Pacific Northwest
NATIONAL LABORATORY

ECONOMIC IMPACT

of Pacific Northwest National Laboratory on the State of Washington in Fiscal Year 2021

U.S. DEPARTMENT OF ENERGY

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ECONOMIC IMPACT

OF PACIFIC NORTHWEST NATIONAL LABORATORY ON THE STATE OF WASHINGTON IN FISCAL YEAR 2021

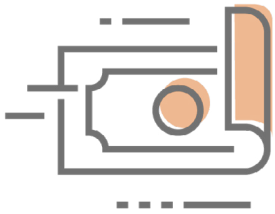
August 2022

JM Niemeyer
JL Blake

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

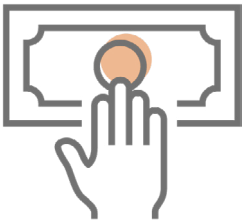
Pacific Northwest National Laboratory
Richland, Washington 99352

HIGHLIGHTS



$1.24B

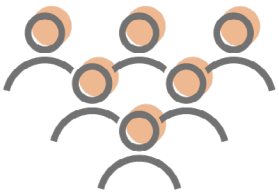
Annual spending



$577M

Total domestic payroll

$515M in Washington State



5,314

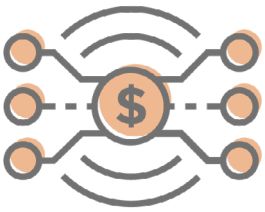
Staff members

87.0% (4,623) living in Washington State in 2021

51% growth in employment 2000–2021

$29.0M

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



$1.81B

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

$702M in Washington State wage income

>7,600 total jobs generated in Washington State

$543M

Domestic purchased goods and services

$81.8M in Washington State

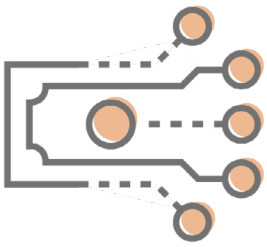
204

Companies formed with PNNL roots since 1965

In Washington State:
14 started in the last 10 years and are still in business with

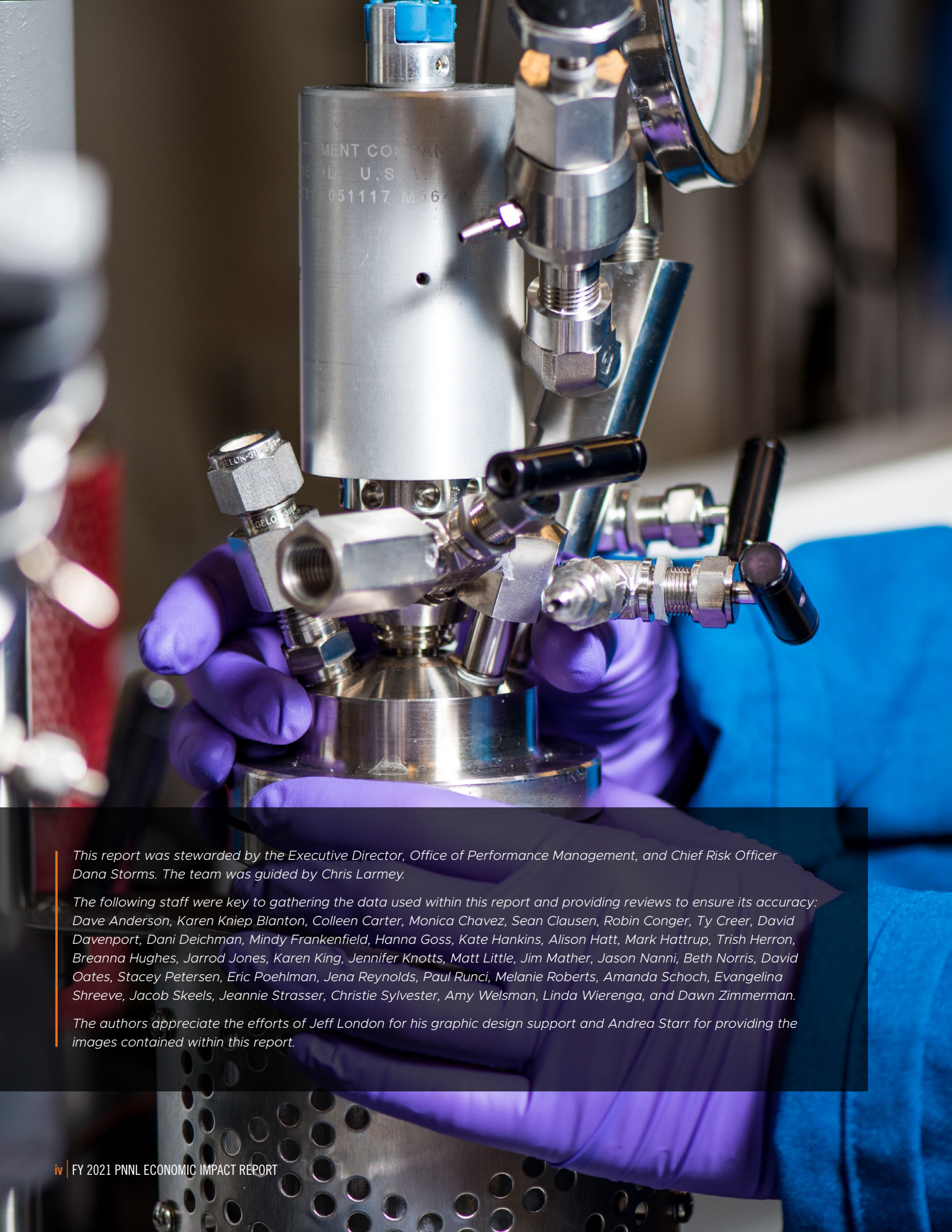
$24.6M revenue

>110 employees



$1.1M

Cash contributions to philanthropic and civic organizations, including **>$500K** corporate support for STEM education, by Battelle



This report was stewarded by the Executive Director, Office of Performance Management, and Chief Risk Officer Dana Storms. The team was guided by Chris Larmey.

The following staff were key to gathering the data used within this report and providing reviews to ensure its accuracy: Dave Anderson, Karen Kniep Blanton, Colleen Carter, Monica Chavez, Sean Clausen, Robin Conger, Ty Creer, David Davenport, Dani Deichman, Mindy Frankenfield, Hanna Goss, Kate Hankins, Alison Hatt, Mark Hattrup, Trish Herron, Breanna Hughes, Jarrod Jones, Karen King, Jennifer Knotts, Matt Little, Jim Mather, Jason Nanni, Beth Norris, David Oates, Stacey Petersen, Eric Poehlman, Jena Reynolds, Paul Runci, Melanie Roberts, Amanda Schoch, Evangelina Shreeve, Jacob Skeels, Jeannie Strasser, Christie Sylvester, Amy Welsman, Linda Wierenga, and Dawn Zimmerman.

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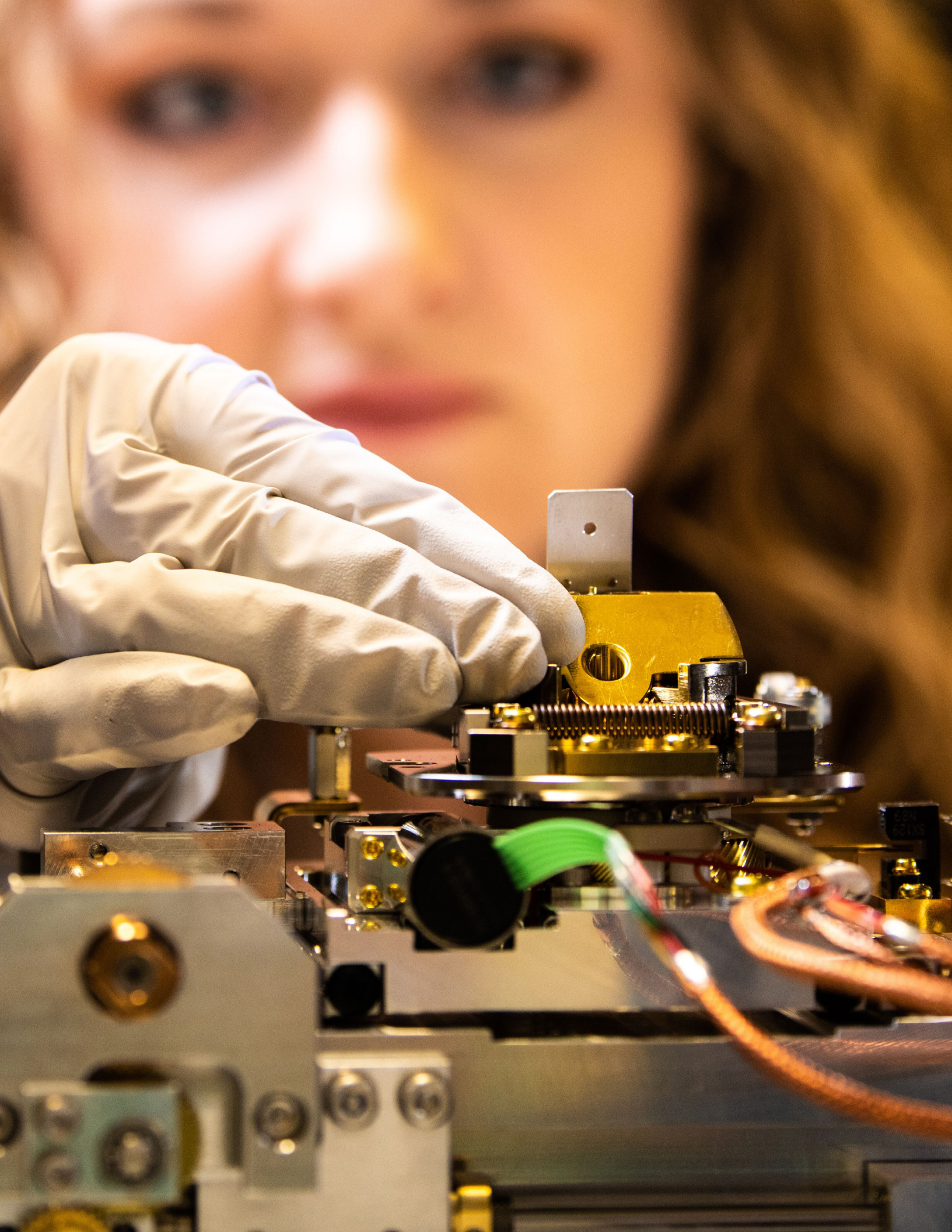
ACRONYMS AND **ABBREVIATIONS**

ARM	Atmospheric Radiation Measurement
B	billion
C^2QA	Codesign Center for Quantum Advantage
DOE	U.S. Department of Energy
EMSL	Environmental Molecular Sciences Laboratory
ESC	Energy Sciences Center
FY	fiscal year
GSL	Grid Storage Launchpad
GSP	Gross State Product
IMPLAN®	IMpact analysis for PLANning
IP	intellectual property
K	thousand
M	million
MESA	Mathematics, Engineering, Science Achievement
OASI	Social Security Old Age and Survivors' Insurance
PNNL	Pacific Northwest National Laboratory
QIS	Quantum Information Science
SC	Office of Science
SSA	Student STEM Ambassadors
STEM	science, technology, engineering, and mathematics
TSP	Teacher-Scientist Partnership
U.S.	United States
WA	Washington State
WDTS	Workforce Development for Teacher and Scientists
WSSEF	Washington State STEM Education Foundation
WSSN	West Sound STEM Network

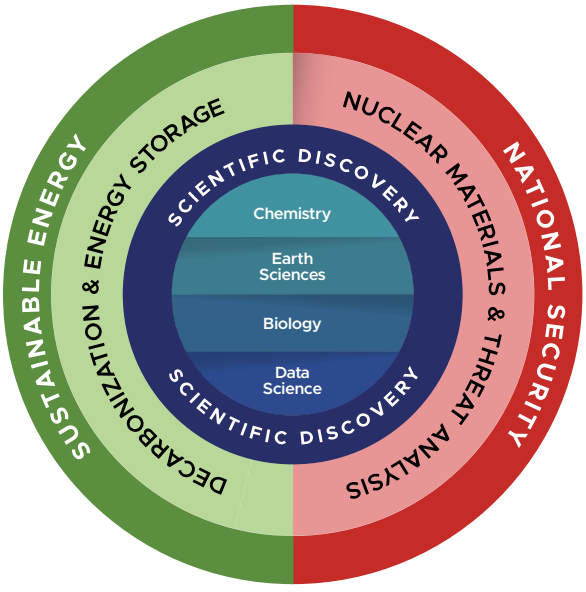


CONTENTS

WHO WE ARE

Pacific Northwest National Laboratory (PNNL), based in Richland, Washington (WA), is one of 17 Department of Energy (DOE) national laboratories, a network of science and technology powerhouses addressing large-scale, complex problems facing society and taking on some of the largest and most challenging questions, from the origins of the universe to Earth's changing climate.

PNNL has deep roots in the Pacific Northwest, reaching back to support for the Cold War mission of the Hanford Nuclear Site in Washington State. After the war, the federal government established the laboratory as a contractor-run, federally funded research and development center. Battelle Memorial Institute manages PNNL on behalf of DOE. Today, PNNL is proud to support DOE's missions in scientific discovery, energy, national security, and environmental stewardship.



PNNL operates under DOE's Office of Science (SC)—the nation's largest sponsor of basic research in physical science. With distinctive strengths in chemistry, Earth sciences, biology, and data science, PNNL's research strives to advance the frontiers of knowledge and apply that knowledge to solve major problems.

PNNL is also committed to sharing knowledge and partnering across sectors to ensure its discoveries and technologies benefit the nation and prepare the next generation of scientists and engineers. PNNL scientists and engineers are improving and modernizing United States (U.S.) energy systems, making them more efficient and more resilient in the face of extreme weather events, physical features, and cyberattacks. Its researchers work in many areas, including advanced power grid modeling, energy storage and renewable energy integration, and grid cybersecurity, to realize a vision of a U.S. energy system that is more efficient, flexible, and environmentally sustainable.

PNNL develops science-based solutions that keep the United States safe. Its research focuses on securing U.S. critical infrastructure, combating global terrorism, detecting and analyzing threats, and protecting citizens from cyber, nuclear, chemical, and biological weapons of mass effect and other forms of proliferation and terrorism.

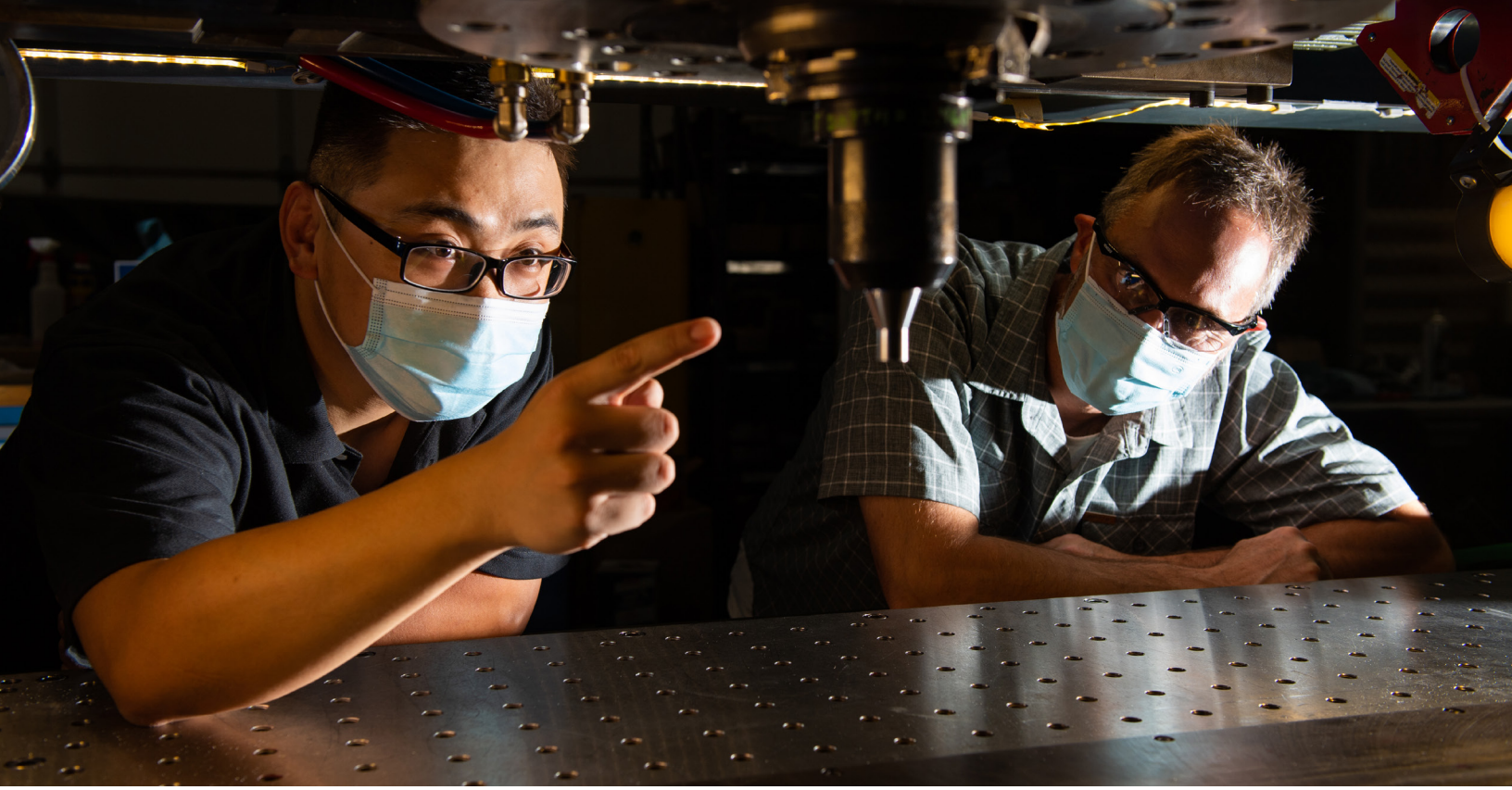
PNNL is home to more than 20 specialized research facilities, including dedicated laboratories for power grid operations, coastal sciences, data analytics, energy sciences, and atmospheric sciences. These resources equip researchers to expand the frontiers of scientific understanding and technological possibility in areas of national importance.

PNNL plays important stewardship roles in the management and operation of two DOE-SC national scientific user facilities: the Environmental Molecular Sciences Laboratory (EMSL) and the Atmospheric Radiation Measurement (ARM) user facility. The instruments and expertise housed in these facilities are available to the research community on a merit basis and enable the research of more than 2,000 scientists worldwide, annually.

LETTER FROM **THE DIRECTOR**

PNNL advances the frontiers of knowledge, taking on some of the world's greatest science and technology challenges, with a focus on advancing scientific discovery, enabling energy sustainability, and enhancing national security. The scientific impact we deliver to the nation and world also contributes significantly to the economic vitality of Washington State. PNNL and its operator, Battelle, have an enduring commitment to support the prosperity and growth of Washington and the communities in which we are located.

In fiscal year (FY) 2021, despite the ongoing challenges of the pandemic, our staff stayed safe and productive, allowing us to deliver on our commitments to our many sponsors. In fact, their great ideas and winning proposals resulted in a record year of funding. It was also a record year for hiring at all levels and in all organizations, resulting in 352 new hires and 892 interns, for a total of more than 5,300 employees.



The tremendous year we had at PNNL translated to positive economic impact for Washington State. For example, the total economic output of PNNL's payroll and domestic goods and services exceeded $1.81 billion (B), we generated more than 7,600 jobs, our annual spending was $1.24B, and the contributions given to philanthropic and civic organizations from Battelle, PNNL, and our staff members totaled more than $1.1 million (M).

I am extremely proud of the contributions that the innovative and dedicated staff at PNNL are making to our state, region, and nation. I invite you to read on to learn how their passion for scientific discovery, technological innovation, and driving solutions to market contributes to the economic vitality of Washington State.

Best regards,

Steven F. Ashby

Dr. Steven Ashby
Director, Pacific Northwest National Laboratory

THE ECONOMIC IMPACT OF SCIENCE

$1.34B
FY 2021 FUNDING

$1.24B
FY 2021 SPENDING

Beyond our scientific impact, the economic impact of our presence in the state and community is significant. This includes the amount of revenue we receive; costs we incur, along with purchased goods, services, and investments; our staff and their spending in the communities in which they reside; and our direct and indirect economic activity.

Funding and Spending

PNNL is a large and vital economic entity, with more than 5,300 staff members, $1.34B in total funding (see Figure 1), and $1.24B in total spending (see Figure 2), making it a top research institution in Washington State.

We use the terms "funding" or "sales" to refer to the total revenue received for projects conducted at PNNL. It is an indicator of the total amount of work done at the Laboratory over a given fiscal year—in this case, FY 2021. We use the terms "spending" or "business volume" as a measure of total costs, or expenditures, charged to third-party clients, and it includes direct costs, such as labor, travel, and procurements, as well as some necessary overhead costs.

We perform the majority of our work for DOE. The DOE contract also allows us to perform work for several other federal and private agencies, as shown in *Figures 1 and 2*.

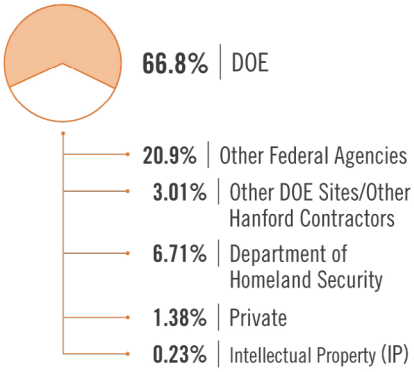


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Figure 1 | PNNL's Funding in FY 2021

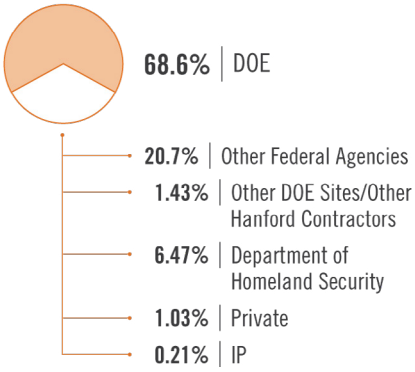

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Figure 2 | PNNL's Spending in FY 2021

5,314
STAFF MEMBERS

352
NEW HIRES

892
INTERNS

Our Staff

Our scientific and technical accomplishments are a tribute to the expertise and experience of more than 5,300 scientists, engineers, and support professionals who work at PNNL and who collectively hold 2,676 advanced degrees. Over the course of the year, we hired 352 staff, in addition to 892 interns.

Our researchers and mission support professionals work side-by-side. Together, they enable the mission and success of PNNL. In FY 2021, the second year of a pandemic that continues to alter the course of our lives, we remained steady in channeling the spirit, knowledge, and considerable scientific capabilities to aid our neighbors and fight COVID-19. Under DOE leadership, staff at the 17 national laboratories worked together to identify near-term actions to address urgent needs, as well as longer-term research and development efforts to ready the nation for the next pandemic. This work is at the core of our mission—to keep the nation and the world safe and secure.

At PNNL, we recognize our strength is in our people. We are committed to fostering a work environment that fully embraces and values diversity, equity, and inclusion. We believe the diversity, depth, and breadth in our people enables the innovation and creativity expected of a DOE national laboratory.

We aspire to be a model organization and a valued partner in the communities where we live and work. Since 87 percent of our workforce, 4,623 people, are residents of Washington State, working mainly on our Richland, Seattle, and Sequim campuses, significant corporate contributions were allocated to Washington.[1] Of those staff living in Washington, 77 percent lived in Benton County and 12 percent in Franklin County.[2]

During the COVID-19 pandemic, our staff has continued to demonstrate resilience and adaptability, as well as commitment to making the world a better place through our scientific contributions, economic impact, and the cultural values we bring to each community.

87.0%
(4,623)
EMPLOYED & RESIDING IN WASHINGTON STATE

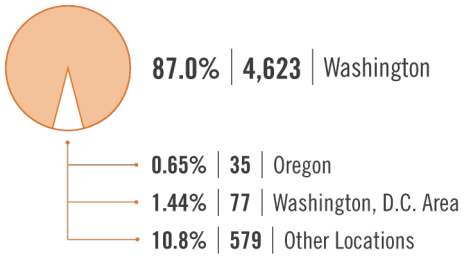

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Figure 3 | Location of Staff Who Work at PNNL

1 Outside of Washington, 77 staff members reside in the Washington, D.C., area; 35 staff members reside in Oregon; and 579 staff members reside in other locations in the United States or in foreign countries.

2 Of the staff members residing in Benton and Franklin Counties, 51.0 percent reside in Richland, 19.4 percent in Kennewick, 13.5 percent in Pasco, and 12.9 percent in West Richland, and the remaining 3.2 percent reside elsewhere in the two counties.

$577M
IN DOMESTIC PAYROLL

$515M
PAYROLL FOR WASHINGTON RESIDENTS

Payroll and Benefits

PNNL's domestic payroll in FY 2021 was $577M, of which $515M went to staff members living or residing in Washington State.

At the end of FY 2021, the average annual wage for our Washington staff members was $111,500; whereas, the state average occupational wage for the same time frame was $69,313.[3] Because we are a research and development organization, we have a large percentage of high-wage professions. As a result, staff members at PNNL likely spend at a higher level and have a larger impact on the state economy compared to the average Washington worker.

While not directly part of wages, benefits packages also contribute to PNNL's economic impact. PNNL's benefits package costs $124M per year and includes an employer-provided health insurance package, employer matching of a portion of employee 401K contributions, a defined-benefit pension plan, disability, tuition refunds, and group life insurance. Our benefits package not only helps us recruit and retain exceptional staff, but we also know the health and well-being of our staff is vital to our collective scientific impact and, in turn, our ability to give back to our community.

3 Weighted average for all occupations that published both average annual wage and number of workers.

Purchased Goods, Services, and Investments

During FY 2021, PNNL spent $543M on goods and services to support research and operations. *Table 1* shows the variety of goods and services purchased, including construction, small scientific equipment, and subcontracts with universities, consultants, and research firms. Of the total, 15 percent ($81.8M) of the purchases were from Washington-based firms.

$543M
IN GOODS & SERVICES TO SUPPORT OPERATIONS

$81.8M
IN PURCHASES FROM WASHINGTON FIRMS

Table 1 | **FY 2021 PNNL Purchased Goods and Services Spending**
(total U.S. domestic and in Washington)

Type of Expenditure	Total ($M)	In WA ($M)
Construction	$70.8	$26.2
Finance, Insurance, Real Estate	$45.9	$21.1
Computers, Lab Equipment, Software, Services, Retail Trade	$123.0	$5.1
Utilities, Transportation, Publishing, Management, Business Services	$175.3	$11.6
Technical and Scientific Subcontractors	$90.4	$11.8
Medical and Health Services	$2.5	$1.2
All Other	$34.7	$4.8
Total*	**$542.5**	**$81.8**

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

$1.81B
GSP FY 2021 PAYROLL
& NON-PAYROLL PURCHASES

>7,600
JOBS

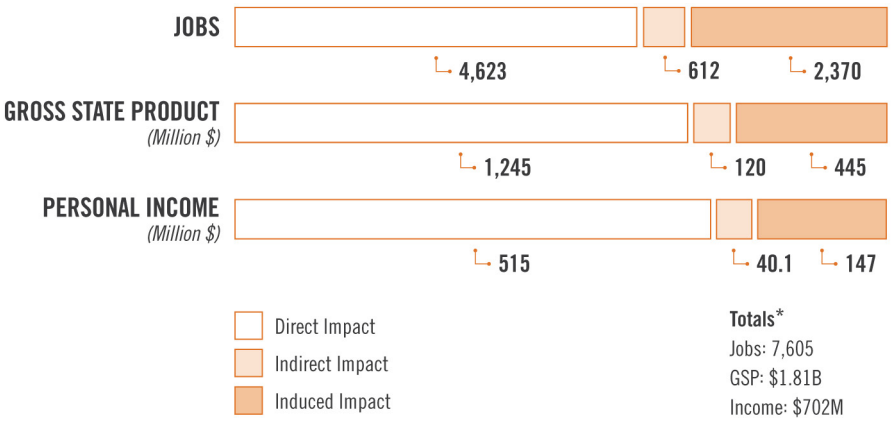
$702M
IN WASHINGTON WAGES

PNNL Operations

PNNL's output, employment, and wages are measurements of what are considered PNNL's *direct* economic activity. In turn, companies that supply goods and services to PNNL and its staff also buy goods and services, producing *indirect* economic activity. Since many of the indirect purchases are made in Washington, much of the indirect economic activity also occurs in the state. When employees of the firms who are either direct or indirect suppliers spend their wages on 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 the total impact on output, employment, or income. The total value of output (goods and services) produced in the state is also called Gross State Product (GSP), and the ratio of total to direct impact is called the multiplier effect.[4]

Figure 4 shows estimates of direct, indirect, induced, and total impacts of PNNL payroll and non-payroll procurement spending in Washington, based on the multiplier effect. The total impacts, including indirect and induced impact, are $1.81B in GSP, more than 7,600 jobs, and $702M in total wages for Washington.



*Detail may not sum to total because of rounding.

Figure 4 | *FY 2021 Economic Impact of Washington Payroll and Purchased Goods and Services Expenditures by PNNL*

4 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 *(see Appendix for more information about the IMPLAN model used in this report).*

Expenditures for New Construction and Renovations

Our primary campus, located in Richland, includes land owned by DOE, Battelle, and commercial parties.

PNNL's campus strategy is driven by a need to enable PNNL's major initiatives, sustain the health of our core capabilities, and support key programs and sponsors.

In 2021, construction of the $90M, 140,000-square-foot Energy Sciences Center (ESC) was completed. The facility, which contains state-of-the-art instrumentation for fundamental research in chemistry, materials science, and computational science, also houses more than 250 staff and collaborators. Washington State invested $8.0M from its Clean Energy Fund over four years to purchase specialized equipment for the ESC, which will advance Washington's leadership in energy sciences and provide collaborative space and equipment for our university and industry partners. This partnership between PNNL, DOE, and the state of Washington speaks to the significance of these shared priorities.

36
CONSTRUCTION PROJECTS SUPPORTED

$10.6M
WASHINGTON-BASED SUBCONTRACTOR REIMBURSEMENTS

The Grid Storage Launchpad (GSL) is another example of a large construction facility at our PNNL-Richland campus enabled by both state and federal investments. GSL will accelerate innovation in energy storage, a key technology in the transition to resilient, clean energy in Washington and beyond. The $75M facility, funded by DOE's Office of Electricity, will host an in operando battery characterization center housing $8.3M in state-funded, advanced imaging equipment. Construction of GSL is expected to conclude in 2023.

PNNL is proud to see one vision come to fruition and excited another is taking shape, as well as to witness the infusion of jobs within the community enabling these major construction efforts.

We made investments in facilities and infrastructure worth $85.3M *(see Table 2)*. All major renovations were performed on buildings located in Washington State, and 86 percent ($73.3M) included reimbursements to subcontractors working on PNNL buildings.[5] Approximately 14 percent of the subcontractor reimbursements were earned by Washington-based subcontractors, at a total of $10.6M.[6] An estimated 36 construction projects were supported by in-state subcontractor construction spending and are included in the total impacts detailed in *Table 2*.

Table 2 | PNNL Construction Spending in FY 2021

FY 2021 Renovations	Total Spending ($M)
PNNL Labor Costs	$9.3
Miscellaneous Procurements	$2.7
Disbursements to Subcontractors *Item: Disbursements to Washington Subcontractors = $10.6M*	$73.3
Total Renovation Spending	**$85.3**

5 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 Washington State's economy.

6 Total costs related to these renovations, other than PNNL labor, are included in the $542.5M non-payroll purchases listed in Table 1.

CASE STUDY

A Cleaner Future: PNNL's Energy Sciences Center Helps Achieve Climate Goals

Decarbonizing today's energy system is essential to a clean energy future but won't be easy. This means achieving net-zero carbon emissions by reusing carbon to reduce the need for fossil fuels powering vehicles, including aviation, heavy-duty, and marine engines, as well as providing alternatives to carbon-based fuels such as hydrogen.

Today, about 73 percent of energy production in the state of Washington comes from renewable resources, more than 65 percent of which is from the region's hydroelectric dams.

Washington State has passed a comprehensive set of climate and energy policies to drive decarbonization of the economy over the next 20+ years. These policies require transition to carbon-free electricity, capture and reuse of carbon from municipal and industrial waste sources, and development of new forms of energy, such as hydrogen, for hard-to-electrify sectors.

The new ESC leverages PNNL's signature capabilities in chemistry and materials sciences to advance scientific discoveries that will support the innovations needed to achieve net-zero carbon emissions efficiently and affordably in Washington and beyond.

Located in Richland, Washington, the ESC was dedicated in 2021. The $90-million, 140,000-square-foot facility provides space for about 250 researchers from various disciplines and brings together both new and existing scientific instrumentation to focus their collective capabilities and innovation on the nation's most pressing energy needs.

"This investment by DOE has created one of the most advanced facilities in the world. The Energy Sciences Center is designed for fundamental catalysis and energy research and will be a tremendous asset for the nation," added Lou Terminello, associate laboratory director of PNNL's Physical and Computational Sciences Directorate.

One of the ways ESC researchers are tackling the net-zero challenge at PNNL is by combining their strengths in computational science, chemistry, and economics—both within the ESC and at PNNL broadly—to examine the entire system for chemical hydrogen storage, from the design of new catalysts to the reactors where the chemical processes take place, as well as the end products and applications. They are going beyond exploring theoretical possibilities and delving into how systems for storing and releasing hydrogen would operate in real-world conditions, at neighborhood scales.

Through collaboration with industry, academia, and others, researchers dedicated to developing novel approaches and testing their feasibility, joined by colleagues who are advancing scientific discovery in chemistry, materials sciences, and computing, will accelerate progress toward the clean energy future we all want.

"It is exciting to see our vision for the Energy Sciences Center realized," said Ashby. "Partnership made this unique facility possible, and going forward, partnerships will be essential to our collective success."

$29.0M
TAXES PAID

State and Local Taxes

PNNL and its staff members paid $29.0M in taxes, which include business and occupation taxes (PNNL only), sales and use taxes, property taxes, and other types of taxes (e.g., motor fuel taxes).[7] Employee taxes were based on the total $515M in wages of employees at PNNL who work in Washington State (for the purpose of this analysis, they are assumed to live in Washington) and the 2021 state and local governments' collection rates (for every dollar of personal income). The rates are an estimated $0.026 in sales, use, and other production-related taxes by individuals; $0.029 in-state and local property tax collections; and $0.002 in other taxes per dollar of personal income.

7 PNNL paid $1.17M in taxes, and its staff members paid an additional $29.0M in taxes. Washington does not have a personal or corporate income tax. In addition, PNNL paid $3.93M into the state's unemployment and workers' compensation insurance systems during the fiscal year. This payment is not included in the total, as it is not considered a tax.

PNNL: BEYOND THE SCIENCE

$286M
IN GSP

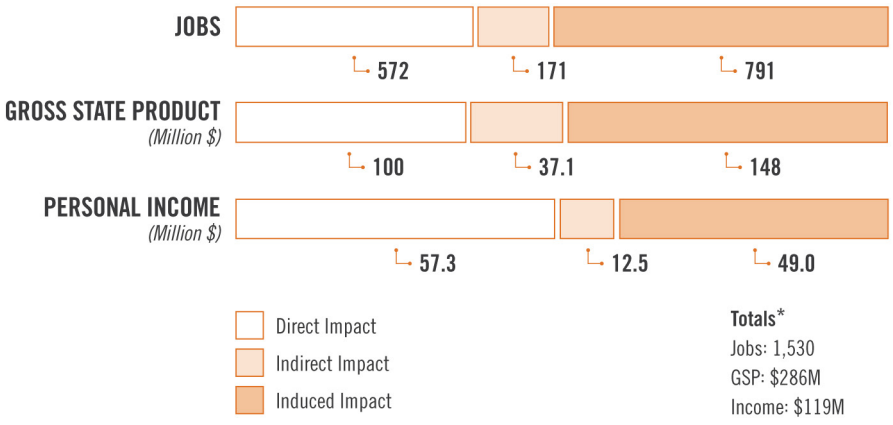
1,530
PNNL-DEPENDENT EXTERNAL JOBS CREATED

$119M
IN LABOR INCOME

While not strictly a PNNL activity, there are certain expenditures—such as spending on health care, the investments of our retirees, the visitors we attract, and the transfer and commercialization of technologies—that bolster the economy and would not occur in Washington State without our presence.

Economic Impact of Closely Related Activity

Spending in the four closely related economic activities—health-related services, retirees, visitors to PNNL, and the commercialization and transfer of technology—also creates significant additional economic activity in the state. Taken together, these activities directly employ 572 people and generate a GSP of $100M. The IMPLAN® model calculates, when the indirect and induced economic impacts are taken into account, a total of $286M in GSP, 1,530 jobs, and $119M in labor income depend on these activities *(see Figures 5 and 6 for more detail)* and can be attributed to PNNL.



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

Figure 5 | Total Impact of Health Care Spending, Companies with PNNL Roots, Visitor Spending, and Retirees on the Washington State Economy in FY 2021

$80.4M
HEALTH CARE EXPENDITURES

$143M
GSP

799
JOBS

$67.7M
LABOR INCOME

Health Care Expenditures

Health insurance expenditures for our 4,623 staff members residing in the state, 2,203 retirees, and their households totaled an estimated $80.4M in FY 2021.[8] PNNL's direct medical and dental insurance expenditures on behalf of in-state employee households were estimated at $50.9M *(see Figure 6)*.

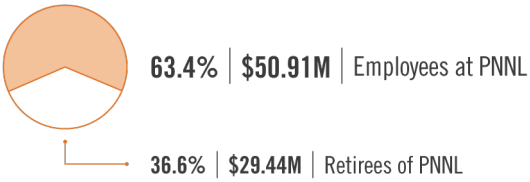


***Figure 6** | FY 2021 Estimated Health Care Spending of In-State Employees at PNNL and Retirees*

8 Total costs of more than $29.4M for retired households were based on Kaiser Family Foundation estimates of per capita expenditures by type for health care in Washington in 2014, adjusted to 2021 dollars.

Retirees

Seventy-two percent of our retired former employees continue to live in Washington.[9] They represent a significant source of consumer spending in the 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 2021, the defined-benefit pension plan for our employees paid a total of $82.8M to 3,050 retirees and their beneficiaries. The PNNL pension benefit was an average of $2,263 per month, per person, in Washington.

Information in *Table 3* assumes our in-state retirees receive 1.38 times the OASI payment of the average retiree in the state, or about $2,214 per month, for a total estimated $58.5M.[10] Combined, pensions and Social Security total $164M, of which $118M is estimated to be spent within Washington on goods and services.[11]

$118M
PENSION & SOCIAL SECURITY INCOME

$94.8M
GSP

505
JOBS

$31.3M
LABOR INCOME

Table 3 | Estimated Washington State PNNL Retiree Income in FY 2021

Income Type	Estimated Average Retiree Monthly Income in FY 2021	Total Retiree Annual Income in FY 2021 Income ($M)
Pension	$2,263	$59.8
OASI (Social Security)	$2,214	$58.5
Total	$4,477	$118.3

9 Direct data from the pension administrator on PNNL retiree locations for FY 2021 indicated, of the 3,050 retirees, 2,203 had Washington addresses.

10 The estimated average monthly payment per OASI retired beneficiary in FY 2021 was $1,607 in Washington. Because PNNL retirees have had salaries about 1.5 times the state average salary, Social Security calculator software shows their average OASI payment would be 1.38 times the Washington average.

11 No estimate is available for spending of personal savings by PNNL retirees.

$1.93M
ESTIMATED TOURISM EXPENDITURES

$2.92M
GSP

22
JOBS

$1.02M
LABOR INCOME

Visitors to PNNL

PNNL hosts thousands of visitors each year, many of whom are from outside Washington State and contribute to the state's visitor economy.[12] Unfortunately, due to the travel restrictions and safety precautions needed to keep our staff and visitors safe during the pandemic, we saw a reduction of approximately 50 percent in visitors, total number of visitor days, and estimated tourism expenditures in FY 2021 compared to FY 2020.

Statistics for out-of-town visitors to our facilities in FY 2021 are shown in *Table 4*, identified through PNNL visitor badges.[13] Visitors contributed an estimated $1.93M to the state's economy based on statewide traveler spending averages, adjusted for Benton County's lower-than-average accommodation costs as a proportion of total spending.

Table 4 | Number of Out-of-Town Visitors and Visitor Days to PNNL

	PNNL Visitor Statistics
Number of out-of-town visitors	1,266
Estimated total visitor days	10,918
Estimated tourism expenditures	$1.93M

EMSL Users

EMSL is a DOE-SC user facility sponsored by DOE-SC's Biological and Environmental Research program. It is operated by and located on the PNNL-Richland campus. Many of EMSL's users are from Washington companies or educational institutions.

12 Direct impact of PNNL visitor spending was estimated from 2018 county-level per capita visitor spending statistics compiled by Dean Runyan Associates, 2019, Washington State Travel Impacts & Visitor Volume, 2000–2018p.

13 A couple 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 including, but 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 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. Direct impact of PNNL visitor spending was estimated from 2018 county-level per capita visitor spending statistics compiled by Dean Runyan Associates, 2019, Washington State Travel Impacts & Visitor Volume, 2010–2018p.

In FY 2021, EMSL supported 801 scientists from around the world who were able to take advantage of outstanding laboratory space, expertise, and equipment to extend the frontiers of biological and environmental science. Forty-five users were from foreign institutions, and 756 users were from the United States.

ARM Users

We also provide overall technical direction for ARM on behalf of DOE. ARM is a multi-platform scientific user facility designed to improve understanding and representation in climate and Earth system models, as well as clouds and aerosols, and their interactions and coupling with 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.

In FY 2021, the 960 unique ARM scientific users included 443 from universities, 45 from industry, 155 from DOE laboratories, 67 from other government agencies, and 250 from foreign institutions. The vast majority of ARM users don't visit PNNL but interact with the facility by downloading data or by visiting one of the remote ARM field sites. Of the total users, 83 accessed ARM's on-site assets, 172 used off-site services, and 705 used data services. ARM employs approximately 60 people at PNNL, some of whom are less than full-time.

Technology Transfer

Technology Commercialization: New Products and Companies with PNNL Roots

Many of PNNL's research activities generate ideas and inventions (i.e., IP) that have commercial value. PNNL prides itself on rapidly deploying this IP into the marketplace in partnership with new or existing firms. Our scientific discoveries can be converted into competitive products or solutions that contribute to creating new jobs, diversifying the U.S. economy, and making a positive societal impact.

One important way PNNL delivers both intellectual and economic value is through effective engagement with entities outside the Laboratory—through partnerships, collaborative research, and the transfer of technologies and software solutions. These relationships help assure the nation derives as much return as possible from U.S. government investments of taxpayer resources. Our work with other government agencies and private companies also connects PNNL researchers with high-priority, real-world problems that allow them to develop a deeper understanding of current and emerging societal needs.

The partnerships we forge sharpen our science, attract talented staff, and inform the Laboratory's strategic priorities. PNNL pursues each partnership as an opportunity to advance the Laboratory's missions in scientific discovery, energy resilience, and national security, while maximizing the positive impact on the U.S. economy and protecting our critical intellectual assets.

To facilitate effective partnerships, PNNL provides several ways to work with the Laboratory, including the transfer of rights to use IP developed at PNNL, direct sponsorship of research, or engagement in Cooperative Research and Development Agreements.

Since 1965, 204 new companies were started with technological or managerial roots at PNNL, and 102 of those are still in business today.

Table 5 provides a breakdown of the activity over the last 10 years. As a national laboratory, we patent and license our technology across the nation and the world. However, place matters when it comes to innovation, which is why almost half the companies created within the last 10 years were located right here in Washington. Fourteen of the 35 companies still in business are located in Washington and collectively employ more than 110 people, with estimated sales of $24.6M. This economic activity of $24.6M, in turn, supports a total economic output of $45.3M, as well as in-state payrolls of $31.2M and 207 jobs throughout the state.

Table 5 | Companies with PNNL Roots (established in last 10 years and still operating)

	Total	In WA
Number of Firms	35	14
Estimated Sales ($M)		$24.6
Employment	>300	>110

Intellectual Property

While there is undoubtedly value in investing in both our current and future quality of life, there are other aspects of PNNL's presence in Washington that are much more difficult to calculate in terms of the state's GSP or employment, such as the IP created by PNNL research and development activities. PNNL transfers technologies—primarily through IP options and licenses—at a rate of almost one technology licensed every eight days, including 46 new license agreements in FY 2021.

In addition, PNNL implemented 114 agreements for commercializing technology with 91 different private organizations. In FY 2021, we had 73 active Cooperative Research and Development Agreements and 197 non-federal Strategic Partnership Project agreements.

Often, federally funded research results in scientific and engineering solutions with IP value. *Table 6* provides additional highlights of our commercialization and technology deployment efforts, including invention disclosures, patent applications, patents issued, commercial options and licenses issued, and license revenues earned. In FY 2021, we collected $2.8M in licensing revenue and reinvested a significant portion of these funds at PNNL for additional commercialization-focused development work.

$2.8M
COLLECTED IN LICENSING REVENUE

1
TECHNOLOGY LICENSED EVERY
8
DAYS

Table 6 | PNNL Statistics on Inventions, Patents, Technology Transfers, and License Income

	New FY 2021	Cumulative 2000–2021
Invention Disclosures	247	5,254
Patents Granted	44	1,105
Licenses and Options	46	754
Total License Revenue Received	**$2.8M**	**$76.7M**

Giving back is in our culture. Whether through charitable giving—from staff members at PNNL or Battelle corporate dollars—or the numerous hours volunteered, we are making a difference.

INVESTING IN **THE FUTURE**

Whether contributing to local organizations, facilitating community volunteerism and leadership, or furthering science, technology, engineering, and mathematics (STEM) education, PNNL has built a strong and enduring foundation of external engagement and outreach. Giving time, money, and talent to help others in the communities where we work and live is our culture.

As a DOE national laboratory, PNNL helps fulfill DOE's commitment to inspire, train, and support the future diverse STEM workforce.

STEM Education and Workforce Development

PNNL's pledge to inspire and develop the future STEM workforce is rooted in the belief that teams of diverse individuals—especially comprising those who have been historically underserved in STEM—will address our nation's most challenging scientific issues and ensure America's competitiveness. PNNL's diverse staff participates in STEM programs and outreach activities, allowing students to interact with technical staff from similar cultural or ethnic backgrounds and see themselves in STEM fields and careers.

PNNL carries out DOE's commitment to inspire, train, and support the next generation of diverse scientists, mathematicians, and engineers through purposeful alignment of STEM outreach and workforce development activities with our PNNL talent strategy and scientific priority areas.

In FY 2021, DOE-SC provided $1.61M direct project funding for DOE Workforce Development Teachers and Scientists (WDTS) Science Undergraduate Laboratory Interns and Community College Internships student programs, visiting faculty, and diversity and outreach efforts.

Mathematics, Engineering, Science Achievement Program

Since 2018, PNNL STEM Education has led the Yakima Valley/Tri-Cities Mathematics, Engineering, and Science Achievement (MESA) Center program in partnership with the University of Washington currently impacting over 400 students from four school districts.

In 2020–2021, nearly 77% of MESA students were from historically underserved communities. Students participate in exploration activities as they seek to develop a STEM identity and pursue post-secondary education credentials and STEM careers. Of MESA's graduating 2020 seniors, 71% planned to pursue post-secondary education for a STEM career. By contrast, in 2017, just 31% of Washington State SAT-takers intended to pursue a STEM degree.

PNNL's STEM Education Service Center pool was $1.76M, which supports the PNNL workforce development strategy and the deployment of PNNL internship programs, and PNNL invested $1.08M in overhead funds to support STEM equity and inclusion, Teacher-Scientist Partnerships (TSPs), and STEM outreach efforts like the PNNL STEM Ambassadors Program. More than 20,000 pre-college, undergraduate, graduate, post-graduate, and faculty researchers benefited from STEM education programs or participated in PNNL's STEM workforce.

Throughout FY 2021, PNNL delivered STEM programs that provide immediate impact and assistance while demonstrating our near- and long-term commitment to our community and the value DOE places on building our future workforce. Notable efforts included

- **PNNL hosted 1,536 in combined intern and research associate positions**, the highest number ever hosted during a 12-month period at the Laboratory, and of that number, 478 were located on-site in Washington State. We continued to deliver a suite of professional development and enrichment activities, connecting with interns regardless of their work location.
- **PNNL developed and launched the Student STEM Ambassadors (SSA) program** with support from DOE's WDTS. SSAs seek to inspire their peers, especially those who are also underrepresented in STEM, to apply for WDTS internships. Despite ongoing COVID-19 pandemic challenges, SSAs reached thousands of students through online presentations at their campuses and minority serving institutions, virtual outreach fairs, WDTS application workshops, and social media campaigns.
- **Quantum Information Science (QIS) interns participated in the Codesign Center for Quantum Advantage (C2QA) effort.** Interns at PNNL and Brookhaven National Laboratory supported the C2QA research thrusts and participated in QIS-focused enrichment activities, tours, and networking sessions, culminating in research symposium presentations. Staff at PNNL also participated in the C2QA Quantum Career Fair to showcase science communication and QIS career opportunities. More than 450 people registered to attend the event, representing more than 200 colleges and universities.

PNNL and the national laboratories collectively train and educate more than 250,000 K–12 students, 22,000 K–12 educators, and over 11,000 undergraduate, graduate, and postdoctoral researchers annually, developing the nation's future STEM workforce.

- **PNNL assisted in the deployment of the Learning Blade tool to local educators**, including Yakima Valley/Tri-Cities MESA program teachers. Learning Blade levels access and equity to STEM courses by introducing underrepresented, underserved, and underfunded schools to careers, tools, and technologies found throughout STEM fields. More than 2,340 online lessons were delivered in FY 2021.
- **An Oversight Committee for the STEM Nexus Initiative advanced equity in STEM education for our local community and underserved populations**. With PNNL's leadership, the Oversight Committee was established as a collaboration between the STEM Nexus Initiative, the Washington State STEM Education Foundation (WSSEF), and myTRI2030 Education Council, comprising education leaders and community members. The committee identified several impactful STEM education projects to pursue within the Mid-Columbia community.
- **The STEM Nexus Initiative distributed 5,000 Microscopy STEM Kits to students and teachers from local middle schools, tribal schools, the Sequim community, and Mid-Columbia region.** The kits included an accompanying lesson plan aligned to math common core and next-generation science and engineering standards.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CASE STUDY

PNNL Partners with Educators: Taking STEM Education to the Next Level

For more than 50 years, PNNL has served as a hub for innovation and research, while connecting students, teachers, and educational partners in the K–20 system to real-world science experiences.

The TSP program provides professional development for educators that advances STEM content and STEM workforce awareness. The program pairs teachers and scientists to bring the world of scientific research conducted at PNNL together with the classroom experience, empowering teachers and scientists to have an impact on the next generation of highly skilled STEM workers. These immersive experiences are for 35–40 hours and challenge middle and high school STEM teachers to solve a scenario-based problem from the real world, with guidance from the PNNL scientists, while they earn clock hours.

We focus on recruiting teachers who can take the scientific content back to their classrooms, amplifying efforts within diverse schools and communities. While traditionally offered in person, in FY 2020 and 2021, we offered TSPs in a remote format, providing continued opportunities for engaging in and learning science, with hands-on activities sent to each teacher to mimic the experience of researching and learning in a laboratory.

TSPs are co-sponsored by important external partners with aligned interests in the scientific scenarios. In FY 2021, PNNL partnered with Educational Service District 123, the Association of Washington Business, the West Sound STEM Network (WSSN), and the Water Power Technologies Office. Together, we delivered three virtual TSP experiences to 36 teachers, which will impact more than 9,000 students across Washington State. Teachers worked on Climate Science and Data Visualization, Groundwater Storage, and Marine Energy scenarios.

FY 2021 marked the first delivery of the Marine Energy TSP, which focused on evaluation of marine energy deployment and how to translate that knowledge to equitable learning in the classroom. This experience was offered to 12 WSSN educators from eight Olympic Peninsula school districts. On average, 45.5% of the student population these teachers serve are from underrepresented groups, 39% are low-income, and only 44% pass their state science assessment, which is below the 47% state average.

Leveraging the demonstrated success of TSPs to enhance the curriculum of classrooms in this region allows PNNL to direct the necessary resources that enable teachers to integrate meaningful technology and curriculum into their classrooms and increase opportunities for all students to gain knowledge and skills in community-relevant STEM fields. Providing early and equitable STEM opportunities and experiences is vital to generating diversity in STEM pathways and growing the future diverse STEM workforce.

$30.8M
INVESTED BY BATTELLE WHILE OPERATING PNNL

$1.1M
IN FY 2021 COMMUNITY ASSISTANCE FROM BATTELLE & PNNL

313K
HOURS VOLUNTEERED BY STAFF AT PNNL OVER THE PAST 10 YEARS

Community Investments and Assistance

While operating PNNL, Battelle has invested a total of $30.8M to improve science, education, and quality of life in Washington State, including investments in the arts and culture, as well as health and human services programs that are important to our community.

In FY 2021, PNNL and Battelle contributions to philanthropic and civic organizations, including corporate support for STEM education, totaled $1.1M. This includes a donation, the second of two $500K investments, to support STEM efforts in Washington.

Over the past 10 years, staff members at PNNL have volunteered 313K hours to community projects. The number of volunteer hours in FY 2021 continued to be lower than in previous years, however, due to the pandemic and an abundance of caution for the safety of our staff and the recipients.

CASE STUDY

The Spirit of Giving

As 2021 began, it became clear many in our region still were impacted significantly and struggling due to challenges from the pandemic. In response, PNNL put out a call to local charitable organizations, inviting them to submit proposals for Battelle grants of up to $10K in February 2021. These grants were specifically designed to help our local nonprofits identify needs and request resources to best serve those in our community.

This resulted in $120K in charitable funding directed to COVID-19 relief support for programs like food security and mental health services, resourcing for nonprofits to purchase personal protective equipment (such as masks and gloves), and aiding organizations with aging facilities to make needed repairs that provide safer environments for their staff and clients.

The spirit of giving also extended to individual staff at PNNL. In September 2021, our staff was given the option of receiving a token of appreciation in recognition of their work or directing a philanthropic gift of equal value to a food bank in their area. The combined impact from PNNL employees who chose to give toward this initiative resulted in nearly $33K in charitable funding. This went to six nonprofits, supporting communities in the Tri-Cities, Sequim, and Seattle, Washington; Portland, Oregon; Washington, D.C.; and College Park, Maryland.

Throughout the duration of the COVID-19 pandemic, Battelle has donated $353K in pandemic-related relief to communities in Washington State.

Financial contributions of $120K were made to several health and human service organizations for COVID-19 community relief efforts in food services and for mental health support. These donations included funds to support Cork's Place, Grief and Compassion Fatigue Training; critical building improvements at the Salvation Army–Pasco to ensure services could be expanded to more community members; Senior Life Resources Meals on Wheels to diversify their food offerings to be more inclusive of economically disadvantaged seniors in our community; as well as local Tri-Cities and Olympic Peninsula food banks.

In addition to monetary donations, staff at PNNL also donated their time throughout the community. One way they did this was by serving on community boards, including the Tri-Cities Regional Chamber of Commerce, Association of Washington Business (AWB), Washington Roundtable, Washington State University–Tri-Cities Advisory Committee, Tri-Cities Development Council, The REACH Foundation, Clallam Economic Development Council, Visit Tri-Cities, WSSEF, and WSSN.

Financial support and sponsorship for several community events and projects was provided, as well, including the Tri-Cities Diversity Summit, the Association of Washington Business' Policy and Manufacturing Week Summits, and the Workforce Portal Pilot program partnering with AWB, Tri-City Regional Chamber of Commerce, Washington State University–Tri-Cities, and Columbia Basin College.

Table 7 | PNNL and Battelle Community Assistance Statistics for FY 2021

Washington State Community Assistance	Total ($K)
Battelle and cash donations to health, human services, and other philanthropic and civic organizations*	$999
PNNL memberships/projects in Washington civic organizations	$106.5
Total**	**$1.1M**

**Includes $730.5K in donations to STEM education.*

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

CONCLUSION

Where scientific innovation and economic impact meet, you'll find PNNL. Scientists, engineers, and support professionals at PNNL contribute scientific knowledge, new ideas, novel inventions, innovative technologies, and processes that help make the world safer, cleaner, and more prosperous. From advancing scientific discoveries to enabling sustainable energy and enhancing national security, PNNL is committed to addressing critical national and global challenges. As we advance scientific understanding and technological solutions, we also are building the economy of tomorrow for the nation and the state of Washington.

In FY 2021, PNNL positively impacted the economic activity in Washington with $1.24B in total spending, 4,623 resident employees, in-state payroll of $515M, and approximately $81.8M in purchases from Washington businesses. This economic activity, in turn, supports a total economic output of $1.81B, as well as in-state payrolls of $702M and more than 7,600 jobs throughout the state.

$1.81B

TOTAL ECONOMIC OUTPUT SUPPORTED BY PNNL PAYROLL & DOMESTIC PURCHASED GOODS & SERVICES

$702M

WASHINGTON STATE WAGE INCOME

>7,600

TOTAL JOBS GENERATED IN WASHINGTON STATE

The growing number of commercial companies in Washington that were formed based on PNNL ideas and assistance has added more than 118 employees and an estimated $24.6M in funding, proving the success of our model for interagency collaboration and technology transfer and commercialization, which has won numerous awards.

An additional $286M in output, in-state payrolls of $119M, and 1,530 jobs are supported through closely related activities, such as companies with PNNL roots, retirees, visitors, and health-care spending.

The COVID-19 pandemic has been an extraordinary time, not just for PNNL in the communities where we live and work, but across the nation and the world. At PNNL, we've been fortunate. Our staff were able to remain productive, with our essential workers on campus employing a defense-in-depth strategy to keep ourselves and our community safe. We hired 352 new staff and provided 892 internship opportunities to expose the next generation's workforce to the caliber of expertise offered only at a national laboratory. We contributed scientific knowledge that helped to advance approaches to diagnose, treat, and prevent COVID-19.

We humbly recognize others in our communities were not as fortunate. To that end, we donated more than $1.1M to community assistance programs within Washington.

Now, more than ever, it is important for PNNL to continue being a vital component of our state's economy. That's exactly what happens when impact and innovation converge.

APPENDIX

To calculate the economic impact of PNNL on the state of Washington, PNNL used IMPLAN® (IMpact analysis for PLANning),[14] 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 546 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.

14 IMPLAN®. Version 3.0. Davidson, NC: IMPLAN® Group LLC, Inc. *www.implan.com.*

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 2019 was used in this analysis, with gross domestic product deflators within the model used to convert impacts to 2021 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.

Table A.1. | IMPLAN® Input Characterization

Expenditures	Input Characterization
Purchases on Goods and Services	Expenditures were assigned a North American Industry Classification System (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 sector was battery storage manufacturing.
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.


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