial options and licenses issued, and license revenues earned. Licensing revenues totaled \$4.2M in FY 2015. A significant portion of these funds are reinvested at the Laboratory for additional commercialization-focused development work.

Table 7. PNNL Statistics on Inventions, Patents, Technology Transfers, and License Income

	New FY 2015	Cumulative 2000-2015
Invention Disclosures	149	3,713
Patent Applications	58	1,038
Patents Received	55	692
Commercial and Research Licenses	30	544
Total License Revenue Received	\$4.2M	\$55.6M

Honors and Awards

During FY 2015, PNNL research resulted in numerous awards for scientific excellence, including five R&D 100 Awards that were first named “finalists” during that year and then ultimately selected as winners at the awards ceremony in FY 2016. These included:

- Columnar Hierarchical Auto-associative Memory Processing in Ontological Networks—or CHAMPION (which identifies cyber threats in near real time)
- Hydrothermal Processing to Convert Wet Biomass into Biofuels (which converts 99 percent of algae into biocrude oil that can be refined for aviation fuel, gasoline, or diesel)
- Pressurized Magic Angle Spinning Technology for Nuclear Magnetic Resonance Spectroscopy—or SPIN (which, for the first time, allows scientists to analyze solids, liquids, and gases in high-pressure environments)
- Power Model Integrator (which combines energy forecasting models to best predict energy needs, reducing electricity generation and transmission costs)
- Subambient Pressure Ionization with Nanoelectrospray—or SPIN (which turns liquid sample into gas-phase ions to be analyzed by mass spectrometry, with 50 times more efficiency).

These five awards bring the cumulative total of PNNL’s R&D 100 Awards to 98.

From the Federal Laboratory Consortium, PNNL won two Excellence in Technology Transfer Awards: Algae-to-Biocrude Oil (which also received an R&D 100 Award, as described above), licensed to Genifuel Corporation; and System for Analysis at the Liquid Vacuum Interface—or SALVI—which was licensed to Structure Probe, Inc. The total of technology transfer awards through 2015 rose to 81, representing almost a quarter of the total Federal Laboratory Consortium awards won by all DOE Office of Science laboratories.

STEM Education and Work-Based Learning

The Office of STEM (Science, Technology, Engineering, and Mathematics) Education and Work-Based Learning (WBL) programs at PNNL respond to the national concern over the lack of U.S. students entering STEM disciplines. As a result, PNNL is helping to prepare the next generation of scientists, engineers, and innovators. We are a trusted and valued collaborator in DOE’s Workforce Development for Teachers and Scientists program and the region’s efforts to improve science and engineering education from grade school to graduate school. PNNL helps to connect the world of research and education by linking academic learning to the world beyond the classroom. The Office of STEM Education programs enable high standards, support excellence, spread innovation, and help meet future workforce needs. WBL programs 1) establish a laboratory climate where developing students is recognized as a valued activity; 2) preserve, share, and pass on academic, research, professional protocol, knowledge, and skills; 3) provide opportunities for empowerment and self-determination that transcend age, ethnicity, gender, and race; 4) expose undergraduate students to other networking opportunities with STEM faculty, professionals, and students; and 5) advise students on academic courses to better prepare themselves for graduate school and, ultimately, for STEM careers.

These programs represent a long-term commitment and investment in the human capital of the nation's and state's future workforce. In FY 2015, the DOE Office of Science provided project funding, and the Laboratory spent \$789,900 for post-secondary student and faculty programs. PNNL's Intern and Fellowship Management and Administration Pool was \$833,900. Finally, PNNL spent \$1,343,900 in overhead funds to support WBL (high school and post-secondary), STEM education, and outreach efforts (K-16).

In FY 2015, there were approximately 5,472 pre-college, undergraduate, graduate, post-graduate, and faculty researchers who participated in STEM education or WBL programs or used PNNL's Intern and Fellowship Service Center.

Employees are called either interns (students matriculating toward a degree) or research associates (post-graduates). Non-employees are called fellows, and they are undergraduates, graduate students, K-12 and university faculty, and visiting scientist appointments. Of these participants, 230 were fellows (non-PNNL employees) and 1,057 were interns or research associates. In FY 2015, 10 fellows and 243 interns/associates were from Washington State institutions.

At the K-12 level, four signature STEM education outreach efforts were conducted in FY 2015. These included 1) Delta High School; 2) Washington State Leadership and Assistance for Science Education Reform (LASER); 3) Washington State Mathematics, Engineering, and Science Achievement (MESA); and 4) the Mid-Columbia STEM Education Collaboratory.

Delta High School is a small, public institution in the Tri-Cities (i.e., Richland, Pasco, and Kennewick), Washington, focused on integrated STEM. LASER is a public/private partnership whose vision is to make science an essential part of the education of today's students for tomorrow's world. MESA efforts are designed to increase the number of underrepresented students acquiring STEM degrees and working in STEM careers. The Mid-Columbia STEM Education Collaboratory is a collaboration between Battelle, PNNL, Delta, LASER, MESA, and other like-minded organizations to design, implement, and mature a local STEM education collaboration zone that realizes changes in the STEM education system that collaborators cannot accomplish individually.

Other 2015 outreach efforts included the PNNL Student Job Shadow Program, DOE Science Bowl, Whitman College Summer Science Institute, Pasco School District Elementary Teacher STEM Professional Development Program, and Educational Service District 123's STEM-IT Program.

Other STEM Education Programs

PNNL has strong post-graduate research programs at the post-bachelor, master, and PhD level. These programs include the PNNL National Security Internship Program and the PNNL Post-Secondary and Post-Graduate Research Internship programs.

PNNL hosts several students each year in programs funded by outside sources or initiatives. These opportunities may require the student to apply to an outside program and request placement with PNNL. These include DOE Office of Science Community College Internships, Mickey Leland Energy Fellowships, Science Undergraduate Laboratory Internships and Visiting Faculty Program, and Department of Homeland Security Fellowship Program.

PNNL also hosts alternate-sponsored fellows and interns funded by home institutions and other sources, as well as the PNNL Pre-Service Teacher program. The STEM Teachers and Researchers project provides Laboratory-based research experiences combined with STEM teaching seminars designed to immerse undergraduates preparing to become teachers in the world of science and technology.

In addition, 31 high school students had academic year or summer research experiences at PNNL. In FY 2015, these programs involved nearly 2,900 students and more than 1,300 educators, almost all of whom were from Washington State institutions. Table 8 shows statistics on the Office of STEM Education and WBL programs.

Table 8. Statistics on the PNNL STEM Education Programs in FY 2015

PNNL Programs in STEM Education	Participation in FY 2015
Post-Secondary Programs	
Four DOE Office of Science University Internship/Fellowship Programs	9 faculty, 67 students
Department of Homeland Security Fellowship	9 students
PNNL Post-Graduate and Post-Secondary Internships	1,057 students
PNNL National Security Internships	53 students
PNNL Alternate Sponsored Fellowships	230 students, faculty, and visiting scientists
PNNL K-12 STEM Teacher Programs	5 students (pre-service teachers)
K-12 Student Programs	
PNNL High School Research Intern and Apprentice Programs	37 students
DOE Science Bowl	132 students
High School Shadow Program	5 students
Delta/Chiawana (STEM) High School Programs	36 faculty, 415 students
K-12 Teacher Programs	
LASER	1,027 educators
K-12 Collective Impact Project	
Mid-Columbia STEM Education Collaboratory (Phase 3: Collaboratory Implementation)	1,345 students and 210 educators

Battelle corporate invested \$269,000 in STEM education in FY 2015. From the beginning of the founding community partnership in 2006, PNNL and Battelle have strongly supported Delta High School. Delta received Battelle cash donations of \$1.5M and PNNL in-kind support of \$2M, which totaled \$3.5M during FY 2007 through FY 2015. All donations in FY 2015 were in PNNL STEM education in-kind support and totaled \$107,000.

PNNL has more than 69 staff members serving as adjunct or joint appointment faculty at colleges and universities. Forty-nine (49) of these staff members teach in Washington State colleges and universities. Many staff members also act as PhD dissertation and master's thesis committee members, guest lecturers, mentors, or volunteers for education programs at both the collegiate and K-12 level.

PNNL Visitors

PNNL hosts thousands of business visitors each year, many of whom are from outside the state of Washington and contribute their spending to the state's visitor economy. Direct impact of PNNL visitor spending was estimated from 2015 state-level per capita visitor spending statistics compiled by Dean Runyan Associates for Washington Tourism Alliance.¹

Table 9. Number of Out-of-Town Visitors and Visitor Days to PNNL Facilities

PNNL Visitor Statistics	
Number of out-of-town visitors	5,672
Estimated total visitor days	41,743
Estimated tourism expenditures	\$6M

Table 9 shows the statistics for out-of-town visitors to PNNL facilities in 2015, identified through PNNL visitor badges.² Visitor badges are issued for a specific period of time, and the total requested number of days was used as an estimate of visitor days. The estimate is intended to exclude local visitors, such as repair persons and vending machine operators, who are required to have visitor badges to access most PNNL facilities but are assumed not to contribute to tourism spending. Total costs of \$6M are based on statewide traveler spending averages, adjusted for Benton County's lower-than-average accommodation costs as a proportion of total spending.

Community Investments and Assistance

Since 1965, Battelle has invested more than \$26M to improve science, education, and quality of life in Washington State. Over the past 10 years, staff members at PNNL have volunteered more than 254,165 hours to community projects, including 43,340 Team-Battelle-volunteered hours in FY 2015. Staff members at PNNL serve on the boards of many community organizations, including: Washington State University Tri-Cities, the Tri-Cities Development Council, Tri-Cities Regional Chamber (of Commerce), the REACH Foundation, Delta High School Advisory Board, Association of Washington Business, and United Way of Benton and Franklin Counties.

Table 10 shows quantitative measures of PNNL and Battelle's community assistance, including corporate and individual financial giving and volunteer labor hours donated. Team Battelle projects in FY 2015 included the Science Bowl, Habitat for Humanity, Tri-Cities Food Bank, For the Love of Giving, and Tumbleweed Music Festival.

¹ Dean Runyan Associates. 2014. Washington State Travel Impacts & Visitor Volume, Compiled for Washington Tourism Alliance, 1991-2013p.

² Several hundred individuals from DOE, other national laboratories, and subcontractors that visit PNNL each year have recognized credentials and do not require visitor badges. No count exists for visits by these individuals, but they also add to the economic impact. Badges are issued for a period of time that includes, but is not restricted to, the dates when visitors are actually at PNNL. This results in an overestimate of the number of days per visitor when visitors are present on-site. In the case of badges issued for site tours and on-site meetings, the raw numbers of days were adjusted downward to better reflect the number of days that visitors actually spend on-site. A similar adjustment was made for badges issued to visitors such as university researchers working at PNNL or needing access to laboratory space.

Table 10. PNNL and Battelle Community Assistance Statistics for FY 2015

Washington State Community Assistance	
Battelle cash donations to health, human services, and other philanthropic and civic organizations*	\$520,000
PNNL memberships in Washington civic organizations	\$101,740
Staff member contributions to United Way	\$202,421

*Includes the \$269,000 donation to STEM education discussed above.

EMSL and ARM Climate Research Facility Users

PNNL operates EMSL and provides the overall technical direction for the ARM Program Climate Research Facility on behalf of the Office of Biological and Environmental Research. Both of these user facilities have a variety of users in the national and international science community. In the case of EMSL, the physical facility is located on the PNNL campus in Richland, Washington. Some users visit in person, while others access the facilities and their capabilities via remote portal. Many of EMSL’s users are Washington State companies or educational institutions (shown in Table 11). With remote access, the group of outside users is broader.

The ARM Climate Research Facility is a multi-platform scientific user facility designed to improve the understanding and representation in climate and earth system models, as well as clouds and aerosols and their interactions and coupling with the earth’s surface. ARM provides the international research community with unparalleled infrastructure for obtaining precise observations of key atmospheric phenomena needed to advance scientific understanding of atmospheric processes and climate models.

Environmental Molecular Sciences Laboratory

Through EMSL, scientists gain a predictive understanding of the molecular-to-mesoscale processes that affect climate, biological, environmental, and energy systems—a necessary step in the development of sustainable solutions to the nation’s energy and environmental challenges.

Research focuses on understanding how soil organic carbon formation, cycling, and sequestration occur via microbial and plant interactions and geochemical and physical processes in terrestrial and subsurface ecosystems; how the formation and aging of aerosols alters atmospheric radiative forcing; how the physical and chemical properties at critical interfaces in energy materials affect their efficiency; and how to predict and control dynamic inter- and intracellular processes for the design of biorenewable chemicals.

EMSL provides a collaborative team research environment that includes high-performance computational capabilities linked directly to suites of state-of-the-art experimental instruments. By shortening the time required to gather, analyze, store, process, and disseminate experimental and computational data, EMSL users can accelerate their time to scientific innovation.

In FY 2015, there were 1,200 unique ARM scientific users: 557 from universities, 27 from industry, 235 from DOE laboratories, 108 from other federal agencies, 219 foreign, and 54 “other.” One hundred and four (104) users used ARM’s facilities’ on-site assets, 423 used off-site services, and 673 used data services. The vast majority of ARM users do not visit PNNL, but interact with the facility by downloading data or by visiting one of the remote ARM field sites. ARM has approximately 53 employees at PNNL, not all of whom are full-time.

Table 11. FY 2015 EMSL Users

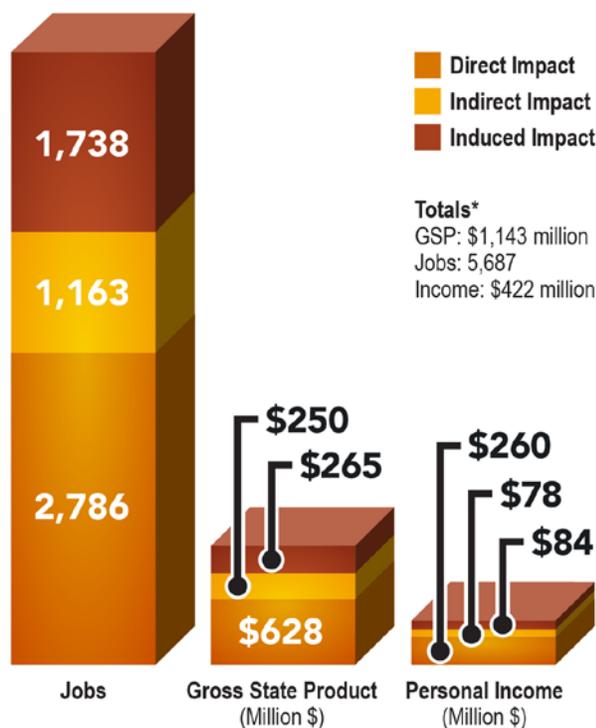
	Total EMSL Users	Washington State Users
EMSL total users	715	309
Number of international (foreign) users	79	0
U.S. users	636	309
Non-PNNL U.S. users	370	43

Economic Impact of Closely Related Activity

The spending by the four closely related economic activities (spending on health-related services, spending by companies with PNNL roots, and spending by PNNL visitors and retirees) also creates significant additional economic activity in the state. Taken together, these activities directly employ 2,786 people and generate a GSP of \$628M. The IMPLAN model calculates that, when the indirect and induced economic impacts are taken into account, a total of \$1.14B in GSP, 5,687 jobs, and \$422M in labor income depend on these activities (see Figure 7).

The impacts of the individual activities are estimated by the IMPLAN model, as follows. PNNL and its retirees' health insurance spent an estimated \$62M on health care in FY 2015, which produces an estimated statewide total impact of 741 jobs, \$106M in GSP, and \$51M in labor income. The companies with PNNL roots had an estimated in-state employment of 2,293 and estimated funding of \$567M. The companies with PNNL roots, as a group, generated a statewide total economic impact of \$964M in GSP, 4,432 jobs, and \$347M in labor income. The estimated in-state visitor spending of \$6M per year generated a total economic impact of \$9M in GSP, 95 jobs, and \$3M in labor income. Finally, the retirees received an estimated \$93M in pension and Social Security income in FY 2015, the spending from which generated a total economic impact of \$73M in GSP, 476 jobs, and \$23M in labor income.

Total Impacts of Health Care Spending, Companies with PNNL Roots, Visitors, and Retirees in FY 2015



*Details may not add to total due to rounding

Figure 7. Total Impact of Health Care Spending, Companies with PNNL Roots, Visitor Spending, and Retirees on the Washington State Economy in FY 2015

Conclusion

PNNL is an economic asset to the nation and the state of Washington. Its scientists and engineers regularly contribute ideas, inventions, technologies, and processes to the nation's and state's body of scientific and technological knowledge that will build the economy of tomorrow. PNNL takes seriously its role in making this knowledge practical, actionable, and commercially viable, and has won numerous awards for interagency collaboration, technology transfer, and technology commercialization. The growing number of 71 commercial companies in Washington State is based on PNNL ideas and assistance, with 2,293 resident employees and an estimated \$567M in funding as proof of the success of the PNNL model.

PNNL's current operations constitute a large source of economic activity in Washington State, with \$955M in total spending, 4,107 resident employees, in-state payrolls of \$384M, and purchases from Washington businesses of about \$76M. This economic activity supports a total of \$1.38B total economic output, total in-state payrolls of \$519M, and 6,786 jobs through Laboratory operations in the state. An additional \$1.14B in output, in-state payrolls of \$422M, and over 5,500 jobs are supported through closely related activities such as companies with PNNL roots, Laboratory retirees, visitors to PNNL, and health care spending. Lastly, PNNL and its employees annually contribute millions of dollars and thousands of hours to education and community services, helping secure the future and making Washington a better place to live.

Appendix A

The IMPLAN Model

To calculate the economic impact of PNNL on the state of Washington, PNNL used IMPLAN® (Impact analysis for PLANning),¹ a widely accepted economic input-output model, to estimate funding, employment, and labor income impacts. IMPLAN, a product of IMPLAN Group LLC, Inc., contains highly disaggregated data on regional economic indicators based on data from a variety of sources, such as the U.S. Bureau of Economic Analysis, and then aggregates the entire economy into 526 sectors. It is based on social accounting between industries and within the distribution chain and contains numerous economic multipliers to quantify direct, indirect, and induced output; employment; and labor income impacts. Output from IMPLAN is in the form of direct, indirect, and induced economic output (gross funding); jobs; and labor income created or supported, as well as their associated multipliers.

Each sector that produces goods and services generates demand for goods and services in other sectors. This iterative process is the multiplier effect. Multipliers can be described through the following definitions:

- Direct effects are the initial change to the industry or institution in question.
- Indirect effects are the changes in inter-industry purchases as they respond to the new demands of the directly affected industries. The direct change creates increases in economic activity for downstream businesses that support these direct industries.
- Induced effects are the increases in household income expenditures generated by the direct and indirect effects.

The Washington State data file for 2013 was used in this analysis, with gross domestic product deflators within the model used to convert impacts to 2015 dollars. PNNL data on purchases of goods and services, associated companies output, employee payroll, retiree income, visitor spending, and health care purchases were compiled and translated into IMPLAN inputs. Table A.1 characterizes the IMPLAN inputs.

¹ IMPLAN. Version 3.0. Davidson, NC: IMPLAN Group LLC, Inc. www.implan.com.

Table A.1. IMPLAN Input Characterization

Expenditures	Input Characterization
Purchases on goods and services	Expenditures were assigned a NAICS code and then translated to their respective IMPLAN sector using the IMPLAN NAICS bridge. Expenditures were calculated as an industry change and retail margins used where needed. Purchases are dominated by the construction, real estate, engineering services, medical and diagnostic laboratories, computer systems design services, and university sectors.
Companies with PNNL roots	Each company was assigned an IMPLAN sector. IMPLAN data were used to derive an output per employee and each company’s output was subsequently calculated in IMPLAN. The dominant sectors were inorganic chemical manufacturing and environmental and technical consulting services sectors.
Employee salaries	Payroll data are calculated in IMPLAN as a change in employee compensation. IMPLAN derives the impact from the model’s income expenditure patterns.
Health care spending	Health care expenditures from employees and retirees were assigned a NAICS code and translated to one of the five primary medical IMPLAN sectors and one retail sector supplying medical-related items and then calculated as an industry change. Margins were used for the retail sector.
Retiree income	Retiree income was calculated in IMPLAN as a change in employee compensation. IMPLAN derives the impact from the model’s income expenditure patterns.
Visitor spending	Visitor spending was aggregated into day-visitor and overnight-visitor spending and calculated in IMPLAN as a change in sectors typically affected by visitor spending, such as accommodation, food establishments, and retail gasoline sectors.

IMPLAN = IMpact Analysis for PLANning
 NAICS = North American Industry Classification System

Appendix B

Benchmarking the Results

Many regions' private and public stakeholders care about the economic impact of major industries and industry clusters. This Appendix reports on benchmarking reviews of economic impact analyses of a peer group that includes other large industries and companies ("peer entities") within the state of Washington and other national laboratories to show where PNNL "fits" on a number of economic dimensions assessed in this study.

It is important to note that the main report used the IMPLAN economic model to calculate the effects of several types of PNNL operations expenditures (and, separately, expenditures for closely related economic activities) on overall economic activity in Washington. Due to lack of certain data on peer entities and study resource constraints, it was not possible to perform the same analysis for the peer entities. Rather, this Appendix compares key economic input data and results from published reports of previously completed economic impact studies on the peer entities to similar economic input data and results from the main report for PNNL operations (most of the other studies did not look at closely related activities). A list of the studies on the peer entities appears at the end of this Appendix. Where an input or output is different from the similar concept in this study, this has been noted in the following tables. Where no comparable data was available in the peer entity study, an "NA" appears.

The other studies are all reasonably recent (within the last 10 years), but the studies were done at different times, for different scopes of activity, and some used different impact assessment methods and variables than in this study, so comparisons with and between peer entities are only an approximation.

PNNL is a medium-large economic entity that consistently delivers at or above its weight compared to its peers. The dimensions that are compared across peer entities are:

1. Scale of the peers' direct economic activity, as measured by total spending or funding, resident employment, purchases of other goods and services, average annual wage rates, and total payroll.
2. Impact on total state economic activity, as measured by GSP, employment, and wage income.

Because the other studies did not look at all of the dimensions examined in this study, the comparison is limited to the dimensions discussed above.

PNNL's Washington State S&T peer group includes Boeing, Microsoft, the University of Washington, and Washington State University. Although they are not S&T companies, comparisons were also done on the first two dimensions for three other large, high-profile employers in the state for which economic impact information is available: the military, life sciences, and wine sectors.

PNNL's national laboratory peer group includes: Argonne National Laboratory (ANL), Lawrence Berkeley National Laboratory (LBNL), Brookhaven National Laboratory (BNL), National Renewable Energy Laboratory (NREL), and Idaho National Laboratory (INL). An economic benefit study was done in 2008 of all of DOE activities in Tennessee, including Oak Ridge National Laboratory (ORNL), but it was not possible to isolate the effects of ORNL alone.

Table B.1. Washington State Peer Economic Comparisons

Company/ Sector & Year of Data	Sales (\$B)	Employment (WA)	Average Wages per Worker (\$K)	Total WA Payroll (\$B)	Other Purchased Goods and Services in State (\$B)	Impact on GSP (\$B)	Impact on Employment	Impact on Total Wage Income (\$B)
PNNL (FY 2015)	\$1.0	4,107	\$93.4	\$0.4	\$0.1	\$1.4	6,800	\$0.5
Boeing Commercial (2014)	\$55.4	67,600	\$113.9	\$9.7 (including benefits)	NA	\$77.3 (sales)	206,100	\$17.0
Microsoft (2011)	\$72.1 (global)	40,300	\$184.8	\$7.5	\$2.5	\$34.3	243,000	\$19.4
University of Washington (FY 2014)	\$5.7 (spending)	34,700	NA	NA	NA	\$12.5	79,300	NA
Washington State University (2014) (Operations)	\$1.0	11,900	\$50.2	\$0.6	NA	\$2.3	20,600	\$1.0
Military (2009)	\$8.7 (output)	103,400	\$49.5	\$5.1	\$2.8	\$12.2	191,600	\$10.5
Life Sciences (2015)	NA	36,200	\$86.0	\$3.1	NA	\$12.5	98,100	\$7.8
Wine Industry (2009)	\$3.6	14,200	\$30.1	\$0.4	NA	\$7.4	29,100	\$1.2

Table B.2. National Laboratory Peer Economic Comparisons

Laboratory & Year of Data	Funding (\$B)	Employment	Average Wages per Worker (\$K)	Total Payroll in State (\$M)	Other Purchased Goods & Services in State (\$M)	Impact on GSP (\$B)	Impact on Employment in State	Impact on State Total Wage Income (\$B)
PNNL (FY 2015)	\$1.02 (total spending)	4,107 (WA State)	\$93.4	\$384	\$76	\$1.38	6,800	\$0.52
ANL (FY 2010)	\$0.67	2,700 (FTE)	\$72.3	\$165	\$195	\$0.70	4,900	\$0.21
LBNL (FY 2009)	\$0.70 (total cost)	3,200	\$80.4	\$259	\$227	\$0.80	6,900	\$0.49
BNL (FY 2009)	\$0.57	2,900	\$86.4	\$250	\$120	\$0.70	5,300	\$0.48
NREL (FY 2014)	\$0.38 (total cost)	1,600 (FY 2012)	\$117.5 (FY 2012)	\$208	\$85	\$0.70	4,100	\$0.32
INL (FY 2015)	\$0.92 (in Idaho)	3,700	\$88.6	\$384	\$130	\$1.60	9,300	\$0.70

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